Fifth Publication of Proposed Means of Compliance with the Special Condition VTOL

The document at hand, Doc. No. MOC-5 SC-VTOL, contains the fifth publication of MOCs with the Special Condition VTOL. It proposes new MOCs, as well as supplements and amendments to the ones already published with Docs. No. MOC SC-VTOL, MOC-2 SC-VTOL, MOC-3 SC-VTOL, and MOC-4 SC-VTOL. All MOC publications will continue to be consolidated in a single document in the Easy Access Rules (EAR) format for general convenience.

Public consultation on the EASA Comment-Response Tool (CRT) at http://hub.easa.europa.eu/crt/

Deadline to submit comments: 26th September 2025

Statement of Issue

EASA has received a number of requests for the type certification of vertical take-off and landing (VTOL) capable aircraft (VCA), which differ from conventional rotorcraft or fixed-wing aircraft. In the absence of suitable certification specifications for the type certification of this type of product, a complete set of dedicated technical specifications in the form of a Special Condition for VTOL-capable aircraft (SC-VTOL) was developed. The Special Condition addresses the unique characteristics of these products and prescribes airworthiness standards for the issuance of a type certificate, and changes to this type certificate, for a person-carrying VCA in the small category, with lift/thrust units that are used to generate powered lift and control.

This Special Condition was subject to a public consultation process and finally issued by EASA in July 2019.

The SC-VTOL establishes the safety and design objectives. This approach, previously utilised for the development of CS-23 Amendment 5, is also used for VCA designs in order not to limit technical innovation by describing prescriptive design solutions as certification standards. The Special Condition does not contain the means that are possible to demonstrate compliance with the safety and design objectives.

The Means Of Compliance (MOC) in the different EASA publications address the applicants´ requests for clarification of EASA's interpretation of these objectives and of possibilities how to demonstrate compliance with them. Some of these MOCs contain material which should be considered as guidance material to assist the applicant with an understanding of the objective rather than providing a defined means of compliance.

In the preparation of these MOCs EASA has followed the same principles, and pursued the same objectives, as with the Special Condition. First, to provide sufficient flexibility to address different architectures and design concepts, although it is acknowledged that all possible cases cannot be considered in these MOCs and alternatives can be proposed by applicants to address some particular design features. And second, the proposed MOCs should enable an equal treatment of all applicants, by establishing a levelled playing field and ensuring that a comparable level of safety in the compliance with the objectives of the Special Condition is achieved by all designs.

EASA is committed to continue supporting the industry in the development of safe VCA. To this end EASA has decided to prioritise the publication of MOC with the Special Condition VTOL and to issue them in a sequential manner. This approach allows EASA to focus its resources where the greatest safety impact will be achieved and where the need for clarity is more urgently required. It will furthermore allow the industry to gain an early insight into EASA's interpretation and expectations from the design objectives of the Special Condition which could have an important effect in the design decisions, instead of waiting until exhaustive guidance for the Special Condition is developed.

In May 2021, EASA completed the first publication of MOCs with the Special Condition VTOL in Doc. No. MOC SC-VTOL, Issue 2. This document considered all comments received during the public consultation of Issue 1, which were furthermore individually responded in an associated Comment Response Document, also published.

In December 2022, the second publication of MOCs was finalised with Doc. No. MOC-2 SC-VTOL issue 3. This publication introduced new MOCs, as well as amendments to some of those already published with Doc. No. MOC SC-VTOL, Issue 2. All comments received during the public consultation of Issue 1 were considered and individually responded in an associated Comment Response Document, also published.

In June 2023, EASA concluded the third publication of MOCs with Doc. No: MOC-3 SC-VTOL issue 2. This publication added a new MOC to the ones already published with the two previous publications. All comments received during the public consultation of Issue 1 were considered and individually responded in an associated Comment Response Document, also published.

In July 2025, EASA published the fourth publication of proposed MOC with Doc: MOC-4-SC-VTOL issue 1. This publication proposed additional MOCs as well as corrections and amendments of the previously introduced MOCs. All comments received during the public consultation of Issue 1 were considered and individually responded in an associated Comment Response Document, also published.

The fifth publication presented in this document introduces additional MOCs as well as corrections and amendments to some of the previously introduced MOCs. Most of the content has been reviewed and discussed with industry standardisation working groups.

Finally, it is recognised that the experience gained during the certification of these new products and their entry into service will allow to increase the knowledge in their certification. It is possible that a better insight into the characteristics of these products is gained, which might result in modifications of elements of the first MOCs that are issued. EASA will do so considering first and foremost the safety of the European citizens but also mindful of the effects on all stakeholders.

Log of issues

Issue	Issue date	Change description
1	18/07/2025	First Issue for Public Consultation

Fifth Publication of Means of Compliance with the Special Condition VTOL

Contents

MOC – SUBPART C – STRUCTURES

MOC VTOL.2205 Interaction of systems and structures

Note:

Section 1. (c)(4) of MOC.VTOL.2205 in Doc. No. MOC-2 SC-VTOL Issue 3, dated 22 Dec 2022 is updated as follows.
Changes are highlighted in blue colour for the reader's convenience.

This change is introduced to align with MOC 2510 where the term improbable is not used.

(4) Probabilistic terms: the probabilistic terms (probable, remote, extremely remote, extremely improbable) used in this MOC are the same as those used in MOC VTOL.2510.

MOC VTOL.2240(d) Equipment containing high energy rotors

Note:

This is a new MOC to the SC VTOL

CS 27.1461 Amdt. X is accepted as means of compliance to SC VTOL.2240(d) for equipment containing high energy rotors. FAA AC 27-1B Change 7 AC 27/1461 provides guidance.

MOC VTOL.2240(d) High Energy Fragments – Particular Risk Analysis

Note:

MOC VTOL.2240(d) in Doc. No. MOC SC-VTOL Issue 2, dated 12 May 2021 is updated by adding an initial bullet point (a) on the category basic as shown below.

