A Brief Study of some Causes of Unavailability of Components and Services over the Lifecycle of an Aerospace Project

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Abstract: Aerospace projects are increasing their lifecycles up to the point where a product is developed to be available in the market for more than 70 years, but requiring daily service support and replacement parts. Therefore, unavailability of components or services can have a severe impact over the product through its lifecycle. In this work we perform a brief study of some causes of unavailability of components and services over the lifecycle of an aerospace project found in the literature, as part of a work in progress to: 1) analyze each one of these causes and their effects; 2) propose recommendations, alternatives and actions to be taken in the early phases of project development; 3) help mitigate such effects over the product lifecycle. To do that, we present: 1) a few basic definitions and concepts; 2) a case of an aeronautical project with increased lifecycle; 3) some causes of unavailability of components and services; 4) discuss the Technology Evolution in some detail, as a cause of unavailability of components that could have a considerable effect over the lifecycle of an aerospace project; 5) some future directions and conclusions. This study intends to help in developing future requirements to guarantee that all the objectives of the project are accomplished on time, with high quality level and with no addition on its cost over the product lifecycle.

Keywords: *Aerospace Project, Avionics, Component Unavailability, Service Unavailability, Component Obsolescence, Technology Evolution.*

1 Introduction

The projects from the aerospace industry are very expensive and time consuming, when compared with projects from other industry segments, such as automotive, heavy mechanics or electro-electronics, mainly due to its needs for especial researches and developments. On the other hand, even when its market demand is high, the production capabilities of the aerospace industry are normally limited. Therefore, the companies that invest in aerospace projects know that these projects are considered long term investments, because the aerospace projects require time in the market for reaching its project breakeven point and then start bringing some profit back in return. An example for illustrating such fact comes from Dr. Steven Udvar-Hazy's assessment of the Boeing B787 Project profitability return at the International Society of Transport Aircraft Trading Conference-ISTATC held in Scottsdale, Arizona, USA in March of 2011, where he said that Boeing will need to sell at least 1,500 B787 aircraft to breakeven after more than 3 years of delays in the project development phase.

The past has shown to the aerospace industry that, once a product is well accepted by the market, it is interesting to stretch its lifecycle time up to the maximum point of profit return from such product. However, the aerospace industry also knows that keeping a product available in the market for long time - sometimes even longer than its original lifecycle time - will require some additional investments on the product along its lifecycle for solving issues that will occur, especially through the operation phase of the product lifecycle. Within the issues that will occur through the operation phase of the product lifecycle are the unavailability of components and services.

Motivated to understand these issues better, this paper presents a brief study of some causes of unavailability of components and services over the lifecycle of an aerospace project found in the literature, as part of a work in progress to: 1) analyze each one of these causes and their effects; 2) propose recommendations, alternatives and actions to be taken in the early phases of project development; 3) help mitigate such effects over the product lifecycle.

2 Basic Definitions and Concepts

Reliability is a metric that represents the probability that a component, device, system or service will perform a required function, under stated conditions for a stated period of time. It is stated in statistical terms, as a probability, which reflects the fact that failures occur at unpredictable times.

Maintainability is a metric that represents the probability that a component, device, system or service will be retained in or restored to operational condition in a specified period of time with prescribed procedures and resources.

Availability is a metric that represents the probability that a device or a component, device, system or service is capable of performing its required function at a given time.

The availability of a system in operation clearly depends on both, the **reliability** and the **maintainability** of the system, according to Table 1.

Table 1 – **Relationships among reliability, maintainability and availability.** Source: Weibull.com (2011).

Reliability	Maintainability	Availability
= Constant	▼Decreases	▼Decreases
= Constant	▲Increases	▲Increases
▲Increases	= Constant	▲Increases
▼Decreases	= Constant	▼Decreases

Most part of this paper will work with the term **unavailability** of component, device, system or service. This term is the inverse of the availability. Therefore, **unavailability** shall be considered as a metric that represents the probability that a component, device, system or service is not capable of performing its required function at a given time.

