Improvements for Future Programs in Aircraft Industry

Félix Calvo Narváez[1], Carlos Rodríguez Monroy[2], Miguel Ángel Peláez García[2]

[1] Dpto. de Tecnologías Especiales Aplicadas a la Aeronáutica, Área de Ingeniería Aeroespacial. Escuela Universitaria de Ingeniería Técnica Aeronáutica. Universidad Politécnica de Madrid. Plaza Cardenal Cisneros, 3. 28040 Madrid. felix.calvo@upm.es. [2] Dpto. de Ingeniería de Organización, Administración de Empresas y Estadística, Área de Administración de Empresas. Escuela Técnica Superior de Ingenieros Industriales. Universidad Politécnica de Madrid. c/ José Gutiérrez Abascal, 2. 28006 Madrid. crmonroy@etsii.upm.es, mapelaez@etsii.upm.es

Keywords: Configuration Management, Aircraft Industry, Improvements.

1. Introduction

The field of manufacturing is nowadays also confronted with many changes due to increasing and worldwide competition, technological advances and demanding customers. 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 two most important objectives of the CM are to guarantee that there is compliance between the products and services that have been delivered to the customer, and to support the process of application for individual certificate of airworthiness, while optimized business performances are taken into account. CM is a discipline that arises from the need to ensure control in the complex process of relationships. CM is well suited to solving complex problems, like in aircraft industry. Its application allows the reduction of periods of integration and design, so that reduce delivery time to customers.

This CM process describes the following activities related to a company standard offer:

- Production of standard specifications and catalogues of options proposed to customers
- Management of a repository of customisation items
- Support to aircraft contractual definition: record and track customer requests and product evolutions.

The main users of the process are the airlines, and the company organizations programs, customer affairs, engineering and upgrade services.

The essential objective of the work tries to indicate areas of future improvement in the current CM which can be useful, and we show possible trends in the light of developments which will mark the Aircraft Industry. We must also talk about the risks involved.

Recent failures in development processes, in the major aircraft manufacturers, have led to significant delays in deliveries to customers. At present, using CM correctly would have been avoided.

The reduction and integration of the design periods results in several processes taking place at the same time. This situation is called concurrent engineering. CM was born to manage processes, relationships and deliverables between the different organizations. CM resolves problems during the life cycle, and that shortens the time the changes to the versions, and good management avoids errors. The law of software evolution reveals increasing complexity (i.e. through changes the structure of a system becomes ever more complex and more resources are needed to simplify it). CM software used tools 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.

The tools can be found on the market 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.

2. Main proposal to improve processes

The procedures to be followed by any actor in any process must be classified inside three types:

- Rigid: the procedure (or steep) is rigid when its fulfilment is obligatory to assure the product integrity. In the example of the Change Process, a rigid procedure could be the assistance of at least one person from design organization to comment the technical solution.
- Semi-rigid: the procedures with recommended but not obligatory fulfilment. These do not affect to the product integrity, but they are recommended to do the process more efficient. This is the theory, finally the main actors will know if this action really improves the process or not. Following with the Change Process, an example could be the Quality Control assistance to the committees, it is not necessary, because of its work is independent, but it is very recommendable to make easier the future modifications attestation.
- Flexible: procedure with little relevance, its realization or not will be decided by the actor thinking in each case if the contribution improve the general process. Taking one more time the example of the Change Process: the cost Controller assistance to the committees. He can know better than anyone if its assistance to the committees is in each case, more or less convenient. Obviously, this decision does not require a company directive.

With this treatment two advantages could be obtained:

- To speed up the process. When the processes are not so relevant, the actors could save some work, and with this, the process could save time and in consequence the program could save money.
- To make the processes more flexible, providing the actors the decision to realize or not some works being based on their own experience.

