Certification Memorandum

Function and Reliability Flight Testing for VTOL-capable aircraft

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Log of issues

Issue	Issue date	Change description
1	31/07/2024	First issue

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1. Introduction

1.1. Purpose and scope

The purpose of this Certification Memorandum is to clarify EASA's general course of action regarding the compliance with point 21.A.35 of Annex I of Regulation (EU) 748/2012 (EASA Part-21) for VTOL-capable aircraft.

Due to the novelty of VTOL-capable aircraft as aeronautical products, this Certification Memorandum is intended to provide complementary information and guidance to GM 21.A.35, GM 21.A.35(b)(2), GM 21.A.35(f)(1) and GM 21.A.35(f)(2) to facilitate the compliance demonstration with 21.A.35.

1.2. References

It is intended that the following reference materials be used in conjunction with this Certification Memorandum:

Reference	Title	Code	Issue	Date
1	Annex I of Commission Regulation (EU) No 748/2012 of 3 August 2012 laying down implementing rules for the airworthiness and environmental certification of aircraft and related products, parts and appliances, as well as for the certification of design and production organisations	PART-21	N/A	As last amended
2	Commission Delegated Regulation (EU) 2024/1108 of 13 March 2024 amending Regulation (EU) No 748/2012	Regulation (EU) 2024/1108	N/A	13/03/2024

1.3. Abbreviations

[Abbreviation]	[Meaning]
AFM	Aircraft Flight Manual
EASA	European Union Aviation Safety Agency
ESS	Energy storage system
F&R	Function and Reliability
ICA	Instructions for Continued Airworthiness
SC-VTOL	Special Condition for small-category VTOL aircraft
SoC	State of Charge
SoH	State of Health
VTOL	Vertical Take-off and Landing

1.4. Definitions

Engine	For the purpose of this Certification Memorandum, an engine used or intended to be used for aircraft propulsion, consists of at least those components and equipment necessary for the functioning and control, but excludes the propeller.
Flight time (flight hours)	Counted from lift/thrust units powered-on and, if applicable, rotors turning until their stop, in a representative VTOL-capable aircraft.
Integration bench	Type specific test bench representative of the aircraft systems and installations relevant for a function and reliability assessment. It may consist of tied-down aircraft.
Operation time (operation hours)	Counted from lift/thrust units powered-on and, if applicable, rotors turning until their stop, in an accepted integration bench or VTOL-aircraft
VTOL-capable aircraft	A VTOL-capable aircraft is a power-driven, heavier-than-air aircraft, other than aeroplane or rotorcraft, capable of performing vertical take-off and landing by means of lift and thrust units used to provide lift during take-off and landing [Art. 1 (p) in Reference [2]. For the purpose of this Certification Memorandum, VTOL-capable aircraft to which the SC-VTOL apply are considered.

2. Background

2.1. Introduction: Function and Reliability (F&R) Testing

According with point 21.A.35(b)2., the applicant shall make all flight tests that the Agency finds necessary to determine whether there is reasonable assurance that the aircraft, its parts and appliances are reliable and function properly for aircraft to be certificated under this Annex I (Part 21), except for sailplanes and powered sailplanes, balloons and airships defined in ELA1 or ELA2, and aeroplanes of 2 722 kg or less maximum take-off mass (MTOM).

Point 21.A.35(f) further prescribes that these flight tests prescribed shall include at least 300 hours of operation for aircraft incorporating turbine engines of a type not previously used in a type-certificated aircraft, with a full complement of engines that conform to a type-certificate; and at least 150 hours of operation for all other aircraft.

GM 21.A.35(b)(2) clarifies that the objective of this testing is to expose the aircraft to the variety of uses, including training, that are likely to occur when in routine service to provide an assurance that it performs its intended functions to the standard required for certification and should continue to do so in service. This GM provides first guidance regarding the content of this testing.

Additionally, GM 21.A.35(f)(1) and GM 21.A.35(f)(2) provide guidance regarding the cumulation of flying time for F&R testing both when 300 flight hours and when 150 flight hours shall be achieved.

