Nuclear Safety

Monitoring Artificial Radioactivity in the Nordic Countries

TemaNord
1995:559

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Final Report of the Nordic Nuclear Safety Research Project BER-2

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December 1994

TemaNord 1995:559

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TemaNord 1995:559

ISBN 92 9120 679 2
ISSN 0908-6692
Printing and distribution: Nordic Council of Ministers, Copenhagen
Printed on Paper Approved by the Nordic Environmental Labelling
Information about the NKS reports can be obtained from:

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The Nordic Council of Ministers
was established in 1971. It submits proposals on co-operation between the governments of the five Nordic countries to the Nordic Council, implements the Council's recommendations and reports on results, while directing the work carried out in the targeted areas. The Prime Ministers of the five Nordic countries assume overall responsibility for the co-operation measures, which are co-ordinated by the ministers for co-operation and the Nordic Co-operation Committee. The composition of the Council of Ministers varies, depending on the nature of the issue to be treated.

The Nordic Council
was formed in 1952 to promote co-operation between the parliaments and governments of Denmark, Iceland, Norway and Sweden. Finland joined in 1955. At the sessions held by the Council, representatives from the Faroe Islands and Greenland form part of the Danish delegation, while Åland is represented on the Finnish delegation. The Council consists of 87 elected members - all of whom are members of parliament. The Nordic Council takes initiatives, acts in a consultative capacity and monitors co-operation measures. The Council operates via its institutions: the Plenary Assembly, the Presidium, and standing committees.

Abstract

This report describes the national systems for monitoring artificial radioactivity in the five Nordic countries (Denmark, Finland, Iceland, Norway and Sweden), including national similarities and differences regarding strategy and equipment. The backbone of the national system for early warning is a network of automatic gamma monitoring stations. It is complemented by manual stations and/or survey teams measuring in predetermined points. Air filter stations are used for nuclide specific analyses of aerosols and gaseous iodine. Fallout maps (especially for cesium-137) and isocurves (dose equivalent rates) are produced based on data from airborne measurements, monitoring stations, survey teams and environmental samples. All five countries have extensive programs for checking food contamination. Whole body counting and organ measurements are used to determine internal contamination. External contamination of people, vehicles, goods etc. is checked with survey meters and other equipment at checkpoints or as needed. Field measurements of various kinds complete the national systems. Current routines and systems for exchange of radiation data between the Nordic countries are summarized. A joint Nordic program for airborne measurements is suggested. Possible future development and planned improvements are discussed.

Key words:

Aerial surveys; Aerosols; Cesium-137; Contamination; Data base; Denmark; Early warning; Fallout; Finland; Gamma detection; Iceland; Mapping; Norway; Portable equipment; Radiation monitoring; Regional cooperation; Sweden

Summary

When fallout of radioactive material is expected or has occurred, authorities need fast and reliable information on the location and characteristics of the fallout. Therefore, each of the Nordic countries (Denmark, Finland, Iceland, Norway and Sweden) has established strategies, equipment and routines to map the national territory after a fall-out, resulting from a radiological accident domestically or abroad. There are also national programs for determining the contamination levels of food, environmental samples, vehicles, goods etc., as well as any external or internal contamination of people.

The national strategies and their practical applications regarding the various types of measurements often coincide or turn out to be equivalent or very similar; in certain cases there are however important differences. Some of these differences are easy to explain or justify, due to radiological differences (such as normal background radiation levels or radon concentrations). Others, however, reflect differences in attitude, available equipment, experience or historic development of procedures and equipment.

In the case of Denmark, Finland and Sweden, the major radiological threat is considered to be a reactor accident at a nuclear power plant outside the Nordic countries. In Finland and Sweden the threat presented by domestic power reactors may however not be neglected. In Norway, foreign nuclear powered naval vessels and submarines constitute an additional threat. In Iceland, such vessels are considered to be the most significant threat.

Automatic gamma monitoring stations form the most important part of the national early warning system. They constitute a fast, sensitive and reliable method for total gamma measurements. However, the number of stations per unit area varies greatly between the countries. Finland has several hundred, and intends to introduce additional stations. Iceland has but one stationary detector; in case of an emergency, however, up to half a dozen extra stations can be organized and installed where most needed. Denmark has 11 stations; Norway has 28; and Sweden has 37 stations. The Finnish strategy is to have both a dense grid of automatic stations and manual measurements by local survey teams, reporting over the public telephone network. Sweden, on the other hand, applies a minimum of stationary automatic stations, relying on other sources (such as survey teams) for additional radiometric information, and at the same time risking congestion of the telecommunications network and incorrect data due to manual report routines for the additional non-automatic measurements. The other three countries take positions in between those extremes.

Generally speaking, the fewer the stations per unit area, the more important their location, in order to create an optimal coverage of the national territory. In some cases, the automatic network is complemented by semi-automatic or manual stations.

The report includes details on the five national automatic gamma monitoring networks regarding the type(s) of detector(s) used; dynamic range; polling periods; radon compensation; and alarm criteria. These stations monitor the total gamma radiation

level on the ground, and may also detect a passing radioactive cloud, thus providing early warning as well as radiation data both under normal circumstances and in the acute phase and later stages of emergency situations.

A map of automatic gamma monitoring networks operated by the Nordic countries is presented at the end of this chapter, including a number of stations located in Russia.

High resolution measurements of airborne radioactivity using air filter stations are made in all five Nordic countries. Air is continuously drawn through a filter for a predetermined period, and the filter is then sent to a laboratory for nuclide specific analysis. Although very sensitive, air monitoring stations do not supply early warning, due to the inherent time delay in the evaluation process. Rather, they are used to assess the situation and predict possible consequences of a fallout. Just as for gamma monitoring stations, the number of air filter stations varies from country to country. The national programs include combinations of stationary and mobile units; low, high and ultra high volume air samplers; equipment for measuring aerosols and/or gaseous iodine, xenon etc.

All Nordic countries have programs or plans for survey teams and local measurements in predetermined points to get fast and detailed information on local dose rates.

All countries except Iceland have a program for airborne fallout mapping.

Mobile gamma monitoring stations and/or air filter stations are used or planned to complement the stationary network.

Field measurements of the following types can be made in areas of special interest in all five countries:

- gamma spectrometry
- total gamma measurements
- gamma analysis of air filters
- alpha and/or beta measurements

There are extensive programs in all five countries for field and/or laboratory analysis of environmental and food samples. Norway has implemented a system of gamma spectrometers, the so-called LORAKON system, basically intended for food analysis. The detectors are used for automatic gamma monitoring during their down time (i.e., when not in use for their original purpose), adding to the national early warning system. Iceland, with an economy strongly dependant on fish and fish products, relies heavily on monitoring radioactivity in Icelandic waters, fish and fucus around the coast of Iceland. Certificates confirming low levels of activity are issued routinely.

External contamination checks (gamma, beta/gamma, or alpha) of people, vehicles, buildings etc. are performed whenever needed. Special checkpoints will be set up as required. Ordinary survey meters are used in most instances. More sophisticated equipment is however available in all Nordic countries, should the need arise.

All countries except Iceland have whole body counters for making individual nuclide specific measurements of internal contamination levels. Iceland relies on assistance from its Nordic neighbors or some other country.

In all five countries, some hospitals and other institutions are equipped and staffed to detect and assess internal contamination by means of organ measurements or analysis of urine samples.

Radiation data and other relevant information can be exchanged fairly easily between the Nordic countries, when and as agreed by the involved parties. As regards data from the national automatic gamma monitoring networks, a national bulletin board system (BBS) using personal computers or a similar system has been established in some countries. If and when such systems are fully operational in all Nordic countries, readings of external gamma radiation levels from the stations in neighboring countries would be available via the national BBS in a standardized format for quick reference. The national data bases are supposed to be updated automatically at predetermined intervals.

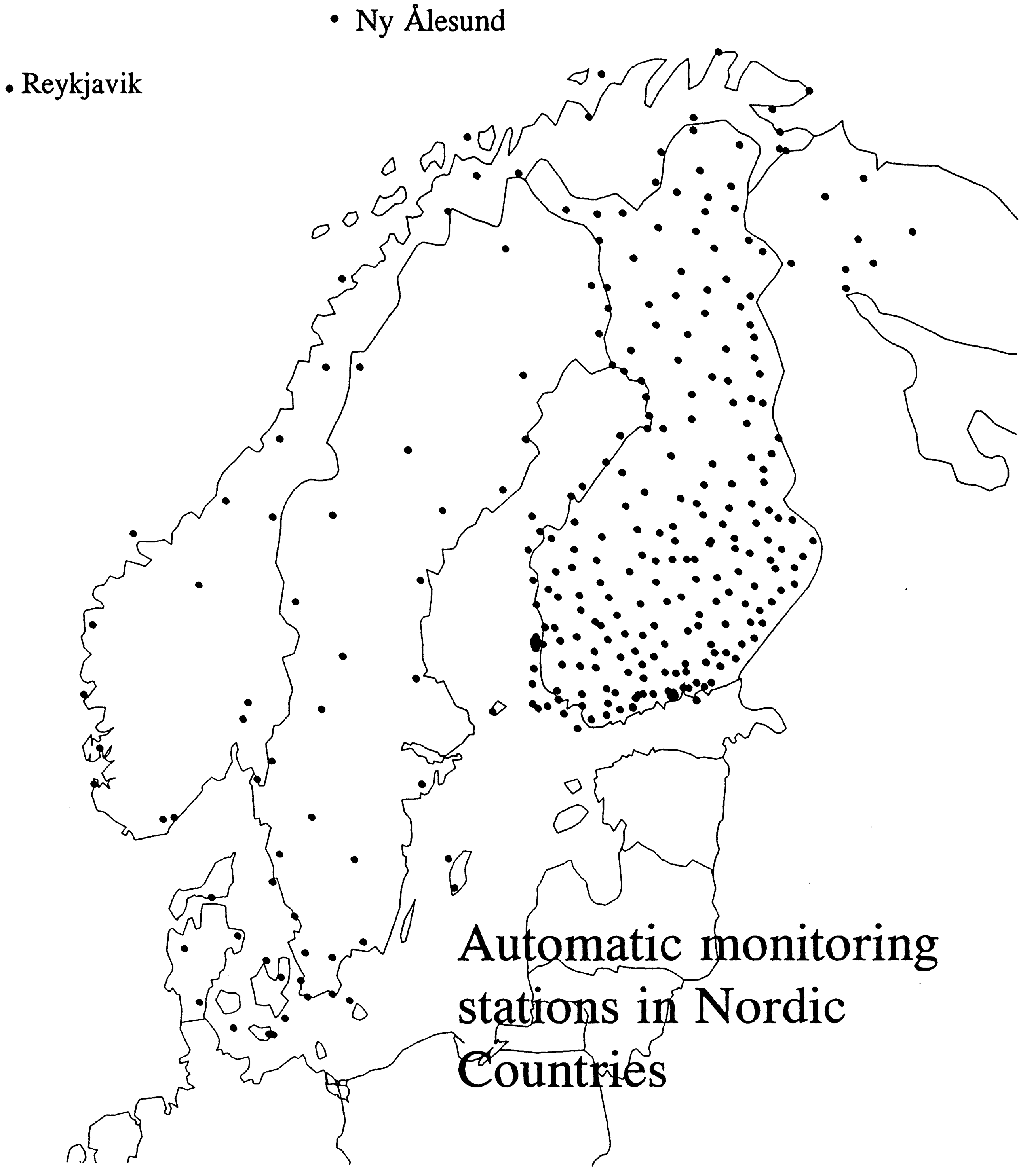
A standardized Nordic system for on-line airborne measurements in acute situations has been suggested, and the findings and recommendations are summarized in this report. The proposed technical solution includes

- airborne radiological and computer equipment
- GPS navigation system and radar altimeter
- on-line data transmission via radio link every 10 seconds
- specifications regarding the ground station, central computer and software

The need for Nordic harmonization of instruments and methods for airborne measurements is recognized, especially with regard to basic installations; radio frequencies; data quality; and exchange of data and results. Cooperation between national emergency preparedness organizations and already existing national Search And Rescue (SAR) organizations is suggested, using SAR aircraft and personnel for radiometric missions.

Available radiometric services in the Nordic countries

Type of measurement	**Denmark**	**Finland**	**Iceland**	**Norway**	**Sweden**
Stationary automatic gamma monitoring stations	11	250	1	28	37
Mobile automatic gamma monitoring stations		1	4 - 6	-	Planned
Semi-automatic or manual stations		240	Planned	-	-
Local survey teams	Yes	Yes	Organized as needed	Yes	Yes
Air filter stations	1 cont. 2 standby	34	1	8 cont. Some 50 standby	8
On-line filter monitoring of gamma or beta/gamma		Yes, 17 stations	Yes	Planned	No
Airborne measurements					
• Fallout mapping	Yes	Yes	No	Yes	Yes
• Air sampling	No	Yes	No	Yes	Yes
Food contamination measurements	Yes gamma, Sr, Pu	Yes, 52 laboratories gamma, Sr, Pu, Am	Yes gamma, beta	Yes, 70 laboratories gamma, Sr, Pu, Am	Yes gamma, Sr, Pu
Environmental sampling	Yes	Yes	Yes	Yes	Yes
Contamination checks of vehicles, goods etc. (alpha, beta, gamma)	Yes	Yes	Yes	Yes	Yes
Field measurements:					
• gamma spectrometry	Yes	Yes	No	Yes	Yes
• total gamma	Yes	Yes	Yes	Yes	Yes
• air filter gamma analysis	Yes	Yes	Yes	Yes	Yes
• beta	Yes	Yes	No	Yes	Yes
• alpha	Yes	Yes	No	Yes	No
Whole body counter(s)	Yes	Yes	No	Yes	Yes
Organ measurements	Yes	Yes	Yes	Yes	Yes
Excreta and body fluid measurements	Yes	Yes	Yes	Yes	Yes



Automatic monitoring stations in Nordic Countries

Svensk sammanfattning

(Swedish summary)

I samband med ett radioaktivt nedfall behöver berörda myndigheter snabb och tillförlitlig information dels om vad nedfallet innehåller, dels om vilka områden som drabbats och hur allvarlig situationen är. Därför har de nordiska länderna (Danmark, Finland, Island, Norge och Sverige) utvecklat strategier, skaffat utrustning och etablerat rutiner för att kartlägga det drabbade området, oavsett om nedfallet härrör från en nationell eller utländsk olycka. Det finns också nationella program för att fastställa graden av kontamination av livsmedel, miljön, fordon, varor m m. Vidare kan intern- och externkontaminering av personer mätas.

Det är fem länder med olika förutsättningar och fem nationella beredskaplaner och strategier. Men påfallande ofta är strategierna och deras tillämpning snarlika länderna emellan. Ibland finns det dock väsentliga skillnader. En del av dessa skillnader är lätta att motivera - de kan t ex förklaras med olika hotbild, varierande naturlig bakgrundsstrålning eller naturliga variationer i radonhalten i utomhusluften. Andra skillnader återspeglar olikheter i bedömningen av läget, tillgänglig utrustning, erfarenhet eller historiska faktorer, och de strategiska skillnaderna blir sedan synliga när man utvecklar metoder och utrustning.

I Danmark, Finland och Sverige anses det största radiologiska hotet vara reaktorolyckor utanför Norden. Det innebär inte att olycksrisken i finska eller svenska kärnkraftverk försummas. I Norge utgör kärnkraftdrivna fartyg och ubåtar ytterligare ett hot. I Island är sådana mobila reaktorer det allvarligaste radiologiska hotet.

Automatiska gammastationer är den viktigaste länken i de nationella systemen för tidig varning. De ger snabba, känsliga och tillförlitliga mätningar av den totala gammadosraten från marken. Men antalet stationer (både totalt och per ytenhet) varierar avsevärt mellan länderna. Finland har sammanlagt flera hundra gammastationer, och antalet växer ständigt. Island har bara en fast mätstation, som dock vid behov kan kompletteras med upp till ett halvdussin mobila stationer på platser där man önskar särskild övervakning. Danmark har 11 stationer, Norge har 28 och Sverige har 37.

Den finska strategin bygger på ett tätt nätverk av automatiska stationer. Det kompletteras av lokala mätpatruller som gör manuella mätningar och rapporterar resultaten via det allmänna telenätet. Risken för falsklarm från det automatiska systemet bedöms som liten. Sverige, å andra sidan, har satsat på ett nätverk som har så få stationer som möjligt för att minimera sannolikheten för falsklarm men tillräckligt många stationer för att inte riskera att missa en plym från en utländsk olycka. I stället förlitar man sig till betydande del på andra typer av mätningar (t ex genom mätpatruller) för att skaffa sig mer detaljerad information. Risken ökar dock dels för problem i dataöverföringen vid en eventuell överbelastning av telenätet, dels för fel i mätdata med tanke på de manuella mät- och rapporteringsrutinerna. De andra tre nordiska länderna har valt strategier någonstans emellan dessa båda extremer.

Ju glesare det automatiska nätverket är, desto viktigare blir valet av plats för de ingående stationerna för att få bästa möjliga täckning av landet. I en del fall kompletteras de automatiska nätverken med manuella eller halvautomatiska mätstationer.

Denna rapport innehåller uppgifter om de fem ländernas gammastationer vad gäller till exempel:

- detektortyp
- dynamik
- uppringningsfrekvens
- radonkompensation
- alarmkriteria

Dessa stationer mäter den totala gammadosraten från marken under normala förhållanden såväl som under akutfasen efter en olycka, och därefter även under senfasen. Men stationerna kan även under vissa förhållanden detektera ett passerande radioaktivt moln och ger då tidig varning.

Samtliga fem länder mäter luftburen aktivitet med hjälp av högupplösande luftmoniteringsstationer. Luft sugs genom ett filter under en känd tid, och filtret sänds sedan till ett laboratorium för nuklidspecifik analys. Metoden är mycket känslig. Den ger dock inte tidig varning, eftersom både luftprovtagningen och utvärderingen är tidskrävande. Däremot är det en mycket användbar metod för att få information om hotbilden: nuklider, aktivitetskoncentrationer, typ av utsläppskälla, risker i samband med markbeläggning m m.

Även antalet luftmoniteringsstationer varierar från land till land. De nationella beredskapsorganisationerna har tillgång till både fasta och mobila stationer, med starkt varierande luftgenomströmningskapacitet (från under 1 m^3/h till över 1000 m^3/h). Beroende på utformningen av stationen kan man mäta aerosoler, gasformig jod, xenon etc.

I samtliga nordiska länders beredskapsplaner ingår mätpatruller, ofta i kombination med lokala mätningar i fastställda punkter för att snabbt få en uppfattning om dosraterna och beläggningssituationen lokalt.

Alla länderna utom Island har ett program för luftburen kartering av det drabbade området.

Följande typer av fältmätningar kan utföras i samtliga fem länder i områden av särskilt intresse:

- gammaspektrometri
- totalgammamätningar
- gammaanalys av luftfilter
- alfa- och/eller betamätningar

Alla fem länderna har avancerade program för fält- och/eller laboratoriemätningar på omgivnings- och livsmedelsprover. Norge har ett landstäckande system med laboratorier utrustade med NaI(Tl) -detektorer för livsmedelsmätningar. Utrustningarna kan enkelt konverteras till automatiska gammastationer när de inte används för mätning på livsmedelsprover. Därigenom utökas möjligheterna till tidig varning. Eftersom Islands ekonomi är starkt beroende av fisk och fiskprodukter görs gammaspektrometriska analyser av dessa livsmedel inte bara i olyckssituationer.

Kontroll av externkontamination (gamma, beta/gamma eller alfa) genomförs så snart behov föreligger. Särskilda mätplatser kan upprättas. Vanliga handinstrument används för det mesta, men samtliga länder har tillgång till mer sofistikerad utrustning om det skulle behövas.

Alla länder utom Island har helkroppsmätare för att göra nuklidspecifika bestämningar av graden av internkontamination hos drabbade personer. Island kan vid behov köpa tjänsten från något annat land.

I alla fem länderna har vissa sjukhus, universitetsinstitutioner etc utrustning som kan användas för kontrollmätningar på kroppsorgan (t ex sköldkörteln) eller av urinprover o dyl.

Mätdata och annan relevant information kan lätt utväxlas mellan de nordiska länderna, när man så önskar. I en del av länderna har man upprättat en datorbaserad elektronisk anslagstavla, där aktuella mätvärden från de automatiska gammastationerna visas. Om och när detta system är fullt utbyggt i hela Norden är det tekniskt möjligt att snabbt skaffa mätvärden i ett standardiserat dataformat från de fyra grannländerna genom att studera deras elektroniska anslagstavlor. Tanken är att dessa ska uppdateras automatiskt med jämna mellanrum.

Ett standardiserat nordiskt system för flygburna mätningar on-line har diskuterats, och resultaten och rekommendationerna sammanfattas i denna rapport. Den föreslagna tekniska lösningen innehåller bl a

- luftburen mät- och datorutrustning
- navigeringssystem (GPS) och höjdradar
- on-line dataöverföring via radiolänk var 10 sekund
- önskemål beträffande markstationen, centraldatorn och mjukvaran

Det finns ett uppenbart behov av nordisk harmonisering av instrument och metoder för flygmätningar, särskilt vad gäller instrumentering, radiofrekvenser, datakvalité och utbyte av data och resultat. De nationella beredskapsorganisationerna bör samarbeta med redan existerande enheter för efterspaning och räddning (s k SAR-organisationer, av Search And Rescue), så att deras flyg- och personalresurser vid behov kan tas i anspråk för radiometriska uppdrag.

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1. Introduction

In the mid 70's a joint research program on nuclear safety was established among the five Nordic countries (Denmark, Finland, Iceland, Norway and Sweden). To that end, the Nordic Committee for Nuclear Safety Research (Nordiska kommittén för kärnsäkerhetsforskning, NKS) was formed.

During its first three periods of existence, each of four years' duration, the NKS program was financed mainly by the Nordic Council of Ministers. The program for the latest period, 1990-1993, was financed through a consortium of ministries and regulatory bodies responsible for reactor safety, radiation protection and emergency organization in the Nordic countries.

Four major areas were incorporated in the latest NKS program:

- BER: Emergency Preparedness
- KAN: Nuclear Waste and Decommissioning
- RAD: Radioecology
- SIK: Reactor Safety

Each of the four areas was made up by a number of projects of joint interest to the participating countries. Thus, a total of 16 projects were carried out. Six of them focused on emergency planning and preparedness. A task group of national specialists in the particular field was involved in each of the projects. For advice and discussions a reference group of independent experts was attached to each of the four major program areas.

This is the final report on the BER-2 project mainly dealing with methods and equipment for measuring artificial activity in the Nordic countries, as well as exchange of data and information between the countries. The project leader was Mr. Janne Koivukoski, Ministry of the Interior, Finland.

The BER-2 project consisted of the following parts:

- BER-21: General measurement methods and equipment
  Coordinator: Mr. Torkel Bennerstedt, TeknoTelje, Sweden
- BER-22: Radiation data exchange between the Nordic countries
  Coordinator: Mr. Hannu Rantanen, VTKK, Finland
- BER-23: On-line airborne measurements in acute situations
  Coordinator: Mr. Bjarne M. Mortensen, Infocon, Denmark

The final report on the entire BER-2 project was edited by Mr. Torkel Bennerstedt.

2. Present situation

A nuclear emergency organization could not fulfill its duties properly without input data regarding the radiological situation. Measurements of air, ground, water and food contamination levels as well as dose rates and dose assessments are crucial when deciding on countermeasures and information to the public. Both measurements and meteorological models are important in this respect.

This obviously calls for monitoring and measurement equipment of various kinds. Apart from political, social and economic factors, the type of instrumentation chosen and the number of detectors used depend largely on the overall nuclear threat to the region in question. Denmark, Finland, Norway and Sweden form a fairly homogeneous region in this respect, whereas Iceland at great geographical distance from the rest of the Nordic countries faces a somewhat different situation.

The most serious nuclear threat to the four continental Nordic countries is presented by domestic and foreign reactors of various kinds (power or research). The situation is schematically depicted in the map on the front cover. In Iceland, naval vessels, submarines and other mobile sources constitute the greatest hazard.

Generally speaking, the five Nordic Early Warning monitoring programs apply two different approaches:

- automatic gamma monitoring stations, focusing on rapid total gamma measurements of fallout
- air monitoring stations, giving priority to sensitive gamma spectrometry of airborne activity for nuclide identification and activity determination

Once a deposition of radioactive material has occurred, several types of measurements are applied to collect data on ground deposition, contamination of foodstuffs etc. The general level of background radiation in the Nordic countries is well known as a result of investigations prior to and after the Chernobyl accident. This information is valuable when studying the effects of any future fallout.

In the long-term assessment of dose to man, a gamma monitoring system, in conjunction with other information, is of value. The downward migration of radionuclides in the ground can be followed over a long period and this provides information that can be used for example to predict vegetation contamination levels. (This is dealt with in the NKS/RAD radioecology projects referred to above; see separate reports.)

Although the five national systems that together form the Nordic radiological measurement system differ in several aspects, the similarities are found to predominate. This is true for policy and organization as well as for equipment and data processing.

As a result of the Nordic cooperation project reported here, national authorities are presented with a tool for quick transfer of updated radiological data, for instance from automatic gamma monitoring stations in neighboring Nordic countries. This can be achieved either by national data bases and national bulletin board systems (BBS) or by a common data base with a common BBS. However, it is not – and should not be – possible to actually poll the stations of the Nordic neighbors. Neither should access to the other countries' central computer be allowed, since it could lead to unauthorized tampering with the system, e.g., changed alarm levels, polling periods etc.

