ARCON/RAMSES: Current Status and Operational Risk

(DGS, Safety Commission)

Chamonix
27th January 2010
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• RAMSES2light
CERN has the legal obligation to protect the public and the persons working on site from any unjustified exposure to ionizing radiation.

- monitoring of
  - ambient dose equivalent rates (in- and outside of CERN perimeter)
  - releases of radioactivity by air, gases and effluents

  allows preventive assessment of radiological risks and the optimization of individual and collective doses

- fixed installed radiation monitoring systems:
  - ARCON (Area Controller, since 1988 – LEP era, CERN in-house development)
  - RAMSES (Radiation Monitoring System for Environment and Safety, since 2007 – LHC era, industry standard based technology)

  (in total ~ 800 monitors, data acquisition and storage, alarms and interlocks)
ARCON/RAMSES at CERN

ARCON:
- LHC injectors
- ISOLDE, n-TOF, AD,
- Experimental areas

LHC: RAMSES

CTF3: RAMSES

CNGS: RAMSES

Legend:
- p (proton)
- (antiproton)
- ion
- proton/antiproton conversion
- neutron
- neutrino
- AD Antiproton Decelerator
- PS Proton Synchrotron
- SPS Super Proton Synchrotron
- LHC Large Hadron Collider
- n-ToF Neutron Time of Flight
- CNGS CERN Neutrinos Gran Sasso
Monitors for Protection of Environment

ARCON and RAMSES use the same/similar type of monitors

Stray radiation Monitoring

Water Monitoring station

Ventilation Monitoring

Wind monitoring

EPIC  ERC  RWM - RWS  VGM - VAS  USA
Operational Radiation Protection Monitors

ARCON and RAMSES use the same/similar type of monitors

Beam-on: to protect workers in areas adjacent to accelerator tunnels and experiments against prompt radiation (mainly neutrons, E < some GeV)

Alarm function

Beam-off: to protect workers during maintenance and repair against radiation fields caused by decay of radionuclides (mainly gammas, E < 2.7 MeV)

No alarm function
Operational Radiation Protection Monitors

Special monitors

Hand&Foot monitor
SGM already prepared for connection to access system

Site Gate Monitor

SGM

Monitoring station

RAMSES: reading of radiation levels directly available ≠ ARCON

Radiation Alarm Unit (RAMSES)
# Alarm Levels for Designated Areas

<table>
<thead>
<tr>
<th>Area classification</th>
<th>Permanent workplaces</th>
<th>Low-occupancy</th>
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<tbody>
<tr>
<td></td>
<td>Warning</td>
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<td>Non-designated Area</td>
<td>Guideline EMDS 788938</td>
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<tr>
<td>Supervised Radiation Area</td>
<td>3 μSv/h</td>
<td>6 μSv/h</td>
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<tr>
<td>Simple Controlled Area</td>
<td>10 μSv/h</td>
<td>20 μSv/h</td>
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<tr>
<td>Limited Stay Area</td>
<td>-</td>
<td>-</td>
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<tr>
<td>High Radiation Area</td>
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<td>-</td>
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<tr>
<td>Prohibited Area</td>
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Radiation measurement: typical sampling time: 100 - 300 s  
→ extrapolation to 3600 s  
→ above limit: alarm

Beam-On: accessible areas are shielded towards beam areas  
→ classification as Supervised Radiation Area or Simple Controlled Radiation Area is sufficient

Monitors in designated areas (accessible during beam on): uniform alarm and interlock levels
Alarm Philosophy

- Two different philosophies:
  
  Either **beam interlock** on alarms or **operator action** following an audible/visual signal. Interlocks are preferred above operator action by RP. Choice is mainly made due to required and available reliability level and weighted according impact on machine operation.

- Transmission of radiation protection alarms
  
  PS complex: Radiation Alarm Repeater Panels → visual and audible alarm to operators, no ARCON interlock on LINAC, Booster of PS beam, RAMSES interlocks in operation at CTF3, action OP and RP

  SPS complex: LASER system -> ARCON interlock on SPS beam, action OP and RP

  LHC: LASER system + visual and audible alarm (to be implemented), no RAMSES interlock on LHC beam (with exception of RF commissioning), Action OP and RP
Alarm Philosophy

- Transmission of alarms from site gate monitors: alarms to be transfered to TCR via RAMSES and ARCON; action OP and RP

- Transmission of environmental alarms (pH and temperature) to TCR; action IE, OP and CV

- No transmission of radiological environmental “alarms=action level”*) to other systems than ARCON or RAMSES; action IE and RP

- No technical alarms of RAMSES or ARCON are transmitted to TCR**) for the time being (for historical reasons)

*) DGS-IE + BFSP: environmental radiation monitoring does not require alarm function

