31-May-2006

Integrated Project Support Study Group

Findings

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Executive Summary

The challenges of the LHC project have lead CERN to produce a comprehensive set of project management tools covering engineering data management, project scheduling and costing, event management and document management. Each of these tools represents a significant and world-recognised advance in their respective domains. Reviewing the offering on the eve of LHC commissioning one can identify three major challenges:

1. How to integrate the tools to provide a uniform and integrated full-product lifecycle solution
2. How to evolve the functionality in certain areas to address weaknesses identified with our experience in constructing the LHC and integrate emerging industry best practices
3. How to coherently package the offering not just for future projects in CERN, but moreover in the context of providing a centre of excellence for worldwide collaboration in future HEP projects.

If CERN can meet these challenges, then combined with the knowledge, expertise & know-how acquired during the LHC project CERN has the unique opportunity to provide a competency centre for integrated project management tools, and thereby offer support to projects such as the ILC.

Unfortunately integrating the existing tools 'as-is' is insufficient to achieve this vision. Evolution of the CAD-EDMS tools is required in order that CERN may address current shortcomings and provide industry best-practices. Specifically an early introduction of rigorous configuration management practices already at the design stage, the introduction of the notion of the 'item', dependency tracking & analysis and introduction of a 3D centric product data management approach is required. This requires more than a change in IT system, but also a change in methodology, practices and organisational culture.

Some of the benefits of evolving the EDMS tools are:

- Earlier detection & reparation of problems thus reducing the number of defects in the fabrication phase, consequently reducing the delays and overall costs
- Improve CAD data exchange with suppliers and the sub-contracted design offices
- Reduce the number of drawings necessary for the pre-study and study and consequently the costs of these phases.
- Facilitate the approval process for new or modified designs with 3D visualisation
- Tighten the tracking of dependencies
- Enhance part compatibility, re-use and detect part incompatibilities
- Improve the traceability from the final produced part to the original design

Additionally benefits of providing an integrated project tool suite are:

- Provide consistent views of a given project across the involved tools.
- Ease the update of the EVM work units
- Ease the search for any type of electronic document
- Enhance the procurement lifecycle from the design offices to delivery.
- Ease the use of the tools by avoiding separate registrations for each tool, and by standardising the access rights through common central group and role assignments.
- Have a common approach regarding the authentication and authorisation mechanisms.

Currently CERN is not in a position to meet all of the ILC requirements, particularly at this phase in the project with respect to their requirements of an EDMS system. This study group unanimously supports their choice of TeamCenter at DESY which is already operational and providing basic multi-site collaboration for the ILC. Given the investment required by CERN to adopt this software, combined with the minimum timescales for implementing such a solution, CERN could not offer an equivalent service within the next 12 months.

In the short term our recommendation is to simultaneously commence integration of the existing tools and launch a pilot project implementation of UGS TeamCenter for CATIA users at CERN. This could provide CERN with a symbiotic relationship in which the ILC project could benefit from CERN's CATIA support and CERN could benefit from existing TeamCenter knowledge. We could also support the distributed model proposed by the ILC by sharing common data across the systems. This would cost:

- UGS TeamCenter pilot : 300kCHF for software, server licenses & consulting + 1 additional FTE
- Integration of CERN tools : 2 FTEs for 2 years
- CDS, Indico & PPT for ILC : 3 FTEs (service, support & customisations)

In the longer term, with the introduction of CATIA as the new CAD system at CERN and the end of the LHC designs approaching there is a unique window of opportunity to carry out change, evolve our current CAD management tools by introducing UGS TeamCenter and adopt industry best practices. If we invest now then we will evolve CERN towards providing the leading project management practices for future projects independent of CERN's future role as host or collaborator.

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1. Introduction

The ILC requirements for project support tools have provided a catalyst for the review of the current tools at CERN. This report examines the status quo at CERN, describes potential scenarios for future evolution and particularly for the context of the ILC examines integration along the lines proposed by the ILC EDMS selection committee.

In particular the study group is asked to address the following:

1. *Elaboration of a vision & strategy for integrated project support involving analysis of user communities & requirements, enumeration of leading tools & best-practices and identification of interoperability and integration approaches.*

2. *Analysis of the status quo at CERN today with its existing tools*

3. *Development of a roadmap for future evolution including potential scenarios with their relative strengths & weaknesses along with technical & other implications as well as integration, in particular the link between management tools and CATIA 3D. The use of UGS TeamCenter as recommended by the ILC should be addressed as a possible option.*

4. *Estimation of costing covering both the one-off setup costs and the recurrent operating costs of the scenarios including support & maintenance efforts.*

5. *Analysis of the implications of the possible use of the management tools by an international community spread over distributed institutes and proposal of a strategy for their implementation.*

2. Review Process

Once the definition & scope of the mandate had been set the process for the study group was to:

1. Carry out an Area-analysis for each of the domains.
2. Examine integration possibilities
3. Propose evolution scenarios.

Had the tools been in a steady state and cover the leading best practices across all domains then the above process would have been relatively straightforward. However it emerged very early on that there was some evolution to be made in the EDMS area with respect to configuration management and 3D data management. Efforts were therefore focused significantly on the various scenarios for evolution in this area. This included on-site visits to CERN by Dassault systems (providers of CATIA and SmarTeam) and UGS (providers of TeamCenter) as well as a discussion with engineers in DESY and Fermilab on their experience. The scenarios elaborated in this report take into account the more detailed analysis carried out during the review of this area.

The following are the key dates of the review process.

Meeting between DG, JP Delahaye, J. Ferguson, W. Von Rüden :	3-Apr-2006
Meeting between W. Von Rüden & J. Purvis :	4-Apr-2006
Study group participants selected :	7-Apr-2006
Initial meeting of Study Group (scope/mandate):	10-Apr-2006
Mandate of study group sent to DG :	13-Apr-2006
PPT/EVM Analysis Meeting of Study Group :	12-Apr-2006
UGS teamcenter presentations/visit :	20-Apr-2006
	16-May-2006
	23-May-2006
Dassault presentation/visit :	10-May-2006
	17-May-2006
EDMS Analysis Meeting of Study Group :	21-Apr-2006
Revised mandate given to study group :	24-Apr-2006
CDS/Indico Analysis Meeting of Study Group :	25-Apr-2006
CAD Analysis Meeting of Study Group :	26-Apr-2006
PLM/multicad analysis meeting with UGS Teamcenter :	27-Apr-2006
Discussion with I. Neilson for Grid VOM solutions :	2-May-2006
Discussion with A. Pace for Certificates :	8-May-2006
Discussion with E.V.Bij for CAE :	9-May-2006

Visit to DESY :	18/19-May-2006
Status report to Wolfgang Von Reuden :	22-May-2006
Visit to UGS to test CATIA-TeamCenter integration :	23-May-2006
Methodology Discussion with R. Folch & A. Bertarelli of TS-MME:	24-May-2006
Conference Call with Dassault :	29-May-2006
Final Costing Scenario Analysis :	29-May-2006

3. Analysis Summary

As the first beams circulated LEP on the 14th July 1989, design studies of the LHC dipoles was already well underway and CERN's administrative information systems were about to undergo a revolution with the introduction of projects such as AIS. The next 16 years heralded a major growth in computerisation of previously manual procedures from drawings to documents, an adoption of many industry best-practices and a particularly early adoption of web-technologies facilitating the world-wide collaboration challenges associated with the construction of LHC and the experiments.

Today CERN has a broad range of project support tools born and matured during this LHC evolution. In a simple scenario these tools can be (and often are) offered 'as-is' for future projects. However the request to this study group has acted as a catalyst for reflecting on the future of these tools and for the first time ever to consider their evolution towards a single, coherent and uniform offering.

This objective is certainly easier to state than to achieve as we have some notable constraints:

- The tools are currently alive & 'in-use' mid-project, so any evolution must be compatible with existing usage
- A single uniform technology underneath would be a misguided investment due to the incompatibilities for instance between open-source requirements and constraints imposed by commercial packages
- Given the significant investment to-date in these tools, a key requirement of any evolution should be to 'future-proof' the existing investments.

Whilst a pessimistic view may see these constraints effectively meaning that a 'blank sheet of paper' style vision is prohibitive, the optimistic view illustrates that CERN actually has an extremely good starting point for further development both with the tools and the associated experience acquired during the implementation, roll-out and running.

Today if a new project, at CERN or elsewhere, needs to use one of our existing tools "as-is" and benefit from the CERN experience then this is feasible. EDMS, CDS, PPT and Indico have all demonstrated successes in supporting other projects. However the twofold challenge in this report is to elaborate a vision for both an integrated solution and for a future problem set for which some details are still unknown

Assuming that future challenges require not only an integrated tools set, but also functionality which goes beyond what we have today particularly in the area of configuration management and multi-CAD interoperability then we have to address two axes: On one axis we need to examine the weaknesses of the existing offering and how these may be addressed. On the second axis we need to elaborate the integration possibilities within the previously mentioned constraints by defining standard protocols for information exchange and clearly separating the responsibilities between the various applications.

This report attempts to elaborate this vision. A structured approach to each area is adopted analysing not only what it does best today, but what are its weaknesses and areas for improvement. Additionally responsibilities are identified with respect to data providers and data consumers. Finally the components are combined together and compared across several potential scenarios for evolution.

The remainder of part I of this document adopts the mandate's 5-point structure to address each point in turn. Part II of this document contains the analysis by area.

3.1 Vision & Strategy for integrated project support

The following is the request of the mandate:

> *"Elaboration of a vision & strategy for integrated project support involving analysis of user communities & requirements, enumeration of leading tools & best-practices and identification of interoperability and integration approaches."*

An overview of the current user requirements for each area is detailed in part II. In the future within the CERN context one may extrapolate these user requirements and apply them to the scenarios relevant to the operation and evolution of the LHC accelerator and experiments. The majority of project support tools at CERN have both a very close match to the requirements of their particular domain, as well as implementing some industry best practices (e.g. OAI harvesting for CDS, EVM for PPT, equipment tracking in MTF/EDMS). However there are also some areas for improvement.

3.1.1 Introduction of full product lifecycle management, CAD interoperability and configuration management

Design work carried out for the LHC project using the current 3D CAD system, EUCLID has been a success. However, based on this experience, three weaknesses have been identified:

1. Management of CERN CAD-designs today is document-centric as opposed to being fully item-centric.

2. The present CERN CAD data management system lacks support for fully interoperable multi-CAD configuration management.

3. Consistency and traceability of designs is compromised by the use of multiple mutually ill-fitting mechanical CAD systems at CERN.

Whilst the current CERN EDMS system was a major step forward in automating manual drawing practices and transferring them to electronic processes, there has been a paradigm shift in industry to move to full 'Product Lifecycle Management' (PLM). In the CERN context this means managing all equipment in a coherent manner from the early design phase to their eventual decommissioning and dismantling. At CERN the critical missing link for PLM is the introduction of the notion of the 'item'[1] already in the CAD design phase (Items are used successfully later in MTF & EDMS in other phases such as with the managing of installed equipment).

In the absence of a full PLM system and this item notion in the design phase we are currently at best managing CAD drawings, but we are unable to effectively manage the interdependencies and versioning between the various components being designed and manufactured for the LHC. The item concept as used today at CERN in the context of manufactured parts remains incomplete without links to the original design data. Historically, at CERN this was largely due to the traditional drawing-centric approach, a belief that a drawing management would be enough for design follow-up, as well as characteristics of the current CERN 3D CAD system, EUCLID, which already included its own local data manager able to support concurrent design. Concern around this point has been raised in the past, but it has taken recent concrete examples to prove the importance of this crucial concept. Introduction of EUCLID's successor CATIA V5 raises this issue again since with a new CAD system one has the liberty to rethink and re-implement one's design processes. A dedicated PDM system, SmarTeam, came together with CATIA. The item and its integration with EDMS play a central role in the design of the ongoing SmarTeam implementation project.

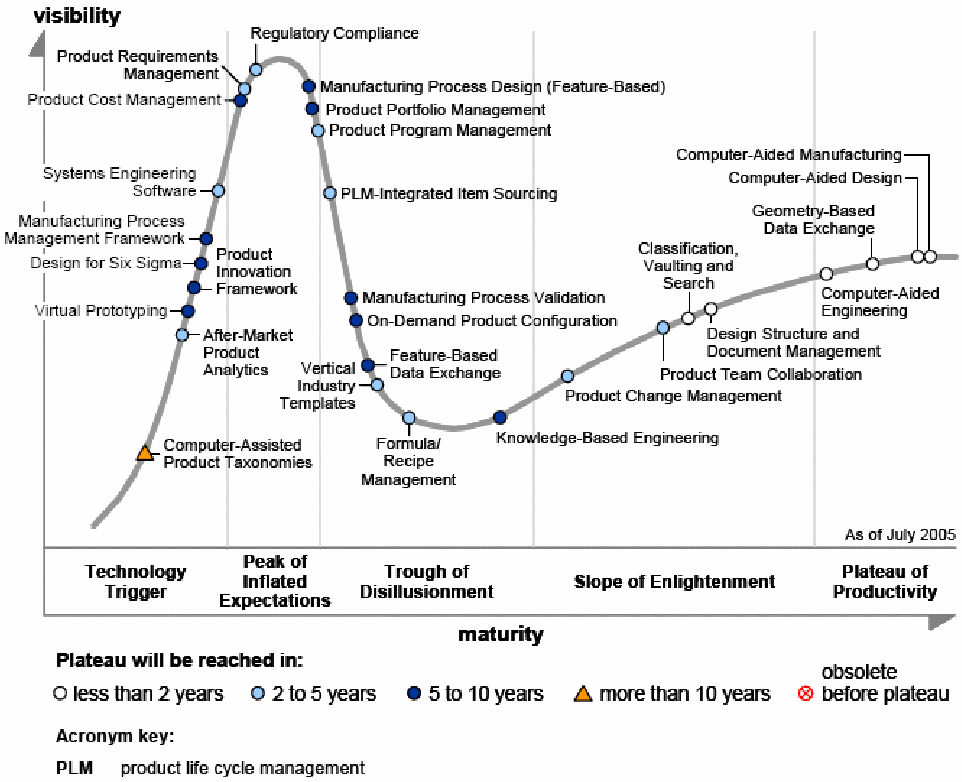
Work had already started in TS-CSE to examine the integration possibilities of the existing EDMS with CATIA using either an integration module (xPLM) for Axalant (underlying CERN EDMS) or with a dedicated local data management software (SmarTeam from Dassault). The former has the advantage of integrating CATIA directly into the EDMS. However, the developer company of xPLM is small and with limited resources, and its relationship with Dassault is not entirely smooth, which makes the future of the product uncertain. Also, the integration is not as tight as what one would normally obtain with a product coming from the same vendor. For these reasons, the preferred solution to-date for CATIA local data management at CERN has been SmarTeam.

CERN is of course not the only organisation facing such challenges and companies worldwide are identifying similar need which has lead to the birth and development of the PLM market. Many sales

[1] See glossary

people are of course offering their tools as the unique solutions to all product lifecycle challenges and it may be difficult to separate the marketing from the achievable.

Figure 1. Hype Cycle for Product Life Cycle Management, 2005



Source: Gartner (July 2005)

The Gartner Hype cycle for Product Life Cycle Management separates those concepts which still require development from those which are presently attainable and provide for solid return on investment. Whilst PLM still has many aspects which are high on the peak of inflated expectations, there are areas demonstrating solid achievements such as:

- Product change management which covers workflow approval process
- Product Team Collaboration which allows collaborators to display, annotate and modify product content via the web
- Design structure & document management which provides for the capturing and sharing of design-related content

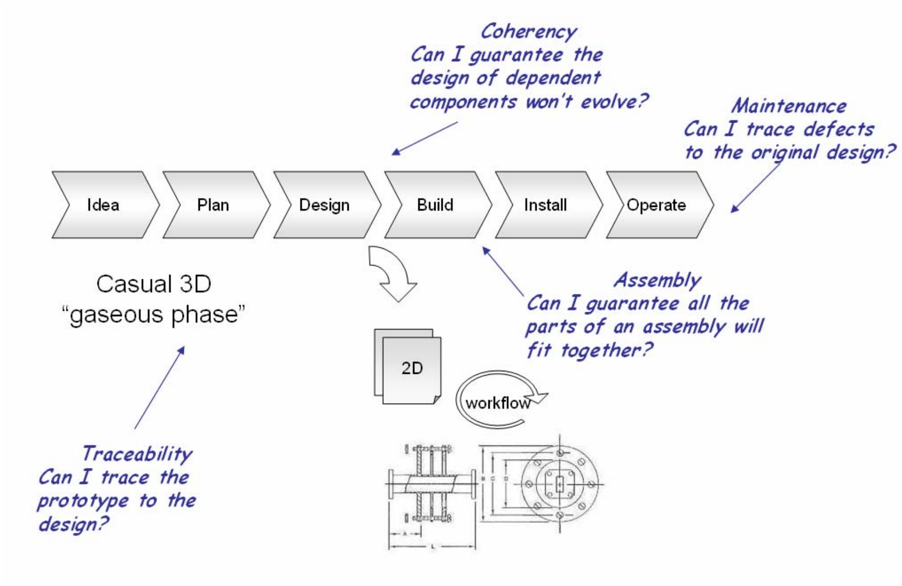
The above functions are already available in the existing EDMS system at CERN, but 3rd generation PLM tools & market leaders such as UGS have tighter integration with CAD and the item concept.

Associated with the hype around PLM many projects are being initiated, but there are also numerous failures. In particular some of the potential pitfalls identified & relevant to CERN are:

- PLM should not be driven as a 'department' effort, but should be organisation wide driven top-down
- Objectives must be clear for what PLM should achieve
- Don't believe in PLM miracles

At the initiative of this study group, contact has been made with UGS to examine the offering of UGS TeamCenter. Additionally a visit to DESY was to understand their experience with implementing TeamCenter.

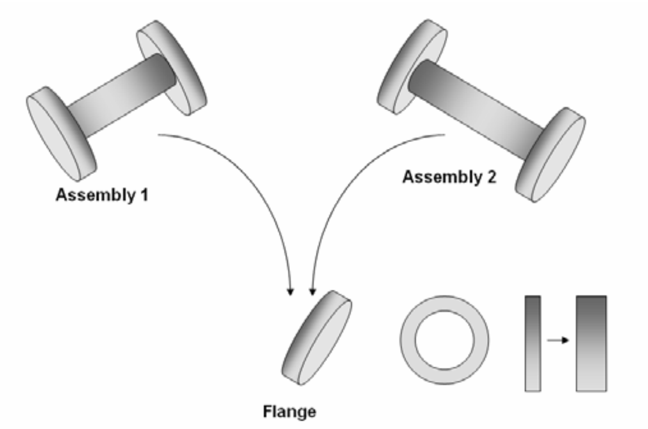
At the meeting in DESY[2] we also met with a representative from Fermilab. Several problems were identified in the current product lifecycle management methodology at CERN and Fermilab. These are illustrated in the diagram below:



Some key common issues which emerged were:

- **Lack of traceability at the Prototype Stage.**
  Since the prototype stage has a strong 'R&D' approach then there is a lack of rigour in declaring the parts, items and assemblies in a structured fashion. Unfortunately this may lead to situations where on completion of the prototype traceability has been lost to the original components & design decisions which led to the successful implementation of this particular prototype. The solution is to ensure a rigourous link between the CAD models and the item definition at the earliest stage possible. This will certainly involve a culture change moving from a 'freedom of expression' casual 3D style to a more methodical implementation already at the R&D phase.

- **2D Design-drawing centric.**
  The deliverable from the design stage is the 2D plans. These plans circulate for approval and are combined with other 2D plans for assemblies. Both Fermilab and CERN sited numerous cases where as a result of the 2D-only view a wide variety of problems (assembly, incompatibility, missing views, partial information..) were missed and only found at the later and more expensive build phase.

