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Henri Métivier, Sven Nielsen, Jouko Tuomisto, Wolfgang Weiss

International Evaluation of the

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

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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, a site visit and interviews with a great number of scientists.

This evaluation was the second international evaluation and the panel noted with satisfaction that STUK had carefully analysed and taken into account the recommendations of the international review panel in 2000. Many of the recommendations had successfully been implemented in organising the work tasks and the professional profile of STUK has also become more visible since 2000 both in the Nordic countries and in the international scene.

The evaluation panel found that STUK has reinforced its position as a top research institute in its field largely due to the multidisciplinary know how and its integration in the main European or international projects. STUK's research is in most areas of high or even the highest quality. However, the evaluation panel made several recommendations on management and scientific issues to reinforce the quality of research activities at the Institute.

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

TIIVISTELMÄ

Henri Métivier, Sven Nielsen, Jouko Tuomisto, Wolfgang Weiss. International Evaluation of the Research Activities of the Finnish Radiation and Nuclear Safety Authority (STUK). Helsinki 2006, 56 s. (Sosiaali- ja terveysministeriön selvityksiä ISSN 1236-2115; 2006:60) ISBN 952-00-2187-6 (nid.), ISBN 952-00-2188-4 (PDF)

Sosiaali- ja terveysministeriö kutsui poikkitieteellisen kansallisista ja kansainvälisistä asiantuntijoista koostuvan asiantuntijaryhmän arvioimaan Säteilyturvakeskuksen (STUK) tutkimustoimintaa. Arviointi perustui arvioijille etukäteen toimitettuun laajaan kirjalliseen materiaaliin ja STUKissa vierailuun, jonka yhteydessä haastateltiin STUKin tutkijoita ja muuta henkilökuntaa.

Tämä arviointi oli järjestyksessään toinen STUKin tutkimustoiminnan kansainvälinen arviointi ja asiantuntijaryhmä totesi tyydytyksellä, että STUK oli huolellisesti analysoinut ja ottanut huomioon vuonna 2000 tehdyn arvioinnin yhteydessä annetut suositukset. Useat suosituksista oli pantu toimeen onnistuneesti ja STUKin asiantuntemuksen näkyvyys sekä Pohjoismaissa että kansainvälisellä tasolla oli lisääntynyt.

Arviointiryhmä havaitsi, että STUK on vahvistanut asemaansa alansa korkeatasoisena tutkimuslaitoksena. Tämä perustuu ensisijaisesti STUKin monitieteelliseen asiantuntemukseen ja keskeisiin eurooppalaisiin ja kansainvälisiin tutkimusprojekteihin osallistumiseen. STUKin tutkimus on laadultaan korkeaa tai korkeinta tasoa useimmilla osa-alueilla. Asiantuntijaryhmä antoi kuitenkin lukuisia sekä hallinnolliseen että tieteelliseen toimintaan liittyviä suosituksia STUKin tutkimustoiminnan laadun vahvistamiseksi.

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

SAMMANDRAG

Henri Métivier, Sven Nielsen, Jouko Tuomisto, Wolfgang Weiss. International Evaluation of the Research Activities of the Finnish Radiation and Nuclear Safety Authority (STUK). Helsingfors 2006, 56 s. (Social- och hälsovårdsministeriets rapporter ISSN 1236-2115; 2006:60)
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Social- och hälsovårdsministeriet bjöd in ett antal experter från flera olika professioner och länder till en panel med syfte att utvärdera STUK:s forskning (Strålsäkerhetscentralen). Utvärderingen byggde på ett omfattande skriftligt material, ett besök på en anläggning och intervjuer med ett stort antal forskare.

Det var den andra internationella utvärderingen och panelen noterade också med tillfredsställelse att STUK omsorgsfullt hade analyserat och beaktat den internationella panelens rekommendationer år 2000. Många av rekommendationerna hade genomförts i organisationen när det gäller olika arbetsuppgifter och STUK:s professionella profil har också blivit mer synlig de senaste åren, både i Norden och internationellt.

Panelen fann att STUK har stärkt sin ställning som ett viktigt forskningsinstitut inom sitt område, till stor del tack vare den tvärvetenskapliga kompetensen och samarbetet med europeiska eller andra internationella projekt. STUK:s forskning håller hög eller högsta kvalitet inom de flesta områden. Dock gjorde panelen flera rekommendationer rörande ledningsfrågor och vetenskapliga frågor för att stärka institutets forskningskvalitet.

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

PREFACE

The Ministry of Social Affairs and Health and Radiation and Nuclear Safety Authority (STUK) agreed that the scientific output of STUK will be evaluated by an international expert panel in 2005. For the first time the research activities of STUK were evaluated in 2000.

The Ministry of Social Affairs and Health invited a multi-professional panel of international and national experts for the evaluation. The panel was chaired by emeritus Professor Henri Métivier (National Institute for Nuclear Sciences and Technology, France). Other members appointed to the panel were Professor Wolfgang Weiss (Federal Office for Radiation Protection, Germany), Dr. Sven P. Nielsen (Risø National Laboratory, Denmark) and emeritus Professor Jouko Tuomisto (National Public Health Institute, Finland).

The Ministry of Social Affairs and Health was pleased to note that the panel considered that the quality of research within STUK was in most areas of high quality and that STUK has reinforced its position as a top research institutie in its field. The panel also found that the professional profile of STUK both in Nordic countries as well as on the international scene had become more visible.

However, the panel issued some new recommendations in order to further improve the high performance of STUK as a research organisation. The panel recommended inter alia, that:

- STUK should continue to apply the policy of succession planning developed during the last 5 years, to transfer the knowledge of retiring experts to the new generation of radiation protection scientists,
- STUK should clarify the interaction, responsibilities and resources allocated to emergency preparedness among those units that contribute to this area,
- STUK should continue strategic planning of research, with the aim of reducing the great number of small projects, and
- STUK should reinforce its efforts made to publish scientific results in peer-reviewed journals.

I would like to thank warmly the evaluation panel for its efforts and constructive proposals to support the work of STUK. The actions to be taken on the basis of the evaluation will be a challenge for the years to come.

Kimmo Leppo
Director General

Health Department
Ministry of Social Affairs and Health

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Background of the evaluation

The objective of this peer review was to provide an evaluation for the Ministry of Social Affairs and Health (MSAH) of the research and health physics functions of STUK. To accomplish this, the MSAH invited four international and national evaluators to carry out the evaluation.

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

- Appropriateness of STUK's activities in relation to relevant issues in radiation protection sciences
- Social relevance and effectiveness of the activities
- Steering by information
- Prioritising STUK's various activities
- Quality of STUK's research activities
- The relation between costs and results

MSAH and STUK supplied the evaluators with material concerning the history, status and strategy of STUK two months before the site visit to STUK. The evaluators made a site visit to STUK to interview the management and personnel of the different laboratories of STUK.

After having studied the material and conducted the interviews during the site visit the evaluators were expected to draw up a final evaluation report. The work was carried out by the evaluation team on the basis of the evaluation material provided by STUK and the information gathered during the site visit to STUK.

The experts had access to all information they needed, and received the answers to all the questions that they presented to the management, as well as to the personnel of the laboratories. They consider that the evaluation was done under the best possible conditions without any constraints and in perfect freedom.

MEMBERS OF THE EVALUATION PANEL

Professor, PhD, **Henri Métivier**, Chairman of the evaluation panel, is emeritus Professor of radiation protection at the National Institute for Nuclear Sciences and Technology (INSTN) in Saclay, Scientific advisor of the Director of the Radiation Protection and Nuclear Safety Institute (IRSN) was Director of research of the former IPSN (Institut de Protection et de Sûreté Nucléaire) and assistant of the director for protection of man and environment.

After obtaining his first degree (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 Commission, the military branch, in 1972. He became the deputy head of experimental toxicology and in 1982, the head of toxicology and cancerology unit of the IPSN. In 1989, he worked for the director of nuclear safety research of the IPSN, then became in 1995 the director of research and took the responsibilities of IPSN-University relationships and the responsibility of fellows doing the PhD. In 1999 he was nominated Professor at INSTN.

His research work has mainly concerned with actinides, speciation of plutonium at low levels for human extrapolation, biochemistry linked to the effects of plutonium in lungs, and connective tissue pathology of the lung whether linked to radiation or not, biokinetics (after inhalation and ingestion) and carcinogenesis of actinides compounds. He has also been responsible for the preparation of French protection rule of workers experimenting with HIV viruses in animals. He has published more than 200 publications, over 50 as a first author in international journals, and 40 as a first author in French journals.

