Meeting of Experts on

“External Dose Rate Monitoring at the Schauinsland Intercalibration site”

Freiburg, ”Black Forest”, Germany

November 28th - 30th, 2007
Introduction

The German Federal Radiation Protection Office (BfS) hosted a meeting on "external dose rate measurements at the Schauinsland intercalibration site" in Freiburg from November 28th to 30th 2007. BfS invited institutions from abroad, which are operating a gamma dose rate (GDR) probe at the Schauinsland site. This group was extended by partners from CBSS (Council of Baltic Sea States), as well as from the EURADOS, AIRDOS and INTAMAP projects. During the meeting participants from national GDR networks gave presentations about the actual status of the modernization of the national dose rate monitoring networks. In addition inequalities and heterogeneity due to differences between national monitoring networks were discussed in great detail. The BfS introduced the intercalibration facility which can be used by all partners. The main purpose of the intercalibration facility is to enable the operation of mixed types of GDR sensors in the German GDR network as well as to support the EU harmonization process, where different detector types are used in most countries.

Part of the meeting was a general overview about the results of the intercalibration experiments done at the Schauinsland intercalibration site in the past years with emphasize on the different response of detectors to terrestrial, secondary cosmic and airborne radioactivity and the influence of the so called self-effect. Actual results of the EURADOS intercomparison experiments performed at the PTB intercomparison facilities in summer 2006 were considered and a new simplified approach of siting characterisation and compensation was presented.

In addition, presentations were given during the meeting concerning data harmonization procedures already applied in the european networks, especially in the CBSS and EURDEP framework including the output of these efforts. Furthermore, the thesis work of Thomas Szegvary from the university of Basel was presented, concerning the correlation between dose rate and radon flux allowing the generation of seasonal mean Rn-222 flux maps with high spatial resolution used in the validation of atmospheric tracer applications. This work strongly depends on the quality of the dose rate data available from the European data exchange platform EURDEP which was described in the presentation of Peter Bossew including a detailed description of the AIRDOS project dealing with harmonization of dose rate data. The INTAMAP project and a report on "Inequalities and heterogeneity due to differences between national monitoring networks" was presented by J.-O. Skoien. These presentations were complemented by Paul Hiemstra who introduced automated interpolation techniques developed at the Universities of Utrecht and Wagening in the so called RGI-182 project in cooperation with the Dutch office of radiation protection (RIVM).

Summary

The purpose of the meeting was to provide a platform for the discussion of the possibilities of data harmonization with the aim to extend and strengthen the cooperation of experts in environmental monitoring techniques in the future. Since in the past years the cooperation in the framework of the CBSS already showed to be successful, it should be considered to extend it towards other international groups like for example EURADOS and EURDEP.

With respect to the correlation between Radon-222 and terrestrial GDR and the capability of GDR networks to provide data of the terrestrial radiation with high resolution in time and
space, as described in the presentation by Thomas Szegvary there is a strong interest by
modelers of atmospheric processes to have data about the Radon inventory, since these
data can be of interest for the control of the Kyoto protocol. Actual data describing the
Radon flux data can be derived from EURDEP but automatic harmonization procedures
must be developed and applied taking into account the pool of information from the
AIRDOS project. There are several authorized mandates to provide an appropriate
framework mainly EURDEP, AIRDOS and EURADOS, but scientifically oriented co-
operations between institutes and universities should be supported in addition.

Concerning data harmonization most participants agreed, that there will be an extended
need for the harmonization of detection methods and strategies in the operation of
networks. With respect to site characterization it was concluded that the knowledge about
uncertainties due this effect together with uncertainties from the physical properties of the
probe must be improved and should become part of the AIRDOS data base in the future.
Nevertheless the effort for all types of harmonization should be kept as low as possible.

An additional topic of extended interest which was identified during the meeting is the
development and integration of spectroscopic devices. Most participants agreed, that the
introduction of spectroscopic detection methods will be one of the most important steps in
the modernization of environmental monitoring systems, since the nuclide vector is one of
the most important informations in the every phase of an accident. The presentations and
discussions concerning spectroscopic devices showed, that there is a need to develop
calibration procedures as well as techniques to calculate dose rate from the spectroscopic
data. These procedures should be added to the intercalibration and intercomparison
programs and should become part of the EURADOS working group for environmental
dosimetry (WG3). Furthermore the results obtained from these detectors should be
traceable to national standards like the PTB.

An other result of the meeting worth to be mentioned was the statement, that nation wide
GDR networks will in most cases not allow to detect dirty bombs, but at least they provide
information about unaffected areas. From the presentation of Mr. Kuča it became obvious,
that in continental areas the increase of GDR due to rainfall are more pronounced
compared to effects reported for example in France or Germany. It was emphasized, that
there is interest to perform a study comparing rain effect as a function of the distance to the
sea based for example on GDR stations in Czech / Germany / Austria or Finland and to
extend this comparison taking into account of summer and winter effects.

During the meeting a comprehensive set of different topics concerning measurement and
quality assurance techniques, geo-statistic interpolation methods and new developments
where addressed and all participants expressed their satisfaction with respect to the quality
of the presentations as well as the intensity of the discussions. A further INTERCAL
meeting is planned in November 2008 in Freiburg. It is expected that an extended set of
data from the Schauinsland intercomparison site will be available and detailed results,
based on both the usage of the Reuter-Stokes reference device and the application of
calibration procedures will be presented.

Ulrich Stöhlker
## INTERCAL 2007
### Participants

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Agenda

Agenda of the Expert Meeting on External Gamma Dose Rate Measurements and the Schauinsland Intercalibration Site

Wednesday 28.11.2007
14:00  Welcome and introduction to the intercalibration facility at the Schauinsland (Stöhlker, Prommer, BfS)
14:30  National reports on the monitoring networks in Finland (Vesterbaka, STUK)
15:00  National reports on the modernization of the monitoring networks in France (Debayle, IRSN)
15:30  National reports on the monitoring networks in Czech Republic (Kuča)
16:00  Coffee break
16:15  National reports on the monitoring networks in Netherlands (Tax, RIVM)
16:45  Wireless gamma monitoring in Baden-Württemberg (Neff, LFUBW)
17:15  National reports on the monitoring networks in Norway (Dywe)
17:45  National reports on the monitoring networks in Austria (Benedik, UBA)
18:15  National reports on the monitoring networks in Germany (Harms)

Thursday 29.11.2007
09:00  Visit of the Schauinsland site
13:30  Lunch
14:30  Schauinsland intercalibration procedure results (Bleher, BfS)
15:00  The EURADOS intercomparison procedures (Neumaier, PTB)
15:30  The AIRDOS project and the need for data harmonization (Bossew, JRC/Ispra)
16:00  Coffee break
16:15  Correlation between dose rate and radon flux allowing the generation of seasonal mean 222-Rn flux maps in Europe (Szegvary, Uni Basel)
16:45  The INTAMAP project first results (Skoien, Uni Utrecht)
17:15  Automated interpolation techniques at RIVM (Hiemstra, RIVM)

Friday 30.11.2007
09:00  Mobile gamma dose rate measurements (Luff, BfS)
09:20  Simple site characterisation procedures (Bleher)
09:40  Web based data visualization and data flow between Schauinsland and national data centres (Harms)
10:10  Coffee break
10:30  LaBr spectrometry, extension for dose rate monitoring networks (Toivonen, STUK)
11:00  Spectroscopic and semi-spectroscopic dose rate stations (Stöhlker, BfS)
11:20  Development of a digital MCA with integrated datalogger (Dambacher, MFM)
11:40  Discussion of next steps and perspectives
13:00  End of meeting
The Austrian radiation early warning system has experienced a huge modernisation step for the gamma measurement stations and the main hardware until the year 2003 as mentioned in several presentations and reports before. After that one major goal was the relocation of the federal radiation warning centre from a military area to the federal ministry in 2006.

In the course of that we established remote access to all systems over different access technologies via internet including mobile access over HSPA. With the new centre came also a connection to each federal alarming centre in Austrian Provinces and the ministry of interior over leased lines. ISDN is now used only as a backup connection.

In summer 2007 the change of the data transfer technology from old analogue lines to TUS (“Telemetry and Security Network”) for all Austrian ambient dose rate meters was finished. With this connection the availability and remote serviceability increased significantly.

During the preparation and change-over of the connection to our measurement sites we accomplished the harmonisation of many locations of our ambient dose rate meters (approximately 60 %, mainly from 2004 to 2006). The preferred location for the probe is always a meadow with no obstacles around, but due to the fact that grassland is not available everywhere we accepted a flat roof as well for the harmonisation process. At every opportunity – if the time allows it - we still want to harmonise a site, in the course of relocation for example. But it seems that one third of our station sites will not be harmonised at all.

A redundant new hot standby data centre was constructed for backup reasons and is ready to operate since March 2007. Nearly all systems are available at this backup centre. In the same year there were also some enhancements of our alarming system. The system is now redundant and a heartbeat polling mechanism was added. An alerting option over SMS Pro (Short Message Service) with delivery guarantee was implemented additionally to the existing alerts via Telephone call and Email.

Concerning the multi- and bilateral data exchange (EURDEP) we established new transfers with Germany since 2006 in addition to our long term exchange partners Slovakia, Slovenia, Czech Republic and Hungary. The ISPRA/EURDEP 2.0 pull modus was activated in October 2007. A data direct exchange with Switzerland is intended for 2008.

Our Aerosol Monitoring Stations with automatic detection of natural and artificial radionuclides in the air (alpha, beta and gamma emitters) in Austria were extended about one device. There are now 10 stations at the Austrian border and 6 stations in the neighbouring countries. In 2008 we want to expand the data collection from foreign countries to 9 stations. We also plan to establish an internet based redundant VPN
connection to all Austrian aerosol sites in 2008 and to neighbouring countries in the future (if possible).

The following larger topics are intended for 2008:

- RODOS Linux with data coupling to early warning system
- TAMOS (Austrian Emergency Response Modelling System) WebGUI
- Radiation Early Warning System: porting/migration to Windows/Single Server
- Emergency data management system - first steps
- Realization/Implementation of IT Security concept
Radiation monitoring network of the Czech Republic
External dose rate monitoring – early warning monitoring

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Abstract

In the first part of this paper overview of components of the Radiation Monitoring Network of the Czech Republic dedicated to external dose and dose rate monitoring is presented:

- Early warning Network (EWN),
- Thermoluminous detectors Network,
- Mobile groups ground-based,
- Airborne mobile groups.

For each of those components layout of monitoring sites, equipment used, monitoring method, data processing and transfer and forms of results presentation is described.

The Early Warning Network of the Czech Republic

![Map of the Czech Republic with monitoring sites marked]
In the second part the EWN is described in more details including:

- measuring points characteristics,
- parameters of measuring equipment and measurement,
- detailed description of data transfer into the central database
- presentation of alert capabilities
- system of spreading the information in case when values above preset thresholds are detected,
- possibilities of controlling the data/information flow in EWN by the crisis staff members.

