Accelerator Data Foundation: How It All Fits Together

Ronny Billen

Pascal Le Roux, Maciej Peryt, Chris Roderick, Zory Zaharieva

CERN, Beams Department
Controls Group
Data Management Section

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Outline

- Introduction
- A Vision, a Strategy and some Tactics
- Accelerator Data Management Domains
- Data Federation
- Covering the CERN Accelerator Complex
- Human Resources
- Conclusions

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Introduction

Two major events can be considered as turning points in data management in CERN's Accelerator Sector:

❶ Purchase of a commercial RDBMS in 1983 ORACLE

- Aimed to address complex technical aspects of LEP
  - Project planning, cabling, documents, magnet data,…
- Since then, many successful database driven systems were implemented, but in a dispersed way
  - PS Controls, LEP Alarms,…

❷ Reunification of "Accelerators & Beams" activities in 2003

- Single groups for *Operation*, *Controls* and *Equipment* for the complete CERN accelerator complex
- Unification of *accelerator data management* was proposed…and accepted by the hierarchy

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The Vision

- Data Management Team in the Controls Group
  - ⇨ Dedicated team of 8-10 database software engineers
  - ⇨ Senior members having also accelerator domain knowledge
  - ⇨ Junior members proficiently up-to-date in database development
  - ⇨ Ambitious technical and human objectives for the team
- Need for a clear vision
  - ⇨ Highest importance attributed to LHC
    - huge complexity, but starting from a relatively clean sheet
  - ⇨ *Rationalize*, *improve* and *federate* the existing data on the older accelerators
  - ⇨ Break up the vast domain into manageable areas
    - Typically a senior and junior team member in each area
- Communicate, communicate, communicate

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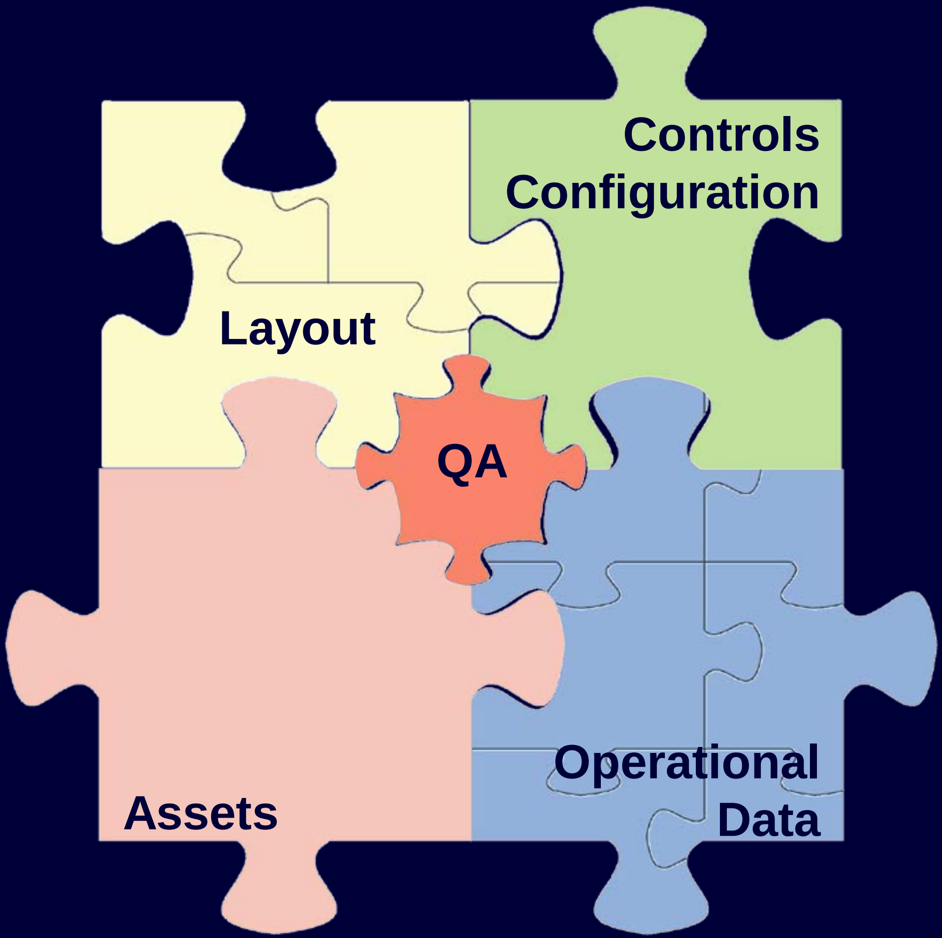
The Puzzle

