# Development Model for a Legacy Software Supporting Cabin Operation

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***Abstract.*** *Pilots have to follow procedures, perform checklists, receive and register some pieces of information, and perform many calculations. To facilitate some of these tasks, Electronic Flight Bags (EFBs) are developed to be used by pilots inside the cabin. Software Quality Assurance (SQA) is a vital discipline in software development, ensuring that software meets quality requirements through various activities such as testing, reviews, and adherence to established standards. This paper presents the current status of research that will propose a new software development model for legacy EFBs.*

## 1. Introduction

The primary objective of aviation is to transport people from one place to another safely. The significance of safety in aviation arises from the inherent risks associated with operating an airplane, which can result in numerous fatalities and substantial economic losses. To mitigate these undesirable consequences, aviation authorities enforce a set of stringent regulations [Marques and Yelisetty 2019].

Software Quality Assurance (SQA) is a vital discipline in software development, ensuring that software meets quality requirements through various activities such as testing, reviews, and adherence to established standards [Fernandes and França 2015].

Given that safety is of paramount concern in aviation, every aspect of an airplane must adhere to a rigorous set of regulations. These regulations encompass hardware components such as hydraulic systems, as well as software components like avionics [Marques and Yelisetty 2019]. Regarding software, the primary aeronautical standard adopted over the past 30 years to ensure the development of high-quality and safe embedded software is RTCA DO-178C [RTCA 2011].

## 2. Problem Characterization and Proposed Solution

Operating an airplane is a complex task. Pilots have to follow procedures, perform checklists, receive and register some pieces of information, and perform several calculations. To facilitate some of these tasks, Electronic Flight Bags (EFBs) are developed to be used by pilots inside the cabin, as showed in Figure 1.

EFBs are essentially a piece of hardware not embedded in the airplane - usually an iPad®- that runs an application related to an airplane operation task. Pilots are the final user the EFB is developed for.

For decades, EFB applications have been developed to support airplane operations. Consequently, many regulations came into place to define EFB's scope and hardware specifications. However, there were no software development criteria for EFBs until 2021, when EUROCAE released its ED-273 entitled "Minimum Operational Performance Standards for Electronic Flight Bag (EFB) Application" [EUROCAE 2021]. Regarding software development, ED-273 specifies a set of objectives such as a Software Development Plan, Requirement validation, Software architecture, and Test. Despite being less critical to flight safety than Airplane Embedded Software, EFBs now have their standard to ensure product quality.

In this scenario, there are two active standards for developing aviation software: the well-established embedded software, RTCA DO-178C, which has been through four versions since 1982, and the other is specific to EFB, EUROCAE ED-273, introduced in 2021.

The aviation industry may be interested in aligning software development processes with only one of these standards, and, in this case, the legacy of RTCA DO-178C holds significant importance within the industry. Therefore, this master's research aims to address the following research question: **Is there a subset of RTCA DO-178 objectives that could be used to show full compliance with EUROCAE ED-273?** Based on the research question, our research hypothesis is **There is a subset of RTCA DO-178 that can be used to show compliance with EUROCAE ED-273 but not full compliance.**.

The objective of this research is to propose an EFB development model that aviation software manufacturers can use for legacy EFBs to comply with EUROCAE ED-273, adapting an established RTCA DO-178C process. The importance this research gives to legacy EFB software comes from the fact that most of EFBs has been developed before EUROCAE ED-273.

The software development model is the outcome of this research and will be composed by three components: the first is the subset of RTCA DO-178C objectives that can be used to show partial compliance with EUROCAE ED-273, the second is a method of showing compliance with EUROCAE ED-273 remaining objectives and finally the third is an approach to deal with a legacy software development history.

**Figura 1. A pilot interacting with an EFB software in an iPad®**

## 3. Methodology

Five steps were identified in the methodology. Figure 2 presents the methodology in a flowchart. Steps 1 and 2 were already performed, and Step 3 was in progress when this paper was submitted.