(a) For Category Basic, the following should be applied:

- Unless protected by shielding, the occupant and flight crew seats and cockpit flight controls, excluding cables and control rods, should be located with respect to the lift/thrust units so that no part of the occupants, flight crew or the controls lies in the impact area of a high energy fragment in any flight configuration.
- For propellers and other types of lift/thrust units, the fragment impact area should be established based on test, analysis, or both. Applicants may use data from propellers or lift/thrust units with similar physical and operating characteristics to establish the impact area.
- The transition phase need not be considered. (Note: The transition phase is defined as the movement of a tilting Lift/Thrust Rotor from a defined starting position expressed as an angle to a final position with a different angle. For instance, a rotor tilting from a lifting to a propelling direction during take-off and climb-out flight phases transitions between the initial and final angle. The continuous thrust vectoring which varies the thrust direction for controlling, manoeuvring or trimming the aircraft is not considered a transition phase.)

(b) For Category Basic 1 and Basic 2 aircraft (0 to 6 passengers), no Particular Risk Analysis is requested for high energy fragments.

(c) For Category Basic 3 (7 to 9 passengers), in addition to paragraph (a), the following methodology should be applied:

[…]

MOC VTOL.2240(e) In Service Monitoring

Note:

The following text fully replaces MOC VTOL.2240(e) in Doc. No. MOC SC-VTOL Issue 2, dated 12 May 2021. Changes and additions are highlighted in blue colour for the reader's convenience.

(a) For the purpose of VTOL.2240(e) parts having an important bearing on safety in operations are parts the failure of which has hazardous or catastrophic effects for the aircraft.

(b) The provisions for In-Service Monitoring established in compliance with VTOL.2240(e) should include the necessary means to verify the continued validity of assumptions made during certification that could affect the integrity of parts having an important bearing on safety.

(c) The In-Service Monitoring programme should address the effectiveness of design, ICA and monitoring provisions, as well other procedures, implemented to comply with the requirements of the SC VTOL.

(d) At the time of certification, the applicant should:

- (1) Identify the parts having an important bearing on safety for which verification of certification assumptions should be carried out.
  - (i) Particular attention should be paid to the parts having an important bearing on safety of lift/thrust units, and with novelties (e.g. novel design features, technologies or applications)
  - (ii) Should the applicant justify that sufficient experience already exists for some parts such that an assessment within the In-Service Monitoring would be of limited benefit, these need not be included.
  - (iii) Examples of certification assumption to be verified by In-Service Monitoring could include:
    1. Failure modes, degradation mechanisms, fatigue and damage tolerance aspects: Location, occurrence, severity, extent, growth rate, and type of damages (e.g. scratch, impact, corrosion, wear, fretting, tightening torque, spalling, crack, disbanding, etc).
    2. Effectiveness of monitoring means and ICAs: Such as chip detection systems, HUMS, lubrication system monitoring means and/or continuing airworthiness tasks, when this help ensuring the continued integrity of the parts.
    3. Operations: Types of operations, usage spectra and environmental conditions.
- (2) Develop an In-Service Monitoring plan detailing how the identified certification assumptions will be verified. This plan should include the activities to be performed, the participants (e.g. operators) and the schedule.
- (3) On a case-by-case basis, regular reporting to the certification authority and/or validation authority on the In Service Monitoring results should be agreed.

(e) Following entry into service the applicant should:

- a. Record the information related to the activities performed as per the In-Service Monitoring plan.
- b. Perform a detailed evaluation of the potential impact on flight safety in case any findings during the In-Service Monitoring that may question the validity of the certification assumptions. When

a potential unsafe condition is identified, report to the competent authority for continued airworthiness.

c. Report the In-Service Monitoring results to the certification authority and/or validation authority as per the agreement reached at the time of certification/validation.

MOC VTOL.2250(f) Aircraft capability after bird impact

> **Note:**
>
> The following text fully replaces MOC VTOL.2250(f) in Doc. No. MOC SC-VTOL Issue 2, dated 12 May 2021. Changes and additions are highlighted in blue colour for the reader's convenience.

This MOC provides methods to demonstrate the remaining capability of the aircraft after a bird impact as required by VTOL.2250(f).
It is applicable to VTOL capable Aircraft in the Category Basic designed to carry 7 to 9 passengers and in the Category Enhanced.

1. Single bird strike evaluation:

(a) In accordance with VTOL.2250(f), VTOL aircraft must be designed to ensure the capability of a controlled emergency landing in the Category Basic, or of a continued safe flight and landing in the Category Enhanced, after impact of a 1.0-kg (2.2-lb) bird. This should be ensured in the most critical configuration for the corresponding velocity of the VTOL (relative to the bird along the flight path of the vehicle) up to the maximum speed in level flight with maximum continuous power, at operating altitude up to 2438 m (8,000 ft.).
Compliance should be shown by tests or by analysis based on tests carried out on sufficiently representative structures of a similar design.
The following parts should be evaluated for a single bird strike:

(1) The windshield directly in front of occupants and the supporting structures for these panels should be capable of withstanding a bird impact without penetration for maximum speeds above 50kt.

(2) Other structures, systems and equipment should also be evaluated. The selection of the areas to be substantiated should be the result of a comprehensive hazard analysis based on:

(i) Exposed areas of the structure and internal equipment and systems inside of these exposed areas in case of bird penetration or shock loads; and

(ii) Their criticality and their ability to ensure continued safe flight and landing (for Category Enhanced) or controlled emergency landing (for Category Basic).

When performing the hazard analysis, direct and induced effects of a bird strike should be considered:

(3) "Direct Effects": to ensure the integrity of the structure and functionality of systems or equipment (including consideration of shock loads) which are critical for continued safe flight and landing (for Category Enhanced) or controlled emergency landing (for Category Basic).

(4) "Induced Effects": to examine the possible consequences of the ejection of pieces from structures, systems or equipment which are struck by a bird on other structures and

systems. For a bird impact on the lift/thrust system, the guidance in MOC VTOL.2240(d) can be followed, when relevant, in the demonstration of compliance mentioned in paragraph (a) of this section.

2. Multiple bird strike evaluation (lift/thrust units):

(a) To ensure continued safe flight and landing (for Category Enhanced) or controlled emergency landing (for Category Basic) following a multiple bird strike, an evaluation should be performed of the effects of a multiple bird strike on the lift/thrust units.

