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LEP Traceability

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Abstract

After more than ten years of production for high energy physics, CERN's current flagship, LEP, will be closed down definitively October 1st, 2000. Starting immediately, some 30,000 tonnes of LEP materials will be removed from the tunnel to make room for LHC installation. The dismantling project is a major undertaking in terms of resources and constraints, which has to be completed in less than one year. Moreover, since LEP is classified as a nuclear installation in France (as if it was a nuclear power plant), special procedures have to be followed in addition to the normal environmental and safety issues. One major facet of the project is the "traceability" of everything that comes out of the LEP tunnel. This implies that each piece of equipment must be identified and tracked from its origin through any temporary storage to its final destination. Special procedures have to be followed for all materials even if they are not radioactive. As much of the equipment as possible will be recycled or disposed of. This paper describes the database design, software and procedures that are envisaged for the implementation of the LEP traceability system.

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After more than ten years of production for high energy physics, CERN's current flagship, LEP, will be closed down definitively October 1st, 2000. Starting immediately, some 30,000 tonnes of LEP materials will be removed from the tunnel to make room for LHC installation. The dismantling project is a major undertaking in terms of resources and constraints, which has to be completed in less than one year. Moreover, since LEP is classified as a nuclear installation in France (as if it was a nuclear power plant), special procedures have to be followed in addition to the normal environmental and safety issues. One major facet of the project is the "traceability" of everything that comes out of the LEP tunnel. This implies that each piece of equipment must be identified and tracked from its origin through any temporary storage to its final destination. Special procedures have to be followed for all materials even if they are not radioactive. As much of the equipment as possible will be recycled or disposed of.

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1 INTRODUCTION

The construction of the LHC requires that the LEP tunnel is cleared of all equipment and services that are not required for the new machine. The tunnel will then be handed over for civil engineering and installation within the time constraints determined by the LHC Project.

2 LEP DISMANTLING CONSTRAINTS

The main constraints for the LEP dismantling project come from the LHC Civil Engineering programme, CERN administrative procedures and the regulations and guidelines concerning INB's (*Installation Nucléaire de base*). Traceability being a requirement of the latter.

2.1 LHC Civil Engineering

The planning of the LHC construction is fully established, excavations for the new injection lines TI2 and TI8, the new experimental caverns and service areas for ATLAS and CMS have already started. Civil works inside the existing tunnel will start in January 2001.

2.2 INB Regulations

Following an agreement signed between CERN and the French authorities in 1984, LEP is classified as an INB and the French body DSIN (*Direction de la Sécurité des Installations Nucléaires*) verifies the application of the appropriate regulations. Similar to a nuclear power plant, these regulations outline what needs to be done for removal of equipment. Detailed reports concerning safety aspects, waste management and operational procedures have been prepared for the French authorities [1,2,3]. Fundamental requirements are firstly *zoning*, to identify all areas in terms of their nuclear contents and secondly *full traceability* of all materials removed from the LEP INB.

The LEP materials are categorised as conventional or very slightly radioactive (*TFA, très faiblement actif*). The materials will be reused at CERN or other institutes, sold for recycling or treated as waste. For any use or destination, appropriate authorised disposal channels need to be established [3]. Periodical reports on the actual location of all material, either conventional or radioactive, will support the transparency of the dismantling exercise.

2.3 CERN Regulations

Since CERN is an international organisation and LEP is located on both French and Swiss territories, a number of rules concerning taxes and customs have to be applied. Appropriate customs documents must accompany any goods that are transported outside or between CERN sites. In the particular case of transportation of radioactive material, specific documents with additional radiation information are must be produced.

3 EQUIPMENT TRACEABILITY

The specification for the traceability system is that it must be possible to determine the location and "trace" in time and space of all equipment removed from the horizontal underground areas of LEP.

3.1 Equipment Inventory

In order to keep track of any piece of equipment, it needs to be identified uniquely. Information concerning machine components was gathered with the help of roughly twenty equipment groups and then it was verified, cross-checked and completed after visits to the tunnel.

