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Implementation of a design and configuration management platform for fusion components on the Tore Supra WEST Project

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HIGHLIGHTS

- A design and configuration management platform is under development for managing fusion components lifecycle at CEA.
- Design platform ensures an efficient sharing of the data and provides connections between the different software and databases involved in fusion components design.
- Design platform rollout on WEST project is ongoing as part of change control and configuration management implementation.

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ABSTRACT

This paper presents the technical solutions and methodologies that are used and under development for managing the design lifecycle of the WEST project (W – *for tungsten* – Environment in Steady-state Tokamak, upgrade of Tore Supra's with actively cooled tungsten plasma facing components) fusion components and explains the interfaces that are implemented or in construction to connect together the different tools like documents management system, CAD modeler, or simulation codes around the data management backbone. It describes the methodologies used on the WEST project to optimize the design process by managing the engineering data workflow and ensuring the consistency between the different 3D representations for design or analysis as well as the specification or interfaces documents. Finally it explains how this platform contributes to reach the project targets in terms of performance, cost and schedule.

1. Introduction

Fusion components development as actively cooled plasma facing components (PFC), is a very complex process which involved many different skills from mechanical design to optical or neutronic analysis to assembly or maintenance processes studies. All these different tasks require specific software and generate a huge amount of data which could be 3D models, analysis results or kinematic sequences. Moreover, during the development phase, many iterations are necessary between analysis and design using specific 3D models depending on the kind of analysis. To ensure the consistency of the results provided by these multiple tools it is essential to control the workflow of the different data used in the design process. The goal of a design platform is to make easier the collaboration between all the persons involved in the life cycle of a fusion component by ensuring an efficient sharing of the data and providing, as far as possible, connections between the different computer software.

This paper describes the global architecture of the design platform which is under development at CEA/IRFM. It presents the way this platform is under implementation on the WEST project [1] for the design of the new Tore Supra's components.

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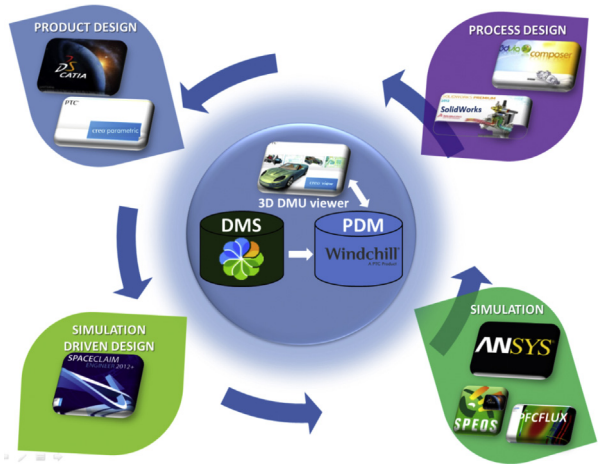

Fig. 1. Design platform architecture.

2. Software architecture of the platform

2.1. General architecture

The general architecture is based on three kinds of software:

- Product data management (PDM) system
- Documentation management system (DMS)
- Simulation and design software

PDM and DMS are the design platform backbone. These systems ensure data storage, integrity and traceability and provide a centralized access to the information for all the project members. PDM deals mainly with the engineering data (CAD, simulation) while DMS manage all the general documentation (specifications, simulation reports, minutes, etc.). The PDM system also provides visualization of 3D digital mockup via an embedded 3D viewer. Simulation and design software which are dedicated to professional experts revolve around these two data management systems (Fig. 1).

2.2. Documents, product data and configuration management software

2.2.1. Document management system

Documents management system is based on Alfresco Enterprise Content Management platform [2]. Documents can follow a life cycle with different status (draft, approved, approval in progress, etc.). The change of status is done through a workflow involving different actors (reviewers, approvers, etc.). Every document which follows a workflow is versioned in order to trace the modifications history. The documents are hosted in a centralized database and are reachable across the intranet or other applications, like the PDM database, by an URL link.