(b) The applicant should consider all critical configurations of the VTOL at all corresponding velocities up to the maximum speed in level flight with maximum continuous power, within the range of airspeed for normal operation up to 4000ft MSL (Mean Sea level).

(c) Any of the following approaches are acceptable:

(1) No loss or degradation of function of any lift/thrust unit following a single impact with a medium sized bird of 0.450 kg.

(2) Demonstration of continued safe flight and landing (for Category Enhanced) or control emergency landing (for Category Basic) considering the total performance degradation following a single impact on every lift/thrust unit with a medium sized bird of 0.450 kg.

(3) Evaluation of multiple bird impacts distributed across the lift/thrust units can be proposed by the applicant considering medium birds and small birds according to the MOC VTOL.2400 guidance (see Figure 1).

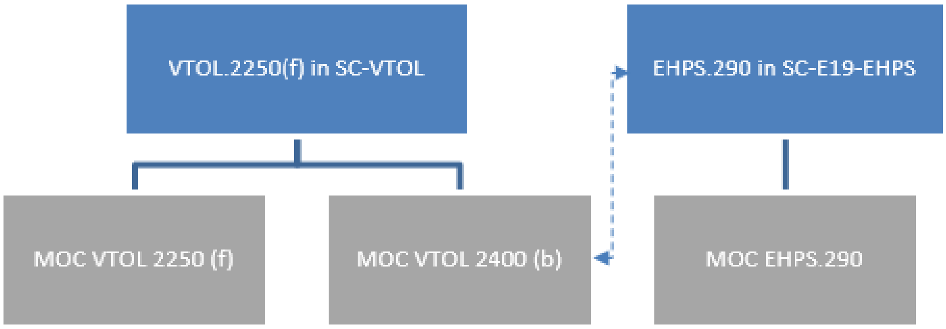


Figure 1- Overview of the Airframe and Propulsion System guidance interaction for compliance to bird strike

MOC VTOL.2270 (a) and (c) Emergency landing conditions: General considerations

Note:
The following text corrects the text in MOC VTOL.2270(a) and (c) in Doc. No. MOC SC-VTOL Issue 2, dated 12 May 2021. Changes and additions are highlighted in blue colour for the reader's convenience.

This MOC provides a set of general design conditions that, when used in their entirety, are accepted to ensure adequate protection of occupants against injuries that would prevent egress in an emergency landing.

(a) CS 27.561(a) Amdt. 6 is accepted as a means of compliance.

(b) CS 27.561(b) Amdt. 6 is accepted as a means of compliance with the addition of 23.561(b)(3)(ii) of a 18 g ultimate inertial load factor in the forward direction for items of mass within the cabin that could injure an occupant for CTOL aircraft.

(c) CS 27.561(c) Amdt. 6 is accepted as a means of compliance

(1) replacing "above and / or behind the crew and passenger compartment" with "above and / or behind and / or adjacent to the crew and passenger compartment"

(2) replacing "rotors, transmissions and engines" by "lift/thrust units, transmissions and energy storage systems", and

(d) CS 27.561(d) Amdt. 6 is accepted as a means of compliance replacing "fuel tanks" by "energy storage systems".

(e) For CTOL, CS 23.561(d) Amdt. 4 is accepted as a means of compliance.

MOC – SUBPART D – DESIGN AND CONSTRUCTION

MOC 2 VTOL.2300 Acceptability of ASTM standard F3232/F3232M-20 for Fly-by-Wire flight control systems

Note:

§5.1 is removed from the table of accepted paragraphs as this requirement do not relate to Flight Controls but Flight Guidance Systems.

MOC 5 VTOL.2300 Hidden Failures in Fly-by-Wire flight control systems

Note:

The following text fully replaces MOC 5 VTOL.2300 in Doc. No. MOC SC-VTOL Issue 2, dated 12 May 2021. Changes and additions are highlighted in blue colour for the reader's convenience.

To demonstrate compliance with VTOL.2300, in line with VTOL.2510, and to reach an acceptable level of safety, specific attention should be paid to latent failures.

The objective is to obtain a design with a minimum number of significant latent failures. Each significant latent failure should be highlighted in the system safety assessment and subject to review by EASA.

In addition to the general considerations in Section **Error! Reference source not found.** of MOC VTOL.2510, the f ollowing applies for fly-by-wire flight control systems:

(a) Definitions:

(1) Latent = dormant = hidden for more than one flight.
(2) A failure is latent until it is made known to the flight crew or maintenance personnel.
(3) A significant latent failure is one, which would in combination with one or more specific failures, or events result in a Hazardous or Catastrophic Failure Condition.
(4) A significant failure condition is one which is classified Hazardous or Catastrophic and contains one or more significant latent failures.

(b) The following approach should be followed:

(1) Double failures, with either one latent, that can lead to a Catastrophic Failure Condition should be avoided as far as practicable in system design. Deviations should be presented and accepted by EASA.
(2) Latent failures that contribute to Hazardous or Catastrophic effects at aircraft level should be avoided in system design.
(3) The use of periodic maintenance or flight crew checks to detect significant latent failures when they occur is undesirable and should not be used in lieu of practical and reliable failure monitoring and indications.
(4) It is recognised that, on occasion, it would be impracticable to meet (1) and (2). In such cases:

(i) The remaining latent failures should be recorded and justified in the PSSA/SSA and reviewed during the design review process for compliance,

(ii) Compliance should be based on both previous experience and sound engineering judgement and should assess:

(A) the failure rates and service history of each component,
(B) the inspection type and interval for any component whose failure would be latent, and
(C) any possible common cause of cascading failure modes.

(iii) The integrity of the evident part and latent part of the significant failure condition should meet a minimum standard:

1. Given that a single latent failure has occurred on a given flight the probability per flight hour of the failure condition should be:

   a. <= 10^{-5}/Fh for Category Enhanced and Basic 7 to 9 passengers or
   b. <= 10^{-4}/Fh for Category Basic below 7 passengers.

2. The sum of the probabilities of the latent failures which are combined with each evident failure does not exceed 1/1 000.