This proposal could be applied to all the processes, not only the Change Process

3. Maturity Gates Model

The Maturities Gates models are intended to enable an effective management of huge projects by defining points of decision and target dates. The maturity gates model divides the A/C Program life into four main phases: feasibility, concept, definition and production (what bring forth the following milestones - see figure 1).
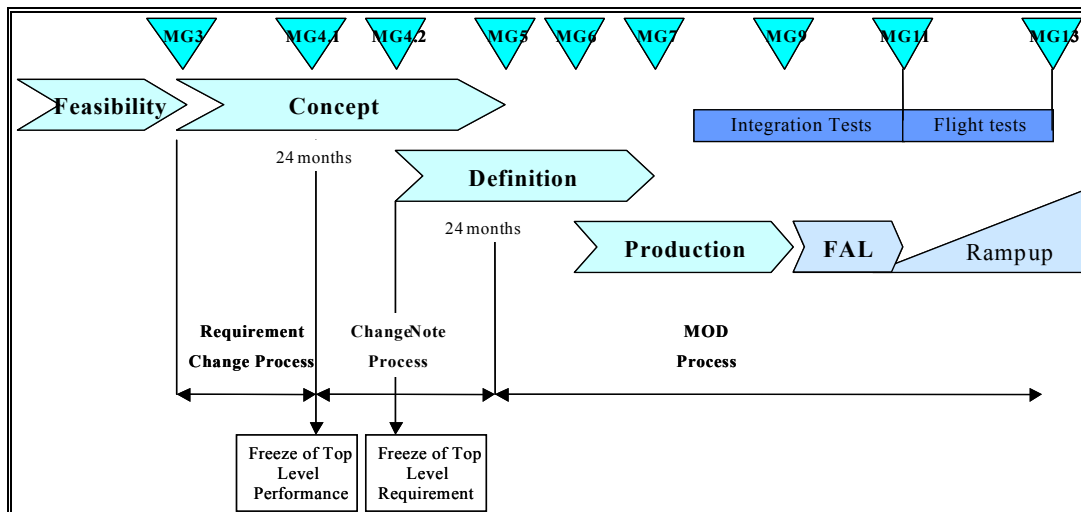

Figure 1. New Milestone Model

MG0 to MG3: This phase involves from the establishment of Product or the A/C idea until the basic concept definition. During this phase the Market situation and its needs are studied in order to identify an A/C concept capable of fulfilling specific Market needs.

MG3 (Entry into concept): Start of concept phase of development based on adequate level of evidence regarding market needs capture (Top Level Requirement to be drafted with formal market validation), aircraft family concept feasibility (technical and industrial) and a draft Business Case. Includes assessment of suppliers' (and first selections) and technology readiness.

MG4.1 (Ready for Authorization to Offer): Implies ability to freeze the level of performances (top level), economics and of the customization policy, which will be marketed after ATO. The uncertainty level of the main parameters contributing to "performance" needs to be consistent with the selected margin (traditionally 4% on specific range and 2.5% on weight). That involves as well to have taken a set of strategic assessments and decisions regarding the choice of concept (e.g. installation architecture), the supplier's involvement, and the technological readiness.

MG4.2 (Ready for Industrial Launch and Entry into Definition): Implies to have frozen all Top Level Requirements and fully selected the baseline configuration. Definition work is started based on preliminary loads with a given uncertainty level and overall systems architecture.

MG5 (End of concept): Implies to have secured the route to achievement of all Top Level requirements. This feasibility demonstration should be at that stage sustained by the results of demonstrators and prototypes.

MG6 (Start of Production): Start of production of the sections included manufacturing of the long lead items.

MG7 (Freeze of Definition): End of the definition phase.

MG9 (Entry into Final Assembly Line): Sections arrive with little/no levels of outstanding work.

MG11 (First Flight): Implies to have demonstrated not only that the 1st prototype can safely fly but also that it has achieved a close level of maturity compared to the first aircraft to be delivered (close to service readiness).

MG13 (Entry into service): Implies to have demonstrated the maturity level of the first aircraft definition.

4. Change Management Process for new projects

The objective is to ensure a common understanding of the change management process across the enterprise. The process shall:

- Provide at the earliest opportunity visibility of an impending change situation.
- Be transparent in terms of identifying the actors (participants) and their tasks in the process.
- Provide clear indication as to the mechanism to initiate, manage and implement change.
- Provide agreed points where the visualization of progress shall be identified.
- Provide an input to design/project reviews.
- Capture/implement the output from design/project reviews.
- Ensure full traceability.
- Maximize the benefits of the concurrent way of working.
- Ensure that change management and communication of data is consistent within a geographically dispersed project team environment.