This activity is intended to be the last certification activity prior to the entry into service. It may result in design changes which correct possible deficiencies shown during the intensive use in an intensive operation like usage, together with possible AFM and ICA changes. There should be thus a flight activity plan, and a final report to be accepted by EASA.

2.2. Best practice and certification experience in Rotorcraft and Aeroplanes

Over the years EASA has cumulated a wealth of experience in the F&R testing with rotorcraft and aeroplanes, which deserves to be considered, along with observed best industry practice, in this certification memorandum.

In a common interpretation of the guidance provided in GM 21.A.35(b)(2), applicants submit for EASA's agreement a detailed test programme, describing how compliance with 21.A.35 is intended to be demonstrated.

In line with GM 21.A35(b)(2), and also GM 21.A.35(f)(1), at least half of the required F&R flight test hours are conducted on a single aircraft (the "main aircraft"), which is representative of the final type design configuration (typically a production aircraft). These hours also correspond to dedicated testing, covering routine operations and some simulation of abnormal conditions.

Flights for customer demonstration and pilot training are often combined with flights with the direct participation of operators (operator flights), to help ensure that the routine flights covering the usage spectrum planned after entry into service are accurately considered.

Other aircraft (prototypes, pre-production, or production aircraft) are also used in the F&R Flight Testing, when their engines and systems can be considered sufficiently representative of the type-certificate-standard. In these cases, differences from the type-certification standard are documented and justified by the applicant in the test programme and submitted to EASA for agreement.

Flying hours obtained with these other aircraft in flight activities not dedicated to the F&R Flight Testing, as for example certification and development, may be counted towards the required flight hours for compliance with 21.A.35. Not only the configuration of the aircraft is relevant, as already mentioned, but also the flights chosen, which should be close enough to the operational flights referred above.

A reduction of 20% to 50% of the flying hours obtained with those other aircraft and in those non-dedicated flights (certification and development) is typically proposed, to account for the differences in configuration and in operation. As a result, the number of hours actually flown under these circumstances is significantly larger than the hours that are finally granted to demonstrate compliance with 21.A.35.

During their participation in F&R testing, the aircraft are subject to maintenance activities representative of a serial program, as per the prepared ICA accounting for the conducted flights. These activities are recorded, along with any additional maintenance, and subsequently analysed.

Also, all malfunctions, anomalies and other discrepancies from the expected behaviour of the aircraft and its systems and components during the F&R test campaign are recorded and subsequently analysed.

At the end of the F&R test campaign, these records and analyses are included in the test report, assessing the need to introduce modifications to the design or procedures (AFM, ICA).

The test report contains a detailed description of the aircraft used in the test campaign, justifying any differences in their configuration from the type-certification standard. It also includes a list of all flights performed - comprising date, flight time, crew, aircraft, type of flight and any other data which could be of technical interest (e.g., mass and CoG) – plus any relevant issues observed and actions performed on the aircraft.

3. EASA Certification Policy

3.1. F&R Testing for VTOL-capable aircraft

Also in the frame of the EASA Type Certification of a VTOL-capable aircraft, the proposed aircraft configuration should be shown to be reliable enough to allow its entry into service.

Reliability and proper function of equipment, systems and installations are demonstrated during type certification by showing compliance with SC-VTOL requirements VTOL.2500, VTOL.2505 and VTOL.2510.

In order to also provide reasonable assurance that the aircraft, its parts and appliances are reliable and function properly, flight testing shall be conducted as per 21.A.35 in accordance with conditions specified by the Agency.

The Commission Delegated Regulation (EU) 2024/1108 of 13 March 2024 amending Regulation (EU) No 748/2012 [Ref. 29] introduces changes to 21.A.35 that should further clarify how it applies to VTOL-capable aircraft. The regulation will enter into force on 01 May 2025, consequently this document refers to the currently applicable amendment status of Part 21.

First, the Regulation (EU) 2024/1108 does not propose to include VTOL-capable aircraft as exempted under 21.A.35(b)2, thus purposefully maintaining for them the obligation to demonstrate reliable and proper functioning prior to the type certification.

