What kind of tools are needed for Configuration Management in Aircraft Industry?

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RESUMEN

Apenas existe literatura sobre el empleo de Gestión de Configuración (CM) en la Industria Aeronáutica. Sin embargo, puede resultar muy útil en el momento actual, en que la complejidad para hacer aviones es creciente y la aplicación de CM resulta muy apropiada. Las piezas de la aeronave se fabrican en países distintos, incluso se montan las mismas piezas en países y factorías distintas. Los diseños en materiales distintos y cada vez más ligeros, no hacen sino incrementar la complejidad, y además se le une que los clientes solicitan versiones muy diferentes del mismo modelo, que son cambiantes con el transcurso de los años.

El objetivo principal del trabajo es conocer qué herramientas se emplean para implementar la CM en el ámbito de la industria aeronáutica, con una inmediata aplicabilidad. Además se pretende que las herramientas sean fáciles de emplear, económicas y que estén accesibles en el mercado, lo que ha sido comprobado durante el estudio.

CM es una disciplina que nace de la necesidad de asegurar el control en complejos procesos de relaciones. CM está muy adaptada a la solución de problemas complejos, y además permite la reducción e integración de períodos de diseño, de forma que disminuyen los plazos de entrega al cliente, reduciendo también los costes.

Palabras claves: Gestión de la Configuración, Industria Aeronáutica, Herramientas

ABSTRACT

There is little literature on the use of Configuration Management (CM) in the Aviation Industry. However, it can be very useful today, where complexity to manufacture aircraft is increasing, and application of CM is very fitted. The pieces of the aircraft are manufactured in different countries, even the same parts are assembled in different countries and factories. Designs in different materials and increasingly lightweight, but do not increase the complexity, and it connects to customers seeking very different versions of the same model, which are changing over the years.

The main objective of the study is what tools are used to implement the CM in the aviation industry, with an immediate industrial applicability. Furthermore it is intended that the tools are easy to use, economical and are available on the market, what has been observed throughout the study.

CM is a discipline that is born from the necessity to assure control in the complex processes relationships. The results included, from the point of view of the change process phases, the activities made for each tool are underhand in several ones, for this reason is difficult to make a distinction of the tools involved in each phase.

Keywords: Configuration Management, Aircraft Industry, Tools

1. INTRODUCTION

One of the Configuration Management (CM) functions is to ensure that all the tools and people that manage the product work correctly and efficiently.

To do that, one of CM activities is to define the requirements that management tools must to fulfil. Moreover, people who work in CM must define the information process flow and ensure that the involved people use them correctly. Enterprise environment of CM: The aircraft industry has high technical investigation and development content.

The scope of this study is to show the tools or applications used in the CM, and to check that those tools let us perform our developments completely.

First, it is necessary to describe the tools: their functions, objectives, from where and how they obtain their information and data, and to which they provided their information. More economic proposal consists of search commercial tools. Delta 1 is the gap between the industrial specified configuration and the effective elements of the final definition dossier decided by design organization. This is the most important delta for configuration management, it has to control and follow it.
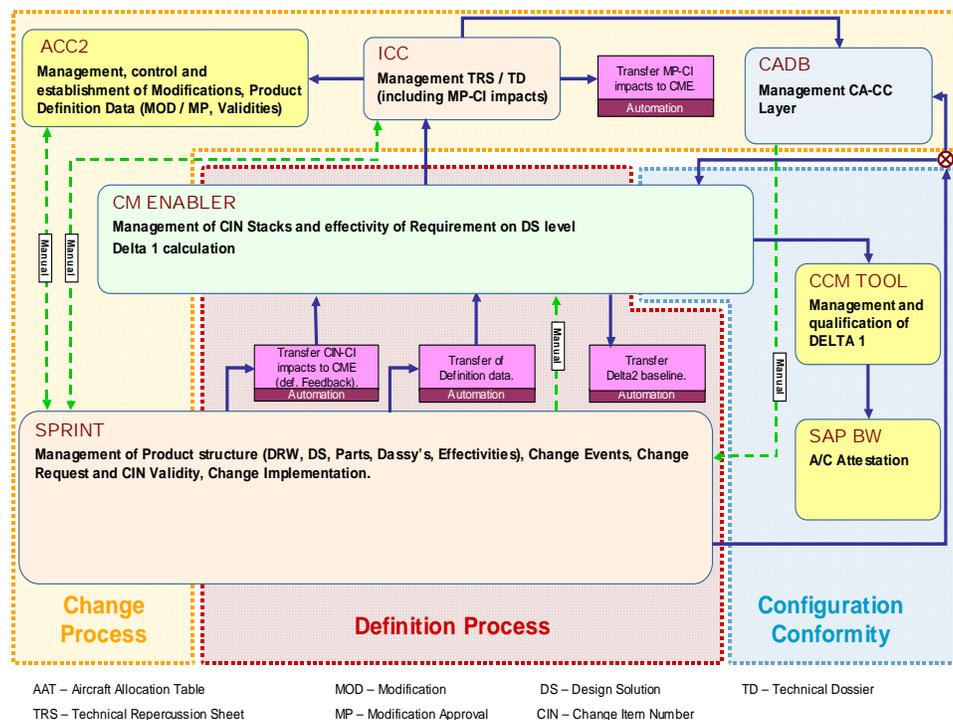