2.2.2. Product data and configuration management system

Product data management and configuration management is performed with Windchill PDMLink [3]. PDMLink enables to manage CAD data from different native formats and to visualize these data in a common digital mockup environment. As documents in a DMS, CAD data can follow in PDMLink a life cycle to reach different status via a dedicated workflow. CAD files are stored in a centralized database inside a vault and can only be accessed or modified by authorized people according to their role.

PDMLink also manage specific data called Part. A Part object can be a piece, a subassembly or a subsystem. Parts are organized in a hierarchical structure and each of them can be linked to all the items involved in its definition (3D CAD models, CAD drawings, simulation models, documents, etc.). Documents (e.g.: requirements, specification) can be stored in PDMLink as a link to the DMS. That way it is possible to link a specification document to an item without duplicating the document between the DMS and the PDM.

PDMLink enables to store a specific configuration via a dedicated object called Managed Baseline. Through this object it is possible to retrieve all the documents linked to an item in the version matching the studied configuration.

2.3. Design software

Design tasks are performed in Catia V5 [4] or Creo Parametric [5] according to the project requirements. For ITER or Broader Approach tasks, Catia is mandatory, for Tore Supra WEST, the tokamak environment is designed with Creo Parametric (formerly Pro Engineer) but subsystems can be designed with Creo or Catia V5. On the whole, because fusion component design is often done in the context of collaborations, it must be possible to work with different design software and to finally integrate the data in a unique environment.

Catia V5 and Creo are directly connected to PDMLink via a software link which enables to access the database directly from the design tool user interface. A check in/check out mechanism is used to modify CAD data and to reintegrate it into the database. Design can also be performed by SolidWorks which is possible to connect to PDMLink in the same way as Catia or Creo.

2.4. Simulation driven design software

Simulation driven design includes all the design activities performed up-front simulation work. It could be a pre-design work in order to validate a concept or, more often, a detailed design simplification in order to optimize a finite element analysis model. This work is presently done with a commercial software called SpaceClaim Engineer [6] which offers dedicated features for CAD model simplifications. With this kind of software the time for 3D CAD data simplification used as input for 3D predictive photonic modeling has been reduced by a factor 6. This tool is not directly link with PDMLink but PDMLink will enable the designer to get the right CAD data for simplification and to store his simplified model linked with initial native CAD model.

2.5. Analysis and simulation software

Different kinds of simulation software are involved in fusion components development process.

Mechanical, thermal or electro-magnetic simulations are done with FEM tools. Specific homemade software are used to perform heat flux simulation, plasma equilibrium simulation, inductive current or magnetic fields simulations. These fusion specific tools enable to define the right constraints to apply in the FEM simulation.

Photonic simulation is done in CATIA with the SPEOS module from OPTIS [7] in the framework of in-vessel diagnostic design and qualification [8].

All simulation software are using specific 3D or 2D models generally created from original design CAD models and optimized for simulation. None of these tools is directly linked to PDMLink database but the configuration management environment enables the simulation engineer to get the right version of the right CAD model and to store all its simulation data (inputs, geometries, meshes, etc.) in Windchill linked with the simulated system part (Fig. 2).

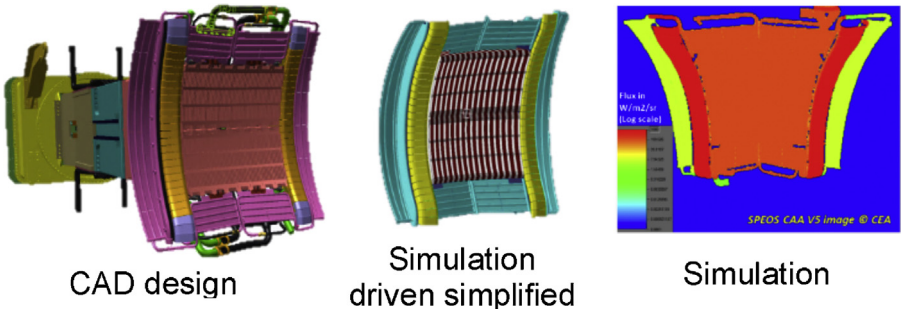

Fig. 2. LHCD antenna photonic simulation with SPEOS.

