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Structured Product Development Process Implementation for a Packaging Company

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Abstract: This paper describes the analysis of a structured development process (SDP) that takes into account the particular specifications and requirements in the manufacture of packaging machines.
The proposed approach is based on the well known "V-model" approach, which aims to support engineering teams in developing complex systems.

Keywords: system, product, development, engineering, process, requirements, project, workflow, management

1. INTRODUCTION

Complex systems are product integrating very different technologies and expertise fields, such as the mechanical and electrical engineering, the mechatronics and the software engineering. It is thus clear how difficult could be to organically combine all these in a single product while keeping competitiveness both on costs and time to market.

To support such complex systems development, the literature proposes several models. The V-model was chosen to be implemented within the product development process into a Multinational Company leader of the food packaging industry market. The implementation started some years ago and it is in a continuous improvement phase.

The V-Model name comes from the V letter which is used to graphically represent the development process phases through the time.

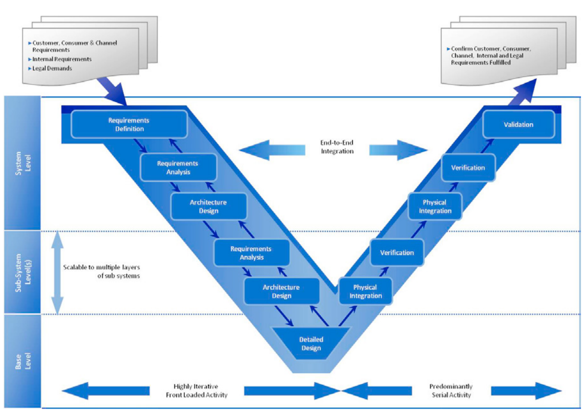

Fig. 1. Example of V-Model

In particular, the left-hand of the V (the descending one) is mainly composed by the requirement analysis and cascade activities, from stakeholder requirements to system, subsystem, module requirements and so on until the desired detail level. Moreover, very important and critical decisions about the system architecture and about the verification and validation criteria are undertaken. The same kind of decisions have to be made at every level, but the root one is the most important because it influences all the decisions at lower levels, it defines a shared vision of the whole system and its features and characteristics. The V peak represents the design activities in their strict meaning, while the right-hand (the V ascending side) is composed by the subsystems verification, system integration, verification and validation activities. The industrial validation and deployment activities are here undertaken as well.

In the graphical metaphor, the descending hand is thicker than the other one. That is to represent that activities have to be undertaken reiteratively in order to minimize error risks. The importance of the decision here taken is so high that, in case of wrong analysis, they could lead to huge money and time losses. Next figure shows an example of the trends for the cost committed and cost incurred curves in a typical Product Lifecycle. As can be seen, about 80% of the cost of the system is committed by the end of Design and Integration, while only about 20% of the actual cost for the system has been spent. Obviously, mistakes made in the front-end of the system lifecycle can have substantially big impacts on the total cost of the system and its success with the users and bill payers INCOSE (2007).

System engineer is the responsible one for the first level analysis and cascade activities, as well as for the system architecture and interfaces definition and for the system verification and validation activities. Thus, he creates a shared vision among project members and coordinates sub-system level teams. Given all this, he is a key figure for every development process.

This paper describes an implementation of the V-model in a real industrial environment. The importance of the paper is therefore, in showing the results related to real cases of industry driven projects in which the V-model design process is actually implemented.

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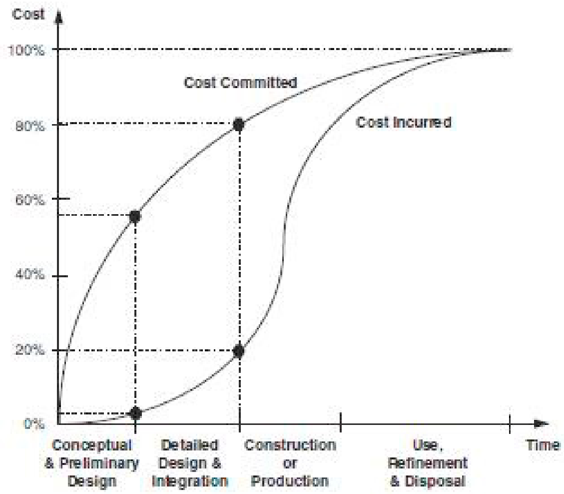