He has acted as a consultant of ICRP in different task groups. He was a member of ICRP Committee 2 (1989-2005) and chairman of human ICRP Alimentary Tract Task Group (ICRP Publication 99). He was a member of a scientific Advisory Group to the CEC Radiation program. To day, he is the evaluator of several CEC's programs. He is a consultant of the OECD/NEA CRPPH (Committee for Radiological Protection and Public Health). He acts as a chairman of the scientific committee of the Department of radiation measurements and units of the CEA, and a member of French Metrology Committee (LNME). He is a consultant for the French Academy of Sciences.

He has participated in organising several international symposia and he has published a collection of about 20 scientific books devoted to nuclear protection and safety. He is a chairman of the editorial board of RADIOPROTECTION, the journal of the French Radiation Protection society (SFRP). He obtained Academic palms in 1992.

PhD **Sven P. Nielsen** is the Deputy Head of the Radiation Research Department at Risø National Laboratory and Head of the Research Programme on Radioecology and Tracer Studies.

After studying electronics and physics he obtained his Masters Degree in Electrical and Nuclear Engineering from the Technical University of Denmark. He obtained a PhD on environmental radioactivity focusing on field gamma spectrometry. The PhD work was carried out at Risø National Laboratory where he joined the Section on Applied Health Physics responsible for radiation safety at Risø's nuclear facilities. In 1986, he joined the Ecology Programme of Risø's Department of Environmental Science and Technology and in 1999 he was promoted to his present position in the Radiation Research Department

His research work has concentrated on environmental radioactivity covering natural and man-made radioactivity. He has been involved in a range of international projects on radiological and radioecological research involving the Nordic countries, the European Commission and the International Atomic Energy Agency. He has been working particularly with radioecological models describing the transfer of radionuclides in the terrestrial and marine environments. The models have been used to describe and study transfer processes in the environment and to make radiological assessments of actual and hypothetical releases of radioactivity to the environment. His publications include 57 articles in international peer-reviewed journals, 60 published conference papers and about 170 extended abstracts and reports.

He is the manager of the project on Monitoring of Radioactive Substances in the Baltic Sea (MORS) under the Helsinki Commission dealing with natural and man-made radionuclides in the Baltic Sea and their radiological impact on man. Members of the MORS Project are laboratories from the countries bordering the Baltic Sea working with radioactivity in the marine environment.

He is a member of the Danish steering group for the Arctic Monitoring and Assessment Programme and Danish member of the Groups of Experts on the Articles 35, 36 and 37 of the Euratom Treaty.

Professor emeritus **Jouko Tuomisto** graduated as a physician from the University of Helsinki in 1965, received his doctoral degree in Medical Sciences from the Department of Pharmacology of the same University in 1968 and PhD in Pharmacology and Toxicology from the University of Kansas, Kansas City in 1972. He was appointed Associate professor of Pharmacology in the University of Helsinki 1977, and Professor of Toxicology and Pharmacokinetics in the University of Kuopio 1978. In 1983, he started organising the Department of Environmental Hygiene and Toxicology (presently Department of Environmental Health) to the National Public Health Institute of Finland. This department grew over the years to an internationally oriented environmental health research institute of European scale with a staff of about 140 people. After his retirement in 2004, he continued in many expert tasks serving the European Union, the World Health Organisation and the Government of Finland.

Professor Tuomisto has published 16 books, over 200 scientific articles in peer-reviewed international journals and a large number of articles in professional and lay magazines and newspapers. The main topics of his scientific work have been neuropharmacology, neuroendocrinology, neurotoxicology of metals, and most recently persistent organic compounds, mostly dioxins. He has also been a member of a number of committees and advisory bodies in the areas of pharmacology, toxicology and environmental health. One of these was the Energy Committee in 1987-1989 delineating various energy production prospects of Finland including nuclear energy.

Director and Professor Dr. **Wolfgang Weiss** is the Head of Department of Radiation Protection and Health of the Federal Office for Radiation Protection (BfS) in Munich, Germany. After obtaining his degree in physics (diploma and PhD) at the University of Heidelberg in 1975, he spent one year as a Post-doc at the Woods Hole Oceanographic Institute, Mass., USA, to study the global distribution of the weapons' fallout (tritium and ^{14}C) in the world 's oceans. In the following years he participated in related global marine research projects.

In 1980 he became the Director of the Institute for Atmospheric Radioactivity in Freiburg, Germany. His early work was on environmental surveillance with a strong focus on noble gas measurements (^{85}Kr, ^{133}Xe). The first automatic remote control dose rate monitoring system for NPPs in Germany was designed by the institute. It became a prototype for the site-specific surveillance systems of German NPPs, which is now mandatory.

After the Chernobyl accident, he designed – on behalf of the German government – a comprehensive national system for the surveillance of the radiological situation of the environment, early warning and decision support (IMIS). This work included the development of specific decision support systems like RODOS, which were developed at the EU level. In this context, he engaged in various aspects of emergency preparedness. Within several governmental cooperation projects between Germany and Russia he established on-line monitoring systems in the vicinity of Russian NPPs.

He was an adviser to the German government during the negotiations of the Comprehensive Nuclear Test Ban Treaty (CTBT) in the mid nineties. His institute hosted a global inter-calibration exercise for all Xenon-measuring systems, which were developed globally to demonstrate that this technology is suitable for CTBT purposes. The Institute hosts an aerosol and a noble gas station of the global monitoring system of the CTBT organisation.

Since 2000 he is responsible for all health-related scientific issues of radiation protection at the federal level in Germany. This includes questions of risk quantification both for ionising and non-ionising radiation, risk communication, radiation protection at the workplace and the full spectrum of medical applications of ionising radiation. His department operates national dose registries for workers and for highly radioactive sources as well as a national UV measurement network. It acts as a regulator for all applications of radionuclides and/or ionising radiation in clinical research. Radon epidemiology (dwellings and miner studies) is another important area of work. Currently a major national research programme on the effects of EMF is operated by the department.

Dr. Weiss is the head of the German delegation of UNSCEAR, member of Committee 4 of ICRP, chairman of ICRP TGs on "Optimisation" and "Emergencies", member of OECD/NEA/CRPPH as well as of the CRPPH Bureau. He is being involved in the definition and implementation of several EURATOM research programmes of the CEC.

SUMMARY AND PRINCIPAL RECOMMENDATIONS

Research is essential to underpin the effective functioning of STUK and the quality of its advice both to the ministry and the public. However, it is always difficult to reconcile the activities of research and the activities of expertise in the organisations whose principal objectives are laid out by the government and the population. The panel estimates that STUK, being an effective organisation, reconciles these two objectives and succeeds to maintain a research organisation of high quality. The most visible parameter of this success is the attractiveness that STUK shows amongst the young doctoral students and the universities. The process of adopting and prioritising new projects and research ideas has become more transparent since the previous evaluation. The panel appreciates that the recommendations formulated in 2000 evaluation were all assessed and, for the majority, also taken into account. The panel considers that the quality of research in STUK is high and at an international level. The professional profile of STUK has become more visible both in Nordic countries and in the international scene. The nomination of Helsinki for the organisation of the 2010 European IRPA congress is the most visible recognition of the efforts.

However, the 2005 panel wishes to put forth new recommendations to further improve the high performance of STUK.

The major recommendations of the panel are:

- To continue to apply the policy of succession planning developed in the last 5 years, to transfer the knowledge of retiring experts to the new generation of radiation protection scientists.
- To continue strategic planning of research, with the aim of reducing the great number of small projects.
- To clarify the interaction, responsibilities and resources allocated to emergency preparedness among those units that contribute to this area.
- Further work remains to be done in adopting and prioritising new projects and research ideas, especially with work crossing the administrative borders.
- To reinforce efforts made to publish scientific results in peer-reviewed journals. STUK should take an initiative that all data of general interest and relevance will be published by the laboratories themselves or in collaboration with other STUK units and universities.
- To enhance the cooperation of research for non-ionising radiation and radia-

tion practices regulation areas and research in the Research and Environmental Surveillance Department.

- To reconsider the unrealistic wish of STUK to increase the share of outside financing of certain targeted laboratories. These laboratories have already a sufficient workload which corresponds to a well-targeted objective. It is difficult for these units to diversify into other activities.
- For emergency preparedness, responsibilities should be more clearly specified and transparent decision mechanisms should be communicated to all concerned.
- To consolidate the multidisciplinary project "Uranium" and seek for new European complementary partners; the project is one of the rare projects in the world having an objective to study the chronic internal exposure.
- To establish, further develop and implement mechanisms and procedures to address and prioritise horizontal issues, which might affect several laboratories of STUK.