Typical time-plots of measured values over one-year period depending on monitoring point location (lowlands resp. mountains) are shown and discussed.
The Dutch National Radioactivity Monitoring Network (NRM)
Modernizing the network since 1990

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Since 1990 the Netherlands has an operational national network for the continuous surveillance of the outdoor radiation level. Primarily it consisted of two networks: LMNI and LMR. The LMNI network, which included 300 ambient dose rate monitors, was founded by the Ministry of the Interior. The LMR network, which contained 60 ambient dose rate monitors and 14 air sampling monitors, was founded by the Ministry of Housing, Spatial Planning and the Environment.

These two networks were combined in 1996 which is considered as the 2nd generation of the Dutch network and is called National Radioactivity Monitoring Network (NRM). However, the technical infrastructure to collect the measurement data from the monitoring stations of LMNI and LMR networks remained. The data of both networks were gathered in a central database and presented to the users through one user application. One of the consequences of this transition was the decrease of the network’s density which then consisted of 177 ambient dose rate monitors and 14 air sampling monitors. Additionally, a number of ambient dose rate monitors is added around the nuclear installations at Borssele and Dodewaard.

The first step to modernize the network was to replace the measurement equipment which took place in 2002. Therefore, an EU tender started for the selection of suitable air sampling monitor and supplier. The FAG59S aerosol monitors were replaced by Berthold BAI9128 aerosol monitors. Before implementing the monitors into the network several tests were performed. The improvements were necessary to meet the requirements of the network.

The technical infrastructure of the network was renewed in 2005 which is then considered as the 3rd generation NRM. A central system to collect and display the measurement data replaced the previous infrastructure. A web server is used to present the data to the users. Furthermore, gamma monitors around the nuclear installation of Dodewaard were dismantled in 2005 because the reactor was shut down. In the course of 2005 the connection to the 14 air sampling monitors were converted from the public telephone network to a dedicated IP-VPN. This conversion will also be applied for the gamma monitors in 2007/2008.

In the near future (2008/2009) it is planned to replace the ambient dose rate monitors of the NRM. Moreover, new gamma monitors will be needed for future planned mobile stations.
Real-time automatic interpolation of ambient gamma dose rates from the Dutch Radioactivity Monitoring Network

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Detecting the occurrence, extent and subsequent development of radiological releases is of great importance. Ambient dose rate monitoring networks are used in many European countries to perform this task. In the Netherlands the National Institute for Public Health and the Environment established the National Radioactivity Monitoring Network (NRM).

In this project we propose a system that automatically produces interpolated maps in real-time based on ambient gamma dose rate measurements from the NRM. These maps improve the interpretation of the NRM by providing a visualization of the data and an estimate of the ambient gamma dose rate at unmonitored locations. An interpolation method called kriging is used to produce the maps. Kriging has two advantages:

- Kriging enables the user to account for trends in the data.
- Kriging provides an prediction uncertainty for each prediction location.

A prediction at an unmeasured location is calculated as a weighted average of the surrounding observations. An important issue is the calculation of the weights. In kriging this is done based on the spatial structure of the data. The spatial structure is captured in a function called the variogram model. It plots the distance between a point pair versus the semi-variance, a measure for the difference between these two points. The variogram model is fitted to a sample variogram calculated from the data. We use an initial guess of the variogram model, obtained from the sample variogram, as the starting point a least squares fitting procedure.

At this stage only the type of soil is used as a trend. An additional predictor could be the amount of precipitation, to include the effect of radon washout. The output of an atmospheric dispersion model could be used as a predictor if the location and size of a radiological release is known. Currently the system is designed to work with non-emergency data. If large local values are included in a dataset, the estimation of the variogram becomes very hard. Trying to deal with emergency situations will be a next step in this project.

Interpolation software available from the site of Paul Hiemstra:
http://intamap.geo.uu.nl/~paul
The INTAMAP project first results

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The INTAMAP (INTeroperability and Automated MApping) project is a three year project under FP6 that started fall 2006, aiming at an automated mapping service for environmental variables (www.intamap.org). The service will consist of an interpolation routine that analyses the data and applies the best suited interpolation method in addition to methods for communicating observations and predictions in an interoperable manner (machine to machine communication). In other words, the user will either have the option of uploading a data set of observations that will be used as the source for the mapping procedure, or he/she will be able to apply the methods on a data set from a data base, e.g. the EURDEP data base.

The interpolation methods will include a set of kriging methods, which are methods particularly suited for giving predictions at locations without observations based on actual observations at other locations. In addition, they will be able to estimate uncertainty of the predictions, which gives a reliable indication of the reliability of the results. Other prediction variables available will include areal aggregates (for administrative regions), probabilities of having exceeded a threshold and part of region above a threshold. A range of kriging methods will be included, from very simple and fast routines (inverse distance weighted and linear variograms) to slower, more complex and supposedly better methods based on Bayesian statistics. A thorough examination of the advantages and disadvantages of each method will be carried out, releasing the user from having to consider these different options. However, a validity system will be developed for the advanced user, with the possibilities of testing different interpolation methods on a data set. The system will also include methods for optimizing the observation locations, either for permanent or mobile measurement devices.

All methods will be available through a web-based interface, applying Web Processing Service methods for communication between a user and the interpolation service. Novel methods are developed for communicating uncertainties of observations and predictions. The gamma radiation observations in the EURDEP data base are used as the first test case for the methods developed within the INTAMAP project. These were analysed to identify different sources of heterogeneity in the data, partly based on the AIRDOS report. One of the problems identified was the heterogeneity that can be observed between networks within and between countries, and that could only partly be described through the findings of the AIRDOS-report. One of the first methods derived was therefore a method to identify and adjust for biases between networks. The method is based on predictions of the gamma radiation based on different parts of the data set, to be able to identify differences between the data set. The figure below is based on an example from the Slovenian network, where there are different networks with different characteristics. We applied the method, and
estimated differences between three networks, of a magnitude that was later confirmed by the Slovenian Nuclear Safety Administration (SNSA). Removal of these biases changes the appearance of interpolated maps. First of all, the range of observations is substantially reduced (top right panel to bottom left panel). Second, the pattern is different (top right panel to bottom right panel). We think the bottom left panel gives a much more correct impression of the radiation situation in Slovenia.

Figure 1. Top panels: The average observations of gamma radiation in Slovenia (left) and the interpolated map before removal of the identified biases (right). The colour scale under bottom left panel apply for these two panels. Bottom panels: The interpolated map after removal of the identified biases with same colour scale as top panels (left) and a similar map with different colour scale (right).

Similar methods have also been developed for estimating biases between countries. Hence, it is possible to interpolate maps that are more homogeneous, and that better exhibit the true spatial patterns of gamma radiation.

The methods implemented so far are best suited for mapping in routine situations. However, the aim of the project is develop interpolation methods also suited for emergency situations. Automatically interpolated maps can in such situations provide an important tool for decision makers when considering the type of counter measures to apply.
Based on European law (Euratom), the JRC collects data of national automatic radiological early warning systems. Data represent external gamma dose rate (GDR) and activity concentrations of radionuclides in air. Sampling is national responsibility, and for legal, political and other reasons sampling and measurement, as well as data processing and evaluation methods vary considerably between countries. As a consequence, data transmitted to the JRC, and presented and stored in the EURDEP system, are not entirely comparable, although they nominally measure the same physical quantity. This may make data difficult to interpret and is therefore a potentially serious QA issue. This is the rationale of the AIRDOS project, aimed to produce an “inventory” of monitoring networks and methods used by them, identify and quantify differences, and make suggestions for harmonization, where deemed necessary and reasonable.

The data which are generated from the true physical process to be assessed, result from a sampling system which is controlled by many “factors” on different conceptual levels: topological network design (spatial distribution, number of stations); station siting (e.g., which height above ground); detector physics and settings (type of detector, counting time); data processing (e.g., correcting for detector background); data aggregation (e.g., calculating means on station and network level); data filtering (e.g., excluding detector malfunction events). Thus, data transmitted to the JRC represent estimates of the process which sometimes underwent substantial processing steps. The data are generated and collected for detecting a possibly harmful radiologic event. Identifying an event, or signal, requires detecting and identification criteria; as next step, identified signals must be classified. These criteria are external quantities (e.g., politically defined, like which alarm threshold to be set) but their implementation into an algorithm also requires knowledge of the statistical properties of the signal and its background.

For this presentation we limit ourselves to the GDR monitoring networks. With some examples we show the differences of the “factors” between networks: network topology as consequence of different network purposes; differences in station siting and set-up; the choice which GDR-related physical quantity is reported; possible inconsistencies in estimating detection limits. We illustrate the possible consequences of such difference with one particularly striking example, the dose-rate “jump” across the Netherlands-Belgium border. We further give some thoughts about identifying spatial and temporal patterns of radiological events, and finally attempt to formally quantify the degree of harmonization between systems.

The result of the AIRDOS project is not only a wealth of technical details, but also a better understanding of the actual and possible (in the case of a true radiological emergency) performance of these different systems, from the point of view of a European-wide picture of a situation. We also identified a variety of open problems, mainly related to detector
response in detail, data processing, statistical questions, network-level response in terms of aggregated variables to a given scenario. Some problems remain unresolved for lack of data, some because analytic methods to tackle them are yet to be developed. What has also not been addressed so far, and therefore remains open pending further investigation, is data transmission on a hardware- and software level.

Authors of the AIRDOS study are, apart from the authors of this presentation, U. Stöhlker (BfS Freiburg, Germany) and U. Wätjen (IRMM / JRC, Geel, Belgium). Additional contributions came from many colleagues from all around Europe.
The European Radiation Dosimetry Group (EURADOS) is a scientific society founded in 1981 to stimulate the collaboration between European laboratories in the field of dosimetry of ionising radiation. Main activities of EURADOS are the collection, processing and dissemination of information on research in dosimetry of all types of ionising radiation, and on the practical co-ordination of ongoing research projects and joint planning of future programmes [1]. The various fields of dosimetry are covered by different working groups. The working group “Environmental Radiation Monitoring” (WG3) has been established in 1994. The main aims of WG3 are the harmonisation of external environmental radiation monitoring in Europe, the stimulation of co-operation between calibration facilities for environmental dosimetry, the establishment of new reference field stations, the development and publication of technical recommendations for dosimetry measurements in environmental radiation fields and the organisation of intercomparison programs.

In 1999, WG3 organised the first intercomparison of dosimetry detector systems operated at national networks used to provide early warning in case of a nuclear accident [2]. It was held at the Risø “Natural Environmental Radiation Measurement Station” in Denmark and at the underground facility “UDO” of the Physikalisch-Technische Bundesanstalt (PTB) in Braunschweig (Germany). When the engagement in environmental dosimetry of the Risø institute ceased, due to the lack of financial support, the PTB established new reference sites on their premises in Braunschweig as well as a cosmic radiation field station on a lake close-by. The latter was financially supported by EURADOS. In 2002 and 2006 two further intercomparison exercises were performed at these new PTB reference sites for environmental dosimetry. The unique combination of the ultra-low background Underground Laboratory (UDO) and two free-field sites (a floating platform on a lake showing an almost pure cosmic radiation field and a free-field gamma ray irradiation facility) provide the opportunity to precisely quantify the “self-effect” of the detectors and to calibrate them almost free of any background and traceable to PTB’s primary standards. In addition, the sensitivity of the detector systems to small dose rate variations, similar to that caused by a radioactive plume passing by, are studied under realistic free-field conditions. A detailed description of the PTB reference sites as well as results of the 2002 intercomparison are given in [3]. As part of the 2002 exercise, an in-situ gamma spectrometry intercomparison was performed simultaneously to the dosimetry intercomparison at the same reference sites.

