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Strengthening the Radiation Protection System in Cuba (SRPS – Cuba)

A co-operation project between Cuban and Swedish institutions, February 2001–June 2003

Statens strålskyddsinstitut
Swedish Radiation Protection Authority

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SUMMARY: This project results from the co-operation between a number of Cuban and Swedish institutions. It started in February 2001 and ended in June 2003 and was made possible thanks to the contributions of the Swedish International Development Co-operation Agency (SIDA), the Centro de Protección e Higiene de las Radiaciones, Cuba (CPHR), and the Swedish Radiation Protection Authority (SSI).

The overall objective was to strengthen the radiation protection system in Cuba, and in this way contribute with the control and reduction of risks to man and the environment from exposures to ionizing radiation. The project focused on four priority areas: 1) Protection of workers and patients exposed to radiation in radiation practices; 2) Preparedness for response to an emergency situation; 3) Environmental radiological protection; and, 4) Exposure to radiation in areas with high levels of natural radioactivity.

The present report summarizes the findings of the whole project period, providing an overview of the overall achievements, as well as listing its deliverables. The results of an evaluation of the project, conducted during the final workshop, are also included. The report ends with a list of generic and specific conclusions and recommendations for implementation of the project's achievements and for further development of co-operation.

SAMMANFATTNING: Projektet SRPS-Cuba har drivits i samarbete mellan flera kubanska och svenska organisationer. Projektet startade i februari 2001 och avslutades i juni 2003. Dess genomförande har varit möjligt tack vare bidrag från SIDA, SSI och CPHR (Centro de Protección e Higiene de las Radiaciones, Kuba).

Det övergripande målet har varit att förstärka det kubanska strålskyddssystemet och på så sätt bidra med bättre kontroll, och minskning, av risk för exponering av joniserande strålning till människa och miljö. De fyra prioriterade områdena har varit 1) skydd av arbetare och patienter som exponeras för strålning i verksamhet med strålning; 2) nödvändig beredskap för en nödsituation; 3) strålskydd av miljön: 4) exponering för strålning i områden med höga nivåer av naturlig radioaktivitet.

Denna rapport summerar de upptäckter som framkommit under projektets gång, och tillhandahåller en överblick av de totala prestationerna, samt en lista på projektets "deliverables" (projektresultat). En projektutvärdering inkluderas också i rapporten. Rapporten avslutas med allmänna och specifika slutsatser och rekommendationer för hur projektets resultat ska implementeras samt för vidare utveckling av ett framtida samarbete.

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1 Summary

This project results from the co-operation between a number of Cuban and Swedish institutions. It started in February 2001 and ended in June 2003. It was made possible thanks to the contributions of the Swedish International Development Co-operation Agency (SIDA), the Centro de Protección e Higiene de las Radiaciones, Cuba (CPHR), and the Swedish Radiation Protection Authority (SSI).

The overall objective was to strengthen the radiation protection system in Cuba (SRPS – Cuba), and in this way contribute with the control and reduction of risks to man and the environment from exposures to ionizing radiation. The project focused on four priority areas, with case studies underpinning each theme.

1. Protection of workers and patients exposed to radiation in radiation practices;
2. Preparedness for response to an emergency situation;
3. Environmental radiological protection;
4. Exposure to radiation in areas with high levels of natural radioactivity.

The present report summarizes the findings of the whole project period, providing an overview of the overall achievements, as well as listing its deliverables (Chapter 5). The results of an evaluation of the project, conducted during the final workshop, are also included (Chapter 6). The report ends with a list of generic and specific conclusions (Chapter 7) and recommendations (Chapter 8) for implementation of the project's achievements and for further development of co-operation.

The general conclusions are listed below, but the report also provides specific ones related to each of the four areas of priority.

1. The project goal, objectives and work plan were fully completed. The project has been a useful experience for both Cuban and Swedish participating institutions.
2. The technical results of the project are considered be an important contribution to the strengthening of the Cuban Radiation Protection System. The results have had an impact at a National Level.
3. Given the ample degree of dissemination that the project results already have in Cuba, there is confidence that the project achievements will have a good continuous implementation.
4. An excellent broad co-operation has been established between Cuban and Swedish specialists in radiation protection, which is expected to continue in the future.

General recommendations are listed below, but the report also provides specific ones related to each of the four areas of priority.

1. The groups that have been working together during these two and half years are encouraged to continue co-operation.
2. The Cuban organizations are recommended to develop a program for further dissemination of the project results within the country, in particular those results obtained in the field of medical practices.
3. It was suggested to explore ways of expanding the experiences of this project to a broader co-operation with other surrounding Cuba countries.
4. The project participants are encouraged to publish the project results in the open literature.

2 Introduction

A collaboration between Cuban and Swedish institutions was launched, under the name SRPS-Cuba, Strengthening the Radiation Protection System in Cuba (SSI Ref. No. 034/36/01), in accordance with agreements set up between the Swedish International Development Co-operation Agency (SIDA), the Centro de Protección e Higiene de las Radiaciones, Cuba (CPHR), and the Swedish Radiation Protection Authority (SSI).

The historical background to this project goes back to 1994, when the CPHR[1] and the SSI started to explore possibilities for co-operation in the field of radiation protection. A bilateral co-operation agreement between CPHR and SSI was endorsed in May 1998. Areas in which SSI might provide assistance and support for upgrading the Cuban radiation protection system were identified and the idea of initializing an assistance project was conceived. A feasibility study was carried out during June-October 1999 under SIDA auspices (contract C7, 1999).

The feasibility study concluded that there existed favorable conditions to successfully carry out a joint project between Cuban and Swedish Institutions. The areas (themes) in which the project should focus were selected among those approved for financing by the Cuban government in 2000-2001[2].

The project started on the 1st February 2001 and ended in June 2003. The first phase of the project concluded in February 2002 with a workshop held in Havana (25 February to 1st March 2002). The achievements of the first phase of the project were summarized in two Progress Reports and in a Mid-term Report. The present report summarizes the findings of the whole project period, providing an overview of the overall achievements as well as listing its deliverables (Chapter 5). Included are also the results of an evaluation of the project, conducted during the final workshop by interviewing specialists from Cuba and Sweden, involved in the project, as well as representatives from Cuban organizations that will be beneficiaries of the project results (Chapter 6). The report ends with a list of generic and specific conclusions (Chapter 7) and recommendations (Chapter 8) for implementation of the project's achievements and further development of co-operation between SSI and CPHR.

