COMPARATIVE ANALYSIS OF THE CERTIFICATION APPROACHES OF THE FAA AND EASA FOR VTOL AIRCRAFT: CASE STUDY OF BIRD STRIKE CERTIFICATION REQUIREMENTS

Maurício Antoniazzi*, Daniel Corrêa de Carvalho Lery, Ivan Resende Leitão, Marcelo Soares Leão, Cristiane Aparecida Martins
Instituto Tecnológico de Aeronáutica (ITA)

*** Corresponding author's e-mail address**: mauricio500@gmail.com

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ABSTRACT

Despite regulatory hurdles, vertical take-off and landing (VTOL) aircraft are expected to enter commercial service in the upcoming years. Until now, both leading aeronautical authorities, the United States of America (USA) Federal Aviation Administration (FAA) and the European Union Aviation Safety Agency (EASA), have presented different approaches to treat the issue. The FAA has changed its initial understanding of the proper certification path, deciding to follow the certification path of Special Class aircraft. At the same time, EASA has preferred to publish an entire set of publications as Special Conditions and Means of Compliance applicable to the VTOL aircraft. These approaches differ in their form and content. This means that differences in requirements can lead to different design solutions to be adopted by applicants, with potential implications on the industry development. A brief survey is also performed on other aeronautical certification authorities' approaches to VTOL aircraft certification. In the present work, a discussion is conducted regarding those issues, and the application of these approaches is presented in the case of the bird strike requirements applicable to VTOL aircraft. Considering that the industry is still in its early stages, it is expected that further changes occur in the applicable regulations with the future goal of harmonizing the rules between the certification authorities.

Keywords: Vertical Take-off and Landing (VTOL) Aircraft, Advanced Air Mobility (AAM), Aeronautical Certification, Federal Aviation Administration (FAA), European Union Aviation Safety Agency (EASA).

1. INTRODUCTION

New vertical take-off and landing (VTOL) aircraft are under development by many manufacturers worldwide, and they are the critical enablers of the Advanced Air Mobility (AAM) conceptual new market expected to develop in the upcoming years. However, the new designs and operational scenarios will bring new challenges for the industry, such as energy storage technology, remote piloting or autonomous operations technologies, air traffic management, and lack of proper infrastructure (Booz Allen Hamilton, 2018). Nevertheless, one challenge of fundamental importance is the certification basis applicable to the new VTOL aircraft.

The current designs of VTOL aircraft have different and unique features; consequently, they do not fully fit into existing certification regulations as fixed-wing or rotary-wing aircraft. For example, features such as distributed lift/thrust units used to generate powered lift and control and that the VTOL aircraft may not be able to perform an autorotation or a controlled glide in the event of a loss of lift/thrust are characteristics that make the new VTOL aircraft designs different from both fixed-wing or rotary-wing aircraft of today.

This fact caused much discussion among the authorities and the industry on which certification path to follow. The possible certification paths are: (a) follow the certification requirements applicable to traditional fixed-wing or rotary-wing aircraft and add special conditions requirements as necessary, (b) develop an entirely new set of requirements, or (c) treat them as a special class and create tailored requirements for each applicant.

The United States of America (USA) Federal Aviation Administration (FAA) and the European Union Aviation Safety Agency (EASA), the two leading aeronautical certification authorities, have presented different approaches to treat the issue.

Initially, the FAA utilized the certification path given by the 14 Code of Federal Regulations (CFR) § 21.17(a), utilizing the Part 23 requirements with additions and revisions as necessary (path "a"). However, that understanding changed, and today, the FAA uses the 14 CFR § 21.17(b) certification path (path "c"), which classifies the VTOL aircraft as Special Class, thus requiring that each applicant has its airworthiness requirements tailored and published for public comments.

EASA, on the other hand, preferred to publish an entire set of publications in the form of Special Conditions and Means of Compliance applicable to the VTOL aircraft, based on CS-23 with additions and revisions (path "b").

As their approach differs in form and content, it can lead to different design solutions to be adopted by applicants, with potential implications on the industry development.

Besides analyzing the different approaches taken by the FAA and EASA, a brief description of the current status of other selected aeronautical certification authorities is also performed.

The objective of the present work is to investigate the steps taken by both authorities that led to their current status, provide a brief description of the current status of other aeronautical certification authorities, and how their different approaches can impact the industry by analyzing the bird strike requirements as a study case.