In total, fourteen European countries, represented by more than 40 scientist and technicians, participated in these three intercomparisons. More than 50 different dose rate detectors were investigated. As an important result, these exercises clearly revealed the need for further efforts towards harmonisation in European environmental radiation monitoring. In some cases, discrepancies observed between the results of different countries would still be unacceptably high in the case of a real emergency situation.
Therefore, a forth intercomparison will be held at PTB from September 8 to 12, 2008 and further exercises are envisaged.

The reasons for significant discrepancies observed in dose rate values reported by different environmental radiation monitoring stations are manifold. The EURADOS intercomparison program so far focused on the basic technical features of dosimetry systems, like their responses to cosmic and to terrestrial radiation, their inherent background, the energy dependence of the response and its linearity at low dose rates. In addition, EURADOS WG3 intercomparisons aim at the implementation of the operational quantity *ambient dose equivalent, \( H^*(10) \), introduced by the Council Directive 96/29/ EURATOM. Therefore, the participants are asked to report their results in terms of this quantity.

The EURADOS intercomparison procedures as well as the PTB reference sites for environmental dosimetry were presented and discussed in this workshop. It turned out, that the approaches of EURADOS WG3 and of the BfS inter-calibration facility “Schauinsland” are complimentary. The participation at regular intervals, in the EURADOS intercomparison programmes and in the inter-calibrations performed at “Schauinsland”, as recommended by AIRDOS to their members, is considered to be a prerequisite to improve the consistency of environmental monitoring results in Europe. A closer co-operation between EURADOS and the AIRDOS community would therefore be beneficial for both sides, as both, the efforts of AIRDOS and EURADOS are strongly directed towards harmonisation of environmental radiation monitoring in Europe.

References:


Radiation emergency monitoring and its value for other applications

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After the nuclear reactor accident in Chernobyl in 1986, most European countries established outdoor γ-dose rate monitoring networks for the purpose of early warning in case of a similar accident. As long as no similar accident happens, collected data is of little use in this context. Still, the data contains information on other, related parameters such as $^{222}\text{Rn}$ flux (Szegvary et al., 2007a) or soil moisture (Carroll, 1981; Jones and Carroll, 1983). This information could contribute to a robust verification of international protocols (Kyoto, Montreal) by $^{222}\text{Rn}$ tracer technique. It could also be very valuable for improving climate change predictions by providing information on soil moisture to land-atmosphere models (Seneviratne et al., 2006). To serve such purposes, additional information regarding the reporting stations is necessary. Efforts towards harmonising national networks (EURADOS, AIRDOS) have been very useful and currently allow to extract the terrestrial component from reported total γ-dose rates (EURDEP), forming the basis for a European $^{222}\text{Rn}$ source description (Szegvary et al., 2007b). To continue to be useful in future, station specific information has to be continuously updated. For further improvements it would also be necessary to identify those stations that are installed above natural soil. Compared to setting up and operating outdoor γ-dose rate monitoring networks, it is an almost negligible effort to generate such additional information. Yet, the availability of it decides on whether collected γ-dose data is useful or not to a large and growing community of scientists and decision makers in the field of climate change.


Szegvary, T., Leuenberger, M.C., Conen, F.: Predicting terrestrial $^{222}\text{Rn}$ flux using gamma dose rate as a proxy, Atmospheric Chemistry and Physics, 7, 2789-2795, 2007a.

Review of the Renewal of Dose Rate Monitoring Network in Finland

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Finland, like many other European countries, built its external dose rate monitoring network after the Chernobyl accident. This network needed to be renewed. The actual renewal of the dose rate monitoring network started at the beginning of 2005 and finished in the end of 2007. Before the renewal, there was a thorough planning and testing phase.

The Radiation and Nuclear Safety Authority (STUK) started to design a new monitoring station and its features during 2003. STUK realized quite soon that several other countries in Europe also had renewals of networks underway or were about to start similar network renewals. In order to make future monitoring networks as harmonized as possible, STUK organized a small expert group working for the Council of the Baltic Sea States in March 2004.\(^1\) This expert group defined 12 recommendations to be taken into account when designing a monitoring station.

STUK began its own development and hardware testing and based its hardware and functions of the monitoring station on these 12 recommendations. At first there were some difficulties to get the manufacturers to meet STUK’s requirements but this was quickly solved and compatible hardware that fulfilled STUK’s requirements were soon available on the market.

The new monitoring station is based on embedded Linux computer and the station functionality is built on MySql-database. All software is presently written at STUK. The communication of the station utilizes a TETRA-based radio network VIRVE, which is for authority use only.

The funding for the renewal was supplied by the National Emergency Supply Agency. The total costs were 2.4 M€. Today 250 monitoring stations have been renewed. The total number of stations decreased slightly but STUK will increase the number of monitoring stations within few years. The target number of monitoring stations is 265 operational stations. From the experience of these few years of running the new monitoring stations, it can be said that the renewal has been successful.

**LaBr₃ Spectrometry for Environmental Monitoring**

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In 2005-2007 Finland renewed its country-wide monitoring network of 260 stations. As a result of the process, the ambient dose rate is measured with Geiger counters and transferred in real time to the headquarters of the Radiation and Nuclear Safety Authority (STUK) and to regional Emergency Response Centres. When the renewal was initiated, the use of NaI spectrometers was considered. These, however, do not have energy resolution good enough for resolving I-131 (364 keV) from natural radiation (Pb-214 at 352 keV). It was envisaged that in future better detectors will emerge and therefore, the station infrastructure must support spectrometric measurements.

Nowadays detectors based LaBr₃ are on the markets. The devices are compatible with standard nuclear electronics and they can be easily connected to a data acquisition system, such as a Linux-based computer at the monitoring stations of STUK.

LaBr₃ detector has excellent properties for environmental monitoring. The detector is large enough (sensitivity) and it has good energy resolution (2.5 - 3 %) as compared with NaI (6 - 7 %). There are two major technical drawbacks which may prevent the usage of LaBr₃ detector for monitoring purposes. Firstly, the material contains impurities of La-138 and Ac-227 which give a nasty background. Secondly, the light output of the material varies as a function of temperature deteriorating the quality of the spectrum (broadening of peaks).

The detector background can be measured accurately in a lead castle. Then, after live-time correction, this spectrum can be subtracted from the monitoring spectra without disturbing statistics essentially. However, absolute stability of the energy calibration is required. This was solved by fitting the La-138 contamination multiplet at 1436-1468 keV (gamma + X rays) using a novel algorithm which treats peaks as a family, not as individuals. The analysis provides peak shift in channel units. The software then adjusts the gain of the amplifier and moves the peak to its original position.

The prototype system controlled by software is stable, provides environmental spectra of excellent quality and is fully automated. The spectra are sent by a secure government communication link to a central database for analysis by an automated pipeline. The study shows that the new technology is mature to be adopted in environmental monitoring.
A LaBr$_3$ spectrum measured on the roof of STUK headquarters in Nov 2007.

Automated analysis of La-138 contamination for energy stabilization.
Development of CZT detectors in cooperation between FMF/University of Freiburg and BfS

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In 2004 BfS and the Freiburg Materials Research Center of the Albert-Ludwigs-University (FMF) have started a cooperation with the goal to develop gamma detectors with spectroscopic capabilities based on the room-temperature semiconductor material (Cd,Zn)Te (CZT). FMF has developed different types of CZT based detectors over the last years and large volume CZT crystals were grown and processed at the FMF. For the characterisation of these large volume detectors a special measuring infrastructure was set-up at FMF which allows to measure the parameters of charge carriers in CZT crystals (holes and electrons) like for example velocity and life-time in vacuum. The signals from the detectors are passed through a charge sensitive amplifier and are digitized using a high grade oscilloscope which allows the analysis of the signals on a digital basis. A specific technique was applied and developed which is called bi-parametric analysis. With this method besides the amplitude of the signal from the detector, the rise-time is analyzed in parallel. Signals with slow rise-time known to be produced by charge transport of holes can be corrected which will optimize the overall resolution of the detection system. Based on this method the energy resolution of the detectors grown and processed by FMF could be improved to about 2 % at 662 keV. But one restriction of the detectors grown so far at FMF is that a good energy resolution was only achievable with crystals of reduced thickness of about 1mm. Thicker crystals show only poor energy resolution.

In addition to the infrastructure set-up do characterize CZT detectors, two portable digital MCA systems have been designed which are based on the microDXP (Digital X-Ray Processor) from XIA and includes all electronics like ADC and FPGA for the processing of the gamma energy proportional signal and the generation of 4k-spectra. Using on this device, CZT, GeHP, CsI and LaBr$_3$ based detectors have been operated at FMF.

Since it is well known that commercially available multi channel analysers are very expensive, the limiting factors in setting up complete spectroscopic units are not only the detector but the electronics as well. Therefore FMF has started the development of a digital GMCA (Gamma ray digital filter analysis and Multi Channel Analyzer) which should be competitive with respect to costs and performance. This system integrates the complete electronics for a standard Geiger-Mueller based gamma dose rate detector including high and low dose tubes, as well as a multi channel analyser unit. The MCA can be used for all types of detectors like GeHP, CsI, NaI, LaBr$_3$ or CZT. Since BfS needs to renew all detectors within the next 10 years, one option could be to use the GMCA as standard electronics for all modernized detectors – independent on the type of detector selected.
**Spectroscopic and semi-spectroscopic dose rate stations**

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At the Schauinsland Intercalibration site spectroscopic devices are in use since about one decade. One system still in operation since 2000 is the so called NanoSpec detector developed by Target based on a 2” NaI scintillator including a photo multiplier (PM) and all further electronics like analog amplifier and MCA. The complete system is highly integrated and installed in a water proofen housing allowing its installation on the Intercalibration platform in a distance of about 70 m from the building. Spectra are collected every 10 minutes on the Schauinsland central computer system using RS485 serial line interface. In 2001 a CsI detector developed by EURORAD with a crystal size of 25mm diameter and 25 mm in height and an energy resolution of 10% was investigated. The scintillator is coupled to a silicium diode. The detector operates without high voltage and was connected to a standard analog NIM set-up including the MCA with 4096 channels (4k). The MCA was connected to the central computer system via RS 232 and spectra were collected every 10 minutes. The complete electronics are designed for the application under standard conditions in a laboratory. Therefore the detector could not be placed on the Intercalibration platform. Instead it was installed outside the building close to the wall. The intercomparison of the count rate of the NanoSpec, the CsI and a standard GS05 GM tube used in the German GDR network is shown in figure 1. It can be seen, that the total count rate of the CsI and the GS05 detectors relative to the NaI system are close to 15 and 25 percent, respectively.