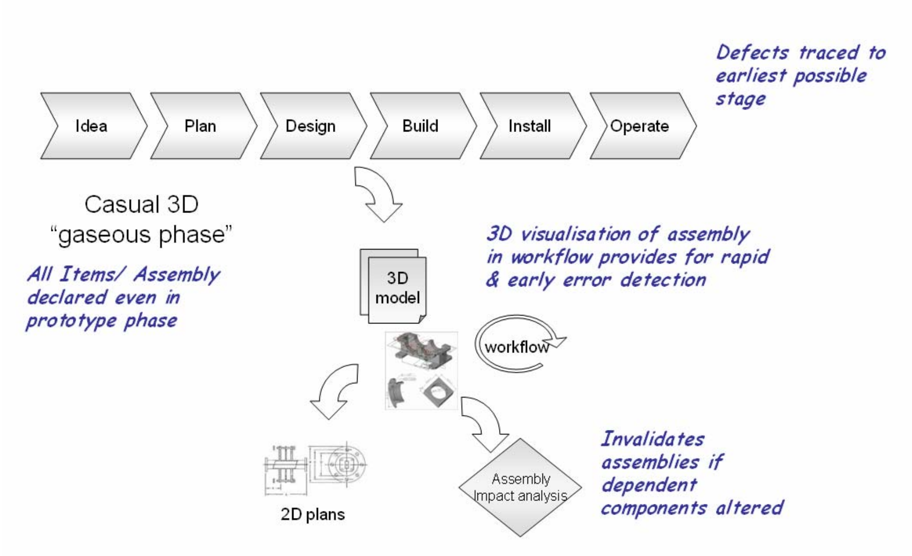


- **Coherency of assemblies**
  In the simplified view above which illustrates two pipe assemblies depending on one flange, we want to ensure, that modifications to dependent articles are handled in such a fashion that we always ensure coherent assemblies. For example when an engineer 'checks-out' the second assembly, if he modifies the width of the flange required for that assembly, this would invalidate

[2] See Summary in Appendix C

the first assembly forcing the creation of a new component and maintaining part-compatibility for the respective assemblies. This picture is an over-simplification as one can imagine the complexity with 20+ levels of components and multiple dependencies but it illustrates the nature of the problem to be dealt with at the heart of effective configuration management systems.

The solution to these problems lies both in the tool and the methodology as illustrated in the diagram below:



In the new diagram we observe that the aforementioned problems are specifically addressed by the following:

- **Declaration of Items & Assemblies from the outset.**
  By imposing a rigorous methodology and having a tight integration between the CAD & PDM tools one may impose that the product-breakdown-structure of items & assemblies is declared right from the early R&D phase. This ensures that once the right functioning prototype had been realised we have traceability to the original design in order to guarantee reproducibility of the success.

- **3D model deliverables from the design phase.**
  It is emerging in industry that 3D visualisation at the design stage is providing early detection and prevention of errors otherwise often undetected with 2D drawings. The 3D models are circulated for approval and annotated in the workflow process. Subsequently only a limited amount of 2D drawings are produced, i.e. those directly required for manufacture.

- **Configuration incompatibility detection**
  With the automatic translation of the CAD files to the JT format TeamCenter can perform some intelligent checking detecting incompatibility of components in assemblies and preventing 'checking-in' of modifications which risk invalidating other assemblies.

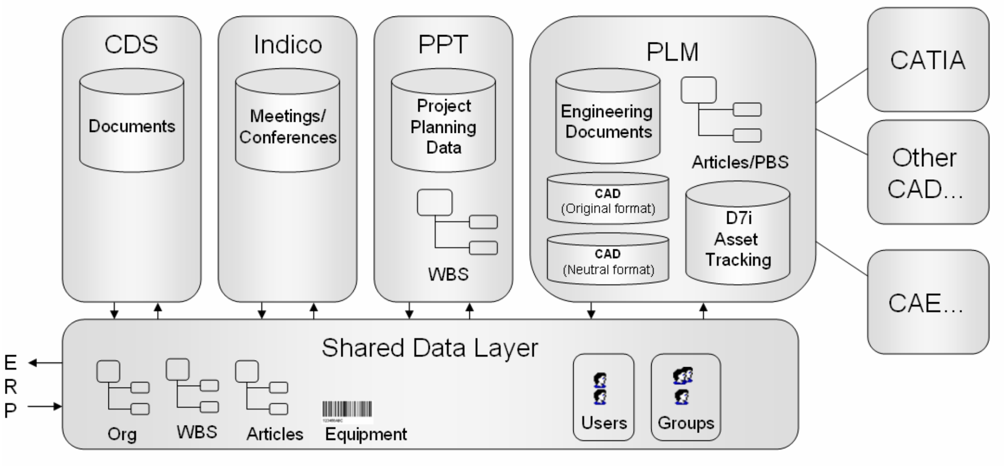
Experience at DESY has shown that addressing these problems not only requires the tools & methodology to be in place, but also a culture change in understanding the move to tighter configuration management, 3D drawing management and the impact these entail.

Concerning CAD interoperability in the CERN context this is currently achieved primarily using a conversion server, which however converts and sends models without managing the interdependencies & history. With the move from EUCLID to CATIA CERN is in a position that it may read files of different formats directly in CATIA. However CERN cannot easily interface or supply other CAD systems with formats which they can read. Direct CAD-to-CAD conversions also run the risk that we lose track of configuration management dependencies. The ideal process is to have the PDM or configuration management system manage the CAD interoperability. TeamCenter achieves multicad by converting all CAD drawings to the neutral JT format. Assemblies may therefore be visualised easily even when parts come from different CAD systems. Furthermore engineers who 'check-out' components from the configuration management system receive both the JT format and the native CAD format used for the production.

3.1.2 Provide an Integrated solution

Concerning integration approaches there are two areas to be addressed: The first area is integration between the various systems for project management, document management etc. The key approach here is not to re-implement, but instead to re-use as much as possible of the current tools thus future-proofing existing investments whilst integrating them into an open architecture which will provide for bidirectional data exchange of the shared information such as work breakdown structure, product breakdown structure, users, roles etc. This can be achieved by a common data layer, a 'foundation' for all shareable data[3]. The second area is user management including authentication & authorisation.

After an analysis of the existing tools we currently have at CERN covering their strengths & weaknesses as well as potential to work in an integrated environment, the following diagram outlines an integrated architectural approach.



The diagram is a significant simplification and implementing and migrating to the above approach requires significant investment.

The following areas have been identified for integration between the applications

PBS, WBS & Other hierarchies

Each of the applications has the concept of various hierarchies, but hierarchical data entered in one application is neither visible nor usable in another application. Responsibilities should be defined for which application 'owns' which hierarchy (e.g. PPT for the Work Breakdown Structure, EDMS for the Product Breakdown Structure) and the hierarchical data should be stored in a central repository accessible to all.

Progress Reporting in EVM & EDMS

In MTF progress is reported on the installation. Similarly but with a different level of granularity progress is reported on deliverables in PPT. Both systems have their own dashboards but neither the data nor the progress reporting is connected. It is probably possible to ease the PPT progress reporting by providing (when relevant/possible) some "pointers" to the EDMS/MTF data, for instance to the manufactured or installed equipments.

CFU documents

We observed that CFU documents start in EDMS as technical designs, are re-entered into CDS e-tendering and also stored in AISMedia. Further analysis should be carried out to avoid the duplication of documents across 3 document management systems.

ECR & financial impact

Whilst there is a workflow for the engineering change requests in EDMS it is currently disconnected from the financial system. Any financial impact is currently reconciled manually. Traceability to potential EVM cost variance is also not possible. An integrated approach should be examined.

[3] The precise implementation details such as Enterprise Message Bus, Service Oriented Architecture or simply common DB repository may be defined at a later stage

D7i & Baan

Both systems provide for asset tracking, but since the teams managing each system are not aware of the functionalities provided by the other then either team risks to fall into the hammer & nail solution syndrome (recall if the only tool you have is a hammer then all your solutions look like nails). For example D7i is used to manage the car pool at CERN, whereas Baan is used to manage the electronics pool. Baan is interfaced to both the financial system and EDH so can provide for 'requests for rental' workflow and automatic re-billing in the financial system. Both systems have advantages, but neither is integrated or even aware of the other.

Standardisation of Item Coding, SCEMs, BOMs to EDH

There is currently no centralised standardisation of materials. This is not due to lack of functionality, but lack of a process. With materials and choices of components being standardised throughout the entire chain from design to manufacturing including procurement seamless integration may be provided thru the various systems. Today bills of materials are manually retyped into EDH and component data manually searched for in a variety of supplier catalogues.

Shared document management facilities.

CDS & EDMS today could benefit by sharing back-end functionality such as auto-numbering, document stamping and document format conversion.

Searching

CDS & EDMS currently have their own search solution. Changing the underlying technology to be a common shared tool is perhaps cost-prohibitive and may not even be technically feasible given the underlying architectural differences. However techniques to providing a uniform and coherent high-level meta-search across all the applications should be investigated.

Archival policy

A common or coherent archiving policy across the document management systems should be examined such as file formats for long term storage.

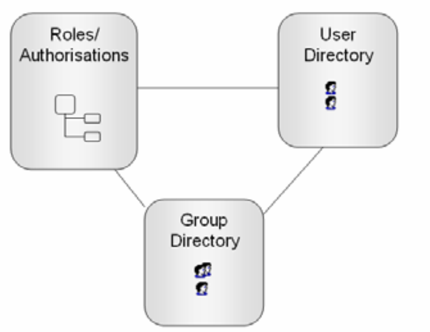
Workflow

Both CERN's EDMS & CDS have their own workflow processes but these work-flow processes have been built in the systems in isolation and do not share any common data, rules or mechanisms between them.

Authentication & Authorisation

In addition to the integration across the data identified above, it is also important to provide an integrated user authentication and authorisation schema. Today a variety of logons are available for the systems including the NICE-login, EDMS-login, AISlogin and CDS login. In addition to the separate authentication mechanisms, authorisation data is not shared across applications (a project leader in one application may not be recognised as a project leader in another).

Discussions have taken place with the Grid community as well as the IT central services concerning authentication mechanisms. Whilst there are a variety of technologies available and certainly personal certificates such as KPI look the most promising for an internationally distributed community, the underlying processes and definition of responsibilities remain the same independent of the chosen technology.



There are 3 main components :

1. The user directory
   This may be a centralised directory (e.g.LDAP or CRA at CERN), or distributed using VOMS. Independent of the technology behind the implementation it embodies the principle of being able to uniquely identify, i.e. authenticate an individual user
2. The roles/authorisations directory
   Authenticating a user is insufficient to allow them to usefully access and manipulate the data. In order to know which data they may read, which data is prohibited and which data may be modified the role of the user together with the associated permissions of that role must be stored
3. The group directory
   This is optional but is useful for functionality where 'groups' are defined for example for people sharing data or sharing workflows. The notion exists ad-hoc in some of the systems today, but not in a uniform fashion across all the systems.

Recently the introduction of CRA has lead to a significant improvement and harmonization of registration and creation of accounts. For example on arrival at CERN a TS newcomer automatically receives a NICE, EDMS & AIS logon.

3.2 Analysis of Status Quo at CERN today with its Existing Tools

A detailed study of the existing tools at CERN today is provided in Part II of this document. Below we summarise this in the form of a SWOT analysis

3.2.1 SWOT Analysis

Strengths

- A leading-edge set of tools for project, product & document management at CERN
- Choice of CATIA
- Experience of various teams thru LHC project

Weaknesses

- Non-integrated toolset with multiple logon systems, no common search and no data-sharing or automatic linking across systems
- PDM is 2D centric as opposed to 3D
- Missing notion of item early in design stage
- Currently some design errors are detected too late and too high a cost
- Gap between CERN EDMS offering and TeamCenter

Opportunities

- Move to CATIA is opportunity for culture change to 3D & introduction of new PLM
- Chance to be come a centre of excellence combining LHC experience, CATIA + TeamCenter
- Future international project support (ILC, CLIC) if we can build the infrastructure now
- Provide an integrated & coherent toolset

Threats

- We continue 'as-before' (perhaps due to budget/manpower constraints)
- We lose future projects to other Labs with more modern tools.
- In Future CERN projects, errors may again be detected too late and too high a cost

3.2.2 Collaborating vs Competing solutions

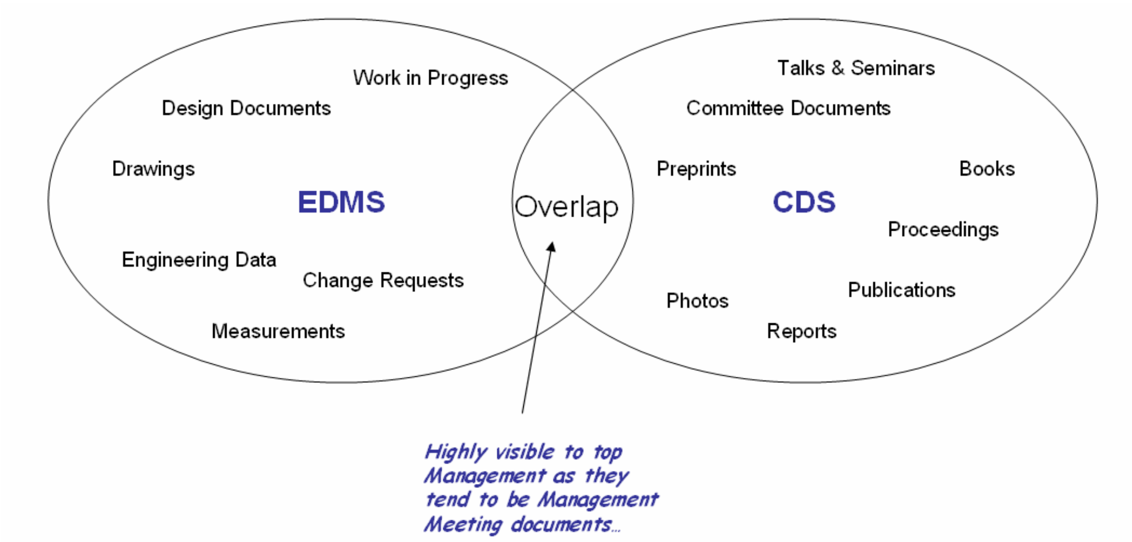
An interesting but important second-system effect also emerged from the collaboration generated by the study group, Abraham Maslow once said that "If the only tool you have is a hammer, you tend to see every problem as a nail." We observe precisely this syndrome with requests to our respective services. For example a request to TS for assistance with a problem will be met with an EDMS-oriented solution whereas a request to AIS for assistance of the same problem would perhaps be met with a Baan or EDH oriented solution. The most effective solution is probably a combination or integrated approach carried out in a collaborative and not competing fashion adopting the best practices from both areas. This has not been the case in the past and as a result customers have sometimes consulted both services to 'compare' potential solutions. Since identifying this issue the study group has already taken coordination actions to improve the situation in order to work in a collaborative & coordinated fashion on new requests. For this to continue successfully at minimum a process should be defined and managed to guarantee coordination.

3.2.3 EDMS / CDS overlap and differentiation

Since both EDMS and CDS are purported as document management systems it is natural to assume that they are susceptible to be merged. This thought is reinforced by the fact that some document types and sometimes whole document sets are currently duplicated in both systems. However before leaping to this conclusion, it is worth reflecting on the real overlap and possible synergy between the systems.

The most pertinent observation is that EDMS and CDS serve documents for different purposes and therefore it is not unreasonable that they have employed different methodologies. The former (EDMS) is targeted to assist internal coordination and management whereas the later (CDS) is targeted at publishing and external dissemination. The primary document types handled are different (engineering drawings and scientific texts respectively), and each system interfaces to an industry standard sub-system for the management of these specific resources (focusing on CAD integration or library holdings respectively). Industry is not going in the direction of offering tools which simultaneously address these needs, so they have independent life-cycles.

A large fraction of the support load associated with each tool is in working with the user communities to integrate their business processes and to customise to the specifics of their environments. There is little or no synergy here. The fact that different underlying technologies were chosen to manage the meta-data is most probably unnecessary and could have been avoided if the requirements had been addressed simultaneously, but there would be considerable work, for little gain to a posteriori try and merge the technologies now. Any such available effort would be more profitably invested in improving functionality and uniformity of access to the two systems.



The core user communities of each tool do not overlap, and each community has tended to use the one tool at hand to address all document needs, rather than getting accustomed to multiple tools. Hence documents more naturally stored in one system are sometimes found in the other. To facilitate storing documents in the correct system, referencing links between the two systems should be enhanced. The most benefit would come from eliminating duplicated common services by using a common foundation of tools, such as the user and group management, the conversion systems or the pdf stamping. In addition, a more uniform approach to user interface and a combined search would reduce the barrier to using each system for its best purpose. To this end, the incorrectly stored documents should be redistributed and usage guidelines established. This does not require the development teams to be merged to best achieve these goals, as this may jeopardize the coherent support of the different user communities currently achieved, but collaboration between the support teams is necessary in order to give common answers to some of their potential clients who are sometimes looking at the possibilities offered by both systems. This should eliminate redundant support efforts

3.3 Roadmap for future evolution

The following is the request of the mandate:

> *"Development of a roadmap for future evolution including potential scenarios with their relative strengths & weaknesses along with technical & other implications as well as integration, in particular the link between management tools and CATIA 3D. The use of UGS TeamCenter as recommended by the ILC should be addressed as a possible option."*

There are two separate main axes for the roadmap. These are: the integration of the CERN project management tools and the evolution of the management of the CAD data, in particular because of the introduction of CATIA. There is no strong link between these two points which may be considered independently.

Whatever the scenario of the evolution of the management of the CAD data, it is not realistic to consider the shutdown of the Axalant system (underlying CERN EDMS) in the short and medium term. The current suite of EDMS tools is strongly involved in the LHC project and will be required in the first phases of the operation.

3.3.1 Integration of CERN project management tools

As detailed above in chapter 3.1.2, the following can be performed in the domain of the integration of the CERN project management tools whatever the evolution of the CAD data:

- Shared Data Layer. In particular, improve/force the link between the PPT WBS and the corresponding breakdown structure in EDMS (known as PBS or Baseline). This will have to be studied project by project.
- Ease the PPT progress reporting by providing (when relevant/possible) some "pointers" to the EDMS/MTF data.
- Avoid as much as possible the multiple entries of technical documents in the e-tendering systems
- Establish common repository for the users, groups, authentication and authorisations
- Share document management facilities
- Provide an uniform coherent high-level meta-search across all the applications
- Examine potential overlap/synergies and/or standardised naming conventions between the two asset management systems D7i and Baan.

The priorities are not necessarily the same if we consider the current CERN situation, with the current LHC efforts, or if we focus on an international collaboration such as the ILC in its design phase.

For the ILC, the points above can be ranked in the following order (from the highest priority to the lowest):

- Authentication (in order to simplify the daily life of the users)
- Common repository for the users, groups and authorisations (to reduce the time needed to administrate the accounts and the associated rights)
- Improve/force the link between the PPT WBS and the corresponding breakdown structure in ILC EDMS (to provide consistent views of the project)
- Provide an uniform coherent high-level meta-search across all the applications (to permit to retrieve all the documents in a single search)
- Ease the PPT progress reporting (at the moment, this would mean pointing to some design data)
- Avoid as much as possible the multiple entries of technical documents in the e-tendering systems (thinking now about these e-tendering issues can save redundant work)
- Share document management facilities (this mainly concerns CDS-CERN EDMS)

If we consider the CERN internal needs, the order may be slightly different

- Provide an uniform coherent high-level meta-search across all the applications (we have today around 1'500'000 documents)
- Share document management facilities
- Common repository for the users, groups, authentication and authorisations (the introduction of CRA eliminated some of the problems linked to the creation of accounts; almost all the tools are able to profit from the NICE login but sharing the "e-groups" and the associated privileges could eliminate redundant administration tasks).
- Examine potential overlap/synergies and/or standardised naming conventions between the two asset management systems D7i and Baan
- Avoid as much as possible the multiple entries of technical documents in the e-tendering systems (even if we can expect a decrease of the number of contracts, it is worth eliminating these redundant tasks).