Thanks to bilateral agreements and Nordic financial support, systems for satellite transmission of early warning have already been established from reactor sites in Kola/Murmansk, Sosnovy Bor and Ignalina to Denmark, Finland, Germany, Norway, Russia and Sweden. It is likely that more nuclear power plants in eastern Europe will be equipped with similar facilities in the future. The bilateral or multilateral written agreements on early warning and exchange of information work both ways, so that the partners in Eastern Europe will be informed on any event of interest in the Nordic countries.

3. Denmark

3.1 General background

The Danish Emergency Management Agency (Beredskabsstyrelsen, DEMA) is responsible for emergency planning and organization aiming at monitoring the radiological situation, alerting proper organizations in case of an emergency and taking other measures necessary to minimize doses and other risks to the population. DEMA has the operative command of the emergency preparedness organization, and acts as coordinator versus other participating organizations.

The types of measurements carried out before and after a fallout and the organizations responsible for these measurements are summarized in Table DK-1. The basic domestic nuclear threats are represented by the two research reactors at Risø and the waste management program. The external threats are mainly due to nuclear power reactors.

The Danish monitoring system is designed to detect releases emanating from foreign and domestic sources.

The general background level of the country (total gamma) is well known due to investigations prior to and after the Chernobyl accident.

3.2 Automatic gamma monitoring stations

The widespread fallout from the Chernobyl accident caused Denmark to install a nationwide automatic gamma monitoring system for early warning, owned by DEMA and operated by Risø. The object is to get an alarm as soon as a radioactive cloud approaches or passes over any of the eleven presently operative stations, fairly evenly distributed over the country. (See map in Fig. DK-1.) The system should also detect and measure deposited radioactive material.

The stations are designed to

- firstly, measure the current dose rate; and
- secondly, differentiate between "man-made" causes of increased readings on one hand and increased radon concentrations and other natural causes of variations in the background level on the other.

To that end, there are two types of detectors at each station:

- A pressurized Reuter-Stokes ionization chamber for total gamma ambient dose equivalent rate measurements, with a range of 10 – 100 000 000 nSv/h.
- A 3" NaI(Tl) scintillator with a 256-channel analyzer, giving the number of counts per second (cps) for each of a number of preset radiation energy windows, representing radon gas and radon daughters; K-40; and some man-made isotopes, such as Cs-137. Thus, radon and background discrimination is obtained.

At each site there is also a rain intensity gauge that gives an impulse for every 1/10 mm of precipitation. Furthermore, the temperature at the station is registered.

The ten gamma monitoring stations outside of Risø form the national early warning system. They are placed in huts erected within premises controlled by DEMA and are linked to DEMA's communication network. The one at Risø is a test station, also used to calibrate the entire system, and is not primarily intended for early warning.

A local microcomputer logs the station continuously and stores the data until called, first by the central computer in DEMA, and 10 minutes later by the central computer at the Ecology and Health Physics Department at Risø. The gamma monitoring stations are polled by DEMA and Risø once every hour. The data thus collected are analyzed using personal computers (PCs). The Risø computer checks that the DEMA computer has got the same information, and supplies the data from the gamma monitoring station at Risø.

At Risø, an alarm display connected to the central computer is placed in the control room of one of the reactors, where it is supervized around the clock. In case of an alarm the health physicist on duty at Risø is notified. If deemed necessary, the health physicist on duty at the National Institute of Radiation Hygiene (Statens Institut for Strålehygiejne, SIS) and the officer on duty at DEMA may be consulted. It is the latter who is authorized to decide whether the situation calls for an alert. All three persons on duty (at Risø, SIS and DEMA) can call the central PC at Risø via a portable PC and a modem over the public telephone network to get more information on the radiological situation at hand. Should there be cause for a more general alarm, additional contact persons at DEMA and SIS are alerted. SIS takes on an advisory role in this context.

At DEMA, an alarm display connected to the central computer is placed in the reception room of DEMA, where it is supervised around the clock. In case of an alarm the DEMA duty officer is notified, so that he is aware of the situation when called by the health physicist at Risø.

When polled by the health physicist, the local microcomputer at the gamma monitoring station can transmit the following data:

- Technical status of the station (technical faults will be displayed immediately at Risø for proper action)
- External radiation intensity, read every ten minutes
- A crude gamma spectrum of the external radiation, read every hour
- Rain intensity
- Temperature inside the hut

A block diagram of a gamma monitoring station is found in Fig. DK-2. An example of the printout is given in Fig. DK-3. Graphs include the total gamma registration plus, separately, contributions from K-40 and radon; net dose rate above background (K-40 plus radon); and precipitation. Good agreement between precipitation and radon levels has been demonstrated.

The alarm level is set at a 10% increase above the normal background level.

3.3 Air monitoring stations

Continuous measurements of airborne activity are performed at Risø, in Jutland and on Bornholm using extremely sensitive high-volume samplers with a capacity of over 4000 m^3/h. The filter is changed weekly under normal conditions; as often as required otherwise. The Risø station also measures gaseous iodine, noble gases and precipitation.

In case of an emergency or when otherwise called for, two air filter stations can be started with short notice (within a couple of hours). One of the stations is located in Midjutland, the other on Bornholm. They are both placed in barracks belonging to the Emergency Center. Filters are brought to and measured at Risø.

3.4 Airborne measurements

Air Force rescue helicopters can be alerted at short notice (15 minutes) to fly toward and around the Swedish nuclear power plants at Barsebäck and Ringhals in search for airborne radioactive material. A total of three helicopters are always available for rescue operations at sea, but in case of a nuclear emergency at Barsebäck or Ringhals, radiation monitoring missions have top priority.

The helicopters are alerted when General Alert is declared at Barsebäck or Ringhals. They are under the command of the Rescue Coordination Center in Jutland (Karup Airbase), and they report currently on VHF radio to DEMA's Command Center, EMACC, and also to their base.

In case of a widespread contamination on Danish soil, EMACC can call for army helicopters equipped with NaI(Tl) crystals and multichannel analyzers to fly over the contaminated area. Data are collected on board the helicopter and decoded and mapped after the flight.

3.5 Foodstuffs and environmental samples

The sampling process is planned and carried out by the central emergency organization in cooperation with the National Food Agency (Levnedsmiddelstyrelsen). Measurements are made by Risø and SIS. In addition to its own facilities, SIS has contracted eleven laboratories at universities, hospitals etc. to analyze environmental and food samples, using mainly germanium detectors but also NaI(Tl) detectors, in case of an emergency.

3.6 Survey teams and local measurements

Six Emergency Center units (three in Jutland, two on Zealand and one on Bornholm) can at short notice (15 minutes) alert a total of 39 survey teams to monitor along selected roads. The teams are equipped with gamma dose rate meters, maps showing measuring points, radio equipment and dosimeters. They report to their home barracks over the radio, and the reports are relayed to the EMACC by telefax or datalink.

A total of 1600 measuring points covering about 5 000 km of Danish roads are marked on the maps.

Emergency teams are available in a number of the bigger communities. They report through the nearest Emergency Center barracks, and the data are transferred to the EMACC. These teams have the same kind of measuring instruments and other equipment as Emergency Center units.

A number of police stations in North Zealand are equipped with gamma dose rate meters. The stations are instructed to read their instruments in case of a Barsebäck accident. They report to the EMACC on the telephone.

SIS may deploy one or two survey teams. Their cars will be equipped with standard survey meters, including a portable plastic scintillation instrument.

Risø can muster ten special car patrols. They measure gamma dose rates 1 m above ground (using a shield, first under and then over the detector to determine whether the plume has passed). Soil and vegetation samples are collected on demand. Air concentrations of nuclides can be roughly estimated by means of a mobile air sampler.

3.7 Contamination

3.7.1 Internal contamination

The University Hospital (Rigshospitalet) and Risø operate whole body counters. The one at the University Hospital is equipped with a scanning NaI(Tl) detector, whereas the one at Risø uses a germanium detector for chair geometry measurements. Staff and equipment for organ measurements are available at ten hospital institutions around the country.

NaI(Tl) and germanium detectors are available at SIS, Risø and ten hospitals for evaluating samples of body fluids, urine, excreta etc. In addition, DEMA has equipped each of the ten hospital departments with an alpha monitor. Other types of equipment normally found at nuclear medicine and similar departments will also be used when needed.

3.7.2 External contamination

Checks for external beta and gamma emitting contamination may be performed by DEMA, Risø, SIS, defense forces and others, using most types of modern portable equipment. The ten hospital institutions capable of performing internal contamination measurements are also equipped to allow checks for external contamination, including alpha emitters.

In case of contamination outside Danish territory, checkpoints manned by Emergency monitoring teams can be established at border stations, ferry harbors etc. to measure contamination of vehicles, trains and deck cargo.

3.8 Faroe Islands and Greenland

Dose rate meters are not available under normal conditions on the Faroe Islands or in Greenland.

Food and environmental samples from the Faroe Islands and Greenland are routinely sent to Risø for analysis.

The gamma spectrometer at an institution on the Faroe Islands is not normally included in the national emergency organization, but may be used if so ordered in an emergency.

Denmark has signed a bilateral treaty with the USA, in which the USA agrees to assist Greenland in case of a radiological emergency.

3.9 Other types of measurements

The Danish Navy Command (Søværnets Operative Kommando, SOK) has at its disposal ships equipped with a gamma monitoring system. It consists of two detectors located in open air and four detectors inside the ship. All detectors are monitored from a central unit with a digital display, giving dose rate readings in Gy/h. The location of the ship and radiation data are continuously reported to SOK.

Water samples may be collected from the ship and sent to SIS for analysis.

3.10 Future development

Denmark and France have signed a bilateral agreement on the development of a system for airborne nuclide specific measurements of ground deposition. Eventually, this is hoped to lead to European coordination of system design, calibration, data formats etc.

Two large NaI(Tl) detectors are to be mounted under army helicopters, fully equipped with a computerized system for spectrometric analysis of the data. At the same time, flight data (altitude and position according to the GPS satellite navigation system) will be recorded. Total gamma dose rates at ground level are calculated, using a set of calibration factors and the registered gamma spectrum. Collected data will be transmitted to a central EMACC computer for evaluation and mapping after the flight.

Presently, SIS does not perform routine measurements of environmental and food samples. There is, however, a high purity germanium detector available that could be used for this purpose. SIS and the National Food Agency could jointly establish a facility for low-level contamination checks of foodstuffs imported from countries outside the European Union.

Table DK-1

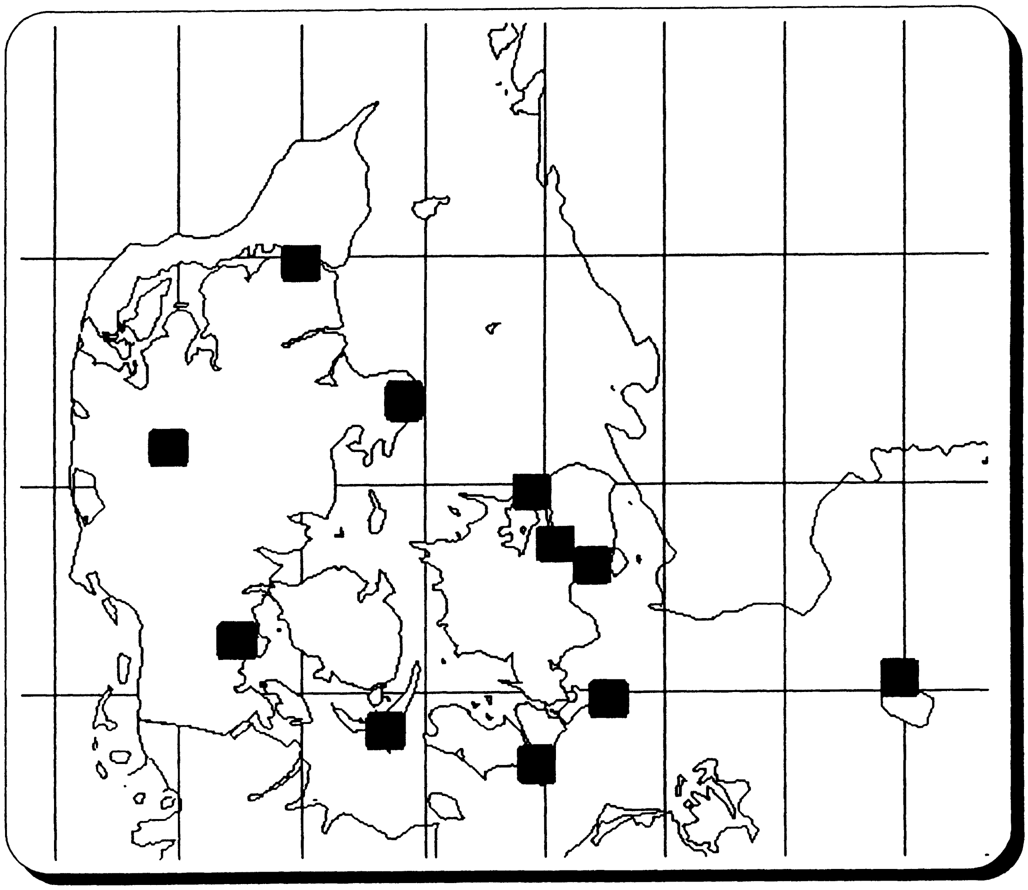
Measurement services in Denmark

Type of measurements	Organization						
	DEMA	Risø	SIS	Def.	Police	Hosp.	Local
Automatic gamma monitoring stations		x					
Air monitoring stations: gamma analysis		x					
Airborne measurements:							
- external gamma				x			
- air filters							
Field measurements:							
- gamma analysis		x	x				
- total gamma	x	x	x		x		x
- air filter gamma analysis		x					
- beta		x	x				
- alpha		x	x				
Laboratory sample analysis							
- gamma		x	x				
- beta (Sr)		x					
- alpha (Pu)		x					
Whole body counting		x				x	
External contamination	x	x	x	x	x	x	x

DEMA	Danish Emergency Management Agency
Risø	Risø National Laboratory
SIS	National Institute of Radiation Hygiene
Def.	Defense forces
Police	State Police
Hosp.	Hospitals
Local	Local communities

Fig. DK-1

Danish gamma monitoring stations



<u>Locations:</u>

Aalborg	Falster	Risø
Herning	Møn	(primarily for
Grenå	Glostrup	test and
Haderslev	Lynæs	calibration
Langeland	Bornholm	purposes)

Fig. DK-2

Block diagram of Danish gamma monitoring stations with radon and background discrimination

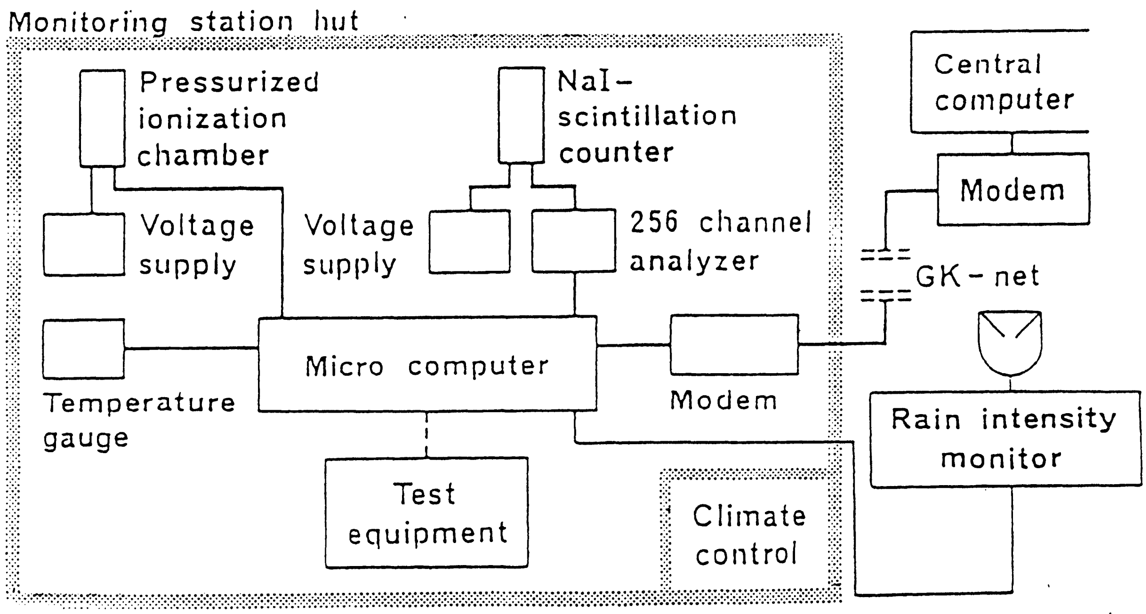
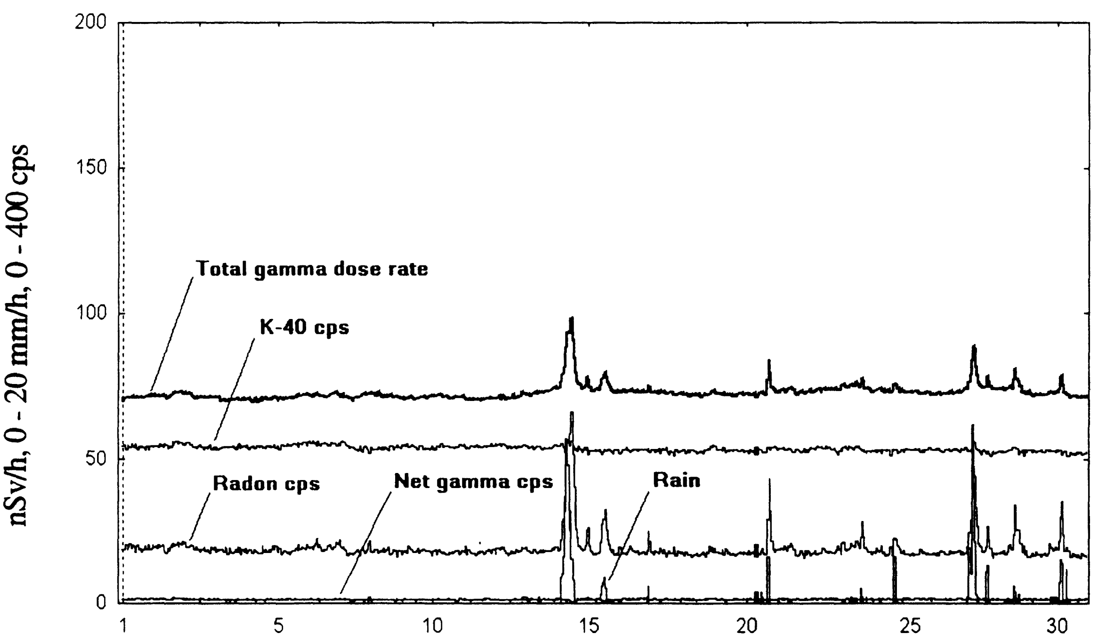


Fig. DK-3

Printout from a Danish gamma monitoring station



PMS Station Aalborg
October 1992

4. Finland

4.1 General background

In states of emergency, the Finnish Ministry of the Interior (Sisäasiainministeriö, SM) directs civil defense operations. If necessary, an emergency radiation monitoring organization is set up. The monitoring of external radiation is then led from sheltered command centers, and special sheltered laboratories are brought into use. Decisions on civil defense measures, information to the public etc. are the responsibility of the Ministry of the Interior.

The Finnish Center for Radiation and Nuclear Safety (Säteilyturvakeskus, STUK) assists the Ministry of the Interior with recommendations on protective measures to be taken. Some other members of the emergency organization are the Defense Forces, the Finnish Meteorological Institute (Ilmatieteen laitos, FMI) and the Seismological Institute of the University of Helsinki (Helsingin yliopisto, Seismologian laitos).

STUK is the central authority and research institute of the radiological monitoring organization. It carries out a wide range of environmental measurements, sampling and laboratory analyses. In an emergency STUK obtains all the results from the other authorities and institutes, and recommends appropriate protective measures. The reporting level applied by STUK is defined as any unusual observation of environmental radioactivity. STUK is also the international contact point in Finland, receiving or sending notifications in case of radiological or nuclear emergencies, in accordance with the IAEA convention and bilateral agreements with the Nordic countries, Russia, Germany and Estonia.

The Seismological Institute of the University of Helsinki also takes part in the national radiation monitoring organization, reporting all nuclear explosions and all earthquakes near nuclear power plants.

The types of measurements carried out before and after a fallout and the organizations responsible for these measurements are summarized in Table FI-1. The Finnish country-wide monitoring system is presented schematically in Fig. FI-1.

The Finnish monitoring system is designed to detect releases emanating from foreign and domestic sources. Among the latter, the following predominate:

- Two nuclear power stations (Loviisa and Olkiluoto), each with two reactors
- One research reactor (Espoo)
- Transports of spent fuel

The national radiation monitoring system in Finland is quite extensive, with about 500 Geiger-Müller tube based measuring stations for external radiation. To date, some 250 are automatic. By the year 2000, all stations will be automatic.

In addition to the gamma stations on Finnish territory, Finland operates eight stations in Murmansk, one of which is fitted with a microcomputer. It is expected that another six stations (one of which will be mobile) will be installed during 1995 around the nuclear power plant in Sosnovy Bor.

4.2 Automatic and manual gamma monitoring stations

4.2.1 Ministry of the Interior

An overview of the locations of the automatic and manual gamma monitoring stations operated by the Ministry of the Interior is given in Fig. FI-2. For monitoring purposes, Finland is covered with a grid of density 40 x 40 km in the south and 80 x 80 km in the provinces of Oulu and Lappland, with one monitoring station in each square.

A block diagram of a gamma monitoring station is depicted in Fig. FI-3.

The Ministry of the Interior operates a network of some 385 external radiation monitoring stations, based on Geiger-Müller survey meters. About 250 are automatic stations and the rest are manual stations. The latter are upgraded to automatic stations at a rate of approximately 35 stations per year. (The difference between automatic and manual stations is basically that the former may be polled at preset intervals or whenever requested by a local or central computer. Both automatic and manual stations have a local display for direct reading of the current dose rate.) The monitoring is carried out by municipal fire departments, base stations of the National Board of Roads, civil aviation authorities at the airports, and others.

The alarm level is set at an ambient dose equivalent rate of 400 nSv/h for the automatic stations and 700 nSv/h for the manual, the latter corresponding to about five times the normal gamma radiation level.

4.2.2 Defense Forces

The Defense Forces operate an external radiation network of 94 continuously operating manual stations, based on Geiger-Müller counters of the type used by the Ministry of the Interior. Alarms are transmitted manually via the public telephone network, the alarm level being 700 nSv/h external gamma radiation (ambient dose equivalent rate). The system will be fully automatized during the 1990's and integrated with the system operated by the Ministry of the Interior.

4.2.3 STUK

STUK has five automatic external gamma monitoring stations in Finland (Fig. FI-4). They are based on Geiger-Müller counters. The system consists of two central data collecting computers and five local monitoring stations that communicate via the public telephone network. The lower alarm level setting corresponds to about twice the normal background radiation level at the station, i.e., 200 nSv/h.

4.2.4 Finnish Meteorological Institute

The Finnish Meteorological Institute operates five automatic external gamma monitoring stations (Fig. FI-5). The stations are based on a pair of NaI(Tl) crystal detectors, arranged to allow separation of gamma emitters deposited on the ground and suspended in the air. The detection limit for artificial activity is about 10 nSv/h (wet deposition). Precipitation data are reported from a number of stations.

4.2.5 Routines for reporting data

The routines for reporting measurement data from the external gamma monitoring networks described above are summarized in Table FI-2.

4.2.6 Nuclear power plant operated systems

The two power plants have installed their own automatic gamma monitoring systems (which are also linked to the system of the Ministry of the Interior). Each system consists of two rings surrounding the power plant. The radius of the first ring is approximately 1 km, and of the second approximately 5 km. For Loviisa the number of detectors in the first ring is 4, and 11 in the second. For Olkiluoto, these numbers are 5 and 10, respectively. All detectors are Geiger-Müller counters of the same type as the one used by the Ministry of the Interior.

4.3 Air monitoring stations

There are two main types of stations for measuring airborne activity:

- Continuously measuring aerosol monitoring stations with alarm capability
- Aerosol sampling stations with filter paper or activated charcoal cartridges to be analyzed in a laboratory

They are operated by STUK, FMI and the Defense Forces. The detection limits for the various types of stations are summarized in Table FI-3.

4.3.1 Finnish Meteorological Institute

The Finnish Meteorological Institute operates 14 aerosol beta activity monitoring stations (Fig. FI-6). The filters are changed weekly. All 14 stations have an alarm system for early warning based on beta counting Geiger-Müller tubes placed above the filter. The system will trigger an alarm in response to an increase in artificial beta activity in the order of 2 Bq/m^3 (after a delay of some four hours). This corresponds to a dose rate about two orders of magnitude (one hundred times) smaller than that required to activate the external gamma dose rate monitoring network discussed above.

The filters from the aerosol monitoring stations and additional filters from four daily sampling stations are measured in a laboratory for alpha and beta activity. The detection limit for artificial radioactivity after a delay of some five days is about 200 $\mu Bq/m^3$.