4.1. Process Flow

The global Change Process within the product lifecycle is divided in five sub-processes: Initiation, evaluation, investigation, decision and implementation phases. In figure 2 is shown the overview about the whole change process.
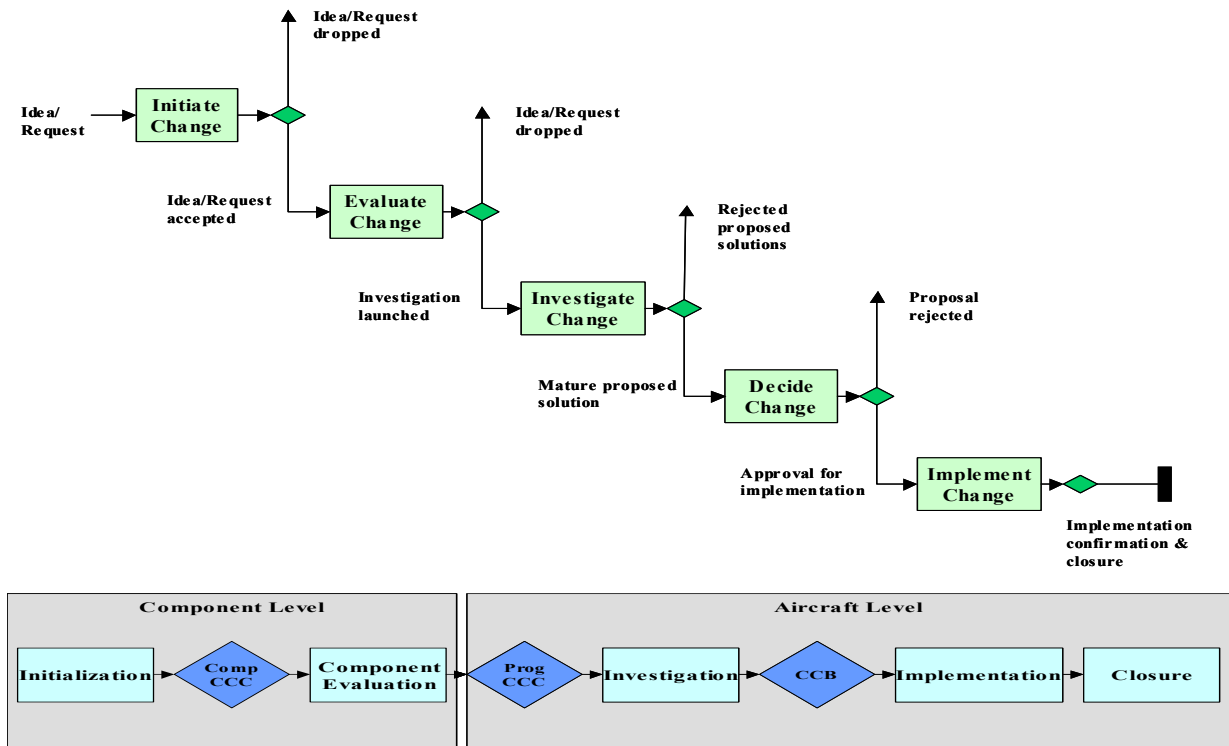
Figure 2. Process flow for future programs

4.2. Process Phases

− Initiate change: the input, which initiates the change process, shall be received from an authorized organization.

− Evaluate change: the repercussions resulting from the idea/request including initial proposed solution(s) shall be collected and evaluated.

− Investigate change: the subject of the idea/request shall be fully investigated and proposed solutions shall be evolved.

− Decide change: a final decision on the acceptance or rejection of the proposed solution(s) shall be taken by the appropriate empowered body and communicated to the involved disciplines.

− Implement change: involved disciplines shall update impacted/affected data (e.g. documents, models).

On task completion the appropriate configuration authority shall be informed and the change process shall be closed.

4.3. Global Process Participants

The following roles for participants shall be identified:

− The Initiator identifies a need for a change/evolution and initiates a change process.