“Appendix 5 – Example of limit latency and residual probability analysis” of CS25.1309 amendment 27 provides a detailed example of such computations

(iv) In addition, a Specific Risk calculation should be performed to demonstrate compliance with the presence of a latent failure. For each combination composed of one evident failure and latent failures and leading to a Catastrophic Failure Condition the probability of the latent part of the combination (e.g. “Sum of the products of the failure rates multiplied by the exposure time” of any latent failure) should be on average equal to or less than $1x10^{-3}$ (=1/1000).

(v) The periodic maintenance checks, which may result from the compliance to this Specific Risk criterion in (b)(4)(iv)), should be considered as candidates for required maintenance tasks, in addition to the candidates for required maintenance tasks already selected for compliance to VTOL.2510.

MOC – SUBPART E – LIFT/THRUST SYSTEM INSTALLATION

MOC VTOL.2400(c)(3) Lift/thrust system installation -likely hazards in operation

Note:

MOC VTOL.2400(c)(3) in Doc. No. MOC 2 SC-VTOL, Issue 3, dated 22 December 2022 is updated by replacing the part of the table corresponding to the "Measuring equipment" for downwash testing with the table below. Footnote (2) is updated as shown below and the explanatory note is added. Changes are highlighted in blue for reader's convenience.

Parameter	Description	Value	Tolerance
Measuring equipment	The sensor dynamic characteristics should be suitable for the phenomena to be measured. A vane anemometer for example should have low enough inertia and bearing friction to capture transients in the downwash. See dedicated section for considerations on ultrasonic anemometers.		
	accuracy wind speed	≤ ± 4.5 km/h	-
	accuracy temperature (if applicable)	≤ ± 3°C	-
	resolution wind speed	≤ 1 km/h	-
	wind speed reporting interval	≤ 1 s [(3)]	-
	Ultrasonic anemometer		
	if the sampling frequency is ≥ 2 Hz, a 1-second moving mean can be performed, and the maximum over the measurement time (≥ 10 s) used for each test point		
	if a 2D anemometer is used, the sensor should be oriented to measure primarily velocities in the horizontal plane		

[(1)] The 2 D circle should be centred on the centre of the smallest enclosing circle (refer to MOC VTOL.2115 Section 7).

[(2)] The accuracy of the hover should meet the accuracy expected in operations. Height, heading and lateral/longitudinal position accuracy values could be the "desired" values used to evaluate the handling qualities in hover as per Eurocae ED-295 standard.

[(3)] or "maximum" reporting function, as long as the sampling is ≥ 1 Hz

Explanatory note:

An ultrasonic anemometer can provide quality measurements with typically a higher bandwidth than a vane anemometer. Extremely short duration gusts, however, may not necessarily affect third parties, and the specified statistical smoothing has been found appropriate for ultrasonic anemometers to provide values comparable to vane anemometers sampling at 1 Hz, while preserving meaningful transients. Other sensors such as LiDAR can be used, and the specifics of their setup should be discussed with the Agency.

MOC – SUBPART F – SYSTEMS AND EQUIPMENT

MOC 4 VTOL.2500(b) Certification credit for simulation and rig tests

Note:

MOC 4 VTOL.2500(b) in Doc. No. MOC 2 SC-VTOL, Issue 3, dated 22 December 2022 is fully replaced by the following.

Changes highlighted in blue for reader's convenience.

1. Scope of this MOC

This MOC provides methods and guidance when using simulation benches and test rigs in the substantiation of compliance with different requirements of the SC-VTOL (for example: VTOL.2500(b), VTOL.2510, VTOL.2135, etc.).

In this MOC:

(a) 'simulation bench' represents a simulator with pilot in the loop capability, used to demonstrate compliance with a requirement in the SC VTOL (See Appendix A to AMC 21.A.15(b)), or a simulator used for validation & verification activities in the frame of System Development Assurance.

(b) 'test rig' represents a laboratory test bench used to demonstrate compliance with a requirement in the SC VTOL (See Appendix A to AMC 21.A.15(b)), or a laboratory environment including models or simulated systems used for validation & verification activities in the frame of System Development Assurance

(c) "certification tests" represent tests used to demonstrate compliance with a requirement in the SC VTOL (See Appendix A to AMC 21.A.15(b)) or for validation & verification activities in the frame of System Development Assurance

This MoC may also apply to any other simulation bench or test rig facilities when proposed to be used as a Means of Compliance or to support a means of compliance (e.g. failure case evaluation to support a "Safety Analysis", etc) for certification requirements.

2. Introduction:

For most aircraft, simulation benches and test rigs commonly used to support aircraft integration tests may also support compliance demonstration. This requires particular attention on complex, highly integrated aircraft: simulation benches and test rigs are efficient and powerful means that enable the evaluation of failure cases which sometimes could even not be tested by flight test. They also offer flexibility to perform the evaluations with different scenarios and enable to check the impact of parameters' variability. Tests on simulation benches and test rigs may be agreed in the Certification Programme to show compliance with some certification requirements, particularly for Handling Qualities (HQ), Performance, Flight Controls and other systems, as well as for Human Factors (HF). This MOC may thus apply to any simulation bench or rig test facilities when proposed to be used as a means of compliance or to support a means of compliance (e.g. failure case evaluation to support a safety analysis) for certification requirements.

In order to ensure that proper results are obtained from the System Test Benches tests, simulation benches and test rigs must be adequately representative of aircraft systems and flight dynamics. At the same time, the limitations for using simulation benches and test rigs must be established. This objective can be achieved by a combination of a controlled development process and configuration management of simulation benches and test rigs, system models behaviour validation (crosschecked when necessary with partial system development bench or flight test results, analysis, desktop simulation) and engineering/operational judgment.

In line with requirement 21.A.33 from Regulation (EU) No 748/2012, for tests to be used for demonstration of compliance with the type certification basis, the applicant shall issue a statement of conformity listing any potential non-conformity, together with a justification that this will not affect the test results, and shall allow EASA to make any inspection it considers necessary to check the validity of that statement.

3. Means of Compliance

To qualify simulation benches and test rigs used as means of compliance and for validation & verification activities for System Development Assurance, the following aspects should be addressed by the applicant:

(a) Identify/list all simulation benches and test rigs proposed in the Certification Programme to be used for “simulation” and “laboratory test” compliance demonstrations (as per Appendix A to AMC 21.A.15(b)), or for validation & verification activities for System Development Assurance.