Figure 1: Management tools functions (general overview)

In this figure can be seen the management tools, these are:

- PRIMES CR: Common Repository
- ICC: Integrated Change Control
- MPM: Modification Proposal Management
- ACC2: Configuration control
- CADB: Component for Attestation Data Base.
- SPRINT: System of PRoduction INTegrated.

- CME: Configuration Management Enabler

- CCM: Configuration Conformity Management

- SAP: Service Assist Processor. Manufacturing tool.

2. TOOLS

There are many enterprises use these programs for different purpose, but aeronautical industry has got that the usual software suppliers adapt programs well known in the industry for these applications.

2.1 PRIMES – COMMON REPOSITORY

Product Related Information Management Enterprise System (PRIMES) - Common Repository: from the "CM point of view".

PRIMES is used to show, access and manage product structure, from upper to lower level, in all layers.

It provides a single and common application for the product structure and permits the product structure visualization of all the national companies.

Figure 2: Example of creating a new product structure

2.2 ICC

Integrated Change Control (ICC): from the "CM point of view".

This tool is the responsible of integration and identification of impacts in product structure. It appears in all the change process phases.

This tool is actually used for all companies and for all the programs. The ICC is the master tool for MP and MP-CI impacts.

It supports the change process and integrates all functions involved in this change process (program, engineering, manufacturing, costing…).

Its main objective is to manage TRS and MP impacts on CI's:

- Compile the TRS and identify the impacts in the product structure (PS).

- Gather "definition feedback" (see note below) from SPRINT.

- Transfer MP-CI impacts to CME.

- Provide the means for definition and proper documentation of product structure impacts.

NOTE: Definition feedback: In the ICC appears the target configuration, and in the SPRINT appears the real industrial configuration. To compare both configurations it is used the definition feedback, comparing the impacts in SPRINT with the impacts in the own ICC.

This tool tries to integrate information in the change process. In this tool could be seen information like:

- MSN (Manufacture Serial Number)

- Aircraft components

- Structures and system installation (ADAP-CI structure)

- CR (Change Request)

- MP (Modification Proposal)

- MOD (MODIFICATION)

- CIN (Change Identification Number)

- TRS (Technical Repercussion Sheet)

- TD (Technical Dossier)

- MAS (Modification Approval Sheet), …

Its principal advantage is the easy form to show all data. For example, when a user is consulting a change request, he could see several links related with it like:

- Associated TRS.

- Associated MOD document.

- CIN number, etc.

Finally, it transfers data like MP-CI impacts to the CME.

2.3 MPM

Modification Proposal Management (MPM): from the "CM point of view".

MPM establishes product definition. It works in layer "As specified".

It is used principally to manage the modification proposal (MP) in the company informatics system.

It collects all the related technical, industrial and cost repercussions. It works with the ACC2 tool to manage i.e. the validities of an MP, the urgency status, MP deletion, etc.

These repercussions become the basis for the decision on implementation (MOD decision), taken during CCB or in continuous process.

First, the MP has to be created in the ICC.

When a MP is created in the MPM, this tool obtains some information from the ICC, like:

- The associated national companies of the ACMT creator.

- The program.