3 A Case of an Aeronautical Project with Increased Lifecycle

In the 2010 Winter Simulation Conference held in Baltimore, Maryland, USA, Dr. Simon Bradley the EADS Vice-President for Global Innovation Network, Systems & Product Architecture & Engineering mentioned the Airbus A300 as the first wide-body twin-aisle commercial aircraft, which Program was launched in 1972, and had its production stopped in 2007. According to Mr. Bradley, the Airbus A300/A310 Long Term Support Team is expected to support the A300 on a daily service support and replacement parts until 2050. This gives a total of 78 years of lifecycle to the Program. Similarly, according to Airbus Industries, the constant evolution of designs across the family, along with the integration of new technologies and materials, has ensured that the A300 has maintained levels of economic and operational performance to attract new customers and generate airline profits well into the 21st century.This is an excellent case of an aeronautical project with increased lifecycle, subject to the causes below.

4 Some Causes of Unavailability of Components and Services

A life-critical aerospace project, such as an airplane can face several kinds of causes of unavailability of components and services that, if not very well managed by all the stakeholders of the project, will affect the availability of the aerospace product, in one of its lifecycle process phases. For example, the unavailability of a Data Concentrator Computer, which is an essential part of the Avionics System Architecture of any aircraft, could affect the dispatchability of an aircraft in the field, therefore affecting the maintainability metric of the overall system and then affecting the aircraft availability. Or the unavailability of a Transponder Radio with its required tests and inspections approved, due to issues on the services offered by a contractor, could make the airline to dispatch the aircraft with its transponder listed in the MMEL (Master Minimum Equipment List) if applicable, and by the permitted period of time. Then, after such period, if a tested and inspected unit is not provided, the aircraft operation may have its maximum ceiling operation limited to a determined altitude depending on the aircraft model. Per requirements, transponders radios are not essential equipments onboard for Air-Transport and Regional (ATR) aircraft, but the aircraft cannot be dispatched with a transponder on without having it attending its tests and inspection requirements, as stated by FAA: "*14 CFR part 91, section 91.413 requires that, before a transponder can be used under 14 CFR part 91, section 91.215(a), it shall be tested and inspected within the preceding 24 months*".

As the number of causes of unavailability of components and services on life-critical aerospace projects are extensive, the objective of our work in progress will present and discuss the causes of unavailability listed below.

- Technology Evolution
- Airworthiness Directives
- Marketing Part Obsolescence
- Tools Obsolescence
- Political Impediments
- Formation of Supplier Oligopolies

But, in this paper, only the Technology Evolution will be covered in the following subsections.

4.1 Technology Evolution

Usually the Technology Evolution on aerospace projects can happen in three different ways, where the first two are: 1) Market Trends; 2) Technology Lead of certain functionality. They are requirements normally proposed by the stakeholders of the aerospace product to create a differential of its product while compared against its competitor's product in items as: overall aircraft levels of economies, operational performance, system reliability and maintainability, etc. The third one is 3) Mandatory Authority Regulations is related to requirements imposed by the International Aviation Agencies around the world, such as the American Federal Administration Agency (FAA), the European Aviation Safety Agency (EASA), or the Brazilian National Civil Aviation Agency (ANAC), which asks the aircraft stakeholders for an especial function improvement or new required design for improving the overall safety and security aspects for the passengers, aircrew or airspace.

Examples of 1) Technology Evolution due to Market Trends are: the development of composite material parts, new wingtips for improving the operational performance of the aircraft, or the replacement of the Cathode Ray Tube Displays by Liquid Crystal Displays for improving the overall system reliability and maintainability. Examples of 2) Technology Evolution due to Technology Lead are: the development of engines that can operate with diverse fuels, to offer aircrafts with better flexibility and operational costs, providing better levels of economies for the operators.

This paper will focus on the Technology Evolution due to 3) Mandatory Authority Regulations for an especial function improvement or new required design, because when the stakeholders of the project are not capable of demonstrating compliance with it, the International Aviation Agencies can prevent the airline from operating the aircraft over certain airspace, due to the unavailability of the new technology.

An example of 3) Mandatory Authority Regulation is the publication of European Commission Regulation (EC) No.29/2009 on January 16 2009 made by EASA in conjunct with Eurocontrol that required the implementation of Controller Pilot Data Link Communications (CPDLC) function to all the aircraft operating general air traffic IFR in the European Airspace above Flight Level 285, to alleviate the voice channel congestion, therefore improving the safety of the European Airspace and the Traffic in european airports.