4.3.2 STUK

STUK has seven stations for continuous measurement of airborne activity collected on glass fiber filters, Fig. FI-7. The air samples are collected close to the ground. The filters are changed once or twice a week, and filters are combined to form a weekly sample for gamma spectrometric measurements. When necessary, the filters are changed and analyzed more often. Three stations are fitted with gamma counting Geiger-Müller tubes for on-line monitoring of the filter as a part of the early warning system. Furthermore, all samplers are equipped with a charcoal cartridge in order to collect radioactive substances that penetrate the particle filter. The filters and activated charcoal cartridges are measured in a laboratory.

4.3.3 Nuclear power plant operated systems

Ground-level air around the Finnish nuclear power plants is monitored routinely with four high-volume air samplers in the vicinity of both nuclear power plants, Loviisa and Olkiluoto (Fig. FI-7). Air is drawn through combined glass fiber and activated charcoal filters. The filter pairs are replaced twice monthly and analyzed by STUK. When a reactor is undergoing refuelling and maintenance, a supplementary sampler is placed in the vicinity of the plant. The collection period is usually one week.

4.3.4 Defense Forces

The Defense Forces have one sampler (the STUK model) in Tampere (Fig. FI-7). The analyzing procedure is identical to STUK's procedure.

4.4 Airborne measurements

Units of the Air Force collect dust samples from the upper atmosphere when called upon. The Air Force also has a helicopter equipped with an efficient high purity germanium detector and a portable spectroscopy system for mapping ground deposition and searching for debris.

The Geological Survey of Finland (Geologian tutkimuskeskus, GTK) has an aircraft equipped with NaI(Tl) detectors, normally used for aerial radiological surveying, but easily applicable for mapping an area after a fallout or searching for debris after a satellite crash.

4.5 Foodstuffs and environmental samples

The Department of Research at STUK has advanced environmental laboratories in Helsinki and Rovaniemi for both direct instrumental and radiochemical determination of radionuclides in environmental and foodstuff samples. They are equipped for alpha and gamma spectrometric measurements as well as beta counting.

STUK has a large nationwide program for monitoring environmental contamination. Soil, vegetation, water and precipitation samples are analyzed. There are, for instance, 18 rainwater sampling stations. See Fig. FI-8.

Everyday foodstuffs as milk, beef, pork and reindeer meat are sampled and analyzed regularly by STUK for contamination. Samples of fish, game, wild mushrooms and berries as well as grains, field and greenhouse vegetables and fruit are surveyed annually.

In a large-scale, long-lasting emergency situation STUK establishes three regional laboratories when necessary. One of these regional laboratories is permanently situated in Rovaniemi. In addition, there are 52 local food laboratories, under the control of the Ministry of Health and Social Affairs and operated by municipal health authorities. These local laboratories monitor gamma radioactivity in food using NaI(Tl) detectors. The radioanalytical and sampling programs are under guidance of STUK.

The laboratories in the larger cities have supplemented their equipment with, e.g., gamma spectrometers with germanium detectors.

4.6 Survey teams

In radiation emergency situations STUK can initiate assessment of environmental dose rates and fallout levels using mobile survey teams equipped with

- a sensitive Geiger-Müller counter inside the car
- a high pressure ionization chamber inside the car
- a semiconductor detector (germanium) and a portable spectroscopy system
- air samplers for iodine measurements
- thermoluminescent dosimeters (TLD) in the accident area
- real time data transmission by NMT telephones to STUK

While en route, the instruments are measuring continuously.

In case of an accident at a domestic nuclear power plant, mobile survey teams are dispatched also by local emergency organizations, i.e., fire departments, rescue services, police, defense forces, civil defense and the organization at the nuclear power plant. The equipment is based mainly on Geiger-Müller detectors, but the teams from the power plant also use air samplers and thermoluminescent dosimeters.

Both nuclear power plants have planned special survey routes in their surroundings, where measurements will be made under accident conditions. All Finnish municipalities have similar plans.

4.7 Contamination

4.7.1 Internal contamination

Internal contamination is measured by whole body counting, organ or sample measurements.

The total number of whole body counters in Finland is three. Two are operated by STUK. One of them is installed in an iron-clad room. The measuring time is typically 30 minutes, and the four NaI(Tl) detectors slide longitudinally over the person to be measured. The minimum detectable activity for Cs-134 and Cs-137 is 30 Bq. The method also permits the profile distribution of radionuclides in the body to be determined. This system can also be equipped with germanium detectors for measurements when more than just a few radionuclides are simultaneously present in the body.

STUK also operates a whole body counter installed in a truck. A germanium detector gives a minimum detectable activity of 50 Bq for Cs-134 and Cs-137 with a measurement time of 1000 seconds.

At the Finnish nuclear power stations there are body monitors for rough, not nuclide specific estimation of body burdens. Gamma cameras at many hospitals can also be used for the same purpose.

There are some 30 – 40 facilities for organ measurements in Finland. The system operated by STUK to monitor the thyroid contents of I-131 consists of a NaI(Tl) detector in a lead collimator. The minimum detectable I-131 activity is about 500 Bq.

There are approximately ten Finnish institutions which can perform measurements of alpha and beta emitting nuclides in samples of excreta, urine or body fluids.

4.7.2 External contamination

Checks for external beta and gamma emitting contamination may be performed by STUK, the Ministry of Interior, defense forces and others, using most types of modern portable equipment.

4.8 Other types of measurements

The Finnish Meteorological Institute collects daily precipitation samples from two stations (Helsinki and Ivalo) with 1 m^3 samplers (Fig. FI-5). The detection limit for artificial beta activity is about 2 Bq/l (delay 3 – 5 days). Also as a routine, all rain samples (evaporated) and two daily samples are exposed to X-ray films (autoradiography) as soon as possible for possible hot particle detection.

4.9 Future development

For the next few years, the following changes are foreseen:

- The remaining manual gamma monitoring stations operated by the Ministry of the Interior and the Defense Forces will be made automatic no later than at the turn of the century.
- A number of cities are planning to establish their own small networks.
- Noble gas measurements to reveal nuclear accidents or incidents and a real-time system for measuring iodine in air will be installed.
- All relevant data will eventually be collected, analyzed, stored and reported by the central computer including data from:
  - firstly, automatic gamma monitoring stations and the meteorological services
  - secondly, air samplers, seismic monitors, environmental samples and field gamma measurements

  The software will be installed in for example 12 county center computers, allowing decision makers there to assess the situation independently.

Table FI-1

Measurement services in Finland

Type of measurements	Organization							
	SM	**PV**	**FMI**	**STUK**	**GTK**	**HYRK**	**Lab**	**NPP**
Automatic gamma monitoring stations	x	x	x	x				x
Air monitoring stations								
- gamma		x		x				x
- beta			x					
Airborne measurements:								
- external gamma		x			x			
- air filters		x			x			
Field measurements:								
- gamma analysis			x	x				
- total gamma	x	x	x	x				x
- air filter gamma analysis		x		x				x
- beta		x	x	x				x
- alpha		x	x	x				x
Laboratory sample analysis								
- gamma		x		x		x	x	x
- beta (Sr)				x		x		
- alpha (Pu)				x		x		
Whole body counting				x				
External contamination	x	x	x	x				x

SM	Ministry of the Interior (including county and local organizations)
PV	Defense Forces
FMI	Finnish Meteorological Institute
STUK	Finnish Center for Radiation and Nuclear Safety
GTK	Geological Survey of Finland
HYRK	Radiochemical Institution, University of Helsinki
Lab	Local laboratories
NPP	Finnish nuclear power plantst

Table FI-2

Routines for regular reporting of measurement data from the automatic and manual gamma monitoring networks operated by the Ministry of the Interior (SM), the Defense Forces, STUK and the Finnish Meteorological Institute (FMI).

Data sent to	Reporting party	What?	When?	How?
STUK	Automatic monitoring stations	24-hour data	Once daily	Telephone polling
FMI	Automatic monitoring stations	24-hour data	Once daily	Telephone polling
SM and/or county governments	Automatic master stations	24-hour data	Once daily	Telephone polling
Area alarm centers (Automatic master stations)	Automatic substations	24-hour data	AAM-95: set intervals	Telephone polling
County government/ Rescue department	Manual stations (measuring continuously or as requested)	Normally 3-month data	Quarterly	By mail

Table FI-3

Detection limits for Finnish air monitoring stations

Type of station	Minimum detectable artificial activity	Remarks
FMI on-line aerosol measuring stations	Alarm level about 2 Bq/m^3	Total beta activity
FMI sampling stations	200 $\mu Bq/m^3$	Total beta activity with 5-day delay
STUK Helsinki station Kotka station Rovaniemi station	0.1-0.3 $\mu Bq/m^3$	Most important gamma emitters (I-131, Cs-137 etc.)
STUK transportable model (Four stations)	0.4-0.8 $\mu Bq/m^3$	Ditto
STUK nuclear power plant	2 $\mu Bq/m^3$	Ditto
Defense Forces	0.4-1 $\mu Bq/m^3$	Ditto

Fig. FI-1

Schematic representation of the countrywide monitoring system in Finland

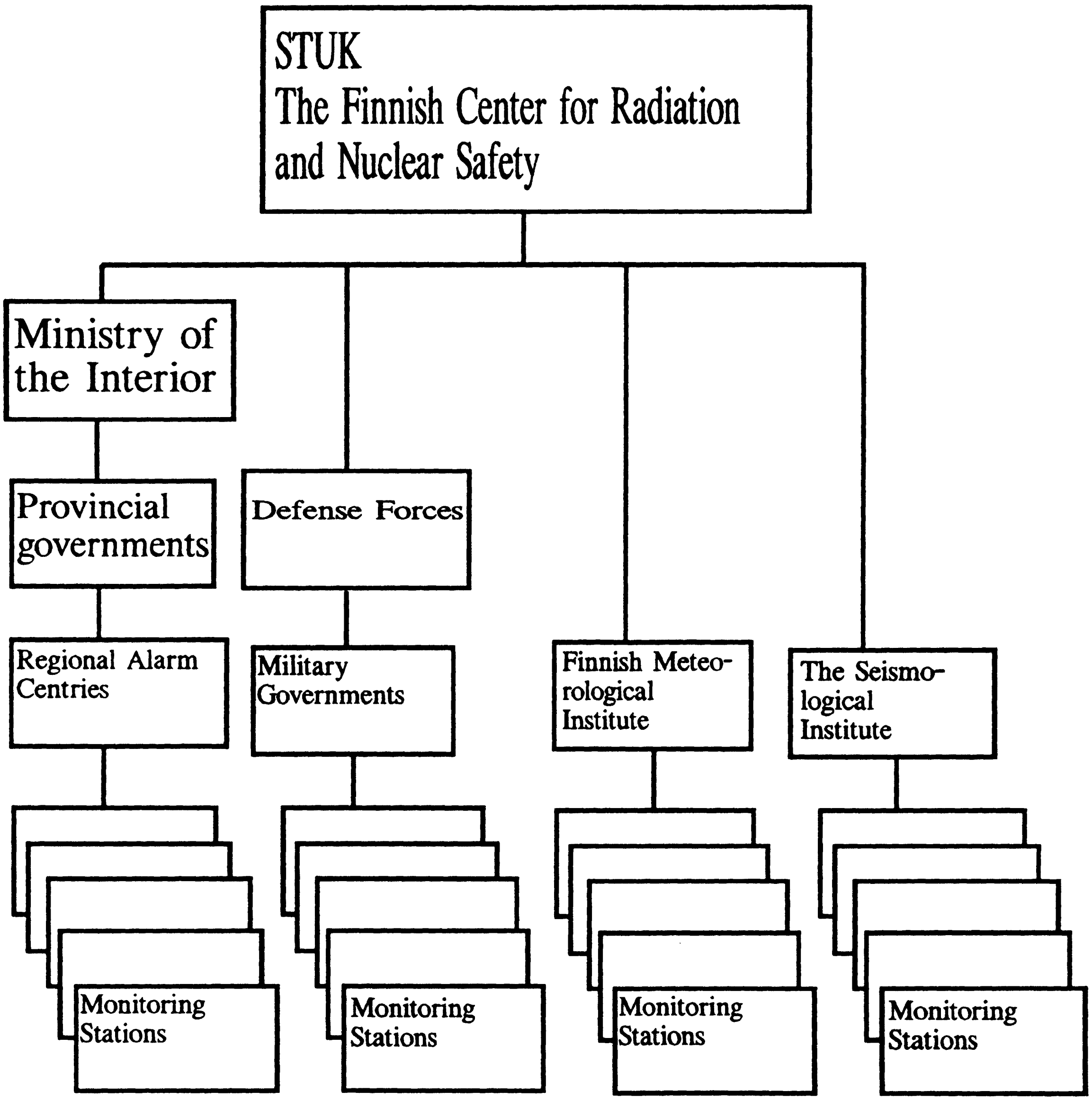


Fig. FI-2

Map of the gamma monitoring network operated by the Finnish Ministry of the Interior

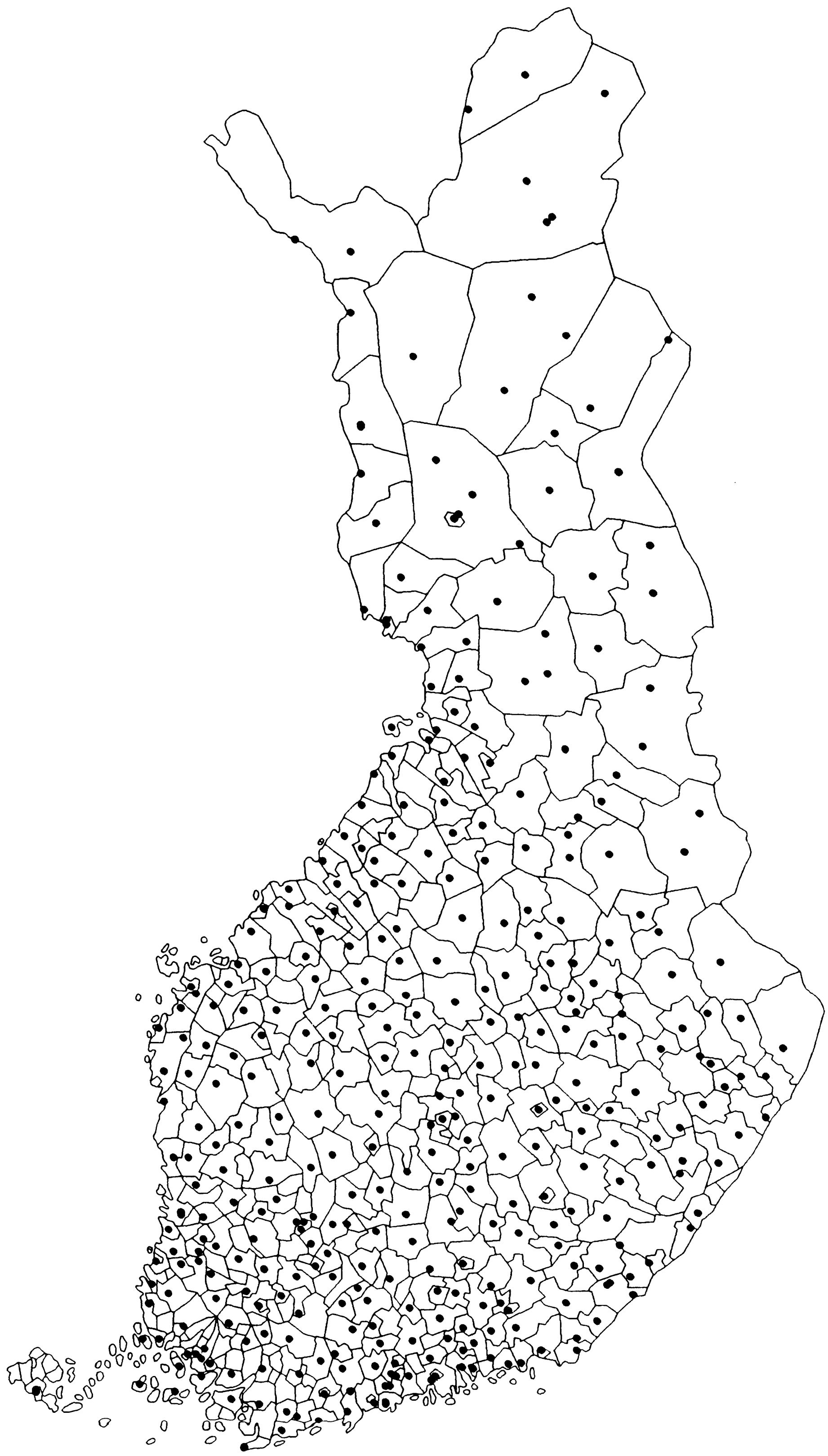


Fig. FI-3

Block diagram of the automatic gamma monitoring stations operated by the Finnish Ministry of the Interior

