A RTCA DO-178C oriented method to develop Electronic Flight Bag Software

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Abstract. Operating an airplane involves many complex tasks, but Electronic Flight Bags (EFBs) have significantly helped reduce pilot workload and improve performance. EUROCAE published the ED-273 standard in 2021 to guide EFB development, raising concerns among manufacturers about meeting new requirements. RTCA DO-178C, a well-established software standard, offers guidance for developing embedded systems. This paper proposes using existing RTCA DO-178C processes to comply with ED-273 for EFBs. Key contributions include mapping the two standards, developing a compliant approach, and evaluating it with expert input.

Resumo. Operar um avião envolve muitas tarefas complexas, mas os Electronic Flight Bags (EFBs) têm ajudado significativamente a reduzir a carga de trabalho dos pilotos e melhorar o desempenho. Em 2021, a EUROCAE publicou o padrão ED-273 para orientar o desenvolvimento de EFBs, levantando preocupações entre os fabricantes sobre como cumprir os novos requisitos. A RTCA DO-178C, um padrão de software já bem estabelecido, oferece diretrizes para o desenvolvimento de sistemas embarcados aeronáuticos. Este artigo propõe o uso dos processos existentes da norma RTCA DO-178C para atender às exigências do ED-273 para EFBs. As principais contribuições incluem o mapeamento entre os dois padrões, o desenvolvimento de uma abordagem compatível e sua avaliação com a participação de especialistas.

1. Introduction

Electronic Flight Bags (EFBs) were developed to simplify pilots' tasks. Most of these applications are developed for iPad® and adopted almost universally as an EFB device. Some EFB application domains include takeoff and landing performance calculation, weight and balance, airport navigation, moving maps applications, briefing, flight planning, and replacement of paper manuals. Figure 1 presents a pilot interacting with an EFB.

The growing popularity of EFBs stimulated the emergence of many EFB manufacturers and the increasing number of EFB application domains. In 2021, EUROCAE published the standard ED-273 for developing EFBs and introduced some requirements related to software development assurance, and made EFB manufacturers concerned about how to follow the new requirements. On the other hand, a 30-year-old software standard, the RTCA DO-178C, establishes considerations for developers, installers, and users when designing embedded equipment using aeronautical software. Several aircraft manufacturers have well-established RTCA DO-178C software processes. We believe it would

be very beneficial for organizations with an RTCA DO-178C compliant process to take advantage of it to comply with the new ED-273. Our work proposes to create an EFB development approach that is compliant with ED-273 guidelines but uses the original RTCA DO-178C processes defined by the aircraft manufacturer. A mapping between the two standards was performed. The development approach was thoroughly assessed by a panel of highly experienced experts in aeronautical software. The main contributions of this paper are (i) the mapping between EUROCAE ED-273 and RTCA DO-178C, (ii) the development approach, and (iii) the evaluation processes defined and executed with the participation of 5 experts in RTCA DO-178C or EFB software development.

2. Related Work

As previously mentioned, the software development for embedded software is already standardized in aviation through the use of RTCA DO-178C [RTCA 2011] and its supplements. Recent works have discussed advances and new software development methods in this field. The authors of this work identified and grouped related works into 6 (six) themes:

- Impacts on the transition from RTCA DO-178B to RTCA DO-178C [RTCA 2011], as explored in the works of [Marcil 2012] and [Youn et al. 2015];
- Model-Based Development, as explored in the works [Marques et al. 2012], [Paz and Bousaidi 2016] and [Sarkis et al. 2020];
- Use of Agile Methods in Software Development, as explored in the works [VanderLeest and Buter 2009] and [Marsden et al. 2019];
- Formal Verification, as seen in the works of [Moy et al. 2013] and [Marques and Cunha 2017];
- Aircraft Embedded Software Loading, as reported in the works of [Marques et al. 2019] and [Marques et al. 2021];
- Mapping between standards, models, and norms with a focus on safety, as reported in the work of [Bhansali 2005], [Ferreirós and Dias 2015], [Marques and Cunha 2015] and [Marques and Cunha 2017];
- Alternative methods of compliance with RTCA DO-178C, as reported in the works [Marques and Cunha 2013], [Marques and Cunha 2019a], [Marques and Cunha 2019b] and [Marques and Cunha 2018].

3. Development approach

The development approach, which is the main contribution of this research, is presented in Figure 2. Before executing any Task from Figure 2, a question about having or not

