AGÊNCIA NACIONAL DE AVIAÇÃO CIVIL
SUPERINTENDÊNCIA DE AERONAVEGABILIDADE

CONSULTA SETORIAL

CRITÉRIOS DE AERONAVEGABILIDADE

JUSTIFICATIVA / RATIONALE

1. APRESENTAÇÃO / INTRODUCTION

A ANAC, Agência Nacional de Aviação Civil, disponibiliza e solicita comentários por meio desta consulta setorial para os Critérios de Aeronavegabilidade para a aeronave Modelo EVE-100 da EVE Soluções de Mobilidade Aérea Urbana LTDA (EVE). Este documento propõe critérios de aeronavegabilidade que a ANAC considera apropriados e aplicáveis para o projeto deste modelo.

ANAC, the National Civil Aviation Agency, through this document makes available and requests comments on the proposed airwortiness criteria for the EVE Soluções de Mobilidade Aérea Urbana LTDA (EVE) Model EVE-100. This document proposes airworthiness criteria ANAC considers to be appropriate and applicable for this model´s design.

2. CONTEXTUALIZAÇÃO / BACKGROUND

O modelo EVE-100 é uma aeronave de propulsão elétrica, de pouso e decolagem vertical (eVTOL), tem um peso máximo de decolagem de 2800kg e é capaz de transportar um piloto e 4 passageiros. Usa 8 motores elétricos fixos com hélices de duas lâminas fixados a uma asa convencional, mais um motor elétrico com uma hélice de cinco lâminas para empuxo horizontal. A estrutura da aeronave e as hélices são feitas de materiais compostos. O modelo EVE-100 tem características tanto de helicóptero quanto de avião e tem uso pretendido para operações conforme o RBAC 91 e RBAC 135, com um único piloto a bordo e regras de voo visual.

The Model EVE-100 is an electric propulsion, vertical take-off and landing (eVTOL) aircraft, has a maximum gross takeoff weight of 2800kg and is capable of carrying a pilot and 4 passengers. The aircraft uses 8 fixed electric engines with 2-blade propellers attached to a conventional wing for lifting, plus one electric engine with a 5-blade pusher propeller. The aircraft structure and propellers are constructed with composite materials. The Model EVE-100 has the characteristics of both a helicopter and an airplane and is intended to be used for part 91 and part 135 operations, with a single pilot onboard, under visual flight rules.

3. MOTIVAÇÃO E FUNDAMENTAÇÃO LEGAL / REGULATORY FUNDAMENTS AND MOTIVATION

3.1. Uma vez que a ANAC ainda não publicou regulamentos de aeronavegabilidade para aeronaves eVTOL, o mecanismo para certificação do Modelo EVE-100 será aquele já previsto pelo RBAC 21 emenda 09, parágrafo 21.17(b) para aeronaves de classe especial. O parágrafo 21.17(b) é uma provisão estabelecida no RBAC 21 para a determinação dos requisitos aplicáveis a casos especiais de aeronaves "para as quais não existem requisitos de aeronavegabilidade emitidos". Tais aeronaves são consideradas classes especiais de aeronaves e para elas está previsto aplicar "partes dos requisitos de aeronavegabilidade contidos nos RBAC vigentes que sejam considerados pela ANAC como apropriados para a aeronave e aplicáveis ao projeto de tipo em questão, ou outros critérios de aeronavegabilidade considerados convenientes para prover um nível de segurança equivalente ao estabelecido pelos referidos RBAC":

21.17 Determinação dos requisitos aplicáveis

...

(b) Para classes especiais de aeronaves (planadores, dirigíveis e outras aeronaves não convencionais), incluindo motores e hélices instalados nas mesmas, para as quais não existem requisitos de aeronavegabilidade emitidos, são aplicadas partes dos requisitos de aeronavegabilidade contidos nos RBAC vigentes que sejam considerados pela ANAC como apropriados para a aeronave e aplicáveis ao projeto de tipo em questão, ou outros critérios de aeronavegabilidade considerados convenientes para prover um nível de segurança equivalente ao estabelecido pelos referidos RBAC.