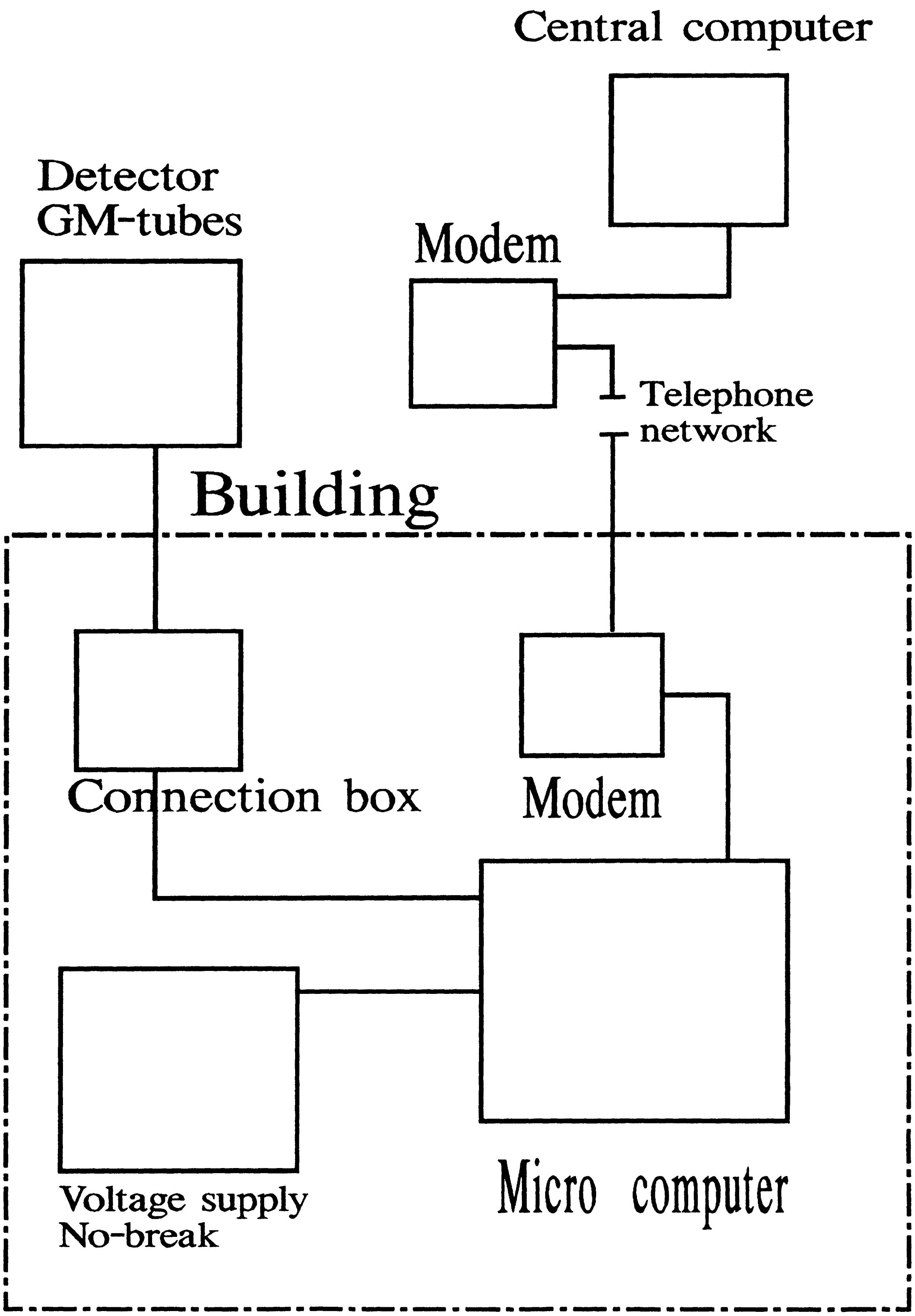


Fig. FI-4

Locations of the five automatic gamma monitoring stations operated by STUK

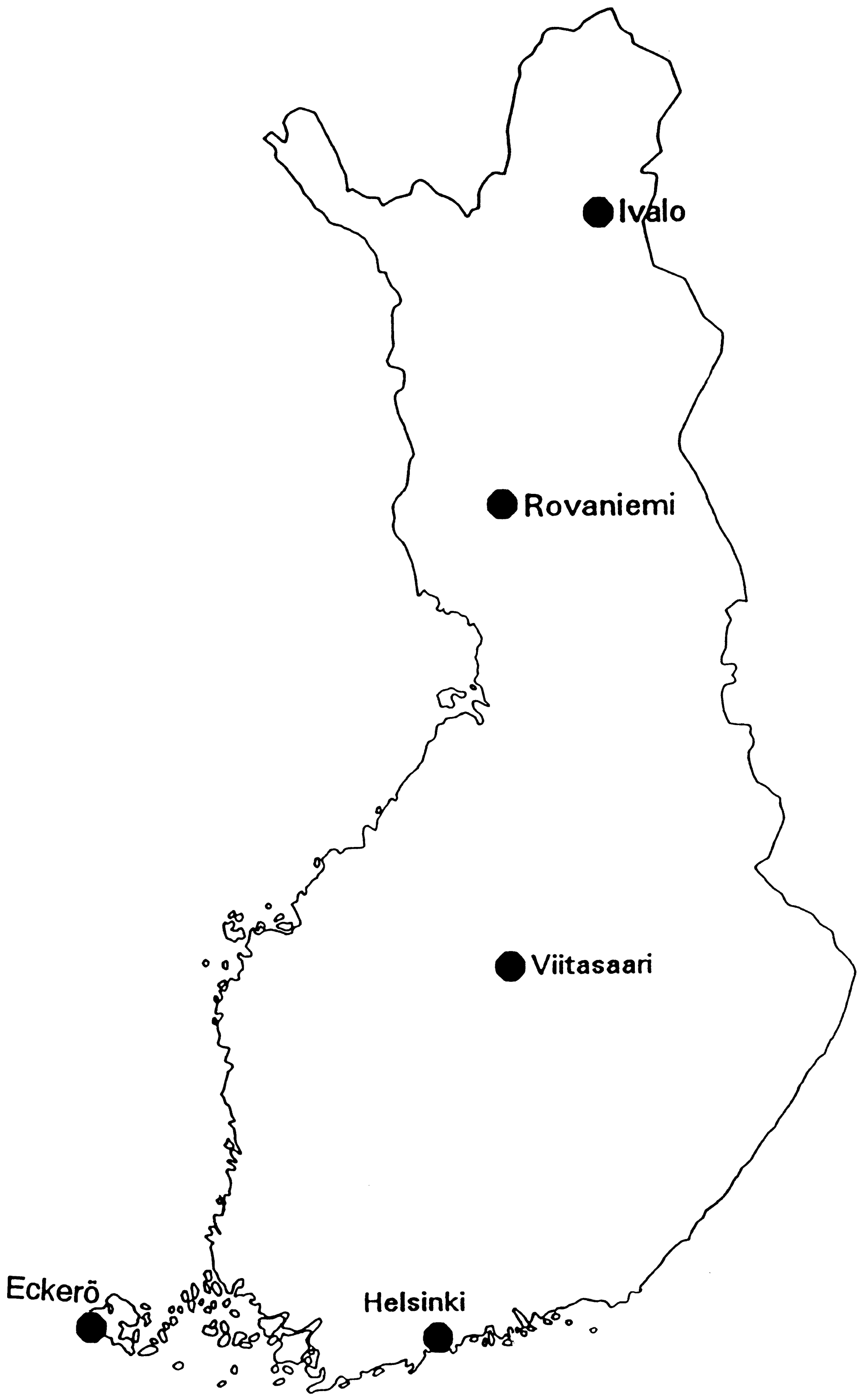


Fig. FI-5

The radioactivity monitoring network of FMI

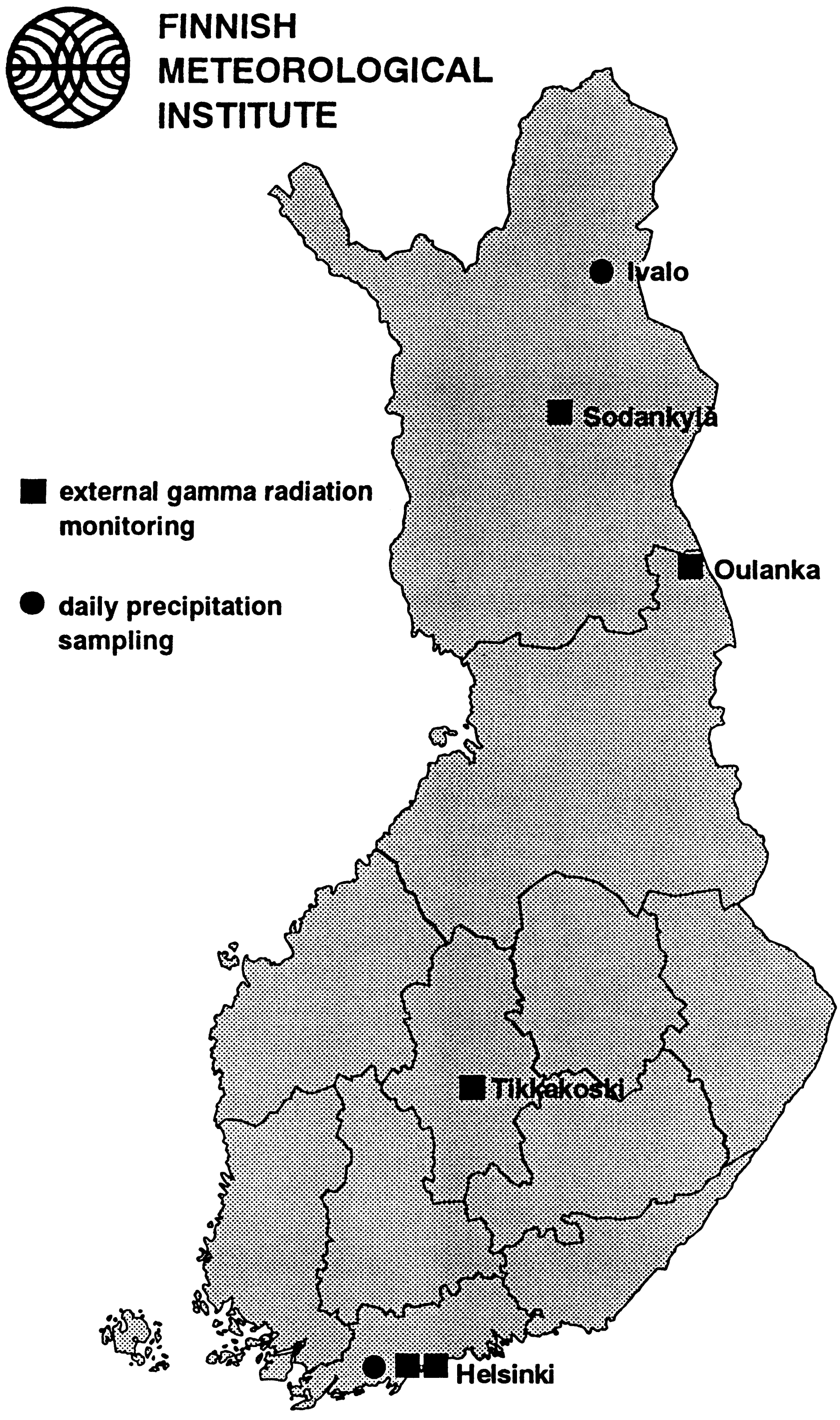


Fig. FI-6

The radioactivity monitoring network of FMI

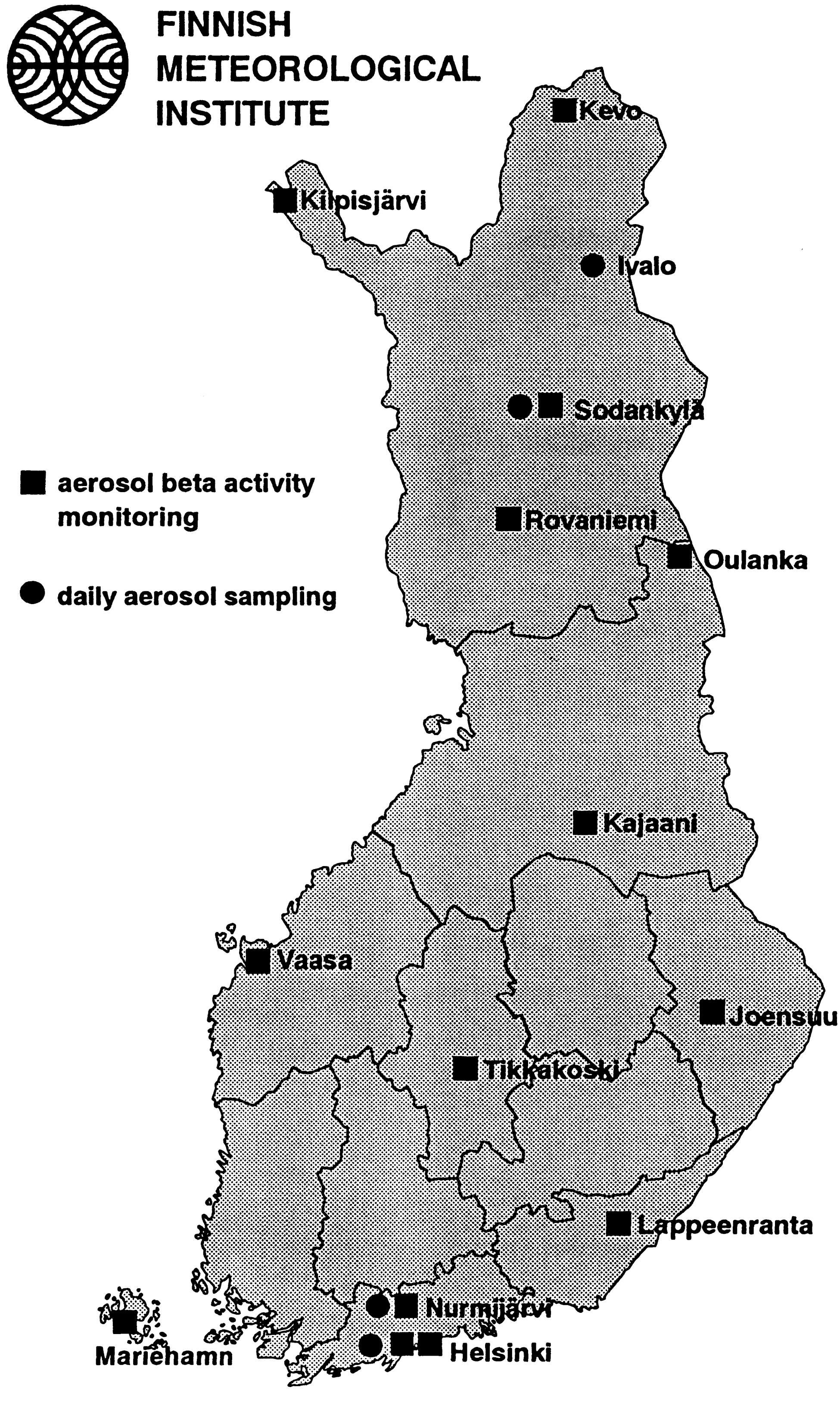


Fig. FI-7

Stations operated by STUK (dots), nuclear power plants (circles) and Defense Forces (star) for continuous measurement of airborne activity collected on glass fiber filters

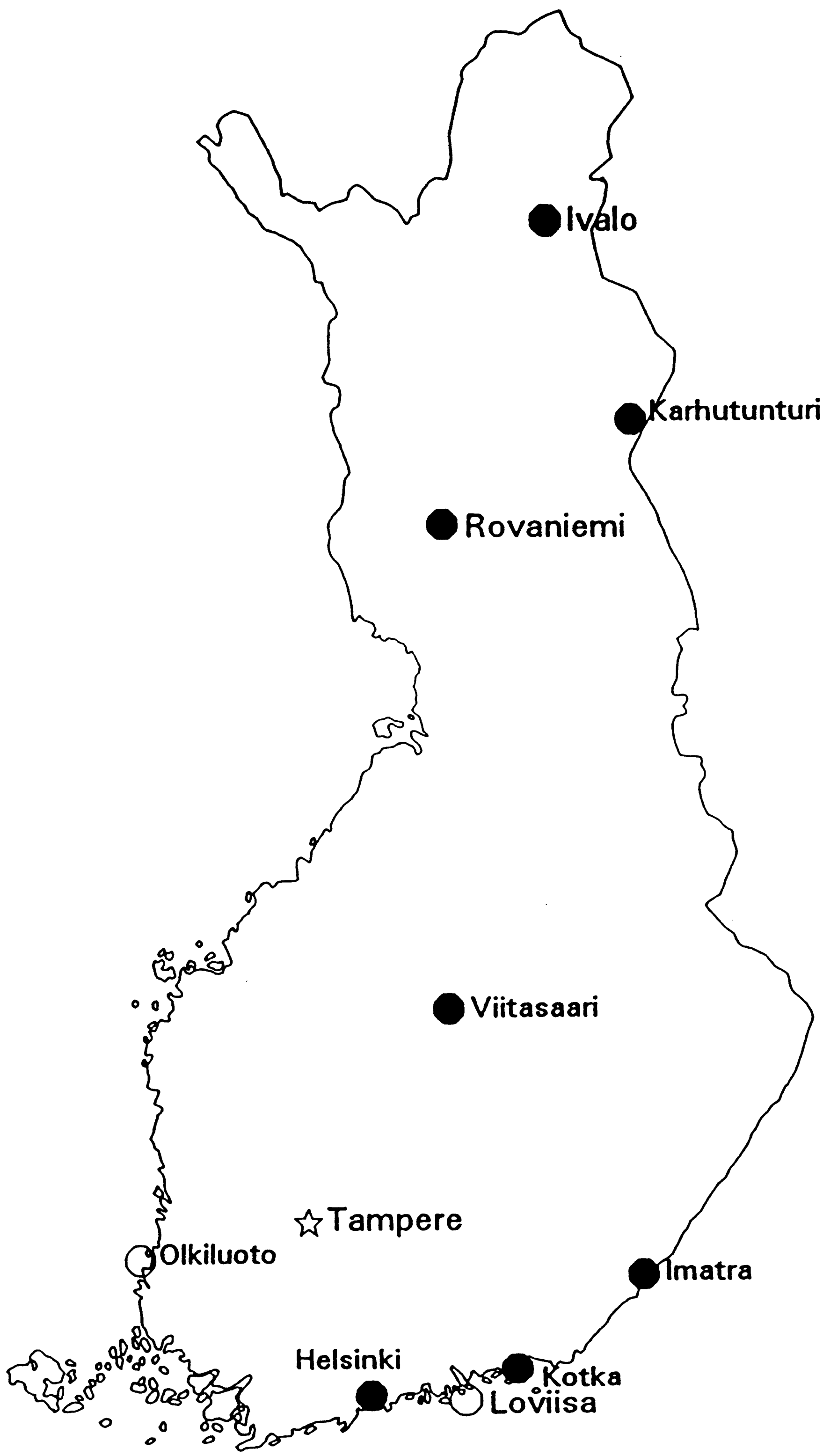
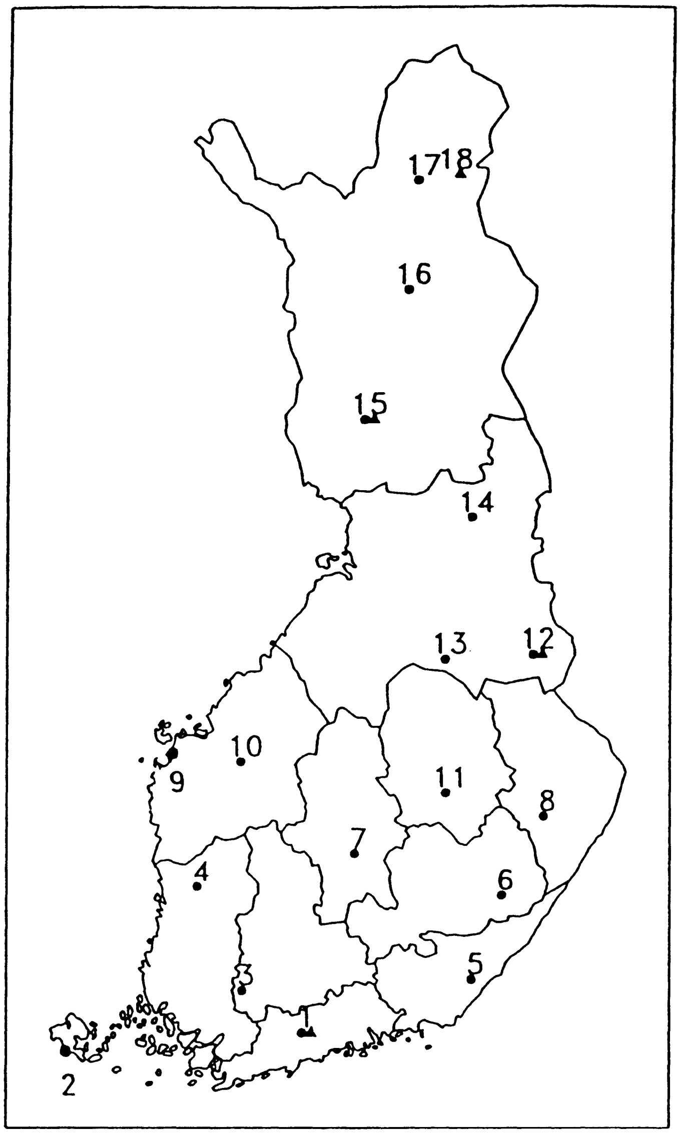


Fig. FI-8

18 STUK sampling stations for precipitation and ground deposition



Sampling stations for deposition samples and determinations made on the samples from different stations:

- • gamma-emitting radionuclides and radiostrontium
- ▲ tritium

1	Nurmijärvi	10	Kauhava
2	Mariehamn	11	Kuopio
3	Jokioinen	12	Kuhmo
4	Niinisalo	13	Kajaani
5	Lappeenranta	14	Taivalkoski
6	Savonlinna	15	Rovaniemi
7	Jyväskylä	16	Sodankylä
8	Joensuu	17	Ivalo
9	Vaasa	18	Inari

5. Iceland

5.1 General background

The Icelandic Radiation Protection Institute (Geislavarnir ríkisins) is the central authority for continuous measurements of radiation and radioactivity in foodstuffs and the environment. Geislavarnir takes on an important advisory and coordinating role in case of a radiological accident or emergency situations.

The types of measurements carried out and the organizations responsible for these measurements are summarized in Table IS-1.

The general background level of the country (total gamma) is fairly well known.

Since Iceland does not have a nuclear power program and no research reactors, there is basically no domestic nuclear threat to the population or the environment. The most important threat, as opposed to the other Nordic countries, is presented by mobile reactors (submarines, other types of naval vessels, icebreakers, satellites), nuclear weapons and other forms of mobile radioactive sources.

Chernobyl showed that Iceland is not likely to be seriously affected even by large-scale foreign nuclear disasters. Also, the remote geographical location of Iceland relative to the European continent as well as USA and Canada is favorable because of a longer response time before a radioactive cloud from an accident abroad would reach the country.

Altogether, the nuclear threat to Iceland is somewhat different and certainly smaller than for the rest of the Nordic countries. This is reflected in the emergency organization and the national radiological measurements program. Neither one has to be as elaborate and formal as in other countries. Mobile threats being predominant, the emergency preparedness organization has to work more on an *ad hoc* basis. This imposes different strains and requires other considerations than in neighboring countries.

5.2 Automatic gamma monitoring station

At present, there is but one gamma monitoring station in Iceland, located in Reykjavík (Fig. IS-1). It is an ionization chamber detector of the type used in Sweden.

The gamma station is in contact with the central computer (a personal computer) at Geislavarnir via a modem and a full duplex telephone line of the switched public system. The reading of the gamma station can be polled at any time from Geislavarnir. This is done automatically twice per day and can be done manually as often as required. Records of the variations in radiation level are kept at Geislavarnir. A block diagram of the gamma monitoring station is shown in Fig. IS-2. A sample printout is given in Fig. IS-3, which also shows a printout from the air monitoring station (see below).

When an alarm is triggered, a signal is sent directly to Geislavarnir. The alarm level is currently set as in Sweden (i.e., at a 300 nSv increase during the last 24 hours). During normal office hours the alarm will be handled routinely by the staff. After office hours a pager calls the attention of the radiation safety officer on duty to assess the situation. If needed, the emergency organization will be alerted.

5.3 Air monitoring station

Geislavarnir ríkisins operates an air monitoring station in Reykjavík. It is located only a few meters from Geislavarnir's gamma monitoring station (Fig. IS-1). The maximum air capacity is 550 m^3/h. An on-line counter using three Geiger-Müller tubes measures the total beta plus gamma radiation level from the synthetic fiber filter. It is an uncalibrated reading in counts per second (cps). Flow rate data and radiation levels are collected by an on-site computer every 15 minutes. If unusual values are recorded the staff at Geislavarnir is alerted by a pager, and a fax is sent to Geislavarnir's office. (Block diagram in Fig. IS-2.) The dust load of the filter can be estimated from the drop in flow rate and the build-up of activity on the filter. The drop in flow rate is very low (typically <10%) over a period of two months.

The continuous monitoring of activity on the filter together with data from the nearby gamma monitoring station makes gamma spectrometric analysis of the filter less important as a part of an early warning routine. Therefore, the laboratory analysis of the filter emphasizes the recording of the low background level and its variation with time. The concentration of Cs-137 in Icelandic air is usually very low, especially in the winter, and long sampling periods are required in order to get detectable amounts. The sampling period is normally kept long enough to collect measurable amounts of Cs-137, even though this can mean extending the period to a number of weeks. With a sampling period of one month and a counting time of 48 hours, the detection limit for Cs-137 becomes 0.03 $\mu Bq/m^3$, which makes it a comparatively sensitive system.

Under special conditions the filter will have to be changed more frequently. Some typical examples of this would be

- an unusual increase in radiation level from the filter of the air monitoring station or from the gamma monitoring station
- meteorological conditions likely to cause transport of air masses possibly containing airborne activity from the American or European continent or the UK

Quick tests are not done routinely, but with a sampling period of one week and a counting time of 2 hours, the detection limit for Cs-137 would be 0.7 $\mu Bq/m^3$.

A sample printout of the air flow rate and total beta + gamma radiation level in counts per second (cps) from the filter is shown in Fig. IS-3, together with a printout from the gamma monitoring station. Records are kept at Geislavarnir.

5.4 Airborne measurements

In case of an emergency, available mobile equipment could be used for plume tracking.

Iceland has no equipment specially designed for airborne measurements of ground deposition. If needed, such equipment would have to be obtained from other countries.

5.5 Foodstuffs and environmental samples

Geislavarnir continuously carries out measurements of food, water and vegetation samples. At its disposal is the following equipment for spectrometric measurements and beta analysis:

- a radiochemical laboratory
- two high purity germanium detectors
- one NaI(Tl) detector
- one beta detector

When necessary, the facilities at the universities of Reykjavík and Akureyri as well as the University hospital can be used for sample measurements. This means an addition of two NaI(Tl) detectors and one system for beta analysis.

Milk from the six largest dairies is monitored every month; so is dry milk from the two national producers. Lamb meat is monitored gamma spectrometrically during the slaughtering season. Fish and fish products, being the backbone of the national economy, are monitored continuously. "Radiation free certificates" are required by some foreign fish merchants. Other foodstuffs are checked as needed.

Samples of ocean water, fucus, rainwater, soil, vegetation etc. are collected regularly and analyzed spectrometrically by Geislavarnir.

5.6 Survey teams and local measurements

Civil defense forces and fire brigades do not carry out any type of measurements on a routine basis but can be called on to perform total gamma dose rate measurements.

5.7 Contamination

5.7.1 Internal contamination

Iceland has no specific systems for whole body counting, but hospitals have detectors that can be used for this purpose. Icelandic hospitals can also perform direct organ scans, and samples of excreta, urine and body fluids can be analyzed for radionuclides. If needed persons who might have been contaminated internally might be sent abroad for monitoring.

5.7.2 External contamination

Checks for external beta and gamma emitting contamination may be performed by Geislavarnir and university and hospital staff, using most types of modern portable equipment. Instruments for alpha contamination checks are also available at Geislavarnir.

5.8 Other types of measurements

Geislavarnir has a number of portable instruments for field measurements of total gamma dose rates.

In case of an emergency, some of the instruments may be turned into mobile automatic gamma monitoring stations. This is achieved by affixing the detector on a tripod and linking it to a data logger, a local computer and a modem. Measured data will be forwarded to Geislavarnir over the public telephone network. These stations can also be programmed to send alarms when called for.

5.9 Future development

- Iceland may install a few more stationary gamma stations and an additional air monitoring station.
- The concept of mobile gamma monitoring stations is likely to be further developed, and the number of such stations increased.
- The alarm criterion for the gamma monitoring stations will probably be lowered (i.e., the additional dose rate level required for an alarm will be lowered; the reason for this being firstly, that the general background level in Iceland is only about half of the normal value in the other Nordic countries; and secondly, the fact that there are less problems in Iceland with radon than in the other Nordic countries).
- Sr-90 analysis of milk, lamb, soil and sea water will be introduced to measure the total deposition of Sr-90 in Iceland.

Table IS-1

Measurement services in Iceland

	Organization		
Type of measurement	Geislavarnir	Universities	Hospital
Early warning:			
Total gamma from monitoring station	X		
Total beta + gamma on filter of on-line air monitoring station	X		
Field:			
Total gamma	X	X	X
Air filter gamma analysis	X		
Laboratory measurements:			
HPGe gamma spectrometry	X		
NaI(Tl) gamma spectrometry	X	X	X
Beta analysis	X	X	
Contamination:			
External	X	X	X
Internal	X	X	X

Fig. IS-1

The automatic gamma monitoring station and the air monitoring station in Reykjavík

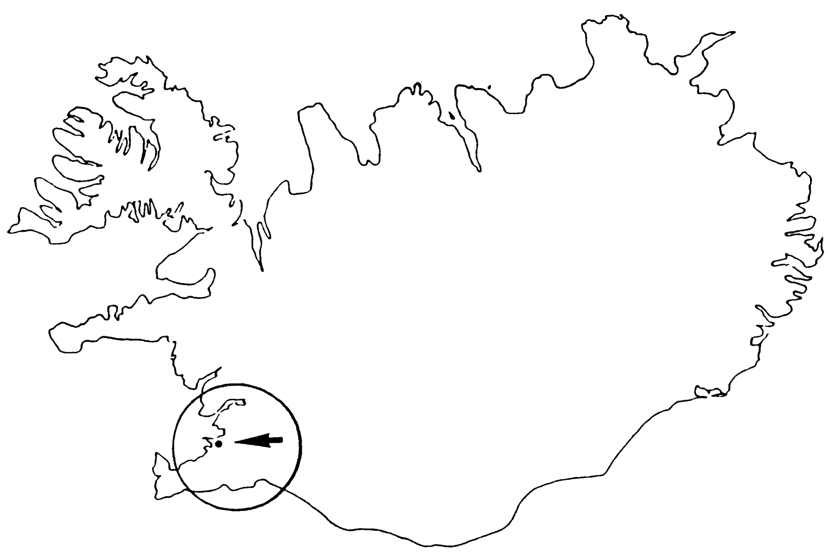


Fig. IS-2

Block diagram of the Islandic gamma and air monitoring stations

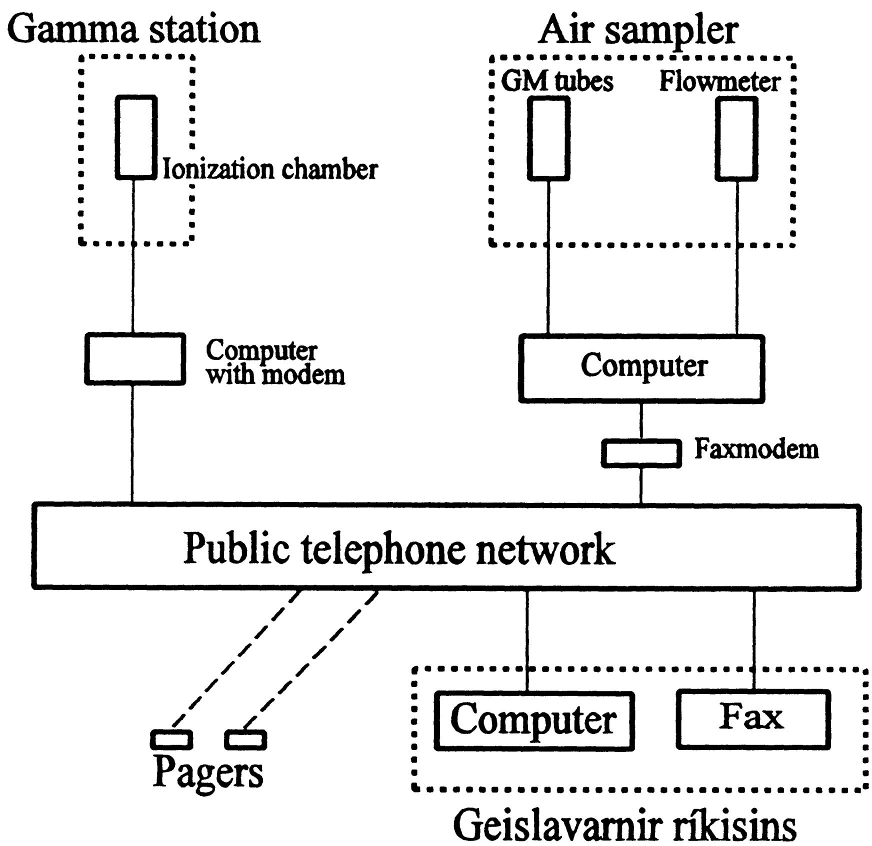
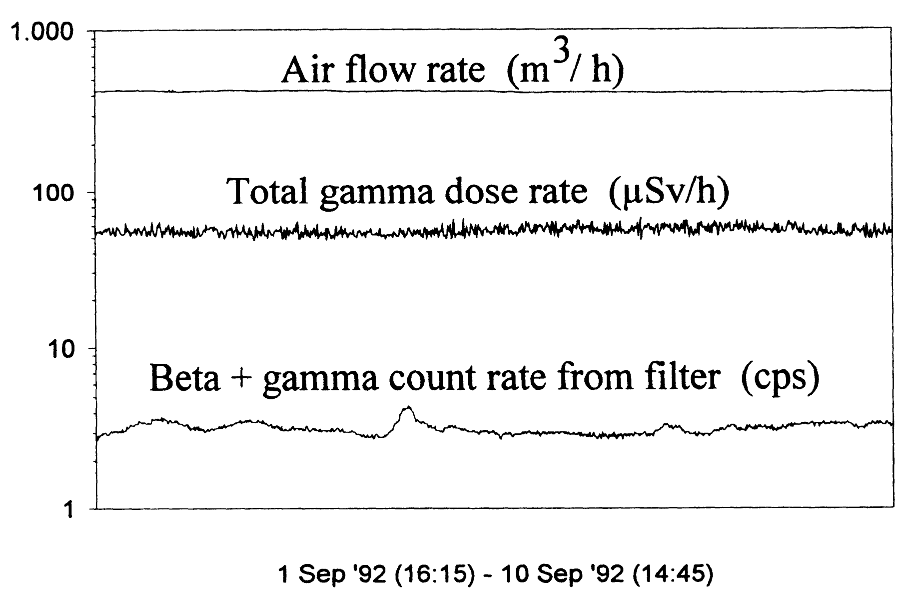


Fig. IS-3

Combined specimen printout from the automatic total gamma and air monitoring stations in Reykjavík



6. Norway

6.1 General background

The Norwegian Radiation Protection Authority (Statens strålevern, NRPA) plays a leading role in emergency preparedness as coordinator and leader of the Advisory Committee (Faglig råd), the central organization in these matters. The secretariat of the Committee is located at NRPA, and in case of an emergency the Committee will convene in the facilities of NRPA. Measurements of various kinds form an integral and important part of this organization. The radiological monitoring program comprises a number of different systems and techniques.