− The Task Owner is responsible and accountable for monitoring and coordinating of all necessary activities to satisfy an idea/request within the whole change process. He/she shall also have the responsibility to prepare decision steps and appropriate reviews.

- Technical/Operational Specialists are experts who are affected by an idea/request and set at an appropriate level of business to perform dispatched task activities. Technical/operational specialists are accountable to: a) investigate change requests and evolve solutions; b) realize solution by updating of impacted data (e.g. documentation, models).

- Decision Authorities, have the responsibility and accountability for decision making on behalf of the project/program for a specific change. Shall be empowered to take the following decisions to:

   - accept or reject an idea/request,

   - launch or reject a change investigation,

   - decide which solution shall be implemented to satisfy an idea/request.

4.4. Decision/Reporting Points within the Change Process

Each process step within the change process is triggered by a decision and appropriately reported.

- Acceptance/Rejection of request, between: initiation phase and evaluation phase.

- Agreement/Refusal to launch investigation, between: evaluation phase and investigation phase.

- Agreement/Refusal that mature proposed solutions are ready for final reviewing and decision, between: investigation phase and decision phase.

- Approval/Rejection for implementation, between: decision phase and implementation phase.

- Approval/Refusal for change process closure. After implementation: final report stage to identify implementation is complete.

5. Change Process improvements

Attending to different criteria, there are several ways of work in the change process:

- By the urgency criteria. The work required can be classify as:
   - Normal: do not have especial urgency. They are not critical to "deliver on time". They represent more than 90% of modifications (European aircraft industry).
   - Urgent: require develop as soon as possible. They could generate problems to "deliver on time". They represent less than 10% of modifications (in Europe).
- By the process criteria. The work process can be classified as:
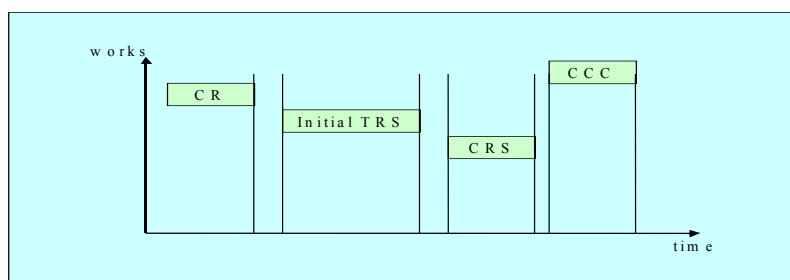   - Work in sequential process. For example (figure 3):

Figure 3. Process with sequential works example

- Work in parallel process. This is only used in exceptional cases, with urgent modifications (example, figure 4):
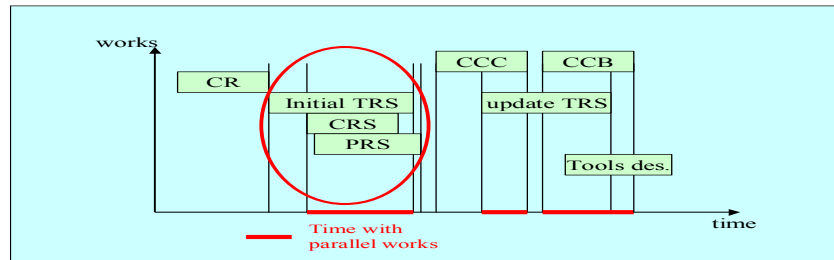

Figure 4. Example of process with parallel works

5.1. Comparison between the different ways of work

In the study made is observed that the most important thing to reduce the global "lead time" of a modification development is the urgency level.

- The "normal" process followed is by sequential works:
  - o It is more robust. It works with solid solutions.
  - o The following actors use information more detailed.
- When the modification is "urgent" it could be processed:
  - o In sequential process.
  - o In parallel process.
- When the modification is "very urgent" it will be processed in parallel, with advanced information.
  - o Advantage: Global reduction of "lead times".
  - o This could carry some risks like:
    - To work with non-definitive solutions.
    - If the modification finally is rejected, a lot of resources will have been spent unnecessary. Money and time will be lost.

The improvements for the company should be: To reduce modifications cost, and to reduce the implementation times.

