RADIATION MONITORING SYSTEM FOR
THE ENVIRONMENT AND SAFETY PROJECT

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Abstract

The project RAMSES (Radiation Monitoring System for the Environment and Safety) will provide LHC with a state of the art radiation monitoring and alarm system. RAMSES will survey the LHC accelerator, the LHC experimental areas and the environment of the LHC. The TIS (Technical Inspection and Safety) division will exploit this system to assess radiation risks and to control the releases of radioactivity. In addition, it will be integrated into the control rooms of the LHC accelerator and the LHC experiments. Obviously, RAMSES will already take into account CERN wide needs to renew the radiation monitoring system around the other CERN facilities. The requirements of the system are derived from CERN’s own safety standards (CERN’s Radiation Protection Manual, SAPOCO), from those of the CERN’s two host states and from European standards. The mandate of the project team covers the system specification, prototyping, tendering, installation and integration of radiation monitors and industrial control equipment for safety systems. This paper outlines the scope, the organisation, the main system functionality and the commercial strategy.
1 INTRODUCTION
The operation of CERN’s accelerators inevitably results in the production of ionising radiation and radioactivity due to the nuclear interaction of high energetic beam particles like protons with matter (air, accelerator components, tunnel structure…).

The radiation levels around the LHC as well as its supporting facilities and in the environment need to be continuously monitored. In case of anomalies alarms need to be generated to warn persons present in affected areas or even, in some cases depending on the radiation level to switch off the source immediately and/or to interlock accesses. Radiation levels in the LHC environment and radioactive releases into the environment also need to be measured in order to prove the compliance of the facility with the environmental regulations in force.

A state-of-the-art radiation monitoring system is required to enable CERN to run LHC under conditions fulfilling CERN’s safety requirements and other legal requirements. Indeed, it is legally required to protect people and the environment against ionising radiation and to use all reasonable measures to minimize exposure (principle of ALARA). These measures must take into account the latest developments in science and technology [1].

The RAMSES contributes to minimize exposure and to document radiation levels by measuring the ionizing radiation and radioactive releases as well as by signaling the presence of excessive radiation via local and remote alarms.

In order to achieve this goal, the RAMSES needs to measure the presence of ionizing radiation, indicating the nature and the quality of the radiation in question, both in the vicinity of the accelerators and in the surrounding environment. The various radiation hazards have been evaluated in various works [2 and reference therein]. The responsibility for monitoring and control of the different radiation fields and of the induced radioactivity is distributed between two sets: the environmental monitoring and the operational radiation protection.

The environmental monitoring includes the measurement of stray radiation (gamma, neutrons and muons), radioactive emissions (ventilation) and effluents (water), samples from the environment, and meteorological data.

The radiation protection monitoring system has to cope with two beam-modes:

BEAM-ON: The RAMSES monitors the stray radiation (neutrons, X-rays, photons, muons and relativistic charged particles) in areas accessible during beam operation, including places in the environment, and radioactive releases.

BEAM-OFF: The RAMSES monitors the dose rates caused by radioactivity induced in accelerator components and its surroundings and by X-rays generated by RF cavity operation. The environmental stray radiation monitors measure natural background levels. The monitors of emissions and effluents survey the residual radioactive releases if any.

The positioning of the radiation monitors in the surveyed areas is of capital importance, therefore it has been derived from numerical calculations and long, professional experience.

Obviously, the quality and accuracy of the information, provided by the radiation monitoring system, is crucial to ensure a quick and efficient intervention to reduce radiation emission. This information should be highly reliable and highly available. Therefore, the system must provide users with the necessary information to identify without ambiguity the nature of the problem and its exact location, continuously 24 hours a day all year around.

Moreover, the system has to cope with the upgrading of existing radiation monitoring systems for all CERN sites to obtain homogeneity with LHC site installations, maintenance and operation.

The RAMSES project is under the responsibility of the TIS and ST division. Because of the importance of this project, the two divisions agreed to join resources and competencies to tackle this task in common. Furthermore, since the RAMSES development will be contracted to an external company, a large participation from the SPL division is required to deal with commercial aspects.
2 BACKGROUND

The current radiation monitoring system (ARCON) was designed for the LEP accelerator in the early 1980s [3]. The radiation monitors are grouped depending on their location area. The radiation survey in an area is handled by an area controller, i.e. an ARCON. The ARCON scans the monitors located in the area it controls and transfers the measurements to a central database. When a high radiation release is detected, an alarm is generated and the persons working in the area are alerted by the activation of local alarm display panels. At the same time, the alarm is transmitted to the accelerator control rooms. The ARCON is based on a VME - M68040 processor running the OS9 operating system and the alarms are transmitted to the accelerator control rooms through MIL1553 field-bus.

The project RAMSES had to be launched because the present radiation monitoring system ARCON is based on an obsolete technology, which cannot be reproduced anymore. In addition, the present system might not be able to fulfil some of the new safety requirements for the LHC project.

3 STRATEGY

As this project is so broad, including aspects such as: radiation monitoring, state-of-the-art technologies, many system interfaces, compatibility with existing systems, management of safety aspects, etc, a strategy had to be defined. This strategy focuses on three main axes: standards and directives, a prototyping methodology and the commercial aspects.