2. METHODOLOGY

The methodology applied to this work is to perform documentary research of the published documents related to VTOL aircraft by the FAA and EASA. A brief review is also performed on a few selected aeronautical certification authorities: Brazil's Agência Nacional de Aviação Civil (ANAC), United Kingdom's (UK) Civil Aviation Authority (CAA), Australia's Civil Aviation Safety Authority (CASA), and China's Civil Aviation Administration of China (CAAC). Analyzing a study case of the bird strike requirements applicable to the VTOL aircraft complements the review.

3. CERTIFICATION AUTHORITIES' APPROACH REVIEW

3.1 The FAA Approach

The FAA adheres to one of two certification processes to approve a new aircraft design depending on whether the proposed type meets existing definitions and airworthiness standards. The current regulations cover three

categories: airplanes, rotorcraft, and balloons. If the new design falls within these categories, the FAA follows the process outlined in 14 CFR § 21.17(a) to determine the appropriate certification standards. In cases where the regulations do not cover certain novel features, the FAA applies special conditions. However, if the proposed design does not fit into existing categories, the FAA follows the 14 CFR § 21.17(b) path to designate it as a special class aircraft. In such cases, there are no individual special conditions as the entire project is considered a special class. The FAA is required to publish the entire airworthiness criteria in the USA Federal Register for public comment. This certification path is reserved for unconventional aircraft such as gliders, unmanned aerial systems (UAS), and powered-lift aircraft (USA Department of Transportation, 2023).

The 14 CFR § 21.17(b) certification path was initially developed in the 1980s to certify airships and gliders to fly in the USA. However, when a civilian model of a tiltrotor (the AW609, formerly from Bell Agusta Aerospace Company, now Leonardo Helicopters) was unveiled in the 1990s, the FAA decided that these types of powered-lift aircraft must also use the 14 CFR § 21.17(b) path (Hirschberg, 2022).

The current designs of VTOL aircraft have different and unique features; consequently, they do not fully fit into existing certification regulations. For many years, especially between 2018 and early 2022 (USA Department of Transportation, 2023), the FAA has applied the certification basis following 14 CFR § 21.17(a), following Part 23 (Airworthiness Standards: Normal Category Airplanes) certification rules and special conditions as required to VTOL applicants. Only VTOL aircraft without wings, such as multicopter designs, would follow the 14 CFR § 21.17(b) path, where powered-lift aircraft would fit (Hirschberg, 2022). That understanding came after the change of Part 23 from prescriptive to performance-based requirements (Amendment 64, which went into effect on 30 August 2017), intended to accommodate new technologies and innovative designs (Hirschberg, 2022).

However, that understanding changed. After several personnel changes at senior FAA executive levels, the FAA reversed its position to address the AAM integration into the USA National Airspace System (NAS) beyond just aircraft certification, including pilot certification and operations (USA Department of Transportation, 2023). In April 2022, the FAA concluded that even if the aircraft could be certified under Part 23, pilots could not. The reason behind this decision is the creation in 1997 of the powered-lift airman certification category to support the development of the civil tiltrotor (Hirschberg, 2022). Despite that, until recently, the FAA had yet to establish corresponding airworthiness standards and operational regulations for powered-lift aircraft and pilots (USA Department of Transportation, 2023).

On 14 June 2023, the FAA published a Notice of Proposed Rulemaking (NPRM) to establish the requirements for pilot certification and operation of powered-lift aircraft. Through the NPRM, the FAA plans to integrate the AAM into the NAS by proposing changes to federal regulations applicable to powered-lift pilots and instructors and temporary changes through a USA Special Federal Aviation Regulation (SFAR) that would supplement existing rules, create temporary alternatives for pilot's certification, remove operational barriers, and mitigate safety risks for powered-lift aircraft.

An SFAR is a mechanism that allows the regulatory agency to gain experience in any new type of operation while enabling limited operations, taking a more conservative safety approach initially, and then making the appropriate safety improvements and permanent changes to the applicable regulations. The proposed duration for the SFAR is ten years. Finally, the FAA will not propose establishing any new requirements for the type certification of powered-lift aircraft, nor is it proposing to revise existing type certification requirements. The FAA has determined that the existing aircraft certification requirements are sufficient to type certificate powered-lift aircraft as a special class under 14 CFR § 21.17(b) (FAA, 2023).