- Ease the PPT progress reporting (from the LHC viewpoint, it is less and less necessary. It is however interesting to investigate the possibilities for the future projects).
- Shared Data Layer (extracting the WBS from PPT is only possible at the beginning of a given project. It is too late and not interesting for the LHC).

If we try to merge the 2 sets of priorities, we can set the points below.

- Common repository for the users, groups and authorisations. At least the sharing of e-groups would be interesting for all.
- Propose a uniform coherent high-level meta-search across all the applications. For instance, we can imagine to profit from the harvesting possibilities of CDS to give access to all the EDMS public documents. On the EDMS side, it should be possible to propose hyperlinks to the CDS documents.
- Authentication. Working on this point will simplify the daily life of the CERN users too.
- Joint CDS-EDMS effort to share document management facilities. The first steps have already been performed with the common analysis of the requirements of some new clients.
- Let read-access to the PPT WBS in order to allow other management tools to profit from these structures. This can be for instance a XML export.
- Examine potential overlap/synergies and/or standardised naming conventions between the two asset management systems D7i and Baan. One of the first steps will be to present the possibilities of both systems to the 2 support teams. Another one will be to review the impact of the recent changes in the management of the Stores (around the SCEMs) and to take into account more viewpoints, from the design offices to the purchasing.
- Profit from the end of the LHC project to identify the possible pointers to the EDMS data and to propose them for future projects.
- Collaborate with the teams involved in the CERN e-tendering systems to suppress the multiple entries of technical documents. For instance, this would imply establishing the necessary QA rules to permit the e-tendering systems to “trust” the technical documents stored in the EDMS.

Some of these points can be studied in parallel. For instance, the persons involved in the supports of D7i and Baan are not the same as the persons in charge of the authentication systems. In general, these integrations will have to be performed by the team members already in place. In order to continue to assure the same level of service, it will be needed to find additional resources.

- CDS-EDMS “common platform”. For example:
    - Joint analysis of the new clients/requirements in order to avoid any redundant work in both support teams
    - Joint analysis of the two system features in order to avoid any redundant work in both development teams
    - Document sharing between systems, especially in order to ease the searching
    - Document conversion service
    - Stamping
- CDS-INDICO tighter integration of the CDS Search into the Indico Platformg.
- Common Searching: Analyse how CDS-INDICO-EDMS can profit from the new search tool recently selected by IT

Lower priority

- D7i-Baan: Examine potential overlap/synergies and/or standardised naming conventions between these two asset management systems.
- Authentication (less and less important after the new possibilities offered by CRA). The next steps would be the possibility to profit from certificates.

Not elaborated:

- Single unit.

  A single unit covering the IT tools & services for product lifecycle management, project management, document management and finance, logistics & purchasing would have a very broad scope and could potentially provide an integrated and coherent set of solutions covering the full lifecycle from idea & design through to manufacturing, purchasing, financing, logistics & maintenance. However the current CERN project management tools have a very close match to the requirements of their particular domain. Consequently, the concerned teams are strongly involved in the daily operations of their domain. For instance, PPT requires a lot of connections with the financial and budget management and operations. Another case concerns the EDMS Team. In fact, most members of the EDMS Team are directly involved in the Design Offices and are daily providing support and consultancy to the project engineers of the LHC project. The management of the EDMS servers and databases has always been performed by IT (currently IT-

DES). Most of the development efforts are now linked to the LHC installation, to the LHC Hardware Commissioning and to the future LHC operation. This integration is also one the reasons of the assignment of Thomas Pettersson as member of the ABOC. Given the mandate, integration between the various software tools may be achieved with an inter-departmental, inter-disciplinary project-team, or by grouping the people into service clusters where people working on similar issues (doc. management, equipment management, etc) in different organizational units meet and coordinate the work. Another possibility would be to attribute a person responsible for this global coordination – someone like a Chief Information Officer. This area has been analysed in further depth in the MBA report of D. Widegren (TS-CSE) and the relevant excerpt is included in Appendix E.

3.3.2 Evolution of PDM and link between management tools and CATIA 3D

A variety of scenarios and possibilities have been evaluated for the link between CATIA 3D, and EDMS tools. The 2 realistic scenarios correspond to the integration of CATIA, EDMS with either Smarteam or TeamCenter. The table below summarises the results:

	Large Project Design and Integration	Product Definition and Change	IHEP Collaborative Design	Design Subcontracting	Asset Management	Information Accessibility & Security	Document Management	3D benefits across Project	CATIA V5 Integration	IT Architecture	LHC Compatibility	Deployment Delay	Costs	Evolution/Future
CERN EDMS (AXALANT/MTF/D7i)	*	*	*	*	***	***	****	0	*	**	****	****	****	*
SMARTEAM (DASSAULT SYSTEMES)	*	**	**	**	0	**	***	*	**	**	0	**	***	***
TEAMCENTER ENTERPRISE (UGS)	**	***	***	***	**	***	***	**	***	****	0	*	*	**
TEAMCENTER ENGINEERING (UGS)	***	****	****	****	0	***	*	****	****	****	0	***	*	****
CERNEDMS + SMARTEAM	*	**	**	**	***	***	****	0	**	**	**	*	***	***
CERNEDMS + TC ENGINEERING	***	****	****	****	***	***	****	****	****	****	**	**	*	****

On the left hand side of the table we see the PDM and on the top axes we see the capabilities provided. A detailed analysis of each of the criteria used in this table is provided below

Large Project Design and Integration

While working on individual equipments, data is organized following the product breakdown structure. However for the integration of these equipments into the whole machine, a more geographical approach is needed to realize the spatial relations between the equipments. Basic features to support this function are:

- Ability to manage matrices and coordinate systems
- Concept of equipment context (same equipment in different caverns)
- Proximity analysis to find neighboring components in a given context
- Rich data model able to map the latest CAD enhancements with large assemblies (partial loading, multi representations …)
- Ability to generate 3D layouts in the PLM, based on survey data

UGS TeamCenter Engineering appears to be the only product supporting all these functions

Product Definition and Change

One of the LHC lessons is that we should be "item or article centric" instead of "document centric". Most PLMs use now "Items" or "articles" to federate documents and data related to an equipment. CERN EDMS is today mainly document centric. However Axalant (underlying EDMS) implements the Item centric approach and there are plans to evolve EDMS CERN in this direction.

SmarTeam was a document management system and is now implementing Items as a parallel structure to the documents structure. Both UGS TeamCenter products (Engineering & Enterprise) have a more coherent approach by building the "As Designed" Item structure directly from the CAD structure.

The management of the different product configurations (Options & variants and alternates) and their evolution in time is not well addressed by documents centric products. UGS TeamCenter solutions put the focus on Items and product structure**. TeamCenter Engineering is more powerful than TeamCenterEnterprise when dealing with complex products.**

Bill Of Material generation, a critical shortcoming of current CERN EDMS highlighted during dipole and DFB manufacturing, seems properly addressed by TeamCenter Engineering. As BOM generation relies on the items, it cannot be achieved in a document centric solution.

TeamCenter Engineering is coupled with TeamCenter Manufacturing which addresses part manufacturing and assembly process planning. Manufacturing module reuses the PBS of TeamCenter Engineering as a starting point. Product definition coherency with manufacturing is assured by coupled lifecycles. No equivalent option exits in the other solutions.

All systems implement life cycles and workflows. Again, differences in the "document centric" or "item centric" philosophies lead to quite different benefits: again the item centric presumably gives a better coherency than a parallel evolution of related documents.

Change management (e.g. ECR/ECO) is commonly linked to versions and revisions of items or documents and workflows. As it is focused on product configuration management, TeamCenter Engineering goes further and offers much more flexibility and features: different models of change management are proposed according to the product type and advancement stage. For instance, TeamCenter Engineering proposes to use also "items" to follow up the changes themselves.

Parts classification has not been implemented in the CERN EDMS but the primary key of CERN EDMS documents, the equipment code, is a type of classification. According to the vendors, parts classification is supported by the other products. However TeamCenter Engineering proposes it as an integrated tool as the others just give the basic components to develop it.

IHEP Collaborative Design

Not all HEP Institutes have the same CAD systems. CERN, ITER, IN2P3, and CEA are using mainly products from Dassault Systemes whereas KEK, DESY, Fermilab, and INFN are using solutions from UGS.

Unfortunately those two companies are worldwide competitors and data exchanges between their solutions are rudimentary. So the choice of the tool depends tightly to the planned common projects.

In a worldwide IHEP collaboration, multi-CAD is today (and has always been) a de facto restriction.

Dassault proposes to deal with this constraint at the CAD system level by integrating conversion to a light format inside CATIA V5 (MultiCax). UGS has developed a similar approach but at the PDM level. Having these "light" files (JT) in the PDM, is a real plus in the daily follow up of the project as all actors can see the 3D data without having to use the full CAD system.

An advantage of UGS JT files is that UGS PDM users can consolidate assemblies of component studies from different systems whereas in SmarTeam the native files are well managed but there is no way to put them together in the provided 3D viewer.

SmarTeam and UGS solutions propose multi-site support by using replicated databases. This is required if two design offices have to work intensively on the same data. Such industrial solutions are probably too expensive and heavy to maintain for IHEPs.

For synchronous design work, both TeamCenter Engineering and Enterprise have an IT architecture, where CAD clients use http protocol to provide better performance for remote access over long distance. For asynchronous design work, TeamCenter Engineering provides tools to ensure traceability throughout the successive import/export cycles.

SmarTeam Web access from the CAD systems is not yet usable.

Design Subcontracting

Whenever possible, CERN design office would like to have subcontractors directly connected to CERN PDM. So we make the same remarks as for the IHEP collaborative design: current architecture of UGS products seems more convenient.

Import/Export facilities of TeamCenter Engineering are a real plus while dealing with non-connected subcontractors. Note that this functionality will also be a big advantage in the integration of LHC data (currently EUCLID data that will be converted to CATIA V5 files).

Asset Management

Asset management means management of the physical equipments including their installation, service, maintenance, upgrades, and eventual decommissioning. The current CERN tool, MTF/D7i, part of the EDMS suite, manages this well. SmarTeam and TeamCenter Engineering do not offer out-of-the-box solutions for asset management, as their focus is clearly on the design phase of the product life cycle. UGS TeamCenter Enterprise, being a more full-featured PLM offers a module for asset management.

Information Accessibility & Security

This criterion covers usual PDM features such as Access Rights, Web Interfaces, Check In/Out.

Current CERN EDMS has been carefully tailored to LHC requirements. The others implement common concepts like roles in projects and Check-In Check-Out. There is no significant difference between them. SmarTeam Web interface is not yet mature.

Document Management

For managing simple documents, including all the engineering document types, presentations, memorandums, etc. the current CERN EDMS works perfectly. SmarTeam and TeamCenter Enterprise are also quite capable of this mode of operation. TeamCenter Engineering is item oriented from the start, which is its strong point in CAD design. However, this makes it perhaps less well suited to straightforward document management.

3D benefits across Project

Designing in 3D with CATIA V5 or other modern CAD systems obliges the designer to structure the product. This is the starting point of the product structure. That's why CAD is at the center of PDM systems.

The idea of UGS of converting every 3D file to JT and the highly integrated viewing tools give a leading advantage to UGS solutions. We see there an open door to leverage the 3D benefits by giving 3D access to many actors (project leaders, engineers or even operators) at the different stages of the life cycle (design, manufacturing, or operation).

In the absence of a JT equivalent, SmarTeam can only provide similar benefit in a "mono-CAD" environment. Dassault Systemes is working hard on promoting their 3DXML format that will play the role of JT within Dassault's PLM solutions but this will take a while.

TeamCenter Engineering gives more 3D power to PDM users than TeamCenter Enterprise: engineers can combine matrices and JT files as building blocks to study and compare new solutions in 3D. The other systems would require that the engineer ask a real CAD user to prepare the work in the CAD systems.

By promoting 3D usage across projects we should reduce the number of drawing versions: drawings would only appear after a given stage in the item life cycle. Parts lists on assembly drawings should be removed (as managed by the PLM) or added only at a later stage, just before manufacturing. **This is not only a question of tools: getting all benefits of UGS solutions would require a deep change in CERN procedures and habits.**

CATIA V5 Integrations

All the different PDM systems concerned have CAD integrations to CATIA V5.

- The Axalant – CATIA V5 integration is developed by xPLM, an Agile partner. The integration is available in CATIA V5 as a toolbar and it uses a layout similar to other CATIA V5 commands. However, as far as we know, those CAD integrations assume that the client is on the main site (no plan to develop integrations for remote access). This is a serious limitation regarding international collaborative design work and subcontracting. The basic CATIA file formats (part, assembly, drawing, and process) and links are recognized in Axalant. The development of the integration to extend the integration to other CATIA file types such as CATIA FEA models may be on demand. xPLM is a small company and they recognise the problems of having full access to the documentation of the API needed for the integration due to difficulties in their relations with Dassault Systèmes.

- The SmarTeam – CATIA V5 integration is developed by Dassault Systèmes. It is well integrated to the CATIA V5 user interface. The many different CATIA V5 files and links between CATIA models are well recognized and represented in SmarTeam. The shortcoming of the integration is that CATIA links are created as links between documents and therefore the item structures are not automatically created from the CAD structures.

- The TeamCenter Engineering – CATIA V5 integration is developed by EB Solutions, a partner of UGS. The integration is available in CATIA V5 as a toolbar and all further PDM related manipulations are in the TeamCenter Engineering's native user interface. The basic but not all CATIA file formats and links are represented in TeamCenter Engineering. In addition to the Axalant integration, TeamCenter Engineering also manages CATIA FEA models. Even though it is not deeply integrated in the CATIA user interface, the integration offers an added value with different its functions. For example, the TeamCenter Engineering – CATIA V5 integration has the possibility to manage CATIA multi-representations thanks to TeamCenter Engineering's management of each instance in an assembly (absolute occurrence). Due to legal reasons, the customer of the TeamCenter Engineering – CATIA V5 integration must have a CATIA V5 CAA licence, which CERN does not have. There is also a less performant version available for those without a CAA licence. That version is however slower and lacks the management of non-hierarchal links.

IT Architecture

By IT architecture we mean the overall quality of the underlying IT solution, i.e., clarity, elegance, standards compliance, performance, etc. This criterion becomes especially important when considering a globally distributed large-scale data management system. CERN EDMS is based on a monolithic PDM tool, on top of which an in-house web-based user-interface layer has been built. This allows anyone to access the system from anywhere in the world. However, CAD integrations are missing from this interface and extending this framework would become very manpower-consuming.

SmarTeam is totally based on software and protocols running on Windows platforms and employs a relatively complex multi-server architecture, which requires considerable expertise to set up and maintain. Multi-site operation is currently achievable by replicating the database between the different sites although a Web-based integration solution is expected in the future, which would facilitate remote-access by small collaborators directly to a larger central database either at CERN or elsewhere.

TeamCenter architecture is much more platform-neutral. TeamCenter services can be run either on Windows or Unix servers in a very flexible configuration. For collaboration between large remote sites, a database replication option exists. Interconnection mechanisms for remote-access and multi-site operations use well-understood modern middle-ware mechanisms and network protocols.

LHC Compatibility

UGS TeamCenter Enterprise has a wider scope than the other products but requires more development and customization effort. Therefore deploying UGS TeamCenter Enterprise would be a large project: it is common to plan for a 2 year project with considerable resources.

Moreover the amount of LHC legacy data is huge and it is not realistic to consider changing the PDM tool in the current phase of LHC project. On the other hand LHC data, which are now in Euclid will be converted to CATIA V5 in the near future and will have to be integrated in the LHC PLM to support LHC in the long term.

Therefore we believe that only solutions involving a progressive evolution from the current CERN EDMS should be considered:

- EDMS – SmarTeam
- EDMS – TeamCenter Engineering

Deployment Delay

Different solutions have different times of deployment. This mainly depends on three factors (time to get budget approved excluded): re-use of existing solutions, re-engineering of processes and complexity of product(s).

- **EDMS – SmarTeam**
This can be done relatively fast as both EDMS and SmarTeam are available today and the project is underway. We are currently faced with an increasing number of CATIA files that are not being managed by any PDM tool today. Low pricing of SmarTeam and our urgent need of managing CATIA documents has lead us to go ahead with a SmarTeam pilot. It is possible to reach a basic level of functionality within a relatively short time (document centric approach). Customisations and developments to reach a higher level of functionality concerning product structures, BOM, and geographical DMU solutions would be a long-term project provided that enough resources were dedicated. However a solution based on SmarTeam will always be limited because there is no extraction of matrices from the CAD systems.

- **EDMS – TeamCenter Engineering**
This is a solution that may take slightly **more time to get to the basic level as TeamCenter is a new tool to us and the processes have to be re-thought.** It is a tool with much functionality to configure. Once implemented, it will probably already be at a higher level of functionality, thus less specific development needed.

Costs

More Detailed cost estimates are provided in section 3.4. For the purpose of this table the short-term total costs of implementing a solution are estimated. These include licensing fees, consulting, support contracts, and the CERN resources required for development and maintenance. While noting that keeping CERN EDMS as-is might be the simplest and cheapest option for now, it must be added that it would not be sufficient in the long run.

The most cost-effective realistic solution in this sense is SmarTeam coupled with the current EDMS, for which most of the licences already exist at CERN and which is free of any annual maintenance costs. Dassault has also made an attractive offer for any remaining components that would be needed. The main cost of a SmarTeam-based solution would come from the required specific development and consulting, which would most likely continue over the years.

TeamCenter Engineering would cost more in the beginning to license (UGS + CAA development platform from Dassault), set up, and configure. There is also a fixed annual maintenance cost of 20% of the initial licence price. However, the amount of CERN-specific development would likely be fairly small (as TeamCenter Engineering already has most of the required features standard). No accurate estimate can be made of the real long-term costs of any particular solution, however, as any potential problems and hidden costs only tend to become clear after some initial period of use.

Unfortunately, the cost gap between SmarTeam and UGS TeamCenter Engineering increases dramatically with the number of potential users: SmarTeam licenses are floating whereas UGS TeamCenter Engineering requires Named User licenses.

Evolution/Future

The CERN EDMS solution could evolve to better implement items. XPLM Company is able to provide a viable interface for CATIA as long as remote access is not required. We have rejected this option in the past because CERN wants to work with external subcontractors and partners. Moreover XPLM is a relatively small company and may end up in trouble with Dassault as it is selling a CAA based solution without being a CAA Partner. Axalant (ex Eigner) is now one of the 2 product lines in Agile portfolio and Agile itself is fairly small compared to Dassault and UGS.

SmarTeam is part of the Dassault Systemes offer in PDM/PLM products. SmarTeam is trying to evolve from simple CAD files management to a full PLM. But somehow its target as a PLM system must be limited as there are now Matrix One and Enovia on top of it in Dassault's products portfolio. SmarTeam has a large user community and it benefits from the weight of CATIA V5 in the CAD market. As SmarTeam does not provide an internal conversion to a unique 3D format, it is not convenient for a multi-CAD environment. SmarTeam combined with CATIA V5 could be proposed as a solution supported by CERN to the IHEP community but this would require strongly reinforcing the current CAD support team.

UGS TeamCenter Enterprise is derived from the old Metaphase product, which came to UGS as it bought SDRC. SDRC was providing a small PDM around its IDEAS CAD software. This solution was not valid for a large number of users and that is one of the reasons why IDEAS clients have been looking at Metaphase. TeamCenter Enterprise is also used as product definition backbone in large companies, which have many products. UGS TeamCenter Enterprise can be customized to address very different businesses. It is really a huge toolbox that needs to be customized to each client's processes. TeamCenter Enterprise has a larger scope than the other products in our short list: it is a real PLM system and there is an overlap with the current CERN project management tools.