2.6. Process design software

Process design software are used in assembly or maintenance processes development. They enable to define assembly trajectories, kinematic studies of articulated tools or dynamic clash detection. The main tools used for these purposes are 3DVia Composer [9] or SolidWorks [10]. SolidWorks is associated with CEA homemade developments. The studies are performed in a virtual reality room 3D immersive environment [11].

3. Implementation on the WEST project

3.1. Context

The WEST project aims at testing actively cooled tungsten plasma facing component in real plasma environment in order to validate this technology for ITER. To do so mostly all the internal components of Tore Supra have to be redesigned or modified inside an existing environment.

3.2. Plant breakdown structure

Definition of the plant breakdown structure (PBS) is the first step of design configuration management. The PBS enables to identify all the tokamak facility systems and subsystems in a hierarchical structure. All these subsystems are identified with a unique reference and are called configuration items. The PBS is the result of a functional analysis; each subsystem is linked to a functional requirement. The PBS has five levels from 0 to 4. The level 0 represents the WEST facility, the Level 1 represents the main WEST systems. Levels 2 to 4 represent the subsystems and their components. In a top-down design approach, the PBS can be used to generate an empty CAD structure which will be completed during the design process. In this context each PBS item is linked to a unique CAD assembly.

In addition to supporting CAD data structure, each PBS item is also linked to different kinds of information or documents such as requirements, specifications, interfaces descriptions, change request or simulation results.

The PBS is managed inside Windchill PDMLink as a Part structure. Each configuration item is represented by a Part. A configuration item follows a basic life cycle with three states: in work, approved or obsolete.

3.3. CAD data management

3.3.1. Data sorting

CAD data are stored in specific PDMLink areas called Products. There is one Product for each level 1 system of the PBS (Fig. 3).

A Product enables to manage specific access rights to its content. Inside a Product it is possible to create a folder structure in order to sort data in different subsystems and eventually to tune the access rights. A last Product called Configuration Management and Integration is dedicated to configuration management process.

3.3.2. Data life cycle

Data are following a basic life cycle using three states: in work, released and obsolete.

Designer has to check a data out of the common space to modify it on his computer. At this stage the modification is not visible by anyone else. To publish the modifications in order to enable data access to other project members (Design Engineer, Simulation Engineer, other designers, etc.), the designer has to check the data into the common space. Each time a modified CAD data is checked into the common space of the database it takes a minor version. A major version is taken when a released data has to be modified (Fig. 4).

CAD data of each subsystem are approved for the first time to initialize the baseline. To modify a Released data, a change order request is created in Windchill and attached to the affected data. This order can follow a validation workflow to allow the modification. The change order will track of change motive and can be linked with a document in the DMS.

3.4. Simulation data management

Fig. 5 displays as an example the way of managing structural dimensioning simulation data of an internal actively cooled protection component of the West project.

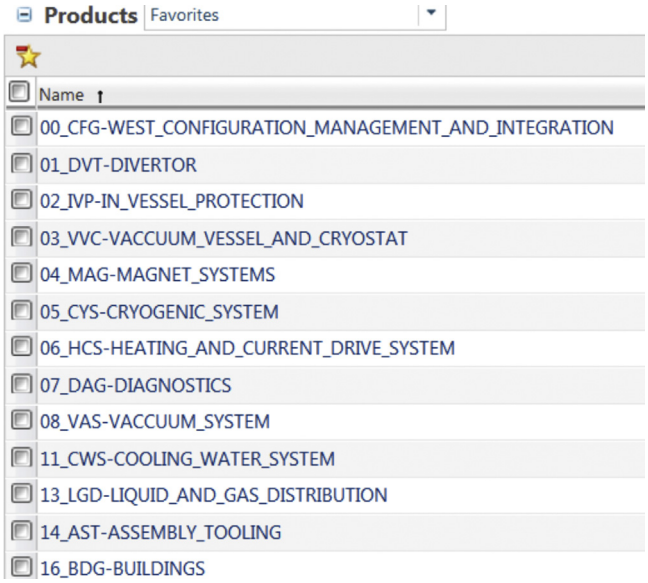

Fig. 3. WEST products in Windchill.