[1] A description of the Cuban Institute for Radiation Protection and Hygiene (CPHR) is presented in Appendix 2 to the project plan, which can be obtained from SSI.

[2] A list of priority projects in radiation protection in Cuba is given in Appendix 3 to the project plan.

3 Project description

3.1 Project overview

The overall objective of the project was to strengthen the radiation protection system in Cuba and in this way to contribute with the control and reduction of risks to man and the environment from exposures to ionizing radiation.

The control and reduction of risks to man and the environment associated with the peaceful uses of ionizing radiation is given high priority in Cuba. For this purpose, a radiation protection infrastructure and a strong regulatory system have been developed. During the last years there have been difficulties in sustaining and upgrading this infrastructure. This has been due, in part, to the economical problems that the country has been facing. There exist limitations for upgrading the personnel qualifications, for substituting obsolete equipment and for carrying out development programs in response to current radiation protection needs.

The overall objective of the present project was to strengthen the existing radiation protection infrastructure in Cuba through co-operation between Cuban and Swedish Institutions, in particular between the Cuban Centre for CPHR and SSI. The specific objectives of the project were to:

1. transfer know-how in the field of radiation protection to Cuban institutions;
2. assist Cuban specialists in the realization of high priority technical tasks in the field of radiation protection;
3. assist the Cuban radiation protection authorities in the development of regulations;
4. create a basis for a future broad co-operation in the field of radiation protection between Cuban and Swedish institutions.

The project focused on four priority areas:

1. protection of workers and patients exposed to radiation in radiation practices;
2. preparedness for response to an emergency situation;
3. environmental radiological protection;
4. exposure to radiation in areas with high levels of natural radioactivity.

During the course of the project, specialists from Cuban and Swedish institutions jointly carried out several technical tasks, i.e. study cases listed below. The study cases had well-defined objectives and scope, and covered each of the four priority areas. The study cases provided not only a broad exchange of technical experience, but also an exchange on ways in which different organizations carry out technical and regulatory work. The study cases addressed problems that were considered of high priority by Cuban institutions and authorities.

3.1.1 STUDY CASES

1. Development of reference levels for optimized doses to patients in medical practices.
2. Joint preparation and conduct of an Emergency Preparedness Exercise. (This study case replaced the one initially planed – Development of reference levels for the Cuban National Network of Environmental Radiation Surveillance, because it was considered more important and useful by the Cuban and Swedish experts involved in the project).
3. Environmental impact assessment of a reference near surface repository for radioactive waste.
4. Estimation of doses that the Cuban population receives from natural radionuclides.

The project was organized in five work packages, one for project management and one for each of the four priority areas, as illustrated in Figure 1. The project had two project leaders, one from Cuba, Miguel Prendes (Director of CPHR) and one from Sweden, Carl-Magnus Larsson (Head of Department of Waste Management and Environmental Protection, SSI), as well as two co-ordinators: Juan Tomás Zerquera (CPHR) and Rodolfo Avila Moreno (SSI).

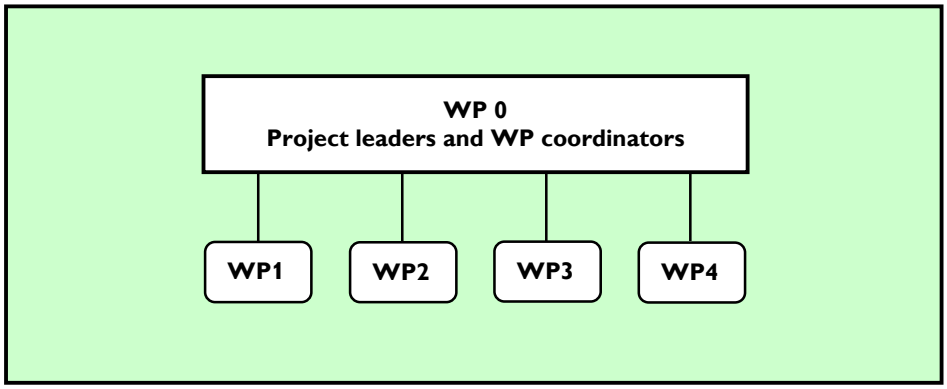

Figure 1
The Organization of SRPS-Cuba in Work Packages (WP). WP 1: Protection of workers and patients; WP 2: Emergency preparedness; WP 3: Environmental Protection; WP 4: Natural radioactivity.

It was initially planned that eight fellowships, four scientific visits and 14 expert missions would be carried out within the project. After the conclusion of Phase I, one fellowship, five scientific visits and four expert missions were added to the original plan.

- *Fellowship* means training of Cuban specialists in Swedish institutions for a period of between one to three months.
- S*cientific visit* means visits of Cuban specialists to Swedish institutions for a period of around ten days, with the purpose of exchanging information and experience, carrying out specific technical tasks within a study case, participating in seminars, discussing regulatory issues, etc.
- *Expert mission* means visits of Swedish experts to Cuban institutions for a period of around ten days, with the purpose of exchanging information and experience, carrying out specific technical tasks within a study case, participating in seminars, discussing regulatory issues, making assessments, giving lectures, etc.

The first phase of the project, for exchange of information, formulation of the study cases and obtaining preliminary results, started on the 1st of February 2001 and concluded with a workshop on the 1st of March 2002. In the second phase, the focus was put on finalizing the study cases and preparing the corresponding technical reports.

The project formulated initially to have 14 deliverables consisting of technical reports, methodologies and drafts of regulatory documents. After the first eight months of the second phase, the list of deliverables was reviewed and updated to account for changes that took place during the first phase of the project (Chapter 5).

3.2 Participants

The following Cuban and Swedish institutions participated in the project.

Cuban institutions

- The Cuban Centre for Radiation Protection and Hygiene (CPHR) lead Cuban organization.
- The Cuban Centro Nacional de Seguridad (CNSN).
- The Cuban Ministry of Health (CMH) including several hospitals.

Swedish institutions

- The Swedish Radiation Protection Institute (SSI) lead Swedish organization.
- Falu Lasarett (FL).
- Karolinska Sjukhuset (KS).
- Studsvik Instrument AB (Studvik).
- KEMAKTA Konsult AB (KEMAKTA).

4 Overview of achievements

A total of nine fellowships, nine scientific visits and 18 expert missions were carried out. Tables 1, 2 and 3 list the main activities that were supported by the project.

Table 1
Main fellowships carried out during the project.