Second, it clarifies in 21.A.35(f) that for *aircraft other than unmanned aircraft* (such as the VTOL-capable aircraft to which this Certification Memorandum applies), the duration of the F&R flight testing shall be as the Agency finds necessary to ensure that its safe operation is demonstrated before the aircraft enters into service and shall be at least 150 hours.

With the present Certification Memorandum, EASA intends to clarify the framework for the preparation of a successful flight test programme for compliance with 21.A.35 for VTOL-capable aircraft, accounting in a proportionate manner for the VTOL aircraft category (enhanced or basic).

It considers particularities in the configuration of electric-propulsion VTOL-capable aircraft, which deserve a specific attention in the definition of the F&R flight test campaign.

The following two chapters 3.2 and 3.3 provide guidance on the duration, the configuration and use of the aircraft involved, as well as on the scope of the F&R tests for VTOL-capable aircraft in the categories enhanced and basic. Finally, chapter 3.4 provides guidance on the content of the test report to be prepared at the end of the F&R Test campaign.

3.2. Category Enhanced

3.2.1. Duration

The overall required duration of the F&R flight testing should be no less than 150 flight hours, if 21.A.35 (f)(2)[1] is applicable.
The following conditions apply:

1. If the VTOL-capable aircraft incorporates any of the following, it should be subject to further 150 hours of operation in addition to the minimum 150 flight hours of F&R flight testing:
    a. new technologies with safety critical functions; and/or
    b. new engines of a type not previously used in a type certificated aircraft;
2. Integration benches may be used to accrue these additional 150 hours of operation of point 1. in agreement with EASA. If integration benches are used, the same benches and test specimen should be used throughout the tests.
3. The duration of the single flights should be representative of the intended operations of the aircraft, aligned with the aircraft concept of operations and the certification limitations and conditions.
4. The minimum number of energy refilling/consumption cycles of the Energy Storage System (ESS) to be accumulated during the F&R flight testing should be agreed with the Agency, if applicable.

[1] Reference will be 21.A.35 f(1)(i) when Regulation (EU) 2024/1108 enters into force.

3.2.2. Aircraft configuration and use

The use of aircraft and their configuration in function and reliability flight testing should respect the following conditions:

1. At least 50 % of the required flight hours should be performed with the same aircraft (referred to as "main aircraft" in the following text), and its configuration should be close to the final type design. If ESS are swapped during normal operation, the number of different sets of ESS for this testing and the initial SoH or degradation condition, as and if applicable, for each set should be agreed with EASA. The main aircraft should be operated with ESS that are replaced only as per the proposed ICA. In case that the ESS are replaced before reaching their end of life, the replacement ESS should present a similar aging or degradation. Acceptable deviations from the final type design configuration should be described, justified, and agreed with EASA.
2. Other aircraft may be used for the remaining portion of the F&R testing if their configurations are close to the final type design. Acceptable deviations from the final type design configuration should be described, justified, and agreed with EASA.
3. No more than 30% of the required flight hours may correspond to flights for development or used to demonstrate compliance with applicable SC-VTOL requirements and engine reliability and durability requirements. These flights should be agreed by EASA on a case-by-case basis.

Note: Engine endurance testing is typically carried out on specific engine test bed, thus not fully representative of the aircraft integration and operation usage. Therefore, it is usually considered inadequate with respect to point 3.

3.2.3. Flight test programme

The F&R flight test programme should include:

1. a continuous operation schedule for the main aircraft in point 1. of section 3.2.2., as though it were in service, which is aligned with the aircraft concept of operations and the certification limitations and conditions.
2. both routine operations and simulation of selected abnormal operating conditions
3. a range of representative ambient operating conditions and vertiports
4. the proposed ICA first line maintenance activities, and any maintenance tasks delegated to the pilot
5. Information about the flight crew composition, which should include, where possible, the participation of an operator's own flying and maintenance crews.