(b) Controlled development process:

Simulation benches and test rigs usually integrate numerous real aircraft systems or components, and modelled systems or components. Although simulation benches and test rigs are not subject to certification, the design of such devices for use as a certification means is deemed of sufficient complexity to stipulate a formalized and structured development process.

(1) The applicant should provide to EASA the development process for the simulation bench and test rig to achieve the applicant own objectives for the scope and intended use.

(2) This development process should include the usage of problem reports to record identified issues and their associated corrections.

(3) When simulation benches and test rigs are re-used from another project, the applicant should propose justifications to ensure the correctness/appropriateness of the rigs for the intended purpose.

(4) This development process should ensure that relevant specifications (e.g. ICD (Interface Control Document) data, model representativeness requirements, etc.) are shared with model suppliers.

(c) Configuration management:

(5) Simulation benches and test rigs configuration should be managed similarly to the test aircraft configuration with a traceability that covers all relevant systems and models as well as the human machine interface (HMI). A change control process should also be implemented.

(2) A detailed status of simulation benches and test rigs configuration should be established for all certification tests (including tests performed without EASA participation) and briefed along with each test order before the certification tests:

(i) The configuration management of simulation benches and test rigs should include the relevant elements for the test objectives (e.g. version of the flight control laws/software, crew alerting system and the electronic check list (ECL) for a “Simulation” test).

(i) Identified deviations from the expected certification configuration should be documented and the representativeness of the configuration justified.

(ii) Problem reports should be established and assessed at system test level for their effects on the representativeness in all relevant aspects (e.g. Human Factor, Handling Qualities, System Performances). This would typically include deficiencies, process deviations and errors in definition or implementation of simulation benches or test rigs.

(3) The tracking and impact assessment of the models' limitations (see section (d) below) and any simulation bench problem reports, deficiencies should be part of the configuration management process.

(4) Consistency of the simulation benches and test rigs design with aircraft design: As part of the configuration management process, the consistency of the aircraft design with simulation benches and test rigs should be guaranteed. The objective is to ensure:

(i) The representativeness of the benches with respect to the expected certification configuration. In the event that modifications are performed once the certification tests have started, the simulation benches or test rigs modification impact analysis should assess the need for additional/modified testing (e.g. new/updated tests, regression tests);

(ii) The identification of the impact of post-test evolutions of the design on the validity of the certification tests performed on the simulation bench & test rig;

(iii) The repeatability of the tests later on.

(d) Representativeness versus the test requirements:

(1) The applicant should provide an overview of the general validation & verification strategy applied for the integration of the different systems and models in simulation benches and test rigs. Integration testing should begin with item-by-item integration building to intra-system, multi-ATA[1]/inter-system and aircraft level integration, using verification at each stage. The intent is not for EASA to verify each step of the integration or over-formalise this process but to share an understanding of this process (and where it is documented) in order to obtain confidence in the representativeness of the simulation bench.

(i) Similarly, for each major simulation bench configuration change, an integrated verification is necessary and should also follow a similar controlled process.

(ii) The intent of the bench should be defined (e.g. test(s) intended to be performed, validation of a procedure) and depending on the intent, the representativeness for the part/scope should be demonstrated.

(2) For "Simulation" and "Laboratory Test" compliance demonstration and for validation & verification activities for System Development Assurance: the certification evaluations performed in the simulation benches or test rigs may be with a system, multi-system or aircraft-level view. The representativeness and limitations should match the test objectives and be synthetised in a single document. The applicant should declare that the tool is adequate for the proposed certification testing.

(i) For "Simulation" compliance demonstration, the certification evaluations performed in the simulation benches are typically with an aircraft-level view, they cover not only the aircraft behaviour or a single ATA, system or item but multiple ATAs or systems as well as the crew procedures and the workload. The demonstration of the representativeness and limitations of the simulation bench should, therefore, also be at aircraft-level, that is multi-ATA/inter-system. Representativeness of simulated failure cases should also be demonstrated.

(3) The representativeness demonstration:

(i) Should cover the steady state and the transient phases and should be based on flight test data when available, as proposed by applicant.

(ii) Where (i) is not possible, for instance for hazardous or catastrophic failure cases, flight test data should be used to validate the model used in the simulation bench and show that it is accurate and can be used for those cases. The demonstration should also include analysis (for example, matching of system behaviour expected by the design office with the simulation bench/test rig behaviour) and comparison with partial or segmented demonstration of a failure case performed in flight when relevant.

(iii) For the system part, qualification test data, partial system bench or flight test results combined with analysis and/or engineering judgement could also be used to assess the system response compared to the related models embedded in the simulation bench.

(4) The representativeness and limitations assessment should also cover the dynamics of data exchanges between systems during the failures and the potential dynamics (including time delays) introduced by the specific hardware and model architecture of the simulation bench and test rig, when the timing may influence the sequence of events and the system/aircraft behaviour.

(5) Models' representativeness and limitations:

(i) For system models, when used instead of the real aircraft systems:

(A) the representativeness and limitations of these models should be established and presented before the evaluation, and

(B) this status in (A) should include the functional and/or operational impacts due to the lack of representativeness or the limitations, and

(C) these pieces of information in (B) should be part of the configuration management mentioned in Section 3.(c) of this MOC.

(ii) The representativeness and limitations (in terms of flight domain for instance) of the simulated aircraft dynamics and the aerodynamic models (including on aircraft the control surfaces hinge moments and free-float positions):

(A) should be demonstrated (by comparison to flight test data when available) and documented, and

(B) relevant tolerances specified in the applicable certification specification for flight simulation training devices may be used as a guideline, and

(C) sound engineering judgment should be exercised to determine whether tolerances of the models are adequate.

(iii) When used to support VTOL.2510 compliance demonstration, the simulation bench:

(A) should be capable of monitoring structural loads during tests through a model, and

(B) if no real time monitoring is available, the simulation bench test data could be post-processed when high load level are suspected, and

(C) the representativeness and the limitations of aircraft loads models used should be established.

(iv) Aircraft on the ground model representativeness and limitations should be part of this status.

