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Configuration management in aerospace industry

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Abstract

In this paper, first the basis of the Configuration Management is defined. Next, how Configuration Management is practiced in aerospace industry is explored. Further, the current challenges of CM in Aerospace industries are discussed with a brief review of the strategic actions taken by aerospace industry to implement Configuration Management. Last, current trends in Configuration Management are explored.

*Keywords:*Configuration Management, Aerospace, Requirements management, Systems Engineering

1. Introduction

Configuration Management(CM) deals with managing changes across the life cycle of a product. Its importance is fully recognised in various disciplines such as design, engineering, production and services.

Configuration Management is defined as "Configuration Management is a management discipline that applies technical and administrative direction to the development, production and support lifecycle of a Configuration Item. The discipline is applicable to hardware, software, processed materials, services, and related technical documentation. Configuration Management is an integral part of life-cycle management" [1]. Here the authors clearly explained the importance of Configuration Management in the development life cycle of a product. This was highlighted in the research conducted by CMSTAT Corporation which described Configuration Management as the act of managing parts of a product and design to ensure that the products perform as intended [2].

All these approaches of Configuration Management were summarised in the International Council on Systems Engineering (INCOSE) Hand Book, which describes Configuration Management as the means to control and document the evolution of requirements [3]. This is illustrated in Figure 1. This document pinpoints that CM deals with controlling requirements throughout the system's life cycle. Configuration Management thus manages the impact of the changes on a project. This approach has evolved into traditional Configuration Management process as shown in Figure 2.

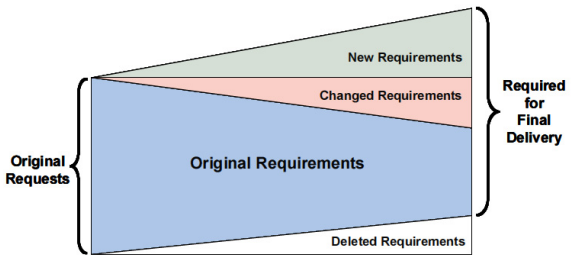

Fig.1. Evolution of requirements[3]

2. Configuration Management process

Configuration Management can be subdivided into four major processes namely Configuration Identification, Change

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Management, Configuration Status Accounting and Configuration Auditing [4], which are described in the below sections.

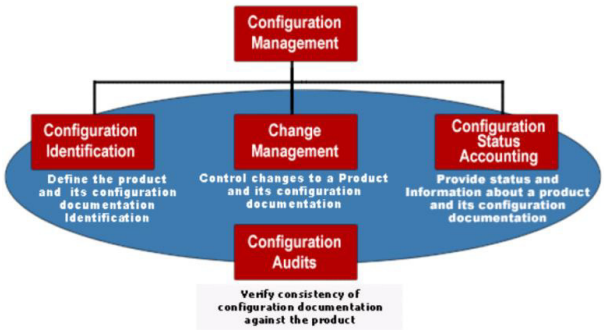

Fig.2. Traditional Configuration Management process[4]

2.1. Configuration Identification

Configuration Identification is the critical element in a Configuration Management process [5]. This process includes identifying various documents which are part of configuration baselines for the system and all low level items which are part of these baselines. Once an item is identified it is called a Configuration Item (CI). Configuration Identification involves all the products including the associated documentation. This determines the various attributes of Configuration Items such as performance, interfaces and provides a definite identity to the components, products and documentation.

2.2. Change Management

Change Management involves the control of changes to a product and its configuration documentation during its life cycle. This is a responsibility of both Configuration Change Control Board (CCB) and Configuration Identification manager. The Change Control Board comprises of stakeholders, customers and other involved teams. The CCB evaluates the changes depending on the critical issues such as safety as a priority and other issues like costs, savings, and trade-offs. Configuration Management thus controls the changes and maintains consistency between the changes and documentation.

2.3. Configuration Status Accounting

Configuration Status Accounting maintains the valid and present information on products and processes for retrieval. This includes any decision on changes and impacts on implementing the changes. Configuration Status Accounting acts as a source to access the complete information on configuration for answering any queries related to design changes, design problems, planning and life expectancy. It involves inquiring the current status of all the changes including new, in progress, completed and rejected changes. This reduces risk and improves the ability to develop, produce, maintain and restore products as per the requirements of the customer and other regulatory authorities.