As per the FAA, this process allows to address the unique and nonconventional features of the powered-lift aircraft without the need for additional processes, such as special conditions or exemptions that would be required if the FAA used the airworthiness standards already in place. Under the special class process, the FAA designates applicable airworthiness requirements

as the certification basis for each aircraft design, including its engines and propellers. This designation of applicable airworthiness requirements may include provisions from the existing airworthiness standards applicable to normal category and transport category airplanes, normal category and transport category rotorcraft, aircraft engines, and propellers (Parts 23, 25, 27, 29, 33, and 35 respectively). It may also include unique airworthiness criteria explicitly developed for the individual product. The FAA will publish the proposed airworthiness criteria for each powered-lift aircraft seeking certification and explain its equivalency determination for public notice and comment (FAA, 2023). After the establishment of the certification basis, the FAA determines the means of compliance, which are the methods, tests, and procedures on how the company will demonstrate compliance with regulations, standards, and airworthiness criteria agreed upon in the first stage of the certification process (USA Department of Transportation, 2023).

3.2 The EASA Approach

EASA has received multiple requests for the type certification of VTOL aircraft. Without certification specifications for this aircraft type, EASA decided that a complete set of dedicated technical specifications as Special Conditions was the proper way to advance their product certification. The Special Conditions address the unique characteristics of these products and prescribe airworthiness standards for issuing the type certificate for person-carrying VTOL aircraft, with lift/thrust units used to generate powered lift and control (EASA, 2018).

Some of the unique features identified by EASA of the VTOL aircraft that differentiate them from traditional rotorcraft or airplanes and therefore justify a dedicated Special Condition include (a) distributed lift/thrust units used to generate powered lift and control, and (b) although hover flight may be possible, the aircraft may not be able to perform an autorotation or a controlled glide if a loss of lift/thrust occurs (EASA, 2018).

The Special Condition has been established considering the Certification Specifications (CS) 23 (Normal-Category Aeroplanes) Amendment 5 when the airworthiness requirements were changed from a prescriptive to a performance-based approach (in harmonization with FAA Part 23 Amendment 64 revision). Additions and modifications to the base text were performed as necessary to reflect the unique features of the VTOL aircraft designs (EASA, 2018), including integrating elements of CS-27 (Small Rotorcraft) where appropriate (EASA, 2019).

To base the decision of the creation of the Special Conditions, EASA has also considered that as the VTOL designs seeking aircraft certification present characteristics of fixed-wing aircraft, rotary-wing aircraft, or both, with a consequence that in most cases, EASA was not able to classify these new aircraft as being either a conventional airplane or a rotorcraft as covered by the existing certification specifications. Therefore, applying the certification specifications for airplanes (CS-23) or rotorcrafts (CS-27), depending on their similarities, and only adding some modifications would not ensure equal treatment to certification applicants. EASA considered that establishing a standard set of conditions will enable fair competition and clarity for potential applicants. In addition, it will allow EASA to view all aircraft with a Certification Basis based on the VTOL Special Condition as a “Special Category” aircraft. This classification will provide greater flexibility in the operational regulatory framework by enabling tailoring requirements to this aircraft type rather than using airplane or helicopter regulations (EASA, 2019). The VTOL Special Condition will apply to heavier-than-air aircraft in the small category, with lift/thrust units used to generate powered lift and control. The distinction from conventional airplanes is based on the VTOL capability of the aircraft. In contrast, the difference from traditional rotorcraft is based on distributed propulsion, precisely when more than two lift/thrust units provide lift during vertical take-off or landing.

EASA has decided to limit the scope of the VTOL Special Condition up to the CS-27 small rotorcraft limits, with a passenger seating configuration of 9 or less and a maximum certified take-off mass of 3,175kg or less. The passenger limit of 9 or less aligns with the CS-23 aircraft certification levels 1 to 3 (EASA, 2019).

EASA has also introduced two certification categories in the VTOL Special Condition, the

Basic and Enhanced, linked to the intended type of operations. Introducing this category differentiation allows proportionality in safety objectives. It enables the application of the highest safety levels to Category Enhanced to protect third parties when flying over congested areas and conducting commercial air transportation of passengers. VTOL aircraft certified in the Category Enhanced would have to meet requirements for continued safe flight and landing and be able to continue to the original intended destination or a suitable alternate vertiport after a failure. Whereas for Category Basic, only controlled emergency landing requirements would have to be met similarly to a controlled glide or autorotation. For this reason, the most stringent system safety objectives are assigned to the Category Enhanced, regardless of the number of occupants (EASA, 2019).

Due to two considerations, EASA has determined that the highest standards for system safety objectives would have to be considered for Category Enhanced. The first is the increased complexity introduced by the new distributed propulsion and corresponding advanced flight control systems. The second is based on the concept of operations of the new VTOL aircraft, where their operations will mostly occur over high-density urban areas for commercial transportation of passengers (EASA, 2019).