TeamCenter Engineering (ex IMAN) is UGS' own child. It is not a full PLM and gives more focus on engineering and manufacturing. Today UGS is in the process of merging TeamCenter Engineering and Enterprise. In reality it seems that UGS is taking the interesting features from Enterprise to implement them in TeamCenter Engineering. The merging will be very long and UGS says that it should be quite straightforward to migrate from TeamCenter Engineering to the new system whereas migrating from TeamCenter Enterprise will be more complicated due to the high level of customization. As a conclusion UGS is pushing us towards TeamCenter Engineering - Fermilab has recently moved its PLM pilot from TeamCenter Enterprise to TeamCenter Engineering.

The combination CERN EDMS + SmarTeam was up until now the current plan at CERN. It would allow us to answer the urgent need of managing CATIA files and is a good occasion to progressively introduce the item centric approach. Moreover, learning progressively SmarTeam was seen as an open door in case we had to move from Agile's Axalant. This policy has been built in a mono-CAD environment (all 3D on CATIA V5) and with a low cost approach. Technically this is not the best solution for CERN, especially, if we consider collaborating closely with partners who use different CAD software.

TeamCenter Engineering fits perfectly in the holes of the CERN EDMS and fulfils all requirements of engineering and manufacturing. Price is very high compared to SmarTeam. A combination of TeamCenter Engineering + CERN EDMS is a coherent and complete solution. It opens the doors of collaborative work and progressive evolution from Axalant to a full UGS-based PLM solution in the long term.

We may therefore summarise the pros/cons of the above in the following two scenarios.

Scenario 1: Integration of CATIA, EDMS and SmarTeam

This is the option which had already commenced prior to this study group. SmarTeam from Dassault understands CATIA files and is by default document-centric. Integrated with EDMS it can provide early introduction of the item concept. This introduction requires customisation effort.

Pro

- Cheap licences
- EDMS includes manufacturing and maintenance follow-up system (MTF)
- Better impact analysis of the Engineering Change Requests
- Allows for the introduction of the item concept
- Tight integration with CATIA (same supplier)
- We can read-any format CAD file (but only produce one format)
- ITER,IN2P3 & Orsay have this architecture

Con

- SmarTeam may not be sufficiently mature
- Inexpensive product, but significant consulting & manpower
- Item concept not mandatory (by default) and requires manual linking of documents
- Doesn't address multi-cad / CAD interoperability issues
- For international projects only works if CERN plays the integrator role.
- Insufficient for international project support outside CERN
- For full item support will need to finish the implementation of design-items in EDMS
- Weaker 3D viewer (compared to TeamCenter)
- Weaker dependency tracking (compared to TeamCenter)

Note:

- Requires new organisation and methods in the design offices (item-centric).
- For ILC (or future projects) the following was suggested by Dassault:
    - all our partners can use our licenses
    - the labs use their own systems to develop equipments and deliver STEP files in the CERN SmarTeam system which is the project reference
    - the labs must use CATIA DMU to study, simulate etc

  While this offer seems attractive in terms of licensing costs, it requires major consulting and customization effort and means CERN must be the sole support centre running a 24/7 service. (requiring minimum 2 additional FTE). <u>The study group does not consider the offer from Dassault for extending Scenario 1 to international project viable</u>.

Scenario 2 : Integration of CATIA, EDMS & UGS TeamCenter Engineering

Implementation may start with a pilot by focusing on the CATIA integration and the collaboration with CERN sub-contractors (Acrotecna for instance). This opens the door for the ILC collaboration. Data exchange with the current EDMS can be foreseen in the short-term. In the long-term, we may envisage a migration of the EDMS documents (e.g. replace Axalant by TeamCenter).

Pro:

- We are combining industry leader CAD with industry leader PLM
- Industry best-practice, rich functionality, seems to be mature in the domain of the CAD integration.
- Gives CERN potential to be leading competency center
- Item centric
- Multi-site (proven). Opens door for ILC & other support
- Multi- CAD interoperability: Read-any CAD & support any CAD. CAD interoperability with the JT"format which allows visualisation and more complex operations such as sectioning, exact measuring, collision detection, interference detection, motion simulation. However, in some cases, it will be necessary to use the CAD system to perform the integration.
- DESY, Fermi, INFN have this model
- Strong 3D viewer
- Strong dependency tracking
- TeamCenter has extraction of CAD matrices
- Neighbourhood/vicinity tracking
- Covers agile functionality
- Works if CERN plays integrator or collaborator
- Probably very good impact analysis of the Engineering Change Requests. Possibility to look at financial consequences.
- EDMS includes manufacturing and maintenance follow-up system (MTF)

Con:

- Licensing cost needs one licence for each registered (web) user on top of concurrent usage licences
- Setup cost - significant consulting & manpower
- Migration cost
- Timescales – perhaps 1 year before operational
- Different CAD & PLM vendor (CAA license)

Note:

- Requires new organisation and methods in the design offices (item-centric).
- The TeamCenter products don't cover the production follow-up (as done by MTF in the current EDMS). They are generally linked to ERP systems (Baan, SAP for instance).
- TeamCenter Project covers a domain similar to PPT but we don't see any added value to envisage the replacement. It seems more interesting to focus on the CAD integration.
- TeamCenter MRO (Maintenance, Repair and Overhaul) could be envisaged to cover the maintenance phase. However, it puts the product (the item) at the center of the MRO function. This can only works at CERN if the design is already item-centric. As above, we don't see any added value yet.

Whilst Scenario 1 is feasible for internal CERN projects and potentially provides the introduction of the item concept, it is a low-license but high-manpower effort. Furthermore even for internal projects only Scenario 2 offers better facilities and lays the foundation for international project support. Therefore the **recommendation of this study group would be to adopt scenario 2**. This would considerably enhance the current state, put CERN in a good position for future projects and already be relevant and applicable to areas such as CLIC or LHC luminosity upgrade. It would allow CERN to participate in the ILC EDMS with a collaborative approach.

3.4 Costs

The following is the request of the mandate :

> *"Estimation of costing covering both the one-off setup costs and the recurrent operating costs of the scenarios including support & maintenance efforts."*

3.5 Implications of use by international community

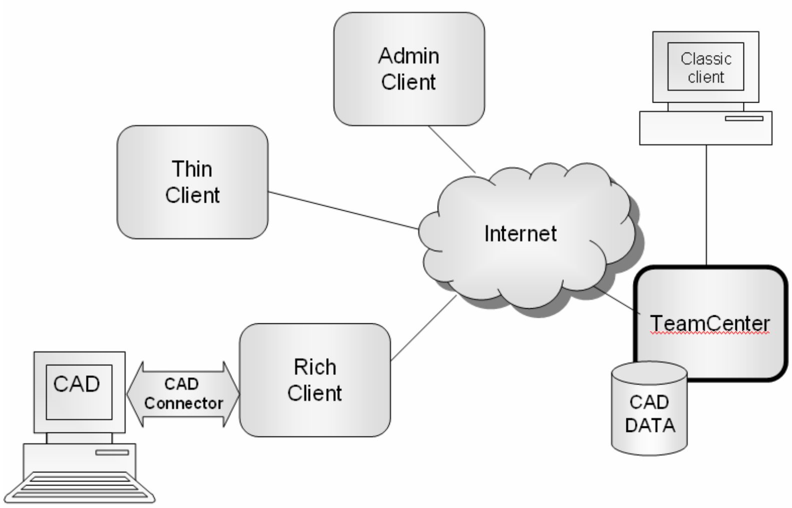
The following is the request of the mandate:

> *"Analysis of the implications of the possible use of the management tools by an international community spread over distributed institutes and proposal of a strategy for their implementation."*

If international community requirements end at 'document management' then in fact the current CERN tools suffice. However the crux of the problem is PLM, item-centric configuration management & multi-cad. For a large organisation and even more important for an internationally spread collaboration, the item centric approach is necessary and document centric is not enough. In fact, the item ID must be the common identifier and reference for all documents concerning an item. The ID of a physical (or to-be physical) object shall be common to all systems and all sites. This will allow for traceability and a common understanding of objects concerned.

As already noted, not all HEP Institutes have the same CAD systems. Dassault proposes to deal with this constraint at the CAD system level by integrating conversion to a light format inside CATIA V5 (MultiCax). This however would oblige CERN to be the sole 'integrator' and for collaborative design enforce other institutes to use the same CAD system (since CERN could not provide CAD models in other formats). This model works in places in industry where a paying authority can impose a CAD system on its subcontractors, but is less applicable in an international collaborative environment. UGS has adopted their conversion at the PDM level. Having these "light" files (JT) in the PDM, is a real advantage in the daily follow up of the project as all actors can see the 3D data without having to use the full CAD system.

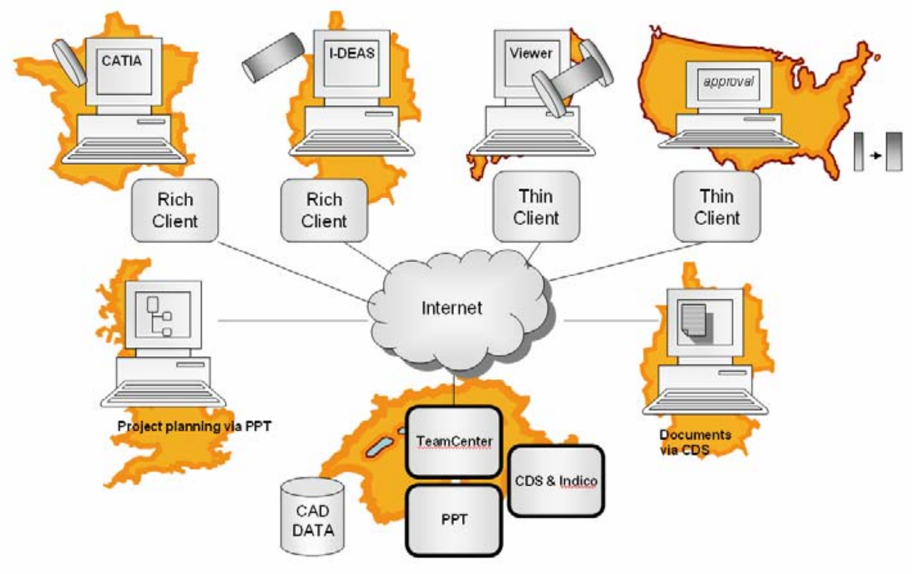
TeamCenter Engineering and Enterprise have an IT architecture which provides two internet based clients and is hence ready for use by an international community. The following model illustrates how CAD data may be checked-out from the vault using the rich client which is accessed from the Internet.



In the above scenario TeamCenter provides both the JT files and the original CAD files in which case different CAD users may continue to work on their sub-systems using their different CAD systems.

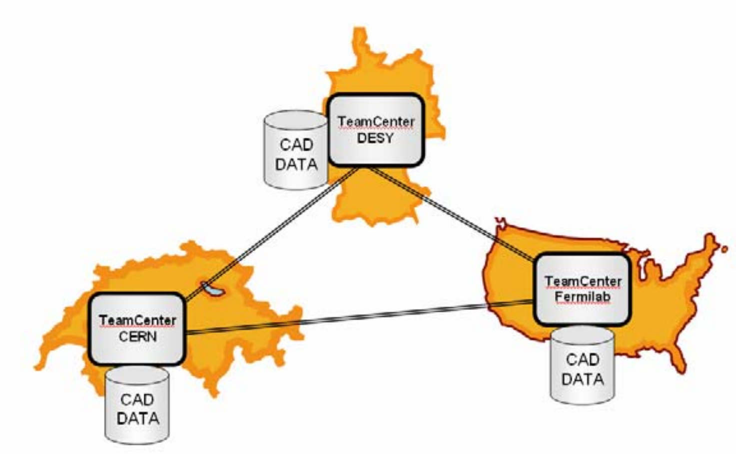
DESY & Fermilab, using TeamCenter in an international collaboration and without local vaults, report acceptable times for check-in and check-out of components. This model is also applicable for working with subcontractors who may or may not use the same CAD system. Performance optimisation may be achieved with the use of local vaults.

The scenario below shows how an international collaboration may use an integrated set of tools where designs for some components are made in one country with one system (e.g. CATIA in France) and in another country in another system (e.g. I-DEAS in Germany) and the resulting assembly may be viewed in Japan and changes authorised for example in the US. In parallel the WBS of the project may be managed in another country using direct access to PPT and resulting documents extracted from CDS.



The above vision is one possible long term vision which is very much CERN centric.

Alternatively if a common data model is used, then TeamCenter multi-site may be used in a collaborative approach. We know that DESY and Fermilab have TeamCenter so using a directory service replication of the relevant data across the sites is feasible. This would present itself with the following architectural model :



In the above scenario there would be a common directory service responsible for knowing which site has which CAD files. It is not necessary that all CAD data is synchronised across all sites, but based on the required files, the directory service is consulted and the relevant imports & synchronisations are made to replicate the CAD data to the local sites as required. For further sites without TeamCenter installations they would simply use the relevant web access as in the previous architecture.

4. Conclusions & Recommendations

In the time available the study group has carried out a comprehensive analysis of the tools, issues, areas for improvement and scenarios for evolution. Included in this analysis is input from a variety of communities both inside CERN and from other laboratories. From this analysis the group has emerged with a vision for the future project tools at CERN which would incorporate the integration of existing tools, the adoption of a PLM in the CAD/EDMS area and a change in working practices and pave the way for international project support. Implementing such a vision would not only have numerous benefits but would also generate significant savings in future projects particularly by the early detection and prevention of errors.

Independent of the outcome of this report, the study group is unanimous that the integration effort of existing tools should be pursued. More coordination is required on the use of the existing tools. Better coordination is required in treating user requests. Further coordination is required in benefiting from common infrastructure developments from document conversion servers to user management systems. In the CAD/EDMS area the 'weak link' had already been identified and a pilot project with SmarTeam and CATIA was underway before this report began. We believe it is therefore time to harness the existing energy and attention in this direction and invest the appropriate Personnel and Material resources to carry out the following:

1. Commence a pilot project with UGS TeamCenter Engineering (ensuring the potential full funding is available if successful completion of pilot)

2. Invest in an integration effort between CDS, Indico, PPT, CERN EDMS and TeamCenter Engineering

3. Offer to support the ILC collaboration with the tools recommended by the ILC EDMS selection committee 'as-is' today, taking on board their enhancement requests where resources permit and eventually offer the integrated suite when available.

Currently CERN is not in a position to meet all of the ILC requirements, particularly at this phase in the project with respect to their requirements of an EDMS system. This study group unanimously supports their choice of TeamCenter at DESY which is already operational and providing basic multi-site collaboration for the ILC.

By simultaneously commencing integration of the existing tools and launching a pilot project implementation of UGS TeamCenter for CATIA users, CERN could already have a mutually beneficial relationship in the ILC project: the ILC project could benefit from CERN's CATIA support and CERN could benefit from existing TeamCenter knowledge. We could also support the distributed model proposed by the ILC by sharing common data across the systems.

In the longer term, with the introduction of CATIA as the new CAD system at CERN and the end of the LHC designs approaching there is a window of opportunity to carry out change, evolve our current CAD management tools by introducing UGS TeamCenter and adopt industry best practices.

If we invest now then we will evolve CERN towards providing the leading project management practices for future projects at CERN. In addition to providing the best solutions for CERN we would also be in a position to offer this unique integrated suite of tools to future international collaborations.

Part II

Area Analysis

Project Planning Tools Area Analysis

Overview of User Requirements

- Define & maintain the Work Breakdown Structure (WBS), workunits with personnel and material resources and deliverables. Maintaining large sets of workunits should be easy and low overhead.
- Support for the Earned Value Management methodology according to ANSI #780.
- Report and Obtain precise physical progress statuses of on-going activities should be easy and low overhead.
- Support a lean project management team, which supposes a collaborative environment, with potentially all key contributors involved in planning, scheduling and progress monitoring and reporting activities. Stakeholders should be pro-actively alerted when changes impact their area of the project.

CERN surveyed several commercial packages, but none of them satisfied all these requirements. So an in-house development was decided.

Functional Description

- import/export facilities (Excel, XML) and web interface for WBS and workunits
- baseline facilities
- Breakdowns: WBS, PBS, Organization and budget code based.
- Pre-defined (static) reports as well as dynamic (OLAP) analysis reports
- EVM with online details for each transaction
- collaborative: alert/ info communication infrastructure
-

History

In October 1998, the ATLAS collaboration expressed the urgent need for a freely available (within the HEP community) project management application to:

- Allow the collaboration to agree on and maintain one single Work Breakdown Structure.
- Identify all tasks to be performed in a common format, centrally stored and managed.
- Consolidate all progress updated through regular progress reports easily submitted via email or via the ubiquitous web browser by partners all over the world…

Such an application did not exist and was to be quickly developed in-house: the Project Progress Tracking (PPT) application was born in 1999.

In the mean time, for the LHC accelerator, the project planning and control information was scattered over many different information sources, and it was hard to obtain a coherent picture of the progress. The LEP project management approach did not scale given the involvement of many industrial partners, the challenging superconducting magnet and accelerator technologies and, last but not least, the tight budget limits and schedule requirements. Indeed, as a reaction to the LHC budget 'crisis' in 2001, realising certain weaknesses in the procedures in place for monitoring progress and cost changes for the LHC project, the External Review Committee and CERN's management requested the implementation of the proven Earned Value Management (EVM) methodology to monitor and control cost and schedule variances. The Project Progress Tracking application was to be quickly extended to meet the new challenge.

The first challenge was to provide a more accurate expenditure forecasting for the LHC contracts. The PPT tool was adapted to meet this challenge, and by gathering progress reports from all on-going LHC contracts an up-to-date expenditure profile for the LHC project was produced in April 2002.

Given this initial success, the next step was to introduce a process for continuous tracking of cost & schedule variations on the LHC project using the EVM methodology. The aims were to:

- Keep all hierarchical levels of the project and organization regularly informed about the status and true cost situation of part/all of the project.
- Ensure that the project definition is complete and no work units or necessary resources have been omitted.
- Involve all project engineers in the process increasing cost and schedule consciousness.

The PPT/EVM software was further used in the CNGS project.

In 2004, it was adopted by the EGEE project, funded by the European Commission and bringing together experts of 70 partners from 27 countries (around 1000 project members in total). The PPT framework was adapted to support an automated monthly timesheet entry and authorization workflow, as well as a financial module compliant with the European 6^{th} framework.

Finally PPT was recently selected by CERN's directorate as the platform to perform the strategic planning of all resources at CERN for the short, medium and long (next 10 years) term. The planning consists of:

- the definition of current and future activities in a Work Breakdown Structure (WBS) which includes the initiatives and new project options,
- an analysis (fact finding) of the quantitative and qualitative resources needed to cover the activities,
- a subsequent screening of these needs against the current and future staff population and its evolution (e.g. fluctuations).

This resource loaded activity planning provides the platform for strategic decisions for the future activities of CERN.This latest incarnation of the PPT framework is called APT (for Activity Planning Tool).

Project Leader & Current Team

Jurgen De Jonghe has led this activity since October 1998.