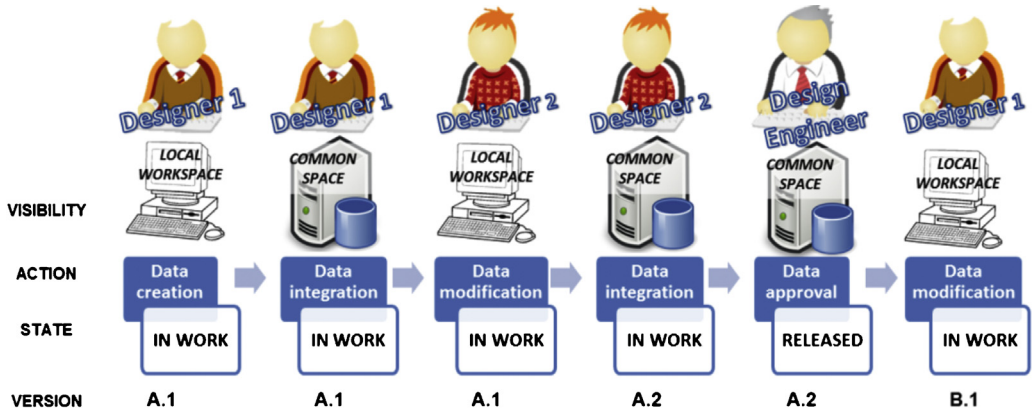

Fig. 4. CAD data life cycle.

The simulation engineer can retrieve the up to date 3D CAD model from the PBS structure. The PBS item corresponding to the studied system can also be linked to specifications or requirements documents that will help to define the correct analysis inputs. Then the 3D design CAD model is simplified and optimized with Spaceclaim to create a model which fits the simulation needs and criteria. This model (.scdoc) is attached to the initial CAD model so it can be reused for other simulations and easily retrieved. The simulation is done in ANSYS [12] and all the simulation data are stored in an Ansys Workbench archive (.wbpz) which is also attached to the right version of the initial CAD model in Windchill.

3.5. Configuration management

3.5.1. Configuration model

A single reference assembly called configuration model is created for each PBS configuration item. This CAD assembly represents the subsystem positioned in the tokamak reference frame. Configuration models are linked to the part object representing the configuration item.

3.5.2. Engineering documentation management

All the official documentation relative to a configuration item and stored in the DMS can be linked in Windchill via an URL link (Fig. 6). Therefore it is anytime possible to access all the information describing a subsystem.

3.5.3. Product baselines

A product baseline enables to put together all the different objects linked to a configuration item in a specific version in order to define a reference configuration. Baseline will include a system and his subsystems, the associated configuration models and all the approved CAD data which are linked to these models (assembly, elementary part, drawings, etc.). An approved baseline cannot be modified so a modification of the product requires to create a new baseline and to cancel the previous one.

4. Results

Design and configuration management platform enables to manage a complete digital mockup (Fig. 7) of the WEST tokamak. Through this mockup, available for every one with an intranet