Specific recommendations for laboratories

Natural Radiation

- The Natural Radiation Laboratory should maintain or increase co-operation with universities in order to establish projects employing MSc and PhD trainees and ensure recruitment of young talented scientists.
- More emphasis should be given to publish results in international peer-reviewed journals in order to maintain the high level of research work on natural radioactivity and demonstrate this to the scientific community.
- Recommendations on natural radioactivity should be compared with those of other European countries having an extensive experience in this field of activity.
- To continue the active role of the group in the health studies, especially in epidemiological analyses. The group has to be associated with European group studying health effects of natural radionuclides in drinking water.

Radiation Hygiene

The panel mainly endorses the 2000's recommendations, and enhances it;

- The laboratory's core activities, which are of great importance to STUK, Finland’s nuclear industry and the radiation protection field, should be maintained at a high level.
- STUK should continue to monitor the ^{137}Cs body content of the population

over the next years. The situation in Finland is unique and the information to be gained is potentially important for decision-makers in the event of any future nuclear accident.

- The laboratory should continue to actively participate in research on chronic internal exposure.
- Efforts to provide information to the public should to be kept at a high level to maintain the credibility of STUK as an authority and impartial body giving advice on radiation protection issues in Finland.
- The laboratory has to engage, as other STUK laboratories, the actual efforts for transferring the know-how between generations of scientists.

NPP Environments

- STUK has to consider the question of critical mass of the laboratory.
- The laboratory has to maintain close collaboration with other STUK laboratories.

Ecology and food chains

- To reduce the number of projects to allow more time for the remaining projects.
- To continue to participate in major European projects.
- To increase the rate of publications in international peer-reviewed journals.
- To prepare a succession plan because 3-4 members of senior staff will retire within the next 5-7 years.

Airborne Radioactivity

- Research activities should be maintained at the present level or increased in order to maintain the high standards.
- From a strategic point of view, high priority should be given to establish a Xenon-analysis capability.
- More emphasis should be given to publish results in international peer-reviewed journals.

Regional Laboratory in Northern Finland

- The final objectives of the laboratory must be redefined as an international observatory of the health of a particular ecosystem of the planet.

- The pressure of STUK to find financing from external sources is not realistic and should be reconsidered. The laboratory has already a sufficient workload which corresponds to a well-targeted objective. It is difficult for the unit to diversify into other activities.

Radiation Biology

- To keep the level of quality of research.
- To keep in mind the particular needs for research in Finland.
- To maintain the link with the Epidemiology laboratory, especially if molecular epidemiology activities in the Radiation Biology laboratory keeps increasing.
- To establish a position on the ethical applications of certain research projects, screening, for example.

Epidemiology and Biostatistics

- To maintain its enthusiasm.
- To avoid the dispersion of its activities too much in spite of the many requests.
- To keep the contact with the laboratories having expertise in evaluation of exposures and doses.

Radiation in health care - Radiation Metrology

- To maintain the expertise in the areas already covered, broaden it to cover new upcoming areas, and increase manpower.
- The laboratory wishes to supplement its expertise in the codes of Monte Carlo. It is recommended to the laboratory, taking into account the number of people, to visit the German and French laboratories having already experience in this field, and associating these codes with voxel phantoms technology.
- To present the excellent results and experience and provide feedback to the international scientific community.

Non-Ionising Radiation

- It is highly important to continue the work of the laboratory because it is either crucial from a health protection point of view, or from public perception.

- Interaction with biological research should be continued and further developed.
- The number of activities supported by the laboratory should be kept under permanent review.
- More publications in international journals are desirable.

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, transfer of radioactive substances in the environment, effects on biota, radiation hygiene, medical use of radiation, dosimetry, and non-ionising radiation. Maintaining and developing of high level competence in field and laboratory analyses in order to cope with abnormal radiation situations is an important part of research activities.

Studies on biological and health effects of radiation cover both ionising and non-ionising radiation. Topics in epidemiological studies have included lung cancer induction by radon, carcinogenicity of natural radionuclides in drilled wells, kidney effects of uranium in drinking water, health consequences of Chernobyl accident, cancer among nuclear workers, cancer risk attributable to cosmic radiation, and cellular phone use and brain cancer. Biological studies of ionising radiation have included radiation-induced genomic instability, radiation-induced bystander effect, hereditary radiation effects, individual radiation sensitivity and biodosimetry. Topics in biological studies of non-ionising radiation included genome-wide and proteome-wide analyses of cell response to mobile phone radiation and to UVA, cellular stress response induced by RF-EMF, effect of RF-EMF on blood-brain barrier function, and effect of UVA on melanoma metastasis *in vivo*.

Exposure of the Finnish population to natural radionuclides via indoor air and drinking water is amongst the highest in the world. The research on radon has involved nation-wide surveys on radon exposure in homes and at workplaces, epidemiological studies, modelling of radon entry, indoor radon mitigation and prevention techniques as well as water treatment methods for removing radionuclides from household water. For preventive actions, information is acquired to promote radon-safe construction and mitigation of high ra-don concentration buildings. Radon and uranium concentrations of water from wells drilled in bedrock are significantly high in Finland and the drilled wells are used more and more as source of household water. Understanding the reasons leading to great regional differences in activity concentrations in Finland is among the current topics for research.

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 and possibilities to mitigate contamination levels in foodstuffs and forest products. After the Chernobyl accident, the radionuclide concentrations in agricultural products decreased rapidly as compared to those in natural and semi-natural products (mushrooms, berries and game). The average radiation dose via foodstuffs from artificial radionuclides is now below one percent of the average annual dose of Finns.

Research on radiation hygiene deals with kinetics of radionuclides in human body and the con-sequent internal exposure to radiation. Concentrations of radionuclides in human body are monitored with whole body counters and using other bioassay methods. Recent studies have included assessment of chronic incorporation of uranium and natural radionuclides from drinking water, as well as monitoring of body content of cesium-137 in groups of people living in regions of higher Chernobyl fallout and consuming local natural foodstuffs.

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. Modern communication technology is exploited to develop real-time radiation monitoring systems and mobile radiation detection and field measurement techniques. Analytical algorithms have been developed for gamma spectrometry and direct alpha spectrometry.

Current research on medical use of radiation mainly focus on X-ray diagnostics where the priority areas include the optimisation of X-ray examination techniques, examinations with high patient doses (CT, fluoroscopic procedures), most radiosensitive patients (children), screening of non-symptomatic patients (mammography), performance of new imaging technologies (digital imaging) and assessment of patient dose. For radiotherapy and radiation metrology, techniques for applied clinical dosimetry and calibration of dose-meters have been developed.

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 protect people, society, environment, and future generations from harmful effects of radiation. Its history is described in the Research activities report edited by S. Salomaa and T.K. Ikäheimonen in July 2005 (STUK-A210). 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 STUK's work.

One key objective of STUK research is to extend professional knowledge that supports regulatory operations and the maintenance of emergency preparedness. The quality of the research done is under continuous self-assessment, and internal procedures have been set up to promote continuous improvement. Peer-review of scientific articles in international journals is used as an external quality measure and independent reviews on the effectiveness and quality of research are carried out every five years. This is now the second time when all STUK 's research activities have been subject to external review by international radiation protection experts and scientists.

Doctoral students at STUK

A panel member took an initiative for the panel to interview doctoral students and recently graduated doctors at STUK. The meeting with the six young people was organised and the following discussions in the meeting were very open.

The review panel interviewed the group on their attitudes how they feel STUK as a working and research training environment. The doctoral grades are given by universities that set the conditions of tutoring. Usually a doctoral student has at least two supervisors, and most university departments require at least one of them being their own professor or docent. Important university departments are e.g. the Department of Chemistry, Laboratory of Radiochemistry, University of Helsinki, and Helsinki University of Technology, just to mention a few. Students preparing their thesis at STUK considered STUK very attractive, and evalu-

ated their tutoring very high. STUK also gives its young employees a possibility for a leave of absence for postdoctoral training at other institutes, usually abroad. This is highly important even if it may be a financial burden. The students showed good communication skills and professional mastering of their fields and indicated that STUK also expects some participation in professional activities outside of their own research topic.

STUK is an attractive workplace for students in MSc and PhD studies due to good working conditions, e.g. good supervision, laboratory facilities and equipment. During evaluation of the laboratories, the panel observed that STUK is also attractive for foreign young top-level scientists.

Another positive feature of STUK's policy towards permanent scientific staff is that it encourages acquiring international experience and strengthening international contacts by visiting foreign organisations.

Some STUK groups consisting of senior staff only (e.g. expert group on radiation protection) could benefit from including younger staff members in order to stimulate discussions and introduction of new ideas.