The various types of measurements carried out before and after a fallout and the organizations responsible for these measurements are summarized in Table NO-1.

The Norwegian monitoring system is designed to detect releases emanating from foreign and domestic sources. The most important domestic nuclear threat is presented by the research reactor in Halden and the isotope producing reactor at Kjeller. Foreign nuclear powered and nuclear armed vessels also constitute a major radiological threat. The national waste management program is a less significant contribution to the total risk.

The general background level of the country (total gamma) is fairly well known due to investigations prior to and after the Chernobyl accident.

6.2 Automatic gamma monitoring stations

Norway has an automatic network of 27 gamma monitoring sites (with a total of 28 detectors) throughout the country (Fig. NO-1), plus one station in Verhnetulomski on the Kola peninsula. The network is used for early warning as well as a rough mapping of the fallout following an accident. Half of the stations are also used for crude spectrometric analyses, and not only a registration of dose rates. There is a concentration of stations in the northernmost regions of the country. The monitoring sites and some technical data are summarized in Table NO-2.

6.2.1 Ionization chamber detectors

There are twelve sites with stationary ionization chamber detectors (Reuter-Stokes), placed approximately 3 m above the ground. They are operated by the Norwegian Institute for Air Research (Norsk Institutt for Luftforskning, NILU).

Every ten seconds the local microcomputer obtains a reading from the detector. From these readings, 1-hour average exposure rates (expressed in μR/h) are computed and stored. All stations are polled by the central computer at NILU at 2-hour intervals. A block diagram of an ionization chamber station is shown in Fig. NO-2A. All data are displayed locally.

Radon compensation is not possible with these stations, since no spectrometric data are available from them. Therefore, the alarm level has to be set fairly high. An alarm is triggered when an increase of the total gamma radiation level by approximately 50 nSv/h has been registered. This setting, however, is individual for all stations, due to variations in local average background levels. The settings can be changed from NILU. The central computer at NILU gives an alarm when the total gamma radiation level has increased by 30 nSv/h as compared to the mean value for the last 10 days; or 300 nSv per 24 hours. The latter is computed as the difference in dose between two moving 24-hour windows, covering the last 48 hours.

6.2.2 Scintillation detectors

There are 16 sites with NaI(Tl) scintillation detectors for total gamma and spectrometric measurements (17, including the station in Verhnetulomski, Kola). The spectrometer consists of the detector and a multichannel analyzer; but there is no separate data logger. Compensation for variations in radon concentration makes this a very sensitive system. Very small variations in the normal background radiation level may be detected. A block diagram of the scintillation detector stations is shown in Fig. NO-2B.

Six of the 17 stations are operated by NILU. The remaining detectors belong to the LORAKON network and are primarily used for food analysis (see the section on Foodstuffs and Environmental Samples below). During their fairly long down time they are put in a laboratory window and used by NILU for background surveillance.

The scintillation detector stations are not equipped with local data loggers and may not trigger an alarm themselves. These stations are automatically polled every two hours by the central computer at NILU. If during the polling any of the alarm criteria below should be exceeded, an alert is signalled by the NILU computer.

The following alarm criteria are applied for the scintillation detector stations:

• Increase in total gamma dose rate above the mean value for the last 10 days	>30 nSv/h
• Increase in total gamma dose	>300 nSv for last 24 hrs
• Increase in the Cs-137 window	>2 cps (counts per second)
• Increase in the Cs-134 window	>2 cps
• Increase in the I-131 window	>2 cps
• Dead time	>2%

6.2.3 Data transmission and alarm response

All stations in Norway are connected to the public telephone network via modems. The main computer at NILU calls each station every two hours to collect the data for storage in a central data base, and alerts NILU staff in case one or more of the alarm criteria are exceeded. The station can be called from NILU and recorded data may be transmitted to NILU at any time, regardless of the automatic polling periods. Transmitted data are stored in NILU's main computer for possible future evaluation.

When an alarm level has been exceeded, NILU staff are alerted by the central computer. This is possible on a 24-hour basis thanks to a nationwide pager system operated by the telephone company. A display on the pager gives coded information on where, when and why the alarm was triggered. If malfunction can be ruled out directly by NILU staff, the Advisory Committee and NRPA are alerted.

6.3 Air monitoring stations

NRPA operates three high-volume air monitoring stations for aerosols and gaseous iodine. The filters are under normal conditions sent to NRPA weekly for gamma spectrometric analysis. With an air flow rate of 750 – 900 m^3/h, the aerosol detection limit is typically 0.1 – 1 $\mu Bq/m^3$ for weekly samples; in case of quick tests it is in the order of 1 – 10 $\mu Bq/m^3$. For gaseous iodine, the air capacity is 12 – 20 m^3/h, and the detection limit about 10 $\mu Bq/m^3$. In addition, NRPA operates two mobile air monitoring stations (140 m^3/h) and one station aboard the ship "M/S Midnatsol", cruising along the coast of Norway.

The Norwegian Institute for Energy Technology (Institutt for Energiteknikk, IFE), operates four stationary air monitoring stations with an air flow rate of about 20 m^3/h. The filters are first sent to the local office of the Norwegian Food Control Authority for a quick preliminary evaluation, after which they are forwarded to IFE for analysis.

NILU operates some 50 – 100 stationary general air quality monitoring stations with a capacity of approximately 1 m^3/h or less, and six mobile stations of about the same air capacity. These stations may be used for radiometric purposes if so recommended by the Advisory Committee.

All filters from the air monitoring stations mentioned above are analyzed gamma-spectrometrically using germanium detectors.

The locations of the stationary Norwegian air monitoring stations are shown in Fig. NO-3.

6.4 Airborne measurements

NILU owns a specially equipped fixed wing, twin engine aircraft that can be used for:

- On-line surveying
  - of ground deposition after a potential fallout of radioactive material
  - in search for radioactive fragments or sources
- Collecting aerosols on filters at an air flow rate of 54 m^3/h. If active charcoal filters are used, gaseous iodine will also be adsorbed, not only aerosols.

Ground surveys are performed using a 16 liter NaI(Tl) crystal connected to a multichannel analyzer and a signal processor mounted for in-flight operation. Complete spectra are acquired in only 333 ms with a detection limit of <2 kBq/m^3 for Cs-137. Radiological data are stored together with information on altitude and position, using GPS satellite navigation. If required, the NaI(Tl) detector system can be replaced by a germanium system, resulting in increased spectral resolution at the cost of decreased efficiency.

The filters are normally analyzed by NRPA, but can also be sent to NILU for evaluation in a germanium detector system.

The Geological Survey of Norway (Norges geologiske undersøkelse, NGU) has instrumentation for airborne mapping of radioactive fallout. The aircraft, which should be a helicopter, has to be rented.

6.5 Foodstuffs and environmental samples

The analysis of radioactivity in foodstuffs is handled by the Norwegian Food Control Authority (Statens Næringsmiddeltilsyn) at the so-called LORAKON stations. The LORAKON system comprises 57 laboratories, equipped with NaI(Tl) detectors and multichannel analyzers.

In case of a nuclear emergency where high-resolution gamma spectrometry is required, food and environmental samples will be measured using germanium detector systems at NRPA, IFE and a number of other organizations.

Strontium-90 analyses of milk and other agricultural products can be performed at NRPA, IFE and NLH, using liquid scintillation detectors or low background beta detectors.

Surface barrier detectors and appropriate procedures for nuclide specific analysis of food and environmental samples containing transuranic elements are available at NRPA, IFE and the Agricultural University of Norway (Norges landbrukshøyskole, NLH). The procedures require radiochemical facilities. Most common combinations of transuranic nuclides and materials can be analyzed.

6.6 Survey teams and local measurements

The Norwegian civil defense organization is equipped with approximately 160 survey meters for external gamma dose and dose rate measurements. The instruments have been distributed to local civil defense patrols for use in emergency situations. The northern part of the country has been given priority. A system of predetermined survey points, time intervals and measuring procedures is in operation in order to establish normal background levels. The instruments will also be used for determining radiation levels following an accident. People, objects, vehicles, soil etc. can be checked for external contamination by applying special probes. Data are transmitted to the Directorate of Civil Defense and Emergency Planning (Direktoratet for sivilt beredskap).

Norwegian defense forces are equipped with some 280 instruments, basically of the same type as used by the Civil Defense. In addition to this, various authorities and organizations around the country have a total of about 120 survey meters.

NRPA and IFE have emergency vehicles with transportable laboratory equipment for measurements and analysis. They can be made operational on short notice. Examples of available equipment:

- germanium detector systems for *in situ* and laboratory gamma measurements
- NaI(Tl) detector systems
- pressurized ionization chambers in vehicles
- high volume air samplers
- survey meters

6.7 Contamination

6.7.1 Internal contamination

There are stationary whole body counters with NaI(Tl) detectors at NRPA and IFE (Kjeller and Halden). One system is of the scanning type (at NRPA); the rest (NRPA, IFE) apply the chair geometries for measurements.

Most NaI(Tl) detectors, e.g., at the LORAKON stations, and portable germanium detectors may be used for whole body counting in an emergency situation. Also, some hospitals have equipment that can be used for whole body counting.

Survey meters owned by defense and civil defense forces may be applied for organ measurements (e.g., the thyroid).

NaI(Tl) and germanium detectors are available at NRPA, IFE and certain hospitals for evaluating samples of body fluids, urine, excreta etc.

6.7.2 External contamination

Checks for external beta and gamma emitting contamination may be performed by NRPA, IFE, civil defense forces, a number of hospitals and others, using most types of modern portable equipment.

6.8 Future development

Development, improvements, investigations and other forms of action have been recommended, planned or initiated in the following areas:

- The number of LORAKON stations should be increased. An automatic direct alarm system for gamma spectrometers in general should be developed.
- The number of gamma monitoring stations and air filter stations should be increased, especially in the southern parts of the country.
- The alarm function for the gamma monitoring network should be speeded up; at present, it may take up to one hour before the emergency organization is alerted.
- The possibility for Norway to join the United Nations Global Environmental Radiation Monitoring Network (GERMON) should be investigated.
- The monitoring systems operated by NILU and IFE should be coordinated.
- The number of mobile air filter stations should be increased. High volume samplers should be included.
- The national alarm function could be improved by introducing gamma measurements using NaI(Tl) detectors or Geiger-Müller tubes on filters in all stationary air monitoring stations.

- A system for local measurements in predetermined points is recommended. The Civil Defense should be equipped with an additional 350 instruments for that purpose. The possibility to cooperate with national Defense Forces should be investigated.
- Special methods and procedures for finding radioactive debris from satellites need to be developed.
- The capacity for strontium-90 measurements should be increased, and faster methods should be investigated.
- An increase in the number of whole body counters should be considered.
- Buoys with NaI(Tl) detector systems and GPS satellite navigation systems for analysis of seawater are being tested at three sites. The results are encouraging. The detection limit is 5 Bq/m^3.
- Noble gas measurements to reveal accidents or incidents will be introduced.
- Mobile spectrometers using NaI(Tl) detectors will be acquired.

Table NO-1

Measurement services in Norway

Type of measurements	Organization							
	NILU	HI	NRPA	LORAKON	Civ.Def.	NGU	IFE	NLH
Automatic gamma monitoring stations	x						x	
Air monitoring stations: gamma analysis			x				x	
Airborne measurements:								
- external gamma	x					x		
- air filters	x							
Field measurements:								
- gamma analysis	x		x	x				
- total gamma	x		x	x	x	x	x	x
- air filter gamma analysis	x		x					
- beta			x		x		x	
- alpha			x				x	
Laboratory sample analysis								
- gamma	x	x	x	x			x	x
- beta (Sr)			x				x	x
- alpha (Pu, Am)			x				x	x
Whole body counting			x				x	
External contamination			x	x	x		x	x

NILU Norwegian Institute for Air Research
HI Institute of Marine Research
NRPA Norwegian Radiation Protection Authority
LORAKON Measurement organization of the Norwegian Food Control Authority
Civ.Def. Directorate of Civil Defense and Emergency Planning
NGU Geological Survey of Norway
IFE Norwegian Institute for Energy Technology
NLH Agricultural University of Norway

Table NO-2

Norwegian gamma monitoring stations

Location	Type of detector	Local alarm	Central alarm	Remarks
Ny-Ålesund	Ion ch RSS 121	Yes	Yes	
Mehamn	Scint S10 Plus	No	Yes	
Hammerfest	Scint S10 Plus	No	Yes	LORAKON
Vardø	Scint S10 Plus	No	Yes	
Vadsø	Scint S10 Plus	No	Yes	LORAKON
Alta	Scint S10 Plus	No	Yes	LORAKON
Kirkenes	Scint S10 Plus	No	Yes	
Tromsø	Scint S10 Plus	No	Yes	LORAKON
Svanvik	Ion ch RSS 1012	Yes	Yes	
Jergul	Scint S10 Plus	No	Yes	
Øverbygd	Ion ch RSS 1012	Yes	Yes	
Harstad	Scint S10 Plus	No	Yes	LORAKON
Bodø	Scint S10 Plus	No	Yes	LORAKON
Tustervatn	Ion ch RSS 121	Yes	Yes	
Høylandet	Ion ch RSS 1012	Yes	Yes	
Trondheim	Scint S10 Plus	No	Yes	LORAKON
Kristiansund	Scint S10 Plus	No	Yes	LORAKON
Vålåsjø	Ion ch RSS 121	Yes	Yes	
Naustdal	Ion ch RSS 1012	Yes	Yes	
Bergen	Scint S10 Plus	No	Yes	LORAKON
Nordmoen	Ion ch RSS 1012	Yes	Yes	
NILU	Ion ch RSS 121	No	Yes	
Vikedal	Ion ch RSS 1012	Yes	Yes	
Prestebakke	Ion ch RSS 1012	Yes	Yes	
Stavanger	Scint S10 Plus	No	Yes	LORAKON
Grimstad	Scint S10 Plus	No	Yes	LORAKON
Birkenes 1	Ion ch RSS 1012	Yes	Yes	
Birkenes 2	Scint S10 Plus	No	Yes	
Verhnetulomski (Kola)	Scint S10 Plus	No	Yes	

Explanations: Ion ch = ionization chamber detector (Reuter-Stokes)

Scint = NaI(Tl) scintillation detectors with multichannel analyzer

LORAKON stations are intended for measuring food and environmental samples, but are used for gamma monitoring purposes during their down time (i.e., when not in use for their original purpose).

Only ionization chamber stations have a separate local logger.

"Local alarm" indicates a prompt alarm feature, triggered locally and calling NILU personnel.

"Central alarms" are issued by the computer as appropriate during the automatic polling of the stations; such alarms are delayed due to the time period between polls.

Fig. NO-1

Norwegian gamma monitoring stations

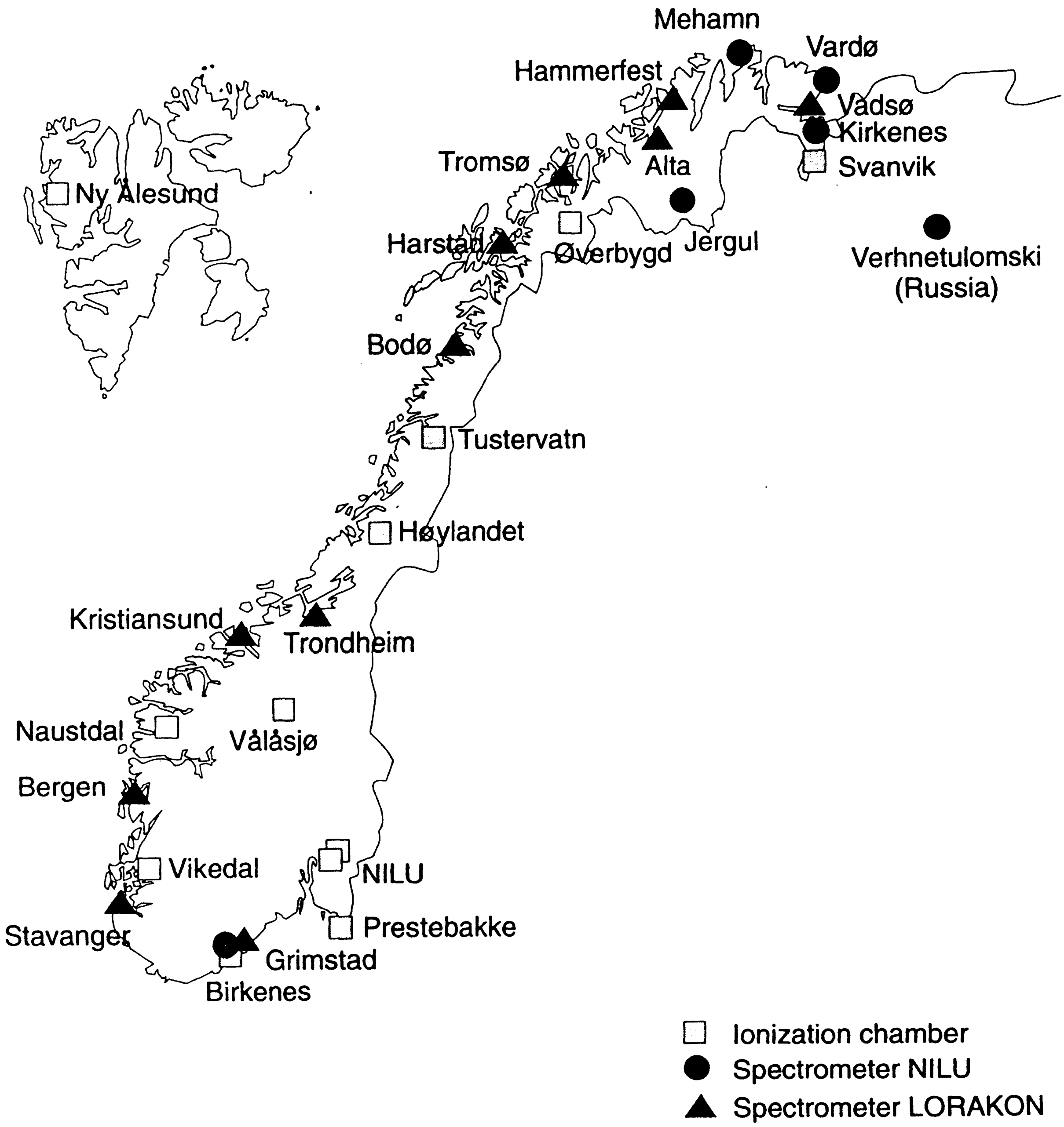
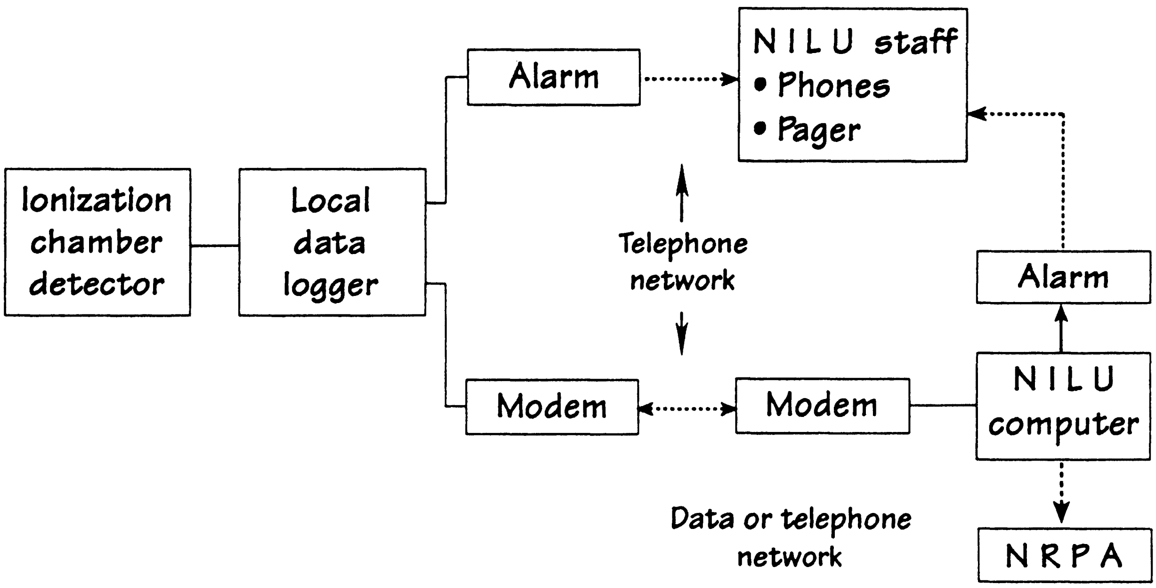


Fig. NO-2

A) Block diagram of the Norwegian total gamma monitoring stations and alarm response



B) Block diagram of the Norwegian gamma spectrometric stations and alarm response

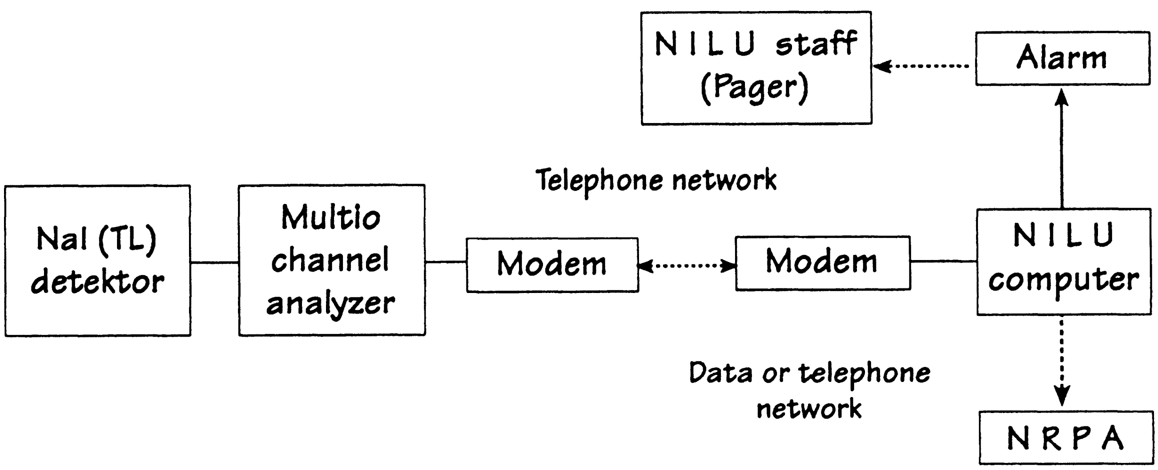
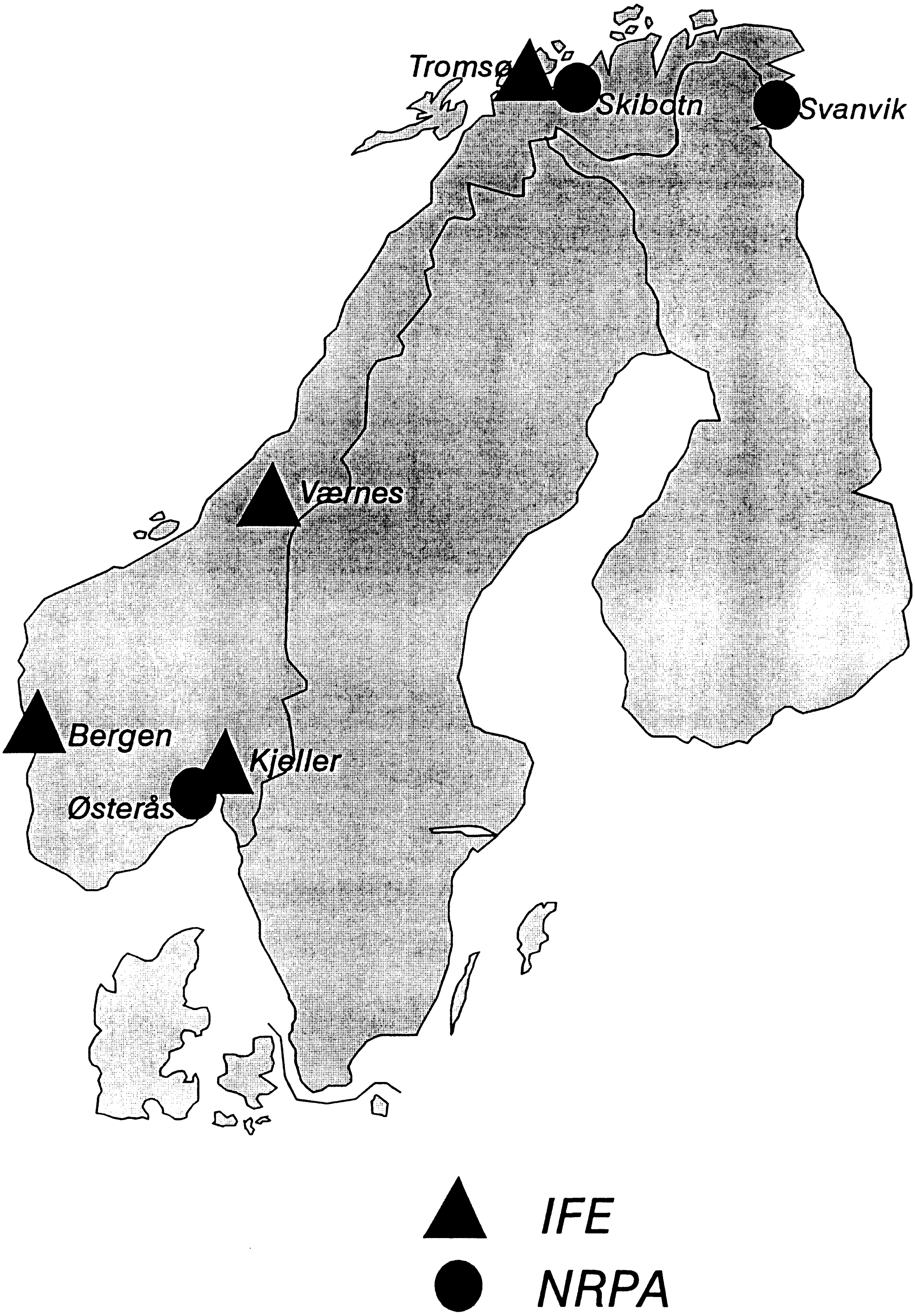


Fig. NO-3

Norwegian air sampling filter stations



7. Sweden

7.1 General background

The Swedish Radiation Protection Institute (Statens strålskyddsinstitut, SSI) is responsible for the operation of the national emergency preparedness organization. Measurements of various kinds form an integral and important part of this organization. The radiological monitoring program comprises a number of different systems and techniques. The Swedish Rescue Services Agency (Statens räddningverk, SRV), having no operative responsibilities, does not receive any radiation data from the monitoring systems.