3.1 Standards and directives

In order to face the issues of radiation protection legislation, quality, project management, operation & maintenance, safety and cost optimization for the RAMSES concept phase [3], standards and directives that summarize expertise and experience in the field of safety and radiation protection have been chosen to guide the project team:

- CERN’s Radiation Safety Manual, Edition 1996. This manual takes into account the legal requirements of the two CERN’s Host States;
- The “Rapport préliminaire de Sûreté du LHC”. Required by the French Regulatory Authority DSIN (Direction de la Sûreté des Installations Nucléaires), this document lists the required safety elements as demanded by the legislation of the two CERN’s Host States;
- Directive EURATOM 96/29. The members of the EU have agreed on adopting this Directive in their national radiation protection legislations;
- Relevant National and international (ISO) norms for radiation protection;
- International Standard IEC 61508 [4]: “Functional safety electrical / electronic / programmable electronic safety-related systems”. This standard defines a generic approach and a technical framework for dealing systematically with safety related activities (see also [5] and [6]). This methodology enables us to minimize system failures, optimize performance of the RAMSES and obtain homogeneity with LHC site installations, maintenance and operation. It is particularly interesting because it defines the skills needed to deal with safety, the required procedures to be defined and carried out, as well as the kind of development methodologies to be used.

3.2 Prototype

The purpose of the prototyping strategy is to clarify the user and safety requirements of the system, to test state-of-the-art technologies, and to test integration with existing systems. The experience gained will be used to define the technical specifications for the tendering procedure. The basic prototype architecture is described Section 4.2.
3.3 Commercial aspects

Since the RAMSES system will be developed and installed by an external company, a market survey will be conducted to select firms for fulfilling the requirements of the project. A Call for Tender procedure will finally provide the name of the selected company.

The quality of the project is dependent on the quality of the technical and contract specifications. We believe that the key to a successful implementation is to provide precise definition of the desired system, leaving no ambiguities to the selected company. This is crucial to avoid misunderstandings and common pitfalls difficult to correct once the system is under development. Therefore, special care has been taken in collecting, analyzing and defining the monitoring and supervision requirements and standards, which will be a valuable guide in writing the technical specifications. Experience gained from prototyping will also be used to define as accurately as possible the system to be developed.

4 ARCHITECTURE

4.1 RAMSES functional requirements

The first step towards defining the system architecture was the identification of the system functional requirements, based on an analysis of the actual system and the safety requirements for the LHC. The result of this study is presented in the RAMSES functional diagram (see Figure 1).

Figure 1: RAMSES functional diagram

The core of the RAMSES is the Radiation Instrumentation. It represents the radiation detectors that are capable to measure the various different types of ionizing radiation encountered at CERN. Just for the LHC, there will be about 350 new detectors to be installed.

The Data Acquisition and Processing is the mind of the system. It gathers information from the Radiation Instrumentation, process this data and generates the appropriate local and remote alarms. It will be a distributed system with a central supervision. Local control units will be capable to work independently of each other and of the central supervision for safety reasons. The local control unit will be capable of generating Local Alarms. The data will be acquired in different formats according to the type of radiation detector. However, the data will be standardized at the central supervision level. The central supervision will be capable to interface with existing radiation systems during the transition period.

Another required function of the system is to be able to communicate with the Access System and to provide Interlocks for systems that are subject to high radiation risk (i.e. RF systems).

For executing off-line analysis, the RAMSES needs to store in a database the Radiation Data. In addition, to achieve the required homogeneity and avoid data incoherence between the different local control units, the system also requires to store in the database its own configuration data such as...
alarms, equipment addresses or interfaces. Imposed by safety standards and French Regulations, the system shall also store in the database **Events**, like alarm information, change of settings, for post-mortem and historic analysis. Furthermore, it requires a global **supervision** manager to monitor the correct functioning of the different parts of the system for diagnostic coverage.

Finally, data is exchanged with all Control Rooms through the **Data Exchange Protocol**.

### 4.2 Prototype architecture

We are using a prototyping methodology to clarify the main aspects of the system design. Various prototypes of the radiation instrumentation have been implemented as it represents the most critical part of the RAMSES. In Figure 2, the overall conceptual architecture is shown and it is highlighted the prototyped part. This part includes one or more radiation monitors directly controlled by one local control unit (Monitor Controller) that can also generate local alarms via Radiation Displays. Radiation monitors can be remotely connected to a local control unit via a local fieldbus. Hardwired connections guarantee a redundant path for the transmission of alarms.

![Prototype architecture](image)

**Figure 2** Prototype architecture

### 5 CURRENT STATUS

From the commercial point of view, the requirements for the radiation monitors (type, number and location) are being reviewed in the light of the last LHC project status. They are almost compiled and ready for final approval by TIS/RP and TIS/TE-EN. The market survey will be launched in February 2002.

The products of various radiation instrumentation manufacturers have been tested and more contacts are being established to evaluate other potential industrial solutions. The use of the recommended SCADA system for the central supervision system is being investigated.

### 6 FUTURE

The time schedule for the RAMSES project is described below. The RAMSES team will continue to prototype and test technical solutions and finalize the inventory list of radiation monitors to be installed around the LHC.
During the first six-month of the 2002, the RAMSES specifications will be written for the Call for tender. By March 2003, the contract with the selected company should be signed. Once the RAMSES design is defined, the first installation will be used as a pilot for validation. Furthermore, the design of the system (or part of it) might require the approval of the INB.

After the installation and commissioning, the safety validation of the RAMSES system will take place. We expect the system to be ready by the 3\(^{rd}\) quarter of 2004.

7 CONCLUSIONS

The RAMSES is an ambitious and complex project that will provide CERN with a highly reliable, homogeneous and state-of-the-art radiation monitoring system for the LHC era. The main challenges of the project are the constraints of integrating a wide range of radiation monitors, including old systems with new ones into the same safety concept, the reliability and availability requirements and the large area to be covered.

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