Current CERN team for project and contract management tools is :

Jurgen De Jonghe, Brice Copy, Kasia Pokorska (EGEE funded)

Domain

Project management and specifically project cost & schedule control

Current Toolset

The current tools include :

- APT : Activity Planning Tool
- PPT/LHC : EVM for LHC
- PPT/CNGS : EVM for CNGS
- PPT/EGEE : Project Planning & Tools for EGEE project
- PPT/ATLAS : Project Planning & Tools for ATLAS project
- CFU : Contract Follow Up

Furthermore the section is also responsible for CFU (Contract Follow Up)

All the above tools are developed & maintained in CERN

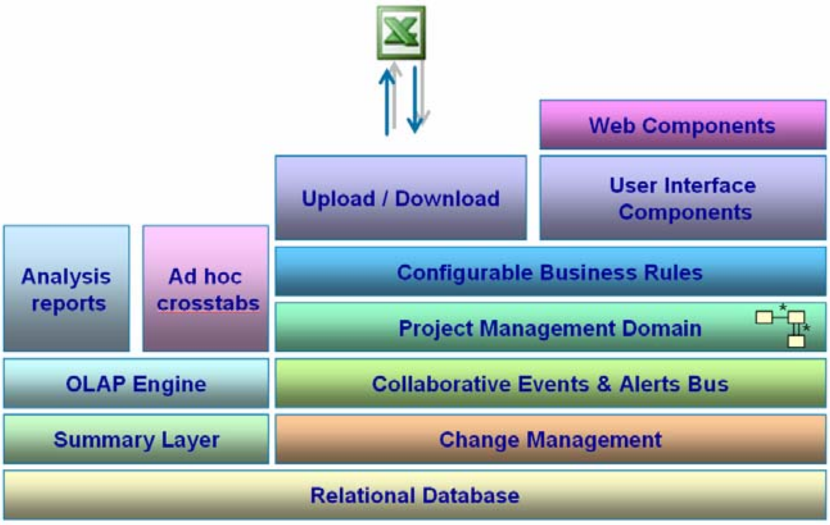
Architecture

PPT is a web application developed on top of the Java Enterprise Edition platform with a central Oracle 9i database. To be able to adapt PPT to different projects' needs quickly with a relatively small team, a high level of reusability and modularity is required at different levels of the application development lifecycle.

At the high level this starts with the design of the generic core PPT repository defining the central project management concepts and support for planning and tracking, monitoring and reporting needs such that it can quickly be adapted to new projects. New development environments and frameworks have reduced the amount of hand-written code substantially through reusable objects, templates and patterns.

Next follows the architecture that relies on reusable coarse grained components that provide basic services:

- The progress reports as well as task modifications are performed via transactions. The history of these transactions is automatically tracked in the central database: every single change can be visualized and undone if needed. A performance and bull's eye chart show this graphically on every level of the breakdown structure.
- A collaborative event system monitors these transactions and interrogates their schedule and/or cost impact … based on this, it derives which stakeholders need to be informed based on their "alert subscriptions".
- The project breakdown structure and constant modifications are a challenge for normal OLAP reporting. A custom automated summary layer was put in place to give project leaders instant feedback and slicing & dicing functionality across different dimensions.
- Defining large amounts of related tasks can be difficult with a web interface. A parser was built to allow the upload of native Excel files with task definitions. If the tasks are valid they are automatically digested and stored in the database.



Technology

The application is accessed via any modern web browser. The server is developed on the standard Java Enterprise Edition platform; it can run on multiple servers.

Licensing

There are no licensing issues for the application server. PPT will run on the free (and open source) Linux + Tomcat stack. The main dependency is currently on the Oracle relational database. Refactoring to make use of the free MySQL is estimated at 4 to 6 man-months.

Key Statistics

- ATLAS Detector
    - 500 MCHF CORE Cost,
    - 150 institutes in 35 countries
- LHC
    - 3.3 BCHF material expenditure under EVM project control
    - Lifespan: 12 years
    - 12,000 workunits, over 300 project engineers
- CNGS
    - 75 MCHF expenditure
    - CERN & Gran Sasso
- EGEE-I
    - 50 MCHF funding from EU (not counting funding from partners)
    - 70 partners
    - > 1,000 project members
- APT
    - 12,000 workunits (short= 3000, medium= 4000)

Pros/Cons of Current Tools

Pros:

- Proven customizable & adaptable framework.
- User friendly and low overhead for project stakeholders.
- 8 years experience supporting HEP projects, including support for notions like CORE cost.
- Multi-project & international HEP project support.
- "Free" for HEP community (although not free for CERN).
- Collaborative: alert/ info communication infrastructure.
- neutral platform
    - on client (web browser)
    - and server (Java)
- import/export facilities (Excel, XML).
- analysis reports (OLAP).

Cons:

- It is a framework, not a turnkey solution that can be hosted outside of CERN (yet).
- Financing was for 'LHC-only'. No resources beyond 2007

- Functionality only provided as needed, not all scheduling or resource leveling algorithms re provided out of the box

CERN Experience

7 years ATLAS, 3.5 years LHC and CNGS, 2 years EGEE, 1 year APT

Lessons learned on s/w

- Agile development methodologies work well at CERN (and in the HEP community in general). Big Upfront Requirements Analysis in general do not give optimal results.
- For each new project we start to support, it's important to have a "Product Owner" to regularly discuss and review the requirements and their changing priorities.
- Software development with temporary people may look cheap but require a lot of training and coaching.

Lessons learned on usage

- More important even than the actual project management tools is the culture change inside the organization. Good progress has been made at CERN.
- Heavy workflow and tight access restrictions are not only harder to implement, they also restrict the transparency inside the project we support. Sometimes this cannot be avoided, but there is value in transparency.
- EVM has certainly scaled very well: today the LHC project leader can perform a daily health check at the click of a mouse, spotting problems early even with 12,000 LHC workunits and 300 project engineers reporting progress on a monthly basis.
- EVM deals with both schedule and cost issues in a consistent way and has alleviated some of the data issues like varying work unit granularity between different areas of the project.

Weaknesses

- EVM cares most about big ticket items, so people tend to get these properly scheduled and pay less attention to work units with cheaper deliverables. But a deliverable can be cheap and still very critical.
- While EVM usually deals with money, it is not accounting… it aims to be roughly correct rather than precisely incorrect. Earned value should be registered as soon as progress is obtained, even before the relevant payments have occurred. This usually results in a slightly positive bias in the Cost Variance. Because of our tight link with the accounting system, baselines are usually too optimistic, simply because Project Engineers want to make sure that they obtain the required budget in time. It's easier to carry over budget from one year to the next than obtain more money, even for being ahead of schedule!

To do better next time

- Due to the late introduction of EVM in the LHC project, the "Control Account Point" structure (think budget code structure) is not compatible with the WBS. While we have alleviated the problem by introducing various other breakdown structures based on the budget codes (Organic, PPA …), it is still suboptimal that we cannot see the Cost Variance along the WBS.
- During the actual construction phase, it would also be advisable to more formally establish the baseline and integrate with the change request process (currently through PLOA's), with a direct link to the Project Management Reserve.
- Duplicate reporting of progress. Today the EVM system will typically describe progress on batch deliveries (e.g. 7 out of 10 dipoles tested) without the link to the real physical parts making up those batches. This is duplication of work with possibility for inconsistencies. The same can be said about the LHC dashboard which is a third way of showing progress.
- The Critical Path Method is a good companion for EVM to focus on tasks that are critical, independent of their cost.
- The positive Cost Variance bias should be auto-corrected. Currently this is being estimated both heuristically (check the correlation between the EV and AC curves) and by examining well defined cases where individual workunit expenditure payment dates can be tracked down and compared to the date of progress reporting. It turns out that on average the progress is reported 18 working days before the payment can be accounted for in EVM.
- Purchasing at CERN should be more involved. The trend in industry is that large contracts are discussed directly on the basis of Earned Value.

Shared Interfaces

- Common WBS (Work Breakdown Structure) with other systems (PPT is Data Provider). While it's understandable that each tool will have secondary breakdown structures, it is also mandatory to establish one common primary structure.
- Common PBS (Product Breakdown Structure), Items / Equipment codes with other systems (PPT is Data Consumer), at least up to a certain level. Project Management tools need not necessarily care about the lowest levels in the PBS (unless they are for some reason part of the critical path).
- Once the PBS is shared, further links can be made such that progress reported on physical parts can be consolidated automatically (PPT is Data Consumer, maybe also Provider).
- Actual Costs come from the accounting system (Data Consumer), contract milestones are shared with CFU through an elaborate Contract Workspace.
- Peoples/roles/budget codes and organization structure are taken from AIS Foundation (Data Consumer)

Costs

Setup costs: 2 man-weeks are needed to install the vanilla product for a specific project. This is comparable with the installation of commercial software.
Operation costs: projects that do not require modifications to the software are maintained with minimal effort. This is comparable with the installation of commercial software.
Customisation costs: depends on the size of the customization (I would delete this one)
Integration costs: what can I say**?**

Considerations

Projects in general (and especially scientific –HEP– projects) go through phases. The initial front-end phase ("gaseous" phase) requires more flexibility (e.g., to re-work the WBS) than the latter phases. This has an impact on the underlying tools.

Future evolution foreseen

PPT was selected by the ILC for the R&D phase. If CERN agrees to this, we would need to extend its scheduling features.

Future work will concentrate on building a larger part of the final solution through reusable pieces of meta data that represent the desired universe for each project.

Alternative Tools

From its initial ATLAS implementation the PPT software has been reused successfully for EVM project control (LHC and CNGS), support for EGEE (I and II) project needs and finally strategic planning at CERN (APT). Along this path, parts of the software have been extracted and integrated in a reusable project management framework. PPT is now more of a framework than an actual tool. This is an on-going process.

In this section we will compare PPT (its EVM flavour) to Primavera[4]

PPT-EVM

PPT-EVM supports a deliverable-oriented project management paradigm that is well suited for large-scale projects with industrial firms (through result-oriented contracts) or external contributors (through partnership agreements). In PPT-EVM, physical progress records are based on deliverables that are achieved. This approach leads to quite objective reports.

For the time being, PPT-EVM scheduling capacities are limited; CERN is improving this weakness and is embedding into PPT-EVM a mixture of three scheduling methodologies:

- Precedence Diagram Method (**PDM**) for one-of-a- kind project activities
- Line-of-Balance (**LoB**) for repetitive activities (series production)
- Linear Scheduling Method (**LSM**) for activities with a linear development

[4] This is based on a comparison by P. Bonnal, AB-SU (2006-03-08)

Resource Constrained Project Scheduling algorithms, suited to large-scale projects are also being implemented.

PPT-EVM is able to support two of the three major project costing approaches suitable for long lead and large-scale projects, namely the:

- so-called US Government approach: inflation is embedded into budget figures
- hybrid approach: a single basis; budget figures reviewed periodically to integrate inflation and price escalation.

With some efforts from CERN, the so-called three-base approach (budgeted / committed / invoiced financial figures) could also be made available and of course it supports the notion of CORE cost (e.g. ATLAS)

PPT-EVM fully supports the Earned Value Management methodology as standardized in the ANSI #780. This methodology is known to have some weaknesses, especially when the project is made of an important quantity of outsourced workunits; PPT-EVM's deliverable-oriented PM approach corrects these shortcomings.

PPT-EVM offers a wide range of reports, graphs, plots… All the graphs promoted by the EVM methodology are available, including bull's eye diagrams! The APT incarnation now contains a fully reusable OLAP engine useable for multi-dimensional ad-hoc reporting.

An important effort has been made to make data editing extremely easy to end users. PPT-EVM provides two means for editing/entering data:

- HTML forms offer quick editing of few data
- Excel spreadsheets for editing or entering large quantities of data, through a nicely engineered download/upload mechanism.

No specific training is required to use the basic functionalities of PPT-EVM.

Of course, PPT-EVM can be fully integrated into CERN's Corporate Management Information Systems (Accounting systems for Actual Costs, Contract Management systems for contract follow-up, amendments, Human Resource Database for personnel information, access rights…) or can be interfaced to other ERP's.

<u>Primavera</u>

Primavera is built around an **activity-oriented project management** methodology that is known to be quite efficient in the framework of Engineering&Construction projects. This project management approach may show its limits when applied to large scale scientific projects as physical progress records are based on percentages that are disconnected to the true deliveries that are not recorded into the system. The so-called "90% syndrome" may become difficult to avoid, especially if the project is a large-scale and complex project involving a lot of contributors reporting the progress.

Primavera's project scheduling capabilities are based on the Precedence Diagram Method (a variant of the CPM/PERT approach). Large-scale projects often involve the fabrication of series production; for this very purpose, Primavera capabilities are weak.

Resource Constrained Project Scheduling algorithms are embedded into Primavera, but because this PM system is weak with project planning, these features cannot be efficiently used.

Primavera project costing capabilities are quite limited, but sophisticated enough for small- and medium-size projects. For commercial reasons, the US Government funded project reporting requirements (Financial Year Budgets…) are efficiently implemented in Primavera.

Primavera also supports the Earned Value Management methodology. The known biases can certainly be corrected through some adhoc procedures, but are not embedded into the tool.

Primavera offers a wide range of reports and graphs that are comparable to the ones of PPTEVM, although add-ons may be required.

Progress monitoring can be done through Web pages. However the Primavera software is needed for advanced users.

Primavera can be interfaced with major high-end Enterprise Resource Planning Systems.

We don't know the cost of Primavera for large HEP projects.

Engineering Data Management Tools Area Analysis

Overview of User Requirements

The EDMS will be used to manage, store, and control all information relevant for the conception, construction, and exploitation of the LHC accelerator and experiments during their whole life cycle, more than of 20 years. (Quote from the EDMS URD)

Functional Description

- Project structure management (PBS reference structure to hold documentation)
- Product structure management (Articles and BOM)
- Document management (all kinds of engineering and technical documents and models with attached files)
- Workflow and approval cycles (especially strong collection of comments about the stored documents)

History

Precursors of EDMS at CERN were the CERN Drawing Directory (CDD), developed to manage the drawings of the accelerator design offices at CERN and Web-based tools for sharing of engineering data by the LHC Experiment collaborations within the scope of the Computer Aided Detector Design (CADD) and Tuovi projects. Following a request from the research sector to look into available industrial solutions for the management of engineering data, the EDMS taskforce (chaired by Claude Hauviller) was created in 1995 and carried out a call for tender, benchmarks and system selection for a CERN-wide Engineering Data Management system. The benchmarked shortlist consisted of CADIM/EDB, Matrix and Metaphase (forerunner of Teamcenter Enterprise). Finally the system CADIM/EDB from the German company Eigner+Partner was selected after a successful pilot project for the ATLAS TRT early 1997. The main reasons for selecting CADIM (later known as Axalant) were its strength in product structure management (articles, bills of materials and variants) as well as the available integrations to the CERN CAD systems AutoCAD and EUCLID and the relative robustness of the software based on Oracle. (The contender Matrix based on ObjectivityDB had shown stability problems at the time.) However, CADIM only had a passive Web-interface, so it was decided to use the TuoviWDM web interface with the CADIM/API as an interim solution. (It should be mentioned that at the time, none of the commercial systems allowed much functionality from a Web-client)

The EDMS service (managed by Thomas Pettersson) was launched in 1997-98 as a combined effort of the EST and IT divisions. Although the system was capable of handling product structures, the engineering processes at CERN were very much document-based and the main focus for the EDMS service was to provide document- and configuration management facilities for the LHC- accelerator and experiments. There was a strong wish to not disrupt the engineering design processes for the LHC, so instead of deploying the CAD-integrations to CADIM, it was decided to integrate the existing drawing management system, CDD with EDMS. The use of EDMS was gradually extended to other projects and engineering documents in general and from 1999-2000 also to electronics designs using an integration between Axalant and Cadence. The Tuovi Web interface was replaced by a CERN EDMS web interface with read-access to data in EDMS via Oracle and write access through an “EDMS common layer” using the CADIM API. The common layer has been used to integrate the asset management system MP5 (later D7i) that was already in use for maintenance management by ST and now is used to track the “As built” equipment for the LHC.

The EDMS service has also done a major effort in the domain of Quality Assurance, formalisation of document templates, release procedures and approval procedures, processes to handle engineering changes. A number of user training courses have also been provided.

Project Leader

Christophe Delamare has lead this activity since 2001

Domain

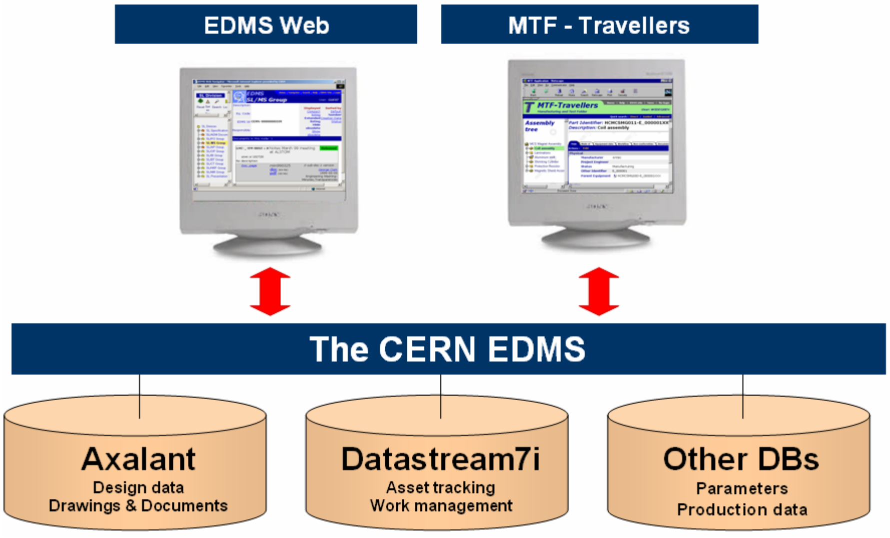
Document Management, Design Data & Asset tracking

Current Toolset

The current tools include :

- Axalant : Design Data, Drawings & Documents (Commercial Product)
- Datastream7i : Asset tracking & Work management (Commercial Product)
- CERN EDMS
- EDMS Web
- MTF Travellers

Architecture



Axalant:

Axalant (formerly known as CADIM/EDB) is a PDM/PLM system from the German company Eigner+Partner. The system is based on Oracle for the meta-data and a file server for the hosted document files. The principal entities in the system database model are: Projects, Items (articles) and Documents. An article or a project can be described by one or many document(s) that contains one or many files.

On top of the Oracle tables there is an application GUI (for Windows and Linux) with forms and tables with a Windows look and feel. The customisation tools DataView and LogiView allow for customisation of the GUI as well as definition of processes and macros to interact with the database. Furthermore there is a C-Api (ECI) that is used by the EDMS web interface and CAD/CAE-integrations. These integrations also allow for automatic conversions of CAD-files upon storage in Axalant. There is also an Axalant Web client that is not currently used by CERN.

Axalant has been extensively customised at CERN, examples are user-registration integrated with IT-Userreg, extended access control via stored procedures, custom release processes, forms, number-generators etc. All CAD drawings archived via CDD are stored in Axalant via a custom LogiView procedure. Electronics designs produced with Cadence (EDA) are archived in Axalant via 3'rd party application "Integrate" and a set of macros to create EDA articles and BOM in the database. Furthermore a file conversion dispatcher is used to handle incoming CAD-exchange files and was in the past used to submit documents to the CDS conversion server.

The supplier Eigner+Partner was founded in 1985 and is known for its strong engineering knowledge and consulting around CAD data management. The software release currently installed at CERN, Axalant2000Sp3, dates back to 2002. Eigner was acquired by Agile in 2003 and since then there has been 2 new releases of the software: Eigner PLM5 and Agile-E5 that are basically evolutions of Axalant. Agile is a company that grew quickly during the .com boom with customers mainly in the electronics industry as well as consumer goods and life-sciences industries. The Agile software (formerly known as Agile Anywhere) is strongly web-based and its PLM strengths lie in operations and supply chain management. The acquisition of Eigner was mainly to get hold of the engineering knowledge and customer base among suppliers to car manufacturers and other engineering companies as well as CAD-integration technology. A promised "Agile unified release" is not yet available and Agile still supports 2 distinct product lines.

One should note that some former employees of Eigner have founded a new company, XPLM, which provides CAD-integrations to Agile and other PLM systems.

D7i:

Datastream D7i is an asset tracking and maintenance management system. Formerly known as MP5 and earlier Rapier, the system has been in use at CERN since 1991 by the TCR and ST division. Nowadays D7i is used to track physical equipments for the LHC via the MTF traveller application. D7i continues to be involved in the CERN maintenance operations for the equipments of several groups such as TS-CV, TS-EL, SC-RP, AT-ACR.

EDMSweb:

CERN Web interface to design data in Axalant as well as “as-built” items (MTF). The “as-built” items (or articles) represent physical equipment with serial numbers etc and is linked to the “As designed” items (articles) in EDMS from which there are links to design documentation and drawings. The web interface is mainly using Oracle iAS and an EDMS common layer of Oracle stored procedures accessing Axalant and D7i tables.