EASA has also worked on developing Special Conditions for the Electric/Hybrid Propulsion System (EHPS) applicable to the VTOL aircraft, which follows a similar approach to the VTOL Special Conditions. This ensures consistency between the certification requirements of the VTOL aircraft and those of the EHPS and, therefore, would contribute to properly integrating the propulsion system in the aircraft. The Special Condition for the EHPS is developed to provide certification requirements independently of the propulsion system design or architecture (EASA, 2021).

Finally, EASA has worked on the Proposed Means of Compliance for the VTOL Special Conditions and the Special Conditions for the EHPS. The Proposed Means of Compliance have been opened for public consultation and are now published as Accepted Means of Compliance by EASA (EASA, 2023).

3.3 Other Authorities Current Status

Despite the different approaches, the FAA and EASA are paving the way for the certification of the new VTOL aircraft. Other certification authorities are following the evolution of the discussion while also working on their regulations. A few authorities in this situation that are worth mentioning are ANAC (Brazil), CAA (UK), and CASA (Australia). CAAC (China) is a noteworthy case as it paves its path.

ANAC (Brazil) released a report with an overview of the AAM market, its impacts on the certification, and its current status on the path to certifying VTOL aircraft. ANAC informs that they are at the definition of the certification basis applicable to the VTOL aircraft, which is an early step until a type certificate can be issued to any applicant. ANAC also mentions an international effort to harmonize regulations among authorities, forming a working group among ANAC, FAA, EASA, and Transport Canada Civil Aviation (TCCA) to align directives toward the VTOL aircraft product certification (ANAC, 2023).

Since the UK left the European Union (on 31 December 2020), its CAA had to establish its set of regulations as, until that date, they were part of EASA (CAA, 2020). However, the UK CAA has informed that they will follow the EASA approach (adopting the Special Conditions for the VTOL aircraft). UK CAA also recognizes that harmonizing regulations among authorities is necessary not only to reduce industry costs and avoid duplicated work but also to maintain high levels of safety in the aviation industry (CAA, 2022).

CASA (Australia) is also working on its regulations and following the FAA and EASA steps. CASA expects to release certification regulations applicable to the VTOL aircraft and its required infrastructure (as vertiports) in the next few years. CASA mentions explicitly that the publication of their requirements depends on the FAA and EASA meeting their deadlines for the initial airworthiness certification publications (CASA, 2023).

CAAC (China) is following its steps and moving forward with VTOL aircraft certification with initiatives apart from what the FAA and EASA are doing. Many VTOL aircraft

manufacturers are operating in China, and one noteworthy manufacturer is EHang, with its Unmanned Aircraft Cloud System (UACS) (system developed for the operation of the VTOL aircraft) being approved by CAAC for trial operations. Besides that, EHang has performed over 9,300 trial flights, supervised by CAAC, for tourism, obtaining operational experience, and expanding its operations across China (EHang, 2023).

4. ANALYSIS AND DISCUSSION

4.1 Possible Impacts on the Industry

The FAA's decision to change the certification approach from 14 CFR § 21.17(a) – FAR Part 23 to 14 CFR § 21.17(b) – Special Class brought concerns to the industry. The two most important concerns are (a) possible delays in issuing their FAA Type Certificate and (b) harmonization of the requirements among certification authorities, which would affect most significantly companies planning to commercialize their VTOL aircraft in different markets (USA Department of Transportation, 2023).

EASA, on the other hand, has decided to adopt a certification approach aligned with the FAA's initial strategy and launched Special Conditions for VTOL aircraft based on CS-23, with revisions, additions, and integration of CS-27 whenever appropriate.

Those different approaches may lead to different requirements, ultimately leading to different design solutions if applicants decide to follow one set of requirements or the other. It may also happen where conflicting requirements may lead to design solutions that make it impossible to certify a particular aircraft with one authority if they have already followed the requirements of another. Another possibility is that applicants may follow the most stringent requirements from both authorities if they plan to commercialize their products on both markets and markets that follow those authorities.

4.2 Case Study: Bird Strike Certification Requirements

The case studied by Cardoso, de Oliveira and Godoy (2022) compares the bird strike requirements between the FAA and EASA, applicable to VTOL aircraft. Some of the differences found are (a) bird mass to be considered (0.9kg for the FAA and 1.0kg for EASA), (b) which aircraft structures to consider in the analysis, (c) aircraft speeds and altitudes, and (d) if multiple bird strikes should be considered or not.

