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An industry approach to shared, cross-organisational engineering change handling - The road towards standards for product data processing

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ABSTRACT

Standards for cross-enterprise communication between systems that actively manage product data and which control the associated workflows – including release and approval processes – have been in industrial use for some time. Experiences gained during the last decade showed that purely data centric approaches, such as supported by IGES, ISO 10303 (STEP) and IFC are not sufficient. Cross-enterprise communication requires not only agreements about data format and semantics, but also about orderly procedures for efficient communication between the stakeholders in a workflow.

This paper presents the background and approach taken for the development of a standard for cross-company engineering change management (ECM), which is currently undertaken as a joint activity between VDA (German Association of the Automotive Industry) and ProSTEP iViP (international association for information integration in industry). Based on the results of this joint activity, which was recently published as SASIG ECM Recommendation V2.0 and as VDA 4965 V3.0, ECM Pilot implementations within member companies were conducted. They proved that a lead-time reduction of the engineering change process of 20%–40% is possible while the quality of the process increases. The approach itself should work not only in engineering change or product data environments, but also in document oriented environments as well as in sectors other than automotive.

The ECM standard provides specifications of reference business processes, including the definition of the participants' roles and the interaction and synchronization ("touch") points where data are communicated. It leverages and builds on other established product data standards wherever possible. Thus, the data model defined by STEP AP214, (Core Data for automotive mechanical design processes) is used to describe the "payload" – i.e. the product data content to be exchanged – at defined synchronization points. OMG's PLM Services provide the framework for sending messages between the stakeholders of an Engineering Change, and business process modelling languages such as e.g. BPEL (Business Process Execution Language), standardized by OASIS, provide the capability to execute the ECM protocol's specification. They ensure the ability to use the latest state-of-the-art internet technologies such as XML and web-services.

1. Introduction

Due to changing market demands and ongoing technological advances, complex products tend to evolve from their original product design. This happens even during product development itself. Changes to technical product specifications are unavoidable, especially for complex products [1], and reflect in part the learning process of professionals during product development.

Empirical studies have provided some figures about Engineering Changes (EC's) in the automotive industry. Ford, GM and DaimlerChrysler conducted in 2005 an internal count of ECs within their supply chain and came up with around 350,000 ECs per year for the three combined. Feedback from each organization about the costs suggest over $50,000 per engineering change. This includes not just hard dollar losses, but also soft/hidden losses such as lost man hours and delays [2]. In [3,4] it is stated that the OEM members of the German VDA (2006) have more than 1,000 change orders per month, with about 7.000 internal and external users involved in commenting. The average process cost per change is 20,000–50,000 Euros (Daimler-Chrysler AG, Mercedes Car Group). Another estimate for the number of orders comes from [5] in which

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the chief engineer of Magna Steyr[1] states that they can have 12,000 engineering changes in one month for one car project.

These examples give considerable figures, justifying the significance of this subject. However, the differences between the reported figures are remarkable. They result partially from different conventions of automotive companies to package changes. Sometimes an EC refers to a change request necessary to address a single problem, but in other cases the term is used as a synonym for ECO (Engineering Change Order). The latter means that change requests are combined into packages or groups of changes. Some companies make only a few but large Change Packages (thus containing a lot of individual part changes) while other companies keep the number of part changes per Change Package small but have a larger number of them.

Furthermore, diverse interpretations of the concept of costs could cause differences in the reported numbers. As an example: the VDA talks only about "process cost", while there are also other costs caused by a change such as the procurement of the modified parts and of tools. A third consideration is that changes counted during series development (before start of production—SOP) will be much higher than during series maintenance (after SOP). Once a car is in production the number of changes decreases significantly because of collecting numerous individual changes into fewer so called "model year change packages". Magna Steyr is mainly concerned with series development. In short, the figures about the numbers and financial volume of ECs in companies stem from different sources that have used different interpretations of concepts.