- MP number (it depends on the program)

- MOD action date: It is the target date for MOD opening. If it was not specify, it will show current day plus ten working days by default.

Another data required for the MPM to fill usually are:

- MP reason.

- MP subject.

- When MP is for customization: to fill in RFC (Request For Change) if the modification requires or not validation.

- The initiator section.

- ACMT request information.

- The involvement section.

- The basic ERS data:

    o ERS number.

    o Target date for decision.

    o The FAL (Final Assembly Line) impact: yes or no.

    o Production validity.

- TRS information:

    o Enter its issue number.

    o Attach the electronic document.

- PRS and CRS document.

After that it is necessary to submit the MP, with its distribution lists and updated involvement list.

After submission of the MP:

- It transfers data to SPRINT by manual form.

- A MP creation workflow is sent to ACC where the MP entry is already created.

2.4 Acc2

Configuration Control (ACC2): from the "CM point of view".

ACC2 works in layer "as specified". It takes product configuration decisions, its control and what aircrafts are considered to carry on the modification.

It is a tool to manage the aircraft allocation table validities, open a MOD, change validities from MP to MOD, etc.

It works nearly MPM to manage the MP's and it provides information to SPRINT tool.

ACC is the reference tool for managing the target aircraft configuration (configuration of the A/C at the delivery).

Configuration data in ACC is managed according to three main activities:

- Aircraft (A/C) configuration decisions. This is the most important activity from our configuration control point of view.

- Certification.

- Propulsions systems.

The "configuration decision" module covers the following topics:

- Availability RFC, MP, MOD, Change Identification Numbers = CIN (pair MOD/MP) and EPAC/TDU.

- Management of the CCB decisions for MP/Mod opening, with validity.

- Management of the evolutions of the aircraft allocation table, and the related consequences on the aircraft target definition.

The certification module covers the following topics:

- Conformity to the JAA type design (or FAA).

- Official approval by certification authorities of all modifications validated by manufacturer.

- Preparation of the individual certification of the aircraft.

The "propulsion systems" module covers the following topics:

- Propulsion system components definition.

The ACC2 tool is the responsible to:

- Link the MP validity.

- Identify the relationship between MSN, version client and standard version.

- Open MOD/MP (with its respective change identification number, CIN).

Finally, ACC2 sends this data to the SPRINT tool.

2.5 CADB

Component for Attestation Data Base (CADB): from the "CM point of view".

This tool works in the layers "As-designed", "As-planned". Its main function is to create CA´s and to update links with ADAP CI's (constituent assemblies and "as designed", "as planned" configuration item).

Equal than ICC, this tool is used for all companies and for all programs.

It works always nearly from ICC; this tool is the principal information provider for the CADB. Moreover, it uses the same user interface, but in fact, they are different functional tools.

In the "as planned" layer, the CA's correspond to a deliverable manufacturer work package.

The main objectives of this tool are:

- To create and manage the constituent assembly cascade inside the product structure.

- To update links between CA's and ADAP CI's.

There is no automatic process that transfers automatically the information between CADB and SPRINT.

CADB carries out the automatic update of the links between the CA's created and managed in the CADB.

SPRINT transfers to CADB the connections CA-ADAPCI, CA-TOPCI, CA-CIN, etc. to link with their respective CA created in CADB.

2.6 SPRINT

Integrated Production System (SPRINT): from the "CM point of view".

SPRINT manages the product structure definition, from the point of view of industrial configuration, it works mainly in the change implementation, though appears in evaluation and investigation too. It is used to manage design.

This is used traditionally for several activities of configuration management, included change process control.

SPRINT is the master tool for:

- CIN (Change Identification Number), CIN validities, AAT (Aircraft Allocation Table).

- Change Events (CE), Change Request (CR)

- CI-LO-DS assemblies, parts, etc.

- Drawing sets.

SPRINT is feed with data from several tools, but they are implemented in tool manually:

- Once opened the MOD it is registered in SPRINT with a number, it could be as change event (CE) or change request (CR) numbering.

- With the CE/CR registered, it is used to specify the target dates, documental index, etc

- After that the information of product structure is introduced into the tool:

    o CI-LO-DS, assemblies, parts impacted, and modifications list (CE, CR, MP).

    o The numbers of planes or documents to check.

    o …

- The next step is report the constituent assembly in the CADB (master tool for CA management). Its objective is to link the CA cascade with the product structure of SPRINT.