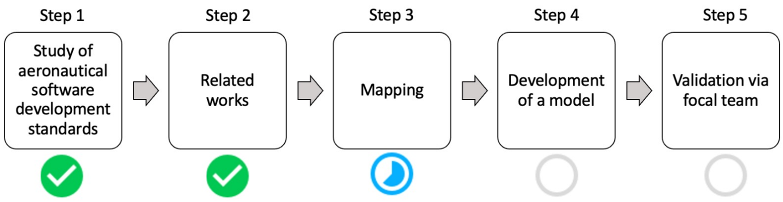


**Figura 2. Research methodology flowchart**

In Step 1, the aviation software development standards (RTCA DO-178C and EUROCAE ED-273) were studied. In this step, it was collected all information on such standards and tried to find common aspects between them.

Inside Step 2, the related work was identified. Because a mapping process between EUROCAE ED-273 and other aeronautical software standards will be performed in Step 3, the goal of Step 2 is to understand how to perform the mapping task. Consequently, some related works that also performed different mapping were selected. Step 3 is an important part of the research, and it identifies which aspects of EUROCAE ED-273 are already contemplated in RTCA DO-178C.

Step 4 focuses on the development of our main contribution to the research. The model will be composed of three elements: the subset of RTCA DO-178 that could be used to show partial compliance with EUROCAE ED-273 objectives, a method to address directly EUROCAE ED-273 remaining objectives, and a proposal to address the future modifications of legacy EFB software. Finally, inside Step 5, the model is evaluated by a focal team composed of experts in aviation software development with good knowledge of software standards for this field.

## 4. Background

### 4.1. RTCA DO-178C

According to [Rierson 2013], since the first version (1982), the goals of RTCA DO-178C were to promote the safe implementation of aviation software and to provide clear and consistent ties with the system and safety processes.

One important concept regarding RTCA DO-178C is the five Development Assurance Levels (DALs). According to the standard, a software risk assessment has to be done to evaluate the contribution a failure in the software will cause to the system. The DAL A is the most critical, while the remaining DALs (B, C, D, and E) progressively eliminate objectives based on the safety impact that software malfunctions can cause to the aircraft.[Marques and Yelisetty 2019]. The 71 objectives of the RTCA DO-178C are organized by DAL. There are objectives for development, verification, configuration control, and quality assurance [Marques and Cunha 2017].

### 4.2. EUROCAE ED-273

EUROCAE is an international organization in charge of developing standards for airborne equipment. In 2019, Working Group 106 (WG-106) studied and proposed the first standard for EFBs, EUROCAE ED-273, released in 2021.

The necessity for creating a standard came from the fact that the increasing number of EFBs applications became a challenge for aviation authorities such as the Federal Aviation Administration (FAA) in the USA, the European Aviation Safety Agency (EASA) in Europe, and *Agência Nacional de Aviação Civil* (ANAC) in Brazil to evaluate and approve them [EUROCAE 2021]. Despite many regulations created before to evaluate hardware components, EUROCAE ED-273 was the first to evaluate software aspects such as function suitability to EFBs, human-machine interface, development assurance, and security.

Similar to RTCA DO-178C, EUROCAE ED-273 also requires a risk assessment to evaluate the application. When this assessment is performed, the application receives one of the two possible Function Qualification Level (FQL): Low or High. Each FQL contains a set of objectives to be accomplished and registered by the development team according to the application FQL.

### 4.3. Related Works

In his study, Ferreirós & Dias (2015) evaluated the distance between CMMI-DEV 1.3 software maturity model and RTCA DO-178C. The purpose of such evaluation was to identify the gaps a software company compliant with CMMI-DEV 1.3 has to dedicate its effort to becoming an embedded software provider. The authors concluded that, despite having some points in common, RTCA DO-178C requires specific technical aspects that are out of CMMI-DEV 1.3 scope, like Verification of Verification Process Results.

A study to find a universal software safety standard was performed by Bhansali (2005) . This author read about 16 critical software standards and identified the 23 fundamental concepts behind them. The work presents and justifies each one of these concepts.

A comparison of means of compliance for Onboard Software Certification was performed by Yan (2009) . In the article, the author explained that despite being adopted as a means of compliance with certification regulation, RTCA DO-178C is not theoretically the only means.

## 5. Preliminary Results

The mapping between what EUROCAE ED-273 requires and what other standards require is still in progress. However, some relationships between these standards have already been found. In this section, two of them are presented.