But one thing is clear: ECs are costly. Moreover, the later they occur, the more significant the time and effort needed to implement them [6,7]. The costs of an engineering change grow by a factor of five to ten as one moves from early design to manufacturing. Typical figures are: Prototype stage: <\$20,000 and after start of production: >\$100,000 [8].

Although ECs form a high cost factor, they are often unavoidable and even necessary to guarantee a high quality end-product. To a large degree they reflect the learning process of professionals in the organization. Focus should therefore not be on attempts to reduce their number or frequency, but on the reduction of costs per change. In particular, all activities that do not add value to the EC process itself should, if possible, be eliminated. Lower costs and time reductions will not only lead to lower overall product development costs and reduced time-to market, but will also encourage developers to increase the EC frequency with, hopefully, a better and more reliable final product. Hence, the improvement of EC will most likely contribute to improved overall Product Lifecycle Knowledge (PLK).

Of course, not all ECs are a result of learning and improvement. Avoidable ECs are for example those due to poor communications, faulty interpretations, missing or late information, and terminology mismatches.

Practically every new insight that results in an Engineering Change invokes a process of redesign, documentation change and related administrative processes. This is an important area where time-consuming, non-value adding activities can be found. The huge number of changes, and the fact that even small changes often result in significant costs and delays in development and production, makes the ability to effectively manage these a key success factor of every product development process [2].

Managing engineering changes across different organizations and disciplines within a single company is a non-trivial task. But today's global engineering environment, in which product development happens in distributed networks involving multiple OEM's, engineering service providers and suppliers (tier 0.5 . . . n), faces even bigger challenges. OEMs and suppliers usually have their own engineering change process and related terminology in place, supported by a wide number of individual workflow and data management systems and specific infrastructures to manage and communicate engineering changes. Thus, every time when change related information crosses company borders, translation and interpretation of data is needed. There is a need for individual ECM processes to communicate across the supply chain using a "universal language" for ECM. This is not the case today.

Currently, the automotive industry deals with multiple ECM systems and supporting processes to communicate changes. These systems include multiple formats and multiple definitions, many of which include manual tasks. All these issues lead to increased confusion, cost and overall inefficiencies in the system. The figures given in this section show that hundreds of thousands of engineering changes take place within the automotive and related industries each year, with each engineering change costing up to EUR 50,000 to process (including direct and indirect costs, but excluding materials and tools). However, the costs of not changing will be quality pitfalls and may cause product/car recalls in the worst case.

Among the high pain points for automotive industry are [2]:

- multiple systems and formats
- multiple definitions and terminology
- multiple processes
- multiple skills sets needed to support multi process/system environment
- missing information
- conflicting changes
- insufficient change tracking
- deficient communication of change to all stakeholders
- manual re-keying of information
- wait time/responsiveness
- confusion
- unauthorized changes processed
- un-reimbursed changes
- translation/interpretation is needed at each point of exchange resulting in costly time and process delays.

A more effective and efficient engineering change management (ECM) procedure may ensure that issues regarding an existing product design are clearly defined and carefully evaluated. It may ensure also that change requests and resulting changes are documented, and that their implementation is controlled throughout the product's life cycle without interrupting the production of existing products.

2. Overview literature

Huang et al. [9] report about an investigation carried out in 1996 within 100 UK manufacturing companies concerning industrial practices in managing ECs. Numerous aspects have been considered including the systems, organisations, activities, influential factors, strategies, techniques and computer aids. Their major concern is the balance between the effectiveness and efficiency of the engineering change management system. The findings reveal that guidelines for good ECM practices are required for most companies involved in the study. The supplier relationships in the European Motor Industry have changed fundamentally in the last 10–15 years due to trends like the reduction of vertical integration, just in time delivery, global sourcing, simultaneous engineering and so on. Suppliers have become much more important for both production and development of more complex components of

[1] Magna Steyr engineers, develops and assembles automobiles for other companies on a contractual basis.