Licensing

Axalant: 300 concurrent user licences, 10 developer licences,

D7i: 40 concurrent user licences.

Key Statistics

- 5000 registered users
- 2100 “active” users (creators or reviewers of data or documents)
- 80’000 actions/month; from more than 10’000 different computers; 20% from outside CERN
- More than 700’000 stored documents (text documents and drawings) associated with more than 770’000 electronic files.
- 10’000 documents registered per month
- 80’000 file downloads per month
- 500’000 registered equipments
- Between 5’000 and 30’000 equipments registered per month

Current Team

Current CERN team for the tools are

SUPPORT (EDMS, MTF, D7i):

First-line Support: C. Laverriere, B. Vercouter (70%), M. Jobert (Temp.)

Second-line Support: S. Mallon Amerigo (50%), P. Martel (50%), B. Rousseau (80%), S. Chalard (PJAS)

Consulting & Training: S. Costa, D. Widegren (SL - 50%), E. Sanchez-Corral Mena (Safety Commission services)

SOFTWARE:

Core Developments: S. Mallon Amerigo (50%), P. Martel (50%), S.Petit (SL)

Reporting & Specific dev.: M. Sahakyan (MC Fellow - 50%), V. Engmark (MC Fellow), R. Lyzwa (MC Fellow), A. Tsyganov (PJAS)

Pros/Cons of Current Tools

Pros :

- 10 years experience
- Balance of industry best plus customized layer for CERN
- CERN ubiquitous
- Proven multi-project & international project support for document management
- Proven in HEP
- Workflow

Cons :

- Future of axalant
- Storage of CAD documents
- Not article-centric

CERN Experience

LHC, Alice, Atlas, CMS, Isolde, LHCb, CNGS, …

Lessons learned on s/w

User interfaces for a PLM system should be Web-based and intuitive. Few engineers have the time to learn how to handle product structures via a complex proprietary user interface.

Lessons learned on usage

- QAP key

Weaknesses

- No document conversion
- Document-centric, not article centric

- Dependencies not managed
- Separate hierarchies from other systems
- Asset tracking info not linked with AIS
- Up-date of progress, MTF update is separate from EVM update

To do better next time
Focus on article
Support for CAD storage, retrieval, visualization & integration

Shared Interfaces

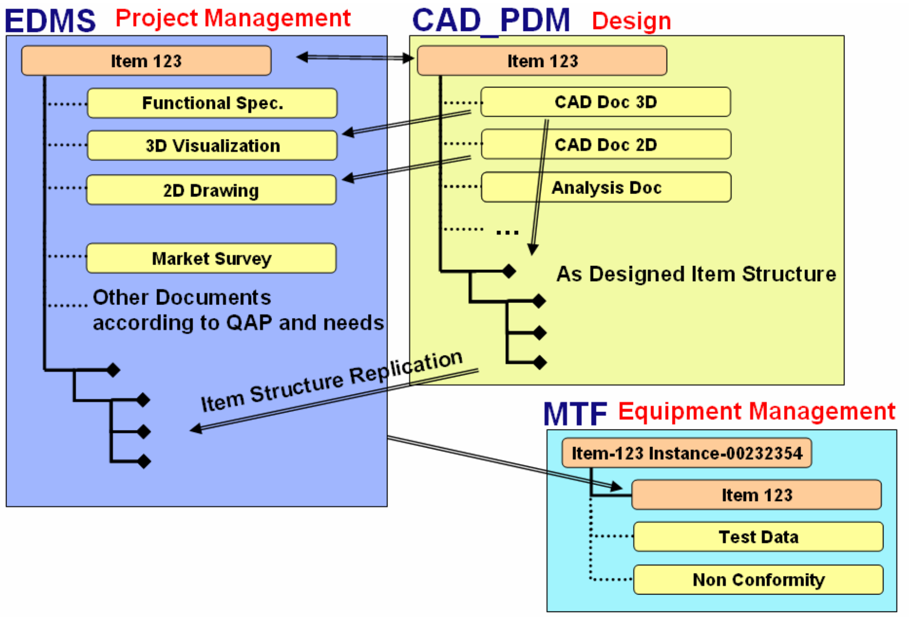
- WBS with other systems. Common WBS (Data consumer)
- PBS with other systems (Data provider)
- Hierarchies
- Groups
- Workflow roles
- People/roles/access (Data consumer)
- Articles / Equipment codes (Data consumer)

Considerations
Move to article will require significant Culture & operation change in departments

Future evolution forseen

Item centric project – Items are today used for the production and maintenance follow-up. It is foreseen to extend the usage of the items to the beginning of the design phase. This has now become possible thanks to the ongoing project of implementing a CAD data manager for CATIA V5, SmartTeam from Dassault Systemes.

This ongoing project includes implementing SmarTeam as a PDM system dedicated for CAD data. First aim is to manage CATIA V5 data in an item centric approach where each item is mapped with an EDMS item.



Alternative Tools
PLM tools such as TeamCenter Enterprise from UGS or Enovia from Dassault.

Document archiving, retrieval, agenda & conference Management tool area analysis

Overview of User Requirements

CERN Document and Conference servers are used by the physics community at large:

- CERN digital library (CDS Invenio*) was accessed by 270,000 distinct users (distinct IP addresses) over the year 2005.
- CERN Conference Management System (CDS Indico) is also used both within CERN and by physicists or conference organisers all around the world.

Digital Library User requirements are of two different types:

- authors who want to deposit (and archive) their production in a long-term well-known and open access digital library → key requirements: workflow, format conversion, version control, OAI compliancy
- readers who want to find quickly and easily scientific documentation in HEP and HEP related domains → key requirements: collection organisation, search/rank engine, collaborative tools

Digital Conferencing User requirements are also oriented in two directions:

- events organisers who want electronic facilities to manage the whole process of the event, from call for abstract to production of proceedings
- participants (either real or virtual, either contributors or attendees) who want easy access to the material, timetable, papers, etc.

(*) CDS Invenio is the name of the package hitherto called CDSware, as of June 2006

Functional Description

CDS Digital Repository (CDS Invenio) provides the following main features:

- Navigable collection tree : at CERN, over 840,000 documents in 600 collections
  - Documents are organised in collections, that can be public or private
  - Regular and virtual collection trees can offer multiple access point to the same data
  - Customizable portal boxes for each collection, aims at preserving the preferred looks and feel of the collection owner
- Powerful search engine : specially designed indexes to provide Google-like search speeds for repositories of up to 1,500,000 records
  - Customizable simple and advanced search interfaces
  - Combined metadata, full text and citation search in one go
  - Results clustering by collection
- Flexible metadata
  - Standard metadata format is used: MARC from US Library of Congress
  - It enables handling articles, books, theses, photos, videos, museum objects and more; almost any kind of "object" can be described by MARC
  - Display of the records and linking rules can be customized for each collection and for all bibliographic fields
- Collaborative tools
  - Users can define their own document baskets
  - Users can define automated email notification alerts to be notified of new documents
  - Users can share baskets within user groups and they can comment, review and rate documents in repository (Amazon-like feature)
- Multiple output formats (HTML, XML, MARC, DC, OAI) enables integration with other systems

CDS Digital Conferencing (CDS Indico) provides the following main features:

- Multiple event support

    - Events can be organised in categories and they can be of three types: simple events, meetings or conferences
    - Users can navigate in the categories or through a time-driven navigation (calendar day/week/month overview)
- Flexible event representation
    - The same event can be shown with lot of different views, depending on the preferences of the organisers
    - Access to the timetable and various listings (participants, contributions...) is proposed
    - All kind of files including pictures, transparencies, minutes or videos can be attached at any level (contribution, session, track, home) of an event
- Full management of conference cycle
    - Simple forms are proposed to create events of various complexity
    - The event manager can easily setup access and modifications rights
    - Call for abstracts, paper reviewing, track management, proceedings, listings, e-payment... are all integrated processes
    - Timetable and conference website can be customized
- End user interactions
    - Registration and e-payment can be activated for end users
    - Abstract submission / Paper submission / Slide upload can be opened to authors

History

CDS Invenio :

HEP community has a long « preprint » tradition - which is not the case in most research areas. Making documents available before publication (in paper form in the early days and electronically later on) is still very HEP specific but is starting to spread with the Open Access movement. CERN's historic role in this movement is strongly correlated with this long-lasting tradition, which CDS has been following up since the emergence of the web in 1993.

1993 CERN Preprint server starts serving CERN series and SCAN series (preprints sent in paper form to CERN by HEP institutes and scanned at CERN)

1996 CERN Web Library (WebLib) merges Preprint Server and Library Server, adding books, periodicals, and other library objects

2000 CERN Document Server (CDS) encompasses multimedia material and internal notes

2002 CDS software (CDSware) solution installed world wide, promoting the OA movement

2004 CDSware used as the document management system by CERN Directorate offices

2006 CDSware package is renamed CDS Invenio, released together with EPFL who actively collaborates at its development

CDS Indico:

When the library studied the quality of its document coverage in the 90s, it was pointed out that the missing part was mostly from documents submitted to conferences. Browsing conference proceedings was the only way to detect papers written by CERN authors, not submitted in the library system. One of the solutions to fill in this important hole was to address the issue at its early point. The Agenda-Maker toolkit and the Indico EU project has offered a platform to facilitate the acquisition and long term management of conference material.

1999 CERN Agenda-Maker starts as a sister application of WebLib for conferences, meetings and workshops, on the request of ATLAS

2002 INDICO Project sponsored by EU as the European Solution for managing and saving conference content in long term

2004 INDICO starts to be deployed at CERN, to replace Agenda-Maker

Project Leader

JeanYves Le Meur

Domain

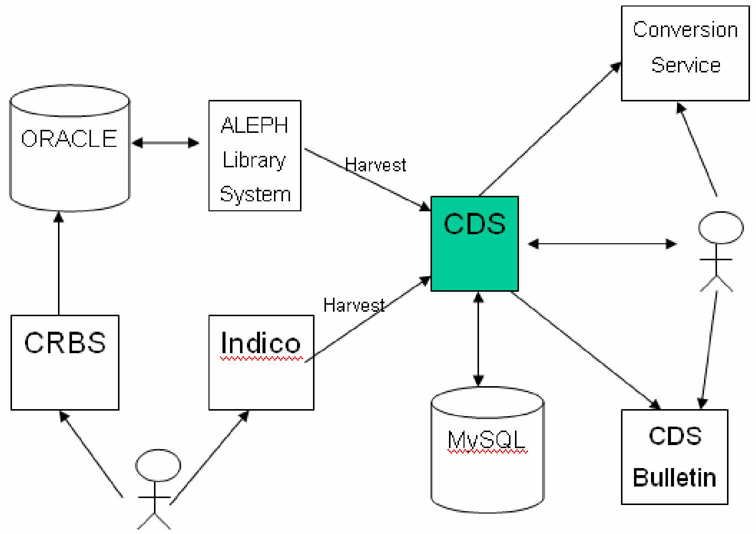
Digital Library, Open Access repository, Digital Conferencing

Current Toolset

The current tools include :

- CDS Invenio
- CDS Indico
- CDS Conversion Server: ensures formats are converted into industry standards for long term storage
- CDS Bulletin Server: releases issues of various publications (weekly bulletin, ATLAS e-news, etc.) on top of articles kept in CDS Invenio
- Conference Room Booking System: independent application still to be merged with CDS Indico
- ALEPH 500: commercial integrated library system used by library staff for specific operations like book circulation, serials management, holdings, etc.

Architecture



Technology

CDS Invenio:

- US Library of Congress standard to describe documents (MARC 21)
- Unicode based
- OAI protocol support
- Freeware technology: MySQL RDBMS; Native Indexes; Apache/Python.

CDS Indico:

- UML for technical documentation
- Unicode based
- OAI protocol support
- Freeware technology: ZODB OO DB; Apache/Python; XML/XSLT

Licensing

- Free software, licensed under GNU General Public Licence (GPL)
- Support license (yearly based) provided to installations wishing to receive support from the CDS team

Key Statistics

CDS Invenio:

- 25,000 distinct users per month
- 270,000 searches per month (~9,000 per day)
- 840,000 records; 360,000 full texts
- 60,000 new acquisitions per year (2,000 by CERN authors)
- 600 collections

CDS Indico:

- Number of events: 11,200
- Number of contributions: 66,000
- Number of attached documents: 100,000

Current Team

CDS Invenio

- Software team: JY. Le Meur (SL), T. Simko, N. Robinson
- Support team: C. Montarbaud, B. Chan
- External funding: 2 (MC) Fellows + 2 UPASs

CDS Indico

- T Baron (SL) + 1 Fellow

Pros/Cons of Current Tools

CDS Invenio
Pros :

- 13 years experience
- Combines the best of traditional library world and modern information retrieval technology
- Supported by a Consortium of users
- Packaged and installed world wide
- Is currently number one OA repository software in data providing
- Long term e-archive features

Cons :

- Library-like maintenance work required to keep the quality (hierarchy organization, tag maintenance, metadata checking, etc)
- Package is big and complex (price to pay for flexibility)

CDS Indico
Pros:

- Manages from simple event to large conference
- Provides global view on all planned events
- Used in HEP and other institutes (deployed world wide)
- Allows harmonization of conf. management in HEP (with major cost savings)

Cons :

- Only two years experience
- Demand is growing too quickly
- No staff behind

CERN Experience

Both CDS Invenio and Indico are used throughout CERN

See Alternative tools for other known/tested products

Lessons learned on s/w

- Importance of the selection of the adequate technology to fit best the application profile
- Importance of applying strict working methods (release cycle, coding policy, etc) due to very high turnover of temporary team members
- Importance of rapid prototyping and dynamic requirement analysis to adapt to changing needs

Lessons learned on usage

- Importance of always trying to clarify/simplify user requests
- Do not underestimate the CERN heterogeneous environment and its specifics

Weaknesses

- Due to the organic growth development, some local components (authentication, group management, etc) were implemented independently of the central ones being developed in parallel
- Impossibility to apply the main CDS Invenio GPL package out of the box at CERN, because of CERN specifics (e.g.: ATLAS approval process for Scientific Notes)
- Difficulties in supporting on-side services, like CDS Bulletin, Webcast server or Format Conversion server which are necessary but have no dedicated resources

To do better next time

- Scope definition to be clear from the beginning, avoiding possible confusion for end-users

- Common foundation tools would have simplified user interaction with multiple CERN systems
- A stronger CERN wide top-down approach to document management would have avoided duplication of efforts (i.e. a CERN management policy), and the consequent importation and processing of large documentation backlogs each time new services (departments, projects or experiments) are integrated into CDS

Shared Interfaces

- OAI
- People/roles/access (Data consumer)
- Hierarchies

Costs

Material costs:

- license ALEPH 500: 28K CHF/year
- Hardware maintenance: ~20K CHF/year

Personnel

See section above “Current Team”

Considerations

CDS Invenio and Indico are both having more and more clients world wide. As they are GPL based, some private companies are already starting to make business with the packages, selling support and providing services on top of these applications. This evolution was actually part of the EU Plan for Indico Project and it is now being realised these days. In fact, both applications were born in the HEP area where practices are specific (very large spread out collaborations with multiple equal-level partners, tradition of preprints, etc) and they are now becoming of interest in many other domains where similar practices are emerging (like OA).

Future evolution foreseen

- Full Integration of Invevio and Indico (Invenio is already used to search Indico)
- Indico as the sole interface for event planning
  - VRVS integration in Indico on-going
  - CRBS integration in Indico planned
  - Audio-conferencing booking integration in Indico planned
- CDSware Consortium (funded by CERN and EPFL) for future software support, with University of Fribourg end Ecole d’Ingenieur de Fribourg as partners

Alternative Tools

CDS Invenio as an Institutional Document Repository system can be compared with:

- Library Automated Systems
  - traditional library systems (as Aleph500, VTLS, Voyager, etc) are used to manage books, periodicals, series but do not cope well with heterogeneous material
  - specific library-oriented features and use experience
  - strong focus on metadata management, not at all on full text

  CERN library is using Aleph500 from Ex-Libris (one of the market leader). The option of relying fully on it for CERN Document Server was studied when migrating to its new version but Aleph was lacking too many features to be considered as an alternative solution.
- Internet Search Engines
  - full text indexing but poor metadata
  - acquisition process based on harvesting only
  - very limited collection organization

  The CDS Invenio Search engine is for most users the visible part of the CDS Invenio “iceberg”. The software is composed of 23 modules, two of them being dedicated to indexing (BibIndex and BibRank) and one to the search interface itself (WebSearch). All other modules are dealing with issues not covered by search engines, like direct document submission process, metadata conversion, records editing and formatting, and much more.
- Institutional Repositories software
  - similar products running OA institutional repositories: DSpace, EPrints, Fedora
  - usually support small size repositories only (less than 50K documents)
  - not “library-oriented” (metadata & acquisition channels restricted)

  These are more direct “competitors” to CDS Invenio. At this day, they would not be able to cope with number of collections and documents supported at CERN.
- EDMS systems (GED)

- different scope & architecture with strong focus on Product Lifecycle Management versus Information Retrieval technology
- specific features linked to equipment/component management in EDMS
- long term archive versus working environment

For more on CDS and EDMS comparison, see chapter 3.2.3

CDS Indico was compared with:

- Commercial products (Eveni; Suvisoft *Corg* software; Conference.com; Softconf:*Start)*
  - Mainly hosting is proposed
  - Mostly service oriented, with “manual” intervention like hotels booking, paper shipping, etc
  - Targets are large conferences. Not convenient for one day workshop
  - No multi-conference features
  - High Cost: each event is charged and additional fees often asked to participants
  - Long Term problem: longevity of the web site requires to pay every year. Strong dependency on ‘small’ company
- Freeware products (CyberChair ; Open Conference System; Zakon Group; *Openconf*; *CDS Agenda)*
  - Very basic features proposed and poor web interfaces
  - Incomplete
  - No much flexibility in the design
  - Aiming at single event management
  - Very little experience: not much used so far by conference organisers

Indico aims to have all conferences in a domain (HEP) share the same platform and to be possibly interlinked. This is not something the market place offers out of the box today, which was one of the motivations behind the EU funding. In this area where we have seen in the past most of the conference organizers developing their own set of scripts to quickly provide computing facilities to the conference site, the cost saving of federating conference computing within a single system is considerable. HEP domain is running an average of 50 conferences/workshops per month, plus 50 more in HEP-related domains.

Computer Aided Engineering (CAD/CAM/CAE)

Overview of User Requirements

Design and engineering analysis tools for mechanical and electronics design. 3D CAD is the main data provider for product design and should be the primary consideration for the implementation of a PLM system and processes. But also data from other CAE tools should be stored in the system.

Quote from the CAD-2000 URD:

The CAD system will be used to create, input, output, integrate and store two-dimensional and three-dimensional design information relevant for the engineering projects and processes at CERN over the next 10 to 15 years. In addition the system must be able to manage metadata.

The system is mainly to be used for Mechanical Engineering, but also users in Electrical, Civil engineering and GIS projects may use or interact with the CAD system.

- CAD data managed by PDM system
    - Versioning, traceability, security, release procedures
- Item introduced at design phase and followed through the complete lifecycle to dismantling
- Same unique Item ID in all systems
- Change management

Functional Description

- 2D and 3D Computer Aided Design (CAD) tools available on PCs
- 3D visualisation and integration tools (DMU)
- Engineering Analysis tools
- Electronics Design Automation (EDA) tools

For the LHC project, the official design tools used are EUCLID and AutoCAD. Euclid is used for 3D design and drafting, and AutoCAD used for drafting

CATIA V5 is officially used as the DMU tool in the LHC project.

CATIA V5 is being introduced as the next CAD design tool but with restricted access and not for designs in the LHC project.

3D design is the production of three-dimensional solid models representing the final design. The 3D models are then used to produce 2D drawings. A 2D drawing is the specification for the shape of the final part or assembly to be produced.