Breaking up the data domain into several pieces



- Advantages
  - ⇨ Logical break-down
  - ⇨ Organized
  - ⇨ Manageable
- Inconveniences
  - ⇨ Integration not considered at the outset
- Therefore
  - ⇨ Emphasize common understanding and good communication between developers
  - ⇨ Federation work began in 2007

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Strategy

- Development work
  - Major effort: requirements gathering, analysis and development work
  - Legacy DB showed lack of *Quality Assurance* at DB and data levels
    - Introduced integrity constraints and naming conventions
- Technology
  - Use of Oracle technology stack (huge in-house expertise)
  - Use of Java, J2EE, JDBC deployed in 3-tier architecture
  - On-line usage of database services for accelerator control
- Responsibilities
  - Acceptance of competence shift with clear limits of responsibilities
    1. DM team developers
    2. Application developers
    3. Data owners
    4. DB infrastructure service

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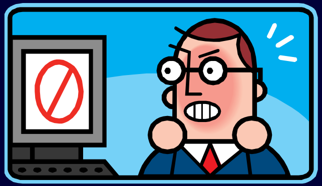
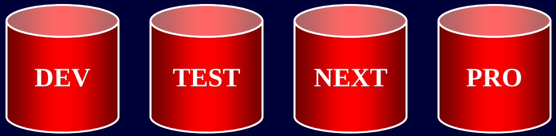
Some Tactics

- The important aspects to make the strategy successful
  - Involve end-users right from the start, throughout the design and development process
  - Communicate constantly on scheduled interventions and their anticipated impact
  - Iterate rapidly based on end-user feed-back
  - Provide adequate environments for development, unit testing, system testing and production
  - Push data ownership to the experts, assist and guide the usage of the data maintenance interfaces





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Layout Data

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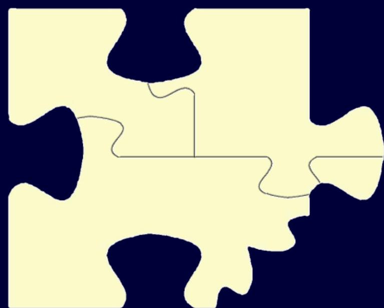
RPPA03



❶ Machine Layout

- ⇨ Accelerator design, magnetic model, beam optics by machine physicists
- ⇨ Mechanical installation & integration work; establishing the as-built model

❷ Controls Electronics Layout

- ⇨ Racks, crates, modules, fieldbus connections
- ⇨ 9,000+ racks for LHC
- ⇨ Essential during installation
- ↳ Starting point for automatic *configuration* of front-end computers

❸ Electrical Circuits Layout

- ⇨ Description of electrical objects in powering circuits
- ⇨ Relationship between power converters, current leads, bus bars, magnets,…
- ↳ Exploited in *operational data* domain

