Fusion Engineering and Design xxx (2017) xxx–xxx

Contents lists available at ScienceDirect

Fusion Engineering and Design

journal homepage: www.elsevier.com/locate/fusengdes

Software tool solutions for the design of W7-X

Sebastien Renard [a,*], Andreas Holtz [b], Christophe Baylard [c], Martin Banduch [b], The W7-X Team [b]

[a] CEA IRFM, 13108 Saint-Paul-Lez-Durance, France
[b] Max-Planck-Institut für Plasmaphysik, Teilinstitut Greifswald, Wendelsteinstr. 1, 17491 Greifswald, Germany
[c] ITER Organization, Route de Vinon sur Verdon, 13115 Saint-Paul-Lez-Durance, France

HIGHLIGHTS

- SmarTeam, a PDM supporting the designer from the start of the design process.
- A digital mockup to visualized design modifications of all W7-X components.
- A tool to investigate the possible collisions between components.
- An improved communication between the different teams.
- Lower occurrence rate of design iterations and reduced lead time.

ARTICLE INFO

Article history:
Received 30 September 2016
Received in revised form 5 April 2017
Accepted 7 April 2017
Available online xxx

Keywords:
W7-X
Digital mockup
SmarTeam
Concurrent engineering
Collision analysis report
PDM

ABSTRACT

As an international research facility, the W7-X project hosts many types of components designed not only by the Max Planck Institute for Plasma Physics (IPP) teams, but also by external partners. At IPP the Design Engineering (DE) division is responsible for design and spatial integration of all the components within the Torus Hall. Two software tools, interfacing with Computer Aided Design (CAD) models, have been developed in-house to assist in the design and installation of components of W7-X. The first, the Digital MockUp (DMU) is a full scale 3D graphical representation of W7-X generated by a Python script using CATIA and information from the Product Data Management system (PDM), SmarTeam. The second, the Collision Analysis Report (CAR) is an Excel table listing the critical distances between a selection of components and their surroundings using the DMU and SmarTeam. SmarTeam along with the DMU and the CAR reduces the risk of design iteration, increases the efficiency of the designers and promotes the communication within the project teams.

1. Motivation/context

As an international research facility, the W7-X project hosts many types of components designed not only by the Max Planck Institute for Plasma Physics (IPP) teams but also by external partners. At IPP the Design Engineering (DE) division is responsible for design tasks and spatial integration of all the components within the Torus Hall where W7-X is installed. The design tasks are performed using a Computer Aided Design (CAD) software, CATIA Version 5. W7-X is a concurrent engineering project as dozens of designers are working simultaneously on components sharing the same space or possibly having common interfaces. Previously the CAD models of W7-X were available but designers could never load the whole environment since the sheer number of CAD models caused CATIA to crash. Only partial loading was feasible leaving designers with massive blind spots. CAD models were stored locally by the designers and made available to other designers, assembly teams, and customers only at a late stage of the design. Additionally, the surrounding components were not to be trusted since they were not necessarily the most recent versions. These challenges were aggravated by the complexity of W7-X and its close packing of components, leading to a situation where designers could not visualize their CAD models in the full context of the machine.

The lack of CAD model sharing and communication led to physical intersection between components, referred to as collisions, causing design iterations that were time and resource consuming,

* Corresponding author.
E-mail address: Sebastien.renard@ipp.mpg.de (S. Renard).

http://dx.doi.org/10.1016/j.fusengdes.2017.04.027

challenging the project planning. To remediate these issues, several solutions were implemented. First a software program, SmarTeam, was implemented to allow designers to store their CAD models starting from the beginning of the design process. Then specific tools were developed internally to improve CAD model sharing and promote the communication within the project team: the Digital MockUp (DMU) for the visualization of models and the Collision Analysis Report (CAR) to check for collisions.

2. SmarTeam

SmarTeam, a Product Data Management (PDM) software, is a central knowledge repository that focuses on managing and tracking the creation, change, and archive of all information related to products. In the case of DE the products are CAD models. SmarTeam was chosen for its deep integration with CATIA. The presence of a well documented programmable interface offers DE computer programmers the option to customize the database interface, automate tasks, and develop new tools based on the needs and feedback of the user. Designers can save their CAD models in the PDM with minimal formatting effort and have the possibility to store additional information regarding these models such as manufacturing tolerances and deformation of the real component during operation.

CATIA and SmarTeam are the backbone of the design activities but the needs of the end users, designers, assembly teams, and customers extend far beyond simple storage and tracking functionalities.

