

# Configuration management of the EU DEMO conceptual design data

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## H I G H L I G H T S

- Description of the selection of the DEMO Product Data Management tool.
- Introduction of the DEMO configuration management philosophy for the CAD design data.
- Description of the enabling tools and systems of the configuration management.

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## A R T I C L E I N F O

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## A B S T R A C T

The EUROfusion Consortium is setting up – as part of the EU Fusion Roadmap – the framework for the implementation of the (pre)conceptual design phase of the DEMO reactor. Configuration management needs have been identified as one of the key elements of this framework and is the topic of this paper, in particular the configuration of the CAD design data. The desire is to keep the definition and layout of the corresponding systems “light weight” and relatively easy to manage, whilst simultaneously providing a level of detail in the definition of the design configuration that is fit for the purpose of a conceptual design. This paper aims to describe the steps followed during the definition of the configuration management system of the DEMO design data in terms of (i) the identification of the appropriate product data management system, (ii) the description of the philosophy of the configuration management of the design data, and (iii) the introduction of the most important enabling processes.

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## 1. Introduction

The arrangement of the DEMO conceptual design work in Eurofusion is rather unconventional and different from what is done in other projects. The design and R&D work is executed in a project structure by geographically-distributed members (Fig. 1). The core PPPT team (Power Plant Physics and Technology) in the Program Management Unit (PMU) is responsible for programme coordination and control, design and physics integration.

Developing the conceptual design of a fusion power plant is challenging due to its size and complexity but also the large number of interrelated and conflicting requirements that must be balanced between physics, operation, maintenance, safety, availability and cost. A thorough systems engineering [1] and configuration management [2] approach is vital to ensure the optimum balance between these requirements is achieved.

The main focus of this paper is configuration management in particular the configuration of CAD design data. The intention is to develop and roll out a process in line with national standards to the DEMO project teams to ensure constancy and robust working practices.

Configuration management of CAD data is a vast topic and cannot be described in its entirety within this paper. As such this paper aims to cover some of the basic aspects including: (i) the selection of an appropriate Product Data Management (PDM) tool; (ii) the definition of the configuration management philosophy proposed for DEMO CAD design data; and (iii) the key enablers of the design configuration management process. The conflicting requirements of creating a robust system whilst also maintaining a light-weight and manageable approach were traded off.

## 2. Selecting the product data management tool

The selection of a product data management tool appropriate for managing CAD data is essential. The PDM tool facilitates

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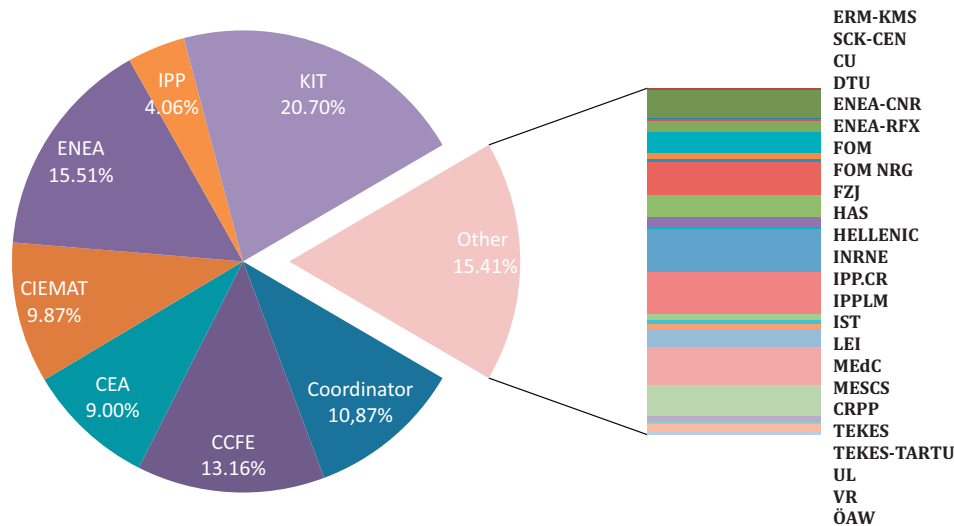


Fig. 1. Research units involvement in PPPT projects, 2014–2018.

configuration management and therefore careful consideration in its selection is required. Given the extensive sole use of the Dassault Systèmes CATIA design tool within the European nuclear fusion community, for general design purposes, establishes the need for good CATIA integration within the PDM tool. Based on this requirement a pre-selection of three potentially suitable tools was undertaken; Dassault SMARTEAM, Dassault ENOVIA V5 and Dassault ENOVIA V6 [3] were selected. Other independent tools were also considered (e.g. ORACLE AGILE) but have been eliminated due to less established CATIA integration and limited user base within the fusion community. From the PDM requirements some high level evaluation criteria were established with the importance weighting corresponding to numbers according to the Fuzzy Analytical Hierarchy Process (F-AHP) [4,5] (Table 1). The evaluation reduced the selection down to two tools, SMARTEAM and ENOVIA V6 each with similar scores. As such, a further evaluation of the two systems was required.