The types of measurements carried out before and after a fallout and the organizations responsible for these measurements are summarized in Table SE-1.

The Swedish monitoring system is designed to detect releases emanating from foreign and domestic sources. Sweden has twelve nuclear power reactors, one research reactor, one nuclear fuel plant and a large waste handling program, including several repositories and a vessel for transporting radioactive waste.

The general background level of the country (total gamma) is well known, thanks to early geophysical measurements and background mapping as well as post Chernobyl measurements.

7.2 Automatic gamma monitoring stations

Sweden has an automatic network of 37 stationary gamma monitoring stations throughout the country. (Fig. SE-1.) The main purpose of the network is twofold:

- to give an alarm if there is a significant increase above the natural background gamma radiation level
- to give an instant overall picture of the radiation situation in Sweden

The distance between the gamma monitoring stations has been chosen to make sure that a radioactive release abroad will be detected by at least one station as it passes over Swedish territory.

The measuring device consists of a pressurized ionization chamber with associated electronics. The 4-liter chamber is filled with argon at a pressure of 600 kPa and placed 2.5 m above the ground in a housing designed to withstand the conditions of the environment. The measuring range is 1 – 6 000 000 nSv/h ambient dose equivalent rate. The average normal background level in Sweden is 100 nSv/h.

The detector at each station is constantly logged by a local microcomputer, and the results are stored locally. The reading of the individual station is presented on a display as a dose rate together with the integrated dose during a preset time. It is also possible to show the integrated dose for the last 24 hours and the corresponding integrated dose for the preceding 24-hour period.

A modem is connected to the microcomputer. The main computer (a personal computer) at SSI in Stockholm calls each gamma station over the public network a preset number of times every day (presently three times per day). The incoming data are stored in the data base of the institute. Evaluation and presentation of registered data can be performed automatically at any time. A block diagram of the gamma monitoring station is given in Fig. SE-2.

The microcomputer at each station is equipped with an alarm function. It is triggered whenever the integrated dose for the last 24-hour period exceeds that of the previous 24-hour period by more than a preset level, presently 300 nSv. The method of two moving consecutive 24-hour windows has been chosen to avoid false alarms from sudden changes in weather and moisture conditions. Radon related temporary dose rate increases by 20 – 40 % of the natural background level are not infrequent, and must not be allowed to affect the alarm function of the station.

The preset alarm criterion of 300 nSv per 24 hours may be changed individually for each station. This setting may be lowered when enough statistical material on unwarranted alarms has been collected from the stations.

In case of an alarm, the station calls a personal pager, displaying the individual code of the station. The radiation protection officer on duty can then call the station and obtain a reading.

After each polling of the stations, the main computer at SSI calculates present trends and gives an alarm via the personal pager whenever needed.

7.3 Air monitoring stations

The National Defense Research Establishment (Försvarets forskningsanstalt, FOA) operates a national air monitoring network of eight stations to detect very low levels of particulate radionuclides in the air. (Map in Fig. SE-3.) In case of a large increase of radioactive particles, the system will be used to assess the time-integrated air concentration in order to predict inhalation doses and ground deposition. Contrary to the gamma monitoring stations, priority is given to sensitivity rather than rapidity.

The objective is to sample and measure ground level air. All stations collect airborne dust on fiberglass filters manufactured by FOA. Air is drawn through the filter by a high capacity centrifugal pump at a rate of at least 1 000 m^3/h. The filters are sent by mail to FOA's Stockholm laboratory, where they are analyzed by high resolution gamma spectrometry in a low-background shielded chamber. The detection limit is of the order of 0.1 – 1 $\mu Bq/m^3$.

Under normal conditions it takes 5 – 10 days after the filter is removed until it has been completely analyzed. A quick check of the filters is always performed right after arrival by screening them for 15 minutes in a primary measurement chamber to detect any artificial nuclides, with a detection limit of 1 mBq/m^3. SSI is notified, should this limit be exceeded.

Some of the air monitoring stations are also equipped with units for sampling

- precipitation
- gaseous iodine
- xenon

Refer to Fig. SE-3 for locations of these stations.

7.4 Airborne measurements

7.4.1 High altitude air sampling

The system for air monitoring includes high altitude air samplers mounted under the wings of an Air Force aircraft. These samplers give information on the height distribution of the activity.

The aircraft carries three samplers under each wing. The samplers can be opened and closed by the pilot during flight. The sampling rate depends on the altitude and speed of the aircraft. Normally four samplers are loaded with fiberglass filters for gamma spectroscopy and two with an organic and soluble filter aimed at delivering material for particulate examination. When there is reason to expect fresh debris, flights can be performed daily and the flying altitudes matched to the anticipated dispersion heights.

7.4.2 Aerial surveys

Airborne spectrometric surveys are of vital importance in finding regions with high deposition while at the same time covering vast areas within a reasonable time span.

In order to avoid contamination of the aircraft, instrumentation and crew, measurements are planned to start well after the release has ceased. The aircraft can be airborne within 48 hours after an alert.

The Swedish Geological Survey (Sveriges Geologiska Undersökning, SGU) has been contracted to carry out the surveys. The flying altitude is of the order of 50 – 100 m. In order to get an overview of the deposition pattern, primary flight lines can be chosen with a separation of 50 – 100 km. A second mapping with more densely spaced flight lines may be performed if desired.

7.5 Foodstuffs and environmental samples

The National Food Administration (Statens livsmedelsverk, SLV) is responsible for sampling and analyzing foodstuffs in Sweden. SSI is responsible for giving advice on sampling and measurements, as well as for checking the quality of the measurements.

Gamma spectrometric measurements authorized by SSI are performed at two government institutes, six university laboratories, Studsvik and at the nuclear power plants. Strontium analyses are performed at SSI. Alpha spectrometric measurements are performed mainly at one university institution, Studsvik and SSI.

Milk is considered the most important foodstuff to check continuously. Leafy vegetables, meat, fish, game, berries etc. are checked whenever needed.

Soil, water and vegetation samples can be measured at, e.g., SSI and a number of university institutions.

A large number of NaI(Tl) and germanium detectors are available throughout the country for gamma spectrometric analysis of food and environmental samples.

7.6 Survey teams and local measurements

7.6.1 Stationary gamma monitoring points

Each of the 286 Local Environmental Health Protection Departments (Miljö- och hälsoskyddsförvaltningar) has a survey meter for making gamma dose rate measurements in predefined reference points every seven months. All in all there are some 900 reference points all over Sweden. These regular measurements are intended as an exercise as well as a collection of reference data to be used in a possible future fallout situation. In an emergency, measurements will be made in the same reference points and the data reported to the applicable county government. The 24 county governments, in turn, will report the data to SSI. Also, each county government has two survey meters for making their own measurements, as appropriate. Within approximately 24 hours after a deposition SSI has a fairly good picture of the fallout situation in Sweden thanks to these local measurements.

In case of an off-site alert or general emergency alarm following an accident at one of the four Swedish nuclear power stations, survey teams from the local fire brigades are automatically dispatched to predefined monitoring points to measure dose rates. Measurements will be made even during the passage of the plume, in order to determine its direction and to establish what areas are not affected by the release (where measures like sheltering can be ruled out directly). Special precautions will be taken to avoid contamination of the equipment.

7.6.2 Mobile air filter stations

The stationary ultra high-volume air sampling stations are supplemented by a set of mobile stations that can be transported quickly to regions where additional sampling capacity is needed. There are presently about 30 mobile air filter stations of different kinds available, operated by:

- the county government in each of the four counties with nuclear power stations (low volume)
- the nuclear power stations (low volume)
- FOA (high volume)
- SSI (low volume)

7.7 Contamination

7.7.1 Internal contamination

A total of about 20 whole body counting units are available in the country, one of them mobile. They are operated by SSI, ABB ATOM, Studsvik, FOA, nuclear power plants and a number of hospitals, universities and other organizations. Most units apply the chair geometry, some with NaI(Tl) detectors, others with germanium detectors. The few scanning units are equipped with NaI(Tl) detectors.

At least 60 gamma cameras at some 30 hospitals are available for checking internal contamination in case of an emergency. NaI(Tl) and germanium detectors are available at hospitals and other organizations for evaluating samples of body fluids, urine, excreta etc.

7.7.2 External contamination

Checks for external beta and gamma emitting contamination may be performed by SSI, FOA, local communities, nuclear power plants and others, using most types of modern portable equipment.

7.8 Other types of measurements

Spectrometric measurements must be applied in order to detect non-natural radiation levels smaller than background variations. This can be accomplished by *in situ* measurements, the most rapid spectrometric technique, since no special sample preparation is needed. Levels down to approximately 1/1000 of the natural background can be detected by *in situ* measurements with high resolution germanium spectrometers.

The radionuclides may be deposited on the ground or still airborne. In the latter case, a helicopter can be used to make measurements in the cloud.

Emergency preparedness resources for *in situ* high resolution spectrometry are available at SSI, three universities, Studsvik and FOA.

7.9 Future development

- One of the southernmost automatic gamma monitoring stations will be moved in a north-easterly direction in order to optimize the probability to detect foreign reactor accidents.
- SSI is considering a number of mobile automatic gamma monitoring stations, to be used in emergencies.
- SSI has decided to buy four mobile NaI(Tl) spectrometers with GPS navigation systems for use in road vehicles and aircraft to determine ground deposition in case of an emergency.
- Three of the Swedish nuclear power plants are planning for a stationary network of gamma monitoring stations around the plant. (Forsmark already has such a network.)
- SSI has initiated a Reference Group for the Baltic Sea States, under the Working Group on Radiation Safety of the Council of the Baltic Sea States. The main concerns for the reference group are early warning and integrated monitoring systems for use by national emergency organizations. At regular meetings, development trends and new concepts are presented, information is shared and harmonization and policy issues are discussed.

Table SE-1

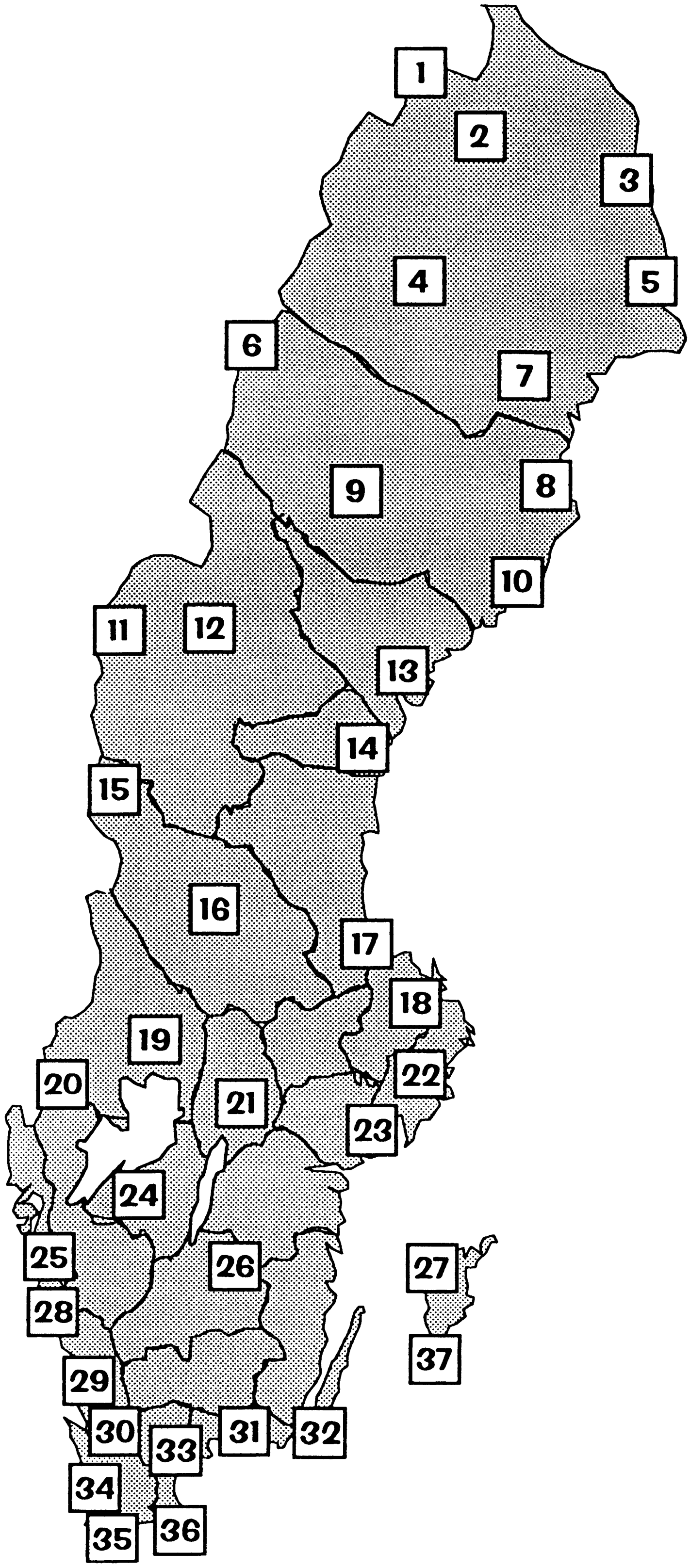
Measurement services in Sweden

Type of measurements	Organization						
	SSI	FOA	SGU	NPP	County	Local	Others
Automatic gamma monitoring stations	x						
Air monitoring stations: gamma analysis		x					x
Airborne measurements:							
- external gamma			x				
- air filters		x					
Field measurements:							
- gamma analysis	x	x	x	x			x
- total gamma	x	x	x	x	x	x	x
- air filter gamma analysis	x	x		x	x		x
- beta	x	x		x			x
- alpha							
Laboratory sample analysis							
- gamma	x	x		x			x
- beta (Sr)	x			x			x
- alpha (Pu)	x						x
Whole body counting	x	x		x			x
External contamination	x	x	x	x	x	x	x

SSI Swedish Radiation Protection Institute
FOA National Defense Research Establishment
SGU Geological Survey of Sweden
NPP Swedish nuclear power plants
County Government of NPP counties
Local Community organizations
Others Universities, Hospitals, ABB Atom, Studsvik etc.

Fig. SE-1

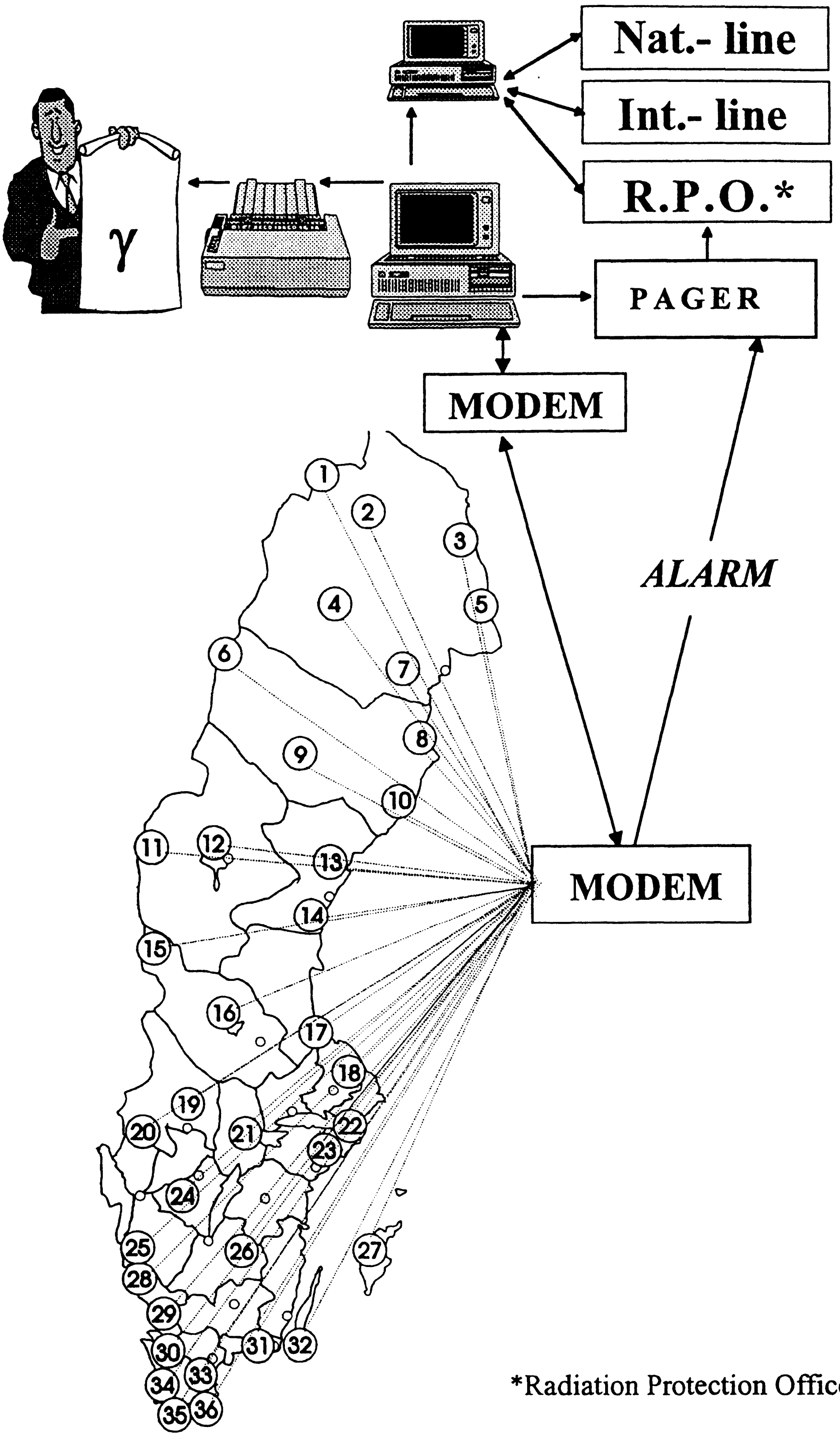
Swedish gamma monitoring stations operated by SSI



1	Katterjåkk
2	Kiruna
3	Pajala
4	Tjåmotis
5	Övertorneå
6	Hemavan
7	Älvsbyn
8	Skellefteå
9	Ulvoberg
10	Umeå
11	Storlien
12	Täng
13	Bredbyn
14	Njurunda
15	Idre
16	Mora
17	Gävle
18	Alunda
19	Gustavsfors
20	Blomskog
21	Örebro
22	SSI Stockholm
23	Åda
24	Skara
25	Landvetter
26	Eksjö
27	Visby
28	Ringhals
29	Halmstad
30	Ljungbyhed
31	Ronneby
32	Ölands s udde
33	Everöd
34	Malmö
35	Smygehuk
36	Sandhammaren
37	Hoburgen

Fig. SE-2

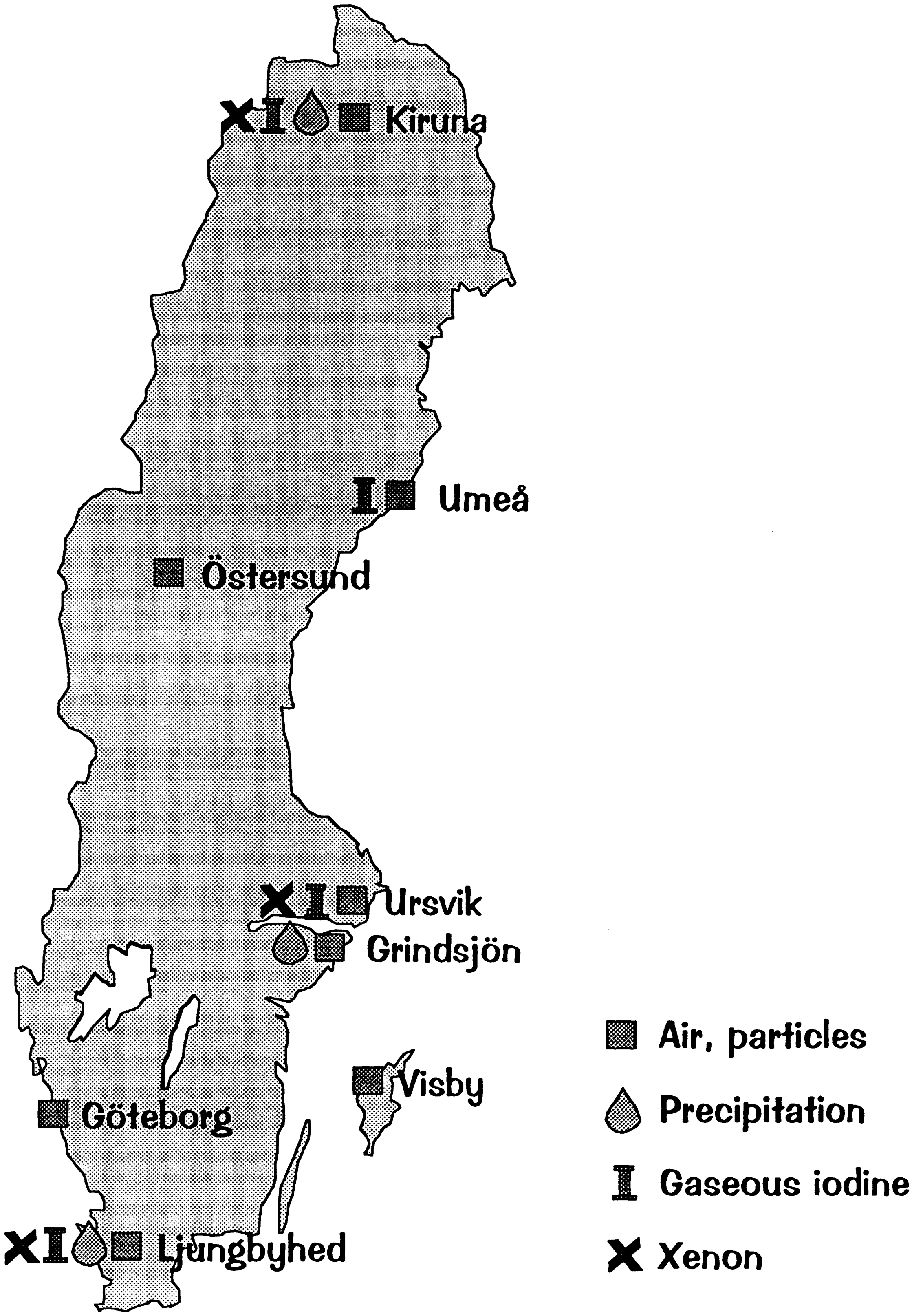
Block diagram of Swedish gamma monitoring stations operated by SSI



*Radiation Protection Officer.