**) with exception of pH and temperature
RAMSES
Radiation Monitoring System for the Environment and Safety

- Designed to **cover all CERN installations**
- 2002: RAMSES limited to LHC due to budget restrictions
- Presently monitoring system for **LHC, CNGS and CTF3**
- Developed, installed and maintained by an **industrial contractor**
- **State-of-the-art** integrated decentralised monitoring system, designed to fulfil SIL 2 level for the basic monitoring, alarming and interlock functions.
- Standard system for **new projects (LINAC4)**; or extension of existing installations (**HiRadMat**)

![RAMSES Project Concept Architecture Diagram](image-url)
RAMSES Reliability and Availability

- Compliant to applicable international standards for radiation protection instrumentation (ISO)
- IEC 61508 closely used as reference
  - Functional safety lifecycle
  - Project Management Plan
  - Hazard Analysis
  - Safety Integrity Levels assigned to safety functions
- Decentralised radiation monitoring system
- Each detector-alarm unit operates autonomously, back-up with batteries, unit continues to operate even if rest of the RAMSES system fails
- Safety integrity level (SIL) 2 for radiation alarms and interlocks
RAMSES Maintenance

Preventive maintenance:

✓ Systematic, regular control of operational reliability for each single equipment item (every 2 weeks to once a year)
✓ Performed by contractor and DGS-RP, DGS-IE

2009:

✓ Hardware and software updates have been implemented in 2009.
✓ Annual maintenance completed

Corrective maintenance (TCR not yet involved):

✓ During working hours: performed by 1st intervention line (DGS/RP-IL)
✓ During non-working hours: RP on-call service and DGS/RP-IL on a best effort basis
✓ Contractor Hot Line (24H/24H, 7d/7d)
✓ Contractor 8 – 48 hours to solve problem on site
RAMSES - Operational Risk

RAMSES statistics:

- 3 false alarms in 2009 (1 hardware failure at LHC-3, 2 at CTF3 – cured by replacement of faulty equipment)
- No false interlock signal in 2009 in LHC
- 99%* data availability in database (* Present checking limit)

Areas are sufficiently well covered with monitor stations, provisions are made to increase redundancy even more
RAMSES data: i.e. LHC restart in 2009

RAMSES ready for CNGS 2006 and LHC 2008
ARCON

- CERN development in the 80’s for LEP
- VME Bus (CPU 68040)
- OS9 (Operating system)
- MIL1553 (field bus) / Ethernet TCP/IP
- Up to 64 counting inputs (current pulses)
- **Still about 380 channels on ARCON**

To be phased out and replaced by RAMSES system:
- ARCON-RAMSES interface (to replace HPSLZ18 server)
- RAMSES2light (RAMSES for injectors)
- RAMSES2 (RAMSES for rest of CERN facilities, i.e. ISOLDE, n-TOF, AD and experimental halls)
# ARCON versus RAMSES

<table>
<thead>
<tr>
<th></th>
<th>ARCON</th>
<th>RAMSES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Developed</td>
<td>80\textsuperscript{th} for LEP</td>
<td>2000\textsuperscript{th} for LHC</td>
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<tr>
<td>Standard</td>
<td>CERN standard</td>
<td>Industrial standard</td>
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<tr>
<td>SIL</td>
<td>&lt; SIL</td>
<td>SIL2 for alarms and interlocks</td>
</tr>
<tr>
<td>Size</td>
<td>~ 380 monitors</td>
<td>~ 400 monitors</td>
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<tr>
<td>Detectors</td>
<td>same type of detectors – different electronics</td>
<td></td>
</tr>
<tr>
<td>System</td>
<td>Grouped (several monitors on one ARCON station)</td>
<td>Autonomously operating monitors, grouped into smaller entities</td>
</tr>
<tr>
<td>Worst risk in case of failure - RP</td>
<td>Several channels fail in case of ARCON failure -&gt; whole area without radiation monitoring</td>
<td>Single channel fails -&gt; radiation monitoring ensured by remaining channels</td>
</tr>
<tr>
<td>Supervision / Software part</td>
<td>HP server, proprietary software no longer supported</td>
<td>PCview SCADA solution, OPC client/server technology</td>
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# Interim Solution for ARCON

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<th>Interim Solution</th>
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<tr>
<td><strong>SIL</strong></td>
<td>&lt; SIL</td>
<td>&lt; SIL</td>
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<tr>
<td><strong>Size</strong></td>
<td>~ 380 monitors</td>
<td>Maintains all existing ARCON channels</td>
</tr>
<tr>
<td><strong>Detectors</strong></td>
<td>Detectors (spares missing)</td>
<td>Spare detectors available to some extent or may be taken from experimental areas – in case of need</td>
</tr>
<tr>
<td><strong>System</strong></td>
<td>Grouped (several monitors on one ARCON station)</td>
<td>ARCON remains operating surveillance system</td>
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<tr>
<td><strong>Worst risk in case of failure - RP</strong></td>
<td>Several channels fail in case of ARCON failure -&gt; whole area without radiation monitoring</td>
<td>Electronic spare parts (from LEP) are tested and operational in case of need</td>
</tr>
<tr>
<td><strong>Supervision / Software part</strong></td>
<td>HP server, in-house developed software</td>
<td>ARCON-RAMSES bridge (eliminates HP server and proprietary software)</td>
</tr>
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</table>
Interim Solution for ARCON

- **ARCON-RAMSES Interface (to replace MIL 1553, HPSLZ18 Server)**
  - Interface completed,
  - Supervision part completed,
  - Final reception of the RAMSES based supervision system for all ARCON was scheduled for end 2009 ➔ 1st quarter 2010 due to a technical problem identified with OPC server software.