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

an RTCA DO-178C compliant process must be answered. All the Tasks from 1 to 6 presented in Figure 2 and this Section are to be executed only when there is an RTCA DO-178C compliant process. When the EFB applicant does not have an RTCA DO-178C compliant process, he/she must submit to his/her regulator an EUROCAE ED-273 compliant process. In this case, creating such a process is out of the scope of this research, even though the applicant could be inspired by the content presented here.
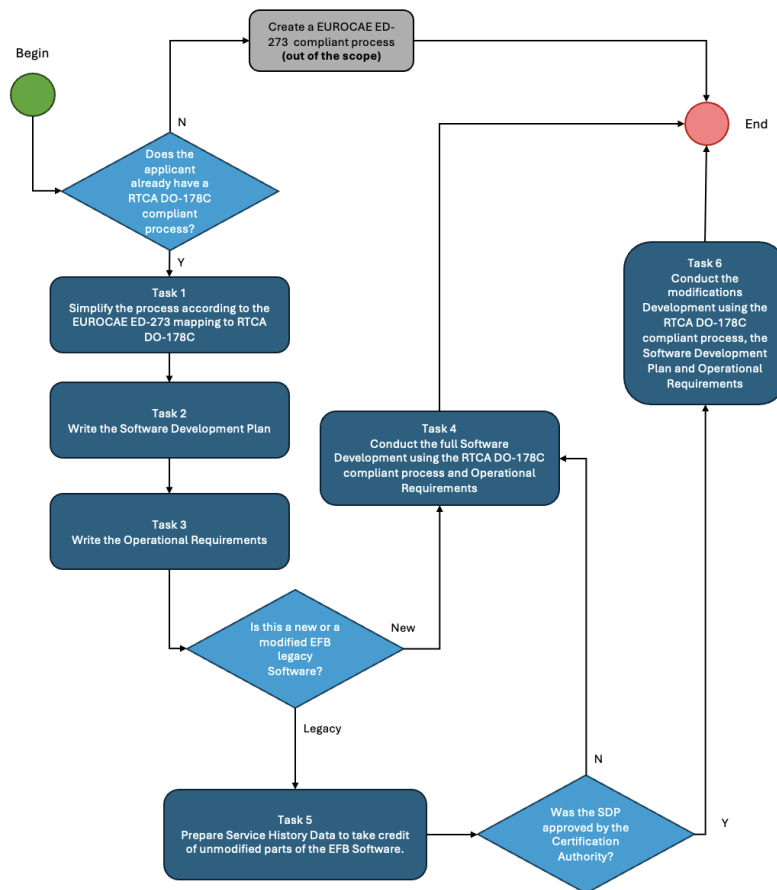

Figure 2. Development flowchart

The mapping between EUROCAE ED-273 and RTCA DO-178C provides a structured approach to ensure that airborne software meets the required safety levels. Figure 3 illustrates an example of mapping created in this research.

4. Evaluation

The focal team comprised five experts in software domain areas like RTCA DO-178C, software certification, and EFB development. Each focal team expert answered five questions related to the proposed development approach. Therefore, a total number of 25 answers were provided by the focal team. The results obtained by the focal team experiment suggest the experts accepted the approach as valid. The answered questions were the following:

- Did you understand the research context?

EUROCAE ED-273					DO-178C		
	Development process objective		FQL allocation		Table	Objective	Activity
	Section	Description	High	Low			
Software development	2.4.2.3.1	EFB Function software requirements definition	x		Table A-2 Software Development Process	1- High-level requirements are developed	5.1.2.a, 5.1.2.b, 5.1.2.c, 5.1.2.d, 5.1.2.e, 5.1.2.f, 5.1.2.g, 5.1.2.j 5.5.a
						2-Derived high-level requirements are defined	5.1.2.h, 5.1.2.i
	2.4.2.3.2	EFB function software requirements validation	x		Table A-3 Verification of Outputs of Software Requirements Process	1- Software high-level requirements comply with system requirement	6.3.1
						2-High-level requirements are accurate and consistent	6.3.1
						3-High-level requirements are compatible with target computer	6.3.1
						4-High-level requirements are verifiable	6.3.1
						6-High-level requirements are traceable to system requirements	6.3.1
	2.4.2.3.3	EFB function compliance with software requirements	x		Table A-6 Testing of Outputs of Integration Process	1- Executable Object Code complies with high-level requirements	6.4.2, 6.4.2.1, 6.4.3, 6.5
						2-Executable Object Code is robust with high-level requirements	6.4.2, 6.4.2.2, 6.4.3, 6.5
					Table A-7 Verification of Verification Process Results	1-Test procedures are correct.	6.4.5
						2-Test results are correct and discrepancies explained.	6.4.5
						3-Test coverage of high-level requirements is achieved.	6.4.4.1

Figure 3. Mapping from EUROCAE ED-273 to RTCA DO-178C

- Do you consider that you received enough information to evaluate the approach with strict criteria?
- Is the approach correct? In other words, is the approach defectless?
- Is the approach complete? In other words, does it need nothing more to fulfill the approach reason for existing?
- Is the approach reasonable? In other words, is it not too much onerous compared to any other alternative means to fulfill the approach reason for existing?

5. Conclusion

This paper addressed a relevant topic for EFB manufacturers: compliance with EURO-CAE ED-273. This relatively new standard brought unprecedented development assurance objectives for EFB development. It is a standard that brings quality to the software through the quality of the software process. The proposed development approach brings benefits to applicants. It was shown that some parts of EFB manufacturers already have an RTCA DO-178C-compliant process. Therefore, it would be much easier to adjust this process and follow only one process for the entire company. On the other hand, the EFB manufacturers that do not have an RTCA DO-178C compliant process will benefit from the proposed development approach because more consolidated literature is available for RTCA DO-178C compared to EUROCAE ED-273.

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