3. The digital MockUp

3.1. Definition

A mockup is defined as a full scale 3D graphical representation of a machine. In the context of W7-X, the DMU is a CATIA product that contains the CAD models of all the systems inside the Torus Hall. It is stored on a file server and is accessible to all IPP personnel.

The W7-X machine and peripheries are structured as more than 150 systems including diagnostics, heating systems, cooling circuits, etc. Each system is composed of one or more sub-systems stored in SmarTeam as a CATIA product (see § 3.2), for a total number of 370 sub-systems. There are over 48,000 CAD models stored in SmarTeam representing all the components and peripheries of W7-X. It is technically possible to load all of them at once in CATIA but it becomes extremely slow, unresponsive, or even crashes. This is because when a product is opened in CATIA, all the child products (not the parts) are loaded in memory. The CAD models from SmarTeam must be optimized before being included in the DMU, meaning that the CAD models in SmarTeam and the DMU will have a different structure but must display the same geometry.

3.2. Optimizations

To understand the optimizations needed to produce the DMU it is important to understand the difference between a CATIA part, CATIA product and a CATIA component. A CATIA part is a 3D entity obtained by combining different mathematical shapes. A CATIA product is a digital entity containing CATIA parts and CATIA products. Both CATIA parts and products are associated with their own files on the physical drive of a computer, respectively called CATPart and CATProduct. A CATIA component is a digital container not associated with a file, therefore it cannot exist on its own and is always a child of a CATIA product. It cannot be opened in CATIA unlike a CATIA product or part. CATIA components can be viewed as folders to help organize the content of a product without creating extra files needed to be stored and managed.

Two specific optimization techniques are used in the DMU: first some CATIA products, marked by the designers in SmarTeam, are replaced by CATIA parts in the DMU. These CATIA parts display the same geometrical information as the CATIA product but in a single file. Second, for each sub-system the remaining CATIA products are replaced with CATIA components. As a result only about 11,000 models are necessary for the DMU instead of over 48,000 models.

Every night, a Python script determines which models were modified by comparing the versions of the sub-systems in the DMU and SmarTeam. Then all sub-systems containing modified models are extracted from SmarTeam and copied onto the machine hosting the process. Each sub-system is recreated with the aforementioned optimization and replaces its previous version in the DMU.

3.3. Benefits and a limitation

The DMU is an independent optimized copy of the CAD models in SmarTeam. This allows the designers to work on CAD models from SmarTeam with a fully detailed structure and have a lightweight version of the entirety of W7-X in CATIA at the same time. Thanks to the optimized structure there are nearly no performance penalties. As the DMU update script runs every night, the modifications performed by one designer are available to all designers the next day and the update process is transparent for the users. One limitation is that the DMU is currently available only to IPP personnel and not to the external partners since the amount of CAD data does not allow for a simple sharing solution.

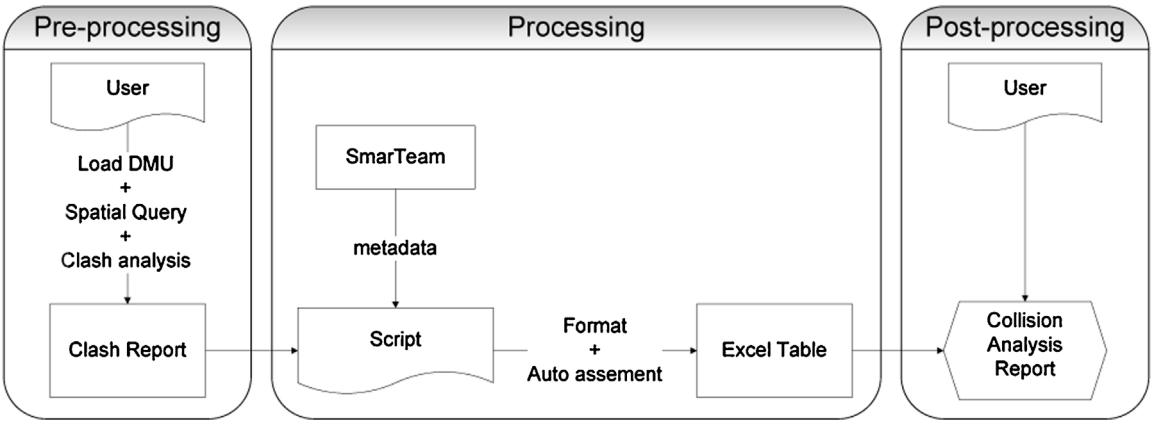

Fig. 1. Creation process of a collision analysis report.

Please cite this article in press as: S. Renard, et al., Software tool solutions for the design of W7-X, Fusion Eng. Des. (2017), http://dx.doi.org/10.1016/j.fusengdes.2017.04.027