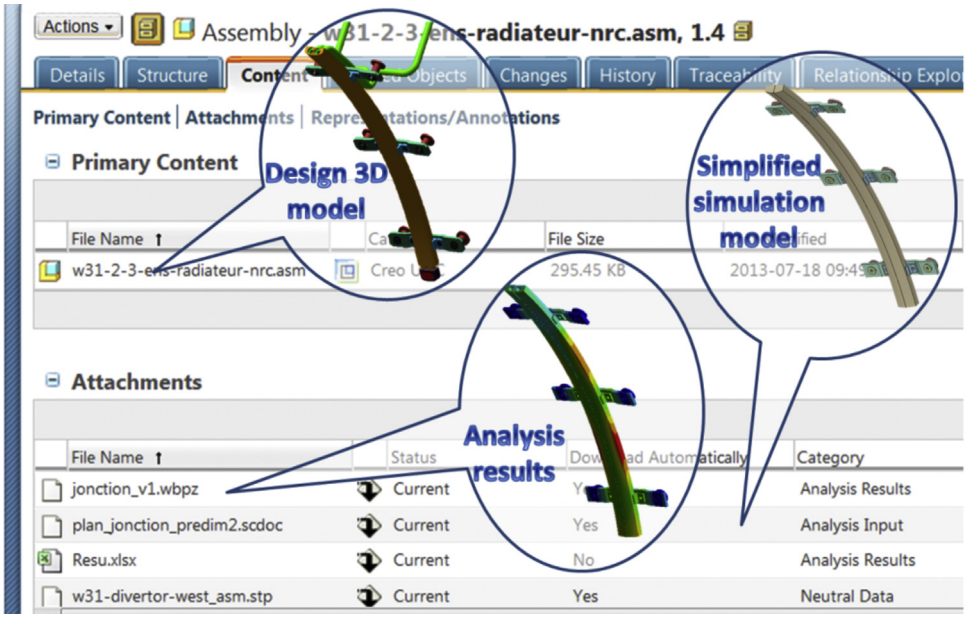

Fig. 5. Simulation data management in Windchill.

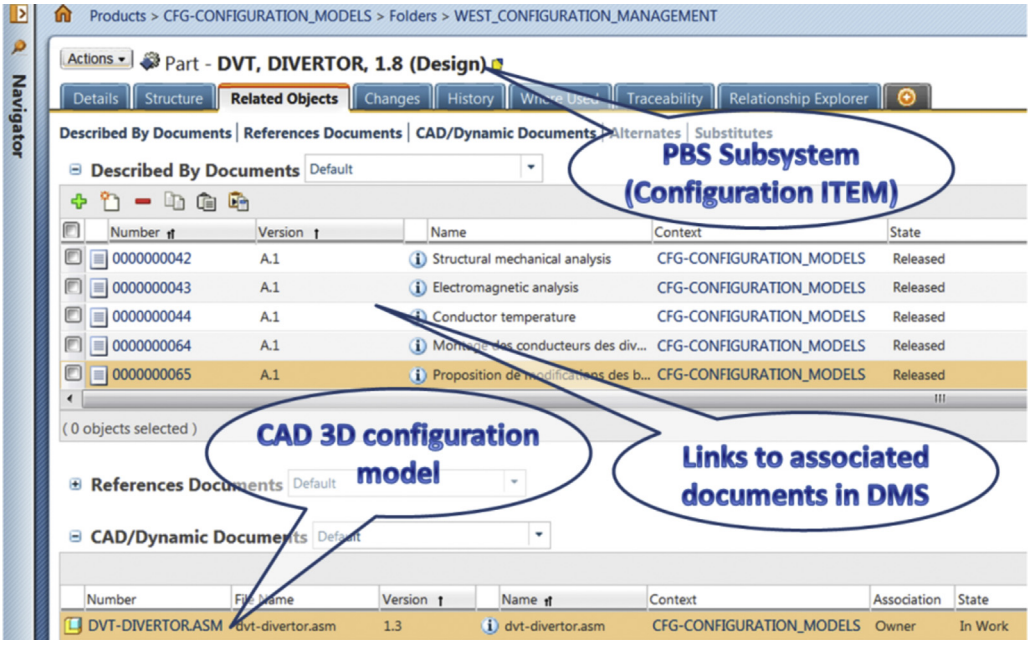

Fig. 6. Configuration item management in Windchill.

Fig. 7. WEST tokamak digital mockup.

browser, it is possible to check design, to access official drawings by a simple right click on a 3D model or to recover simulation data and results. Engineering data are no more reserved for design office but are shared between all the project members. That way the design process is more efficient and optimized in terms of resources and planning.

5. Conclusion and future achievements

Today the different software presented in this paper are deployed and operational. Their full integration on the WEST project is ongoing as part of change control and configuration management implementation. A study is also started to extend the platform perimeter to assembly process and tokamak components management during exploitation phase.

From an IT point of view it could be interesting to develop connections between PDM database and simulation software in order to avoid as far as possible manual actions of data transfer. Connection between FEM tools and different homemade specific fusion simulation codes is also an important topic. Integration between PDMLink and Alfresco DMS could be improved by synchronizing versions and states of the documents in DMS and of their corresponding link in PDM.

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