- Back-up for LHC injector chain ARCON:
  - Electronic spare parts are tested and available
  - Spare detectors still critical ➔ To be taken from experimental areas (according to a predefined list), new spare detectors will be bought within the RAMSES II light project
  - Improved reliability of ARCON network link ➔ ARCON network star points are secured by UPS
  - Improved battery and power supply surveillance ➔ Installed on all ARCON
ARCON-RAMSES Interface

Moniteurs provenant zones autres

All connected by the existing CERN TCP/IP infrastructure (Ethernet).

Moniteurs

Châssis VME ARCON

LASER → Alarmes

SIS → Interlocks

Serveur HP (HPUX 10.20)

RADMAIN GRAPH XRP2

MIL 1553
SNMTCR SVMTCR

Ethernet

Interface ARCON RAMSES

Serveur Supervision RAMSES

Completion 1st quarter 2010
Operational Risk - ARCON

- Problem of supervision server (outdated system (HP server) to communicate with continuously up-dated modern software systems (Operation) for data and alarm transmission – to be cured by ARCON RAMSES bridge

- Failure of an entire ARCON system will result in the loss of radiation monitoring for a whole area -> beam stop and replacement of ARCON

- Monitor failures -> spare monitors to be installed (worst case: from experimental areas)

Worst case scenarios:
1) faulty ARCON equipment – similar to a broken magnet, septa or power supply -> beam stop
   Replacement of an entire ARCON: 1- 3 days
2) ARCON software (for equipment control):
   Difficult to maintain, common weak point to all ARCONs

Final solution: RAMSES2light
RAMSES2
Operational Risk - ARCON

- Basic guideline defined in SR16 (Safety Rule 16, BE/OP)
  - Specific action and information for PS Complex available to operators on: [http://cern.ch/rp-ps](http://cern.ch/rp-ps)
  - Specific action and information for SPS Complex defined in technical note EDMS 969891.

To be added to OP shut-down lectures – see FOM 19/1/2010

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<tr>
<td>Name</td>
<td>Surveyed installation</td>
<td>Action in case of monitor failure</td>
<td>Alarm Zone</td>
<td>A Alarm</td>
<td>B Alarm</td>
<td>Alarm transm.</td>
<td>Mon. fault</td>
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**Safety Commission**

**Technical Note**
CERN-SC-2008-080-RP-TN

**Procedures to be followed in case of an ARCON system or monitor failure**

Helmut VINCKE

**Abstract:**

This paper provides the procedures required to assure a safe SPS machine operation in case of a failure of single ARCON monitors, a full ARCON subsystem or its alarm transmission functionality.
## Operational Risk - ARCON

### PS complex

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Operational Risk - ARCON

Example (EDMS 969891) – *RP part only, DSO actions to be included*

**PAXTA40:** *(monitor in SPS interlock system)*

**Function:** stray radiation monitor to protect personnel in the ECA4 cavern at floor level during SPS operation.

**Procedure to be followed in case of failure or unavailability of monitor:**

- SPS operation to be stopped
- Inform RP on the monitor problem (phone: 75252 or 74848).
- ECA4 floor to be cleared and closed.
- If not possible to block access to floor level of ECA4 only, the whole ECA4 area to be cleared and closed at the surface.
- Operation may continue – after clearance by DSO, RSO and RP (beam permit sheet?)

**SPS complex:**

- underground installation
- -> less impact of ARCON failures when compared to PS complex
RAMSES 2 Light Project

Replacement and consolidation of ARCON by RAMSES for the entire LHC injector chain

✔ Project passed Finance Committee in March 2009 (extension of existing RAMSES contract)

✔ Project includes ARCON replacement, consolidation, new projects (LINAC4, HiRadMat) and spares

✔ Contract amendment and related order signed in December 2009 (after having solved EMC problems)

✔ Two phase project – depends on accessibility of areas during accelerators operation:
   ✔ Commissioning and acceptance tests of instrumentation in accessible areas ➔ October 2010
   ✔ Full commissioning and acceptance tests by the end of 2010-2011 shutdown period
Conclusion

- RAMSES (LHC) has proven to be reliable (SIL2 level)
- Provisions had been made to increase RAMSES redundancy even more
- Actions had been taken to secure injectors for LHC run 2010
- ARCON (injectors) to be replaced by RAMSES2light latest until end of shut-down 2010/11
- RAMSES2light replaces and consolidates existing monitoring system at the LHC injectors
- Technical alarms from RAMSES and ARCON to be transferred to TCR
- Radiation alarms from site gate monitors to be transferred to TCR