No	Title	Institutions involved*	WP	Phase
1	Health physics	CMH, KS	1	I
2	Radiation Protection in X-rays diagnostics	CPHR, FL	1	I
3	Radiation Protection in nuclear medicine	CPHR, FL	1	I
4	Methods for EIA	CPHR, SSI, KEMAKTA	3	I
5	Methods for measurement of radionuclides in environmental samples	CPHR, SSI	4	I
6	Radiation Protection in radiotherapy	CPHR, KS	1	II
7	Methods for dose estimations	CPHR, SSI	3	II
8	Evaluation of doses from natural radionuclides	CPHR, SSI	4	II

** Refer to Section 2.2 for full list of organizations.*

Table 2
Main scientific visits carried out during the project.

No	Title	Institutions involved*	WP	Phase
1	Dosimetry and metrology of ionizing radiation	CPHR, SSI	1	I
2	Regulatory issues in protection of workers and patients	CPHR, SSI	1	I
3	Adaptation of Software and tools to the Cuban conditions	CPHR, SSI	2	I
4	Regulatory issues in emergency preparedness and reference levels	CNSN, SSI	2	II

** Refer to Section 2.2 for full list of organizations.*

Table 3
Main expert missions carried out during the project.

No	Title	Institutions involved*	WP	Phase
1	Status of the radiation protection in X-rays diagnostics in Cuba	FL, CMH, CPHR	1	I
2	Status of the radiation protection in nuclear medicine in Cuba	FL, CMH, CPHR	1	I
3	Status of the radiation protection in radiotherapy in Cuba	KS, CMH, CPHR	1	I
4	Development of reference levels for optimization of doses to patients	SSI, CPHR, CMH	1	I
5	Evaluation of the Cuban early warning and response systems	SSI, CPHR	2	I
6	Evaluation of the Cuban strategy for radioactive waste management	SSI, CPHR	3	I
7	Evaluation of the systems for temporary storage and final disposal of radioactive waste in Cuba	KEMAKTA, CPHR	3	I
8	Transfer of software for EIA and dose estimations	SSI, CPHR	3	I
9	Evaluation of doses from natural radiation in Cuba	SSI, CPHR	4	I
10	Transfer of standards to the Cuban Secondary Standard Dosimetry Laboratory	SSI, CPHR	1	II
11	Assistance for performing the EIA of the waste repository	SSI, CPHR	3	II
12	Installation of software and tools for Emergency preparedness	SSI, CPHR	2	II
13	Evaluation of the Cuban laboratory for environmental monitoring	SSI, CPHR	4	II
14	Complementary radon measurements in Cuba	SSI, CPHR	4	II

** Refer to Section 2.2 for full list of organizations.*
Notes: Comparison with initial plan.

The following Sub-sections highlight some of the main results derived from the fellowships, scientific visits and expert missions, as well as from the planning meetings. In general, the project was carried out with a minimum of disturbances or delays.

4.1 WP 0 – Project management

Objectives

- To lead the project and to co-ordinate activities common to all technical packages.
- To exchange information about the process of planning and follow up of activities.
- To keep contact with involved organizations in both countries.
- To manage the project budget.

Deliverables

- Midterm report – prepared in March 2002.
- Final project report, i.e. this report, which incorporates the findings and recommendations of all other four work packages.

Results

Two meetings between project leaders and coordinators took place in Havana, in April 2001 and November 2002, including visits to the principal Cuban institutions involved in the project. Details of these meetings can be found in the Progress and Midterm reports.

A workshop was held in Havana, 25th February – 1st March 2002, at the end of the first phase of the project, with the following purposes:

- to discuss the progress in the Study Cases of the Work Packages 1-4;
- to prepare a first draft of the Technical Documents that will be delivered at the end of the project;
- to prepare a work plan for the next phase of the project;
- to discuss possible interactions with international organizations and projects;
- to provide exchange of information between Cuban and foreign specialists in current topical issues in different fields of radiation protection.

Eleven specialists from Swedish institutions participated in the workshop, together with more than 20 specialists from Cuban organizations. Invited experts from the following organizations also participated in the workshop: International Commission on Radiological Protection (ICRP), International Union of Radioecology (IUR), Institute of Radiological Safety- IRSN (France) and the Centre for Nuclear Research- SCK-CEN (Belgium).

The workshop consisted of plenary sessions, in which 25 oral presentations on scientific and technical issues were made, and working group sessions where the project activities were discussed in detail. The workshop participants made a one-day study visit to the CPHR. Some of the Swedish experts also visited the radioactive waste treatment plant.

A second workshop was held in Havana, 2-6 June 2003, i.e. at the end of the project, with the purpose of discussing the technical results and formulating the conclusions and recommendations of the project. Ten specialists from Swedish institutions participated in the workshop, which was also attended by more than 30 specialists from Cuban organizations. In addition, an expert from Sweden, with experience in how to involve stakeholders in the siting process of radioactive waste repositories, was invited to participate in the workshop.

The presentations made during both workshops have been included in a CD that also contains all project documentation (see Chapter 5).

4.2 WP 1 – Protection of workers and patients

Objectives

- To evaluate and propose regulatory requirements for approval of dosimetric services.
- To evaluate the current status of radiation protection of patients in Cuba focusing on the optimization of doses, quality assurance, selection of reference levels and training of personnel.
- To develop reference levels for optimized doses to patients in medical practices that involve exposure to ionizing radiation.

Deliverables

- Implementation of the Cuban standards for absorbed doses in water for irradiation with gamma rays (Co-60) and X-rays.
- Regulatory requirements for acceptance of dosimetric services.
- Proposal of optimized reference dose levels for medical practices.

Results

The main results obtained in this work package are listed below.

- Proposed reference dose levels for medical practices of diagnostic radiology and nuclear medicine.
- Manual of National Standard Protocol for quality controls of gamma cameras and dose calibrators in Cuba.
- Web site with a database for nuclear medicine phantoms in Cuba in order to share the local resources (phantom bank).
- Manual of national protocol for the combined used of reference dose levels, physical phantoms and quality criteria for clinical images in diagnostic radiology.
- National training program (course) for medical physicists, technologists and physicians working in nuclear medicine.
- Installation and Commissioning of a new Linear Accelerator in the Cuban National Institute of Oncology.
- Implementation of the Cuban standards for absorbed doses in water for irradiation with gamma rays (Co-60) and X-rays (methodology).
- Inter-comparison of the SSI and CPHR standards of absorbed doses to water.
- Implementation of calibration service for radiotherapy dosimeters in term of absorbed doses in water in the SSDL of Cuba.
- Draft of regulatory document concerning the regulatory requirements for acceptance of dosimetric services.
- Safety Guides for radiotherapy and nuclear medicine practices. These guides were compared to the Swedish regulations.