History

EUCLID 3D CAD was introduced for LEP in 1982. It was used for LEP design and integration as well as for the LHC. AutoCAD (2D) has been available on PCs from 1988. Pro/Engineer was used for some mechanical CAD projects from 1990 to 2002. CATIA V5 was selected as successor to EUCLID by CAD-2000 working group[5] and is in use for LEIR. Various other CAD systems are being used by partner institutes.

FEM: Ansys was introduced in mid-80's. Several specialist tools exist, but users of many of these tools have been migrated to Ansys.

EDA: Daisy was introduced in 1988. It was replaced by Cadence. P-CAD is being used for smaller designs.

Project Leader

Eric Van Utyvinck (CAD)

P. Baehler (Design tool support from IT)

E. Van der Bij (Electronics design)

[5] CAD-2000: A taskforce for the selection of a new mechanical 3D CAD-system for CERN. http://cern.ch/cad2000

Domain

- Mechanical design
- Drafting
- Digital mock-up, integration analysis, installation analysis
- Cooling and ventilation design
- Electrical cable routing
- …

Current Toolset

The current CAE tools in use at CERN include:

CAD-systems:

- EUCLID
- CATIA v5
- AutoCAD

Structure Analysis and Field Calculations:

- Ansys
- StarCD, Mafia, ESAcomp etc

Electronics Design Automation:

- Cadence
- etc.

+ Other specialist tools

Data management:

- EDMS/CDD for archiving
- Consult for exchange of 3D models.
- SmarTeam (implementation ongoing at the time of writing)

Architecture

- Centralized installation management. All supported CAD software are configured and managed by the CAD team.
- Conversion service for CAD data for external collaborators. EUCLID and AutoCAD designs can be converted into various formats. Designs from many other software packages can be converted to the CERN formats.
- Centralized management of CAD design data. EUCLID has its local databases, and official AutoCAD and CATIA designs are stored on centralized directory structure. Local data management for CATIA and AutoCAD with SmarTeam is entering pilot soon.
- Centralized management of official CAD drawing data. All official CAD drawings are stored on the EDMS, where they can be distributed to the outside collaborators.

Technology

Not really applicable – market purchased software but covering a 35 year time period.

Programming languages from CAD APIs: F77, LISP, VB/VBA
CERN specific developments: Tcl/Tk/iTcl Vbscripts SQLPLUS and legacy C++
In the context of CAD data exchange: we use specific CAD conversion tools: WorkView3DPRO, 3DEvolution and CatiaConnect

Licensing

Most of the products use the FlexLM license manager. The figures below indicate the number of concurrent user licences for the main modules. (There are additional licences for special modules and interfaces.)

CatiaV5: 200 concurrent floating licences

EUCLID: 97 seats

Autodesk Mechanical: Site licence

Ansys: 45 research, 5 industrial

Cadence: 30x2 (Many different modules)

SmarTeam: 200 concurrent floating licences

Key Statistics

Average number of different users pr. week, Q1 2006:

- CATIA V5: 40
- EUCLID: 114
- Autodesk Mechanical: 380
- Ansys: 45
- Cadence: 70

(Source IT Licence monitoring system.)

Current Team

TS-CSE-CAE:

User support, EUCLID core services, CAD data exchange with partners and subcontractors, methodology, specific developments, and integration tools for the LHC.

CERN STAFF:

Section leader: E. Van Uytvinck

Responsible for EUCLID: B. Feral

AutoCAD: C. Andrews

CATIA V5: P.O. Friman

SmarTeam pilot: T. Hakulinen

EUCLID to CATIA V5 data migration: Y. Boncompagni

In addition, a project associate from Protvino paid by CAEC, R. Zalyalov: maintains old EUCLID applications and helps in EUCLID to CATIA V5 data migration.

Pros/Cons of Current Tools

- Support for multi-CAD
    - CATIA V5 support integration of models from various formats. For traceability a PDM tool is needed to trace links between original and converted files, including the history of versions.
- Not item centric

CERN Experience

For many years CERN CAD team has been facing support and development problems of considerable complexity with very limited resources and funding. Industrial strength CAD tools are being used and supported, but with considerably smaller budgets than in the industry. Budgets for specialized software solutions and consulting have been tight, which has lead to development of many home-grown solutions to the problems that needed to be solved.

The CERN CAD support has quite an unusual level of programming skills for a support team. Complex applications have been developed to support the LHC integration, EUCLID to CATIA migration, and the new CATIA environment. As one of these applications was a service for exchange and conversion of CAD data between CERN and outside collaborators, our team also has quite a good background in CAD data exchange.

It has been possible to maintain a certain standard of CAD support at CERN. However, it would certainly be possible to considerably improve user support and methodology. However, this would require more manpower. Currently the ratio of users per support personnel is very high compared to the industry.

Lessons learned

The usual PLM approach is based on the Bill of Materials (BOM) concept, which means managing the construction hierarchy, i.e., vertical links between assemblies and parts. Integration, on the other hand, needs a transversal approach. It has to focus on the design in context, which means identifying geographically close components irrespective of their logical organization. Project-wide integration requires a geographical approach and complex management of positions and coordinate systems.

Integration deals with black boxes (envelopes). It would be useful to focus on the interfaces. Using a different system for integration from that for equipment design is heavy but possible. This requires conversion of all CAD models into a format understood by the integration tool. This would ideally be a neutral format, which is either exact, or if approximate, sufficiently accurate for the specific use. A light approximate neutral format, such as VRML, works well for large integration studies. An exact format like STEP is better for small integrations. The integration coordination has to impose one CAD system or file format as a reference in which all collaborators have to deliver their envelopes and interfaces. This is one of the reasons why at CERN the integration of the accelerator has been more successful than integrations of the detectors: LHC had chosen EUCLID has the reference tool for the integration.

Within equipment design multi-CAD is a disaster: using AutoCAD and EUCLID on the same equipment has always been a nightmare for the support and a disaster for global efficiency. This CERN policy has been a big mistake and had a very detrimental effect. History, traceability, and interdependencies of models are lost in the data exchanges. In order to avoid these kinds of problems in the future, project organization needs to be such that entire well-defined equipment studies can be done with a single tool. Only in the integration phase should multi-CAD designs be mixed.

Tools like the new PLM or the ones deployed for LHC require strict methodology, commitment of the hierarchy, and dedicated resources. No tool can replace an integration team.

Lessons learned on usage

Note that AutoCAD 2005 and Autodesk Inventor are widely used outside the main CERN drawing offices, notably by the LHC experiments.

Weaknesses

- Document-centric approach to CAD design management.
- Multi-CAD management is a mess. It should be avoided internally at CERN if at all possible and need much better methodology and software support to deal with outside collaborators.

To do better next time

Focus on PLM with CAD, Multi-CAE 3D archiving

Shared Interfaces

N/A

Costs

Funding is from IT dept: budgets for specialized software solutions and consulting depends from the CAEC committee. CAEC budget has been reduced sharply during the last 5 years.

Considerations

CATIA V5 shall be the main data provider from CERN and the principal system to consider for PLM. But we also need to include data from other tools and address a multi-CAD environment as well as long term archiving (in a standard format like STEP and viewable formats like 3D-XML or JT).

Future evolution foreseen

CATIA V5 replacing EUCLID

Cadence under migration to Windows, Integrate integration with Axalant only offered on SUN Solaris. The current solution on Windows is use of the Cadence archiver and manual upload to EDMS, but a more automated PLM solution for Cadence is desirable.

Alternative Tools

Catia V5 has been selected by the "CAD 2000" project and it is now very strong on the CAD market.

In the near futur UGS NX will be a good alternative but development has been delayed for a while due to the merging between UG and IDEAS.

Only Catia V5 provides a solution to recover Euclid3 data.

Glossary:

Authentication The process of attempting to verify the identity of the sender of a communication such as a request to log in.

Authorisation The process of verifying that a known person has the authority to perform a certain operation.

BOM A Bill of Material (BOM) is an ordered list of the parts, sub-assemblies, and assemblies and raw materials that define a product. Normally created and maintained within the Project Structure Management function, it defines the type, number, quantity, and relationships of parts and assemblies.

CAD *Computer Aided Design*. A term for all computer-assisted design activity. For the purposes of this document, CAD refers mainly to the 3D or 2D design authoring tools such as CATIA, AutoCAD, or I-DEAS.

DMU *Digital Mock-Up*. Integration of separately designed parts and assemblies while testing for mutual compatibility (interfaces, dimensions, collisions, etc.).

EDMS *Engineering Data Management System*. Old term for a system used to manage product data including CAD designs and all associated documents. Nowadays the terms used are usually either *PDM system* or *PLM system*. In this document EDMS is used as a proper name and it refers exclusively to the current CERN EDMS system.

ERP *Enterprise Resource Planning*. Management of all resources of an organization in a coherent and integrated manner.

GDE Global Design Effort Planning, designing and funding the proposed International Linear Collider, an electron-positron collider costing billions of dollars, will require global participation and global organization. An international team leads the Global Design Effort for the ILC, headed by Barry Barish, former director of the LIGO laboratory. The GDE team sets the strategy and priorities for the work of hundreds of scientists and engineers at universities and laboratories around the world. Their goal: produce an ILC Reference Design Report by the end of 2006 and an ILC Technical Design Report by the end of 2008. Physicists and policy-makers will use the reports to decide the future of the project.

IGES Products may be designed as either a two-dimensional, three-view drawing layout, or as a full three-dimensional model with associated drawing views and dimensions using a Computer Aided Design (CAD) system. The IGES format serves as a neutral data format to transfer the design to a dissimilar system. Translators, developed to the IGES Standard, are used to export a design into an IGES file for exchange and for importing the IGES file into the destination system.

ILC The International Linear Collider is a proposed new electron-positron that would allow physicists to explore energy regions beyond the reach of today's accelerators The nature of the ILC's electron-positron collisions would give it the capability to answer compelling questions that discoveries at the LHC will raise, from the identity of dark matter to the existence of extra dimensions. In the ILC's design, two facing linear accelerators, each 20 kilometers long, hurl beams of electrons and positrons toward each other at nearly the speed of light. Each beam contains ten billion electrons or positrons compressed to a minuscule three-nanometer thickness. As the particles speed down the collider, superconducting accelerating cavities give them more and more energy. They meet in an intense crossfire of collisions. The energy of the ILC's beam can be adjusted to home in on processes of interest.

ITEM. An item in PLM is a data object, which carries a unique identifier across all the involved systems and which completely describes the usually physical part or piece of equipment including all the specification, design, configuration, and manufacturing data. Multiple instances of this ‘design-item’ can then be created to describe the actual individual manufactured equipment with all the associated test data, service logs, etc. This part of the PLM is already carried out at CERN by system called Manufacturing and Test Folder (MTF).

JT format JT is a mature lightweight data format that already enjoys widespread use in the automobile and aerospace industries and is equally suitable for all manufacturing industry applications. The success of JT and applications that exploit it is such that JT has become the preferred common data format for many large end-users. The JT data representation is:

- a rich data model with robust entity support
- a high-performance, compact persistence archive format for graphics data
- the best-in-class for supporting large assembly/model interactive capabilities
- CAD-neutral supporting all major MCAD applications
-

MTF *Manufacturing and Test Folder*. CERN system for managing installed physical equipment. Part of EDMS.

Multi-CAD Management of design assemblies, where some parts or sub-assemblies have been created with different CAD authoring tools. True multi-CAD management requires that in addition to managing the configuration, i.e., the product tree on a meta-data level, the assembly can be properly integrated using a DMU-tool. This normally requires that an intermediate neutral CAD file format be used, which can preferably be both produced and consumed by all CAD-systems concerned.

PBS Product Breakdown Structure A structure that identifies the Products that are required and that must be produced. It displays the system in a hierarchic way.

PDM *Product Data Management*. Management of product data, often in a somewhat limited sense. Typically in the CAD context one often talks about *local PDM* for a CAD system, which includes management of CAD designs but usually not the more complex life-cycle and workflow management, which are often managed by a higher-level PLM or ERP system.

PLM Product Lifecycle Management (PLM) Definition
CIMdata defines PLM as:

- A strategic business approach that applies a consistent set of business solutions that support the collaborative creation, management, dissemination, and use of product definition information
- Supporting the extended enterprise (customers, design and supply partners, etc.)
- Spanning from concept to end of life of a product or plant
- Integrating people, processes, business systems, and information

It is important to note that PLM is not a definition of a piece, or pieces, of technology. It is a definition of a business approach to solving the problem of managing the complete set of product definition information—creating that information, managing it through its life, and disseminating and using it throughout the lifecycle of the product. PLM is not just a technology, but is an approach in which processes are as important, or more important than data. It is critical to note that PLM is as concerned with “how a business works” as with “what is being created.”
Three core or fundamental concepts of PLM are:

1. Universal, secure, managed access and use of product definition information
2. Maintaining the integrity of that product definition and related information throughout the life of the product or plant
3. Managing and maintaining business processes used to create, manage, disseminate, share and use the information.

While information includes all media (electronic and hardcopy), PLM is primarily about managing the digital representation of that information.

PPT Project Progress Tracking

STEP STEP (ISO 10303) is an International Standard for the computer-interpretable representation and exchange of product data. The objective is to provide a mechanism that is capable of describing product data throughout the life cycle of a product, independent from any particular system. The nature of this description makes it suitable not only for neutral file exchange, but also as a basis for implementing and sharing product databases and archiving. STEP provides a complete product information architecture, which *includes* a file exchange format, and several other implementation methods. IGES and DXF are just geometry file exchange format specifications.

WBS Work Breakdown Structure ("WBS") : A task oriented detailed breakdown, which defines the work packages and tasks at a level above that defined in the networks and schedules. The WBS initiates the development of the Organizational Breakdown Structure (OBS), and the Cost Breakdown Structure (CBS). It also provides the foundation for determining Earned Value and activity networks.

Appendix A PLM Market overview:

The PLM market has undergone a consolidation with many mergers and acquisitions over the last years. Many IT suppliers claim to have PLM solutions, this is the case for IBM, SAP and Oracle as well as CAD/CAM/CAE suppliers like Ansys and Autodesk. Recently even Adobe, Microsoft and Google have entered the market, but PLM related software is a minor part of their operations. The main actors in the PLM market place are thus major CAD-suppliers who offer full PLM solutions:

Dassault Systemes (CAD: CatiaV5, SolidWorks, PLM: Enovia, Smarteam and recently; Matrix)

UGS: (CAD: Unigraphics, SolidEdge, PLM: Teamcenter Engineering, Teamcenter Enterprise)

PTC: (CAD: Pro/ENGINEER, PLM: WIndchill)

Agile is the last major independent “pure play” PLM supplier. As this company also is the supplier of the CERN system Axalant/E5, its future should be monitored carefully. The Agile partner **XPLM** is now an independent suppler of CAD-integrations to Agile as well as other PLM systems like Teamcenter and SAP/PLM.

Autodesk is the biggest CAD/CAM-supplier with $2 billion revenue, but has no real PLM solution, only a local data management system “Autodesk Vault.)

Ansys Inc is the main supplier of Design Analysis tools, but works with partner offerings in the domain of data management and CAD.

Cadence and Mentor are the market leaders of EDA tools.

Most of the PLM product offerings are toolboxes that consist of several system components that may have their origins from different suppliers in the past. The PLM suppliers get a major part of their revenues from consulting and custom implementations and development for their industrial customers.

Given the penetration of Web technology and internet access, it is somewhat surprising that there are few web-based hosted “out of the box” PLM providers on the Internet. Exceptions are: Windchill PDMLink On Demand from PTC, Arena solutions (formerly bom.com) and the Finnish Kronodoc that has origins at CERN. (Their offering is restricted to the Nordic markets and does not target CAD/PLM.)

Appendix B: Mandate

Mandate of the Integrated Project Support Strategy Study Group

The LHC project has provided CERN with a unique opportunity to develop a comprehensive set of project management tools, gain experience in the related processes and build up competencies in the supporting domains. Specifically these areas are: Engineering Data & Technical Documentation Management, Project Scheduling & Costing (including EVM), Event management and Document management.

Whilst the initiatives in each of these areas were orchestrated predominantly by the LHC project leader, the growth and development within each area occurred independently resulting in a powerful, but disjoint set of tools – a 'silo' approach. In order to provide an improved foundation for future project support at CERN the study group will analyse a vision for a common approach providing a coherent and integrated set of project support tools.

The study group is asked to address the following:

1. Elaboration of a vision & strategy for integrated project support involving analysis of user communities & requirements, enumeration of leading tools & best-practices and identification of interoperability and integration approaches.

2. Analysis of the status quo at CERN today with its existing tools

3. Development of a roadmap for future evolution including potential scenarios with their relative strengths & weaknesses along with technical & other implications as well as integration, in particular the link between management tools and CATIA 3D. The use of UGS team center as recommended by the ILC should be addressed as a possible option.

4. Estimation of costing covering both the one-off setup costs and the recurrent operating costs of the scenarios including support & maintenance efforts.

5. Analysis of the implications of the possible use of the management tools by an international community spread over distributed institutes and proposal of a strategy for their implementation

The group is asked to produce a report by the end of May 2006.

Appendix C : Summary of DESY visit

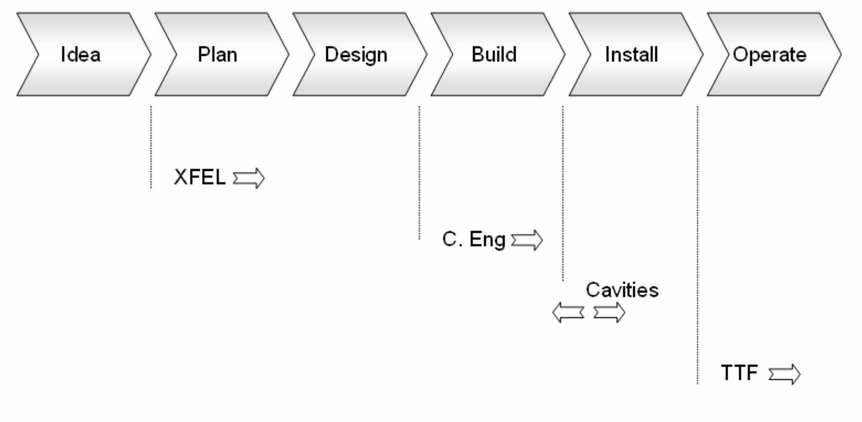
Dates : 18-19 May

CERN participants : James Purvis (IT-AIS, Christophe Delamare (TS-CSE), Eric Van Uytvinck (TS-CSE)

DESY participants : Lars Hagge, Johan Burger

Fermilab : Don Mitchell

The discussion focussed around PLM and the benefits usage at DESY for the various project lifecycle stages. The illustration below outlines how TeamCenter is used at DESY for various parts of the product lifecycle for various projects



Experience

DESY have experience with Teamcenter across the full product lifecycle, but with various projects (no one project covering entire lifecycle). For XFEL for example the Civil Engineering is being used by external companies on-site who are directly accessing Teamcenter. The tendering imposes the use of the CAD & PLM system. For TTF it is being used for maintenance & operation

As a CAD system I-DEAS is being used. Solidedge is also being used but the policy is to try to avoid casual 3D and introduce certification of draftspersons.

Management and traceability from the design through to the serialised parts is achieved. There are release procedures for documents, parts and assemblies.