2.4. Configuration Auditing

Configuration Audit will ensure that each and every one of the earlier stages have been applied correctly and integrated in the organisation. This activity will generate an audit report. Configuration audit is carried out at different stages of product life cycle. Audit performed before baseline establishment assures compliance to the requirements. Functional audit is carried out to verify performances and functional characteristics achieved for Configuration Identification. Physical audit is carried out on as Built Configuration Identification to verify conformance to product Configuration Management documents.

Further a wider and clear description of Configuration Management was given by various researchers. CM is illustrated as a bridge between the Engineering department and the rest of the world [6]. It has been reiterated that the function of Configuration Management is to ensure whatever is crossing the bridge is documented properly with minimum restriction on communication between design engineering and rest of the world. It has been described further that if there are changes during the life cycle of a product, Configuration Management disciplines and process will provide the vehicle to communicate properly to the rest of the world.

3. Configuration Management in Aerospace industry

It has been revealed that many aerospace companies are applying the latest practices in Configuration Management for all their advance capabilities [7]. If the Configuration Management is not applied properly it can unfavorably impact the quality of the product, delay the launch of their product and increases the life cycle cost of all their products.

These companies have adopted three basic tools for implementing the best in class Configuration Management [7], namely

- Standardisation of the processes
- Extending the Configuration Management with advanced capabilities
- Enabling Configuration Management

3.1. Standardisation of the processes

In order to implement Configuration Management successfully the initial step is to standardize all the processes at all department levels across a company. This includes formalizing at all the levels of the organisation and having a centralized control to manage the change processes and thus monitor the configuration of a product.

3.2. Extending CM with advance capabilities

Configuration Management by the best in class Aerospace and Defence companies, uses a much wider definition of a product, which includes various processes like design, engineering and manufacturing, in a combined structure. This includes manufacturing and design details that are used at all the stages of the life cycle of a product. The documentation of

the product is included as part of the Configuration Management.

It is important to these organisations to cater for the requirements of regulatory bodies, governing the life cycle activities of the product, and stringent maintenance practices.

3.3. Enabling Configuration Management

In order to implement the best practices of Configuration Management it is necessary to maintain a centralized database. This improves the performance, with minimal errors in the product data. This is done with the help of technologies such as Product Data Management (PDM) and Product Lifecycle Management (PLM). PLM consists of set of procedures used for implementing Configuration Management [8].

One of the senior officials from an Aerospace and Defence (A&D) company describes the importance of CM as "With a formalized Configuration Management process, the change management status is visible to everyone and documents can be retrieved easily".

3.4. Challenges of CM in Aerospace & Defence industries

The configuration of a product imposes a great challenge for Aerospace and Defence industries. The products they develop, usually require a large number of components/assemblies, and are highly complex in nature. Also these companies are bound by various regulatory bodies and are required to manage complex and diverse teams to respond to all the demands of the customer [7].

The major factor which drives Aerospace industries to implement Configuration Management is delivering a product as per the customer requirements, while managing the cost, schedule and quality of the product

3.5. Strategic actions by Aerospace and Defence industries

Configuration Management is an issue which deals with entire lifecycle of a product. Its impact encompasses right from design, until after sales service of the products [7]. The strategic actions suggested are:

- Better control of change management in various departments
- Enhance communication between manufacturing and design departments
- Better change management inside the engineering department
- Enhance cost control in the manufacturing department

Research was carried out by the Aberdeen Group in various Aerospace and Defence companies, in analysing the strategies to implement Configuration Management. Theresearch showed that majority of the Aerospace companies, are concentrating on improving change management activity, to effectively implement Configuration Management.

4. Trends in Configuration Management

In the current scenario of a competitive market, customers are very specific in requirements and demanding different variants of the same product. In order to increase the Return on Investment (ROI) and reduce the time to market, several new approaches are being explored. In this scenario CM has gained immense focus in various industries especially to streamline the product life cycle. The following sections describe a selection of these approaches which are applicable to Configuration Management in Aerospace industries.