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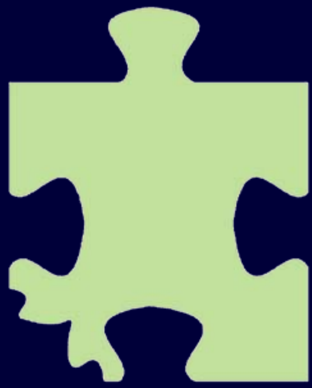
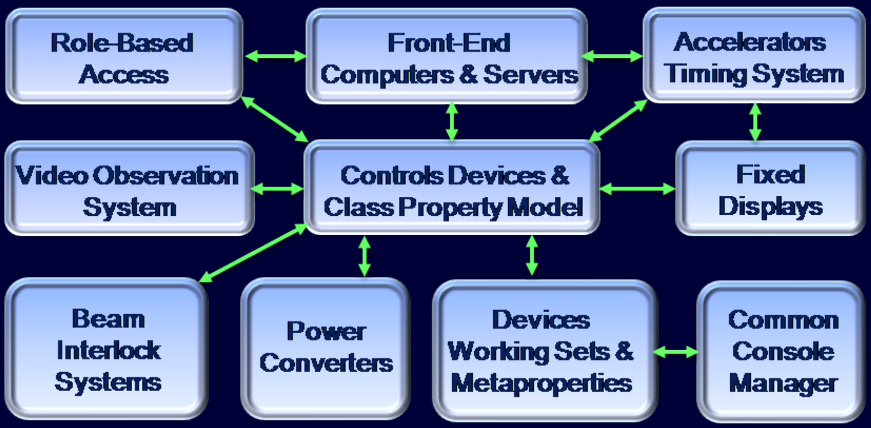
Controls Configuration



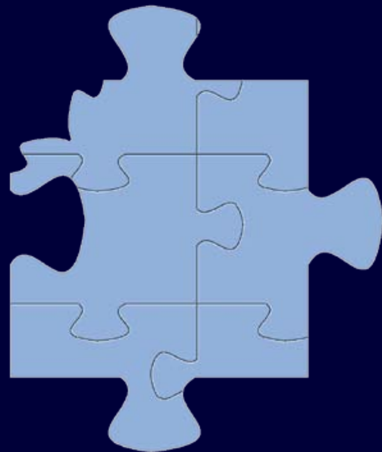


TUA004

- Control system topology
  - From front-end computers to control room consoles
  - 65,000+ controls devices
  - 5 device-property models
  - Rejuvenated legacy DB
- Interactive interfaces and APIs
  - 200+ re-developed Oracle ADF interfaces (Java-based forms)
  - 150+ Oracle APEX reports
  - Java APIs for control room apps
  - Pro*C APIs are being replaced

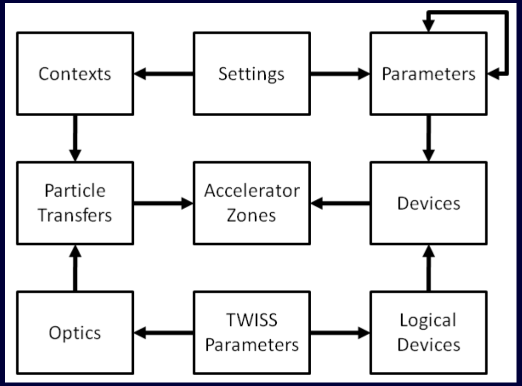
THP108

Operational Data



❶ Settings

⇨ Parameter space for LSA



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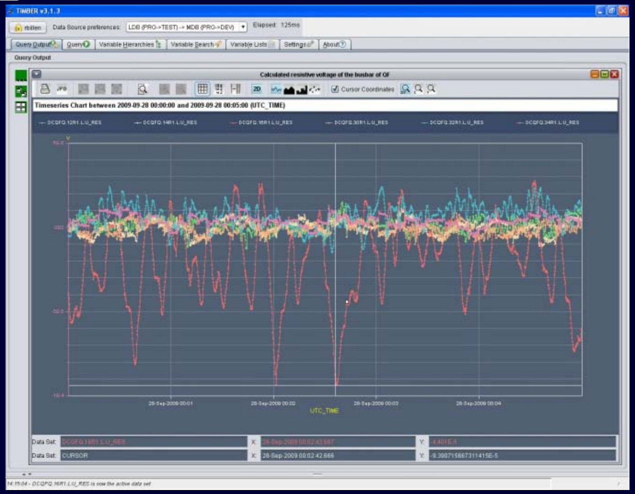
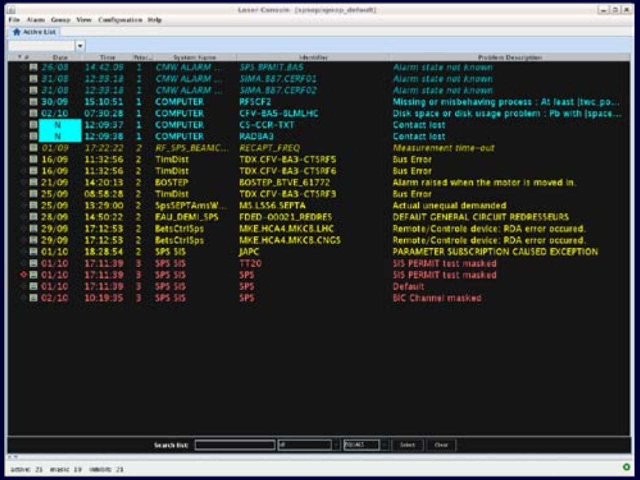
❷ Measurements & Logging