**Intercomparison**  
GM-tube, CsI- and NaI- detector

![Graph showing intercomparison of count rates](image)

**Figure 1** Comparison of the count rate of a NaI and CsI detectors with a GM tube

In 2003 the intercomparison was extended using a coplanar grid (CPG) Cadmium Zinc Tellurid (CZT) and a hemispherical CZT detector with a crystal size of 1 and 0.5 cm³ and an
energy resolution at 662 keV of 3 and 5 %, respectively. Spectra from both CZT detectors were recorded using standard NIM electronics.

Figure 2  Comparison of 2 different CZT detectors and a GM tube with a NaI detector

As can be seen from figure 2 the overall sensitivity of the CPG and the hemispherical CZT detectors are in the range of close to 10 and 5 percent compared to the NaI, respectively.

Figure 3  Comparison of a GM tube, GeHP- and the NanoSpec 2” NaI-detector from 21th March to 11th April 2005 during a period of snowmelt. The K-40 activity concentration rises together with the total count rate of GDR, GeHP and NaI detectors; the Pb-214 activity concentration does not follow this trend.
Two years later the comparison was extended using a 10 percent GeHP detector which is still under continuous operation. In the first 2 years the detector was cooled with liquid nitrogen, today an electrically cooled system is used, since filling the detector two times a week with liquid nitrogen turned out to be much too difficult and even dangerous for the personnel involved. The detector is installed in a small cabin with the sensitive detector volume of 1.5 m above ground. A compact 4k MCA166 multi-channel analyser is connected to the GeHP detector providing all analog detection electronics and high voltage. The complete set-up is installed close to the intercalibration platform and the MCA166 is read out every 10 min via RS232. As can be seen from figure 3 the overall sensitivity of the 10 % GeHP crystal is close to 50 percent compared to the 2" NanoSpec detector. The intercomparison was extended considering the count rate in the main gamma transitions of K-40 and Pb-214. Early March 2005, the intercomparison site was covered by snow, which melted almost completely until the 5th of April. It can be seen, that the total count rates of all detectors are rising during this period, since the activity from the soil increases. The Pb-214 activity concentration however, shows a different behavior since it is only related to the atmospheric concentration of radon progenies and not to the radiation from the ground.

Figure 4  The LaBr$_3$ detector installed at the high volume sampler of the Schauinsland trace analysis system for detection of air-borne gamma activity concentration. Eu-152 spectrum measured for one hour is shown on the right side. The detector has an energy resolution of 3 percent.

During the last years, the investigations have been extended in several ways. In total 3 LaBr$_3$ detectors together with 3 digital MCAs from XIA have been ordered. As shown in figure 4 one prototype system based on a LaBr$_3$ detector using standard NIM electronics has been installed close to the filter of the Schauinsland trace analysis system which is used to detect air-borne gamma activity concentrations with an air flow of 500 m$^3$/h and a minimum detection limit of 1 $\mu$Bq for Cs-137.

Due to recently occurring instabilities of Geiger-Mueller based tubes, which possibly due to failures in the production process typically occur in the first months of operation, an investigation was started with respect to the replacement of Geiger-Mueller low dose tubes by alternative detector types. One special requirement added to the general specification of these new detectors is to assume a capability to provide a signal proportional to the energy of the incident photons. Based on this feature, the complete detection system should be...
enabled to distinguish between natural and artificial radiation. Early 2007 a specification was released describing semi-spectroscopic detectors incorporating scintillators or semiconductor based low dose rate detectors and a GM tube as high dose rate detector. An investigation was started together with the ThermoFisher company and 2 systems were installed on the Schauisland intercalibration site and in Rendsburg, which are based on the standard RadEye hand-held gamma dose rate detector used as stationary detector. Both systems are running since January 2007, and up to now these stationary GDR probes using a small NaI crystal have shown an excellent long term stability.

![Image](image1.png)

**Figure 5** The RadEye handheld gamma dose rate detector used as stationary detector

One further pre-requisite concerning the introduction of spectroscopic devices is the investigation of the compliance of the sensitivity of spectroscopic detectors with respect to the IMIS requirements. The sensitivity, which is directly related to the size of the crystal, forms together with the energy resolution of the complete system the most important parameter of spectroscopic devices. The requirements defined in IMIS are a minimum detection limit of 180 Bq/m$^2$ related to Cs-137. This limit has to be compared with the experimentally obtained value of about 1500 Bq/m$^2$ which can be achieved using CZT detectors with a crystal of 1 cm$^3$ in size.

![Image](image2.png)

**Figure 6** The first autonomous CPG-CZT based spectroscopic GDR detector together with a standard GDR probe (in the background) of the German GDR network installed at the Brocken mountain
In 2006 the first autonomous stand-alone spectroscopic device based on a 1.5 cm³ CPG-CZT detector with an energy resolution of 2.8 % at 662 keV together with a SMC-2000 MCA has been installed at the Brocken mountain, at the meteorological facility of the German weather service about 1400 asl. Using the – at that time - new developed linux based data-logger, the spectroscopic device is operated in parallel with a standard GM tube. Spectra are read out every 10 minutes by the data logger and are transferred every 10 minutes to the communication servers in the service nodes of the German GDR network using the telecommunication infrastructure of the German weather service. One further pre-requisite was the extension of the data base in the central servers for the treatment of spectroscopic information. Today all spectra from 3 CZT based spectroscopic devices installed at the Brocken, the service node in Rendsburg and at the Schauinsland intercalibration site as well as the spectra from the GeHP and two LaBr₃ based detection systems installed at the Schauinsland are stored in the standard data base of the GDR-network. Furthermore different tools have been developed allowing the analysis and visualisation of the spectroscopic information.

As a result of these long term developments concerning spectroscopic devices for the application in stationary GDR networks it became obvious, that besides the detector the electronics including the MCA is the limiting factor with respect to the overall costs and performance. Therefore a specification was developed early 2007 describing the functionality of a digital multi channel analyser designed for the application as stand-alone spectroscopic unit. Based on the co-operation with the University of Freiburg it is intended to develop such a device within the next 12 months.
Program for French Radioactivity Alert Network Modernization

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Abstract:
French radioactivity alert networks, set up shortly after the Chernobyl accident, have today more than fifteen years of existence. Some components of these networks (computers, probes, etc) are growing old today and their replacement is becoming essential. Before beginning this programme, IRSN wished to benefit from the experience feedback of the European countries and began technical visits in 2006. Since 2007, studies concerning the sensors allowing the measurement of the ambient gamma dose rate in the air, as well as the development of prototypes for airborne particulates and water radioactivity measurement were initiated. In parallel, the development of a centralizing interface for all data was launched, with the aim of proving the technical feasibility of the adopted solution but also allowing the first tests of the various apparatuses. IRSN intends to modernize the whole tools by the end of 2009.

This presentation deals with the results of the IRSN study, particularly concerning the European technical feedback synthesis and the first achievements of the modernizing project.

Context for modernisation of continuous remote radioactivity measurement networks

Radiological monitoring of the French environment is one of the fundamental missions of the IRSN (Institut de Radioprotection et de Sûreté Nucléaire – Institute for Radiological Protection and Nuclear Safety). In order to complete this mission, the Institute develops and operates four continuous remote radioactivity measurement networks; two networks dedicated to the atmospheric compartment and two networks dedicated to the aquatic compartment. The oldest of these networks, Téléréay, has been in existence since 1991, measuring ambient gamma radiation. If a major radiological event occurs, the airborne path forms the preponderant vector for radioactivity dispersion and population exposure. Knowledge of air contamination is also necessary to make a prognosis about the amplitude of fallout to the soil, so as to decide upon any actions to protect or restrict consumption of foodstuffs. Therefore, networks will be required to participate in all phases of an accident (threat, urgency and post-accident) for a predictive evaluation of contamination and its characterisation until a return to the normal situation.

Internal studies carried out since 2005 about the redefinition of the IRSN monitoring strategy and the analysis of existing networks, have concluded that they must be renovated to achieve maximum efficiency under all circumstances; national coverage adapted to the environmental context and installation risks, sampling and metrology of magnitudes of interest, transfer and data processing efficiency.
In order to guide its choices about the organisation of the future alert network, the Institute wished to share operating experience from European countries. The study carried out in 2006 consisted of collecting information in Europe about the general organisation of networks for remote continuous monitoring of the dose rate and for making automated aerosol measurements. It collected technical information about the different elements forming part of the measurement acquisition system, starting from the type of detector used and any additional sensors (meteorological, spectrometers, etc.), until the centralisation system, including transmission and processing of data.

The results of this study were used to guide some of the Institute’s choices to implement the network modernisation project. In the medium term, this modernisation should be able to provide reliable, reactive and sensitive alert networks capable of detecting radioactive contaminations in the atmosphere at relevant geographic points, at a very early stage.

Technical and functional analysis of the existing situation

At the moment, the organisation of remote monitoring networks is based on completely separate and monolithic networks. Each network has its own communication means, its own centralisation system and its own database. In some cases, the same company has provided all elements making up the network acquisition system, from the sensor to the centralisation system. This concept severely limits capabilities for upgrading and modernising tools.

Figure 1 : Technical axis for modernization

Therefore, modernisation initiated by the Institute naturally turned towards the use of a single modular network. The selected idea was to use a single communication mode for all networks. A centralisation system will be used to collect information from the different types of sensors located in the environment. This technical orientation will guarantee the durability and upgradeability of the system.
Redeployment strategy

Deployment of dose rate probes

The main purpose of the automated dose rate measurement network is to trigger an alert if an abnormal radiological situation arises so that population protection actions can be taken. A uniform geographic coverage of probes over the entire country is necessary to achieve this. Thus, the way in which a radioactive plume varies can be monitored over the entire country in real time. The large urban centres (prefectures and sub-prefectures) will be given priority so as to concentrate monitoring close to populations, and also for ease in installing probes.

Monitoring of nuclear sites will also be reinforced. The installation of IRSN probes will take account of probes already installed by the operator. However, inter-comparison points will be set up to check the consistency of the operator's measurements. If operator data are available, they will be collected by the IRSN Supervisor, as is the case for example with EDF data.

Uniform coverage of the country shall enable good monitoring of frontier zones, particularly through maintenance of probes located on summits. The presence of these probes at high altitude would enable earlier detection of a far radiological event, since air mass circulation velocities are greater at these altitudes. Probes located in adjacent countries shall be kept so as to have points for comparison with probes in European countries. Among other functions, this would be useful for checking the uniformity of radiological values in Europe.

Monitoring of populations in overseas territories and departments shall be continued, and probes located in prefectures in these overseas departments and territories shall be maintained.

Deployment of aerosol monitors

The purpose of automated aerosol monitoring is to quickly qualify and quantify radionuclides present in the atmosphere in the case of a radiological event, to contribute to determining the dose received by the population within the limits of equipment detection possibilities. To achieve this, all of France shall be covered as uniformly as possible, so as to monitor the geographic movements of a radioactive plume in real time.