4.3 WP 2 – Emergency preparedness

Objectives

- To evaluate the existing system for early detection of an accidental contamination of the Cuban territory and to implement, if technically and economically feasible, an upgraded early warning system.
- To assist specialists from the Cuban National Network of Environmental Radiological Surveillance in the establishment of reference levels (register levels, alarm levels, emergency levels, etc).

Deliverables

- Possible ways for improvement of the Cuban National Radiological Environmental Surveillance Network.
- A system of reference levels (register levels, alarm levels, emergency levels, etc) for Environmental Radiological Surveillance in Cuba.
- Software and tools for aiding the decision making in case of an emergency.

Results

The Cuban national network for monitoring gamma dose rates, based on the equipment delivered by the International Atomic Energy Agency (IAEA), was designed and implemented. The following work was done.

- A code was created for automatic transmission of registered data to the CPHR.
- Sensors and other devices were created to measure wind speed and to determine wind direction automatically. A code to correlate the wind speed, the wind direction and the dose rate was developed.
- A mobile dose-rate measurement system, using a GPS device, was donated by SSI to CPHR. Additionally, a code to manage this equipment and extract, analyze and present the data gathered by the system was developed.

A methodology for establishing reference levels for the Radiological Environmental Surveillance Network was elaborated. Two reference levels were defined for the national network: record level and alarm levels. The first is based on statistical processing of measurements and the second is based on the tendency observed in measurements carrying out after a record level has been surpassed. This level takes also into account the dose limit for the public.

Software for evaluating the radiological situation in the event of an emergency was transferred to the Cuban counterpart. These tools, namely LENA, DOSECALC and Emergency Data GIS, allow to obtain results needed to assist the decision-making in an emergency situation.

During the first Workshop held in 2002, the possibility of performing a Top Table exercise was considered, which would involve the stakeholder organizations from the National Emergency Response System. Although, such exercise was not included initially in the project's objectives, it was decided to conduct it, taking into consideration the fact that the Swedish experts had good experience and all the needed tools. It was also agreed to consider a scenario, which would undertake a severe nuclear accident in a Nuclear Power Plant located about 400 Km away from the border of the country.

As a result, a Top Table Exercise was organized to train the main National Authorities involved in emergency response. The objectives were as follow:

- to identify complex circumstances that will arise if a severe accident occurs in a Nuclear Power Plant located in Florida, likely to have a radiological impact all over the country;
- to practice the co-operation between different response organizations and analyze the decision-making process according to the organizational structure at national level for response to a radiological emergency.

4.4 WP 3 – Environmental protection

Objectives

- To exchange experience regarding national strategies for management of low and intermediate radioactive waste from medical and industrial applications of radioisotopes.
- To upgrade the capabilities and capacities of the Cuban institution for carrying out Environmental Impact Assessments (EIA) and dose estimations.

Deliverables

- Comparison of Cuban and Swedish systems for radioactive waste management.
- EIA of a reference repository for radioactive waste management.
- Methodologies and software for EIA and dose estimations.

Results

This work package studied the national radioactive waste strategy in Cuba, by comparing it with Sweden's strategies, and with international recommendations.

It was verified that the Cuban regulatory system, by incorporating extensively the IAEA's recommendations, has a general structure in accordance with international recommendations.

The CPHR has demonstrated through its laboratory facilities in Havana and Cienfuegos, that Cuba is able to make high quality measurements in every aspect relevant for radiation protection, from the high-accuracy dosimetry measurements needed from radiation therapy to blood dosimetry.

The workpackage also included transfer of safety assessment methodologies and tools. A training program was implemented for CPHR experts, and the safety assessment of reference repositories was carried out, using the delivered software, demonstrating that CPHR have the basic capability needed to develop these tasks.

4.5 WP 4 – Natural radioactivity

Objective

- To improve the capabilities of the CPHR for assessment of doses to the public from natural radiation. Special emphasis was put on assessment of doses to people living or working in areas with high radiation background, including doses received via radon inhalation.

Deliverables

- Estimation of doses to Cuban population from natural radionuclides.
- Methodologies for measurement of natural radionuclides in environmental samples and calibration standards.

Results

Results of studies carried out in Sweden and in Cuba, emphasizing on areas with high natural radioactive background, have been discussed. Methods used in Sweden for determination of radon concentrations in dwellings and for estimation of doses due to radon inhalation resulted in methods in use in CPHR been improved. The calibration factor for radon measurements using CPHR's techniques has been obtained through calibration in SSI's radon room. Specialists from both institutions have discussed regulations of radon concentrations in houses and buildings. Training to CPHR specialists in these matters has been provided at scientific visits to Cuba by Swedish experts and at two fellowships in Sweden of CPHR specialists.

The assessment of the doses, received by the Cuban population from natural radionuclides, have been completed and typical figures for those doses have been obtained, on the basis of available measured data and the field measurements carried out during the project.

Three scientific visits, i.e. field excursions, were made to the central and western parts of Cuba. Terrestrial gamma radiation were measured at these sites, and were found to be generally low. Sites with enhanced radiation were encountered at Elguea, at the Hierro-Mantua gold mine, and at Loma Alta's abandoned magnetite iron mine in the Escambray Mountains. At Elguea, there are rather large areas where radon and radium are contained in hot spring emerging waters. At Hierro-Mantua, the enhanced radiation is associated with mineralization of copper and gold, and at Escambray with accumulation in tuffs.

In order to study the exposure to natural radiation to workers and visitors in Cuban show caves, radon concentrations and gamma ray exposures were measured in Cueva St. Tomas, Tapiada's Cueva, Cueva del Indio and Cueva Jose Miguel, all within the district of Viñales in the province of Pinar del Rio, Western Cuba. At the same time, "*in situ*" gamma spectrometric measurements were carried out. The radon levels were found to be low and the doses to workers and visitors thus insignificant.

Visits were made to water processing plants at Havana, including at the Albear Aqueduct. During these visits, measurements of gamma dose rates were made on the water delivered, tubes, valves and other equipment. No enhanced radiation was measured and the radon concentration in the water thus didn't exceed present international recommended limits for radon gas in drinking water.