⇨ Store time-series data, keep on-line

⇨ Beam and equipment measurements

WEP005





❸ Alarms - LASER

⇨ Capture, store, notify anomalies

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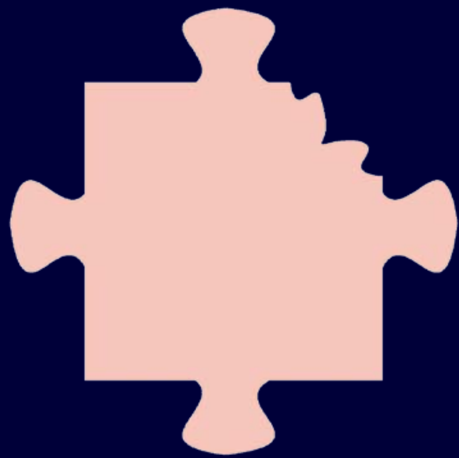
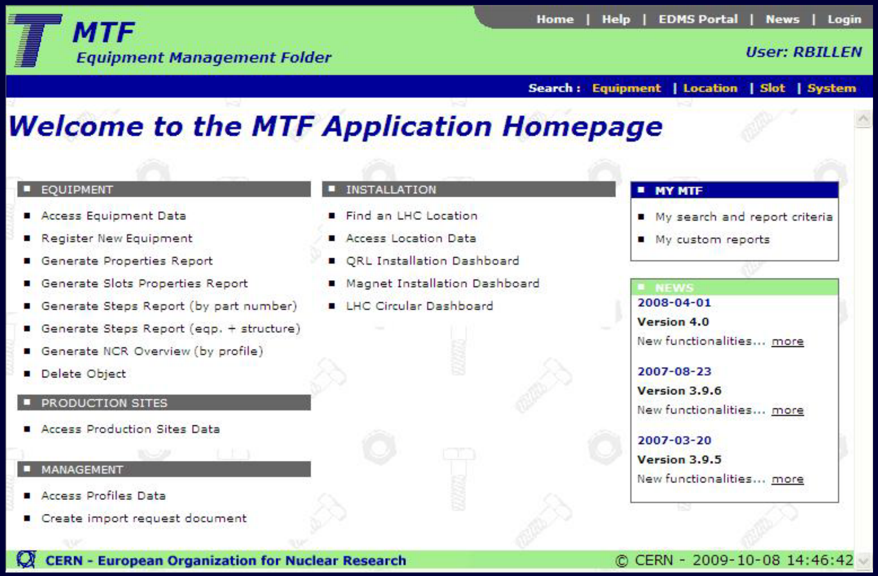
Assets Data





- Physical components
  - CERN-centralized asset management
  - CERN-wide part identifier
  - Commercial system enriched with home-made interfaces
  - Keep track of complete lifecycle of the asset