Note: This status on models' representativeness and limitations should be established and briefed before the certification tests.

(6) When the performance and/or Handling Qualities impact is an expected output of a failure case assessment in the simulation bench,

(i) the representativeness and limitations should be documented (e.g. ground effect, ground reaction and braking models), and
(ii) this should be supported by a combination of flight test results, analysis, desktop simulation and engineering/operational judgment to provide a qualitative/reasonable assessment of the performances' representativeness, and
(iii) depending on the intended evaluation, the most appropriate simulation bench configuration (i.e., using models versus real systems) may vary. This choice should be justified, documented, and briefed before the evaluation.

(7) For Human Factors assessments,

(i) the representativeness of systems and simulation means is not a key driver in the early stages of the development and should not necessarily prevent simulation bench usage as long as the nature of the limitations does not compromise the validity of the data to be collected.
(ii) partial certification credit may still be granted while using a non-conformed test article, provided that the item to be evaluated is simulated with an adequate level of representativeness.

(8) When the simulation bench is used for purposes of Human Factors evaluation certification,

(i) the simulation bench should be designed to maximise the subject pilot´s immersive environment to demonstrate and validate the Human Factors Data.
(ii) it is recommended to ensure a sterile environment (no outside noise or visual perturbation), with realistic simulation of ATC communications, subject pilots wearing headsets, etc.

(9) For all evaluation certification tests, the applicant should present the full list of problem reports and simulation bench limitations and their related cockpit effects with an assessment of their impacts on the representativeness of the certification exercise. Problem reports that are considered to not affect the evaluations by either comparison to Flight Test data, Analysis or Engineering Judgement do not need to be presented to EASA. Regardless of EASA attendance or not to HF or HQ evaluations, this data is expected to be directly visible in the certification data package, for example data could be included in the evaluations test reports.

(10) The Applicant should describe the strategy in use to select which requirements are to be tested in the simulation bench and/or test rig and which in the real platform/equipment. This strategy should explain, as a minimum:

(iii) The rationale as to why the simulation bench / test rig is more suitable for a given test.
(iv) The justification on the adequacy of the bench to carry out that test.
(v) That if a requirement cannot be 100% covered by the simulation bench or test rig environment:

(D) identification of which parts of the requirement can be tested in the simulation bench or test rig is expected;
(E) identification of which parts of the requirement cannot be tested in the simulation bench or test rig, why they cannot be tested in that environment and which validation and/or verification will be done instead is expected.

(11) To ensure representativeness, a selection of tests should be run in the simulated platform (simulation bench and/or test rig) and in real platform for comparison:

(vi) In order to demonstrate the representativeness of the simulation bench and test rigs, the applicant should perform a sub-set of the tests in both environments: ion the simulation bench and/or test rig and also in the real platform/equipment, and compare the results.
(vii) The outcome of this comparison should be documented.
(viii) An analysis of the results should be performed to ensure that the planned tests are still in scope of the representativeness of the simulation bench and test rigs.
(ix) This sub-set of tests should include a large enough sample of test cases to cover the full functionality.
(x) For simulation benches, this process should include a comparison of the simulation bench's handling qualities and performance with the real aircraft.

(e) Recognition of the simulation bench in the design organisation manual (or equivalent) as a certification means:

If the simulation bench is planned to be used to generate compliance data (this applies for instance if some certification tests are planned to be performed on the simulation benches or test rigs):

(1) For any test facility used to produce deliverables (e.g. certification reports), the personnel and the processes should be managed via procedures under the control of the Design Organization.
(2) The simulation bench should be recognized as an asset of the applicant Design Organization.
(12) The applicant should document:

(i) how the simulation bench is recognized in the Design Organisation Manual (or equivalent) as a certification means;
(ii) which processes of the Design Organization are in place that are related to the aspects and considerations discussed in this MOC.

(f) Automatic testing and analysis tools

(1) Automatic testing and analysis tools, if used, should be subject to a controlled development process (see Section 3.(b)) and configuration management (see Section 3.(c)). This includes automatic testing and analysis tools that are not considered to be part of the simulation and test rigs but are used to process the associated verification data.
(2) Pass/fail criteria should be reviewed and

(i) should take care of the bench and system dynamics, and
(ii) special care should be taken if static or quasi-static criteria are used, and
(iii) a manual review of the critical cases (e.g. safety-critical monitors, reconfigurations after failure) should still be performed to identify if the dynamic of the parameters used to compute the pass/fail criteria is correct, or to detect unexpected behaviours outside the direct parameters under analysis.

(3) If the automatic testing or analysis tool eliminates, reduces, or automates processes for this simulation bench, then the tool should be qualified to a way acceptable to EASA. For example, guidance from ED-215/DO-330 Software Tool Qualification Considerations may be followed.

(4) Limitations and problem reports should be recorded, and

(i) their impact should be assessed as part of the configuration management process, and
(ii) a process to address these limitations needs to be established and could include identification of temporary corrective actions (e.g. manual review) pending correction.

MOC VTOL.2510 Equipment, systems and installations

Note:

MOC VTOL.2510 in Doc. No. MOC SC-VTOL, Issue 2, dated 12 May 2021 is modified by updating references to standards and improving the text to adapt it to the new version of those standards. Other changes to align with other MOCs such as 2300 are also introduced. The changes to the different sections are presented with a dedicated note.

Note:

The section 2. Applicability is adapted as follows. Changes and additions are highlighted in blue colour for reader's convenience.

2. Applicability

As specified in VTOL.2500(a), paragraph VTOL.2510 is intended as a general requirement that should be applied to any equipment or system as installed, in addition to specific systems requirements, considering the following:

(a) General - If a specific SC VTOL requirement exists which predefines systems safety aspects (e.g., redundancy level or criticality) for a specific type of equipment, system, or installation, then the specific SC VTOL requirement will take precedence. This precedence does not preclude accomplishment of a system safety assessment. For example, requirement VTOL.2430 predefines a required level of redundancy in the energy storage and distribution systems.

(b) Subpart B, C and D - While VTOL.2510 does not apply to the performance and flight characteristics of Subpart B and structural requirements of Subparts C and D, it does apply to any system on which compliance with any of those requirements is based. For example, it does not apply to an aircraft's inherent stall characteristics, but it does apply to a stall warning system used to enable compliance with VTOL.2150.