STUK is to be congratulated on its improved record of training doctoral students as compared with the previous evaluation in 2000. These activities are very valuable for STUK's professional recruitment of competent people in future years when several experts in key positions will retire. It is also a valuable asset in maintaining and obtaining international collaboration with research institutes in other countries. STUK's policy facilitates recruiting competent personnel in general, as it improves the scientific image of the institute.

The panel recommends that the increased profile of training activities of doctoral students and scientific education of its own personnel are continued.

Research in the field of emergency preparedness in STUK

In case of nuclear or a radiological accident STUK provides a great number of expert services and decision support at national level. E,mergency preparedness and radiological situation assessment of STUK relies heavily on the competence of some of its laboratories (Radiation Hygiene, Ecology and Foodchains, Airborne Radioactivity). These units are also responsible for the environmental surveillance in Finland, which is one of STUK's regulatory activities. This matrix organisation is well suited to maintain a high level of preparedness. In case of an emergency, additional information (e.g. source term information) is provided by the unit for Nuclear Reactor Regulation and by external organisations. The unit for Emergency Preparedness is the focal point of all these activities; it is responsible for the emergency operation and management of STUK as well as for the planning and participation in national and international exercises. The interaction between research and regulatory functions is developed through international standards and regulatory guides.

One of the key objectives of STUK research is to extend professional knowledge that supports the maintenance of the high standard of emergency preparedness. One of the main ar-

eas of research during the period 2005 to 2006 is the "preparedness for nuclear and radiation accidents, the production of data on methods how to protect and restrict the harms of radioactive fallout and to develop methods that allow to follow and predict the radiation situation." Research activities are embedded in major European research projects with special emphasis on the unique situation in the Nordic countries. Three of the seven laboratories in the Department of Research and Environmental Surveillance have key obligations in emergency preparedness. The Research Director of STUK acts both as chair of the department and takes responsibility for the overall conduct of research at STUK, as well as emergency preparedness.

The panel has been informed that there are specific regulations and procedures in place which describe the ways in which the Research Director and the head of the unit for Emergency Preparedness work together and how priorities are defined to meet the needs of the unit for Emergency Preparedness.

The interviews with the laboratories participating in the matrix organisation have documented that – despite existing procedures – there seems to be a lack of transparency and clarity with respect to responsibilities for decision making and for prioritising the overall research needs in the area of emergency preparedness. The action programme for research for years 2004-2006 identifies a great number of individual research activities which – from the point of view of the various laboratories – are areas of high priority. However, the panel felt that mechanisms for the prioritisation of research and development activities addressing horizontal issues which might affect several laboratories or the function of STUK as a whole are not as well developed as is the case at the level of the laboratories. For example, a consistent system for managing, processing, and assessment of all data available at the various laboratories of STUK and from external organisations was identified to be missing.

It is recommended that

- Responsibilities should be specified more clearly and transparent decision mechanisms should be communicated to all concerned.
- Mechanisms and procedures should be developed and implemented to address and prioritise horizontal issues which might affect several laboratories of STUK.

General Recommendations

The panel notes with satisfaction that STUK has carefully analysed and taken into account the recommendations of the international review team in 2000. Many of the recommendations have been implemented successfully in organising the work tasks and the professional profile of STUK has become more visible both in the Nordic countries and in the international scene.

Most units were enthusiastic about research even if there were big differences in the relative proportions of research and routine duties. For natural reasons the scientific productivity was highest in units concentrating mostly in research, i.e. in radiation biology and epidemiology. These laboratories also had the largest number of enthusiastic doctoral students. But also in many other units a desire for improved publication record could be sensed, although in the limits of time available. In some cases a defensive mood was encountered in the sense of not seeing that the work is not finished until it is also published. In other words, publishing the results was not seen as an integral part of the everyday work. In some cases also defensive attitudes were observed as to ownership of the raw data. According to the Finnish legislation the ownership in governmental research institutes is very clear. The data are not owned by the unit or by the researchers but by the institutes and thus by the society that has paid for it. Hence the institute can, in principle, see that the work is finished including publication, if not by the original data collector, then by somebody else in the house or in collaboration with other research institutes or universities. This should be made clear in all units.

The recommendation from the evaluation in 2000 of sharing analytical services and equipment across laboratories has been followed. The panel notes with satisfaction that cooperation on analytical competence, equipment and capacity across units is very good. Permanent working groups on sampling and pre-treatment, radiochemical analyses and gamma spectrometry have been established with participation of all laboratories.

Nevertheless, some of the recommendations of the international review team in 2000 remain valid and further permanent efforts by STUK are required in the following areas:

1. To seek opportunities for involving senior scientific staff of STUK in the work of UNSCEAR. With regard to the international recognition of the quality of STUK in the radiation protection field, the panel recommends to the Finnish authorities to engage an action in the UNO to re-discuss the member state participation of Finland and probably other countries to this scientific committee.

2. To continue strategic planning of work with the aim to consolidate the resource allocation by substantially reducing the great number of small projects.

3. To continue applying the policy to succession planning, developed in the last 5 years, to transfer the knowledge from retiring experts to the new generation of radiation protection specialists.

4. To regularly review the balance between service-based activities and research activities.

5. The previous panel gave recommendations on creating larger units that would develop critical mass and give more flexibility. These concerns are still valid, and the panel recommends that in a few years when several persons retire, these recommendations are given due consideration before filling the key positions.

6. The panel recommends that STUK should pay attention to the goal that all data of general interest and relevance will be published by the units themselves or in collaboration with other STUK units or universities. This principle may be more important and effective than setting a minimum number of publications per academic person per year.

The timing of internal programme planning by STUK and the external evaluation by the international review teams should be synchronised; so far STUK has developed action programmes for research (2004-2006) which are based on STUK's strategic plan (to be updated 2006). It is not obvious how the 2005 recommendations of the international panel can best be used by STUK.

STUK as a governmental organisation in Finland has several functions, e.g. as a research centre, a regulator and an expert organisation. One way for measuring success of research activities is the number of original publications in peer-reviewed journals per academic person year. In this respect some progress has been made during the last 5 years.

STUK has developed general and clear rules for encouraging research publications. A goal for STUK's research is to produce one original publication per each year per scientist. But, on the other hand, STUK's research supports the work and credibility of STUK as a regulator and an expert organisation. To enhance its policy of publication, STUK must define laboratory by laboratory the type of journal that the scientists will have to sign. In setting publication rules it should be appreciated that not all important papers will be accepted by the so called prestigious journals with high impact factors. Different laboratories may be in different situation, when e.g. important practical information on drinking water may need quite a different forum as compared with fundamental research on bystander effect.

There are no general rules available how this impact and the success of STUK's research can be measured, and therefore STUK should develop appropriate concepts. However, the proposed rules are of good quality and rather unique in many European laboratories. We also have to appreciate that STUK is strongly encouraging its staff to publish in books.

With a general tendency of decreasing budgets the role of external research funding becomes more important. STUK is encouraged to consider possibilities of introducing an internal bonus system for those research teams that raise external funds for targeted research, which is beneficial for the mission of STUK.

REVIEW OF DEPARTMENTS AND LABORATORIES

1. Natural Radiation

The Natural Radiation Laboratory is responsible for:

- Research on occurrence and risks of radon in indoor air, natural radioactivity in household water and terrestrial and cosmic radiation.
- Studies on mitigation of elevated indoor radon concentrations and on treatment methods of natural radioactivity in household water.
- Measurement services for indoor radon concentration and radioactivity in household water.

The former evaluation panel recommended that projects in the areas of indoor radon exposure and radioactivity in drinking water be retained at a high level; the laboratory has clearly promoted the prevention of harmful effects of indoor radon and household water radioactivity by means of research, co-operation with municipal authorities and communication. The laboratory has produced high quality material on the prevention of indoor radon and handling of household water in co-operation with other parties

The database established by the Natural Radiation Laboratory on radon levels in a large number of dwellings, their locations and building techniques is an important tool for continued work on reducing the indoor radon levels in Finland. The database provides background for research on improved estimates of the health risk from indoor radon and documentation of effects of mitigation measures, and the panel recommends that the work in this area be continued at the existing level.

The information from the database can be used to illustrate effects of different ways of reducing the radon exposure of the Finnish population, e.g. overall reduction of radon levels in all dwellings or, reduction of those levels only that exceed intervention levels. The panel recommends that remediation strategies are evaluated and advice given to the building industry and authorities.