TUB004

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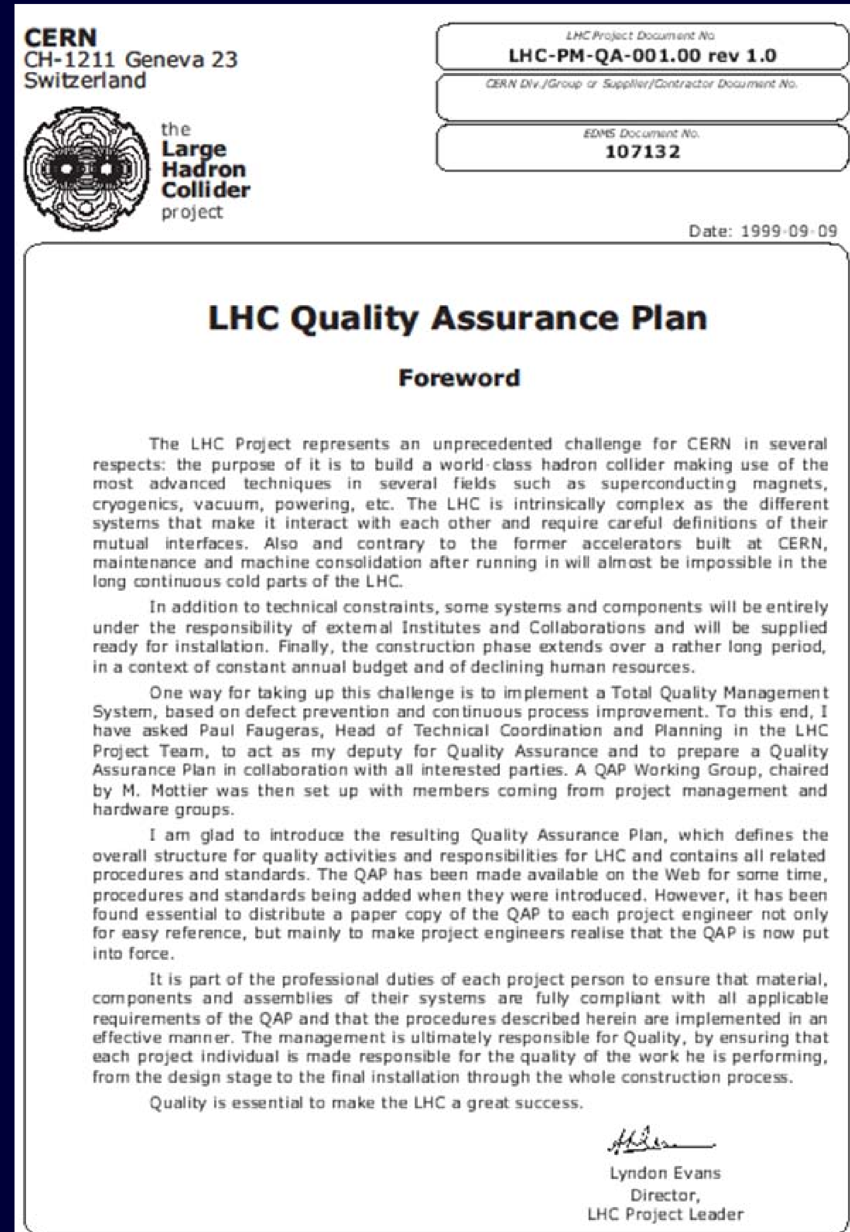
Quality Assurance

- Fitting the pieces of the puzzle
  - QA starting point: identification of objects
    - Equipment code catalogues as official references
  - Supporting QA tools
    - Including a Naming database
- Basis for Data Federation
  - Imposed naming conventions
  - Clear procedures, standards and instructions to be followed by all



CERN
CH-1211 Geneva 23
Switzerland

the **Large Hadron Collider** project

LHC Project Document No.
LHC-PM-QA-001.00 rev 1.0

CERN Div./Group or Supplier/Contractor Document No.

EDMS Document No.
107132

Date: 1999-09-09

LHC Quality Assurance Plan

Foreword

The LHC Project represents an unprecedented challenge for CERN in several respects: the purpose of it is to build a world-class hadron collider making use of the most advanced techniques in several fields such as superconducting magnets, cryogenics, vacuum, powering, etc. The LHC is intrinsically complex as the different systems that make it interact with each other and require careful definitions of their mutual interfaces. Also and contrary to the former accelerators built at CERN, maintenance and machine consolidation after running in will almost be impossible in the long continuous cold parts of the LHC.