To support these lines of reflection, the IRSN emergency situations and crisis organisation department is carrying out a retro-modelling study based on a catalogue of typical French nuclear accidents. The results of this study will provide valuable information about the most suitable number of stations and network typology to obtain an optimised network for better early detection of a radiological event.

In the organisation of the future network, it is envisaged to couple aerosol monitors with dose rate probes and possibly meteorological sensors. Thus, these proximity sensors will become genuine diagnostic assistance tools to justify an increase in radioactivity.
Advantages of transportable monitors

The choice of the number of dose rate probes or aerosol monitors making up these networks is a compromise between a good national coverage and an acceptable cost in purchasing probes and maintaining them. One alternative to the use of a large number of fixed monitors would be to use transportable monitors so as to densify a particular zone in case of crisis. Equipment would be deployed in the threat phase and could thus densify monitoring systems on the terrain in the case of a crisis.

These transportable monitors could also provide a solution to contamination of sensors in an emergency or post-accident situation because they could be deployed after the releases have stopped to notify when a normal situation has been restored.

Modernisation of instrumentation

Choices about replacement of radiological sensors in remote measurement networks cannot be made through a choice *a priori* based solely on technical documentation given by the supplier. All these sensors will have to be tested under real environmental conditions to obtain relevant comparison elements. This is why the IRSN considered it essential to set up a technical evaluation platform that will be used to perform synchronised tests of different types of sensors including dose rate probes, aerosol monitors, gamma spectrometry probes, meteorological sensors, etc.

![Figure 2: Platform for tests](image)

Dose rate probes

The study of probe types used in different European countries demonstrates that the Müller Geiger counter is used in most networks continuously measuring the ambient gamma dose rate. The advantages of a Müller Geiger counter over a proportional counter are not clearly defined, except for a historical reason based mainly on cost.

The IRSN did not consider it useful to have a specific probe developed for replacement of probes in the Téléray network, considering that manufacturers of this type of unit have good
operating experience which should not be questioned. Therefore the IRSN chose to acquire the principal dose rate measurement probes currently on the market, so that it could test them by performing a comparative study of their performances. By 2008, this study will be used to select the detector(s) that will replace Rados RD02 probes currently used in the network. A first study will consist of characterising probes based on standard IEC-1017 to determine their behaviour during the different climatic, mechanical, electrical and radiological tests. Later, dose rate probes will be tested on an evaluation platform, more particularly so as to evaluate their reactivity and generally their behaviour when a radioactive source appears or disappears.

Aerosol monitors

In its monitoring network modernisation plan, the IRSN has identified a need to upgrade its automated network for continuous measurement of aerosols, to reduce constraints related to maintenance and particularly consumables. There are some operating difficulties with the existing network, particularly related to severe clogging of the filter.

Modernisation of this network shall make it possible to develop a new aerosol monitor concept. The Institute would like to make a compact monitor capable of beta counting and gamma spectrometry on aerosols. Gamma spectrometry is given priority considering that it is required to use this network mostly for identification of radionuclides.

The IRSN would like to have prototype monitors made based on received technical replies, so as to test them under real conditions. Technical adjustments will be necessary before series development of these monitors, so as to guarantee that the product made complies with the need.

![Aerosol monitor](image)

**Figure 3** : Aerosol monitor (exterior and interior view of the monitor)

**Gamma spectrometry probes in air**

Existing dose rate measurement probes are incapable of characterising radionuclides in a plume in real time. Moreover, during modernisation of aerosol monitors, the problem related to the measurement of iodine and more generally of halogens has deliberately been ignored, to exclude use of consumables in automatic monitors.
One possible way of overcoming these problems would be to envisage using a network of atmospheric gamma spectrometry probes. At the moment, new probes of this type are available on the market. They have better characteristics than any NaI detectors usually used for this type of measurement. In particular, these are LaBr\(_3\), CZT or CsI probes. The tests that will be carried out with these probes in the future will be used to validate the possibility of using them to qualify radionuclides present during an increase in radioactivity. Gamma spectrometry probes in the aquatic surroundings

For monitoring the aquatic compartment, the IRSN has two automated networks of gamma spectrometry probes, one dedicated to monitoring of large French rivers and the other to monitoring of nuclear medicine wastes and for which the probes are located in waste water at the inlet into some treatment stations. The first network does not need to be modernised at the moment because it was set up fairly recently. On the other hand, operating experience with development and operation of the network dedicated to monitoring of nuclear medicine wastes now shows up a number of limits in terms of reliability of the equipment used, its maintenance and the rigidity of the technical architecture limiting the IRSN treatment autonomy. These limits make it necessary to redesign this network. The main purpose of this upgrade is to develop a lightweight and reliable system, particularly concerning metrology, but also the quality of materials used, to perform measurement campaigns at permanent fixed points or during isolated services.

The IRSN will study technical developments concerning the choice of materials and the choice of detectors used in this type of probe.

![Figure 4: Probe dedicated to the nuclear medicine wastes](image)

**Meteorological sensors**

Meteorological data are essential in data analysis when radioactivity increases. Almost all European countries have associated meteorological sensors with dose rate probes and / or aerosol monitors. The main data collected apply to rain, humidity and wind. Following this observation, meteorological sensors will also be qualified on the technical platform in order to evaluate their performance, their robustness and constraints related to their maintenance.
Modernisation of telematic systems

At the present time, the communication method used in France to import data from alert networks makes use of the Switched Telephone Network (STN). However, this network is not completely reliable because it could become saturated in a crisis period and therefore could not guarantee that data are transmitted.

It is necessary that the communication means selected for future remote measurement networks should be reliable, secure and that they tend towards communication in real time. In a crisis period, it is very probable that all communication networks would be saturated, particularly for example with the GSM network. This is why it is necessary to select a telematic system capable of operating under all circumstances, to import data. It is not impossible that this may be done using two communication modes, for example one ADSL for use in routine situations, and the second of the satellite type to enable a backup solution in a crisis situation.

Studies involving different technical and institutional partners have begun to define an appropriate tool to help define the choice of this telematic tool.

Modernisation of supervision

The centralisation system must perform two main objectives. The first consists of automatically importing, validating and storing data. The second consists of efficiently managing alarms by making a relevant analysis of the data and a high performance real time information transfer.

The "Panorama" software package is selected for the future network supervision software. This tool must guarantee modularity of the network, the objective being to be able to interface it with any type of sensors in the environment: dose rate, meteorological, aerosol, etc. The evaluation platform using the "PANORAMA" supervisor has already confirmed the feasibility of a single supervisor supervising several types of dose rate probes and meteorological sensors through a connected network (IP /Ethernet type). The study will be continued for aerosol monitors, so as to reach a more general conclusion about this feasibility.

Conclusion

The main milestones in this modernization allow for the choice of future dose rate probes for the Téléray network by the end of 2008. Before these new probes are deployed, it is planned to use the new PANORAMA supervisor to take control over importing data from existing Téléray probes to check the feasibility of such a project on a large scale. Deployment of new probes will begin starting from 2009. Deployment of automated aerosol network monitors is planned to start in 2010, considering that the series production of this type of monitor will take longer because of the innovative nature of the monitor and consequently constraints related to its series manufacturing.
Radnett is the early warning monitoring network in Norway. It consists of 28 stations evenly distributed all over country, including one station on Spitzbergen. Radnett replaced the old network established in 1986. The work with Radnett started summer 2006 and was completed February 2008.

The stations are based on the GammaTracer XL-3 detector from Genitron. This is a probe with two low dose and one high dose GM-tubes with a total sensitivity of 10 nSv/h to 10 Sv/h $H^{*}(10)$. The network also supports the Technidata IGS421 probe with identical specification. Each station has also a Vaisala DRD 11A yes/no precipitation sensor. Both sensors are connected to a data logger from Scanmatic\(^2\) which handles data sampling, data analysis and communication. The data logger sample data each 10 minute and can store up to 10 weeks of information. The data logger is placed inside a cabinet which also contains a GSM/GPRS modem, power supply, 24 hour battery backup, high voltage protection, isolation transformer and other components. The sensors are usually placed on a 3 meter high pole with the cabinet placed underneath the sensors or inside a neighbouring building.

Each station communicates with a central system through the internet over a GPRS connection. The connection is always kept alive to assure the stations are always available. So far communication over GPRS has worked well. So far our only experience is short periods of communication loss, less than 10 minutes, and also no problems during high traffic peaks like New Year eve. The central system polls data from the station each hour on regular basis. In case of an increase in dose rate the station will alert the central system which then starts to poll the alarming station each 10 minute and will alert an officer on duty by e-mail and sms. If the central system is unreachable the station will send a sms directly to the officer.

After 18 months of operation the experience with Radnett is good. There have been some problems with probes breaking down shortly after installation. This was fixed after installing new probes. And the central system has had some problems with instability due to difficult network infrastructures. These problems have been solved continuously by Scanmatic.

Future development includes:

- Replacing the old AAM-95 probes that monitors air sample filters so that they use the same platform and infrastructure.
- Development of a mobile station that can be used in field applications.
- Over time upgrade battery to support 72h backup power

\(^2\) [http://www.scamatic.no](http://www.scamatic.no)
Here we present a short overview of the nuclear reactor monitoring system of the federal state Baden-Württemberg, Germany. The owner of the system is the Umweltministerium Baden-Württemberg (Ministry for environment of the federal state BW). The technical operator is located in the LUBW (State department for environment, measurements and nature protection Baden-Württemberg). The system is developed by T-Systems, Germany. The aim of the system is to monitor five supervised areas. There are three full rings around the NPPs which are located in Baden-Württemberg (Neckarwestheim, Philippsburg and Obrigheim) and two half rings monitoring the foreign plants in Fessenheim (F) and Leibstadt (CH).

Online data exchange is practiced with various partners emphasizing dose rate networks of the neighbor states and countries and their meteorological data for disperserion calculation. Actually there is about 1 GB traffic to collect and spread data of our data exchange partners. The LUBW is operating three own networks: a wireless dose rate network (120 probes), a radio-aerosol network with 11 stations (proprietary development) equipped with gamma spectrometry yielding in automatic nuclide specific activity concentration measurements. Furthermore there are 11 meteorological stations.

The centre pieces of the nuclear reactor monitoring system are the central data base (data storage and alarming) and the communication server which converts the formats and is doing the push and pull of the data. Both servers are fully redundant windows clusters. Furthermore there are eight application servers located directly at the power plants and the instances of civil protection and disaster management. All data is replicated from the central data base to the application servers in a 1-minute-cycle providing them in case of a network breakdown. The telephonic alerting system is a server equipped with a voice software which is able to phone, send faxes, sms and emails in case of radiological alarms and system alarms like delayed data or lost servers. The server for dispersion calculation is triggered by the central data base in case of a radiological alarm. The data of the dose rate network is published directly online in the internet (http://brsweb.lubw.baden-wuerttemberg.de/brs-web/home.cweb?AUTO_ANONYMOUS_LOGIN).