### 5.1. Development Plan

EUROCAE ED-273's requirement 039 states that a development plan shall be defined. According to EUROCAE ED-273's recommendation 032, a development plan should describe software development methodology and processes, configuration management processes, quality assurance processes, and development environment, including framework and tools. Objectives from 1 to 4 found in RTCA DO-178C are equivalent to what EUROCAE ED-273 requires by "Development plan - minimum considerations".

### 5.2. EFB Function Operational Requirements Definition

EUROCAE ED-273's requirement 044 demands that all applicants have to define function operational requirements. There is not a RTCA DO-178 objective that matches such a requirement. After all, operational requirements define what the EFB is expected to perform, and according to Rierson (2013) , this would be similar to system requirements outside the scope of RTCA DO-178C. Figure 3 summarizes what was presented in this section.

| EUROCAE ED-273 | | | | MAPPING | | |
|---|---|---|---|---|---|---|
| Requirement ID | Requirement Title | Recommendation ID | Recommendation content | STANDARD | ITEM | COMMENT |
| REQ 039 | Software Development Plan – minimum consideration | REC 032 | Software development methodology and processes | DO-178 | Table A-1 Objectives 1-4 | Software Development Plan |
| | | | Development environment including framework and tools | | | |
| | | | Configuration management processes | | | Software Configuration Management Plan |
| | | | Quality assurance processes | | | Software Quality Assurance Plan |
| REQ 044 | EFB Function Operational Requirements Definition | REC 037 | The operational context | NA | NA | Not applicable |
| | | | The supported operational environment | | | |
| | | | Behaviour in normal and degraded operating conditions | | | |
| | | | The inputs entered by the user or acquired from other sources | | | |
| | | | Non-functional requirements | | | |

**Figura 3. Relation between two EUROCAE ED-273's requirements and other aeronautical standard**

## 6. The Development Model

As stated previously, the development model will be composed by three elements: a subset of RTCA DO-178 objectives that could be used to show partial compliance with EUROCAE ED-273, a method to directly address EUROCAE ED-273's remaining objectives, and an approach to deal with legacy history.

Once the research is still in progress, the development model is not finally concluded. However, a small exemplification of the model can be presented. The model will assume that an existing RTCA DO-178 compliant process is running in the applicant organization. This process will be adapted so that a new DAL will be created to represent an EFB compliant with EUROCAE ED-273. Therefore, the subset of RTCA DO-178 objectives that could be used to show partial compliance with EUROCAE ED-273 will be applicable to this EFB's DAL. For instance, according to Figure 3, there will be an indication in the adapted RTCA DO-178 process stating that the new DAL has to comply with RTCA DO-178 Table A-1 Objectives 1-4.

We have already found some EUROCAE ED-273 objectives that do not find an equivalent objective in RTCA DO-178, as Figure 3 shows. In this case (i.e. EFB Function Operational Requirement Definition), it is been evaluated a method to write and validate this type of requirement. The method is still not defined.

## 7. Final Remarks and Next Steps

As Figure 2 shows, the current step of the research is the mapping creation from EUROCAE ED-273 to RTCA DO-178C. When this step is finished, the next is model development that can deal with EUROCAE ED-273's objectives not traceable to other standards and a proposal to deal with aspects related to legacy applications. The final step is to create a focal team of aviation software specialists to evaluate the development model.

The initial findings from this research further support the hypothesis that the final model will closely resemble RTCA DO-178C. Should the research validate this hypothesis, the possibility of establishing a new RTCA DO-178C DAL specifically for EFB development emerges.

It is important to mention that most parts of aviation manufacturers have their EFBs. Because those aviation manufacturers already have an organizational software development process to comply with RTCA DO-178C, the proposed model will benefit them because it would be much easier to adopt an RTCA DO-178C organizational process than to create a whole new process.

For EFB software developers who do not comply with RTCA DO-178C, the results obtained by this research will at least guide them in creating their process. The scientific and technological contributions of this research include: 1) The mapping with traceability between EUROCAE ED-273 and RTCA DO-178C; and 2) The proposed model. A video explanation of this paper is provided on https://youtu.be/AVsI-7jvS5w.

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