Figure 1 shows the EASA timeline schedule for airlines that operates in Europe to demonstrate compliance with European Commission Regulation (EC) No 29/2009. The EASA plan for the CPDLC mandate stated that aircraft with the certificate of airworthiness first issued on or after January 1, 2011 operating general air traffic IFR in European Airspace had to be equipped with data link capabilities by January 1, 2011, while the aircraft with airworthiness certificates issued before January 1, 2011 must be equipped with the data link capabilities by February 5, 2015.

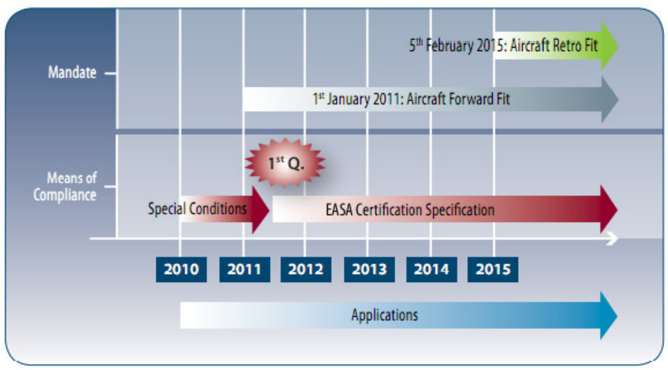

Figure 1 – The original EASA timeline for airlines to demonstrate compliance of CPDLC Implementation. Source: Eurocontrol (2011).

The CPDLC mandate is part of the Eurocontrol LINK 2000+ Programme, which also requires improvements in the European Air Traffic Control (ATC). Currently, they are operational only in a small area of the European Airspace (Figure 2) . Its west side and east side are expected to be fully operational by 2013 and 2015, respectively.

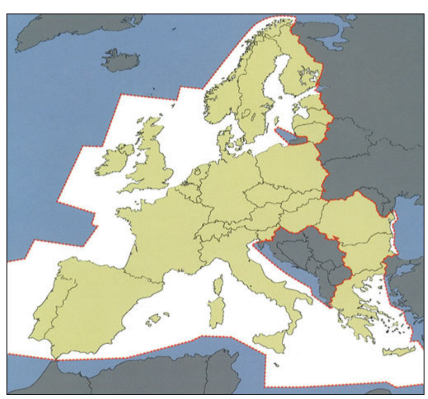

Figure 2 –The designated European Airspace which requires compliance with the EC No 29/2009. Source: Spectralux™ Avionics (2011).

Per the mandate definition, the airlines seeking Data Link Services Airworthiness and Conformance to European Commission Regulation (EC) No 29/2009 but that are not capable of demonstrating compliance with it, will not be allowed to operate above the Flight Level 28.500 ft. Such limitation would force most airlines to start elaborating a plan for replacing its fleet of airplanes with such limitation, for new models of aircrafts which complies with the EC No 29/2009.

5 Some Future Directions

The future objectives of the work in progress are to study the other five (5) proposed causes of unavailability of components and services and their effects over the lifecycle of an aerospace project, to propose recommendations, alternatives and actions to be taken in the early phases of project development to help mitigate such effects over the product lifecycle, and their sufficiency.

6 Conclusions

This paper presented a complete example of unavailability of a component, which could have a considerable impact over the lifecycle of the product. Based on what was presented we can conclude that, during the whole lifecycle of an aerospace project there will be many situations that, if not well managed by the stakeholders of the project, could end up causing the unavailability of a component, device, system or service, and then affecting the availability of the final product. To anticipate such situations and promptly address the best possible solutions before having an effect over its components, devices, systems or services, it is required to have robust process with recommendations, alternatives and actions to be taken in the early phases of project development to help mitigate such effects over the product lifecycle.

In the work in progress we intend to understand better the six possible causes of unavailability of components, devices, systems or services presented in Section 4, to analyze its effects and to propose recommendations, alternatives and actions to be taken in the early phases of project development that could help mitigate such effects over the product lifecycle, and their sufficiency.

This is intended to help in developing future requirements to guarantee that all the objectives of the project are accomplished on time and with no addition on its cost over the product lifecycle.

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