5.2. Proposal

- This study recommends:
  - o To work in parallel when the time saved is an important question:
    - In urgent serial solutions.
    - In retrofitted solutions. Always important for the planning and to reduces the concessions.
  - o To work in sequential process: In the no urgent serial solutions, with a lot of time to implementation (i.e. mod for low weigh reductions).
- To make the "parallel work with several solutions" stronger, the proposal make is remake the change request (see figure 5). This will make with recommendations and several technical solutions in the new Change Request (C.R.B) sent from Configuration Control to the involved people, in this case: Design, Costing and Manufacturing. To work at least these 3 departments at the same time:
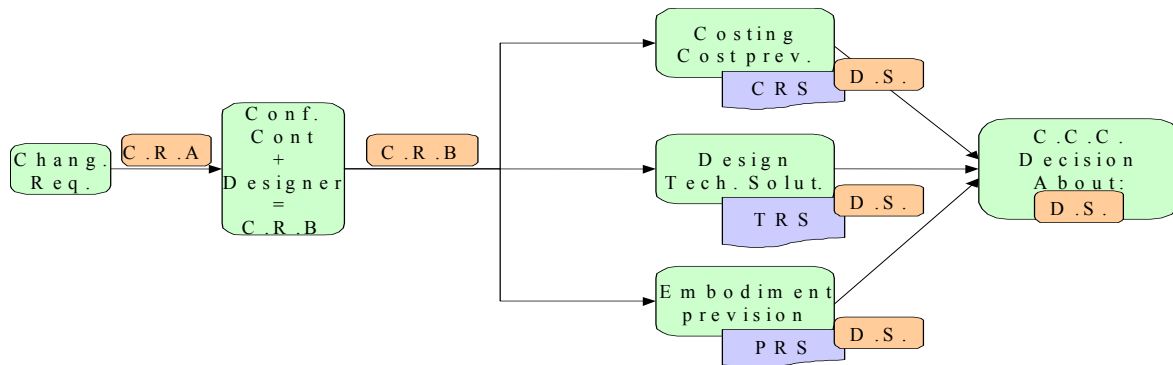
Figure 5. Proposed process

- The time used to remake the C.R.B with more information is always minor than the time saved in the next steps. This C.R.B will be realized between the Configuration Controller and designer of this part.
- This permit to several organizations to start the work with advanced information (or several proposals, if they were necessary), with more robustness.
- The committee should always have the capacity to order: a) work in parallel; b) several solutions evaluation; c) work with advanced information, determining it.

5.3. Expected results

- The improvements for the company are:
  - To reduce cost of modifications.
  - To reduce the implementation times.

6. Change Process during concept phase for future programs

The objective of this Change Management Process is to research and to carry out a modification implementation within a framework (scenario), which is defined in the Scenario Management sub-process, in order to get an optimal solution for an A/C configuration that can be perfectly definable and feasible for the activities to perform in the Definition Management sub-process. So this sub-process could be defined as a connection between the framework creation and the process will must define it in detail. In this way, it describes, analyzes the impact of a change and implements it to become this framework into something completely defined.

7. Organization integration

In the companies with a lot of disciplines evolved and related, could appear some problems with these organizations relationship. These problems can be more important to the CM work, making this work more difficult. They are due to:

- The autonomy: People in each organization treat to make its task as independent as possible to the other organizations. In other words, some times the workers owns the wrong idea that their work: Start with the one order "input", they make a work based on this input, and the work finish with a "deliverable", forgetting other processes other processes related with them and important for the efficacy and efficiency on the CM processes.
- The stagnation or change resistance: Some proposals of change (necessaries or improvements) can have the opposition of some people that develop this work. This could be due to:
  - People have done the same task from several years ago, and now they present resistance to learn another form of task.

o This new proposal increases the work of this person. It has more resistance, without thinking on the enterprise development.

An example of this could be the implementation of new management tools.

This situation makes the processes more rigid and makes the enterprise more vulnerable to the environment changes, obstacles for possible improvements and impacts on development times. These position are very prejudicial for any enterprise, but especially for the companies with high investigation and technological contain like in our case, the aeronautical companies.