The wireless dose rate network is equipped with the GammaTracer XL Radio and the GammaTracer Basic type. The system is called Skylink/Shortlink from Genitron Instruments, Frankfurt, Germany. The monitoring sites are located as close as possible to the inhabitants (fire stations, schools, kindergardens, city halls, etc.) building a ring with a radius of 10 km around the NPPs. The dose rate monitoring network is an autarkic system with two data bases on two redundant servers. After the receiver has picked up the data
from a radio probe, it is sending the data via ISDN to the Skylink data base. A redundant transmission via satellite modem is planned for 2008. The security for data transmission between receivers and probes is achieved by the fact, that most of the probes are caught by two receivers: a wide range antenna called Skylink (100 km) and one of four Shortlink receivers covering a radius of 5 – 10 km around each NPP.

 Actually we are testing the methods of Czarnecki et al. (1988) which is calculating mean values of time and site of gross dose rate. The probes of each supervised areas are combined to a so called ensemble to get the site mean of these 30 probes. The time mean is just the sampling interval of the probes (10 min). The aim is to decompose the dose rate into a summary of the total mean, the site specific mean, the time mean and a pure statistical deviation, which is considered to alerting purposes. The limit of detection decreases to 5 nSv/h. This helps to minimize weather effects and to detect defect probes and creeping increases in dose rate.
Mobile real-time NBR-data transfer

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The 5 litres plastic scintillator (FHT 1376) from Thermo is a mobile system for detection of gamma radiation with extreme high sensitivity (1 nSv/h to 20 µSv/h). Tests in the laboratory even showed the increase of the gamma radiation in a closed basement room over the weekend evoked by radon decay products in the air from about 29 nSv/h to 31 nSv/h. The FHT 1376 can differentiate between gamma radiation from natural and artificial sources against fluctuating background conditions. This so called Natural Background Reduction (NBR) system can be used for the rapid detection and location of gamma emitting radioactive sources due to a very small sampling interval of one second. In 2005 the BfS bought 6 of these systems to support the defence group against nuclear hazards (NGA). These systems are also equipped with a separate high sensitivity neutron scanner, alternatively usable to the additional build in GM-tube for higher dose rates. Additionally to the NGA-application, where the main goal is the detection of small scale strong radioactive sources, it is a useful tool for the scanning of large scale contamination after a nuclear accident or a dirty bomb attack. Supported with a GPS (Global Positioning System) radiation data, position and time are recorded on a Windows based notebook. In the original application the measured data can be evaluated only after the mobile measurements has been finished or interrupted. Online data transfer in open file formats are not supported so far. Thus the BfS developed the real-time data transfer to the BfS data centre in an open file format, based on the Thermo software Mobilog. The Mobilog program is still responsible for the communication with the FHT 1376 device, the gamma dose rate and NBR-calculations, while the data treatment is initiated by a batch program together with several small tools.

Additional necessary hardware for the data transfer is only a simple GSM/GPRS modem with a mobile contract. A file parser that transforms the binary data files into different ASCII file formats together with an error tolerant ftp program is the basis of this application. This batch automatically starts all necessary programs on the laptop, activates the stored configuration and gets the actual time from a public time server before the measurement starts. Thus handling of the transfer routines is easy and mainly error reduced. Typical ASCII file formats are supported by the parser program: csv (semicolon separated columns), mwsd (BfS database import file), kml/kmz (Google earth file format for direct visualization) and IDF (IDF 2007). The data transfer interval is variable, beginning with a transfer interval of one minute. This limit originates from the Thermo software, that only save data in a one minute interval to the hard disk. Before the transmission of the data starts, an md5 sum is calculated for the converted files to ensure a correct file transfer (mwsd format only). Thereafter the files are packed with a zip program to reduce the amount of data. Fig. 1 summarizes the internal data flow and the data handling.

The good coverage of the mobile network in Germany allowed a continuously data transfer every 10 minutes during a 9 hours test ride of over 470 km in the northern part of Germany. Anyway, this is not guarantied everywhere, so in case of disturbances in the mobile communication, the ftp program recognizes the failure and the data is stored on the laptop.
As soon as the connection is automatically established again, all data prepared for transfer is copied immediately. Obviously, the original raw data from the Mobilog program and also the transferred ASCII files are also still available on the notebook for local data visualization if necessary. Using this system, the actual data even from different measurement teams can be stored online in the main database of the data centre and from there it can be combined for the evaluation of the whole situation. Thus all information can be combined while the measurement is still ongoing. From the operation control centre the different measurement teams can be controlled and guided while decision makers can be informed during the operation about the actual situation. This offers an optimal information flow and result in fast decisions and reactions.

While the database part in the BfS is not yet completely finished, the State department for environment, measurements and nature protection of the federal state Baden-Württemberg uses the system productively in combination with their KFÜ-client system (Rupp, 2007). The software for the real time data transfer is provided as open source and available from the authors on request.

**Literature:**

IDF; Description of a Data Interface Specific to International Data Exchange Purposes – International Data Exchange Format (IDF), 2007, Version 3.24; BfS-SW2 Freiburg; MUF RP Mainz

Modernization of the German GDR network

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The German gamma dose rate monitoring network consists of about 2000 stations, homogenously distributed over the whole country. Today, the data loggers operated at these stations are more than 15 years old. To modernize the network, the BfS decided to develop a new system in house. Basic requirements of the new data loggers are: IP-based data transfer, compatible to old GM-tubes and logger housing, manufacture independent, cheap, easy to use and robust. As a result, a Linux based data logger based on Axis CPU with own evaluation software has been developed. Together with the intelligent power supply unit, that monitors the rechargeable batteries and the power supply for the tube and the modem, the system operates autonomously up to three days without mains supply. The system integrates two USB ports for e. g. system backup as well as three serial ports supporting in total more than four different measurement devices. Based on the standard Linux features, the data logger supports data communication with modem, fixed network and GSM/GPRS as well as intranet or DSL.

Figure 1  The components of the linux based data logger and possible interfaces

Part of the new system is a microcontroller based counting device (QIS) that counts the pulses from low and high dose GM tubes. The QIS is interfaced with the linux data logger
via RS485. Compared to the old system, the communication between data logger and the QIS as part of the detector is significant error reduced over distances of up to 1000 m and the complete set-up is able to detect technical failures for example with respect to the high voltage as well as typical errors like increased pulse rates from exhausted GM-tubes.

The most important advantage of the new data logger is the ability to integrate detectors from different vendors as well as spectroscopic and semi-spectroscopic detectors. NaI-, CZT- and LaBr$_3$-detectors have been installed and are operated since several months or even years. To ensure the detection of even small radiation events, each station is able to generate radiologically induced alert messages. Threshold values of the measured dose rate data are dynamically calculated, to accommodate the threshold to the different environmental conditions and temporally changes in the background radiation in case of e.g. snow coverage. For the maintenance of the system an html/cgi based user interface as well as different remote commands have been implemented.

In the past 2 years a study was performed based on prognosis calculations in the vicinity of all NPP installed in Germany up to a distance of 200 km. The aim of this study was to investigate a possible reduction of the number on GDR stations. In a first step it was decided to reduce the number on GDR stations along the German boarder, since GDR data are exchanged through EURDEP and radioactive clouds potentially released by a NPP outside the German territory would be detected by the GDR networks of neighbouring countries.

![Figure 2](image.png)  
Figure 2  The German GDR network with 2000 stations together with NPP in Germany and neighboring countries indicated by a circles with a radius of 100 km
Figure 3 The GDR stations which will be removed between 2008 and 2010

From the study it turned out, that for this special scenario the number of GDR stations outside a radius of 100 km around a NPP can be reduced by a factor of 2 without relevant loss of information about the radioactive plume and the radiological situation under standard meteorological conditions. Following this study, the future number of GDR stations in Germany was decided to be reduced to about 1740 probes.

The process of the probe reduction was already started in 2007 and will continue until 2010. In parallel the data loggers in the GDR stations will be modernized using the linux based data loggers describes above and the future network will consist of the following probe types:

- 70 non-spectroscopic autonomous probes of the XL2 type from Genitron,
- 400 probes of the DLM1450 Type (GM-Tube) in the vicinity of NPP
- 200 linux data loggers equipped with spectroscopic probes
- 1070 stations using linux data loggers that will either be equipped with GM-tubes or semi-spectroscopic detectors

BfS plans to put all hard- and software developments to an open source status. Organisations will be free to download the design of the hardware and the code of the software for their own purpose. It was emphasised during the meeting, that this might lead to reference implementations for gamma dose rate monitoring networks in Europe.
During the phase of the modernization of the Schauinsland intercalibration site in summer 2007 the operation of the probes has been interrupted by nearly 2 months. Today most probes are operational since August 2007 and sending data to the participating institutions and the BfS. The data are regularly copied to the central data base of the BfS GDR network and the ftp server in Freiburg. In future the data will be presented via a web based server. The server will not only show radioactivity data and allow a comparison between all types of probes operated at the Schauinsland but also provide access to the meteorological data taken by the BfS at the station. The figure below gives a first impression about the future web interface. Part of the presentation will be a webcam which is planned to provide actual photographs of the intercalibration site on a regular basis every hour.

The web interface to the GDR probes operated at the Schauinsland intercalibration site
In the German gamma dose rate network as well as in most European countries different types of detectors (Geiger-Mueller counters, proportional counters, scintillators and semiconductor based detectors with semi-spectroscopic or even spectroscopic capabilities) are used in parallel to measure ambient gamma dose rate. As can be seen from figure 1 the characteristics of these different detector types shows large variations even with respect to the most important criteria like for example sensitivity, linearity, energy dependence, self-effect and response to secondary cosmic radiation.

![Figure 1](image)

Figure 1  Response of different detector types to the total background radiation at a typical site in northern Germany

A project to compare the response of different detector types was started in 1996 at the Schauinsland mountain close to Freiburg, Germany, where the German office for radiation protection (BfS) runs a trace analysis laboratory since about 50 years. The facility is constructed on the Schauinsland mountain (1200 m above sea level). In contrast to the inter-comparison experiments performed by the European Dosimetry group (EURADOS) (Wissmann et al. 2006) and (Sáez-Vergara 2005) the aim of this inter-calibration experiment is to compare different gamma dose rate detector types over long periods and under rather unfavorable climatic conditions. Thus, the facility is intended to characterise the behavior of different probe types under environmental conditions and it complements the EURADOS inter-comparison exercises, which a carried out every 2 to 3 years and focus on the self-effect and response to secondary cosmic component.
In Summer 2007 the Schauinsland intercalibration facility was re-designed for the simultaneous inter-comparison of 20 different devices measuring ambient gamma dose rate (GDR) under the same environmental conditions. Figure 2 shows the facility with 20 probe holders installed in a circular arrangement with a radius of 5 m. This design allows the simultaneous calibration of all detectors at the same time using radioactive sources.

