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Use of Structured Total Approach in Developing a System for Emergency Power Generation for Aircraft with Fly by Wire

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Abstract. This paper presents a Systems Engineering (SE) approach for development of the Emergency Electrical System (EES) for aircraft with Fly by Wire. After creating the model of the EES and its components relationship, these components were analyzed using the method Total View Framework, which has proved to be an important tool in the design and development of complex products. The proposed method, which includes aspects of the product, the processes and the organization, is justified in light of the failure of performance of traditional project management. In traditional approaches, the inherent complexity in product development is not taken into account. The authors believe this approach will promote the identification of items that meet the requirements related to quality, safety and reliability of multiple factors at the stage of project design.

Keywords. System Engineering, Emergency Electrical System, Aircraft, Fly by Wire

1 Introduction

The contemporary world is characterized by the development of extremely complex technologies and products and, therefore, an increasing number of variables and attributes to meet the requirements. Among the main features that can be mentioned: reliability, security, maintainability, robustness, precision and durability. These technologies and products of high complexity have the outset of the development marked by a need, desire or expectation of the stakeholders, which are defined by requirements.

An important and competitive market of the aviation industry is occupied by vendors of aircraft manufacturers. In many cases a given system can contribute up to 30% of the final cost of the product and subsystems may have an even higher

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technological level of complexity than the product that receives it. This scenario requires strong competition among system suppliers, demanding that you understand fully, the aircraft manufacturer's business, as well as the company operating the aircraft. In this context, this paper discusses the development of an Emergency Electric System (EES) for an aircraft also under development. The model anticipates the needs of the system with the breadth of product lifecycle host, considering the simultaneous development of the aircraft and emergency system.

2 Objective

One of the inspiring aspects of System Engineering (SE) is its applicability across a broad range of industries. This paper aims to present the main concepts of SE, including the Total View Framework, a method for managing the complexity of the relationship among products, processes and organization elements, their interactions, as illustrated in Figure 1, and its application during the development of an Emergency Electrical System (EES).

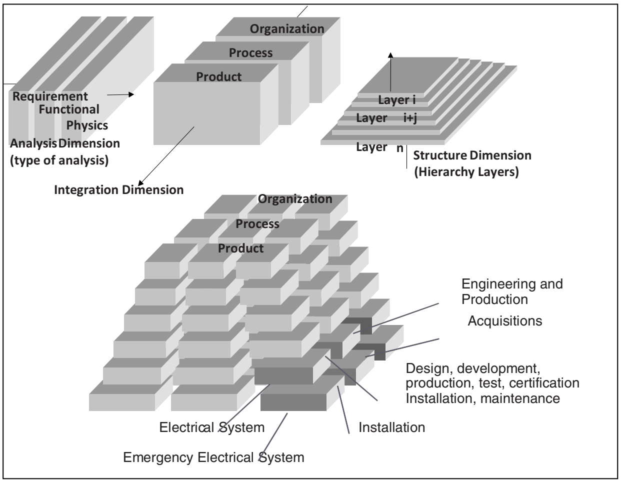

Figure 1. Total View Framework. Source: [5]

3 The Traditional Model

The reference model for comparison, which in this article will be called “The Traditional Model”, is supported in the application cited by [1], in which the focus on the product is clear. An enhancement of the original model was described by [2] who suggests the introduction of new elements in the product design team with the modification of the previous approach procedure.

The reduction of development time with the adoption of teams composed by simultaneity was treated by [3], among others. The performance teams in the environment resulting from the overlap of the development model with the culture of the organization was handled by [4]. The Traditional Model of reference has achieved significant cost and time reduction; however its effectiveness is impaired for major development projects. This model cannot deal with the increased complexity of a new product development, and provide only a partial view of the system elements and their interactions.

The proposed scenario for the model is that a small team colocalized and with great technical ability and authority, can resolve any problems found. In a scenario of large projects, for which a larger number of specialists should interact to find solutions, the communication quality is impaired as well as the effectiveness of actions. The model of total structured approach instrumentalizes the development process with tools to mitigate the problem.

4 Total Structured Approach Model

The sequence of work with The Total Structured Approach Model to the EES is shown in the Figure 2. For each job step it will select a case or scenario that may explain the use of the model.

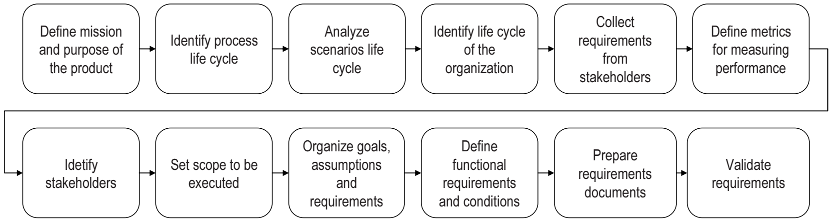

Figure 2. Sequence of Work

The work was based on the methodology of [5] and aims to gather all necessary information in advance for product development through a systemic view of organizational, process and product. The methodology involves analysis of context, stakeholder survey, requirements definition and product architecture. This method allows the analysis of interference and interactions of the Emergency Electrical System (EES) with other aircraft systems.