(c) Subpart E - In certain VTOL configurations, the lift/thrust system is closely integrated with other systems, such as the flight control system, and will also affect "continued safe flight and landing" or the "controlled emergency landing". Therefore the "lift/thrust control systems" and "lift/thrust system installation hazard assessment" will be addressed through the requirements VTOL.2500 and VTOL.2510 of Subpart F.

(d) The safety assessment process should consider all phases during flight and on ground when the aircraft is in service. While this includes the conditions associated with the pre-flight preparation, taxi phase, etc., it, therefore, does not include periods of shop maintenance, storage, or other out-of-service activities

(e) *Jams of flight control surfaces or pilot controls addressed by subparagraph (d) Flight Control Jams of MOC VTOL.2300(a)(2) "Protection against likely Hazards for Fly-by-Wire flight control systems" are excepted from the requirement of SC VTOL 2510(a)(1).*

Explanatory note:

Jam of flight control surfaces or pilot controls are addressed in terms of qualitative and quantitative safety objectives in MOV VTOL 2300(a)(2)

It should be noted that as part of SC VTOL 2510 Safety assessment, failure conditions related to surface jam should be identified and addressed when relevant. When performing the VTOL 2510 quantitative analysis of such failure conditions, Jams of flight control surfaces or pilot controls, which are already addressed by subparagraph (d) "Flight Control Jams" of MOC VTOL.2300(a)(2) "Protection against likely Hazards for Fly-by-Wire flight control systems" are not expected to be considered.

This MOC does not cover "Airworthiness Security" aspects. Interactions and interfaces between the system safety assessment process and the security assessment process exist however. Therefore, should a function be implemented or a system/equipment installed on the aircraft as a result of the airworthiness security assessment process, this function or system/equipment needs to undergo the system safety assessment process.

Note:

Section 3. Reference documents is updated as follows: changes are highlighted in blue colour for reader's convenience.

The following references are quoted in different sections of this MOC as a source of additional guidance:

(a) EUROCAE ED-79B/ARP4754B, Guidelines for development of civil aircraft and systems
(b) EUROCAE ED-135/ SAE ARP4761A, Guidelines and methods for conducting the safety assessment process on civil aircraft, systems, and equipment.
(c) EUROCAE ED 344, Guidance for Common mode analysis for lift-thrust system for VTOL enhanced category.
(d) AMC 20-193( ), Mult core processors.
(e) AMC 20-115( ), Airborne Software Development Assurance Using EUROCAE ED-12 and RTCA DO-178.
(f) AMC 20-152( ), Development Assurance in Airborne Electronic Hardware (AEH)
(g) AMC 20-189( ), Management of Open Problem Reports.
(h) AMC 25-19 Amdt. 24, Certification Maintenance Requirements

Note: Section 4. Definitions, the following changes are proposed.

Definition of “complexity” the source is replaced from “ED79A” into “AMC 25.1309”

Definition of “derived requirements” the source is adapted from “ED-79A/ARP4754A and ED-12C/DO-178C” into “ED-79B/ARP4754B”

Definitions of “development assurance” and “development assurance levels” are replaced by the following definitions.

Development assurance:

All those planned and systematic actions used to substantiate, at an adequate level of confidence, that development errors have been identified and corrected such that the system satisfies the applicable certification basis (Source: ED-135/ARP4761A).

The DALs are determined by the safety assessment process. Two types of development assurance levels are identified in this document:

(1) FUNCTION DEVELOPMENT ASSURANCE LEVEL (FDAL): The level of rigor of development assurance tasks performed to Functions. Note: The FDAL is used to identify the ARP4754B/ED-79B objectives that need to be satisfied for the aircraft/system functions. (Source: ED-135/ARP4761A).”
(2) ITEM DEVELOPMENT ASSURANCE LEVEL (IDAL): The level of rigor of development assurance tasks performed on Item(s); e.g., IDAL is the appropriate software level in DO-178C/ED-12C, and design assurance level in DO-254/ED-80 objectives that need to be satisfied for an item. (Source: ED-135/ARP4761A).”

“Malfunction” definition is replaced by the following.

Malfunction: A condition where the operation of a function is different than intended, excluding the loss of function. (Source: ED-135/ARP4761A).

Note: Section 5. Abbreviations, the following change is proposed.

(e) MCP – Multi Core Processors
(f) PRA – Particular Risk Analysis

Note: Section 8. Safety Objectives (a), the following notes are updated. Changes are highlighted in blue colour for reader’s convenience. Section 8. Safety Objectives (b), reference to ARP4761 is replaced by EUROCAE ED-135/SAE ARP 4761A.

Note A In general no consideration~~s~~ of the system architecture for an FDAL (IDAL) reduction are acceptable, as the FDAL classification in Table 5 already constitute a proportionate approach. An alleviation is granted to additional members as referred to in ED-135/ARP4761A Appendix P, where the following applies: For Category Basic 1 and 2, when at least two members are contributing to a given failure condition they should be assigned at least the FDAL (IDAL) defined in Table 5. Other additional members should not be assigned lower than FDAL (IDAL D).

Note D: The applicant is not expected to perform a quantitative analysis for minor failure conditions. It is underlined that a compliance statement is also expected in the SSAs or FHAs for those failure conditions.

Note:

Section 9. Safety Assessment Process (a), the following changes are proposed. Unchanged text is not reproduced for clarity. Changes are highlighted in blue colour for reader's convenience.

[…]

Guidance on how to perform the Safety Assessment process can be found in ED-79B/ARP4754B and ED-135/ARP4761A. […]

The depth and scope of the analyses are dependent on the system criticality and/or complexity .The Safety Objective Verification Approach should be defined in the Safety Program Plan: Guidance material derived from AMC 25.1309 Figure A2-2: Depth of Analysis Flowchart may be considered with the reservation that service experience is limited to the fleet of aeroplane type(s) for which the applicant is the holder of the Type Certificate(s), the owner of the data, or, if accepted by EASA, has an agreement in place with the owner of the data that permits its use by the applicant for this purpose.