In addition to technical constraints, some systems and components will be entirely under the responsibility of external Institutes and Collaborations and will be supplied ready for installation. Finally, the construction phase extends over a rather long period, in a context of constant annual budget and of declining human resources.

One way for taking up this challenge is to implement a Total Quality Management System, based on defect prevention and continuous process improvement. To this end, I have asked Paul Faugeras, Head of Technical Coordination and Planning in the LHC Project Team, to act as my deputy for Quality Assurance and to prepare a Quality Assurance Plan in collaboration with all interested parties. A QAP Working Group, chaired by M. Mottier was then set up with members coming from project management and hardware groups.

I am glad to introduce the resulting Quality Assurance Plan, which defines the overall structure for quality activities and responsibilities for LHC and contains all related procedures and standards. The QAP has been made available on the Web for some time, procedures and standards being added when they were introduced. However, it has been found essential to distribute a paper copy of the QAP to each project engineer not only for easy reference, but mainly to make project engineers realise that the QAP is now put into force.

It is part of the professional duties of each project person to ensure that material, components and assemblies of their systems are fully compliant with all applicable requirements of the QAP and that the procedures described herein are implemented in an effective manner. The management is ultimately responsible for Quality, by ensuring that each project individual is made responsible for the quality of the work he is performing, from the design stage to the final installation through the whole construction process.

Quality is essential to make the LHC a great success.

Lyndon Evans
Director,
LHC Project Leader

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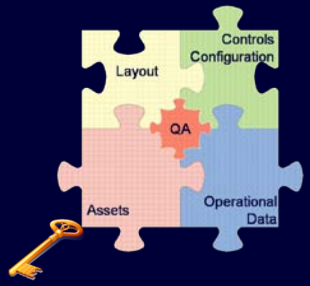
Data Federation

- The perfect solution for data integration…
  - ⇨ Unique identifier (i.e. primary key) for each object throughout all data domains
- …was not put in place, so…
  - ⇨ How do we solve this problem?
- Exchange of keys between the domains
  - ⇨ Object Identifiers are truly unchangeable primary keys
    - Not the object name! It may change over time
  - ⇨ Several implementations on a case-by-case basis
    - Database views, materialized views
    - Use of 'grant select' or database links
    - PL/SQL code for more complex data propagation
    - Execution on manual, semi-automatic or automatic basis
- Best illustrated by example