**Table 1**  
Evaluation criteria and their importance.

Evaluation criteria	Importance/weight
Easy access to contributing RUs, access control	High
Safe central CAD data storage	High
Document numbering-automatic allocation of part number	Medium
Long term perspective (upgrade after the CDA phase)	Low
Simultaneous engineering possibility	Medium
Low CAD management time	Low
Recording and retrieving of CAD document hierarchical structures	Medium
Version control	High
Ability to manage products configuration variants	Medium
Multiple design option management	High
Product development phase management (e.g. pre-concept, concept, scheme, etc. . .)	Low
BOM management (for costing/weight analysis/procurement & manufacturing)	Low
Standard Part and Off Shelf (COTS) parts management	Low
Multi-site access	Medium
Web access	High
Multi-CAD storage	Low
Expertise at RUs	High
Acceptance of the choice	High
Search functionality	Medium

Using ITER as a benchmark with current experience of implementing an ENOVIA PDM system, requiring direct access by all research units, highlighted the complexity of establishing such a system [6]. It was agreed, that a more light-weight PDM solution was required for the early phases of DEMO, a statement strongly supported by an Expert Group, established to advise PPPT. As such a recommendation was adopted for the implementation of a PDM tool limited for use locally by the PMU mainly for the version control, interface management and variants/options management of the design data. Nevertheless it would support exchange of data through IDM (ITER Document Management), the document management system of the Eurofusion consortium. The result would be a simplified interface for all the research units. The new requirements were as follows:

- Robust knowledge of the chosen tool must be available in the fusion community to be provided to the PMU.
- Low infrastructure management time requirement (easy to administer and handle due to the limited resources of the PMU).
- Tool must be easy to configure 'out of the box' with options for simple in house customizations if required.

As a result of the new requirements SMARTEAM was selected as the preferred choice. Some clear advantages being

- High level of expertise and competence in implementation and use of SmarTeam for CAD configuration management within the fusion community including Culham Centre for Fusion Energy and Fusion for Energy Broader Approach department in Garching.
- Open database access allowing easy customizing and manipulation of the data for enhanced functionality and/or reporting purposes.

It has been noted that Dassault plans to limit its effort on the future development of SMARTEAM in preference for its new PDM systems. Therefore the future potential of SMARTEAM may be somewhat limited, however migration of the data to ENOVIA V6 or similar system is possible, if required.

### 3. Configuration management philosophy for DEMO CAD design data

One of the key benefits of configuration management is access to the right data at the right time. Often version control is confused