Although gathering information on equipment pieces is an iterative process, it is fairly simple compared to bulk material. A vast amount of material like piping (vacuum, cooling, RF), cables and cable trays, will be placed in containers before evacuation. Clearly, a preliminary identification of this bulk material, with details of its original location, cannot be established.

3.2 Traceability Tools

Every piece of equipment, which comes out of the LEP tunnel, is attributed a unique "Trace-LEP" number. This number is represented as a barcode on a sticker, which is stuck on the equipment (see Fig. 1). For bulk material, the barcode sticker will be glued on the container. A member of the Traceability Team (a *Tracer*) must identify the container's contents on the fly.

Figure 1: Barcode sticker

The *Tracers* will be equipped with laser barcode readers and located at strategic places. The barcode reader chosen is the handheld Falcon 320/325 series from Percon®, which offers a 16-line screen, 486-class processor and real-time RF connectivity. The latter permits the barcode readers to be connected to the central database, so reading of the barcode can immediately result in an additional event in the piece's history.

3.3 Procedure

In October 2000, as soon as LEP physics stops, there will be a 3-week period to establish all safety conditions in terms of radiation, electricity, fluids, gasses and cryogenics. Once the underground areas are declared as "safe", dismantling teams will start taking LEP apart. All equipment will be disconnected and dismantled, (and bundled in the case of bulk material), in order to be evacuated through one of the seven access pits via a 10-ton crane or a 3-ton elevator. Tracers will be present at the bottom of the pits (traceability and radiation check) and at the top of the pits (traceability check and dispatching towards their destination).

Three types of destinations can be distinguished:

- *Temporary Storage Area*: for equipment that is to be reused at CERN in the near future;
- *Transit Zone*: for equipment that will be sold to a contractor for recycling;
- *Radioactive Waste Storage*: for slightly radioactive material that must be disposed of.

Depending on the destination, appropriate transfer slips will be generated for the CERN transport service. At all destinations, Tracers will record the arrival of the equipment concerned (see Fig. 2).

At the Transit Zone, equipment is loaded on the contractor's trucks, and after weighing and a final radiation check, pro forma sales documents are produced. After leaving CERN premises, the responsibility of the equipment's traceability is transferred to the contractor.

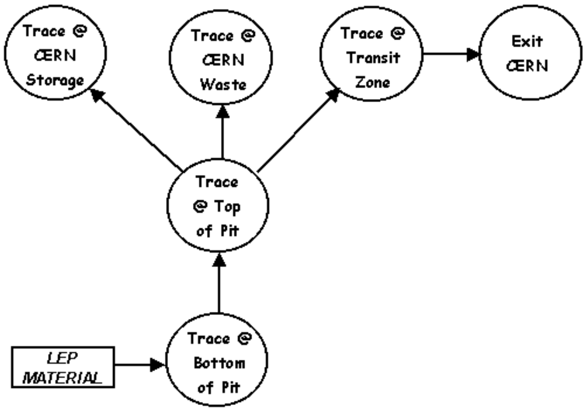

Figure 2: Schematic Tracking Procedure.

4 DATA MANAGEMENT

For the management of the equipment's information, it was decided to develop something in-house. For data storage, a dedicated database was designed using Oracle. The surrounding software needs were analysed, modelled with UML and implemented using both Java and C++.

4.1 Database Design

Applying the relational model, a simplified Entity Relationship Diagram (ERD) was derived (see Fig. 3).

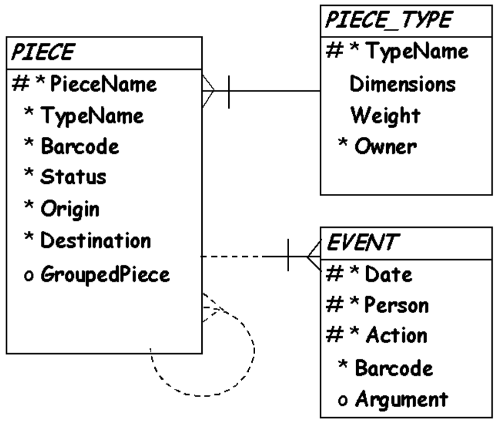

Figure 3: ERD for LEP traceability data.