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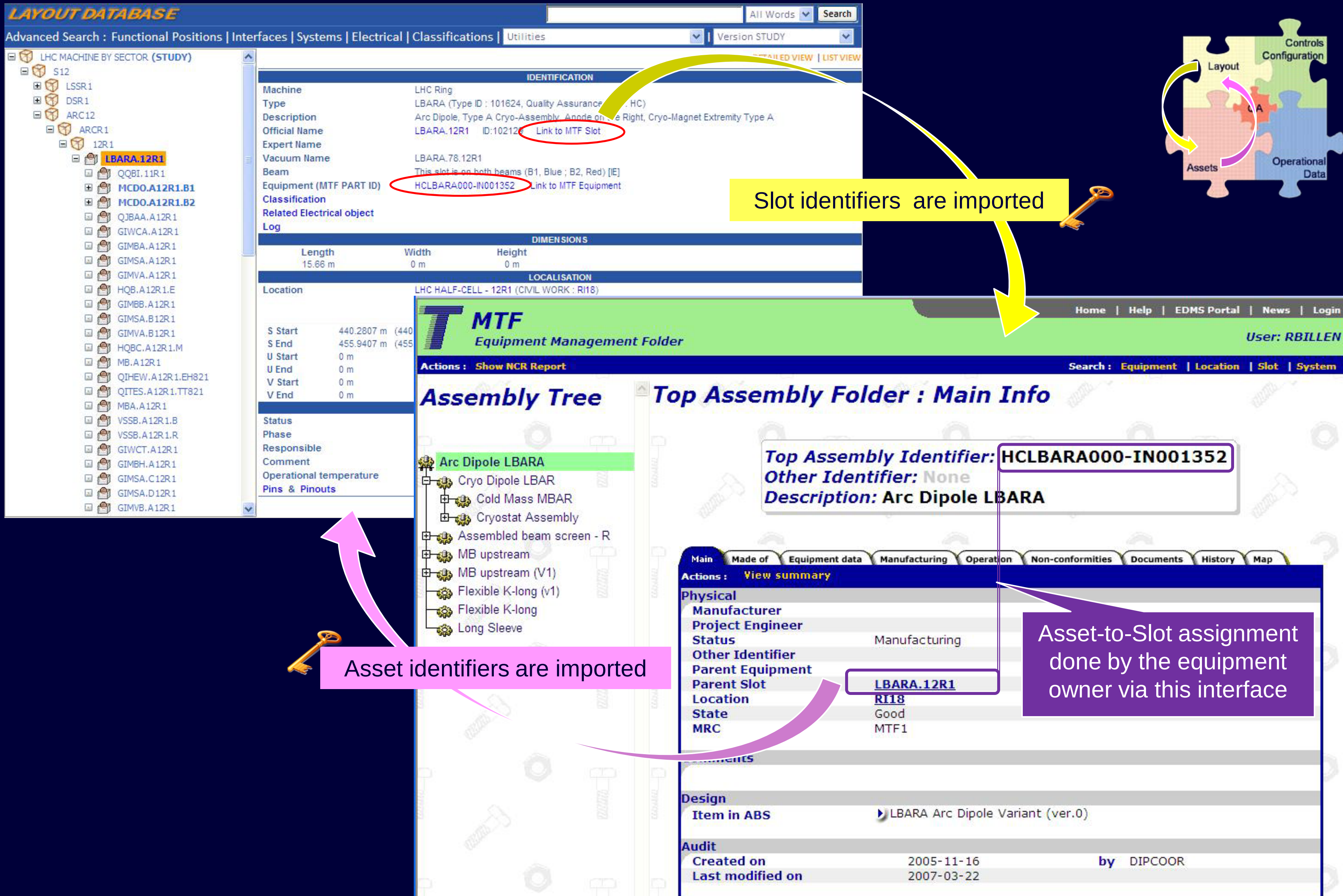
Assets Installed in Layout Slots



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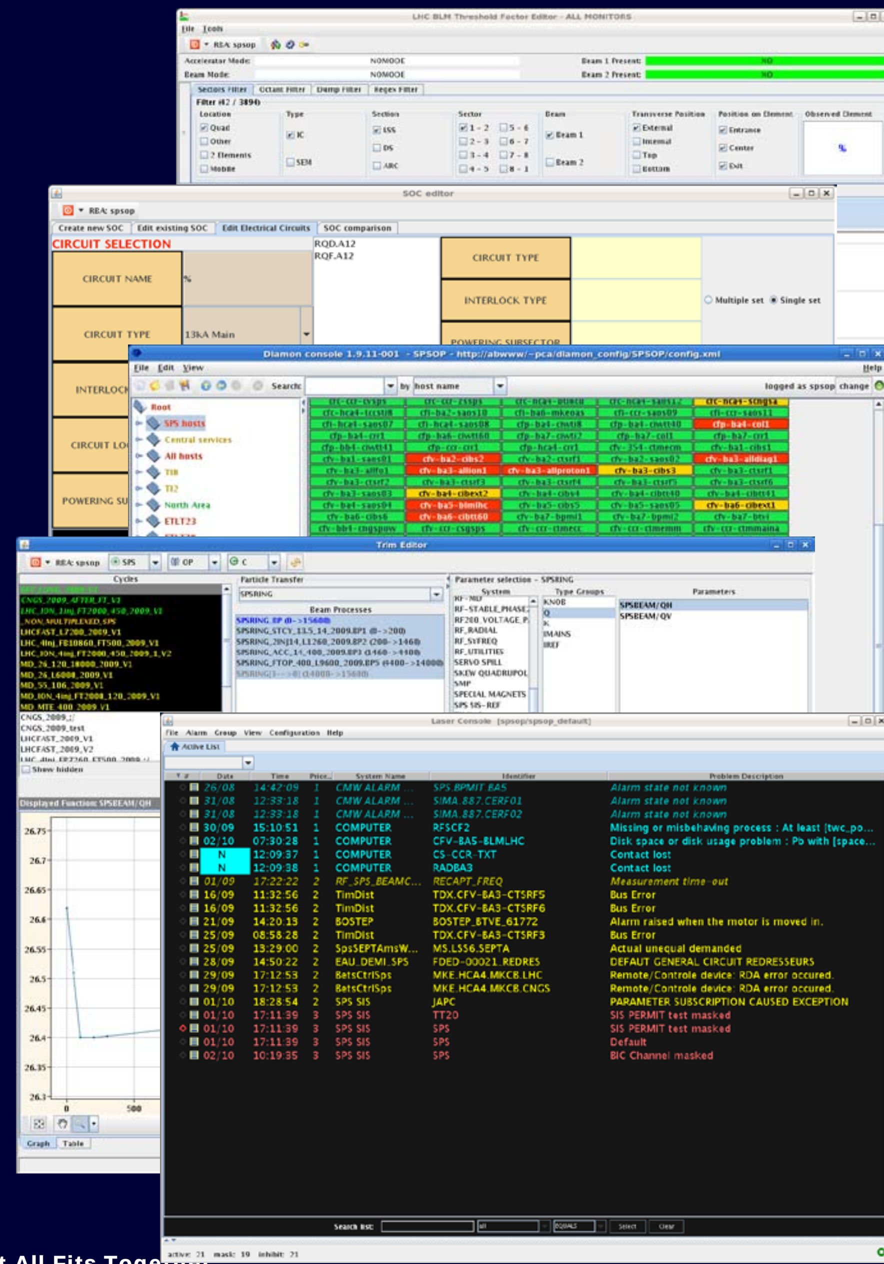
Other Examples of Data Propagation