Because ANAC has not yet established airworthiness standards for eVTOL aircraft, the mechanism for type certification of EVE model EVE-100 will be that provisioned by RBAC 21 Amd 09, § 21.17(b) for special class aircraft. RBAC 21, § 21.17(b) is a provision established for determining applicable requirements to special cases of aircraft "for which airworthiness standards have not been issued". Such aircraft are considered as a special class, for which is provisioned to apply "portions of those other airworthiness requirements contained in effective RBACs, considered by ANAC to be appropriate for the aircraft and applicable to a specific type design, or such airworthiness criteria as ANAC considers able to provide an equivalent level of safety to those RBACs."

3.2. Assim, conforme a regra de aplicabilidade do § 21.17(b), os requisitos de aeronavegabilidade para aeronaves de classe especial são compostos por:

- porções dos seguintes RBACs: RBAC 23, RBAC 25, RBAC 27, RBAC 29, RBAC 31, RBAC 33, e RBAC 35 que forem considerados pela ANAC como apropriados e aplicáveis a este projeto de tipo específico, mais
- quaisquer outros critérios de aeronavegabilidade considerados pela ANAC como adequado para prover um nível de segurança equivalente ao dos regulamentos existentes.

So, according to the applicability rule in § 21,17(b), the airwrthiness requirements for special class aircraft are composed of:

- *portions of the following RBACs: RBAC 23, RBAC 25, RBAC 27, RBAC 29, RBAC 31, RBAC 33, e RBAC 35 considered by ANAC as appropriate and applicable to this specific type design, and*
- *any other airworthiness criteria considered by ANAC as adequate to provide an equivalent level of safety to these extant airworthiness standards.*

3.3. Esta proposta contém os requisitos existentes aplicáveis e outros critérios de aeronavegabilidade desenvolvidos, compilados conforme o § 21.17(b), para a certificação de tipo do modelo EVE-100 da EVE. No caso deste modelo, serão considerados requisitos já emitidos do RBAC 23 EMD 64 e RBAC 33 EMD 34, em efeito nesta data. As hélices terão um certificado de tipo próprio, separado do da aeronave.

This proposal contains the existing applicable reqirements and other developed airworthiness criteria, compiled accorrding § 21.17(b), for the type certification of EVE´s Model EVE-100. For this model, are considered requirements issued in RBAC 23 AMD 64 and RBAC 33 AMD 34, effective on this date. The propellers will be type certified separately from the aircraft, having their own type certificate.

3.4. Em vista da novidade do projeto de tipo, e da necessidade de viabilizar transferências de aeronaves entre diversos Estados de Operação, esta proposta de critérios de aeronavegabilidade foi objeto de discussões e alinhamentos com EASA, FAA e a indústria. A justificativa técnica que explica os critérios adotados está contida na seção 5 TECHNICAL DISCUSSION.

Considering the novelty of the type design, and the necessity of enabling transferability of aircraft among different States of Operation, these proposed airworthiness criteria where object of discussions with EASA, FAA and the industry. Section 5 TECHNICAL DISCUSSION presents the technical basis for the adopted criteria .

3.5. Importante ressaltar o fato de estes critérios de aeronavegabilidade serem apropriados e aplicáveis somente a este projeto de tipo específico. Não se trata de regra geral, aplicável a qualquer

pessoa a qualquer tempo, tal como um regulamento de aviação civil. É aplicável somente a este regulado, o qual conhece em detalhe esta regra específica.
Também ressalta-se o fato de que, para cumprimento do §21.17(b), qualquer critério de aeronavegabilidade desenvolvido para este projeto de tipo deve ser criado de modo a prover um nível de segurança equivalente ao dos RBACs vigentes aplicáveis.

Please notice that these airworthiness criteria are appropriate and applicable exclusively to this specific type design. It is not the case of a general rule, applicable to any person anytime, as is the case of an RBAC. It is applicable to this person only (EVE), which knows this specific rule in detail.
Equally important is the fact that, to abide by §21.17(b), airworthiness criteria developed for this type design must be developed in order to provide an equivalent level of safety to the existing applicable RBACs.