SPRINT feeds several tools with information relative to the product structure. These elements give the necessary information for the calculation of Delta 1 and to identify the "definition feedback". The data transfer from SPRINT could be resumed in:

- CA cascade to CME to calculate the delta 1.

- Links CA-CI-P/N (part number) to CADB tool.

- Product structure and drawing sets to CME.

- Impacts CIN-CI to CME.

- Generate an "Excel" document to relate the CE/CR with CIN impacts (definition feedback).

- With this, product structure will be affected.

2.7 CME

Configuration Management Enabler (CME): from the "CM point of view".

This tool is used for delta 1 calculation. In other words, it calculates the remaining design work.

One of their principal advantages is that CME is capable to calculate automatically the "delta 1".

This tool is master for:

- Delta 1 calculation.

- CIN stack.

It works with several tools regarding and providing information.

The CME principal functions are:

- Calculate requirements and Requirements resolution. When a new Modification appears, this can affects the old structure of CI's, changing the aircrafts affected by the old modifications (their effectivities) and including the effectivity of the new Design Solution. This effectivity adjust is called requirement resolution.

- Manage Change Identification Number (CIN-CI) impacts that come from SPRINT (Delete CIN-CI. They are only managed in CME in exceptional cases, usually they are managed in SPRINT).

- Analyse effectivities discrepancies, "delta 1" report and CM general issues.

Transfer data for posterior "delta 2" calculation. "Delta 2" is the effective and released items of the definition dossier that are not covered by any planned order (it includes all the things that design team finally decide manufacture and isn't planned at production organization, in example orders losses).

It obtains information from SPRINT and ICC/CADB:

1) CIN's (change identification numbers). 2) CI's (configuration items). 3) LO's (link objects). 4) DS's (design solutions). 5) CIN-CI impacts. 6) CI-LO-DS structure.

Any discrepancy on effectivity observed in CME, must be reported back to SPRINT, and/or ICC/CADB, where it will be fixed and solved manually.

2.8 CCM

Configuration Conformity Management (CCM): from the "CM point of view"

CCM is a tool for configuration conformity; it is used for delta 1 management and qualification.

In other words:

- CME calculates the delta 1, it says how many works are still to be made, but not the importance or magnitude of this works.

- CCM shows the importance and the magnitude of these works (complexity, time necessary…) and manages it: work in progress, work realized, etc. and its impacts on the aircraft from the technical and A/C life cycle relevant milestone point of view.

The information flow trough CCM:

- Get "delta 1" calculated in CME.

- Manage and control the "delta 1".

- Provides information to SAP, to support aircraft attestation.

2.9 SAP

Service Assist Processor (SAP): from the "CM point of view". SAP is a tool for configuration conformity; it is used for aircraft attestation. Its objective is to relate manufacturer with the others configuration management tools.

3. MANAGEMENT TOOLS RELATIONSHIP

3.1 GENERAL OVERVIEW

Figure 3 shows the tools architecture, the information transfer and the main application for each one. It is a schematic resume of the explained before.
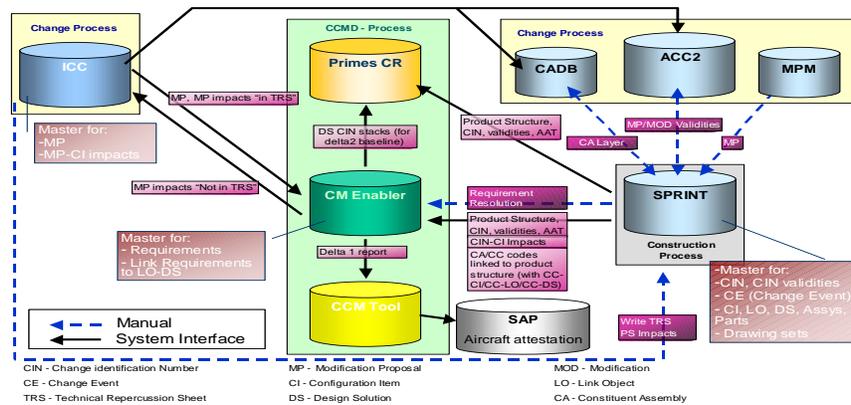
Figure 3: Management tools relationship (general overview)