Fig. 2. Cost commitment and incursion in the Product Lifecycle INCOSE (2007)

In the next section the literature about the Systems Engineering principle is briefly described. Afterwards the activity objectives and motivations are explained then process implementation and available tools are shown in order to provide the necessary information to the description of the activities and outcomes that are largely explained in the rest of the paper. Finally next development steps are described as conclusions.

2. RELATED WORK

System engineering receives a great attention in current literature. A good overview on this matter can be found in the INCOSE (International Council on Systems Engineering) Handbook Haskins (2010).

In particular, System Engineering process for structuring work flow and activities related to the development of complex mechatronic artifacts have been studied and presented by several contributors. For example the VDI (the association of German Engineers) published guidelines VDI (2004), Vasić and Mihailo (2008), dealing with the development of a modern mechatronic product in its entirety. In this way it creates an essential basis for the communication and cooperation of experts in the disciplines involved.

Recently, the Guide to the Systems Engineering Body of Knowledge (SEBoK) has been published, Pysteer and Olwell (2013). It provides a compendium of the key knowledge sources and references of systems engineering, organized and explained to assist a wide variety of users. It is a living document, accepting community input continuously, and regularly refreshed and updated.

In Hundal (1997), the author examines the importance of systematic designing and estimating costs during the design process - a time when it can be controlled most effectively. Cost models based on operations, weight, material, throughput parameters, physical relationships, regression analysis, and similarity laws help illustrate the various techniques.

2.1 Systems development life-cycle

The backbone activity of every industrial process that aims to produce an artifact, including mechatronic devices and packaging machines, is formed by the Systems Development LifeCycle (SDLC). SDLC is the process of managing the entire life cycle of a product development from its conception, through design and manufacture, to deployment. It begins from the collection of the stakeholder needs and their translation on system requirements and terminates with the release of a real system. Several SDLC methods for supporting the design of mechatronic systems have been theoretically developed and some of them were subsequently introduced in real applications.

Boggs, in Boggs (2004), presents an introduction on the SDLC methodologies, including the *incremental model*, the *spiral model*, the *Win–win spiral model*, the *V-model* and the *W-model*, concluding by some thoughts on the application of Six-Sigma concept to SDLC.

2.2 Model Based System Engineering

Model-based systems engineering (MBSE) is the formalized application of modeling to support system requirements and architecture development, detailed design, verification and validation activities, beginning in the conceptual design phase and continuing throughout the entire development process, INCOSE (2007). This vision illustrates the use of a singular model, rather than several documents, for capturing requirements, analyzing problems and designing systems.

Many of the MBSE methodologies integrates and improves the traditional SDLC techniques. The main MBSE methodologies are illustrated in the Estefan survey Estefan (2008).

2.3 Conclusion

Market pressures demand that the systems leverage on technological advances to provide a continuously increasing capability at reduced costs and within shorter delivery cycles. The increased capability drives requirements for increased functionality, interoperability, performance, reliability, and smaller size and determined the born of the mechatronic systems. The design and development of these systems requires a multidisciplinary approach through the integration of mechanical, electrical, electronics and software engineering. Each discipline focuses on a particular aspect of the system and exploits different domain-specific models that should be merged and integrated. In order to cope with this situation several tools implementing different capabilities are commercially available and start to have quite a large diffusion among industrial development communities. However, the implementation of tools is not enough to develop performant mechatronic systems, but optimal industrial processes are necessary. In fact, although the importance of innovation is fully realized by most enterprises and they continue to spend more and more on innovation, many of these initiatives do not generate satisfactory profit or competitive advantage, Boston Consulting Group (2006). The problem does not lie in the invention part or the generation of innovative ideas,