4. CONVITE A CONTRIBUIR / COMMENTS INVITED

4.1. A ANAC convida quaisquer pessoas físicas ou jurídicas interessadas em contribuir com o tema, todavia a consulta é mais direcionada aos afetados por esta proposta, a saber:

- potenciais requerentes de um Certificado de Tipo de aeronaves similares;
- potenciais operadores de aeronaves similares, bem como de respectivos sítios de pouso e decolagem.

4.2. As seções a seguir, de discussão técnica e dos critérios propostos se encontram somente em língua inglesa.

This consultation to the industry is open to any person insterested in contributing with the subject. Nevertheless, it is aimed to the persons affected by this proposal, i.e.:

- *potential applicants to a Type Certificate for similar aircraft;*
- *potential operators of similar aircraft;*
- *potential operators of take-off and landing sites for similar aircraft.*

4.3. As contribuições deverão ser encaminhadas à Agência por meio de formulário eletrônico disponível no endereço: https://www.gov.br/anac/pt-br/acesso-a-informacao/participacao-social/consultas-setoriais/consultas-em-andamento, até o dia 16 de fevereiro de 2024. **Os comentários mais proveitosos para a ANAC são aquele que referenciam uma porção específica dos critérios de aeronavegabilidade, explicam a razão da alteração recomendada, e incluem dados de embasamento.**

Contributions are sent to ANAC by the electronic form available at https://www.gov.br/anac/pt-br/acesso-a-informacao/participacao-social/consultas-setoriais/consultas-em-andamento until February 16th, 2024. *The most helpful comments reference a specific portion of the airworthiness criteria, explain the reason for a recommended change, and include supporting data.*

4.4. Os comentários recebidos serão publicados no endereço eletrônico da ANAC em até 10 (dez) dias úteis após o final do prazo da Consulta Setorial, e o Relatório de Análise de Contribuições (RAC) correspondente será publicado após a análise de todas contribuições.

The comments received will be published at the ANAC Portal within 10 workdays after the end of the consultation, and a corresponding Contribution Analysis Report will be published after the analysis of all contribuitions.

5. TECHNICAL DISCUSSION

5.1. ANAC selected this proposed set of airworthiness criteria for the following reasons:

5.2. **Aircraft-Level Requirements**

5.2.1. These airworthiness criteria are proposed using the common knowledge and existing regulations to develop certification requirements for the EVE-100 which is an Electric Vertical Takeoff and Landing (EVTOL) aircraft. The evolution of the EVTOL concept stems from the unique characteristics inherent in EVTOL technology, necessitating a different approach to regulatory standards. These

airworthiness criteria were developed for the EVE-100 aircraft project, taking into account the proposed concept of operations (CONOPS) for this specific project.

5.2.2. The EVE-100 introduces novel design elements and operational dynamics, prompting a comprehensive reassessment of certification criteria. The certification framework underwent meticulous scrutiny by a multidisciplinary team comprising of engineers, pilots, regulatory experts, and industry stakeholders. The analysis focused on aligning the requirements with the distinctive features of EVTOL technology. The EVE-100 is propelled by electric vertical takeoff and landing systems and presents unique challenges and operational flexibility. The certification criteria have been updated to encompass specific technological nuances, ensuring a robust evaluation of airworthiness to provide an equivalent level of safety to the existing standards.

5.2.3. The proposed operational aspects of EVE-100, including vertical takeoff and landing capabilities, demand a reevaluation of traditional certification requirements. The proposed airworthiness criteria take into account the operational intricacies while maintaining a level of safety that is commensurate with such operations and risk. Requirements from RBAC 23 that are considered not applicable to the EVE-100 project were excluded from this proposal, except the requirements for Flying Into Icing Conditions, a configuration that the applicant intends to pursue in the future.

5.2.4. In the pursuit of international harmonization, the revised certification requirements aim to align with global aviation standards, ANAC took into account several interactions with different certification authorities and international organizations to ensure coherence with regulatory frameworks worldwide for similar vehicles and operations.