Concentrations of radioactivity in water from drilled wells are anomalously high in Finland, and the Natural Radiation Laboratory has investigated techniques for the removal of natural radionuclides from drinking water. The panel recommends that this work be continued at the present high level to reduce problems in cases where concentrations exceed the limits given in the Drinking Water Directive.

The group participates in significant health effect studies of chronic ingestion of uranium at relatively low concentrations. It would be useful to develop collaboration with outside laboratories performing the same type of experiments with animals and occupational health physicists with experience on acute exposure.

The occurrence of relatively high levels of indoor radon and of radioactivity in drilled wells is likely to persist in Finland for many years, thus requiring STUK to remain active in these areas. The panel recommends that the Natural Radiation Laboratory maintains or increases cooperation with universities in order to establish projects employing MSc and PhD trainees and to ensure recruitment of young talented scientists.

In order to maintain the high level of research on natural radioactivity and to demonstrate this to the scientific community the panel recommends that more emphasis to be given to publish results in international peer-reviewed journals in addition to an already impressive list of reports for the national stakeholders involved in indoor radon.

Conclusions

Natural Radiation Laboratory's work is of significant importance to STUK and the Finnish authorities. The laboratory provides authorities and the Finnish public with detailed and reliable information on natural radioactivity. The activities dealing with indoor radon and radioactivity in natural water are excellent. The laboratory has a significant impact on authorities and building companies

Recommendations

- The panel recommends that the Natural Radiation Laboratory maintains or increases its cooperation with universities in order to establish projects employing MSc and PhD trainees and to ensure recruitment of young talented scientists.
- In order to maintain the high level of research on natural radioactivity and to demonstrate this to the scientific community the panel recommends that more emphasis to be given to publish results in international peer-reviewed journals.
- It would be good to compare Finnish recommendations with those given in other European countries with a large experience in this field of activity.
- The panel recommends the laboratory to continue the active role in the health studies, especially in epidemiological analyses. The group should establish cooperation with other European groups studying health effects of natural radionuclides in drinking water.

2. Radiation Hygiene

The Radiation Hygiene Laboratory is responsible for surveillance and research on artificial and natural radionuclides in man. The radiation exposure for various population groups of people and radiation workers is determined using direct and bioassay methods. The results are used to estimate and control internal radiation doses.

Another important function of the laboratory is to contribute to emergency preparedness of STUK with special emphasis on internal contamination.

In the area of environmental surveillance the laboratory is responsible for the gamma spectrometers operated in about 40 local laboratories around the country, for the calibration and maintenance of these instruments as well as for registering the results from each laboratory. This responsibility for the functioning of measurement equipment in the 40 local laboratories is complemented by responsibilities of the unit of Ecology and Food chains.

A considerable part of the laboratory's activities consists of various expert services for private companies, such as estimation of the organ and whole body doses of nuclear power plant workers and other radiation workers.

The laboratory actively participated in a European community project of optimisation of monitoring for internal exposure (OMINEX), which demonstrated good integration of the laboratory in the European scientific community.

The laboratory is active in an important STUK project which is dealing with the chronic exposure to uranium and natural radionuclides in drinking water. As the Natural Radioactivity Laboratory, the Radiation Hygiene Laboratory has been associated with European groups studying health effects of chronic exposure.

The former panel stated that the laboratory’s core activities – which are of great importance for STUK, Finland’s nuclear industry and the radiation protection system – should be maintained at least at the present level (2000). This panel notes to day that the core know-how has been reinforced in this area. New personnel has been trained systematically in key fields of know-how; internal dosimetry (direct and indirect measurements), detector technique, radioactive waste and decontamination processes. In transferring knowledge to the next generation, the essential tools are the quality manual, data bases and publications.

The former panel also recommended to continue the long-term monitoring of critical fission products in the unique Finnish environment and to achieve a realistic and comprehensive assessment in event of any future accident involving a release of radionuclides into the environment, and to complement this task by studying sources of activity in the national diet.

It was also recommended that emphasis be placed on publishing unique data sets held by the laboratory. The laboratory is measurement data will be systematically transferred in to databases.

Lastly, efforts to provide information to the public should be kept at a high level to maintain the credibility of STUK as an authority and impartial body on radiation protection issues in Finland. Customer-oriented communication has been continued since 2000.

The 2005 panel notes that STUK – following the recommendation of 2000 – has taken the initiative to maintain the laboratory's core activities that are of great importance to STUK. Given the fact that the head of unit will retire in the near future, further initiatives are needed to secure the present situation.

In the area of emergency preparedness, the unit provides valuable input to STUK's high quality emergency preparedness activities as a part of an internal network. The questions of the panel on the various responsibilities of different units of STUK contributing to emergency preparedness (Radiation Hygiene, Ecology and Foodchains, Airborne Radioactivity) and for decisions on research priorities were not fully answered in the interviews. Therefore the panel recommends that clear and transparent responsibilities should be specified.

The overall responsibility for the work of the 40 local laboratories and for the assessment of a radiological situation based on the results from these stations remains unclear and it is recommended that clear responsibilities should be established.

According to the research planned for the next 5 years as described in the publication "Research activities of STUK 2000 - 2004" (STUK-A210), the methodological work on the development of methods for direct and indirect measurements and the Nordic projects on the assessment of internal dose seem to be of high priority. Despite declining levels, the monitoring of the ^{137}Cs body content of reference groups should be continued.

The list of publications demonstrates the valuable work of the unit in international networks; the panel notes with satisfaction the active participation of the head of laboratory to the preparation of a report of the ICRU international reference organisation for measurements. These efforts should be encouraged and continued.

Conclusion

The group has a significant obligation for STUK and the Finnish radiological protection establishment. The group is also fully integrated in the European scientific community and Nordic society. Long-term monitoring is needed for a realistic assessment of exposure and complete management of radiological accidents.

This group needs to continue to participate in international conferences and symposiums by presenting the results of its highly original research results.

Recommendations

The panel mainly endorsed 2000's recommendations, and enhances them:

- The core activities of the laboratory – which are of great importance for STUK, Finland's nuclear industry and the radiation protection establishment – should be maintained at a high level.
- STUK should continue to monitor the ^{137}Cs body content of reference groups over the next years. The situation in Finland is unique and the information

to be gained is potentially important for decision-makers in the event of any future nuclear accident.

- The laboratory should continue to actively participate in research on chronic internal exposure.
- Efforts to provide information to the public should be kept at a high level to maintain the credibility of STUK as an authority and impartial body on radiation protection issues in Finland.
- The laboratory for Radiation Hygiene should increase efforts to transfer the know-how between generations of scientists.

3. NPP Environments

The NPP Environmental Laboratory has the main task of monitoring radioactive substances in the environs of Finnish nuclear power plants. The laboratory carries out the work as contracted services to the power plants; this work takes about 50% of the working capacity and reduces the capacity of the laboratory to do scientific work. However, the extensive environmental data produced during routine monitoring are valuable for more comprehensive studies. In addition the NPP laboratory is responsible for a permanent monitoring programme of the Baltic Sea under the auspices of the Baltic Marine Environment Protection Commission (HELCOM).

The former panel recommended achieving critical mass and exploiting potential synergism in analytical activities, creating closer collaboration, concentrating radiological analyses in one laboratory, or restructuring by integration with the laboratory Ecology and Foodchains. Co-operation between the laboratories has been developed, and the NPP laboratory staff clearly favours the present organisation. The NPP Environmental Laboratory has established close collaboration with other STUK laboratories on gamma spectrometric analyses and use of other analytical equipment. Furthermore, joint projects have been implemented with several other laboratories (Natural Radioactivity, Airborne Radioactivity, Northern Finland).

The recommendations of the former panel that 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 were successfully followed. All research projects concerning the Baltic Sea have now been reported.

The NPP Environmental Laboratory has made a significant contribution to develop and establish the department's quality system and accreditation of sampling methods and analytical work. The panel considers this a very important accomplishment that will ensure that the analytical quality will remain high at STUK's laboratories and recommends that this work be maintained at the present high level.

The panel appreciates the significant results from the NPP Environmental Laboratory on radioactivity in the Baltic Sea and the important contribution in the future report on "Radioactivity in the Baltic Sea in 1999-2004 " in the framework of the HELCOM MORS project. It is important that the Helsinki Commission (HELCOM) combines these efforts with the OSPAR Commission for a better knowledge of all European seas.

A comprehensive synthesis on plutonium behaviour in seafood and sediments would be appreciated because certain assumptions described in the research activity report (difference between ^{238}Pu and ^{239}Pu) need to be re-investigated.

The panel considers it important that the NPP Environmental Laboratory maintains close collaboration and carries out research projects with the other laboratories working on environmental radioactivity.