Fig. SE-3

Monitoring stations operated by FOA



8. National comparisons

8.1 Automatic gamma monitoring stations

8.1.1 System design

	Denmark	Finland	Iceland	Norway	Sweden
Operated by	Risø	Ministry of the Interior STUK Defense Forces FMI	Geislavarnir	NILU	SSI
Number of sites	10 (+ Risø 1 for cal.)	About 490	1	27 (+ Kola 1)	37
Sites per 1 000 km²	0.23	1.45	0.01	0.07	0.08
Number of					
- GM counters	0	250 automatic 235 manual	0	0	0
- ionization chambers	10 (+1)	0	1	12	36
- NaI(Tl) detectors	10 (+1)	5 aut pairs	0	16 (+ Kola 1)	0
Dynamic range	Ion ch: 10 nSv/h - 100 mSv/h	10 nSv/h - 10 Sv/h	1 nSv/h - 6 mSv/h	Ion ch: 10 nSv/h - 1 mSv/h	1 nSv/h - 6 mSv/h
Height above ground	2.2 m	2.5 m	2.5 m	Ion ch: 3 m Scint: 2-7 m	2.5 m
Precipitation sampling?	Yes	Yes	No	Yes, at two sites	No
Total gamma?	Yes (all)	Yes (all)	Yes	Yes (all)	Yes (all)
Gamma spectrometry?	Yes (all)	NaI: Yes	No	NaI: Yes	No
Separate local data logger?	Yes (all)	Aut: Yes Man: No	Yes	Ion ch: Yes NaI: No	Yes (all)
Normal automatic polling period	Every hour	Once daily	Twice daily	Every 2 hours	Every 8 hours
Manual polling	Any time	Any time	Any time	Any time	Any time
Detector/central PC communication	Public tele network	Public tele network	Public tele network	Public tele network	Public tele network
Nordic data exchange format applied?	Yes	Yes	Yes	Yes	Yes

8.1.2 **Alarm system**

	Denmark	**Finland**	**Iceland**	**Norway**	**Sweden**
Alarm criteria	Gamma level up >10%	Gamma level up Aut >400 nSv/h Man >700 nSv/h NaI > 10 nSv/h	Gamma level up >300 nSv/24h	**From central PC:** >30 nSv/h above last 10-day average background; or gamma level up >300 nSv/24h **From ion ch det:** >50 nSv/h above average summer background **From NaI(Tl) det:** >30 nSv/h above last 10-day average background; or gamma level up >300 nSv/24h; or Cs-134, Cs-137 or I-131 window up >2 cps; or deadtime >2%	Gamma level up >300 nSv/24h
Alarm from detector?	No	Yes	Yes	Ion ch: Yes NaI det: No	Yes
Alarm from central PC?	Yes	Yes	Yes	Yes	Yes
Alarm via pager to stand-by staff?	Yes	Yes	Yes	Yes	Yes
Suppression of radon induced alarms?	Yes	GM: No NaI: Yes	Software handling	Ion ch: No NaI det: Yes	Software handling
Alarm in case of malfunction?	Yes	Yes	Yes, when polled		Yes

N. B. : This table does not include local gamma monitoring stations operated by nuclear power plants or research reactors

8.2 Air monitoring stations

	Denmark	Finland	Iceland	Norway	Sweden
Operated by	Risø	A: FMI B: STUK C: NPP D: Def Forces	Geislavarnir	A: NRPA B: IFE C: NILU	FOA
No. of stations @ air flow rate in m^3/h	3 @ 4000	A: 14 @ 10, 4 @ 150 B: 3 @ 900, 4 @ 150 C: 8 @ 60 D: 1 @ 150	1 @ 550	A: 3 @ 750-900 B: 4 @ 20 C: 50 @ <1	1 @ 5800 7 @ 1050
Detection limit ($\mu Bq/m^3$) - normal conditions	0.1	A: 200 B: 0.1-1 C: 2 D: 0.4-1	0.03	A: 0.1-1 B: 5-50 C: 50-500	0.1-1
- quick test (counting time)	-	B: 2-10 in Helsinki, Rovaniemi	0.7 (2 hours)	A: 1-10 (2 hours) B: - C: -	1000 (15 min.)
Total gamma + beta monitoring of filter?	No	B: Yes, at three sites	Yes	A: No B: No C: No	No
Normal filter change rate	Once weekly	A: Weekly B: Once or twice weekly C: Twice monthly D: Twice weekly	Monthly	A: Weekly B: Twice monthly C: Daily	Three times a week
Number of stations sampling		B:			
- gaseous iodine	1	7 (12 m^3/h)	0	A: 2; B, C: 0	4
- noble gases	1	0	0	A, B, C: 0	3
- precipitation	1	1	0	A: 1; C: 50	3 (+1 stand-by)
No. of mobile stations @ air flow rate in m^3/h	10 @ 6	B: 7 @ 150 (Four in continuous operation)	0	A: 2 @ 150 B: 0	6 @ 320 20 @ 6

8.3 Strategic considerations

8.3.1 General

Gamma networks, air monitoring stations, survey teams, laboratory equipment etc. serve several purposes. The first objective is to detect any increase of the radiation level not caused by radon or other natural factors, and to provide early warning by automatically giving an alarm signal as soon as possible once the alarm criteria have been exceeded. The second objective is to get a rough national fallout map as soon as possible after deposition of radioactive material. After this initial phase, additional measurements will be made to determine dose rates, nuclide specific fallout patterns, food contamination etc.

Generally speaking, the Nordic countries apply the following strategy to map the country and determine the contamination level:

- Automatic gamma monitoring stations are used for early warning. It is a fast, sensitive and reliable method. However, the number of stations per unit area varies greatly among the countries, as does the population density. The fewer the stations, the more important their location gets, to create an optimal coverage of the national territory. In some cases, the automatic network is complemented by semi-automatic or manual stations.
- Air filter stations are used for very sensitive nuclide specific measurements. The Icelandic station and several Finnish stations are fitted with beta and/or gamma detectors for on-line monitoring of the filter as a part of the early warning system. Sweden has explicitly declared that this type of monitoring is believed to create more problems than it solves, basically due to radon and radon daughters (which create a greater problem in Sweden than in Iceland).
- Survey teams and local measurements in predetermined points are frequently applied to get fast and detailed information on local dose rates.
- Most countries have a program for airborne mapping of the fallout.
- Mobile gamma monitoring stations and/or air filter stations are used to complement the stationary network.
- Field measurements in areas of special interest are used for
  - gamma spectrometry
  - total gamma measurements
  - gamma analysis of air filters
  - alpha and/or beta measurements
- Field and/or laboratory analysis is made of environmental and food samples.
- External contamination checks of people, vehicles, buildings etc. can be performed as the need arises.
- Most countries have several whole body counters for measuring internal contamination.
- There are a number of hospitals and other institutions in all countries that are equipped and staffed to determine internal contamination by means of organ measurements or analysis of urine samples.

8.3.2 Denmark

Spectrometric plume and fallout data are considered to be as important as total gamma radiation dose rates. The ambition is to perform a crude mapping of the entire country within 48 hours after a fallout, yielding nuclide specific deposition charts and total gamma dose rate isolines.

As regards gamma monitoring stations, priority has been given to a system allowing automatic separation of contributions due to radon and other natural causes for variations in the background level. Hence, the early warning system comprises a number of monitoring sites, each equipped with one NaI(Tl) detector and one ionization chamber detector.

Three ultra-high volume air samplers offer sensitive measurements to supplement the early warning system.

For mapping purposes, there exists an elaborate system of survey teams and fixed measuring points.

8.3.3 Finland

The overall strategy emphasizes automatic, stationary solutions. For mapping purposes there also exists an elaborate system of survey teams and fixed measuring points.

A dense grid of automatic gamma monitoring stations is highly prioritized, unique among the Nordic countries. It is supplemented by an equal amount of manual stations, which will be converted to automatic stations in the near future.

Separation of variations in the normal background level, e.g., due to varying radon concentrations, is not generally included, but possible with a limited number of NaI(Tl) detector stations.

The system of air monitoring stations is also very elaborate, in the Nordic perspective. So is the local laboratory network for food measurements.

8.3.4 Iceland

The lack of any major domestic nuclear threat puts Iceland in a rather different position compared to the other Nordic countries. Mobile radiation sources constitute the major risk.

So far, there is only one stationary gamma monitoring station. Radon induced variations of the gamma radiation level are compensated for manually, and unwarranted alarms due to increased radon concentrations are discriminated through software applications. The automatic station may be supplemented by a number of mobile stations, should the need arise.

A single stationary air monitoring station forms part of the early warning system. The total beta plus gamma activity of the filter is measured continuously.

Special survey teams may perform total gamma dose rate measurements in case of an emergency. Routine measurements of this type are being planned.

Foodstuffs and environmental samples are continuously being measured.

8.3.5 Norway

About half of the automatic gamma monitoring stations are total gamma measuring ionization chamber detectors, and the rest are gamma spectrometric NaI(Tl) detectors, routinely offering radon separation as well.

There are a great number of air monitoring stations, especially of low air capacity.

The food measurement program is elaborate within the framework of the LORAKON system. The number of LORAKON stations however needs to be increased.

A large number of survey meters are used for regular measurements at predetermined survey points.

8.3.6 Sweden

The ambition is to get a fairly good picture of the fallout situation within approximately 24 hours after the deposition of radioactive material.

The number of gamma monitoring stations is designed to ensure that any plume passage over Swedish territory, from foreign or domestic accidents, will be detected. It is not deemed optimal to have a much greater coverage than the present, since the additional information would be marginal. Also, the risk of false alarms increases with the number of detectors, no matter what their operating principle. It has therefore been decided to complement the automatic gamma monitoring system and air filter stations with local and airborne measurements, to be applied in case of an emergency.

Local dose rate measurements are performed manually in about 900 predetermined points. This not only gives SSI rapid information on the situation in the whole country, but also offers local authorities a better basis for decision on protective measures as well as information to the public.

Radon induced variations of the gamma radiation level are not compensated for. Unwarranted alarms due to increased radon concentrations are discriminated through software applications.

The overall strategy emphasizes flexibility at the risk of problems caused by the massive collection of data and flow of manual reports from local survey teams in case of an emergency. Under normal conditions, local measurements are made in a total of some 900 survey points across the country every seven months. The data thus collected throughout the years allow local community officials to make quick assessments in case of an emergency, without having to consult the central authorities.

There are several high or ultra high volume air monitoring stations. Quick preliminary filter evaluations make them a part of the early warning system.

Food and environmental samples are measured continuously.

9. Radiation data exchange between the Nordic countries

9.1 General background

The Chernobyl accident revealed the need for a rapid and reliable system for international transfer and exchange of radiation data, especially readings from automatic gamma monitoring stations. Various systems have subsequently been suggested to solve this problem.

The purpose of the BER-22 project was to propose such a system for data exchange among the Nordic authorities responsible for radiation protection. In this project a demonstration system was set up, and a specification was written for a full-scale system that may be established in the future.

9.2 Objectives of the BER-22 project

The objectives of the project may be divided into the following main categories:

- To specify the essential radiation data to be transferred between countries
- To specify a common format for the data exchange
- To exchange actual monitoring results and collect feed back
- To make experiments with different telecommunications methods and select the optimal solution
- To make a proposal for the specifications of the future operational system for exchange of radiation data

9.3 Remarks

In this chapter a number of abbreviations and expressions will be used that might not be transparent to radiation safety officers, emergency preparedness experts or other specialists not familiar with present development or standards within the global data and telecommunications community or modern computer terminology. Therefore, a brief introduction might be in order.

Edifact	Electronic data interchange for trade and commerce
RDE box	Radiation Data Exchange box
Procomm+	A telecommunications software product
WMO-GTS	A World Meteorological Organization network

x. 25	A packet switching network standard
TCP/IP	Transmission Control Protocol / Internet Protocol
PC	Personal Computer
Funet	Finnish university network
Nordunet	Nordic university network
FTP	File Transfer Protocol using TCP/IP
SCO Unix	A Unix operating system implementation for PCs, produced by Santa Cruz Operation, Inc.

9.4 Project proceedings

The technical work of the project was carried out by the Finnish State Computer Center (VTKK) at Jyväskylä, Finland. The following organizations played an active role in specifying the data format and testing the methods with actual data:

- Denmark: Risø National Laboratory
- Finland: Ministry of the Interior/Rescue Department
- Norway: Norwegian Institute for Air Research (NILU)
- Sweden: Swedish Radiation Protection Institute (SSI)

9.4.1 Specification of essential data and exchange format

This was a more demanding task than expected. The first proposals made by VTKK were based on the assumption that the key aspect is the integration of the different applications. Thus, the format was aimed toward program-to-program transfer, and an Edifact standard was used as a model.

This approach turned out to be premature, since the data were not further processed or used in any application but only printed out or viewed on the screen. For this purpose the applied format was far too cryptic, and also its contents did not satisfy most users. Thus a more straightforward model was implemented in which the format was a simple ASCII file which could be easily printed out and viewed on different terminals. Also, more emphasis was given to the actual contents of the file.

Several meetings and test periods were required to single out the essential data to be transferred and to decide on the best possible format. It took some adjustment of the different standards in each Nordic country before the common format was finalized and agreed upon. However, there was no disagreement as to the importance of the data. But the adjustment to a format, usable in each country alongside with the national standard, was time consuming.

In the final version specified below, the data to be transferred are compressed into an 80 characters wide easy-to-read format. It can be used both with computer applications and viewed on the screen. It can also easily be developed into an Edifact message, should such a demand arise later.

9.4.2 Method for data exchange

At first, a simple PC based bulletin board system situated at VTKK in Jyväskylä was applied. This so called RDE box was built using a procomm+ product for development. The box was accessed through the public telephone network, and a variety of file transfer methods were available.

This method was selected mainly to get a quick start of the actual transfer and begin to collect feedback. This box, however, served continuously throughout the project, although some participants had difficulties in accessing the system through their switchboard, and the box could only serve one user at a time. Also, the data structure was considered too simple with only the latest data available.

Other methods were studied as well, including the WMO-GTS network. There are no direct benefits from using this network with its cumbersome data format and heavily loaded data communications. The data communications will be transferred to the x. 25 network in the future; however, this would not be of any significant advantage for our purposes; thus, the use of this network was rejected.

Since the TCP/IP network is available to many participating organizations, it was agreed that this method will be studied more carefully. Thus a PC based Unix environment was established at VTKK with access through international networks (Funet/ Nordunet).

9.4.3 The Unix environment

The Unix environment offered a more elaborate platform for development than the previous PC based bulletin board system, and the system implemented has more characteristics than the RDE box.

The system can be described as follows:

File System

```
                 -RAD. HISTORY
    /USR/BER -   -TEXT
                 -ENVI
```

The home directory contains the following files:

• .RAD	latest radiation files for each country
• .REM	respective remarks files if any
• .TXT	permanent information files
README. BER	a brief description of the system
USER. LOG	user log file

The RAD. HISTORY directory contains old radiation files named FIN. RAD. 921215 etc. , where FIN stands for Finland. During test periods files were moved daily and kept for about a week.

The TEXT directory is a place for any transferred text files such as correspondence, reports, ideas etc.

The ENVI directory is for environment development purposes.

At the moment, users apply a common user identification. They can reach the system either using FTP file transfer or by terminal login. The terminal users are logged in to the USER. LOG file. The users are asked to enter their name and organization when accessing the system, and a time stamp is included and the entry logged. After this, the name and time stamp of the latest radiation files of each country is shown for easy reference.

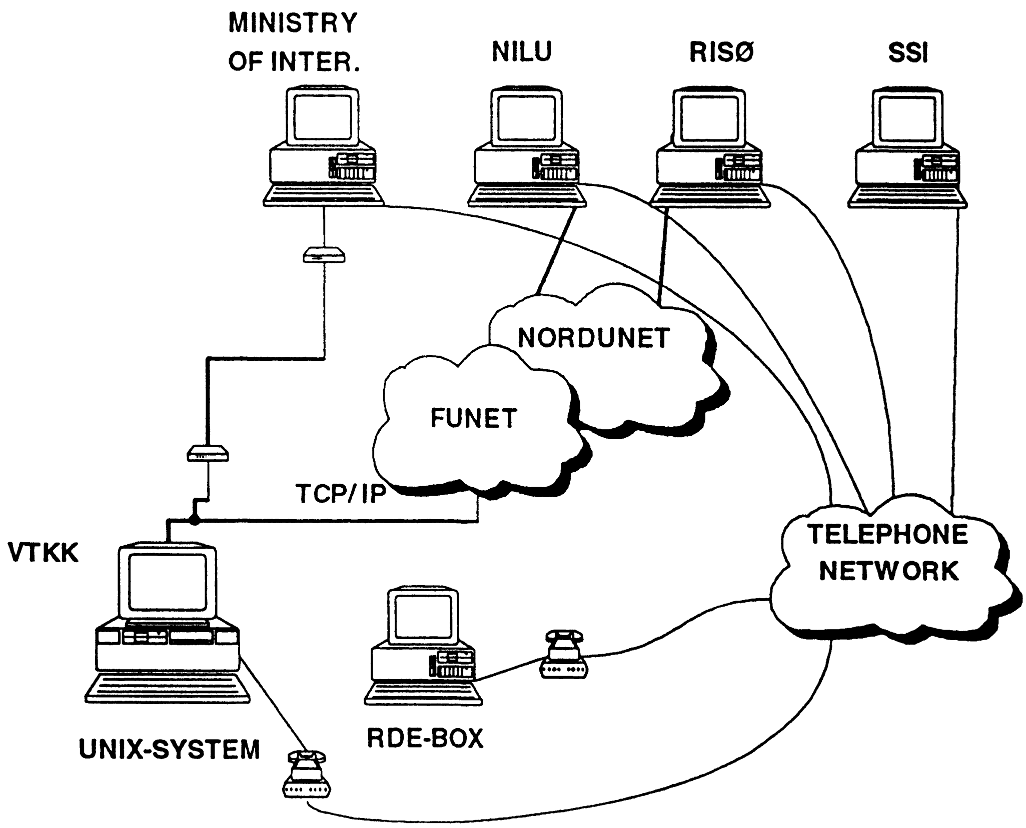
During test periods the files from the RDE box were transferred to SCO Unix and vice versa.

9.4.4 Proposed permanent information files

The following contents of the permanent info files are proposed:

- A brief description of the monitoring network
  Type of monitoring stations
  Interrogation interval
  Other relevant information on the network
- Position of the monitoring stations (longitude, latitude)
- Contact persons with telephone and fax numbers
- Additional information

The following figure shows the full test environment with communications facilities to participating organizations:



9.4.5 Alternatives for the operational system

Alternatives were discussed and studied, using the feed back collected from the experiments. It was soon discovered that in a normal situation the radiation data of the neighboring countries do not have significant importance; but, on the other hand, during an exceptional situation there is a great demand for fast accesss to accurate and up-to-date information. Anyway, the exchange of data should become routine since in a real situation there is no time for learning the methods.

9.5 Possible alternatives for the system

9.5.1 A. Mutual data transmission

In this system there is a mutual exchange of information among participating countries. The transfer file is created daily and sent to one or several distribution points in each participating country, by electronic mail or using file transfer.

Advantage:
+ No need to build or maintain a central data base

Disadvantages:
- Many connections needed
- Expensive to send routine data
- If sent only when necessary, who defines the demand?

9.5.2 B. Common data base in one of the Nordic countries

In this case everybody will send their data to one central distribution point, which all interested parties will have access to.

Advantages:
+ Compatibility is not an issue
+ Only one connection needed for each party
+ The development efforts can be optimized

Disadvantages:
- The real-time demand leads to excessive data transfer
- If the data are kept only in one place, the access might be broken when most urgently needed

9.5.3 C. National information data base with common access

Each country will appoint one organization which is responsible for keeping an information system that can be accessed from the Nordic neighbors.

Should other organizations in a country also need to have access to the data, they have to make arrangements to that end with the responsible organization.

Advantages:
+ Easy to keep real-time data available
+ Data are transferred only when needed
+ The transfer cost is payed by the party needing the data

Disadvantages:
- Many connections needed
- Compatibility might be a problem unless joint development is applied

9.5.4 Agreement

It was agreed that alternative C above is the recommended approach for the future.

9.6 Conclusions

Modern technology offers many possibilities in enhancing the rapid exchange of radiation information between the Nordic countries. But adjusting the slightly different methods and conventions of each country is not done overnight. This will be an even bigger issue if and when the cooperation is extended to the Baltic republics, which should be a natural step in the future.

The experts selected for this work are often the most sought-after and busy in their respective organizations. Therefore, the development of the data exchange system needs to be prioritized and will be carried out in seemingly small steps, as in the case of the exchange format specification.

The project has made some progress in the field of radiation data exchange between the Nordic countries, and this work should continue in the future in some form. The participants will naturally use their understanding and knowledge of the problems and possibilities of this matter in their future routine cooperation. But an official continuation is also recommended in order to benefit fully from the previous work.

The format specified below can actually be strongly recomended for a wider international use as a concise and proven standard for radiation data exchange.

9.7 Future development

During the project, data were exchanged between the participating organizations on a more informal basis. If it is decided to establish an operational procedure of exchanging data, it is recommended that it is done in the following steps:

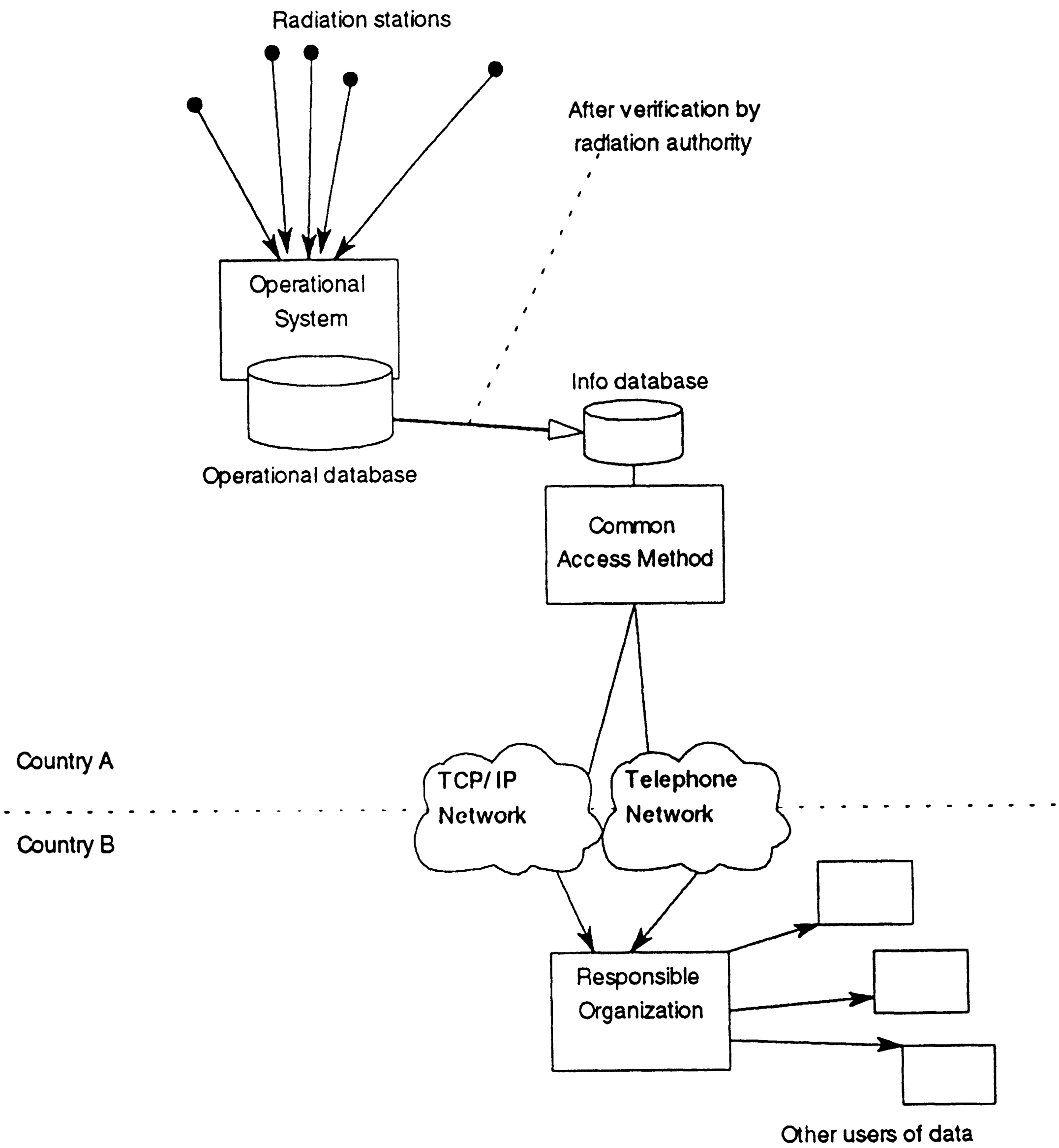
1 Make the formal decision on the structure of the operational exchange system; inform all organizations concerned

2 Establish the system
- Select the responsible organization in each country
- Form a group to execute the following tasks:
  - Opening of distribution points and telecommunications connections
  - Information and guidance
  - Coordination and follow-up

3 Development project
- Establish a project to develop the system toward an information data base. The duration of this project is expected to be 1 – 2 years.
- Proposed task list:
  - Specify the contents and structure of the data base
  - Specify the access method
  - Make a prototype data base

- Demonstrate the data collecting, combining and presentation
- Collect the feedback and propose future enhancements

The following sketch shows the general layout of an envisaged future system:



9.8 The exchange format for radiation measurements

9.8.1 General aspects

The objective was to define a common Nordic data format that could be adopted by all countries and used in their daily national routines, as well as in the exchange of radiation data between organizations and countries.
The format has to serve

- people using simple terminal emulators and only viewing the data or printing it
- automatic data collecting software

The file name has two parts, separated by the period: FILE. EXT

- where FILE is always a 3-character abbreviation of the country name in question, using
  - DEN for Denmark
  - FIN for finland
  - ICE for Iceland
  - NOR for Norway
  - SWE for Sweden
- and EXT is one of the following extensions:
  - RAD for radiation data
  - TXT for permanent information file
  - REM for remarks associated to radiation file

Examples of correct file names:
DEN. RAD • FIN. RAD • ICE. TXT • NOR. TXT • SWE. REM

9.8.2 Format of the RAD file

- ASCII file 80 characters wide for easy viewing.
- All times are to be entered in UTC.
- All dose rates are to be given in nSv/h. For higher dose rates an exponential format is used, giving multiplying factors for nSv/h. μSv is noted by E3 (i.e., 1 000 x nSv), mSv by E6 etc. For example, a dose rate of 230 μSv/h will be expressed as 230E3. This is done in order to lessen the possibility of misinterpretation in a stress situation.
- An information section may be included in the beginning of the file. It may contain any information deemed necessary, but should at least have a header consisting of country name and date for update and column labels. This section will leave the first position blank in order to facilitate the automatic import of data.

