Abstract. During the operation, maintenance, and dismantling periods of the ATLAS Experiment, the traceability of all detector equipment must be guaranteed for logistic and safety matters. The running of the Large Hadron Collider will expose the ATLAS detector to radiation. Therefore, CERN must follow specific regulations from both the French and Swiss authorities for equipment removal, transport, repair, and disposal. GLANCE Traceability, implemented in C++ and Java/Java3D, has been developed to fulfill the requirements. The system registers and associates each equipment part to either a functional position in the detector or a zone outside the underground area through a 3D graphical user interface. Radiation control of the equipment is performed using a radiation monitor connected to the system: the local background gets stored and the threshold is automatically calculated. The system classifies the equipment as non radioactive if its radiation dose does not exceed that limit value. History for both location traceability and radiation measurements is ensured, as well as simultaneous management of multiples equipment. The software is fully operational, being used by the Radiation Protection Experts of ATLAS and trained users since the first beam of the LHC. Initially developed for the ATLAS detector, the flexibility of the system has allowed its adaptation for the LHCb detector.

1. Introduction

The ATLAS detector is one of the major experiments that compose the LHC (Large Hadron Collider), the biggest particle accelerator ever built [1]. This experiment will analyze the most basic aspects of matter, allowing a better understanding of the beginning of the universe. During its operation, ATLAS will be exposed to radiation, therefore, CERN has to comply with specific regulation from French and Swiss authorities for equipment removal, transport, repair, and disposal.

Following the agreement, the experimental area of ATLAS, was divided in two zones for waste: the Radioactive Waste zone (Zone de Dechets Nucleaires – ZDN) and the Conventional zone (Zone de Dechets Conventionnels – ZDC) [2]. The Radioactive Waste zone is composed of material which has
been calculated to be radioactive after ten years of LHC operation at nominal luminosity and two years of cooling, while the Conventional zone is composed of material which will be non radioactive at that same period and conditions. However, during the operation of ATLAS, the radiological conditions are different when compared to the assumptions made for the waste zone. Consequently, the radiological risk for maintenance are the short-lived radioactive isotopes – by nature not taken into account in the waste study, but responsible in fact of finding significant radioactive material inside the Conventional zone. Therefore, this zone is separated in two sub-zones: the Conventional non radioactive zone, no radioactive material should be in this zone, and the Operational zone, where the material can potentially result to be radioactive during the ATLAS openings. Specific procedures shall be followed for the equipment handling according to the zone and its respective radiological risk.

The people involved with the ATLAS experiment who have access to the detector installations have different roles in the detector activities, which must be reflected on any procedure related with the detector equipment. No matter the role, every person must follow the procedures to ensure location traceability and to measure the dose of the part when making any action.

This article presents Glance traceability [3], which has been developed to fulfill the ATLAS safety and logistic requirements for equipment removal and installation from/in the detector facilities. The architecture of the system is discussed, followed by the conclusions and results achieved during its development and working period.

2. The Glance Traceability

The system provides a set of tools to make the data management, ensure the location traceability, allow the measure of the radiation dose and label printing. The history of the equipment radiation dose and location is also kept. The functionalities of the system are described below.

2.1 Equipment data management

At the beginning of the system, the inventory of ATLAS equipment was stored in MTF (Manufacturing and Test Folder) [4], an interface developed at CERN to handle information during the manufacturing phase for the different piece of LHC equipment. In order to fulfill all the necessities of ATLAS, a specific database was created in parallel to store all information related to equipment positioning and to manage extra information such as the electronic configuration of the detector. After discussions, to ensure more consistency and access control, the MTF data was transferred to the ATLAS repository and came under the control of the Glance traceability system.

Each piece of equipment inserted in the ATLAS Equipment database must have a unique identifier, that might have been imported from MTF, created by the part responsible, or generated by the system. The ID generation is made taking into account the detector system to which the part belongs, its subsystem, and the institute, creating then a sequence of meaningful characters. These characters will be concatenated to a number generated by a query on the repository which checks the pre-existing IDs, avoiding then the generation of identical equipment identification. Figure 1 shows an example of the process to create an ID using the system.

![Figure 1. ID generation](image-url)
Besides a unique identification, the insertion interface will also assign the part to pre-defined equipment types, relating it to physical values such as weight, material composition and geometrical dimensions. Figure 2 shows the interface to assign the equipment characteristics and to insert them into the database.

The search interface allows filtering the equipment data by its characteristics and its position. The system displays a 3D view of the ATLAS facilities, making possible to select the exactly position of the equipment to be found. Figure 3 shows an example of a simple search made by the system.

After the search and selection of the desired equipment, the system provides an interface where is possible to modify the data describing the equipment, such as equipment type, other ID, or its responsible. The assignment of the responsible is controlled by the system in a way that is only possible to select people registered in the CERN database or external companies. If the existing options of equipment types are not adequate to the part, the creation of a new equipment type is possible. Figure 4 shows the interface to manage equipment data, with an example of multiple equipment management by the use of tabs.