The interaction, responsibilities and allocation of resources concerning emergency preparedness should be clarified for all STUK units that contribute to this area covering both routine work as well as emergency situations.

The research plans for the next five years as described in the publication “Research activities of STUK 2000-2004” (STUK-A210) comprise activities that are important for maintaining and developing STUK’s expertise on environmental radioactivity.

Conclusions

The work of the NPP Environmental Laboratory is significant to STUK and the Finnish nuclear power plants. The laboratory provides the Finnish public with reliable information on environmental radioactivity near the Finnish nuclear power plants. The laboratory has a fine record in their routine activities, in international collaboration and in scientific publishing. For the routine work a small coherent laboratory is undoubtedly efficient, but the panel has some doubts on the possibilities of scientific progress and efficient training of new experts in a small unit.

Recommendations

- STUK should consider the question of critical mass of the laboratory.
- The NPP Environmental Laboratory should continue the close collaboration with other STUK laboratories and maintain the international collaboration with other Nordic and European laboratories.
- The laboratory should continue the work on quality system ensuring that the analytical quality at STUK’s laboratories remains at the present high level.

4. Ecology and Foodchains

The Ecology and Foodchains Laboratory is responsible for studies on distribution and transfer of radionuclides in terrestrial and aquatic environments including agricultural and forest ecosystems. A range of associated activities is included covering countermeasures, rehabilitation strategies for contaminated areas in the context of emergency management and development of decision support tools.

The laboratory also carries out monitoring programmes on artificial radionuclides in deposition, foodstuffs and surface and drinking water. The monitoring results are reported annually and delivered to the European Commission on a regular basis.

The panel notes a substantial effort by the laboratory in the areas of nuclear emergency management and decision support systems as well as radioecology and dose assessments. The activities in these areas are well integrated in international projects and hence demonstrate that STUK is well established in the European research community in these fields.

The panel observed a successful international effort to assess doses and risks to critical groups of fauna and flora with the aim of protecting the Finnish environment in DSSNET, FARMING, FASSETT, and other European research projects.

Similarly as the Radiation Hygiene Laboratory, the Ecology and Foodchains Laboratory has various responsibilities, e.g. for research, emergency preparedness and for the 40 local laboratories. The basic questions and issues needing clarification are identical with those discussed in the chapter of Radiation Hygiene Laboratory.

The former panel also recommended that radionuclide analysis services should be shared with other STUK laboratories. This panel notes that this has been almost fully implemented during the last five years.

Since 3-4 members of the unit are retiring in the next 5-7 years, the question of how to transfer knowledge is obvious and STUK has to take a decision on the future role of this unit.

The international review team considers a part of the work proposed for the next 5 years important to STUK. This includes the work on emergency preparedness, specific radioecological problems addressed in the Nordic programme, and specific issues related to radiation protection and the exposure of biota, which specifically addresses problems of nuclear waste storage.

Based on a purely research-based efficiency scale the publication record is below the standards defined by STUK. However, preparing and developing material like the handbook on radiation protection in urban environment compensates for this deficit. Nevertheless, the unit should undertake further efforts to improve their publication record.

Conclusions

The work of the laboratory is important to STUK, and also in the framework of emergency preparedness, to maintain and further develop radioecological expertise. The integration in European projects is very good. However, the number of projects is too large.

Recommendations

- To reduce number of projects to allow more time for the remaining projects.
- But to continue to participate in main European projects.
- To increase rate of publications in international peer-reviewed journals.
- To prepare a succession plan because 3-4 senior staff will retire within the next 5-7 years.

5. Airborne Radioactivity

The Airborne Radioactivity Laboratory has various responsibilities, e.g. for research, emergency preparedness, and as a certified laboratory in the CTBTO network. It gives a very qualified and significant contribution to emergency preparedness of STUK. The laboratory is responsible for e.g. monitoring external dose rate and airborne radioactive substances. The nation-wide dose-rate monitoring network consists of 290 stations. A real-time radiation monitoring and information system, known as USVA, has been developed and is continuously maintained.

The most technical developments of the unit represent state of the art. The various activities of the unit are performed with great efficiency and efficacy. The unit raises substantial funds from external sources. However, only a small fraction of the available resources is allocated to research.

During the last 5 years the work has specifically been targeted to meet STUK's needs both at national and at international level. The previous recommendation to better “share radionuclide services with other laboratories inside STUK” has not been considered in depth by STUK management. Based on the interviews in the respective units, the panel is of the opinion that the previous recommendation has not been fully implemented. The interaction, responsibilities and allocation of resources concerning emergency preparedness should be clarified between the units involved. As also in the other units, there seems to be a lack of transparency and clarity with respect to responsibilities for decision making and for prioritising the overall research needs in the area of emergency preparedness.

The Unmanned Aerial Vehicle (UAV) project should be further developed only if it is requested as a support service and funded by third parties, not as a STUK-driven project.

The technical systems used for monitoring of airborne radioactivity should be maintained at the present high level, since they are of importance for emergency preparedness. A consistent system for managing, processing, and assessing of the various data provided by different laboratories of STUK and external organisations is missing. This is a major obstacle for the performance of STUK in an emergency situation. STUK should seriously consider developing and implementing such a concept and implement such a system in order to improve its performance in this field.

As a certified laboratory within the CTBTO system, the unit is planning to establish a Xenon-analysis capability. From a strategic point of view, high priority should be given to implement these plans.

With one exception (assay techniques for analysing radioactive particles present in environmental samples), the priority areas for research and technical development for the next 5 years as described in the publication "Research activities of STUK 2000 - 2004" (STUK-A210) are of high priority.

Research work represents a relatively minor part of the activities of the laboratory which allocates more emphasis and resources on operational duties on emergency preparedness and environmental surveillance. The publication record is a fair representation of the various activities of the unit.

Conclusions

The unit develops and operates state of the art technical systems which are of key importance to meet STUK's obligations in the areas of emergency preparedness, environmental surveillance and CTBTO. The small fraction of manpower dedicated to research activities is at the margin of representing critical mass. It should not be reduced further. The establishment of a Xenon-analysis capability would consolidate and strengthen the state of the art scientific and technical measurement capabilities of STUK.

Recommendations

- The panel recommends that research activities be maintained at the present level or increased in order to maintain the high quality research.
- From a strategic point of view, high priority should be given to establish a Xenon-analysis capability.
- The panel recommends that more emphasis be given to publishing results in international peer-reviewed journals.

6. Regional Laboratory in Northern Finland

The goal of the laboratory's research is to study the transport and accumulation of radionuclides in arctic and subarctic food chains, and in locally produced foodstuffs. The laboratory has several permanent sampling areas and an extensive network of research institutes, laboratories, authorities, enterprises and private persons etc. that collaborate in collecting samples and information in northern Finland.

The panel noted that the head of the Regional Laboratory of Northern Finland retired in 2005 and was succeeded by a young well-qualified scientist and welcomes that the labora-

tory has expanded the number of staff by December 2005 with yet another young scientist as recommended in the previous evaluation. Furthermore, the panel congratulates the laboratory on the plans of moving to new premises above ground in Rovaniemi together with other government laboratories, which will provide a stimulating environment together with other scientists. The panel is of the opinion that the increased group size combined with a young age profile and the plans of moving the lab offer very stimulating challenges and possibilities for the laboratory.

The laboratory is located far from the rest of the STUK, and the panel is pleased to learn that means for travelling between Rovaniemi and Helsinki are sufficiently available to ensure a very good contact.

A long-time experience and data of series of observations on environmental radioactivity is important for knowing and understanding long-term trends and for maintaining expertise in case of emergency. It is also obvious that the initial objective of this laboratory can be regarded as completed and could lead decision makers to stop the activity of control. It would be a serious error, in the opinion of the panel, because this laboratory involved in long time-series of measurements, is to the benefit of public health in monitoring major biogeochemical cycles of our planet, adapted here to the Arctic areas. It is today necessary that a thought is given both at European and world levels to begin to support the continuing existence of such observatories. This does not mean permanent uncontrolled financing, but the observatory must: i) collaborate with and provide material for specialists in other fields of activity, ii) be evaluated regularly (approximately every 10 years) to check its usefulness in an international network of observatories of the environment.

The panel also notes that the assessment of publications must improve along with the arrival of the young scientists. Earlier it was difficult for a single scientist, i.e. the former head of the laboratory; she was constrained to accumulate data without always being able to exploit it.

This laboratory is a European window in the Arctic and must be internationally considered as the most effective laboratory for a remote monitoring of the border area and Russian territories. Without hesitation, the laboratory deserves to be recognized at the European level, and needs to receive financing that corresponds to the expectations of Europe.