These three base tables make up the skeleton to hold all tracking information:

- The table <u>Pieces</u> holds attributes on individual pieces of equipment: barcode, type, statuses (actual, disposal, radioactivity) as well as origin and destination; the *GroupedPiece* attribute covers composite pieces and possible disassembling and reassembling.
- The table <u>Piece Types</u> describes the common attributes per type of equipment (dimensions, weight, composition, owner, etc.).
- The table <u>History</u> contains all recorded events for all equipment pieces; an event can be seen as an *action* executed by a *person* at a certain *time*.

The information in *Pieces* gives the last snapshot of the piece of equipment, while the *History* gives its dynamic evolution over time. Combining the two tables allows a full traceability on all equipment.

4.2 Software Engineering

The user and software requirements have been established based on the activities of the Tracers and the data flow from their barcode readers to the database. Depending on the function and location of the Tracer, different actions are possible. For example:

- Check details of the piece of equipment
- Assign type and origin to bulk material
- Introduce radiation measurement
- Confirm or change TFA status
- Change equipment destination
- Generate transfer slip
- Acknowledge reception at destination
- Assemble or disassemble equipment

Not all of the above actions can be performed by simple manipulation of the barcode readers. At some locations, the extra functionality must be provided by web interfaces in order to give a dynamic picture of the database information.

All the necessary software functionality is being developed in-house by a team of three software engineers.

4.3 Implementation

Two types of barcode readers will be in use during the dismantling period. The "online" type has an integrated antenna and is able to connect directly to the database server. The "offline" type has no such connection and needs to work with local files that need to be periodically offloaded and downloaded to and from the database.

Due to the hardware limitations of the barcode reader, an implementation in Java and C++ is foreseen for the online and offline version respectively.

4.4 The Real World

LEP dismantling traceability has been analysed, thought over and discussed for over 18 months now. The implementation of the solution is ongoing, but one has to foresee that not all will go perfectly well in reality.

Backup solutions mainly imply manual interventions in stead of the automated, computer networking based way of working. The objective is to maintain a continuous flow of material from LEP towards its final destination, whilst maintaining full traceability.

5 POST-LEP TRACEABILITY

As from 2 October 2000 the LEP becomes the LHC INB, which also includes the SPS machine and its extraction lines up to the targets.

5.1 LEP Equipment

Any LEP equipment that stays at CERN in order to be reused needs continuous tracking. Web-based tools will be developed and provided in order to fulfil this necessity. For reuse in SPS or LHC, a logical link must be made to the equipment's previous trace history.

5.2 LHC Equipment

Traceability in the LHC must be seen in the much wider context of the LHC Quality Assurance Plan (QAP). In the QAP all equipment destined for LHC will be identified from their creation and their trace covers the complete lifecycle of the equipment, including related drawings, documents, measurements, etc.

The MP5™ asset management tool from Datastream Systems has been selected as the standard software for the LHC equipment follow-up. Eventually, this Oracle®-based tool will be the standard CERN-wide.

5.3 SPS Equipment

SPS was constructed in the early seventies and commissioned in 1976. In its lifetime SPS has seen many drastic changes, going well over design parameters for the high-energy proton fixed target programme; as proton-antiproton collider; as lepton injector for LEP and as future LHC injector. All layout modifications have been followed up internally, but with the INB regulations, a more sophisticated tracking system needs to be worked out with proper management, transparent accessibility and reporting.

6 CONCLUSIONS

Traceability has always been an implicit concept at CERN but without major importance or external requirements. With the dismantling of LEP this is no longer the case. All tools are being put in place in order to have a foolproof traceability system in place during the dismantling activities.

Since traceability will be a requirement for SPS and LHC as well, the concepts to be elaborated and implemented for these installations will undoubtedly be based on the experience with LEP dismantling.

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