ISBN: 978-3-95450-209-7 ISSN: 2226-0358 doi:10.18429/JACoW-ICALEPCS2019-MOPHA063

TOWARDS A COMMON RELIABILITY & AVAILABILITY INFORMATION SYSTEM FOR PARTICLE ACCELERATOR FACILITIES

K. Höppner*, Th. Haberer, K. Pasic, A. Peters
HIT, Heidelberg Ion Beam Therapy Center,
University Hospital Heidelberg, Germany
H. Humer, Austrian Institute of Technology, Vienna, Austria
J. Gutleber, A. Niemi, CERN, Geneva, Switzerland

Abstract

Failure event and maintenance record based data collection systems have a long tradition in industry. Today, the particle accelerator community does not possess a common platform that permits storing and sharing reliability and availability information in an efficient way. In large accelerator facilities used for fundamental physics research, each machine is unique, the scientific culture, work organisation, and management structures are often incompatible with a streamlined industrial approach. Other accelerator facilities enter the area of industrial process improvement, like medical accelerators due to legal requirements and constraints. The Heidelberg Ion Beam Therapy Center is building up a system for reliability and availability analysis, exploring the technical and organisational requirements for a community-wide information system on accelerator system and component reliability and availability. This initiative is part of the EU H2020 project ARIES, started in May 2017. We will present the technical scope of the system that is supposed to access and obtain specific reliability statistical information in ways not compromising the information suppliers and system producers.

THE HIT MEDICAL ACCELERATOR

The heavy ion accelerator at HIT is used for raster-scanning radiation of cancer patients (cf. [1, 2] for an overview) with different types of ions from three sources [3] in several treatment rooms, two with horizontal fixed beam exit (operational since 2009) and the heavy ion gantry with rotatable beam exit (operational since 2012 [4]), and a beam exit for experiments (see Fig. 1). Each combination of source and destination may be used for medical treatment, represented within the Accelerator Control System (ACS) by the so-called *virtual accelerator* number. A radiation plan consists of a series of beam pulses chosen from a catalogue of 255 different energy values (88–430 MeV/u for carbon, 48–220 MeV/u for protons), 6 focus sizes, 15 intensity values (2×10^6–5×10^8 particles per second for carbon, 8×10^7–2×10^{10} pps for protons), and 36 exit angles in case of the gantry. These tuples of beam settings are named the MEFI combinations. Both the virtual accelerator as the MEFI combination may be changed from beam pulse to beam pulse (multi-plexed operation).

* klaus.hoeppner@med.uni-heidelberg.de

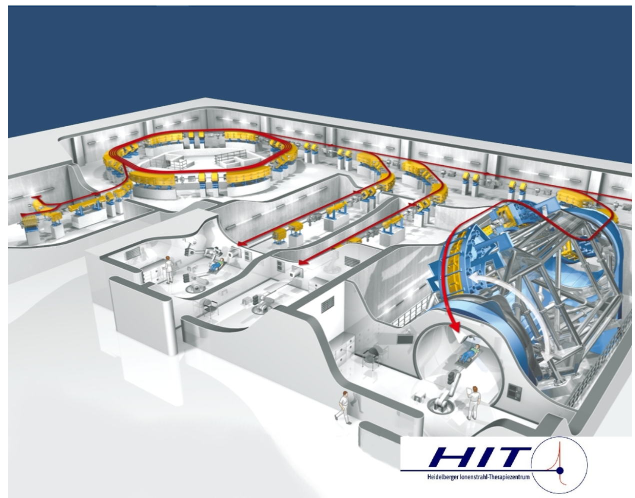

Figure 1: HIT accelerator facility with ion sources, linear accelerator, synchroton, two horizontal beam exits and gantry for medical treatment. The experimental area is not shown.

THE ARIES PROJECT

The ARIES (Accelerator Research and Innovation for European Science and Society) project [5], running since May 2017 until April 2021 and co-funded by the European Commission under its Horizon 2020 programme, brings together a consortium of 42 beneficiaries from 18 countries: accelerator laboratories, technology institutes, universities and industrial partners to jointly address common challenges for the benefit of a number of projects and infrastructures in high-energy physics, as well as in photon and neutron science. By promoting complementary expertise, cross-disciplinary cooperation and a wider sharing of knowledge and technologies throughout academia and with industry, ARIES will significantly enhance the science and technology base for European accelerators.