Recommendations

- The objectives of the laboratory must be redefined as an international observatory of the health of a particular ecosystem of the earth.
- The pressure from STUK to find external financing is not realistic in this case and should be reconsidered. The laboratory already has a sufficient workload corresponding to a well-targeted objective. It is difficult for the unit to diversify into other activities.

7. Radiation Biology

The Radiation Biology Laboratory is involved in research of the biological and health effects induced by ionising and non-ionising radiation, in doing biological dose assessment by chromosomal analysis, as well as contributing to biological expertise for the assessment of medical consequences of radiation exposures.

For financial reasons the laboratory has made the choice of not working on animals. This choice is therefore not a dogmatic one, since the laboratory may collaborate with other international laboratories having the infrastructures to work on the animals. This is to be encouraged to avoid the possible drifts between molecular and cellular biologists, and physiologists and pathological anatomists.

From the research point of view, the laboratory has made the best possible choices and now takes an active part in the new challenges of radiobiology, in collaboration with the best laboratories of the world. Indeed, bystander effects, genomic instability and adaptive response are very challenging for the radiation protection establishment. The laboratory needs sound results before any new research areas are suggested.

In spite of the attractiveness of the new scientific challenges, the laboratory meets its objectives best by focusing its research on the main problems of the Finnish society, i.e. high chronic exposure by natural radionuclides, UV exposure, mobile phones, etc. The prioritisation and elimination of projects were accomplished over the recent years exactly according to the previous recommendations.

Besides the fundamental research, the laboratory continues, as a core activity of STUK, intensive activities in biological dosimetry and biological indicators with international partners. International co-operation is a very important part of the work in biological dosimetry. This trend should be maintained and further developed in the future as well.

Radiation Biology Laboratory continues to carry out studies on understanding health effects of exposure to ultraviolet radiation. Collaboration with the Epidemiology Laboratory has to be continued.

Conclusion

The Radiation Biology Laboratory combines top-level research with the needs of the Finnish society. It is a well respected laboratory in the international scientific community, its publications are numerous and of high quality.

Recommendations

- To keep the level of quality of research.
- To keep in mind the particular needs for research in Finland.

- To maintain the collaboration with the Epidemiology Laboratory, especially if molecular epidemiology research will be further enhanced.
- To evaluate the ethical applications of certain studies, for example, screening.

8. Epidemiology and Biostatistics

Among the important changes since the international evaluation of 2000, the panel notes the establishment of the Laboratory of Epidemiology and Biostatistics, now independent of the laboratory of Radiation Biology.

This laboratory is young and very enthusiastic, the connections with the Tampere University are close, the people having mutual contacts. Contrary to other laboratories, research is the principal activity (96 %) of this laboratory. The strengths of radiation epidemiology studies are the unique radiation exposure situations in Finland (high and chronic natural radiation doses, mobile phones), personal identification numbers and high quality registries. Lastly, the laboratory benefits from the positive attitude of people participating in the studies.

The aims of the laboratory are classical; to increase knowledge on health risks related to ionising and non-ionising radiation in human populations and to assess medical consequences of radiation exposure.

The laboratory is fully involved in all major international studies concerning the epidemiology of the ionising radiation as well as non-ionising, too. Nevertheless, the laboratory has maintained some specific Finnish studies (epidemiology of cabin aircrew), which enables it to keep a critical review with respect to the international studies.

But like all the laboratories of epidemiology of this branch of research, all the aspects are covered with the risk of a great dispersion. Indeed, the topics of radiation epidemiology are: the effects of nuclear weapon tests and Chernobyl fallout in Finland, health risks of mobile phones, health effects of UV radiation, health effects of natural radiation, and health effects of occupational exposure. This dispersion is clearly observed everywhere. Conversely, the involvement in many European and international projects is essential and should continue. Moreover, the laboratory must continue to strongly imply itself on the situations specific to Finland; uranium and radon.

In future special attention has to be paid to the number of projects so that new projects would be started only when it is ensured that there are enough financial and human resources to carry out these projects.

The number of publications is very high, mostly they are collective publications of international projects. This makes it difficult to evaluate the real effort devoted by the laboratory staff.

The laboratory also takes part in an interdisciplinary project of the STUK "Uranium toxicity" in drinking water. This is to be encouraged and, as for the other laboratories, it is now

important to extend this research to other European laboratories with comparable objectives, but with different means. This research is particularly important in order to answer the question about the validity of an extrapolation of the biological effects after acute or chronic intoxication.

Also taking into consideration Finnish special conditions, the laboratory continues to study the effects of UV, noting the fair skin of Finns, and also, noting industrial options, the possible effects of the mobile phones. Even the international community would probably expect that these effects be studied in this institute.

This laboratory is new and enthusiastic, and care should be taken to continue collaboration with other laboratories.

Conclusion

This laboratory is new, enthusiastic and is largely open to university and international networks of epidemiology. Like all epidemiology laboratories, this laboratory is working on many topics and hierarchization of projects has to be a permanent effort.

Recommendations

- To maintain its enthusiasm.
- Not to let its activities disperse too broad in spite of the many requests.
- To keep the contact with the laboratories having expertise in evaluation of the exposures and doses.

9. Radiation in Health Care – Radiation Metrology

The Radiation Practices Regulation is the department of STUK which is responsible for the supervision and regulation of the use of radiation. The regulation and supervision concerns the use of radiation in health care, veterinary medicine, industry, education, research, and work where natural radiation is of special concern.

The unit has various obligations in the areas of implementation and supervision of regulations in medicine, for the maintenance of the national standards for dose quantities of ionising radiation, the operation of the national dose register, and the approval of individual dose monitoring services. However, only a small fraction of the available resources is allocated in the field of research (20%). The work is performed in collaboration with national hospitals and integrated in international networks and research projects.

During the last 5 years the 2000 recommendations have been implemented with great success. The reference levels for X-ray examinations are regularly checked and complemented if necessary. There is no further involvement in research on boron capture therapy. There are good reasons not to implement the recommendation to transfer “the software for the assessment of risk from radiation exposure to the epidemiology group”.

The research plan of the unit as described in the publication “Research activities of STUK 2000 - 2004” (STUK-A210) includes all techniques and issues which are currently discussed by the scientific community. Due to the rapid technical development cycles of the instrumentation used for medical diagnosis and therapy, this work is and will be an area of high priority for radiation protection and STUK should consider increasing the resources in this area. In the research related to dosimetry and safety of radiotherapy, the laboratory wishes to supplement its expertise with use of Monte Carlo calculations. Taking into account the number of members of the unit it is recommended to visit the German and French laboratories that have already experience in this field, associating these codes with voxel phantoms technology before starting this important work. The German and French experts of the panel offer support to organise the meetings.

So far the unit only deals with the medical use of ionising radiation and individual dose monitoring. Non-ionising radiation is explicitly excluded. As the panel observed an increase of applications of diagnostic instruments using non-ionising radiation (e.g. MRI systems), consideration should be given to include these systems in the scope of work of the unit.

The panel is impressed by the good quality of the series of annual reports "Radiation practices” and more especially the chapters describing "abnormal incidents". The diversity of the reported incidents shows that the department is well integrated in the multiple activities employing ionising radiations, particularly in the medical world or its expertise of very high quality can only be very beneficial for the constant improvement of the health care in Finland. It would be good, if on the basis of these analyses, STUK would prepare an international publication awakening the international organisations on the most sensitive aspects of these technologies.

The unit has a good publication record that demonstrates its engagement in many areas. Integration in international networks (ICRU, IAEA) is excellent.

Conclusions

The quality of the expertise of STUK in this field is very high. Some points are missing due to manpower. It is easy to enhance this expertise by reinforcing international communications and exchange of experts.

Recommendations

- To keep the expertise in the areas already covered, broaden it to cover new upcoming areas, and increase manpower.
- The laboratory wishes to supplement its expertise in the codes of Monte Carlo. It is recommended to the laboratory, taking into account the number of people, to visit the German and French laboratories that already have experience in this field, associating these codes with voxel phantoms technology.
- Present the excellent results and experience and provide feedback to the international scientific community.

10. Non-Ionising Radiation

The laboratory carries out regulatory functions, research and technical development work to serve the needs of the radiation safety, regulation and biological studies. As other STUK laboratories, it develops radiation protection standards, disseminates public information on NIR and provides expert services.

The unit has a high professional profile in the area of dosimetry. It is integrated in international activities.

Since the last evaluation, the monitoring of solar radiation has continued; NIR laboratory has been measuring continuously the sun's UV radiation in the summer and sent real-time information on UV index, measured during the last two days, to STUK's www pages. The development of accurate radiometry for UV radiation is one of the focus areas of the NIR laboratory.