5 Emergency Electrical System (EES)

Emergency Electrical System (EES) for aircraft must be designed to ensure electrical power enough to a minimum set of equipment enabling the pilot to make the landing maneuver safely. In the Fly by Wire aircraft, the flight control is made of electronic and hydraulic systems. The best technological solution developed is a wind generator, which combines weight with an adequate availability of power proportional to the size of the turbine and aircraft speed. The turbo generator is housed in the body of the aircraft and it is ejected for receiving the air flow when in an emergency situation. The system has a unit called Transformer Rectifier Unit (TRU), which produces electric power in direct and alternating current as required by the manufacturer of the aircraft.

The product mission should establish clearly the function of the product that should guide the actions during the project. For the product analyzed, the mission was well established: "Emergency Electrical System (EES) is capable of generating electrical power in a general emergency scenario of the main system aircraft to keep the minimum functionality of the operation in flight until landing."

5.1 Product Life Cycle Identification

It is very important to have the time to market reduced due to market competitiveness, while maintaining the same quality standard and reducing the product development cost. Facing this scenario, it is worth emphasizing the importance of inter and multidisciplinary activities, with the need for involvement of various functional business areas at the stage of product development.

To perform the product development analysis is important at this stage to deploy a set of processes, with their flow of inputs and outputs. From the complete landscape of the life cycle of the product, it is possible to understand the interactions and the requirements to deploy widely. The Product Life Cycle and its phases, as well as the scope considered in this study are represented on Table 1.

Table 1. Product Life Cycle

Marketing	**Development**	**Production**	**Support**	**Closure**
Technical-commercial proposal	Architecture definition	Production Planning	Correction and improvement	Products and services issue
Negotiation	Supplier definition	Components manufacturer	Maintenance	Products and services acceptance
Engineering alternative	Preliminary design	Assembly	Technical support	Contractual obligations verifications
	Drawing preparation	Electrical Test		Financial obligations verifications
	Qualification documents	Hydraulic Test		Documentation and contractual obligation
	Production guide	Integrated Test		
	Organization	**Production**		

6 EES System Structure Diagrams

This section proposes an approach to analyse the EES life cycle representation through the Structure Diagram, as shown in Figure 3. Functional analysis of the product life cycle processes was made from the IDEF0 diagram that describes the system functionality, control mechanisms and data flows across all functions of the system, highlighting the integration of the whole.

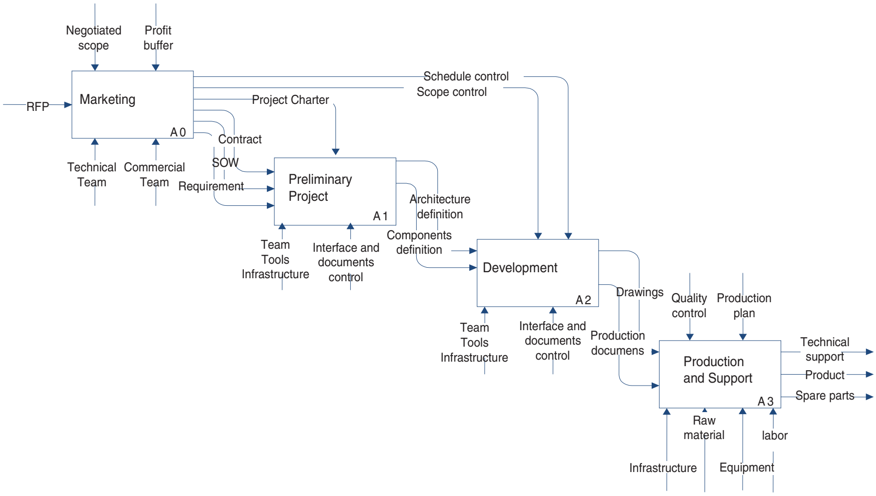

Figure 3. Process - Lifecycle Structure Diagram (IDEF0)

The marketing step involves Project, Proposal Preparation and Negotiation. This step has as input the Request for Proposal (RFP) and as output, loss of the business, a Contract Signed or a Statement of Work (SOW). The preliminary stage includes the Conceptual Definitions, Initial Settings and Joint Definitions phases. The entrance is marked by the Contract and the outputs are: Product Definition, Product Requirements and Work Plans.

After the preliminary design stage there is the Project Development. The development has as input the Detail Design, Construction, Prototype Field Test and Validation Tests, and has as output the Validated Product.

The last stage of the product life cycle is the production and support stage. This stage, which takes as input the drawings, production documents and production plans at the Production Preparation can follow three alternative paths. The Logistics Product phase is the product produced as output. The phase Spare Parts Logistics has as its output, parts sold. And during Engineering Support, the output is characterized by technical information.

7 Stakeholders Analysis

According to [6], stakeholder is any group or individual who affect or is affected by the business of an organization. Therefore, stakeholder analysis, done by a systemic view of the product, process and organization, involves the analysis of all life cycle process performing organization environment, i.e. how product, process and organization can influence the environment in which organization operates. The perfect understanding of stakeholder needs is essential in applying the Systems Engineering concepts.