The main goals of ARIES are linked to developing and demonstrating novel concepts and further improving existing accelerator technologies, providing European researchers and industry with access to top-class accelerator research and test infrastructures, enlarging and further integrating the accelerator community in Europe, and developing a joint strategy towards sustainable accelerator science and technology.

ARIES comprises a strong industrial participation with 8 industrial partners, including three small and medium en-

ISBN: 978-3-95450-209-7 ISSN: 2226-0358 doi:10.18429/JACoW-ICALEPCS2019-MOPHA063

terprises and one association. Innovation will be fostered by joint co-development programmes with industry, by supporting innovative technologies with market potential, and by advancing concepts and designs for medical, industrial and environmental applications of accelerators for the wide benefit of European science and society.

The goals of ARIES work package 6.3 task (CERN, HIT) are:

- establish standard body of RAMS knowledge for particle accelerator applications;
- compile and rank existing RAMS standards, methods and practices in major laboratories;
- analysis of optimal RAMS characteristics for particle accelerator systems;
- spreading the identified best RAMS practices in order to introduce a common baseline; assessing the feasibility of an Open Data Infrastructure for accelerator reliability.

Highly reliable operation becomes ever more critical for future energy-frontier machines as well as many applications (e.g. accelerator-driven systems, hadron therapy). Through workshops and expert discussions the network will at first compile Reliability, Availability, Maintainability, Serviceability (RAMS) methods and practices at major and representative particle-accelerator facilities, create an inventory, and apply some ranking. Further analysis will then allow defining an optimal RAMS characteristics for particle accelerator systems. The identified best RAMS practices will be communicated to the partner institutes as well as to the entire accelerator community in order to introduce a common RAMS baseline. The feasibility of an Open Data Infrastructure for accelerator reliability will be assessed through topical workshops and expert exchanges.

IMPROVEMENT OF RELIABILITY, AVAILABILITY, MAINTAINABILITY, SERVICEABILITY (RAMS)

Reliability and maintenance data are vital to analyse and improve system performance. RAMS methods are well established in industry, with the OREDA (Offshore & Onshore Reliability Data) project [6] founded by several oil and gas companies as an good example. Contrary, the particle accelerator community does not possess a common platform that permits storing and sharing reliability and availability information in an efficient way. In large accelerator facilities used for fundamental physics research, each machine is unique, the scientific culture, work organisation, and management structures are often incompatible with a streamlined industrial approach.

As a pilot example we choosed the HIT medical accelerator for testing and implementing a workflow to collect and analyse reliability statistical data. First, HIT is a rather small accelerator facility with just a single installation, making the communication between technical experts easier. Second, since HIT is a medical accelerator, it already has to fulfill several legal requirements as part of the risk management that is necessary for the treatment of humans. Thus, a culture of documenting maintenance tasks and critical incidents is already existing, with the disadvantage that most protocols are kept as single, non-related documents, not allowing an easy statistical analysis.

For implementing a reliability and availability information system at HIT, we are performing the following steps:

1. Development of a database model for a RAMS information system. This task was outsourced to the Austrian Institute of Technology (AIT), who implemented a database model mainly based on the well established OREDA standard (see Fig. 2 on the following page). AIT imported the model into their Oracle database server and provided a web front end. This step is mainly finished.

2. HIT allocated a scientist and a master thesis student for the task of designing and creating a tool chain to collect data from various sources as shown in Fig. 3 on the next page, like:
   - Operating log books
   - Technical logs
   - Maintenance logs
   - Technical documents.

   As a feedback from some technical experts we got the requirement, that the workflow to implement a RAMS information system must not increase the workload of technical groups. Most of them have their own workflow to document maintenance tasks and failure events. Unfortunately, for historical reasons these workflows are quite unique and incompatible, sometimes stored in own engineering data and document management systems. We found the most technical groups are entering their data into self-designed Excel sheets. For this reason, we are currently designing Excel sheets that keep the original design as much as possible. The implementation of scripts to parse the Excel data with Python using the `xlrd` module is under preparation.