UV radiometry is well performed and the achieved accuracy is sufficient. Development with the Metrology Research Institute at Helsinki University of Technology (TKK) is a good example of collaboration with universities.

The information to the public on health effects of UVR is a priority and active communication about UV radiation risks continues. Information material on STUK's www pages is remarkable.

Collaboration with the Finnish Funding Agency for Technology and Innovation (TEKES) and European Space Agency for EM-field dosimetry is productive. The laboratory is an essential partner for developing exposure systems and dosimetry for biological studies of radiation from mobile phones.

Active participation in ICNIRP activities is an acknowledgement of the high quality of the laboratory. Taking into account the development of the Finnish industry in mobile phones, research on possible health effects of RF radiation from mobile phones should be continued by STUK as an independent body.

Conclusion

The unit has a broad variety of activities. The work in the laboratory is mostly technically demanding measurement technology, and therefore contacts with partners working on effects are essential to maintain relevance. The scientific reputation of the laboratory is very high and the international co-operation is very active. Taking into account the size of the laboratory, the publication record is reasonable and the results are mainly published in international journals. Other results that are of general scientific interest are only published in Finnish.

Recommendations

- To continue the work of laboratory is highly important because it is either crucial from a health protection, or from public perception point of view.

- Interaction with biological research should be continued and further developed.
- The number of activities supported by the laboratory should be kept under permanent review.
- More publications in international journals are desirable.

ANNEX A: Key words and specific technologies

Natural Radiation

Keywords: Natural radiation, radon, building materials, radioactivity, radon entry, home, workplace, municipality health authorities, building authorities, radon-safe building, survey, geology, soil, radon prognosis, risk mapping, indoor air, radon mitigation, emanation, air exchange, uranium, radium, ^{210}Pb, ^{210}Po, water treatment, water purification, household water, drinking water, drinking water regulations, epidemiology, lung cancer, leukemia, stomach cancer, urinary organ cancers, uranium toxicity.

Specific technologies: Alpha track, ionisation chamber, Lucas cell, gamma spectrometry, sub-slab suction, radon well, alpha spectrometry, liquid scintillation counting (LSC), low-background LSC spectrometry, alpha-beta discrimination, pulse-shape analysis, ion-exchange, radon removal by aeration, granular activated carbon (GAC) filtration, uranium removal by anion exchange, radium removal by cation exchange, reverse osmosis, nanofiltration.

Radiation Hygiene

Keywords: Internal radionuclide contamination, internal radiation dose assessment, whole-body counting, bioassay, internal contamination and radiation doses of workers, internal doses of population and population groups, nuclear bomb test and Chernobyl-derived contamination of population and of special dietary groups.

Specific technologies: Stationary whole-body counter with scanning techniques, mobile whole-body counter, lap geometry counters, thyroid counters, partial body counter for low-energy gamma emitters, liquid scintillation counters and gamma spectrometers for sample measurements, counter for foodstuff monitoring, surface contamination monitors, conditioning and storing service for radioactive waste (sealed sources of low or medium level).

NPP Environments

Key words: Environmental radioactivity, environmental monitoring of nuclear power plants, environmental effects of nuclear power plants, marine radioecology, terrestrial radioecology, Baltic Sea, quality assurance, development of methods, transuranics, dating of sediments, analysis of particles, emergency preparedness.

Specific technologies: Low-level gamma-ray spectrometry, alpha spectrometry, beta spectrometry, radiochemical methods, liquid scintillation methods, sediment dating methods, environmental sampling methods.

Ecology and Food chains

Key word: Forest radioecology, freshwater radioecology, agricultural radioecology, exposure pathways, environmental modelling, countermeasures, radiation protection of the environment, radionuclides in the food chain, environmental monitoring, nuclear emergency management, decision support, multiattribute risk analysis, stakeholder involvement.

Specific technologies: Gamma, beta and alpha spectrometry, liquid scintillation counting, atomic absorption spectrometry, radiochemical methods for ^{3}H, ^{14}C, $^{89,90}Sr$, $^{239,240}Pu$, ^{210}Pb, ^{226}Ra, ^{210}Po, sampling of soil, deposition and forest vegetation, RODOS system, GIS systems.

Airborne Radioactivity

Key words: Airborne radioactive material, radiation monitoring, external dose rate, atmospheric transport, mobile radiation measurement, radioactive particles, particle analysis, fallout mapping, dose estimation, emergency preparedness.

Specific technologies: Computer codes for atmospheric transport, dispersion and doses of radioactive substances, nation-wide external dose rate monitoring and information system, nation-wide surveillance of airborne radioactive material, mobile laboratory for environmental monitoring, gamma spectrometry, direct alpha spectrometry, autoradiography, analyses of individual radioactive particles.

Regional Laboratory in Northern Finland

Key words: Environmental radioactivity in northern Finland, terrestrial radioecology, arctic and subarctic food chains, lichen, reindeer, monitoring of foodstuffs produced in northern Finland, radioactivity in Russian arctic sea areas, arctic monitoring, emergency preparedness, quality assurance

Specific technologies: Gamma spectrometry, alpha spectrometry, beta spectrometry, radiochemical methods, environmental sampling methods, surveillance of airborne radioactivity and fallout in Finnish Lapland, nation-wide external dose rate monitoring USVA, mobile laboratory for environmental monitoring.

Radiation Biology and Epidemiology

Key words: radiation biology, molecular biology, molecular cytogenetics, biodosimetry, transcriptomics, proteomics, epidemiology, biological monitoring, health effects, health risk assessment; ionising radiation, radon, uranium, cosmic radiation, α-particle irradiation, X-ray and γ-ray irradiation, microbeam irradiation, narrow/broad beam α-particle irradiation, non-ionising radiation, UV-A/UV-B, solaria, sunbathing, RF-EMF, mobile phones; radiation-induced cancer, hereditary effects, non-targeted radiation effects, chromosomal aberrations, radiation induced bystander effect, radiation-induced genomic instability, individual radiosensitivity, thyroid cancer, brain cancer, secondary sarcomas, minisatellites, mutations, single nucleotide polymorphisms (SNPs), genome-wide gene expression changes, proteome-wide protein expression changes, endothelial biology, apoptosis, blood-brain-barrier, kidney function, bone turnover.

Specific technologies: SSCP, DNA sequencing, cDNA expression array, gene differential display, two-dimensional gel electrophoresis, PDQuest protein expression pattern analysis, differential display proteomics, mass spectrometry protein identification (Maldi-ToF), protein activation (phosphorylation) assay, immunohistochemistry, Western blotting, Southern blotting, Northern hybridization, FISH chromosome painting, comet assay - single cell gel electrophoresis, PCC (premature chromosome condensation), PCR-RFLP, apoptosis assays, gap-junction function, non-invasive 3D deep tissue imaging, artificial human tissue systems, primary human skin explants.

Radiation Practices Regulation

Key words: Medical use of radiation, ionising radiation, radiation dosimetry, diagnostic x-ray imaging, radiation protection, patient dose, image quality, radiation risk, radiation metrology, standard dosimetry, calibration techniques, personal dosimetry, individual dose monitoring.

Specific technologies: Dosimetric techniques, calibration techniques, x-ray spectrometry, Monte Carlo calculation methods, image quality evaluation tools, surveys on medical use of radiation, surveys on individual dose monitoring.

Non-Ionising Radiation

Key words: Non-Ionizing Radiation (NIR), low-frequency electric (E) and magnetic (H) fields, radio-frequency EM fields, microwaves, infra-red radiation, visible light, ultraviolet radiation (UVR), laser radiation.

Power lines, magnetic resonance imaging (MRI) devices, electronic article surveillance devices (EAS), metal detectors, radio-frequency identification devices (RFID), high-frequency heaters, broadcasting stations, mobile phones, base stations, microwave dryers, radars, lasers, sunlamps and sunbeds, UV-phototherapy, solar UVR.

Specific technologies: EM field measurement techniques, exposure measurements, metrology, calibration, primary and secondary standards, traceability, Helmholtz-coil, TEM transmission cell, waveguide chamber, anechoic chamber, calibrated antenna, automated SAR measurement system, calorimetry, in Vitro exposure chamber, in Vivo exposure chamber, quartz-halogen lamp, detector-based calibration, filter radiometer, portable calibrator, radiometry, UVR dosimetry, broadband UV-radiometers, spectroradiometers, solar UVR measurements, weighted magnetic field measurement, numerical EM field dosimetry, experimental RF-dosimetry.

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