Organization Traditional models suggest the main function of the firms to maximize the profits and the business return on investment. But, stakeholder theory asserts that organizations need to consider the interests of groups that may affect or be affected by these organizations [7].

In this work the authors considered only the stakeholders whose interests are directly linked to the phases of the Development, Production and Support, among the steps identified in the product lifecycle.

8 Requirements

According to [8], the requirement is a condition to drive a system or component to satisfy a specification, a standard or a contract. Therefore, meeting the stakeholders' needs is a fundamental factor in the product requirements development.

In this paper, all the demands of the stakeholders have been translated into technical requirements to ensure meeting their needs. Firstly, the authors structured the Measures of Effectiveness analysis, as indicated in Table 2. Effectiveness Measures aimed at assessing the level of stakeholder satisfaction, and from these measurements, the product and organization can be evaluated.

Table 2. Measures of Effectiveness - Stakeholders Product Operation

Stakeholders	**Interest**	**Measures of Effectiveness**
Passengers	Reliable and safe product	Product reliability (failure rate)
Crew	Reliable and safe product Ease operation High dispatchability	Product reliability 1 min between reading the instruction and operation SR - Schedule Reliability
Insurer	Premium reducing	Risk of loss
Customer: Aircraft carrier	EES to provide safe landing	Success landing rate in EES operation

From the Measures of Effectiveness analysis, the requirements were defined.

All stakeholders' requirements must be grouped, organized and classified. It is important that the requirements established from stakeholders needs are temporary, as there are many factors that contribute to change them throughout the product life cycle. Considering the requirements process analysis as a static is just a big mistake [9]. Therefore, the requirements should be reviewed, corrected, changed, and revalidated continuously.

9 System Functional Analysis

In this section the EES system will be analysed according to their functions and interactions with other plane system interfaces. To model the product functional analysis, a Data Flow Diagram (DFD) was used. The DFDs of Product in operation is represented by Figure 4.

Figure 4 presents a context diagram that shows the elements of the environment for the product or organization. The arrows represent the flow of data, materials or energy. The direction of the arrows represents these elements into or out of the product or organization.

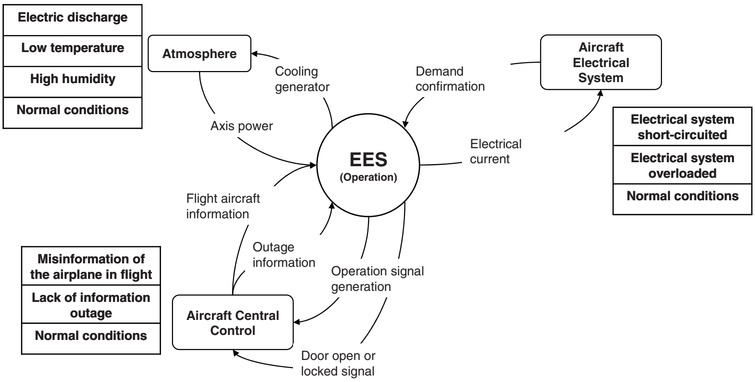

Figure 4. Product Operation Functional Diagram

For the product in operation, the system operation modes, the operating conditions, the states and the environmental factors identification are shown in Table 3.

Table 3. Operation Modes, Operating Conditions and Identifying of the Environment Elements of Product in Operating

	Modes	
	In flight - electrical malfunction	In maintenance
	Condition	
	Operational	Non Operational
Environment	**State**	
Aircraft electrical system	Short circuit or overload	Short circuit or overload
Atmosphere	Special conditions (electrical discharge, low temperature, high humidity)	Normal conditions
Aircraft Central Control	Wrong information Lack of information	Normal conditions

According to [5], from the technical requirements, you can do the functional analysis and develop functional product architectures and organization that are fundamental to the physical analysis.

In the physical analysis, the product and the organization physical architecture are identified and developed. The architectures provide functional and physical elements, their decompositions, and internal and external interfaces, which represent the process of requirements defining alternatives.

The need of a manual override was raised in the setting of electrical failure in flight with open failure information.

The system also features a standalone unit that provides locking and ejection of the turbo generator that can be triggered manually or with systemic identification of severe power problem. The system must meet the requirements of the approved body, in which the host aircraft will operate.

10 Conclusions

This paper has as main objective to show the importance of the systemic approach, stakeholder analysis, their interests, needs and expectations, and the anticipation of life cycle process requirements necessary to meet their needs in the development of a project.

Traditional methods applied to product development also address relevant issues, but are too much focused on product operation and development, overlooking the other crucial life cycle processes necessary to meet the expectations of stakeholders. The method presented in this paper provides a structured and integrated approach to complex product, its life cycle processes and their performing organization integrated development.

The conclusions are that the method, used to suit the environment of product development, provides a way to overcome the deficiencies of traditional planning, it is feasible, produces good results, especially when covered with high complexity, performs the unfolding of the requirements to the level of components from suppliers and ensures the integration of the solution and treatment of internal and external requirements in the organization, processes and product.

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