4.1. CMII Model

The CMII Corporation has undertaken research on the traditional CM practices across industries and comes out with a different model which has given enterprise perspective instead of design orientation which is called E-CM (Enterprise CM). CMII model is an integration of Configuration Management, project management and quality assurance into one unified unit. CMII gives Configuration Management an enterprise-wide perspective by lifting it out from design orientation. In CMII emphasis is transferred on improving the capability to incorporate changes and keep the requirements concise, clear and valid [9].

With CMII, the hierarchy of administrative requirements used to run the business is subjected to the same controls used to manage products. With CMII, all parties use one common change process. As shown in Figure 3, the goals of CMII are to achieve consistent conformance and continuous improvement. Deviations and/or waivers are rare, if ever, needed. CMII controls requirements and concentrates on business process infrastructures that are broken. Every organisation should rely on their processes, enabling tools and continuous improvement in change process if they expect to produce a high quality product [10].

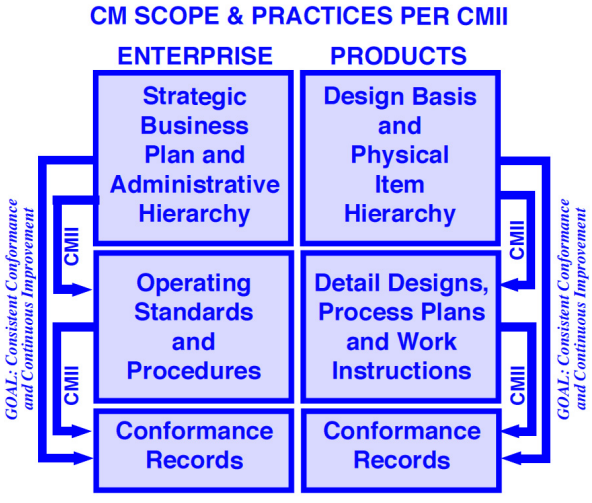

Fig.3. CMII Model of Configuration Management [9]

4.2. Handling CM with Systems Engineering

For many industries the configuration of new product is inevitably more complex than the previous one. Each new version often integrates more systems from different engineering disciplines than the previous one. It has been described that the 21st century engineering organizations face a new challenge as they strive to create the best products in the shortest possible time [11].
Various researchers stressed the importance of Systems Engineering as the best approach for handling the configurations of complex products like in Aerospace Industry. Systems Engineeringcombines four concepts: requirements engineering, system modelling, integrated product change management, and quality management to create processes for planning and developing complex products thereby streamlining product development. Systems Engineering allows businesses to plan their entire integrated product creation process and then simulate each step of it as they proceed. Systems Engineering uses the concept of virtual product design in the product's lifecycle. This will help organizations make better planning and feasibility decisions during the product's creation. In addition, by allowing everyone to work from the same set of requirements and collaboratively sharing system models, users from multiple engineering disciplines, e.g. mechanical, electrical, software, can work as a single globally distributed team.

4.3. Agile Configuration Management

Traditional Configuration Management consists of various activities such as identifying configuration items, change management, configuration status accounting and configuration auditing.

Agile Configuration Management is a concept currently receiving much attention, is proposed as an CMdoes not mean to do minimal amount of Configuration Management, instead it minimizes & streamlines the work to carry out the entire Configuration Management tasks which are necessary. It can easily get adapted to the changing Configuration Management requirements. It's a mixture of good CM processes, good CM tools and CM automation. If any one of these fails Configuration Management process cannot be very agile [12].

In the Agile Configuration Management process, changes move through the process as units. Here the CM manager is comfortable in endorsing a change rather than files associated with the change. Thus the change based Configuration Management simplifies peer reviews. A change identifier is enough to identify the change for a review. Many change-based Configuration Management tools will allow producing a report from this identifier. Some of the tools even allow reviewing comments against the change so that the comments are not lost.

In agile environment the process/technology allows organizations to approve a change, by altering its promotion status and nothing else. The technology allows viewing the baseline based on change promotion states and allows automated baseline definitions. Thus with this automation, the views and baseline definitions are made available with slight or no human interference.

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