The solution is evident, but not easy:

- To make aware: it is very important to think always work for the company global improvement.
- To inform: this is the complementary to this first point. This consists to inform all the evolved organizations on the reasons of the changes. At this point "CM Organization" has the responsibility to inform why the management changes are necessary. In example when a change in the product structure is proposed (new structure treatment, new tools, etc.) it is necessary to explain "why is this".
- To collaborate: requires improving the global enterprise task. At this point "CM Organization" must to provide support to all the organizations related with it.

The product evolution on its own structure since it is defined from design is transferred to manufacturing engineering. In this way, there are several interfaces and relationships between the structure layers of design and manufacturing.

8. Others Problems and Conclusions

Before the committees treated all modifications not closed, this could make these committees duration was two or three days, the repercussion was that the assistance to this committees proved low. Because of this, we should try that the committees only treat the urgent and more important modifications, so they take place in only one day, and the involved people assist to their respective hours. Another problem found with the configuration is the different aircraft numbering in the manufacturing organization. The main problem is that the "Sequence Aircraft" manoeuvres at the same time that the production planning, and with this the "Connexion matrix" too. This could generate a lot of pitfalls to assure the configuration, and more if the assembly to be delivered has only one Connexion Matrix for one work package but this work package is divided in several parts to be delivered to different factories. There are certain pressures to change this. This is difficult, but the most important thing that manufacturing engineering is trying to do, is that all the inputs and outputs of this organization are with MSN numbering.

The organizational structure of a classic aircraft manufacturer in addition to the usual managers: engineering, production, project office, maintenance, quality, etc. had a department for assistance to executives, which was devoted to documentation and its control. In the course of the years, this department has been converted, because of the need for more effective management of documentation and the greater complexity of systems and equipment required for aircrafts development and production. This joined outsourcing of certain parts, as well as globalization, has led inexorably to the creation of Configuration Management Department, undertaking difficulties of this new situation, working on simplifying processes, and optimizing resources to try reduce the time per unit associated with this increased complexity, thus resulting in lower unit costs.

References

Appleton, B.; Sayco, M. (2003). "SCM Branching Strategies". IEEE Computer Soc. Los Alamitos, CA, USA.

Berczuk, S.P.; Appleton, B.; Brown, K. (2003). "Software Configuration Management Patterns". Addison-Wesley Professional, Pearson Education. NJ, USA.

Blanchard, B.S. (2008). System Engineering Management", Fourth Edition. Wiley Series in Systems Engineering and Management. John Wiley & Sons, Inc. NJ, USA.

Crnkovic, I.; Asklund, U.; Persson-Dahlqvist, A. (2003). "Implementing and Integrating Product Data Management and Software Configuration Management". Artech House. London, UK.

Dam, S.H. (2007). "DoD Architecture Framework: A Guide to Applying System Engineering to Develop Integrated, Executable Architectures". SPEC Training. Virginia, USA.

Duvall, P.; Matyas, S; Glover, A. (2007). "Continuous Integration: Improving Software Quality and Reducing Risk". Addison-Wesley Signature Series, Pearson Education. NJ, USA.

Forsberg, K.; Mooz, H.; Cotterman, H. (2005). "Visualizing Project Management", Third Edition. John Wiley & Sons, Inc. NJ, USA.

Greenfield, A. (2008). "The 5 Forces of Change – A Blueprint for Leading Successful Change". Management Books 2000. UK.

Hass, A..M..J. (2003). "Configuration Management. Principles and Practice". Cockburn-Highsmith Series Editors. Pearson Education. NJ, USA.

Jorgensen, H.; Owen, L.; Neus, A. (2008). "Making Change Work". IBM Global Services. http://www-935.ibm.com/services/us/index.wss/ibvstudy/gbs/a1030541?cntxt=a1000453

McGraw, G.; Chess, B. (2008). "A Software Security Framework: Working Towards a Realistic Maturity Model". Inform IT Network. Pearson Education, Informit. Indiana, USA.

St. Charles, D. P. (1990). "Simultaneous Engineering. Integrating Manufacturing and Design", 1st edition, pp. 160-164. Society of Manufacturing Engineers. Dearborn, Michigan, USA.