5.3. **General**

5.3.1. The proposed airworthiness criteria include new or modified definitions to explain the unique capabilities and flight phases of the EVE-100 and the meaning of certain terms used in regulations that have been incorporated by reference. In the event of a loss of engine power, airplanes and rotorcraft inherently have the ability to glide or autorotate, respectively. Although the aircraft may sustain damage, the ability to glide or autorotate allows the aircraft to reasonably protect the occupants. However, not all EVTOLs have these capabilities. To address this, the ANAC proposes a definition for “Continued Safe Flight and Landing” (CSFL) unique for the Model EVE-100, that modifies language from the existing definition in RBAC 23.2000; the ANAC also proposes a new definition for “controlled emergency landing” to capture the level of performance the Model EVE-100 must meet, equivalent to a glide or autorotation, for certain failure conditions in which continued safe flight and landing cannot be ensured.

5.3.2. ANAC proposed to keep the requirement 23.2005 as reserved. Certification authorities have classified the EVTOL into two main categories, often associated with the complexity and capabilities of the EVTOL aircraft. The first category usually has specific applications with relatively straightforward operational requirements and does not intend to engage in commercial air transport at urban centers. Some EVTOLs boast advanced features, larger passenger capacities, and target operations at high densely populated areas such as at urban centers. The choice between these EVTOL categories depends on specific operational needs and regulatory considerations. For the EVE-100, ANAC proposed these airworthiness criteria taking into account that the aircraft will be used for commercial operations in urban centers, equivalent to what is currently known as enhanced or advanced category. The category will be named in the future, when operational requirements will be developed for the operations of this type of aircraft.

5.3.3. ANAC also proposed the introduction of the "Critical change of thrust" to address the most adverse effect on performance or handling qualities resulting from failures of the flight control or propulsive system, either singular or in combination, not shown to be extremely improbable. Specific performance and handling quality requirements applicable to different flight phases are then established for such critical condition so that an adequate level of safety for such a critical failure condition is ensured.

5.3.4. In addition, because many of the proposed airworthiness criteria are performance-based, like the regulations found in RBAC 23, the ANAC has proposed to adopt RBAC 23.2010 by reference, which would require that the means of compliance used to comply with these proposed airworthiness criteria be accepted by ANAC. Because no EVTOL consensus standards are currently accepted by ANAC, the means of compliance for the EVE-100 aircraft will be accepted through the ANAC equivalent of the issue paper process (FCAR).

5.4. **Flight**

5.4.1. Although RBAC 23 replaced prescriptive design requirements with performance-based rules that are more easily adaptable to new and novel technology, these performance-based rules were written for conventionally configured airplanes equipped with reversible flight controls for fixed-wing takeoff and landing operations. To accommodate EVE's ability to engage in vertical takeoff and landing operations, these proposed airworthiness criteria adopt language from other regulations, where appropriate, with changes to allow safe operation. ANAC developed the proposed criteria to address the integration of alternating sources of lift. While ANAC has experience certifying indirect flight-control systems such as fly-by-wire systems, EVE's design uses a unique, integrated flight and propulsion-control system that requires new airworthiness criteria.

5.4.2. ANAC proposed to accommodate a broader range of operational scenarios and added the EVE.2105(e) aiming to comprehensively assess the hovering capabilities under diverse conditions, providing a thorough understanding of its performance envelope. For landing, ANAC updated the requirements from RBAC 23 to include the effect of temperature as part of the critical combination to determine characteristics for approach, transition and landing. For flight characteristics, ANAC proposes new requirements EVE.2135(a)(5) and EV.2135(a)(6) to request the aircraft to be controllable at any failure not extremely improbable in the flight control and propulsion systems, including degraded modes of operation in both systems. and during the vertical takeoff and landing phases for the wind limits defined for any azimuth angle. The requirement 23.2135(a)(3) was removed as it is considered to be applicable to mechanical type of failures and the new 23.2135(a)(5) covers all failure conditions. The 2135(b),(c) and (d) were replaced or removed as the aircraft takeoff and landing are vertical, the aircraft has a single pusher and the aircraft is not acrobatic. The new requirements EVE.2135(b) and EVE.2135(c) are focused on ensuring the transitions from lift sources are smooth and that any parameter required (or that may prevent) to a safe flight are accounted for as operating limitations.

5.4.3. ANAC also proposes updates to 23.2140 expanding the scope of the text to encompass all flight phases for the lateral and directional axes. Even on cruise, no trim control may be required, as the aircraft should automatically make this compensation in normal mode. ANAC has also introduced the option to use a protection for stall rather than the exclusivity of a warning on EVE.2150.