During the scientific visits to Cuba and the fellowships in Sweden, CPHR specialists were provided knowledge and practical experience in field gamma radiometry (using scintillation detectors), gamma "*in situ*" spectrometry (using scintillation and HpGe detectors) and radon measurements in soils using manometers. At the Department of Hydrogeology at the Institution for Limnology, Uppsala University, training was given in analyses of tritium by liquid scintillation counting. During the fellowships, training was also given at the Studsvik research reactor facility. The training focused on gamma and alpha spectrometric measurements of environmental samples.

The CPHR's radon monitor SARAD RM2000 was repaired and calibrated at SSI. Calibration of CPHR's radon detectors was also performed at SSI.

5 Deliverables

This SSI report summarizes the activities undertaken within the project. The scientific and technical results are described in detail in five published technical reports:

1. Protection of Workers and Patients (83 pages).
2. Emergency Preparedness (40 pages).
3. Environmental Protection (45 pages).
4. Doses to Cuban Population from Natural Radiation (55 pages).
5. Emergency Preparedness Exercise (12 pages).

Also, Guidelines for Radiological Diagnostics (10 pages) and Nuclear Medicine (200 pages) were prepared, and distributed to all relevant Cuban Hospitals and other institutions.

In addition, a CD with the following project information was prepared:

1. The Progress and Midterm reports.
2. The five technical reports, as listed above.
3. The Guidelines for Radiological Diagnostics and Nuclear Medicine.
4. The proceedings from the two workshops.

This report is available from SSI and the rest of the material listed above can be obtained by contacting the CPHR:

Centro de Protección e Higiene de las Radiaciones
6195 Habana 6
CP; 10600
Cuba

cphr@cphr.edu.cu

6 Project evaluation

An evaluation of SRPS – Cuba was performed in June 2003, partly coinciding with the final project workshop in Santa María del Mar (Havana, 2 – 6 June 2003. A preliminary oral report on the outcome of the evaluation was delivered during the workshop.

6.1 Background

The purpose of the evaluation was to obtain feedback from project participants in order to:

- assess whether the project objectives had been fulfilled;
- identify problems encountered during the course of the project;
- provide guidance for the potential continuation or follow-up of the project.

This evaluation report is based on a questionnaire sent to project participants in both Cuban and Swedish institutions. The questionnaire also formed the basis for interviews with project participants representing key organizations, including on-site interviews with representatives of six Cuban institutions. Tables 4 and 5 summarize the participations in the evaluation.

Table 4
Evaluation of SRPS – Cuba: Cuban participants.

Organization	**Work Package**	**Information provided by (interviews)**
Centro de Proteccion e Higiene de las Radiaciones, CPHR	1, 2, 3, 4	Dr. Jorge Carranza Dr. Juan Tomás
Centro Nacional de Seguridad Nuclear, CNSN	(1), 2, 3	Ing. Igor Sanabria Ing. Alba Guillien Ing. Yamil López
Ministerio de Salud Publica, MINSAP	1	Dra. Rosario Villa
Centro de Control Estatal de Equipos Medicos, CCEEM	1	Ing. Dulce María Martínez Ing. Roxana de la Mora Ing. Cunsuela Varena Ing. José Luis Alonso
Centro de Investigaciones Clínicas (Havana)	1	Dr. Batista Dr. Marco Coca Perez
Instituto de Nefrología (Havana)	1	Dr. Fraxeda
Hospital Salvador Allende (Havana)	1	Dr. Pedroso
The Agency for Nuclear Energy and Advanced Technologies, Ministry of Science Technologies and Environment	1, 2, 3, 4	Angelina Díaz (President)

Table 5
Evaluation of SRPS – Cuba: Swedish Institutions.

Organization	Work Package	Information provided by interviews
Swedish Radiation Protection Authority, SSI	1, 2, 3, 4	Anja Almén Ulf Andersson Mikael Jensen Gustav Åkerblom
Falu Lasarett, FL	1	One questionnaire
Kemakta Konsult AB, KEMAKTA	3	One questionnaire

6.2 Observations from interviews – Cuban partners

Cuban partners representing all aspects of the project were interviewed. There was a certain bias towards WP 1 (see Table 4), which was expected considering the vast number of 'consumers' of project output in the field of medical and occupational exposure. For example, there are in the order of 2,500 equipment in radiology and approximately 4,200 exposed workers within the medical field in Cuba – the medical field involves all aspects of radiology including radio-diagnostics, radiotherapy and nuclear medicine.

6.2.1 WP 1 – MEDICAL AND OCCUPATIONAL EXPOSURE

Cuban partners unanimously stated that the objectives for WP 1 had been fulfilled. In several aspects, the project also provided an output that goes beyond the original project plan. They particularly stressed:

- the usefulness of the guidelines for quality control, which help in establishing uniformity in radiology throughout the country, and which have also been helpful in getting personnel involved in quality issues;
- the establishment of a phantom bank accessible via the internet;
- the developing cooperation between personnel involved in radiology in different provinces of Cuba, which also involved annual meetings.

The Cuban partners had identified no problems of any real significance or potentially jeopardizing the project. In some cases, logistics (*e.g,* transportation within Cuba) had been a minor problem, and in one instance, a study visit to a Swedish hospital had not been possible (but subsequently carried out during a scientific visit held after the workshop). Also, several partners mentioned that the timeframe for bringing the project to conclusion had been tight, and that follow-ups are necessary in order to implement the project achievements. Possibly, this would involve the setting up of an educational program to help implementation.

Attitudes towards a continuation of the project were somewhat split. Some partners were of the opinion that the project had produced very useful results, but that it was now up to the Cuban institutions to implement these throughout Cuba – and that the project already had been instrumental in 'getting people to talk'. Others remarked that a broad continuation would be desirable where Cuban institutions could benefit from being able to use Swedish experts' participation in different courses in different regions in Cuba. An example could include the training of medical doctors and other personnel that have no real experience in radiology, as well as of personnel directly involved in relevant medical treatments.

A distinct problem that needs addressing is that equipment is aging and becoming obsolete. This makes some of the project's outcomes difficult to apply. However, highly functional equipment also exists, in many cases obtained through donations and international cooperation. The funding for maintaining functional instrumentation continues to be a major problem, but is given priority by the Ministry of Public Health (MINSAP). The transfer of equipment was not a part of the SRPS – Cuba project and was not further considered as part of future collaboration. Nonetheless, a second-hand gamma camera and other equipment have been donated to the Centro de Investigaciones Clinicas through the assistance of FL.