3.3. Category Basic

3.3.1. Duration

The overall required duration of the F&R flight testing should be no less than 150 flight hours, if 21.A.35 (f)(2)[2] is applicable.
The following conditions apply:

1. Reserved.
2. Reserved.
3. The duration of the single flights should be representative of the intended operations of the aircraft, aligned with the aircraft concept of operations and the certification limitations and conditions.
4. The minimum number of energy refilling/consumption cycles of the Energy Storage System (ESS) to be accumulated during the F&R flight testing should be agreed with the Agency, if applicable.

[2] Reference will be 21.A.35 f(1)(i) when Regulation (EU) 2024/1108 enters into force.

3.3.2. Aircraft configuration and use

The use of aircraft and their configuration in F&R flight testing should respect the following conditions:

1. At least 50% of the required flight hours should be performed with the same aircraft (referred to as "main aircraft" in the following text) and its configuration should be close to the final type design. Acceptable deviations from the final type design configuration should be described, justified, and agreed with EASA.
2. Other aircraft may be used for the remaining portion of the flight testing if their configurations are close to the final type design. Acceptable deviations from the final type design configuration should be described, justified, and agreed with EASA.
3. No more than 50% of the required flight hours may correspond to flights for development or used to demonstrate compliance with applicable SC-VTOL requirements and engine reliability and durability requirements.

Note: Engine endurance testing is typically carried out on specific engine test bed, thus not fully representative of the aircraft integration and operation usage. Therefore, it is usually considered inadequate with respect to point 3.

3.3.3. Flight Test Programme

The F&R flight test programme should include:

1. a continuous operation schedule for the main aircraft in point 1. of section 3.3.2., as though it were in service, which is aligned with the aircraft concept of operations and the certification limitations and conditions.
2. both routine operations and simulation of selected abnormal conditions, according to their probability estimated in certification.
3. a range of representative ambient operating conditions and vertiports
4. the proposed ICA first line maintenance activities, and any maintenance tasks delegated to the pilot
5. information about the flight crew composition, which should include, where possible, the participation of an operator's own flying and maintenance crews

3.4. F&R Test Report

The F&R test report should provide, as a minimum, an accurate and comprehensive record of:

1. the actual duration of the F&R test campaign, following 3.2.1 or 3.3.1 as per the applicable aircraft category,
2. the actual aircraft used and their configuration, following 3.2.2 or 3.3.2 as per the applicable aircraft category, including:
    a. the justification of any differences in configuration from the type-certification standard
    b. if different sets of ESS were used: their number, their initial and final SoH or degradation condition as and if applicable,
    c. the line maintenance activities performed on each aircraft during the test campaign, including the date and the associated flight, as well as any additional maintenance activity.
3. the corresponding flight test programme, by reference, prepared following 3.2.3 or 3.3.3. as per the applicable aircraft category,
4. a log of the individual flights performed, identifying:
    a. the date and time,
    b. the aircraft,
    c. the ESS present when different sets are used in the F&R testing, including the initial and final SoC or energy content and SoH
    d. the flight crew,
    e. the flight time,

f. the purpose of the flight (e.g. compliance with certification requirement VTOL.XXXX),
g. any relevant maintenance activities performed before or after the flight, as per the prepared ICA, as well as any additional maintenance,
h. any other actions performed on the aircraft,
i. any malfunction, anomaly, or any other discrepancy from the expected behaviour of the aircraft and its systems and components,
j. other data which could be of technical interest (e.g., mass and CoG).

5. if integration benches are used in accordance with points 1. or 2. of 3.2.1:
   a. the detailed description of the bench configuration,
   b. the individual bench operation(s), including the dates and times of start and stop,
   c. the maintenance activities performed as per the prepared ICA as well as any additional maintenance carried out during the test campaign,
   d. any other actions performed on the bench,
   e. any malfunction, anomaly, or any other discrepancy from the expected behaviour during the bench operation.

Finally, the F&R test report should analyse the above records and assess the need to introduce modifications to the design or procedures (AFM, ICA).

3.5. Who this Certification Memorandum affects

This Certification Memorandum affects applicants for a TC or restricted TC of a VTOL-capable aircraft.

4. Remarks

1. For any question concerning the technical content of this EASA Certification Memorandum, please contact:
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