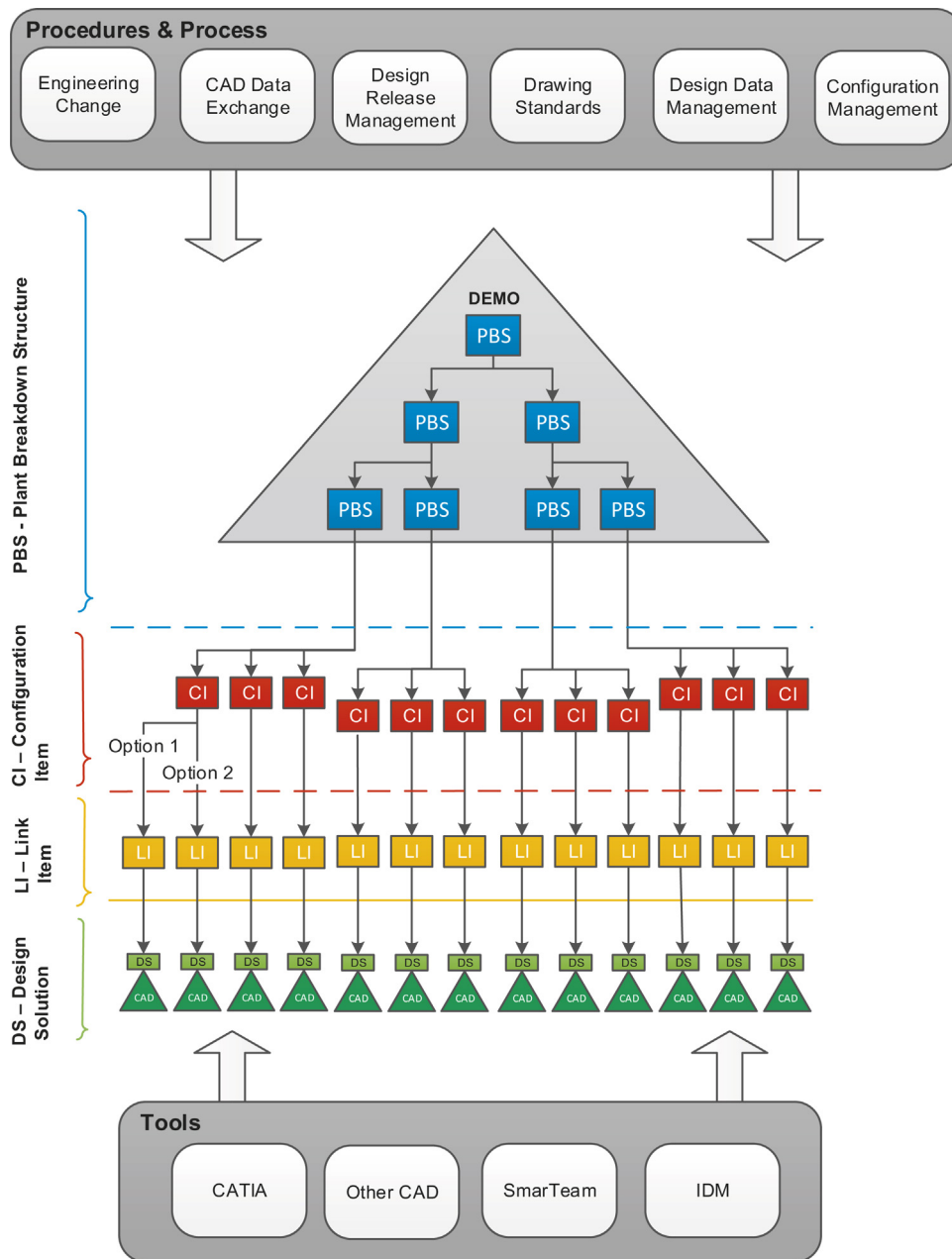


Fig. 2. Visualization of the configuration management philosophy for the design data.

with configuration management. Whilst it is important to version control, configuration management deals with accessing the correct data and subsequently the correct version of that data. In the conceptual design phase many options to a solution may exist, i.e. multiple CAD data sets each with various version states. This makes configuration management essential in order to support the design process. Fig. 2 shows an overview of how the CAD data is configured within the product structure. This structure is replicated in the SMARTEAM PDM tool and is the methodology used to implement configuration management [7].

The Plant Breakdown Structure (PBS) is the tree structure off which design data is hung. It represents and manages the hierarchical parent-child relationship of the plant, e.g. the Toroidal field coil under the Magnet systems in the tree. The PBS in this instance is broken down by system starting with DEMO at the top and the cascading system and sub-system hierarchy structured below.

The Configuration Item (CI) is the lowest level of assembly within the PBS tree. It represents the point at which change management and version control are implemented. The advantage of such a system is that the Configuration Manager has the ability to select the appropriate configuration level during the various development phases, e.g. for the conceptual development this level could be set at the toroidal field coil system or the vacuum vessel system. Once the design matures the configuration level could be reallocated further down at sub-assembly level, e.g. toroidal field coil casing.

The Link Item (LI) is the link between the PBS tree and the CAD data that hangs off it. The LI acts as the switch that allows the turning on and off 'configuration' of options and attribute filtering.

The Design Solution (DS) is the unique container, which holds the CAD data. The same CAD data may be used in many DS instances. The DS is the highest level object in the design data structure subject to change management and version control.

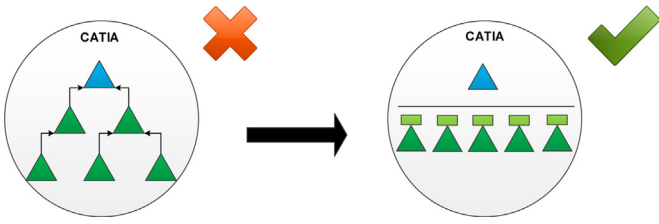


Fig. 3. Moving from a hierarchical CAD product to a wide and flat structure.