The development of quality guidelines through the project may help Cuban institutions underpin their proposals for exchange and upgrading of equipment.

6.2.2 WP 2 – EMERGENCY PREPAREDNESS

The Cuban counterparts, which in this area principally are CNSN and CPHR, stated clearly that the objectives of the workpackage have been fulfilled, and that – as for WP 1 – the project output actually goes beyond what was initially foreseen in the project plan. A number of aspects of this WP 2 were specifically emphasized by them:

- for the first time ever, an emergency preparedness exercise was organized in Cuba (6th June 2003, at the end of the project workshop). The scenario was developed jointly between Cuban and Swedish partners as a 'learning exercise' (similar to what is at times carried out in Sweden) and involved decision-making and assessments based on a hypothetical release from one of the Florida-based nuclear reactors;
- transfer of monitoring equipment and the related software (developed by SSI) for real-time monitoring of environmental radiation, as part of a national system for surveillance and preparedness.

The project facilitated the establishment of a national plan for emergency situations, where advice and suggestions from the SSI have been taken into account.

The Cuban counterparts indicated no problems of any real significance.

There was a clear interest in continuing the collaboration in this field, regarding, *e.g.* scenarios for accidents and human factors. Cuban partners specifically emphasized the possibility offuture collaboration to establish links between Cuba and a 'western' country (i.e. Sweden), who has direct experience from fallout and the related actions, e.g. as a result of the Chernobyl accident. During the workshop, it was also discussed that Cuban and Swedish institutions should collaborate to develop a national plan for waste management in Cuba, considering both radioactive and non-radioactive waste.

In discussion with CNSN, the possibility of setting up an agreement of co-operation (similar to the one between SSI and CPHR) was mentioned and is to be explored.

6.2.3 WP 3 – ENVIRONMENTAL PROTECTION

Cuban partners clearly felt that, as with the other workpackages, the project objectives have been fulfilled. The Cuban partners specifically stressed that:

- new regulations regarding safe management of radioactive waste had recently been approved and shortly be published in the Gaceta Oficial, in which advice from the SSI had been incorporated;
- a guidance document on clearance levels, both for solids and for gaseous and liquid effluents, had been published, yet again with incorporated SSI advice.

The project also provided the means, and a reference case, for the analysis of long-term radiation safety for repositories for radioactive waste, including, *e.g.* high-activity sealed sources and other radiation sources used for various purposes.

Again, the Cuban counterparts identified no significant problems during the course of the project, other than (as stated previously) that the timeframe was strict, which caused the project to operate under a certain 'time-stress'.

The Cuban counterparts expressed a clear interest in continuing the collaboration, potentially in the form of a follow-up project. Two areas were highlighted: the development of safety criteria for radioactive waste; and, further development and adaptation for Cuban conditions of detailed regulations concerning clearance of radioactive material. Both these areas are also central to SSI's work, and seem promising for potential future collaboration.

6.2.4 WP4 – NATURAL RADIATION

The Cuban partner – in this field CPHR - involved in WP 4 stated that the objectives of the WP had been fulfilled. In particular, it was emphasized that the project had contributed to:

- improved dose estimates to the Cuban population resulting from natural radiation, based on assessments made in both 'normal' areas and in areas with elevated background radiation;
- the establishment of international contacts within the field of natural radiation, where previously such contacts had been scarce.

No significant difficulties had been experienced during the project. The work within the WP involved transportation between different provinces within Cuba, but had not posed any major difficulties. Customs' declaration of measuring equipment brought to Cuba by Swedish partners had in one instance been a problem in that the instrumentation had being retained by Cuban customs' authorities for several days.

There was a clear interest from the Cuban partner to continue work on natural radiation in a follow-up to SRPS-Cuba. Such a continuation should expand the current measurements of natural radiation to other provinces and geographic areas in Cuba. Furthermore, there was a need to explore radiation exposure associated with the handling of Naturally Occurring Radioactive Materials (NORM) in work activities, in particular where the levels of natural radionuclides have been enhanced through human actions (Technologically enhanced Naturally Occurring Radioactive Materials, T-NORM).

6.3 Observations from interviews and written comments – Swedish partners

The comments received and reviewed below were largely collected in interviews with SSI staff during the workshop, but were also received as written comments from participants representing SSI, FL and KEMAKTA.

6.3.1 WP 1 – MEDICAL AND OCCUPATIONAL EXPOSURE

Swedish partners generally stated that the objectives of WP 1 had been fulfilled. Furthermore, it was emphasized that:

- the Cuban experts in the field had a very high competence and that technical discussions were useful – the Cuban participants putting in substantial time and effort and providing a very efficient and pleasant 'working climate', which was of vital importance for the fulfillment of the objectives.

Some of the participants felt they had been involved for too short time (replacing staff that had left) to fully contribute to the project. Improved descriptions in the interim reports of the project achievements would potentially have helped alleviating this problem. The SSI staff also felt that it was sometimes difficult to give the project full attention, due to pressing obligations at SSI. In one instance, there was severe external criticism against the commitment and project management at SSI within this

particular WP. In a few cases, the lack of knowledge of the language (*i.e*. Spanish) had contributed to difficulties.

There was a willingness of Swedish participants to assist in further implementation of project's results, possibly in the form of a follow-up project to SRPS-Cuba. There was also a general feeling that the very good contacts that have been established between the Cuban and Swedish institutions would prevail.

6.3.2 WP 2 – EMERGENCY PREPAREDNESS

The Swedish partner (in this case solely SSI) clearly considered the objectives to be fulfilled, and clearly extended beyond the initial goals. Some of the major points raised were that:

- an emergency preparedness exercise had been successfully carried out;
- SSI staff, through international collaboration, had been able to assist in transfer of monitoring devices to Cuba;
- Cuban counterparts had worked with a very high degree of commitment, which had been vital for completion – and extension – of the project objectives.

Again, some of the interviewed staff had spent relatively limited time on the project, and therefore, had similar comments as those expressed by some WP 1 participants (see above). It had also, at times, been difficult to maintain contact with Cuban counterparts between missions. There was also some concern over the implementation of project results post SRPS-Cuba.

SSI participants expressed a need for, and a willingness to, participate in a follow-up to SRPS-Cuba, with emphasis on, *inter alia*, implementation and evaluation of the surveillance systems; exercises; and, up-grading of technical equipment.