5.5. **Structures**

5.5.1. ANAC understands that the flight and ground loads for EVTOLs comprise three types of flight configurations: vertical, transition, and forward. Therefore, the proposed airworthiness criteria are not based solely on the forward-flight requirements of RBAC 23 (for airplanes) or the vertical-flight requirements of RBAC 27 (for rotorcraft). The EVTOLs also rely on a transitional type of lift, which may include a combination of forward and vertical flight loads. The aerodynamic flow field during a transitional type of lift can be considerably different from what is traditionally observed during forward and vertical flight. In some flight configurations, the aircraft may experience a combination of forward and vertical flight loads. In other configurations, the aircraft may undergo a completely new type of aerodynamic flow field, not experienced during strictly forward or vertical flight. Therefore, ANAC finds that additional airworthiness criteria are necessary for structural design.

5.5.2. ANAC proposed a new requirement for the structural design envelope.EVE.2200(g) highlights each of the three different flight phases. Their load envelopes must be considered to determine the structural design envelope. ANAC also chose the EASA SC-VTOL requirement for EVE.2205 because it is more direct and includes not only failures but also the malfunctioning of the system that may affect structural performance.

5.5.3. For structural loads, ANAC proposes to include a new EVE.2215(b) to make it clear that the aircraft should not undergo structural damage due to vibration or buffeting. ANAC also proposes to include the effects of ground gusts to determine ground loads on EVE.2220. A new EVE.2225(c) is added to address loads on engine-driven lifting-device assemblies due to flight and ground conditions, as well as limit input torque. ANAC proposes to establish a new EVE.2241 to account for the effect of the interaction between structural modes and the aerodynamic among the various rotors and the aircraft structure, and the EVE.2245(c) to address the aeroelastic stability of each component and rotor.

5.6. **Design and Construction**

5.6.1. ANAC proposes to adapt the flight control requirements driven by the unique characteristics of the EVE-100 aircraft, with its lifting rotors and vertical flight capabilities, demanding specific

requirements to ensure stability, maneuverability, and safety throughout all flight phases. ANAC also proposes a new requirement EVE.2300(a)(3) and EVE.2300(c) to maintain a proactive safety stance, preventing control authority exceedance, and fostering optimal human-machine interaction.

5.6.2. The decision to not mandate compliance with ditching requirements is rooted in a thoughtful evaluation of the EVE-100's operational context, in which the aircraft will not operate over water beyond the distance that allows it to perform a controlled emergency landing on shore.

5.6.3. ANAC recognizes the threat from bird strike in the environment in which EVE-100 is intended to operate. This environment is more severe than that in which rotorcraft or part 23 fixed wing aircraft operate today. The EVE-100 has inherent design features and expected operations that potentially expose the aircraft to a higher probability of impact with birds and will operate at altitudes similar to a rotorcraft. ANAC proposes new requirement (EVE.2311) where the aircraft must be capable of continued safe flight and landing after a bird strike from a bird size of 1.0 kg (2.2-lb), consistent with rotorcraft industry testing. The applicant must perform an evaluation at the aircraft level to determine what parts of the aircraft are exposed to potential bird strikes.

5.6.4. ANAC adapted the RBAC 23.2320 to include protection for occupants to be adequately safeguarded even in normal operational conditions, such as boarding and disembarking concerning the propellers. ANAC also proposed the applicability of 23.2325(e) for fire protection in the cargo compartment and the new EVE.2330(d) to address the concern about fire in the battery compartment.

5.7. **Powerplant**

5.7.1. RBAC 23 (amendment 23–64) addresses electric propulsion, but only for conventionally configured airplanes that use propulsion for forward thrust. EVE-100 new and novel design uses a distributed propulsion system to provide forward thrust, lift, and control. While some of these design features can be addressed by existing airworthiness standards in RBAC 23 and RBAC 27, other features require the development of new airworthiness criteria. The proposed airworthiness criteria address multi-engine isolation in a distributed propulsion system, simplified control of distributed propulsion, integration of a propulsion system into aircraft flight controls, and energy-system crashworthiness associated with vertical takeoff and landing capability. The proposed airworthiness criteria in EVE.2405 capture all powerplant control functions.