![Figure 2](image)

**Figure 2** The Schauinsland Inter-calibration facility in Summer 2007

<table>
<thead>
<tr>
<th>Pos</th>
<th>Monitoring network</th>
<th>Device type</th>
<th>GDR (nSv/h)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Baden-Württemberg</td>
<td>XL</td>
<td>GM</td>
</tr>
<tr>
<td>2</td>
<td>Germany (BfS)</td>
<td>GS05</td>
<td>GM</td>
</tr>
<tr>
<td>3</td>
<td>Germany (BfS)</td>
<td>GS05</td>
<td>GM</td>
</tr>
<tr>
<td>4</td>
<td>Germany (BfS)</td>
<td>RadEye</td>
<td>Nal</td>
</tr>
<tr>
<td>5</td>
<td>Netherlands</td>
<td>RS03/232</td>
<td>PC</td>
</tr>
<tr>
<td>6</td>
<td>Finland</td>
<td>XL2-3</td>
<td>GM</td>
</tr>
<tr>
<td>7</td>
<td>Finland</td>
<td>IGS421 A1-H</td>
<td>GM</td>
</tr>
<tr>
<td>8</td>
<td>Switzerland (NADAM)</td>
<td>GM</td>
<td>83</td>
</tr>
<tr>
<td>9</td>
<td>France</td>
<td>Alnor</td>
<td>GM</td>
</tr>
<tr>
<td>10</td>
<td>-</td>
<td>-</td>
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</tr>
<tr>
<td>11</td>
<td>Slovenia</td>
<td>AMES</td>
<td>GM</td>
</tr>
<tr>
<td>12</td>
<td>Austria</td>
<td>RS03/A232</td>
<td>PC</td>
</tr>
<tr>
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<td>Germany (BfS)</td>
<td>XL2</td>
<td>GM</td>
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<td>PC</td>
</tr>
<tr>
<td>20</td>
<td>Germany (BfS)</td>
<td>IGSS10</td>
<td>PC</td>
</tr>
</tbody>
</table>

Table 1 Probes installed at the intercalibration site and the terrestrial component measured at the individual detector positions
After completion of the modernization, the different components of the natural radiation fields at Schauinsland intercalibration facility were characterized. The contribution of charged particles and photons of the secondary cosmic radiation (SCR) takes about 0.05 µSv/h. The terrestrial radiation has a slightly higher value. However, this normal background value can be increased by a factor of 2 or 3 by rain events and reduced to some ten percent by snow cover in winter. As can be seen from figure 3, the variability of terrestrial dose rate contribution at different positions on the intercalibration platform was investigated. This variability is in the range of about 10%.

The terrestrial dose rate contribution is not constant over the whole area and shows a variability between the different positions. It was investigated using a handheld device and differs between 72 and 82 nSv/h. During rain events the background value can be increased by a factor 3 and can be reduced to 10% by snow cover in winter.

Figure 3 Observed dose rate at different probe positions of the intercalibration site measured with a hand-held NBR detector (Type 672 E10) in standard height of 1 m and at 2 positions in height of 1.7 m.

The facility provides rich additional instrumentation: several monitors are operated at the Schauinsland site, allowing to extend the investigation of the GDR detectors by taking into account air-borne activity concentrations of aerosols, nuclide specific activity on ground, intensity of the cosmic radiation, neutron flux, soil moisture, amount of precipitation, air pressure, temperature and for example $^{222}$Rn-exhalation. Today, 18 different detector types are under operation representing about 20 states of the EU. The observed data are transferred to a common data base, thus allowing systematic evaluations of the data.

Intercomparison methods

With the data available since the start of the operation of the modernized intercalibration facility, direct comparison and correlation methods have been developed. For example, comparison methods are used to detect technical problems with a given device and to
compare the time evolution of observed data of different probes for single rain events. On the other hand, mean values of measured data observed by different probes in a given time period can be compared and correlation methods based on a linear regression allow to assess the relative response of different probes to variations of the natural radiation field. In figure 4 data from all detectors are compared to the FHZ600 proportional counter. As can be seen, the observed range of measured data from different devices covers an uncertainty range of +20 \%.

The observation period was September 1\textsuperscript{st} to November 15\textsuperscript{th} in 2007 and data from 11 devices were analysed. First results are presented for the mean values of observed data within this period. Three devices on the basis of proportional counters show mean values between 0,12 and 0,13 \(\mu\)Sv/h, 6 devices with Geiger-Müller tubes show mean values between 0,09 and 0,13 \(\mu\)Sv/h. Two other devices using scintillator detectors show mean values of about 0,06 \(\mu\)Sv/h. The response to variation of background data due to rain events with enhanced level of natural activity was analyzed using linear regression method. The observed response factors relative to a chosen reference probe were between 0,8 and 1,16.

![Figure 4](image)

Figure 4 Observed mean dose rate of 11 different devices. The observation period was September 1\textsuperscript{st} to November 15\textsuperscript{th} in 2007.

Furthermore we developed procedures to compare and correlate data obtained from the different probes installed at the intercalibration site. Direct comparison methods are developed to detect technical problems of probes and to compare the time evolution of observed data of different probes for single rain events. On the other hand, correlation methods – e.g. linear regression method – are used to compare mean values and to assess the sensitivity of different probes to variations of the natural radiation field.
Figure 5  Correlation of data from 2 different devices. Each point represents a couple of ambient GDR data for a given 10 minutes interval observed by GS05 and the reference device FHZ600. Black stars represent data using the original calibration of GS05 and blue stars represent the data set for recalibration in $H^*(10)$.

As has been described so far, the uncertainties of the response of different detector types are due to the different characteristics of the detectors: they show large variations with respect to sensitivity, linearity, energy dependence, self-effect and response to secondary cosmic radiation. Self-effect and response to secondary cosmic component of detectors used in European networks have been investigated in the EURADOS inter-comparison exercises (Wissmann et al. 2006). In addition some GDR detectors have been characterized in co-operation between BfS and the German metrological institute PTB (Wissmann et al. 2007).

Figure 6  Relative response of different devices due to enhanced level of terrestrial radiation during rain events. Data are assessed by linear regression analysis of observed 10min and 1h GDR values. Observation period was 1st September to 15th November in 2007.
Relation to AIRDOS project

In 2004 the European Commission concluded a contract with JRC, Ispra concerning a study project entitled “Evaluation of existing standards of measurement of ambient dose rate; and of sampling, sample preparation and measurement for estimating radioactivity levels in air” (AIRDOS). This project covered detailed assessment and evaluation of systems for continuous measurement of external GDR in the EU. A questionnaire was developed, send to the EU member states and evaluated. Based on this work, a comprehensive data base was developed, describing and characterizing all of the GDR networks in Europe in detail Bossew et al. (2007).

As has been described above, GDR probes are differently affected by:

- cosmic background radiation, which is caused by radiation from space (and depends on altitude above sea level)
- self-effect (i.e. internal background or zero-effect of the probe)
- geometry of the measurement (e.g. height above ground)

The cosmic radiation sensitivity varies with different altitude and gamma probes (the over- or underestimation ranges from -40% to +60%), as well as the self effect which varies from 2-50 nSv/h with different gamma probes. Due to the diversity of monitoring networks of European countries, these effects should be corrected in order to adjust the measurements.

The following corrections can be made with known information to most of the networks:

- self-effect-corrections (some countries do not correct the self-effect or cosmic background themselves)
- correction of the cosmic radiation with empirical functions depending on the altitude above see level (above sea level)
- subtraction of the artificial radiation (mostly derived from the Chernobyl accident 1986)
- correction of the height of the probe above ground

As an extension of the continuous investigations additional experiments were performed at the Schauinsland to investigate the influence of the SCR as a function of the altitude and the GDR relative to the height above ground on measured data. As a continuation of the work done in cooperation with the PTB (Wissmann et al. 2007), the detector response with respect to the secondary cosmic radiation has been investigated within measurement campaigns at two different lakes: lake Stechlin (altitude 62 m) and lake Schluchsee (altitude 925 m). This response depends on the detector type and the geometry of the detector. Following Wissmann et al., the expected SCR contribution at lake Stechlin is 0.033 µSv/h and at lake Schluchsee is 0.041 µSv/h.

It was already known, that GM probes tend to overestimate SCR component. For GS05 type probes calibrated in H*(10), the SCR component is overestimated by a factor of about 1.6. On the other hand, scintillation detectors mostly underestimate SCR component due to energy cut-off in the electronics of the data acquisition system in the order of 2-3 MeV (see fig. 7). For example, NBR probes of type 672 E10 - calibrated in H*(10) underestimate SCR component by a factor in the order of 0.3. At Schauinsland mountain, the calculated SCR
component is 0.046 μSv/h. However, the expected SCR response is only about 0.016 μSv/h in case of the hand-held NBR device used for the comparison experiment of figure 3.

Figure 7  
Response to the secondary cosmic component of 6 hand held NBR probes and 2 GS05 GM tubes as a function of air pressure.

In the German GDR network probes are mounted 1 m above ground. Only at the Schauinsland intercalibration site a height of 1.7 m has been chosen, since in winter time the snow cover will in general exceed a height of 1 m. Also in most European countries, GDR networks are designed to serve especially as early warning systems and the height of the probes above ground changes between 1 and up to 20 m. To correct for GDR data provided by probes mounted at different heights above ground, the GDR as function of height of the detector above ground has been measured by Thomas Szegvary in cooperation with BfS in July 2007 (Szegvary 2007a). The measurements were performed at the Schauinsland look-out tower, which has a height of in total 22 m and the highest platform is 18 m above ground.
The Schauinsland look-out tower and measurement of the response to the secondary cosmic component of 6 hand-held NBR probes and 2 GS05 GM tubes at lake Schluchsee close to the Schauinsland mountain.

During the measurement at the look-out tower 5 different detector types have been used and the gamma dose rate has been measured at 10 different heights for the XL2, FH40G, GammaTracer and the hand-held 3 liter NBR scintillation detector. Due to its size, measurements with the 5 liter NBR scintillation detector have been performed at 6 positions of the tower, where the platform is enlarged (see fig. 8 and 9).

![Figure 8](image1.jpg)

![Figure 9](image2.jpg)

Figure 8: The Schauinsland look-out tower and measurement of the response to the secondary cosmic component of 6 hand-held NBR probes and 2 GS05 GM tubes at lake Schluchsee close to the Schauinsland mountain.

Figure 9: Gamma dose rate as a function of the height of the detector above ground measured on Schauinsland look-out tower (picture from Szegvary 2007a)
All results obtained at the Schauinsland, by EURADOS and EURDEP/AIRDOS are part of the framework of the harmonization of measurement techniques of ambient gamma dose rate in Europe. One goal of these investigations is the preparation of the a common European map of the terrestrial gamma dose rates using EURDEP data from which seasonal maps of terrestrial gamma dose rates at the European scale can be produced using geo-statistical methods. A first proposal and methods for its application has been reported by Szegvary et al. (2007a, 2007b).