6.3.3 WP 3 – ENVIRONMENTAL PROTECTION

Participants in WP 3 unanimously expressed that the project objectives had been fulfilled. Some of the remarks made by Swedish participants included:

- the high competence of CPHR staff had made the project efficient and run very smoothly;
- visits of Swedish experts to Cuba had been well organized and fruitful and resulting in the development of both regulatory and assessment tools for use by Cuban institutions.

No major problems were encountered by any of the Swedish participants. SSI staff expressed the view that there had been too little time to develop further co-operation with the Centro CNSN, which – like SSI – is a national *regulatory* authority. As for WP 2, it had also been difficult to maintain close contact in the intervals between missions to/from Cuba.

There was a clear interest from SSI to continue collaboration in this area. The development of national waste strategies, plans, regulatory guidance, and assessment tools – also extending beyond radioactive waste – should be given priority. This would also require closer collaboration with CNSN, possibly through setting up an agreement of co-operation between CNSC and SSI, similar to the existing agreement between CPHR and SSI.

6.3.4 WP 4 – NATURAL RADIOACTIVITY

The Swedish participant (SSI) expressed the view that it was doubtful whether the objectives under this WP had been achieved. Part of the reason for this was that – when viewed in retrospect – the project plan was too ambitious, and would have required more field measurements from the Cuban counterpart than what were feasible. Nevertheless, it was pointed out that:

- the Cuban counterparts had greatly facilitated the expert missions, and that, this being a rapidly developing field in Cuba, the competence of CPHR was needed to establish a good overview of the situation with regard to naturally occurring radioactive materials.

As stated above, the main 'problem' of the WP was the too ambitious project plan. However, the project plan could still guide future collaboration, where also increased attention should be given to technical issues and further characterization of work places.

6.4 Overall conclusions from the evaluation

The majority of the comments received were positive. It became clear in the evaluation that both Cuban and Swedish participants were highly committed to the project. Some Swedish participants were critical of the project's management and constraints in terms of time and priority to the project. Nevertheless, participants views were that the objectives had been fulfilledbut that full implementation of the results may take several years. In general, there was support for a continuation of cooperation, possibly in the form of a new project, which would also underpin the full implementation of the results achieved under SRPS-Cuba.

7 Conclusions

The following general conclusions were made.

1. The project goal, objectives and work plan were fully completed. The project has been a useful experience for both Cuban and Swedish participating institutions.
2. The technical results of the project are considered be an important contribution to the strengthening of the Cuban Radiation Protection System. The results have had an impact at their National Level.
3. Given the ample degree of dissemination that the project results already have in Cuba, there is confidence that the project achievements will have a good continuous implementation.
4. An excellent broad co-operation has been established between Cuban and Swedish specialists in radiation protection, which is expected to continue in the future.

In addition, the following specific conclusions were made in the four priority areas of the project.

7.1 Protection of workers and patients

1. A national methodology, considering Cuban conditions, to evaluate the reference levels in Nuclear Medicine and X-rays Diagnostic was established and implemented.
2. The reference levels for different studies in Nuclear medicine and X-ray Diagnostic were proposed.
3. A protocol for the combined used of reference dose levels, physical phantoms and quality criteria for clinical images was developed and is being analyzed, as a tool for quality control in the diagnostic radiology practice.
4. A national quality control program was developed and implemented in Nuclear Medicine. It included a manual of quality control procedures and the establishment of a course. A Web site for the phantom bank was also designed and established in order to share the local resources it.
5. The current state of all the nuclear medicine instruments in Cuba was evaluated, according to the established quality control program. These results must be taken into account, as a premise, for optimization of dose reference levels.
6. A calibration service based on absorbed dose standards at Co-60 beam was successfully implemented. As an evidence of equivalence between the SSI and CPHR dosimetry standards was run the bilateral inter-comparison.

7.2 Emergency preparedness

1. The national Network of Environmental Radiological Surveillance of the Cuba Republic has strengthened its monitoring capacity and has become more operative.
2. The assimilation and the use of software and calculation tools has put the emergency evaluation group in better conditions for taking decisions in case of a radiological emergency.
3. The developed methodologies allow for Cuban experts to define reference levels for the measurement of rate of gamma dose absorbed in the air.

7.3 Environmental protection

1. CPHR has demonstrated, through its facilities in Havana and Cienfuegos, that Cuba is able to make high quality measurements in every aspect relevant for radiation protection, from dosimetry high-accuracy measurement needed for radiation therapy to blood dosimetry.
2. On a general level, it is obvious that the Cuban regulatory system, by incorporating extensively the IAEA's recommendations into the legal system, has a general structure in accordance with international recommendations.
3. The safety cases carried out were important to apply the acquired experience in EIA methodology and to start the application of compartments model in the modeling stage, for radiological impact assessment of the conceptual radioactive waste disposal system. They also prepare the necessary resources (human and material) to face up to the task of EIA for the future Cuban radioactive waste disposal system.
4. Preliminary, both evaluated designs (vault and boreholes), for disposal of radioactive waste, meet the safety criteria, i.e. they are below the annual dose limit for public member.

7.4 Natural radioactivity

1. As result of the work carried out, an assessment of the data on exposure to natural radiation has been made. The existing data required, for an evaluation of the received doses to the Cuban population, are for the main part sufficient and of excellent quality. However, data are still lacking for the very small part of the population in their homes, outdoors or at work, whom may be exposed to enhanced gamma radiation or radon gas. These people may live in areas or at sites with higher than normal concentrations of uranium and thorium in the ground or in houses constructed by locally produced building materials with enhanced radioactivity. There may also be workers exposed to radon in underground premises or working with materials that contain above normal levels of natural radioactive elements, e.g. radium-containing scale inside oil pipes.
2. Scientists at CPHR have upgraded their knowledge about natural radiation and techniques for measurements of and analyses for natural radioactive elements and isotopes, thanks to the training given within the framework of this project.
3. Representative information on the exposure in some Cuban areas with higher than normal radiation has been obtained.

8 Recommendations

The following general recommendations were given.

1. The groups that have been working together during these two and half years are encouraged to continue co-operation.
2. The Cuban organizations are recommended to develop a program for further dissemination of the project results within the country, in particular those results obtained in the field of medical practices.
3. It was suggested to explore ways of expanding the experiences of this project to a broader co-operation with other countries surrounding Cuba .
4. The project participants are encouraged to publish the project results in the open literature.

In addition, the following specific recommendations were made in the four priority areas of the project to Strengthening the Radiation Protection System in Cuba.