3. Once a sufficient amount of RAMS data collected, we have to implement the statistical analysis. The database model allows to achieve statistical data based on
   - population size and length of observation periods,
   - taxonomies identifying sub-systems,
   - different failure modes,
   - environmental conditions (e. g., additionally to temperature and humidity, in the case of accelerators the lifetime of parts also depends on the fact, whether the part was operated under radiation).

Another feedback we got from technical groups were concerns about the privacy and safety of data. Thus, in the design of the database model, a role-based access and a privacy concept was considered and implemented. As general rule, the privacy and ownership of data within the RAMS information system never changes. Only the technical experts and administrators of an organization are able to view

ISBN: 978-3-95450-209-7 ISSN: 2226-0358 doi:10.18429/JACoW-ICALEPCS2019-MOPHA063

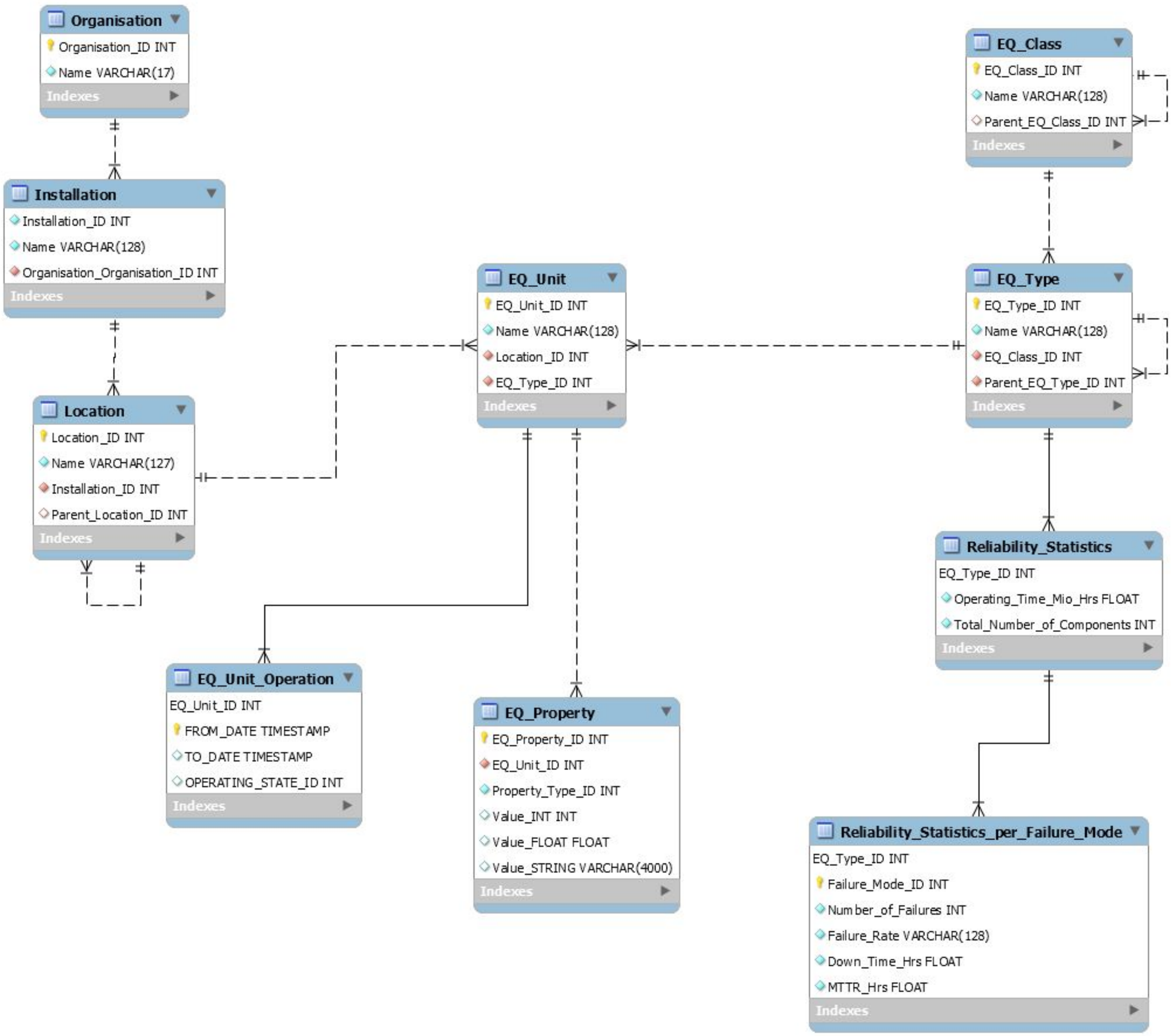

Figure 2: Simplified database model, representing equipment classes, type and units with their properties and reliability statistics. The tables keeping taxonomy data and environmental conditions are not shown.

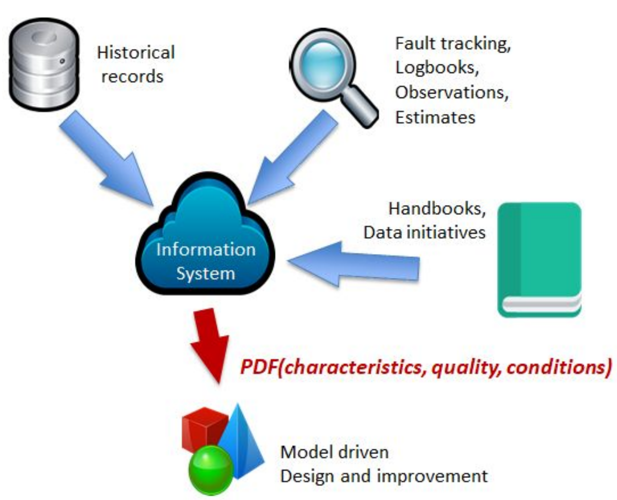

Figure 3: Workflow for collecting RAMS data from various sources.

or change sensitive data like the manufacturer of a particular equipment unit. Only anonymous statistics are shared between the organization.

CONCLUSION