Figure 10 Average terrestrial gamma dose rates for summer (left) and winter (right) 2006 for Europe (picture from Szegvary 2007a)

References:

J. C. Sáez-Vergara, I. M. G. Thompson, R. Gurriarán, H. Dombrowski, E. Funck and S. Neumaier The Second EURADOS intercomparison of national network systems used to provide early warning of a nuclear accident. Radiation Protection Dosimetry (2006) ncl112
Monitoring of ambient dose rate is an important feature of radiological emergency preparedness. Automatic monitoring networks using dose rate probes exist in most European states. Additional information is needed for the interpretation and comparison of observed ambient dose rate data from different monitoring networks – e.g. on European scale. Obviously, the physical properties of the detectors have to be known. In addition, site characterization techniques are needed for the interpretation and comparison task. This information are of special interest for the interpolation of dose rate data – e.g. EURDEP, INTAMAP – and for data assimilation techniques used in decision support systems like RODOS.

For this comparison purpose, the definition of an ideal site and standard conditions for the mounting of the probes are helpful. The German national monitoring network (BfS network) approach uses the following definition: The probe is installed 1 m above extended flat and smooth grassland. Obviously, buildings and walls in the vicinity of a real probe site will influence measured dose rate data by shielding effects especially in case of fresh deposited activity concentration after an accidental release. Other relevant disturbing objects are trees and bushes (filtering effect) and sealed surfaces (run-off effect).

The proposed simple site characterization procedures follow basic concepts described by Zähringer, Sempau 1997. In this study, the potential impact of disturbing objects in the vicinity of a probe on measured dose rate was analyzed systematically using Monte Carlo calculations. On the other hand, experience is taken into account from extended site characterization procedure used by BfS since many years. However, other monitoring networks uses locations, where probes are mounted on roofs or fixed on walls. Thus, the BfS approach was extended to such locations.

Method 1: Full probe site questionnaire

<table>
<thead>
<tr>
<th>Contribution of surface type to zone area</th>
<th>Parameters</th>
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<tbody>
<tr>
<td>Zone 1 (0-3m)</td>
<td>Zone 2 (3-7m)</td>
</tr>
<tr>
<td>Grassland</td>
<td>0,25</td>
</tr>
<tr>
<td>Sealed</td>
<td></td>
</tr>
<tr>
<td>Shielded</td>
<td></td>
</tr>
<tr>
<td>Trees, bushes</td>
<td></td>
</tr>
</tbody>
</table>

Input Site characterisation

Region of additional uncertainty

Figure 1 Proposed full site questionnaire. Green marks indicate input parameters, blue value denote parameters of evaluation model.
Two different site characterization procedures are proposed. The first method uses the following full site questionnaire. For each location, the contributions for 4 different types of surfaces to zone area 1 up to 4 have to be assessed from adequate site documentation material like photographs, sketch-maps and aerial views of the vicinity of the site. With this information, a simple algorithm will assess two evaluation factors, which give the lower and upper limit of the region of additional uncertainty of measured dose rate taking into account the impact of perturbation objects.

<table>
<thead>
<tr>
<th>Surface type / disturbing object</th>
<th>Yes / no</th>
<th>weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sealed or shielded surface</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Trees, bushes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mounted on roof</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mounted on walls</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Evaluation factors</td>
<td></td>
<td>lower</td>
</tr>
<tr>
<td></td>
<td></td>
<td>upper</td>
</tr>
</tbody>
</table>

Fig. 2 Proposed simple site questionnaire. Green marks indicate input parameters, blue value denote parameters of evaluation model.

The second method uses a very simple site questionnaire and could be used as a site classification method. However, it is based on the method described above. The presentation gives an overview on the site characterization procedures and present examples for three real locations. More extended instruction manual for the procedures are in preparation.
The Modernization of the Schauinsland Intercalibration site

Bundesamt für Strahlenschutz; 38226 Salzgitter; Germany;

The Schauinsland trace analysis facility has been established in 1957 primarily for the observation of cosmic radiation. During the cold war period fall-out from nuclear weapon tests has been detected with the detectors installed at the Schauinsland observatory. Since that time, the facility was used for the surveillance of radioactivity in air. Since the early 80th of the last century a GDR probe of the federal gamma dose rate network (WADIS), formerly operated by the civil defense organisation, is operated at the Schauinsland. Later on additional probes form neighboring countries were also installed to compare data from different detector types. This intercomparison exercise was continuously extended over the past years. In 2007 the number of probes installed exceeded the maximum number provided at the old intercalibration platform and it was decided to renew the complete setup. On the following pages this process is presented based on illustrations and photographs.

Figure 1 Placement of the 20 probe holders installed on the flat meadow

The intercalibration platform is installed 1200 m above sea level and designed for the long term intercalibration of GDR probes form different institutions and complements the EURADOS intercomparison campaigns, which are typically performed every 2 or 3 years at the PTB in Braunschweig.

On the modernized platform up to 20 probe holders are installed on a flat meadow with a radius of 5 m. The probes are installed 1.5 m above ground. Each probe holder is connected via data, control and power cables with the measuring room inside of the main building of the Schauinsland facility.
The measuring room

The Schauinsland facility integrates the intercalibration site as well as a correspondent measuring room inside the building. All cables from the intercalibration site are guided to a special rack with lightning arrestors. From this central point all data loggers of the different probes are interfaced individually. In addition, one central server is installed using a 16 port serial interface to connect probes with serial interface. The software running on this server is based on a MySQL data base. A web-interface is under construction to allow all external users to access the data from the Schauinsland site together with meteorological and other radiological data via internet.
Figure 4  Satellite view of the Schauinsland intercalibration site before the modernisation

Figure 5  Satellite view of the Schauinsland intercalibration site after the modernisation
Figure 6  The old intercalibration platform in Winter 2007

Figure 7  Flattened area for the new intercalibration site and the old infrastructure
Figure 8  Re-arranged intercalibration site and empty conduits

Figure 9  The new infrastructure at the flattened site
Figure 10  The intercalibration site after completion

Figure 11  The measuring room inside the main building of the Schauinsland facility providing the technical infrastructure, computer and electronics
Figure 12  The 20 positions of GDR detectors and their assignments

<p>| | |</p>
<table>
<thead>
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<tbody>
<tr>
<td>1</td>
<td>Germany, GammaTracer</td>
</tr>
<tr>
<td>2</td>
<td>Germany, GS05</td>
</tr>
<tr>
<td>3</td>
<td>Germany, GS05</td>
</tr>
<tr>
<td>4</td>
<td>Germany, RADEYE</td>
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<td>5</td>
<td>Netherlands, RS03/232</td>
</tr>
<tr>
<td>6</td>
<td>Finland, XL2-3</td>
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<td>7</td>
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<td>8</td>
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<td>9</td>
<td>France, ALNOR</td>
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<td>Slovenia, AMES</td>
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<td>12</td>
<td>Austria, RS03/A232</td>
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<td>13</td>
<td>Germany, XL2</td>
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<td>14</td>
<td>Germany, XL2-LND</td>
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<td>16</td>
<td>Germany, FHT681, NBR</td>
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</tr>
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<td>18</td>
<td>Germany, FHZ600A</td>
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<td>19</td>
<td>Germany, FHZ601A</td>
</tr>
<tr>
<td>20</td>
<td>Germany, IGS510</td>
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</table>
Figure 13  The positions of additional GDR and meteorological detectors at the intercalibration site and their assignments

<p>| | |</p>
<table>
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<td>15</td>
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</tr>
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<td>16</td>
<td>Germany, FHT681, NBR</td>
</tr>
<tr>
<td>21</td>
<td>Germany, GammaTracer</td>
</tr>
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<td>22</td>
<td>Switzerland, GammaTracer</td>
</tr>
<tr>
<td>23</td>
<td>Germany, Rain-Detector</td>
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<td>24</td>
<td>Germany, SMC</td>
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### Glossary

<table>
<thead>
<tr>
<th>Acronym</th>
<th>Description</th>
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<tbody>
<tr>
<td>BfS</td>
<td>German Federal Office for Radiation Protection</td>
</tr>
<tr>
<td>GDR</td>
<td>Gamma Dose Rate</td>
</tr>
<tr>
<td>INTAMAP</td>
<td>INTERoperability and Automated MAPping</td>
</tr>
<tr>
<td>AIRDOS</td>
<td>Project for the harmonization of radioactivity measurements in Europe</td>
</tr>
<tr>
<td></td>
<td>“Evaluation of existing standards of measurement of ambient dose rate; and of sampling, sample preparation and measurement for estimating radioactivity levels in air”</td>
</tr>
<tr>
<td>CBSS</td>
<td>Council of Baltic Sea States</td>
</tr>
<tr>
<td>EURADOS</td>
<td>European Radiation Dosimetry Group</td>
</tr>
<tr>
<td>EURDEP</td>
<td>European Data Exchange Platform</td>
</tr>
<tr>
<td>EURORAD</td>
<td>French Company (CZT, CsI detectors)</td>
</tr>
<tr>
<td>GPS</td>
<td>Global Positioning System</td>
</tr>
<tr>
<td>GPRS</td>
<td>General Radio Packet Service</td>
</tr>
<tr>
<td>GM</td>
<td>Geiger Müller tube</td>
</tr>
<tr>
<td>HSPA</td>
<td>High Speed Packet Access</td>
</tr>
<tr>
<td>ISDN</td>
<td>Integrated Services Digital Network</td>
</tr>
<tr>
<td>JRC</td>
<td>Joint Research Centre, Ispra, Italy</td>
</tr>
<tr>
<td>LMNI</td>
<td>Dutch network, which included 300 ambient dose rate monitors</td>
</tr>
<tr>
<td>LMR</td>
<td>Dutch network, which contained 60 dose rate and 14 air sampling monitors</td>
</tr>
<tr>
<td>LUBW</td>
<td>State department for environment, measurements and nature protection</td>
</tr>
<tr>
<td></td>
<td>Baden-Württemberg, Germany</td>
</tr>
<tr>
<td>NBR</td>
<td>Natural Background Reduction</td>
</tr>
<tr>
<td>NGA</td>
<td>Defence group against nuclear hazards</td>
</tr>
<tr>
<td>NRM</td>
<td>Dutch National Radioactivity Monitoring Network (combination of LMNI and LMR)</td>
</tr>
<tr>
<td>NPP</td>
<td>Nuclear Power Plant</td>
</tr>
<tr>
<td>IRSN</td>
<td>Institut de Radioprotection et de Sûreté Nucléaire, France</td>
</tr>
<tr>
<td>MCA</td>
<td>Multi Channel Analyzer</td>
</tr>
<tr>
<td>PM</td>
<td>Photo Multiplier</td>
</tr>
<tr>
<td>RIVM</td>
<td>National Institute for Public Health and the Environment / The Netherlands</td>
</tr>
<tr>
<td>RODOS</td>
<td>Slovenian Nuclear Safety Administration</td>
</tr>
<tr>
<td>SNSA</td>
<td>Slovenian Nuclear Safety Administration</td>
</tr>
<tr>
<td>STUK</td>
<td>Radiation and Nuclear Safety Authority, Finland</td>
</tr>
<tr>
<td>TAMOS</td>
<td>Austrian Emergency Response Modeling System</td>
</tr>
<tr>
<td>TUS</td>
<td>Austrian Telemetry and Security Network</td>
</tr>
</tbody>
</table>
Acknowledgements

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The views expressed herein are those of the authors and are not necessarily those of the European Commission.