The items layers of PBS, CI and LI allow configuration management of the CAD data below. The layers are managed and represented by items in the SMARTEAM database. The yellow line in Fig. 2 is an important boundary between the items and the design data objects. Using this item centric approach allows the simple manipulation of the tree structure and product attributes without affecting the CAD data. In essence, this establishes configuration as a management process as defined in ISO 10007:2003 standard [8] and not a design process which it can often be mistaken for.

Configuration management facilitates many functionalities such as baselining, alternate (option) management, status accounting and electronic bill of material generation. However, one of the most important aspects of configuration management is change management. It is one, if not the main, focal point of product development. Change management can be considered as any change to the configuration and must be underpinned by a robust process.

The described approach results in the CAD data structure being wide and flat (Fig. 3). The hierarchy of the product is established through the configuration (items management).

A common mistake is to build this product hierarchy within the CAD design environment making change management and configuration management virtually impossible. Left to their own devices CAD designers would naturally create large hierarchical assemblies within the CAD design environment. The result is that change of a lower level assembly cascades all the way up the tree requiring up-issue of all impacted assemblies. This makes change management overly cumbersome and inefficient. Additionally without a defined plant breakdown structure the designer is required to select where

the top of the assembly tree should end. In theory they could choose the very top level DEMO PBS or anywhere in between, further complicating configuration and change management.

Taking the CAD hierarchy shown on the left of Fig. 3 and applying configuration management with a PBS structure one can generate a Digital Mock Up (DMU) of the DEMO design to rapidly visualize the large amount of data (Fig. 3 right). DMU is primarily a tool for product visualization and geometric analysis; the visualized data (3D model) is a low resolution image of the native CAD and is how substantial performance benefits are won. Since the DMU is generated off the configured PBS the LIs will always point to the correct CAD data with which to generate the DMU. This means the DMU can be filtered and regenerated on the fly to look at options or different baselines by simply filtering through the attributes carried by the LI switches. This way one always looks at the correct CAD data at the right time.

Fig. 4 shows an example how the above theory is implemented in practice and also how multiple options can be stacked under the configuration item. By toggling values on the link item the relevant design solution can be represented, as shown in the picture by the switch signs. It is this CI-LI-DS relationship that allows management of the configuration.

#### 4. Enablers of the configuration management of the design data

There are various enablers of the design configuration management, i.e. appropriate procedures and processes established and tools used. Due to the early stage of the DEMO development and very importantly the strong ties to the global configuration management system yet to be established, such procedures are still under development, except for the following topics described below, which are considered highly important. As for the tools, CATIA, SMARTEAM and IDM are selected to play a key role in the design configuration management.

As mentioned above, one of the most important enabler of such a system is a robust change management procedure. Engineering change is the process of systematically reviewing all modifications

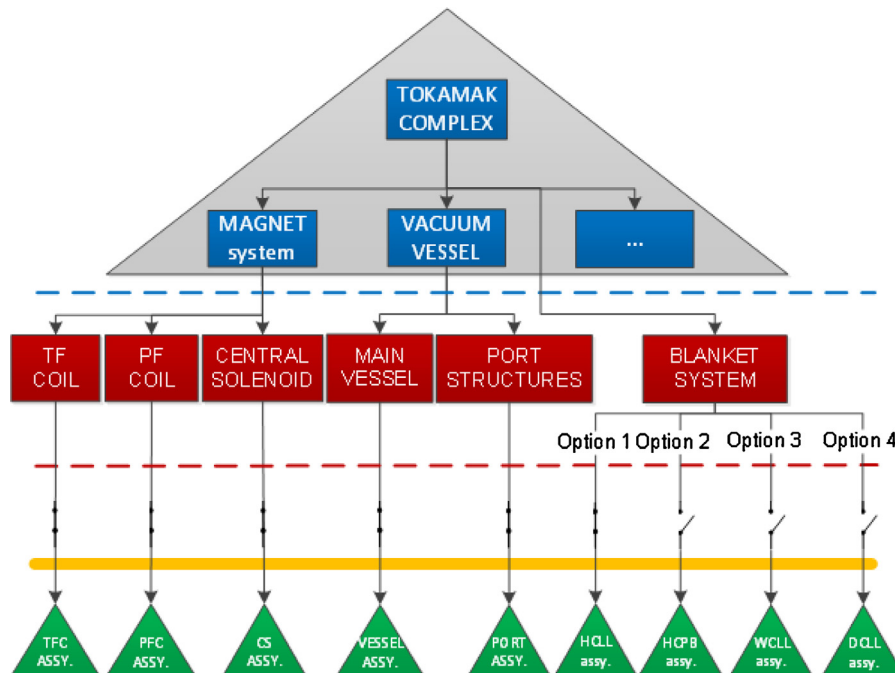


Fig. 4. An example of the implementation of the configuration management philosophy of the design data.