Reliability and data sharing concepts have worked and provided value within various industries. There is no principal reason why a similar concept shouldn't work in an academic environment of accelerator facilities. Up to the current state of the implementation of a RAMS information system as part of the work package task 6.3 of ARIES, it looks like the real challenge is not a technical one. Established database models like OREDA fit into an accelerator environment with rather small changes. The main issue are the personnel resources to collect the reliability data. Thus, a main focus of the WP 6.3 task has to deal with allowing technical experts to enter their reliability data as easy as

ISBN: 978-3-95450-209-7 ISSN: 2226-0358 doi:10.18429/JACoW-ICALEPCS2019-MOPHA063

possible. Another part of the task will have to deal with concerns about the privacy of sensitive operational data.

ACKNOWLEDGEMENTS

This project has received funding from the European Union's Horizon 2020 Research and Innovation programme under grant agreement No 730871.

REFERENCES

[1] Th. Haberer *et al.*, "The Heidelberg Ion Therapy Center", *Radiother. Oncol.*, vol. 73, pp. 186–190, 2004. doi:10.1016/S0167-8140(04)80046-X

[2] S. Combs *et al.*, "Particle therapy at the Heidelberg Ion Therapy Center (HIT)", *Radiother. Oncol.*, vol. 95, pp. 41–44, 2010. doi:10.1016/j.radonc.2010.02.016

[3] A. Peters *et al.*, "Five Years of Accelerator Operation Experience at HIT", in *Proc. 3rd Int. Particle Accelerator Conf. (IPAC'12)*, New Orleans, LA, USA, May 2012, paper TUOAB03, pp. 1083–1085.

[4] M. Galonska *et al.*, "The HIT Gantry: From Commissioning to Operation", in *Proc. 4th Int. Particle Accelerator Conf. (IPAC'13)*, Shanghai, China, May 2013, paper THPWA004, pp. 3636–3638.

[5] The ARIES (Accelerator Research and Innovation for European Science and Society) project, https://aries.web.cern.ch/

[6] The OREDA (Offshore & Onshore Reliability Data) project, https://www.oreda.com/