- Beam loss monitoring electronics
  - ⇨ Module data needed for beam interlocks
- Commissioning sets of circuits
  - ⇨ Electrical layout needed to drive settings
- Configuring front-end computers
  - ⇨ HW/SW configuration derived from layout data
- Driving settings from SW devices
  - ⇨ From device-property to Device-parameter
- Generating alarm definitions
  - ⇨ Based on controls configuration



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Covering the CERN accelerator Complex

- Architecture, design and implementation was set out with LHC in mind
- Retrofit to existing accelerators is in progress
  - ⇨ Integrate the existing data into the current model
  - ⇨ Extend the model to cater for specifics of other accelerators
  - ⇨ High level controls and settings management of the PS-complex is the most difficult challenge
  - ⇨ Renovation project with convergence towards LHC has been launched

TUP019

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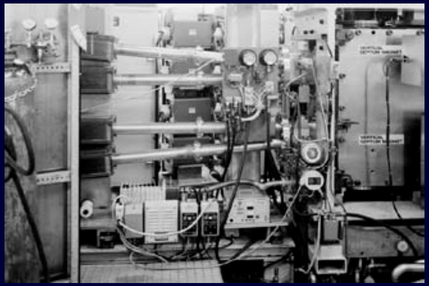


Human Resources

- The people are the most important assets in the process of *analysis*, *design*, *development* and *maintenance*
- The core team of database engineers have to:
  - Follow and use the technology effectively
  - Acquire specific domain knowledge
  - Show flexibility in adapting to the changing user requirements
  - Impose data access methods to application developers
- Their *responsibility* is proportional to the *database complexity*

	tables	constraints	code	volume
Layout	134	495	55,602	5.3 GB
Configuration	514	1,524	30,326	9.7 GB
Settings	281	1,392	9,026	14.6 GB
Logging	55	103	14,431	+17 TB
Alarms	207	191	24,915	62.8 GB

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Conclusions

- What's the important message here?
  - Data management is an organizational issue
  - The accelerator domain is a very wide area
    - Legacy, in-house developments, commercial systems are part of our environment
  - Ensure single source of maintained, consistent data
    - Avoid confusion, doubt and errors
  - In case of data propagation
    - Procedures for execution and verification of the data synchronization are mandatory (i.e. Quality Assurance)
- A database is only as good as the correctness of the data it contains
- Software comes and goes, data stays forever

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Questions?

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