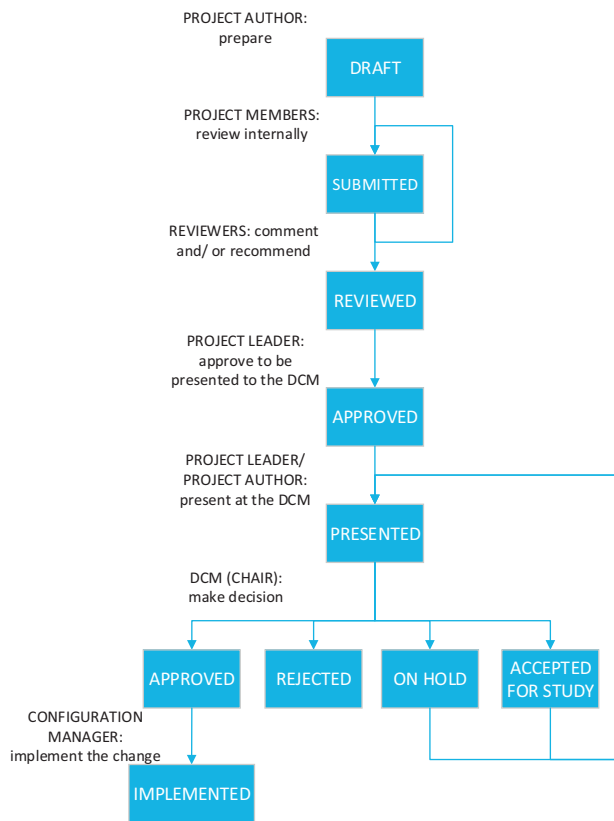


Fig. 5. Design Change Request (DCR) procedure.

to a configured baseline to ensure that the impact of changes on performance, cost and schedule are identified and the change classification is identified before implementation. Engineering change is therefore required to introduce, remove or modify existing items in the baseline. There is currently a Design Change Request (DCR) procedure in place for the DEMO development, which is designed to accommodate the limited available resources whilst providing as much functionality of the design change management as possible (Fig. 5).

The DCR procedure is initiated by one of the design groups working on a DEMO system, which generates and internally reviews a DCR before it is submitted to the design authority body called Design Configuration Meeting (DCM) for consideration. The meeting members (the project leaders selected to lead the development of the major DEMO systems) are steered to an agreement by the meeting chair, and make one of the following decisions for the DCR: (i) approval; (ii) rejection; (iii) acceptance for further study in the event vital information relevant to the decision is lacking; or (iv) on hold, due to concerns regarding maturity or possibility to obtain the necessary information. Finally, at the end of the procedure, the configuration manager is responsible for the actual implementation of the proposed change in case of approval.

Since the SMARTEAM system is installed for the DEMO integration and used only locally by the PMU, a way for CAD data exchange had to be established. One of the main criteria for selecting a data

exchange system was the familiarity of all the contributors with the system. This resulted in the document management system of the Eurofusion consortium (IDM) being used for this purpose. The engineering section of IDM is in any case developed to host analysis data files, plant break-down structure and other technical information, so the programming effort invested in the code to allow the storage and therefore the exchange of CAD data was rather low. Contributors are asked to compress all the relevant files and upload them to a pre-structured area of IDM/engineering. As usual, a unique ID number is assigned to each model along with the following: title, model number, designer name (co-designers/contributors), date, link to related IDM documents, link to previous version, CAD model file and a brief description.

## 5. Conclusion

The purpose of Configuration Management is to establish and maintain control of requirements and documentation throughout the life cycle of a system. In this paper the definition of the configuration management of the DEMO conceptual design data has been presented. It is based on the three following tools: CATIA for the CAD design, IDM for CAD information exchange and SMARTEAM as local PMU PDM tool, selected through the described procedure. During the design phase of a system changes are inevitable and managing the impact of changes on a project is the task of configuration management. The proposed configuration management philosophy of the DEMO design data results in a robust system that makes sure one visualizes the correct data at the right time. Moreover the introduced wide and flat CAD data structure significantly improves change management. The paper also introduces selected enabling procedures, such as the design change procedure, to systematically review all engineering changes to a configured baseline, and the CAD data exchange procedure that is essential from the very beginning of the development.

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