8.1 Protection of workers and patients

1. To update the regulatory framework to support the implementation of the developed reference levels.
2. To extend the implementation of the Quality Control protocol for Diagnostic Radiology practice to the national health system.
3. To work on the recognition and promotion of the Medical Physics and Radiation Protections Societies for Diagnostic Radiology Researches.
4. To propose to the regulatory authority a methodology to optimize the doses periodically in Nuclear Medicine and in Diagnostic Radiology using the results obtained in this project.
5. To extend the measurements of reference levels to other examinations (not only conventional but also computed tomography, dental, etc.).
6. To continue delivering the quality control course on Nuclear Medicine.
7. To create an expert national group to audit the implementation of national quality control programs in Nuclear Medicine and Diagnostic Radiology.
8. To develop a calibration service for dental measuring system at the SSDL.
9. To disseminate of the absorbed dose to water standards to the hospital users.

8.2 Emergency preparedness

1. To implement models of atmospheric transport for evaluation of the consequences of accidents in nuclear plants located in neighboring countries.
2. To improve the Network of Environmental Radiological Surveillance: design of an automatic system for the measurement of aerosols, establishment of reference levels for the measurement of aerosols and precipitation and introduction and automation of meteorological variables.

3. To improve the strategy of evaluation of different situations of radiological emergency. Inter-comparison and evaluation of the different emergency groups.
4. To develop international co-operation for the control of radiation sources and prevent their use with terrorist purposes.

8.3 Environmental protection

1. To develop a National Strategic Plan, with written set of actions andtarget timescales leading to safe waste management.
2. To carry out a waste inventory, classification and characterization of wastes according to requirements of the strategic plan.
3. To identify waste conditioning and treatment requirements, and packaging, the optimal set, given the overall strategy, i.e. not to consider each waste separately.
4. To identify interim storage facilities and disposal routes, site selection, design construction, operation, monitoring and final closure.
5. In order to manage and dispose of the radioactive waste, and assess the safety of the proposed facilities for radioactive waste, CPHR must have competence and necessary means to take part in the regulatory dialogue as described above. This implies that CPHR and CNSN must maintain their capability in dose and risk assessment, scenario development, management of modeling tools, etc.
6. It would be valuable to extrapolate the obtained Methodologies to non-radioactive waste, like a diagnosis and evaluation tool during the hazard waste isolation process.
7. Taking into account the project's experience, continued co-operation between Sweden and Cuba in the field of safety assessment would be valuable . SSI is presently developing modeling software, and there is interest from both sides to cooperate in the use and evaluation of the tool.

8.4 Natural radioactivity

1. To complete the investigation on exposure to Cuban workers to radiation from NORMS and TENORMS.
2. To investigate the situation associated to scale at oil and nickel industries.
3. Investigate the acquirement of additional equipment that CPHR still needs for effective work on protection against and investigation on natural radiation, based on the list that CPHR prepared.

9 List of acronyms

CMH	Cuban Ministry of Health (Cuba)
CCEM	Centro de Control Estatal de Equipos Medicos
CNSN	Cuban Centro Nacional de Seguridad (Cuba)
CPHR	Centro de Protección e Higiene de las Radiaciones (Cuba)
EIA	Environmental Impact Assessments
FL	Falu Lasarett (Sweden)
GPS	Global Positioning System
IAEA	International Atomic Energy Agency
ICRP	International Commission on Radiological Protection
IRSN	Institute of Radiological Safety (France)
IUR	International Union of Radioecology
KEMAKTA	KEMAKTA Konsult AB (Sweden)
KS	Karolinska Sjukhuset (Sweden)
MINSAP	Ministry of Public Health (Cuba)
NORM	Naturally Occurring Radioactive Materials
SCK-CEN	Centre for Nuclear Research (Belgium)
SIDA	Swedish International Development Co-operation Agency (Sweden)
SRPS	Strengthening the Radiation Protection System
SSDL	Secondary Standard Dosimetry Laboratory
SSI	Swedish Radiation Protection Authority (Sweden)
Studsvik	Studsvik Instrument AB (Sweden)
T-NORM	Technologically enhanced Naturally Occurring Radioactive Materials

2004:01 Further AMBER and Ecolego Intercomparisons
SKI nr 2004:05
SSI och SKI

2004:02 Strengthening the Radiation Protection System in Cuba (SRPS – Cuba), A co-operation project between Cuban and Swedish institutions, February 2001–June 2003
Avdelningen för avfall och miljö.
Rodolfo Avila, Carl-Magnus Larsson, Miguel Prendes och Juan Tomás Zerquera 80 SEK

SSI Rapport

STATENS STRÅLSKYDDSINSTITUT, SSI, är central tillsynsmyndighet på strålskyddsområdet. Myndighetens verksamhetsidé är att verka för ett gott strålskydd för människor och miljö nu och i framtiden.

SSI är ansvarig myndighet för det av riksdagen beslutade miljömålet *Säker strålmiljö*.

SSI sätter gränser för stråldoser till allmänheten och för dem som arbetar med strålning, utfärdar föreskrifter och kontrollerar att de efterlevs. Myndigheten inspekterar, informerar, utbildar och ger råd för att öka kunskaperna om strålning. SSI bedriver också egen forskning och stöder forskning vid universitet och högskolor.

SSI håller beredskap dygnet runt mot olyckor med strålning. En tidig varning om olyckor fås genom svenska och utländska mätstationer och genom internationella varnings- och informationssystem.

SSI medverkar i det internationella strålskyddssamarbetet och bidrar därigenom till förbättringar av strålskyddet i främst Baltikum och Ryssland.

Myndigheten har idag ca 110 anställda och är belägen i Stockholm.

THE SWEDISH RADIATION PROTECTION AUTHORITY (SSI) is the government regulatory authority for radiation protection. Its task is to secure good radiation protection for people and the environment both today and in the future.

The Swedish parliament has appointed SSI to be in charge of the implementation of its environmental quality objective *Säker strålmiljö* ("A Safe Radiation Environment").

SSI sets radiation dose limits for the public and for workers exposed to radiation and regulates many other matters dealing with radiation. Compliance with the regulations is ensured through inspections.

SSI also provides information, education, and advice, carries out its own research and administers external research projects.

SSI maintains an around-the-clock preparedness for radiation accidents. Early warning is provided by Swedish and foreign monitoring stations and by international alarm and information systems.

The Authority collaborates with many national and international radiation protection endeavours. It actively supports the on-going improvements of radiation protection in Estonia, Latvia, Lithuania, and Russia.

SSI has about 110 employees and is located in Stockholm.

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