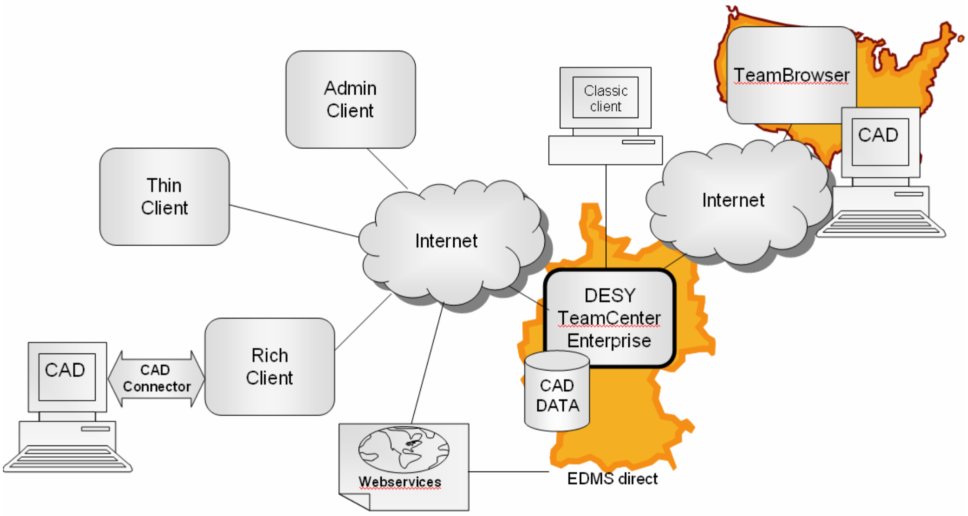
For Maintenance DESY uses Pergrine Asset Centre. If you create a component in this package then via webservices an item is automatically created in the EDMS.

Costs & Timescales

DESY selected TeamCenter (Metaphase) in 1999, signed the contract in 2001 and were operational after a year. They talk about a 4 year learning curve starting to really reap the benefits in the last couple of years.

International Collaboration

DESY already have a proven model of international collaboration using their TeamCenter setup and installing access to the system in Fermilab. The setup was less than an hour and engineers in Fermilab were able to access CAD data, perform check-out and continue working on the data in the US.



Analysis

Both DESY and Fermilab reported challenges in the culture change of moving to a more rigorous approach and of moving to 3D centric. Also migration efforts can significantly delay introduction if too much focus is on Legacy data.

DESY & Fermilab have I-DEAS as their CAD system as well as KEK & INFN. This simplifies CAD exchange but the exchange is always via the PDM and not via the CAD system. They report 1 hour for 200Mbyte data transfer between DESY & Fermilab – performance that is similar to on-site performance.

Concerning costs, DESY obtained a very good deal with UGS because they act as a showcase for UGS in Germany. They also negotiated with them when the product was metaphase and before it became UGS Teamcenter.

Concerning timescales it took DESY approx 2 years including a time period when 2.5 UGS people were on-site consulting, to get up & running. Fermilab have been working on TeamCenter for 2 years but haven't yet a production service up and running.

An added benefit of the tight coupling of PDM and CAD data is that at any one point in time one can look at the system to see who is working on what design. This avoids the surprises of a new idea being published or put forward as alternative design proposals with all the incompatibility problems it may generated.

DESY are now up to speed with their TeamCenter implementation and it was marginal effort for them to setup a configuration for the ILC. This setup is running & providing support for an international collaboration.

Appendix D: Summary of meeting with Ramon Folch and Alessandro Bertarelli (TS-MME)

The core challenge is managing complexity. Recent examples (including but not limited to DFB) of this illustrated the fact that:

- Product structure evolves over time
- Change is iterative since changes in the design may be required due to :
  - Information from calculations
  - Information from production
  - Information from Cabling
  - Information from installation
  - Information from interference
- When you change 1 component you need to be able to know if you can modify it and where it is used tracking dependencies
- Furthermore you need to track if components are released, in progress, being manufactured etc, so versioning needs to be tracked
- Changes may even be made after manufacturing due to interferences in which case the designs need to be modified a-posteriori ensuring coherency & traceability
- Conversely design may evolve even after parts have gone to be manufactured but this evolution must be controlled.

Currently with the design/2D-centric approach a lot of the dependency & status tracking of the above is being done with Excel sheets in addition to EDMS. Traceability to the original design drawings is week and sometimes non-existant. There are also no links to the purchasing for production and it is even difficult to obtain precise quantities of parts to be ordered. The basic problems which need to be addressed are therefore:

- Configuration Management
- Rigour at the design stage
- A move to 3D-centric viewing as opposed to 2D plan approval
- CAD integration support for subcontracting
- Change in working methodology & culture

It was observed that changing the tool is not sufficient but the working methodology must also be changed. Both Ramon & Alessandro have industry experience and compared the methodologies & tools in industry with CERN. In general they converge with the conclusions of this study group for aiming for an item-centric integrated 3D management approach such as that provided by TeamCenter

Appendix E: Excerpt from MBA Thesis in e-business

"Increasing efficiency and productivity in an international research organizationwith e-business solutions- Technology-driven process improvements at CERN."

Authors **:** Niklas Olsson & David Widegren (TS-CSE)

University: University of Gävle, Sweden, Department of Business Administration,

This MBA thesis is the outcome of a master thesis project carried out during autumn 2004 and spring 2005 as the final part of the MBA program in e-business at University of Gävle. The project was done at CERN in Geneva, Switzerland, and its purpose was to see how the case organization could streamline its business processes by a more efficient usage of its information systems infrastructure.

In the context of this study group it is useful as it examines overlapping questions. In particular a new integrated information infrastructure was proposed and a new organization for its support was recommended. The proposal included the assignment of a Chief Information Officer at CERN as well as a reorganization of three existing groups providing information systems within the organization. The relevant sections of the MBA report are included here with permission of the authors.

[6.2] A new information management infrastructure

In the previous chapter we have tried to show how a better use of information systems also can improve different processes in the organization. For each studied process, we have given some specific proposals of how to change the current information systems infrastructure. Although it is possible to implement these proposals all by themselves, we think that it might be wise to also consider them as building blocks in the drafting of a global CERN e-business strategy.

Looking at CERN on an organization-wide level, we identified two main groups of fundamental problems with the current information management infrastructure. In a few words they can be summarized as this:

- *Isolated islands of information systems.*
  We have found several examples of systems that today are functioning completely independently of each other even though they are supporting linked processes and partly are containing the same information. An example of this is the case with the CERN Inventory, MP5 and BAAN that all are managing information related to physical equipment but that do not communicate with each other.

- *Overlapping functionality between systems.*
  There are also many examples where different systems are being used to perform similar functions. One example of this is the three systems being used for document management at CERN; EDMS, CDS and AISMedia. Another example, is the fact that there are four advanced commercial business systems used within CERN that offer similar functionalities; MP5, BAAN, Qualiac and Axalant.

We believe that one explanation of how these problems have occurred is that both the systems and the use of them evolve over time. Many of the commercial systems at CERN have for example widened their capabilities by providing more functionality in each new version. As a result, systems that from the beginning had completely different scopes have today, functionality-wise, partly grown together without being integrated.

At the same time, we are strongly convinced that an even more important factor for causing the current situation is the organizational structure concerning information management support. This will however be further discussed in section 6.3.

In order to solve these problems from a technical point of view, we propose to draft a global strategy for achieving a new integrated information management infrastructure as illustrated in figure 29.

Our proposal would be to create a common infrastructure built up on three information backbones where the existing administrative Foundation would be complemented by the Fixed Asset Inventory and Documentation Platform that we have presented in the previous chapter.

Such a solution would, in our opinion, offer CERN a more flexible and generic way of integrating both commercial systems and in-house developed tools without the risk of falling in the same traps as before since all common information would be shared.

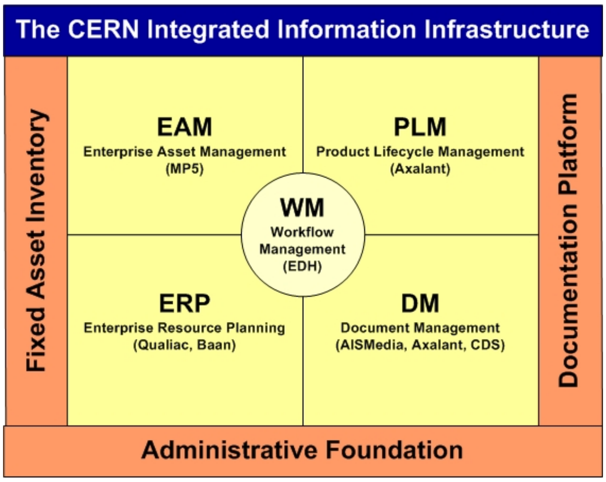


Figure 1, Proposed architecture for an integrated information infrastructure at CERN.

[6.3] A new organization for information management support

CERN is a large organization comprising a huge number of technical and administrative disciplines that all have different needs of information systems support. However, despite the broad range of activities, we are convinced that a stronger coordination effort within this domain would be most beneficial for the organization.

A striking fact is that there are three different groups at CERN that provide support for three different document management systems that partly contain the same documents. We doubt that this would be the case if there would have been a better coordination between the three groups or if they would have been more closely linked together in the organizational structure.

We also believe that the number of commercial business systems being used would be much lower if there would not have been several groups providing the support for this kind of tools. In fact, as we see it, many of the architectural problems that have been pointed out are in fact caused by a lack of coordination or collaboration between the different groups providing support in this domain.

This lack of coordination or collaboration can probably partly be explained by the fact that there is no organizational unit or management function responsible for these kinds of tasks today. We therefore strongly recommend that CERN immediately nominates a Chief Information Officer, CIO, with a clear mandate for coordinating all efforts concerning information systems within the entire organization.

The CIO would maintain a complete overview of the information management needs making sure that no resources would be wasted by duplicating functions or systems. The mandate of this new management position would also include clearly pointing out the purpose of each system and to draw up the borderlines between them.

In addition to this, we propose to more closely link together the currently separated information systems support resources. This can obviously be done in many different ways, where one possibility would be to keep the current organizational groups but in addition having them coordinated and supervised by the CIO.

Another possibility would be to simply merge the current groups into a completely new organizational unit. In practice, this would mean linking the current AIS group, the EDMS team and the CDS team into an integrated organizational-wide service for information systems support.

Independently of the selected organizational solution, we propose to gather the concerned activities into a number of services that all would be under the overall responsibility of the CIO. Examples of such services would be document and design data management, fixed asset management and administrative information management.

All new development and implementation efforts would also be carried out on a project basis with people involved from each of the different concerned groups. Such a more matrix-oriented organization would hopefully avoid creating parallel tools and system functionality in the future.

We also propose the creation of a separate unit purely working with the automation and improvement of processes on an organizational-wide basis. Today there exist a team in the Finance Department working with the streamlining of administrative procedures and another team in the Technical Support Department working with process streamlining and quality assurance on the technical side.[6]

In our opinion, it would be more efficient to merge the two teams in order to work with process streamlining and quality assurance throughout the entire organization. This would for example avoid spending time and resources fine-tuning an information management process on the technical side that then would be followed by some completely manual work on the administration side – or the other way around. As we all know, sub-optimisation in a system is very rarely economically justified.

An example of how a new possible organization for information systems support at CERN could look like is shown in Figure 30.

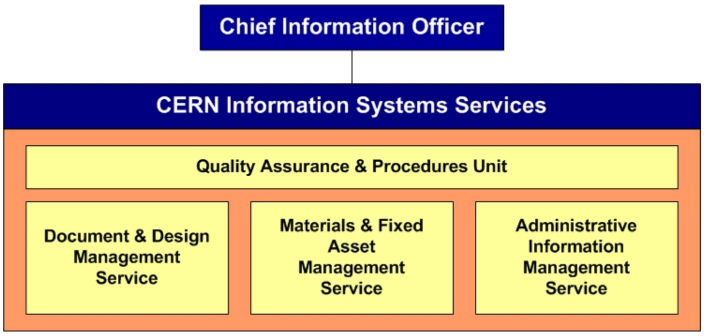


Figure 2, Example of a new possible organization for information systems support at CERN.

[6] In the CERN organization this corresponds to FI-OP-CS and TS-CSE-QMS.

Appendix F: Computing Support for the ILC

Computing Support for the ILC (&CERN) management tools

(J.P. Delahaye, J. Ferguson, W. von Rüden)

Following the proposal by the DG in June 2005 to the ILC community of the CERN management tools which have been developed for LHC and the recent recommendation of the ad-hoc committee, this note is a first attempt to propose an integrated planning and engineering support for the ILC (&CERN) management tools to be run by CERN-IT. The decisions taken by the DG at a meeting held on 03/04/06 are summarized in conclusion.

1. Recommendation of the ILC-EDMS Selection Committee

Following the offer to the ILC community by the CERN DG to provide some of the CERN tools developed for LHC and the analysis by an ad-hoc international ILC EDMS Selection Committee chaired by T.Markiewicz/SLAC (J.Ferguson as CERN representative), the recommendation of the committee has been recently presented at the ILC-GDE meeting in Bangalore (copies of the slides attached). It consists of a patch-work of tools (slide 5) made up by:

- CERN Indico
- CERN Document Server (CDS)
- DESY EDMS: UGS TeamCenter

The main reason to choose CDS is indicated on slide 13 "CDSware was chosen as it will eventually be integrated with InDiCo, has flexible work flow configuration, strong support team & willingness to host". This is followed by "We do feel a beta test is required before this decision is cast in stone".

The major reason not to choose CERN EDMS is also explained on slide 13: "Decision between Axalant (CERN/LHC) and Teamcenter (DESY/XFEL) products for hard-core EDMS came to conscious choice of a “tightly” coupled 3D CAD-EDMS Teamcenter designed to support collaborative engineering over the battle tested older product used to build the LHC that uses an “integration team” to ensure part compatibility. Intrinsic to this decision was the admission by all parties that TeamCenter had all the basic hooks required to develop its “work flow” and needed time & experience". This is followed by the statement: "CERN would help in this effort"!

Moreover, these three tools are requested to be embedded in an appropriate environment as explained on slide 7 and shown on slide 10 with a unified Search & Store Interface.

Following the presentation, J.P.Delahaye pointed out that the choice of tools from various laboratories make additional requirements for which the resources have to be analysed. He also discussed with B.Barish afterwards about possible alternatives based on a more coherent package of tools. B.Barish would welcome and possibly consider alternative proposals.

2. Project Planning Tools (PPT and APT)

B.Willis, chairman of the ILC R&D board, decided recently to use the CERN PPT and APT tools to structure and follow up all R&D ILC activities during the present phase up to 2010. Such tools are also presently considered (in parallel with the US based PRIMAVERA tools) for Work Breakdown Structure (WBS) and estimate the M&P resources of the ILC possible construction.

3. Our analysis

The DG's offer to provide the managements tools which have been developed and widely used for LHC is well recognized and appreciated by the community. The choice of two CERN tools out of three areas for ILC as well as of PPT for the R&D activities reflects this interest and is recognition of CERN's competence in this domain.

The initial selection of recommended tools is a good start, but surely not sufficient to provide integration and adequate support. A horizontal foundation is required in addition to manage the population of users and their access rights, which vary in time as people join or leave the project. This is done best via e-groups based on certificates, a technology now being introduced by the Grid community. Such developments will enhance as well CERN's environment. A close integration of the various tools in a common environment and coherent architecture had always been foreseen, but much of the work has been postponed due to a lack of resources.

We also believe strongly that it would be extremely benefitial for the project if the entire informatics support would be in the hands of a single team in one laboratory, even if the recommended products are originating from distinct places. It is therefore more a question of global competence, trust and commitment, rather than technical choices, which will evolve anyway during the project lifecycle. Splitting the support across multiple sites is a recipe for failure.

The separate development at CERN of EDMS and CDS (and others) is a consequence of distributed activities in multiple Divisions in the past. Independently from ILC, the integration of Indico, CDS and EDMS will need to be done in any case.

All future large HEP projects (LHC upgrade, ILC, CLIC ….) are long-term and internationally distributed. They will need an integrated set of management tools taking advantage of existing solutions but not necessarily limited to them (although a good starting point). Following the completion of the LHC and based on the experience acquired during the project, it is a logical time to review and possibly adapt our collection of project management tools using the best existing tools, adapting them to the technological development and the evolution of users requests, integrated in a common environment, and supported by a single unit in one laboratory.

CERN is the best place to provide this environment due to the LHC experience and the recognised global expertise in the field. The development and support by CERN of a coherent and integrated set of tools would be very profitable for the entire HEP community including CERN and could also serve other large projects like ITER. It would put CERN in a leading world-wide position in this strategic area..

4. Our recommendation

CERN proposes to take the responsibility for the computing support of the ILC project, to define, develop and support a common set of management tools, initially composed of:

- INDICO
- CDS
- UGS TeamCenter (and possibly CERN EDMS)
- PPT or APT (for WBS structure and cost analysis)
- Foundation to manage user registration, certificate authority and access control

The same set of management tools will be made available for CERN purposes, thus substantially improving the present situation.

CERN sets up the project team in IT with the mandate to provide the ILC computing support. A project leader needs to be nominated whose first task would be to analyse the users' need and to establish a work plan.

The arrival of the ILC project is a unique opportunity for CERN to complete the consolidation started in 2004 by re-grouping the dispersed computing services from several departments into IT. This concerns in particular the EDMS services in TS.

5. Resources

Setting up and supporting the ILC-GDE team will require additional resources. The team needs to be composed (at least part-time) of people having experience with the proposed products plus additional developers to adapt the environment to the needs of ILC and CERN future. The project would be well advised to select a competent and charismatic leader, given the complex nature of the task. While the initial core team can be kept small, it will have to rely strongly on other services already well established at CERN such as mail, web, helpdesk and general computing support. We expect the support needs to grow as the project gains momentum.

Given the present personnel situation in IT, it is totally excluded to support ILC without adding additional resources. The fact that the UDS and AIS services are being further reduced puts CERN in a difficult position towards other institutes as we may loose our credibility once people realise that our support is being reduced.

Required: 1 team leader – coordinator, also liaises with the users

1 engineer for INDICO (the last developer just left due to lack of money) and CDS (the team in understaffed and cannot take on new responsibilities within new people)

1 engineer for APT/PPT (being support by temporary persons, not to be renewed as the IT plan for AIS was refused)

1 engineer to introduce/support UGS centre (to be discussed with TS)

Available: Part-time help on best effort basis to link to the other IT services (certificates, foundations, mail services, directory services, user support, etc)

Note that the four engineers under “required” are to be found for IT, but not necessarily via new hires. Some of them could possibly be found via synergies inside CERN, given that there are still computing services in other departments which overlap with IT. We could also imagine that other labs might be willing to contribute financially, but we discourage strongly to opt for a distributed support solution. Of course, IT would re-arrange its organisation to make experienced staff available and integrate the newcomers into the existing teams.

A modest material budget of ~50 kCHF/year is needed mainly for dedicated servers, storage and backups. Additional budget will be needed to acquire UGS licences, cost to be evaluated or information to be obtained from DESY.

6. Decisions

The decisions taken during a meeting held on 03/04/06 on the subject with the DG are summarized below:

- The support of the management tools should not be distributed but under the responsibility of a single laboratory

- A close integration of the various management tools in a coherent environment and coherent infrastructure with a common web interface to the users and possibly an horizontal foundation, would greatly improve the CERN management tools.

- In order to answer the request of the ILC, the integration of the management tools, which was foreseen to be done after the LHC completion, could be advanced at the condition that the resources are affordable.

- A responsible will be nominated by W. von Rüden to make a proposal, in collaboration with an EDMS expert (T.Petterson?) of a possible project at CERN to integrate the present or best possible tools in a common environment and of the corresponding M&P resources following a review of the users requests. A report summarizing the outcome of the study is expected in two months. It will include:

    - The integration of INDICO, CDS, EDMS, PPT or APT,

    - An evaluation of a possible evolution of the tools and especially the adaptation of EDMS to 3D documentation with CATIA or the use of UGS TeamCenter

    - A study of the legal implications of the use of the tools by users distributed in various laboratories

    - The estimation of the human resources, those available at CERN as well as those missing. Both the development and the maintenance should be addressed.

    - A possible proposal of a better adapted CERN infrastructure in a single unit for a more efficient project development, support and maintenance

- Another meeting will be held in June to review the proposal and to decide on the scope and resources to be allocated.

- In case the project is launched, the use of the integrated set of management tools, as a coherent ensemble, will be proposed to ILC with CERN support. If the ILC insists on a distributed management, individual tools like INDICO or CDS, will be proposed to ILC but without any CERN support.

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