The differences can lead to different design solutions and highlight the importance of harmonized requirements among the certification authorities. More important than that, following one set of requirements may avoid obtaining the certification with the other authority due to significant differences, making it impossible to compete in specific markets. Or to find a competitor who decided to follow only one set of requirements from a particular authority and have a lighter, less expensive design than another competitor who chose to implement requirements from both authorities and will eventually have a more costly and heavier product, thus jeopardizing competition.

4.3 Bird Strike Requirement Analysis on VTOL Aircraft Under Certification with the FAA

Currently, there are two VTOL aircraft that had their Special Class Airworthiness Criteria, following the 14 CFR § 21.17(b) certification path, already published by the FAA: (a) Model M001 Powered-Lift by Archer Aviation Inc. (FAA, 2022a), and (b) Model JAS4-1 Powered-Lift by Joby Aero, Inc. (FAA, 2022b). A comparison analysis of the certification requirements applicable to those aircraft designs related to bird strikes and the previous case study is performed.

The bird strike requirements analyzed are identical for both VTOL aircraft designs. The FAA recognizes that the threat from bird strikes in the environment where VTOL aircraft are intended to operate is harsher than the environment in which rotorcraft or normal-category airplanes operate today. The VTOL aircraft will operate at lower altitudes and, due to their design characteristics, will be much quieter than conventional helicopters. As a result, birds will have fewer cues to the existence of the aircraft due to quiet approach environments. These factors combined increase the aircraft's

exposure to birds (FAA, 2022a, 2022b).

Based on the research reported by the Aviation Rulemaking Advisory Committee (ARAC) Rotorcraft Bird Strike Working Group (RBSWG), the FAA proposes a bird impact size of 1.0kg, consistent with rotorcraft industry testing. The applicant must evaluate the aircraft design to determine what parts are exposed to potential bird strikes and ensure that the aircraft can continue safe flight and landing after a bird strike. The FAA also proposes a requirement for bird deterrence devices to reduce the potential for bird strikes. Research, testing, and use of bird deterrence technology have effectively reduced bird strikes. Alerting birds to the presence of the aircraft allows them to avoid striking the aircraft. Bird deterrence systems may include, for example, light technology to aid birds in detecting and preventing the aircraft (FAA, 2022a, 2022b).

Compared with the study conducted by Cardoso, de Oliveira and Godoy (2022), the FAA has harmonized the bird mass with the EASA requirement. However, still in a more generic way (the applicant must evaluate which areas are more exposed to bird strikes), and there are no requirements for multiple bird strikes. On the other hand, the FAA proposes a requirement for bird deterrence devices, which EASA does not require. Documents for EASA type certificate applicants for the VTOL aircraft, such as the ones published by the FAA for Joby Aero and Archer Aviation, were not found in this research.

5. CLOSING REMARKS

5.1 Limitations of the Present Work and Suggestions for Future Works

The present work focused on the different approaches the FAA and EASA took regarding the definition of the certification basis applicable to the new VTOL aircraft under development. A brief review of the current status of a few selected aeronautical authorities was also conducted, and a study case of the bird strike requirements was performed.

With only one specific case of requirements (related to bird strikes), significant differences were found between the certification requirements of both authorities.

Other systems requirements, such as propulsion, flight controls, energy storage systems, and crashworthiness devices, could also be evaluated.

It was also impossible to discuss this work's topics with certification authorities and engineering personnel from VTOL manufacturers, which could provide a rich perspective of this evolving scenario.

Another area for improvement is the brief review of the activities performed by other aeronautical certification authorities related to the VTOL aircraft. That review can be deepened and widened to more aeronautical certification authorities from different countries.

The presented limitations are suggested as future works as they will complement the initial findings of the present work.

5.2 Conclusions

Upon analyzing the path taken by both the FAA and EASA, it is evident that they adopted different approaches. The FAA ultimately chose to follow the certification path outlined in 14 CFR § 21.17(b), which requires the publication of a Special Class Airworthiness Criteria for each applicant that outlines the applicable regulations specific to their design. In contrast, EASA opted to publish a set of documents for VTOL Special Condition and Means of Compliance based on CS-23, incorporating revisions, additions, and integration of CS-27 as necessary. All applicants seeking VTOL aircraft certification under EASA rules will follow this set of documents.

While both authorities aim to maintain and increase the safety levels for VTOL aircraft design and operations, the differences in the bird strike case study show that the different requirements may lead to different design solutions with implications on the industry development and competitive landscape.

Considering that the industry is still in its early stages, it is expected that further changes occur in the applicable regulations with the future goal of harmonizing them among the certification authorities. Achieving this goal will ensure a leveled competitive field for all companies developing novel VTOL aircraft.

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