3.2 TOOLS USED IN THE CHANGE PROCESS PHASES

Remembering the general "change process phases", the management tools related with the modifications could be situated by phases as follows:
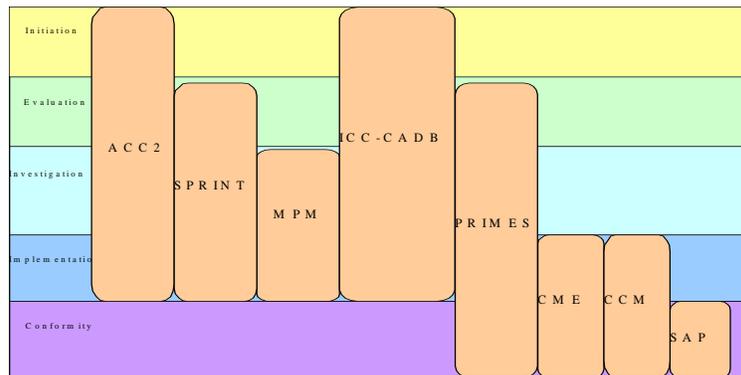

Figure 4: Tools used in the change process phases.

- INICIALIZATION: When a "change request" (o change event) is created, first of all it is introduced in the ICC, in this tool could be seen all the product structure that it affects to.

- EVALUATION: After the CCB accept the CR, it is assigned an MP number and it is ordered to make an evaluation TRS. In this phase, it is introduced the CR-MP (or CE-MP) in the SPRINT. The TRS is launched in the ICC. ICC and SPRINT make the modification management in this phase.

- INVESTIGATION: In the investigation phase take place the same tools than in the evaluation, because of the process in tools is continuous, to introduce information and update. For the MP and the MOD-MP validity is used also in this phase the MPM and the ACC2 tools. After TRS, the PRS and the CRS will be realised, and they will be launch in the ICC tool.

- IMPLEMENTATION: The CADB creates the constituent assemblies (CA) cascade. In this phase, SPRINT affects the product structure, modification effectivities, and links the CA created in CADB, with the CI impacted by the MOD.

Information contained in ICC, MPM and ACC2 is updated.

Product Structure and Drawing sets information contained in the SPRINT and ICC is transferred to CME, "requirements" and "delta 1" calculation

Configuration Conformity could be contained at this phase. For the configuration conformity are used:

- CME and CCM, for "delta 1" calculation (CME) and qualification and control (CCM).
- CCM and SAP, for the aircraft attestation.

4. GENERAL PROCESS IN MANAGEMENT TOOLS

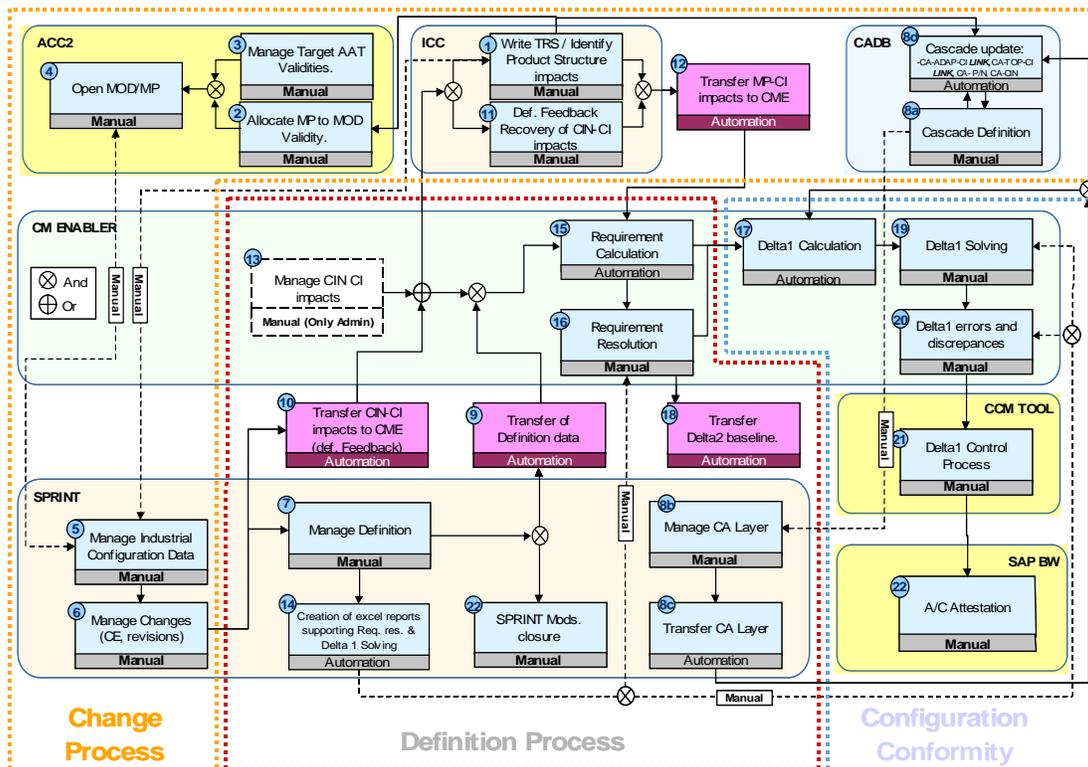The main process following by information in the management tools could be seen in figure 5:

Figure 5: General Process in Management tools

The steps followed could be resumed as follows:

1) First, it is necessary to identify the modifications impacts in the product structure.

2) After the Configuration Control Board (CCB) accepts the modification in base to an initial Technical Repercussion Sheet (TRS), is assigned a Modification Proposal (MP) number to this. At this moment, the modification must to pass at the ICC tool. Sometimes and with the objective of work advances this modification could be introduced into SPRINT tool with the CR o CE number.

3) After that, the MP is introduced in the ACC2 and MPM tools. With them, the change controller could manage MP and their validities. In other words, the aircrafts targeted for this modification.

4) It is very important before follow with the process, that the product structure will be affected by the modification. In other words, to impact the product structure with the Change Identification Number (CIN).

    The target of this action is to give process visibility and traceability, showing in all moment the affected parts. This must be made even the technical solution is not mature.

    This structure could change with the evolution of the modification. SPRINT tool do these actions.

5) At this level people works with SPRINT: To impact the product structure, effectivities calculation, and definition changes.

6) Modification receives a MOD number and with this a CIN number (MOD+MP).

7) Affected CA´s (constituent assemblies) are impacted by the MOD-MP in CADB tool.

8) CA cascade given by CADB is related with CI-LO-DS structure given by the SPRINT, unifying the product structure.

   This structure completed of CA-CI-LO-DS is transferred to CADB.

9) Information contained in SPRINT is transferred to CME tool with the objective to "delta 1" calculation. CIN-CI impacts are transferred to CME.

10) Requirements calculation. "Delta 1" calculation.

11) Data transfer from CME for the "delta 2" calculation.

12) "Delta 1" analyse for each MSN. The possible discrepancies must been studied, the ones that responds only with an information implementation failure must be solved at this point. CCM tool controls "delta 1". It evaluates the importance of "delta 1" quantified (but not evaluated) in the CME.

13) CCM information is transferred to the SAP tool for the aircraft attestation.

5. CONCLUSIONS

CM discipline is essential in very complex projects like aircraft design, but also recommended for integrating other projects or programs that manages products built by components, with many activities or processes.

The reduction and integration of the design periods results in several processes taking place at the same time. The tools mentioned let us:

1. Accommodate the change.

2. Accommodate the reuse of standards and best practices.

3. Ensure that all the requirements (all the released information) remain clear, concise and valid.

4. Communicate (1), (2) and (3) to each user promptly and precisely.

5. Ensure that the results conform to the requirements in each case.

From the point of view of the change process phases, the activities made for each tool are underhand in several ones, for this reason is difficult to make a distinction of the tools involved in each phase.

Tools mentioned allow fulfil with functions and requirements of CM. All of them are compatibles, and they let to transfer information easily. Moreover, its cost is reasonable. The tools can be found on the market (i.e. CATIA V5 -IBM, Microsoft suppliers, etc.), and have been adapted to suit the needs of the aviation industry.

These tools define the information process flow, and ensure that the involved people use them correctly and efficiently.

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