Besides changing basic information, this part of the system also allows to print labels for traceability and identification, identify equipment location and measure the radiation dose.

Figure 2. Equipment insertion into the ATLAS Equipment database

Figure 3. Search interface for equipment data
2.2 Radiation control

The radioactive monitoring inside the ATLAS installations is necessary to prevent exposure and contamination of collaboration members. In order to make that control, equipment going inside or outside the cavern must have its radioactive dose measured, which will be used as base for the choice of the procedure to be followed when handling the material.

When starting the dose measurement procedure, the value of the background radiation shall be taken, being used for the calculation of the safe threshold. The interface allows the measure through a radiation monitor. During the measuring, many values are acquired discretely, with the average between them being used to calculate the threshold.

Depending on the area where the measurement is performed, the system allows the storage of different background values.

The measurement of the equipment dose is made through the interface, having its value acquired also by the radiation monitor. The system makes a comparison of the value of the equipment dose to the radiation threshold. If the limited is exceeded, an alert message is shown, and a radioprotection expert should be consulted for the proper procedure.

2.3 Tracking the location

During the operation, maintenance, and dismantling periods of the ATLAS Experiment, the traceability of all detector equipment must be guaranteed for logistic and safety matters. To accomplish this
requirement, the system has functionalities that make possible to associate the equipment to either a zone outside the underground area, or a functional position [5] in the detector.

For the underground area, the choice of the location is made through the integration of Glance traceability with the ATLASLocation3D, which is a 3D graphical user interface that allows the association of equipment to an existing functional position of the cavern. This application offers a schematic view of the detector, identifying the zones, and splitting the ATLAS sub-detectors. Online information about available slots for association of boards in crates is also provided. This program, integrated with the system allows the assignment of locations inside the radioactive zone only if the person has the privilege to do it.

Locations outside the cavern, such as buildings or workshops, are listed in a drop down menu. In the case that the destination of the equipment is not there, it is possible to create new areas by the use of an option on the interface that allows the management of this kind of information. Figure 4 shows how this can be done, displaying in addition some possible views of the detector by the use of ATLASlocation3D.

![Figure 4. Making the traceability](image)

2.4 Labels

All equipment shall have a label containing information needed for its identification in the ATLAS Equipment database. In case of removal, the equipment should also be labeled with information of original location and destination, as well as its radiation dose every time that it goes in or out of the detector facilities.

The labels can be generated and printed by the integration of a program that receives the information retrieved from the glance interface and generate them. The label for identification contains the part ID, plus a barcode having that same information, being useful for quickly entering the data into the system to make a consult by the use of the barcode reader. If the equipment dose exceeds the radiation threshold an alert figure is shown on the label along with the date of the measurement. Figure 5 shows an example of labels generated by the system.
3. Architecture

Glance traceability accesses data from Oracle databases using AJAX, that is a group of interrelated web development techniques used to create interactive web applications. With Ajax, the system can retrieve data from the server asynchronously in the background without interfering with the display and behavior of the existing page.

Data retrieved from the server are described in XML format, acquired through the Glance Retrieval Tool. This tool is an API of the Glance Project [6], that was developed for the ATLAS collaboration and allows data retrieval of heterogeneous and spread repositories through the same search interface [7]. The XML data is parsed on the system with JavaScript, making possible its use by the interface.

To update the database, the system communicates with the web server via the Common Gateway Interface (CGI) using programs developed in C++, which receive the user’s input and passes it to the repository. The GNU CgiCC library [8] is used to implement these programs. The updated data about the modified equipment is put together in an XML description and transferred to a CGI, leading to the use of the Xerces-C++ library [9] to parse it before use it.

For the location traceability, the ATLASlocation3D is the most important tool. This 3D graphical user interface (GUI) was developed in java/java3D starting from ATLASeditor3D [10] to show the ATLAS detector and its installation in a 3D view. The underground area is divided by zones and functional positions, offering a complete visualization of the cavern, and allowing the choice of the location.

The communication with peripherals is also a fundamental part of the system. Printer and radiation monitor can provide data to the interface through Java applets. The FH 40 G Multi-Purpose Survey Meter, connected to an external probe, is used for taking the radiation protection measurements; radiation readings are fetched by the applet through the Java Communications API. To print labels, the layout is generated by another applet using the data given by the interface.

4. Conclusion

Because of the radiation exposure at the detector facilities during its operation, the ATLAS experiment must manage the material handling inside and outside of its installation. Glance traceability was then developed, accomplishing that necessity of this experiment.

The system is operational since the first beam in September 10th, 2008, being used by the radioprotection experts and members of sub-experiments. A similar version for the LHCb experiment was created and it is in full operation.

The next steps would be: the integration with the CERN ISRAM waste database; manage storage of equipment/tooling in specific area workshop/buffer zone; and equipment hierarchy management. Storage of radioactive equipment should also be foreseen.

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