- Data Columns separated by one character:

Name	Length	Contents
STATION	16	Station name or other identification
LAST10	6	Mean dose rate of last 10 days
YMEAN	6	Mean dose rate of yesterday
YMAX	6	Maximum dose rate of yesterday
YTIME	2	Hour of yesterday's maximum value
TMEAN	6	Mean dose rate of today
TMAX	6	Maximum dose rate of today
TTIME1	2	Hour of today's maximum value
TLAST	6	Last measured dose rate of today
TTIME2	2	Hour of last value
REMARKS	13	Column for additional information. The following characters may be used for quick reference: A for Alarm C for a Comment added in a REM-file

The following is an example of the contents of the file:

DATA FROM NORWAY Updated: 930514 1337
The time is given in Norwegian standard time (UTC + 1)
Warning: The data is automatically updated and can not be garanteed to be errorfree!
The data is for information only

		Date			Date					
		**** 930513 *****			******** 930514 ***********					
STATION	BACKGR. 10 DAYS nSv/h	MEAN VALUE nSv/h	MAX VALUE nSv/h	AT Hr	MEAN VALUE nSv/h	MAX VALUE nSv/h	AT Hr	LAST VALUE nSv/h	AT Hr	REMARKS
BIRKENES	111	115	119	07	117	119	07	114	12	
PRESTEBAKKE	95	98	100	24	100	101	11	100	12	
NORDMOEN	75	78	80	24	79	80	06	78	12	
SVANVIK	52	55	56	07	54	55	03	53	12	

10. On-line airborne measurements in acute situations

10.1 General background

The BER-23 project, presented in this chapter, was initiated following Danish and Finnish experiments in 1986 – 1989 on airborne measurements. These experiments took place during and after the Chernobyl accident in order to exploit the experiences from the accident and to develop methods and organizations which could be put into effect in similar future situations.

In all the Nordic countries the need for airborne equipment to find and measure contaminated areas was realized immediately after the Chernobyl accident and investigations were started in all countries, normally based on existing geological survey instruments or airborne filter methods.

The Danish Emergency Management Agency was directed – with a promise of the necessary budget – to design and establish a new system, comprising stationary measuring stations and several sets of instruments for an airborne system based on helicopters from the Danish SAR (Search And Rescue) service.

SAR is a common term for national (normally military) rescue services. Although their tasks are mainly civilian in peace-time, SAR units have full-time staff with military training and special equipment, allowing actions in all types of weather.

In 1989 a demonstration of a Danish developed system took place in Finland. That version made use of DECCA navigation and on-line data transmission to the ground station.

The objective of BER-23 was to investigate present technical possibilities in airborne measurements, especially concerning navigation, on-line data transmission and the advantages of standardization of methods and instruments.

10.2 Summary and conclusions

The final report (in Danish) on the BER-23 project is in the form of recommendations in three main areas:

1 A technical solution for an automated airborne system
- The airborne equipment
- Navigation
- On-line data transmission via radiolink
- Ground station, computer and software

2 Standardization of instruments and methods
   - Basic installations
   - Radio frequencies
   - Data quality
   - Exchange of data and results

3 The organization
   - Using the national SAR services
   - Tactical command of helicopter missions in the SAR service

10.2.1 The technical solution

The suggested technical solution includes recommendations for the total instrumentation, i.e., the detector, a 3-D navigational system, local data storage, on-line data transmission and the central computer at the command center.

- The airborne equipment
  It is recommended that, between missions, the airborne equipment is stored in containers, ready for installation in an aircraft. During storage the detector module should be calibrated and tested regularly. The instruments are divided into two separate parts: one to be mounted on the outside of the aircraft, and an electronic part to be installed inside. -The aircraft should be preinstalled with cabling and connectors for power supply and antennas.
  A mobile rugged computer (PC or similar) should be used as the operator interface and have enough capacity to
  - store and analyze spectral data (requiring an I80846 processor or the equivalent and a disk capacity of at least 50 Mb)
  - handle on-line data transmission via radiolink (expected sampling frequency: 256 channels every second, and transmission of extracts every 10 seconds)

- Navigation
  It is recommended to use a GPS receiver and a radar altimeter. The standard GPS offers an accuracy of <100 meters; and <10 meters, if differential techniques are used.

- On-line data transmission via radiolink
  It is recommended that relevant extracts of the measured data are transmitted to the command center at a rate of one transmission every 10 seconds.

- Ground station, computer and software
  It is recommended that standards, or minimum demands, should be defined for the following items:
  - Data format
  - Data quality
  - Transmission protocol
  - Presentation of results from the data analysis
  - Basic topographical computer based mapdata

  and if possible, but not necessarily, on:
  - Computer type
  - Operative system
  - Programming language

10.2.2 Internordic harmonization

Even a relatively small degree of harmonization of the national airborne systems of the Nordic countries offers substantial possibilities for sharing equipment and aircraft in an acute situation, and can thereby minimize the total Nordic budget for such systems. The necessary harmonization or standardization to achieve this are:

- Preinstalled basic facilities in the aircraft (cables, connectors and antennas).
- Prepared radiofrequencies for data and voice communication. The data transmission should make use of existing or planned public networks (NMT, GSM or Mobitex).
- Standards for
  - data quality
  - presentation of results
  - computer produced maps
  - data format
  - transmission protocol
  - geographic coordinate system

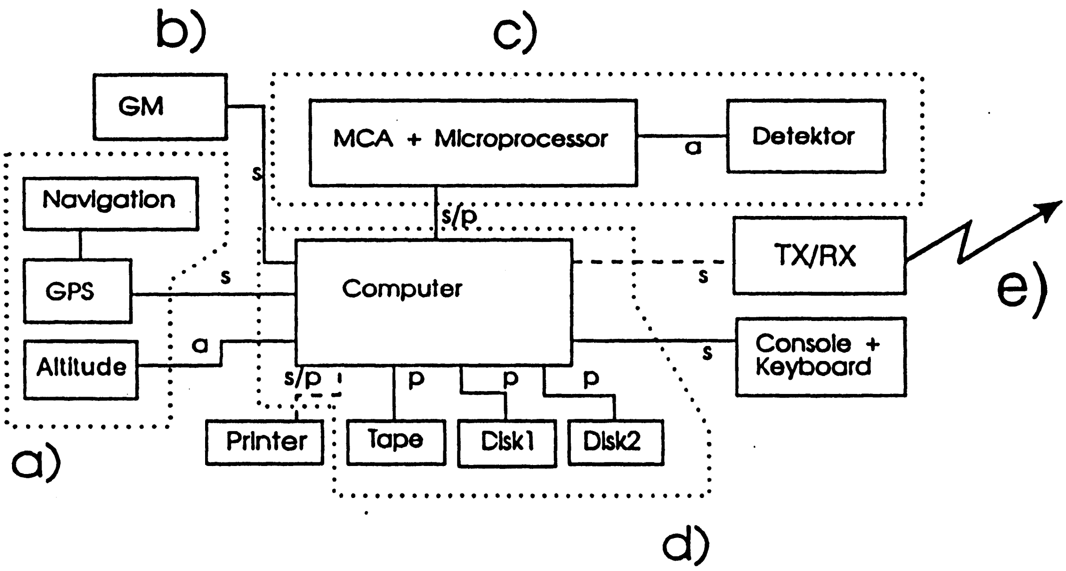
10.2.3 Internordic coordination – Using the SAR services

It is recommended that the Nordic emergency preparedness organizations cooperate with the existing national SAR (Search And Rescue) organizations in the individual countries, benefitting from already established and functioning aircraft and personnel.

Such a cooperation would not only serve to cut expenses in establishing and operating an airborne reconnaissance system, but would also put the complicated task of tactical leadership of large airborne radiological reconnaissance missions into the hands of trained professionals.

10.3 A model for an airborne system

As an example of a system which basically follows the above mentioned recommendations a block diagram of the new Danish system is included:



a)	Trimble SVeeSix GPS receiver and radar altimeter	Helicopter equipment
b)	Geiger-Müller detector	Permanently installed in helicopter
c)	NaI(Tl) detector module	Removable external container
d)	Computer module with peripheral units	Mission installed
e)	TX/RX radiolink	Mission installed

Possibility to add meters for air temperature and air pressure.
Optional video camera to be installed in external container with NaI(Tl) detector.

Detector type:	16-liter NaI(Tl) with a GR 820 Exploranium Multichannel Analyzer
Available helicopters:	8 Sikorsky S-61 (SAR) and 12 Fennec (Danish Army)
Basic installations:	2 – 4 Sikorsky SAR helicopters
NaI(Tl) detectors:	2 sets in external containers for Fennec helicopters
On-line radiolink:	NMT being investigated; Planned: 9600 baud TX/RX
Computer type:	PC compatible (I80486 or equivalent), 25 Mb disk
Data sampling:	256-channel spectrum every second
Calibration:	Periodically in storage; and before each mission
Readiness:	15 minutes for SAR helicopter with GM detector Approximately 2 hours for missions with NaI(Tl) detector

10.3.1 Specialist independent system

It is recommended that an aerial survey system should be made as independent as possible of the presence of specially trained experts (e.g., physicists or geophysicists) for the operation of the system during missions.

This can be achieved if the complicated and technically demanding calibrations and electronics tests of the equipment are performed on a regular basis at the storage sites, without having to install the equipment in the aircraft.

Simple pre-mission calibrations and tests are still needed, but may be performed by the crew and (if on-line data transmission via radio is installed) the command center physicist for the mission.

The main prerequisite to make the above possible is that the equipment is highly automated.

10.3.2 Elements of an ideal national airborne survey system

1 Prepared equipment packages, stored at geographically appropriate locations and regularly checked on-site by experts (calibration and electronics tests every 3 or 6 months)
2 A number of aircraft with basic installations (fittings, cables, connectors and antennas)
3 Flight crew, specially educated in installation and operation of the detector equipment, and regularly trained through exercises
4 A reliable on-line radiolink for data transmission and voice communication between aircraft and command center
5 For possible cooperation with neighboring countries:
Prepared procedures for tactical cooperation, intercommunication, exchange of measuring data and results

10.4 Data collection

The measured data from the detector will be stored locally in the computer onboard the aircraft on a RAM disk, harddisk or some other medium. A full spectrum (256 or 512 channels) should be collected once every second.

It is however recommended that airborne surveys utilize the obvious advantages of on-line data radiolink communications with the command center, both for flexible tactical leadership and because of the possibilities of on-line control of the equipment in the aircraft.

For data radiolink it is recommended to use public networks (which in the Nordic countries means NMT, GSM data or Mobitex). The very low operating altitude (50 – 100 meters) will allow the use of these networks from the aircraft.

10.5 Types of aircraft

It is recommended to use helicopters, for reasons of flight security and operational flexibility. Helicopters are, however, expensive to operate and maintain. Also, a very high level of alertness is required. Economic and practical reasons therfore dictate that cooperation with existing services in possession of helicopters be established. Already existing organizations under governmental control are the national SAR services and the national defense forces.

The main reason to recommend helicopters rather than airplanes for the first phase of the survey is flight security. Several hours of continuous flying at an altitude of 50 – 100 meters and a horizontal velocity of 200 km/h puts an enormous stress on the pilots, thereby reducing their capacity to perform the tasks of the mission in question. Also, the ever changing topography together with obstacles like TV and radio masts and electric power lines, require an extreme maneuverability of the aircraft, which has to perform rapid changes in velocity and altitude. These demands can only be met by helicopters and highly trained personnel.

Airplanes could preferably be used in the later phases of the survey, when the general distribution of the fallout has already been roughly determined.

For collection of air filter samples, airplanes are to be preferred over helocopters.

The use of the national SAR services and/or defense forces will ensure that maintenance and training is built into the organization.

10.6 Measuring equipment

It is recommended that the airborne detector equipment is highly automated and independent of physicists and other experts during missions.

Geiger-Müller counters are recommended for basic installations, both for total gamma measurements and dose monitoring by crew members.

For navigational purposes GPS receivers are recommended, as this system is very reliable, offers high accuracy and receiver modules are inexpensive.

The operator interface should be built around a rugged computer (PC or similar type), which can handle the following tasks:

- Operator interface for the detector equipment for configuration, setup and pre-mission calibration
- Display of
  - 3-D position reports
  - measurement data
  - status information from connected instruments
- Exchange of text signals via data radiolink with the command center

10.7 Central computer

The main computer system at the national command center should be sufficiently powerful and flexible, taking into consideration the demand for dynamic decision making in acute situations, often based on measuring data from mobile units. Data and information from many different sources must be combined, processed and presented immediately in a simplified form.

10.7.1 Hardware

To achieve this, databanks in the main computer must be prepared and updated currently – which requires large disk capacity. The computations during the acute situation demand high-speed hardware. Not to forget that several users of the system will be working independently in parallel.

The configuration of the computer center will thus either comprise several separate computers interconnected via a network, or it will be a mainframe or a minicomputer system offering multitasking and multiuser facilities. Furthermore, the main computer system must have external modem connections to

- Corresponding command centers in neighboring countries
- Other international authorities or organizations
- Meteorological institutes
- Nuclear research centers
- Government, Civil Defense, Police and Military authorities

10.7.2 **Software**

The application software should include facilities as:

- Handling the communication protocol to the aircraft
- Logging of all signals
- Dynamic dose control of all aircraft and crew members
- Display of the aircraft's current position on a computer generated map
- Simultaneous display of several areas, which are being surveyed
- Presentation of calculated contaminated areas on computer based maps
- Exchange of text signals between the aircraft and the command center
- Training facilities with set-up parameters for simulated accidents
- Replay of "historic" events from the log
- Detailed map data
- Databank with general information

10.7.3 **Basic data**

To present data in a way which can be easily understood, it is often necessary to combine the calculated contaminated areas with topographical data in the form of simplified computer generated maps.

The following data should be fed into the computer in advance:

- All necessary map data (in grid or vector form)
- Normal background and similar data for purposes of future comparisons
- Administrative data such as
  - population density
  - administrative borders

Most of the basic data above already exist in the separate national institutions. It is thus important that preparation of the basic databanks is done already when designing the command center's computer system.

10.7.4 **Basic software**

For operational systems utilizing mainframes or minicomputers, Unix with X11-Windows is recommended for graphical interfacing. If PCs or similar computers are used, OS/2 or Windows-NT is recommended.

C, FORTRAN and Pascal are the recommended programming languages.

The recommendations above ensure the highest degree of freedom as regards the choice of hardware. This is advantageous since it is normally difficult to define hardware standards. Also, the restrictions in the freedom of choice in software are kept at a minimum by applying the above recommendations.

10.8 Organizational considerations

10.8.1 Airborne surveys in national border areas

As airborne fallout from nuclear accidents does not respect national borders, the question of cooperation between two neighboring countries may automatically arise.

The problem may be solved in different ways. Either the total responsibility is left to one of the countries for predefined border areas. This implies that aircraft from the responsible country are allowed to cross the national border during survey missions. Another possibility is that the activities are coordinated between the countries, making border passages unnecessary.

Some of the practical problems in combined and coordinated surveys are:

- Bilateral agreements must exist, including contingency plans for the initiation of surveys, comprising all formalities such as
  - recognition of the fact that an emergency is at hand
  - identification of responsible authorities in both countries
  - clearance with military authorities
  - procedures for tactical mission control during surveys
  (This latter point being the most important one for ensuring flight security)
- Communication channels for voice and data must be prepared. If the aircraft are using NMT, GSM or Mobitex radiolinks, some technical switching problems must be solved with the national PT&T authorities in planning the organization.
- Procedures for exchanging measurement data as well as results between the two national emergency preparedness organizations during and after the accident must be set up. This is important because further processing and interpretation of these data may differ in the two countries, taking political and similar considerations into account.

10.8.2 Utilizing SAR helicopters

The practical and economic advantages in using SAR helicopters and the SAR service organizations in general have been mentioned above and are discussed in greater detail in the complete final report on the BER-23 project.

When investigating a possible Nordic cooperation, some additional advantages from an organizational point of view deserve to be mentioned:

- Existing internordic collaboration
  The Nordic SAR services collaborate daily in their normal work. This means that they are already familiar with each other's aircraft, procedures and capacity. They also know how to communicate and ensure flight security in combined rescue operations.
- Governmental control
  The Nordic SAR services are public institutions, mainly under the respective military services. Thus they form part of a larger organization with its own established maintenance and training facilities. It is therefore easy to implement new tasks and ensure the execution of relevant standardization and training programs.
- Large capacity
  The great number of aircraft, trained crews and technical facilities of the rescue

services offers a reserve capacity, which would be difficult to achieve in other ways within reasonable economic limits.

10.8.3 Prerequisites

The cooperation between SAR services and the national emergency preparedness organization must work smoothly in an acute situation. It is therefore mandatory that realistic exercises are performed regularly. Hence, airborne surveys must be included in the normal program of the SAR services, and funds made available for that purpose, in order to ensure a reasonable degree of readiness at all times.

10.9 Future development

The BER-23 project has left several questions only partly answered; and new questions and areas of interest in aerial survey systems have been defined but only investigated briefly. The following subjects either need further investigation or may be developed into new projects:

1 Internordic cooperation with SAR services
A long scheduled exercise with participants from the SAR services of two Nordic countries should be conducted, using the existing framework of the Swedish – Danish Barsebäck organization. The results would include:
- Experience in tactical missions control
- Cooperation between two national command centers
- On-line data transmission using two national public networks

2 Further technical investigations
Referring to the technical parts of the BER-23 project, further investigations would be of value on the following subjects:
- On-line data transmission
It would be valuable to investigate in detail – and perhaps through tests – the possibilities of using the NMT and Mobitex public networks as radiolink from aircraft to the command center.
- Navigation
The accuracy of 100 meters of normal GPS equipment could be enhanced to 10 meters by using differential techniques or off-line post-mission corrections of the raw data.
- On-line, on-board spectrum analysis
Modern, powerful computers apparently have the capacity to perform the desired calculations.

3 International cooperation
Under the BER-23 project contacts were established with French and Russian organizations in order to investigate existing systems for airborne radiological measurements.
The French contacts have now developed into a closer cooperation between Danish and French emergency preparedness organizations. The parties have

agreed to cooperate in order to develop methods and equipment. (See the BER-23 final report, Appendix D, for details.)

The Russian contacts were established during meetings in Moscow in June 1993. Detailed information on the technical and organizational status of the present Russian preparedness systems was given. Close personal contacts were also established and have since been expanded, mainly in order to exchange information and find areas of common interest. (See the BER-23 final report, Appendix F, for details.)

It might be of value for the Nordic organizations to make use of and expand these international contacts.

11. Concluding remarks

Past experience shows that early warning and radiation monitoring will play an increasingly important role in the future, and cannot – or will not – be the concern of single nations but rather of regions or continents. The issues below have been raised by individuals or bodies taking part in the Nordic project presented in this report. Some are merely a statement of facts, whereas others reflect plans, hopes or aspirations. The views expressed below are not necessarily shared by the authors of this report, by NKS or by concerned national or international organizations. The questions brought up here are, however, interesting and challenging enough to warrant further discussion.

- Nordic and international harmonization of early warning and information policies, decision making, intervention levels, countermeasures etc. should be further developed. The IAEA as well as the Nordic countries could play a leading role in this work.
- Work to facilitate bilateral and multilateral agreements on early warning, notification and exchange of information and data should be prioritized.
- The European Union and IAEA are discussing a joint system for transfer of radiological data (gamma dose rates and nuclide specific measurements). Once this system is fully developed, it might prove valuable for all Nordic countries to adopt it.
- Compatible systems for transmission of radiological data and other relevant information between the Baltic Sea states region, Iceland and Norway would be valuable.
- One can foresee multilateral agreements giving access to national computerized bulletin board systems (BBS) or databanks in all Nordic countries, Estonia, Latvia, Lithuania and Russia; at a later stage also in other European countries.
- Only radiation data that have been cleared by the proper authority should be available to other organizations or countries via the national databank or BBS. The necessary process of scrutinizing the data should not take more than 3 – 6 hours.
- It should be considered whether a system similar to that of Téléray in France should be adopted in the Nordic countries. If the answer is Yes, it would mean that radiological data from all gamma monitoring stations (and possibly also other types of measurement data) would be available to the general public on text TV.
- The ISDN network will offer more flexible and modern telecommunications with all monitoring stations. It is planned to be a worldwide system for exchanging data services via the public telecommunications system. Once in operation (within 2 – 3 years), it will make possible on-line full duplex communication with all automatic gamma monitoring stations. This, together with a new generation of data loggers offers a possibility for alarms directly from all stations, and not only when polled (as is the case for Nordic NaI(Tl) detector based stations presently).

- Continued Nordic cooperation in the field of rapid data exchange is recommended. The development of agreements, regulations, routines etc. within the European Union (EU) should be closely watched. The Nordic experience may prove fruitful in future discussions on EU policies in this field.
- International (not just Nordic) drills and exercises regarding exchange of information and measurement data will be organized regularly in the future.
- Denmark and France are engaged in a cooperation program regarding airborne measurements, which could be extended to involve all Nordic countries.

12. Additional information

Additional information can be obtained from the following national authorities and organizations:

Denmark

Danish Emergency Management Agency
(Beredskabsstyrelsen, BRS)
Datavej 16
DK-3460 BIRKERØD

Risø National Laboratory
(Forskningscenter Risø)
P. O. Box 49
DK-4000 ROSKILDE

National Institute of Radiation Hygiene
(Statens Institut for strålehygiejne, SIS)
Frederikssundsvej 378
DK-2700 BRØNSHØJ

Finland

Ministry of the Interior
(Sisäasiainministeriö, Inrikesministeriet)
PB 257
FI-00171 HELSINKI

STUK
(Finnish Center for Radiation and Nuclear Safety, Säteilyturvakeskus, Strålsäkerhetscentralen)
PB 14
FI-00881 HELSINKI

Iceland

Icelandic Radiation Protection Institute
(Geislavarnir ríkisins)
Laugavegi 118 D
IS-150 REYKJAVIK

Norway

Norwegian Radiation Protection Authority
(Statens strålevern)
P. O. Box 55
NO-1345 ØSTERÅS

NILU
(Norwegian Institute for Air Research, Norsk Institutt for Luftforskning)
P. O. Box 64
NO-2001 LILLESTRØM

Sweden

SSI
(Swedish Radiation Protection Institute, Statens strålskyddsinstitut)
SE-171 16 STOCKHOLM

Monitoring Artificial Radioactivity in the Nordic Countries

The Nordic countries are covered by a network of stations for the measurement of radioactive material, whether it is airborne or deposited on the ground. Even minor contamination can be revealed, and therefore the stations have an important function in the emergency preparedness systems established in each of the countries. A scheme has been worked out so that warnings can be transferred across the borders to neighboring countries.

The Nordic Committee for Nuclear Safety Research - NKS
organizes pluriannual joint research programmes. The aim is to achieve a better understanding in the Nordic countries of the factors influencing the safety of nuclear installations. The programme also permits involvement in new developments in nuclear safety, radiation protection, and emergency provisions. The three first programmes, from 1977 to 1989, were partly financed by the Nordic Council of Ministers.

The 1990 - 93 Programme
Comprises four areas:

* Emergency preparedness (The BER-Programme)
* Waste and decommissioning (The KAN-Programme)
* Radioecology (The RAD-Programme)
* Reactor safety (The SIK-Programme)

The programme is managed - and financed - by a consortium comprising the Danish Emergency Management Agency, the Finnish Ministry of Trade and Industry, Iceland's National Institute of Radiation Protection, the Norwegian Radiation Protection Authority, and the Swedish Nuclear Power Inspectorate. Additional financing is offered by the IVO and TVO power companies, Finland, as well as by the following Swedish organizations: KSU, OKG, SKN, SRV, Vattenfall, Sydkraft, SKB.

ADDITIONAL INFORMATION is available from
the NKS secretariat , POB 49, DK-4000 Roskilde, fax (+45) 46322206

The Nordic Council of Ministers

ISBN 92 9120 679 2
ISSN 0908-6692

Monitoring Artificial Radioactivity in the Nordic Countries

1995:559