5.7.2. The proposed EVE.2430(a)(2) considers that the probability of lightning strike occurrence should not be considered in the case of catastrophic events. The inclusion of the term "areas" makes it clearer that it is not about the probability of the aircraft being struck by lightning but rather considering, in the requirement demonstration, the areas of the aircraft with a higher likelihood of incidence. ANAC proposes also the new EVE.2430(b)(3) and (b)(4) to address the need for energy reserve to safely complete the flight, even in situations requiring a deviation from the planned route. This requirement is proposed, allowing the definition of reserve values to be specified during the type certification, even knowing that it will be mandated through an operational requirement in the future. It is noted that this requirement addresses a crucial aspect for this type of aircraft, given the advancements in electric propulsion technologies and primary energy storage in batteries.

5.8. **Electric Engines**

5.8.1. The electric engines proposed for installation on the EVE-100 use electric power instead of air-and-fuel combustion. These electric engines are designed, manufactured, and controlled differently than aircraft engines that operate using aviation fuel. These engines are built with an electric motor, a controller, and a high-voltage system that draws energy from electrical storage or generating systems. The high-voltage system is a combination of wires, power-conditioning components, and connectors that couple an energy source to an electric engine, associated motors, and a controller.

5.8.2. ANAC proposes a new Subpart H to address all the concerns about electric engines, taking into account requirements from RBAC 33 and new requirements to capture the level of safety the Model EVE-100 must meet.

5.9. **Equipment**

5.9.1. Regarding lightning protection, ANAC considers that due to the concept of operation of the aircraft, the probability of lightning strike occurrence should not be considered for limiting the requirements applicability in the case of catastrophic events. The EVE.2430(a)(2) was adapted for an electric aircraft, maintaining the focus in the aircraft “areas” where the occurrence of lightning incidence is

likely. Notice that this is not about the probability of the aircraft being struck by lightning, but rather considering in the requirement demonstration the areas of the aircraft with a higher likelihood of incidence, which is linked with the concept of lightning zoning. Due to the consideration above, the applicability of EVE.2515(a) was not limited to aircraft approved for IFR operations. Because of that ANAC proposed to not include the caput of the rule, in reference to RBAC 23.2515. For EVE.2515(b), associated with less critical failures, it is considered reasonable to limit the requirement's applicability to scenarios with a higher probability of lightning incidence and operationally more critical. Therefore, the limitation of applicability to aircraft approved for IFR operations was maintained. It is also considered that it should be extended to systems with Major failure conditions, in addition to Hazardous. An attenuating factor for these less critical cases is the requirement for demonstration for less severe lightning levels. Because of that, ANAC proposed not to include the term "significantly" and include "For an aircraft approved for operation under instrument flight rules (IFR)", in reference to RBAC 23.2515(b).

5.9.2. Regarding HIRF protection, due to the concept operation of the aircraft, VFR operations can represent a scenario of high exposure to interference due to the possibility of operating at lower altitudes, thus closer to RF transmitters, and for long exposure times. Therefore, unlike the lightning requirement, in EVE.2520(b), ANAC does not foresee mitigating factors to justify a limitation of the applicability of this requirement just for aircraft approved for IFR operations. It is also considered that it should be extended to systems with Major failure conditions, in addition to Hazardous, with the attenuating factor for these less critical cases being the requirement for demonstration in less severe environments." Because of that ANAC proposed not to include the terms "for airplanes approved for IFR operations" and "significantly", in reference to RBAC 23.2520(b).

5.9.3. Regarding static electricity protection, in EVE.2335, ANAC deemed appropriate to include a specific requirement, rather than this subject being covered by more general requirements that consider environmental factors.

5.9.4. ANAC decided also to require the installation of recorders for type certification of EVTOLs. Current requirements would not require the installation of recorders for the vast majority of EVTOLs. They were developed for planes and helicopters with simpler and well-known technologies. EVTOLs introduce several new technologies with unique safety considerations. Data retrieved from the recorders will provide valuable insights into the performance of these technologies, identifying potential safety issues, and easing any future investigation and fleet monitoring.

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