[…]

Any assumptions made during the safety assessment process need to be documented, justified and validated.

Note:

Section 9. Safety Assessment Process (b) Common mode considerations is fully replaced by the following. Changes are highlighted in blue colour for reader's convenience.

Common mode analysis (CMA) is an analytical method to define independence principles and associated requirements, and verify that those independence requirements have been implemented sufficiently.

The CMA serves also as a tool to identify any lack of independence and to develop mitigation means to reduce the likelihood or the effect of a common mode failure resulting from a lack of independence. The CMA should be performed early in the safety assessment process, because it has an impact on the definition of the safety requirements as well as on the system architecture.

Sources of common mode failures include development, manufacturing, installation, maintenance, shared resource, event outside the system(s) concerned, etc. When identifying mitigation means for specific common modes, the means should be appropriate to the common mode failure/error.

It is important to note that even Items that are developed to IDAL A may be subject to development error. Such error may simultaneously affect several instances of the same item with potential functional or safety consequences. EASA has experienced cases, where a development error in IDAL A item has even resulted in simultaneous failures of all affected equipment. Therefore, it should not be assumed that IDAL A items are protected from such development errors and consequently they should be included in the scope of the common mode analysis irrespective of the FDAL/IDAL of the system/item.

The following structured approach described in Appendix M of ED-135/ARP4761A is accepted to accomplish a common mode analysis:

(1) Establish project specific CMA questionnaires (identifying common cause types and potential common cause sources and common failures, which could affect the independence). ED-135/ARP4761A paragraph M.3.1 and table M-1 can be followed for this purpose. ED-334 provides some VTOL specific guidance that can be used to tailor CMA questionnaires. These should be used to identify independence shortcomings, define, evaluate, and verify independence principles and independence requirements

(2) Identify the independence principles and requirements for the aircraft, system and item level. ED-135/ARP4761A paragraph M.3.2.2, B.4.3.3, D.4.2.2 and D.4.3.1 can be followed for this purpose.

Independence principles are identified by design analysis and examination of safety analyses (e.g. fault tree analysis of Failure Conditions). These Failure Conditions should cover both the availability (i.e. loss) and integrity of functions and protections.

(3) Examine the implementation to verify that the independence principles and requirements have been accomplished. ED-135/ARP4761A paragraph M.3.2.2 and M.3.3.2

The analysis of the implementation:

(i) should be conducted at aircraft, system, equipment and item level (Airborne Electronic Hardware items including architecture and Software items including architecture), and

(ii) should address both the availability (i.e. loss) and integrity of functions and protections.

(4) Document the results of the above steps of the CMA process. ED-135/ARP4761A paragraph M.3.2.1.4 , M.3.2.2.4, M.3.3.1.4 and M.3.3.2.4 can be followed for this purpose.

Additional considerations may be appropriate for some specific systems and functions. In particular for Fly-by-wire Flight Control Functions, MOC 4 VTOL.2300 applies.

Note:

Section 10. Development Assurance Process. The following changes are proposed. Unchanged text is not reproduced for clarity. Changes are highlighted in blue colour for reader's convenience.

(a) Development Assurance Level (DAL) allocation

[…]

Guidelines, which may be further used for the allocation of development assurance levels to aircraft and system functions (FDAL) and to items (IDAL), are described in the document ED-135/ARP4761A, appendix P, considering the limitations in MOC VTOL 2510 section 8 note A.

[…]

(b) Aircraft/System development assurance

For the aircraft and for systems of FDAL A, B, C or D, this MOC recognises the ED-79B/ARP4754B as acceptable guideline for establishing a development assurance process from aircraft and systems levels down to the level where software/ Airborne Electronic Hardware (AEH) development assurance is applied.

The extent of application of ED-79B/ARP4754B to substantiate functional development assurance activities may vary depending on the complexity of the systems, on their level of interaction with other systems and criticality of each system. Early concurrence with the Agency is essential

(c) Software development assurance

[…]

(4) For Category Basic 3 […]

(ii) if some are 'derived requirements', a mechanism is in place to properly identify, validate and verify those derived software high-level requirements as described in ED-79B/ARP4754B section 5.4.

(f) Multicore processors

This MOC recognises AMC 20-193 () as accepted means of compliance for requirement VTOL.2510(a)".

MOC VTOL.2517 Electrical wiring interconnection system (EWIS)

1. Purpose

This MOC describes an accepted means for showing compliance with VTOL.2517 when an Electrical Wiring Interconnection System (EWIS) is part of the design.

EWIS was introduced as a new system in the large aircraft certification specification, CS 25, as Subpart H. The introduction followed the investigations of a mid-air explosion of the TWA 800 in 1996, and the MD 11 Swissair crash near Nova Scotia, Canada, in 1998. These, and subsequent investigations, found common degrading factors in electrical wiring systems. The preparatory rulemaking work was performed under the Ageing Transport Systems Rulemaking Advisory Committee (ATSRAC). The rulemaking led to the introduction of wiring and its components as an aircraft system, to deal with the possible impact on the safety of the aircraft. This was accompanied with rules for specific maintenance tasks on EWIS and training of technical personnel.

Though the introduction happened in CS 25 in Amendment 5, the notion of EWIS has been taken over in other product types as well. With the novel designs in the eVTOL (electrical Vertical Take off and Landing) domain, the industry indicated the wish to take on board relevant parts of the EWIS rules for their design. The introduction of electric motors requires high electrical power systems, potentially increasing the likelihood of known risks and introducing new risk types. The generic CS 25 Subpart H requirements and the accompanying AMC material is of generic nature and therefore also relevant for eVTOL aircraft.

This MOC is supporting this choice and giving guidance how to use and interpret this certification material to demonstrate compliance with VTOL.2517.

2. Certification Considerations

The following table summarises the certification considerations developed in this MOC in order to demonstrate compliance of the EWIS with VTOL.2517 and consequently with all applicable requirements in the Special Condition:

Certification Considerations	SC-VTOL Requirements
Design and Installation	VTOL.2517, VTOL.2255, VTOL.2400, VTOL.2430, VTOL.2525
Function and Installation	VTOL.2500, VTOL.2505, VTOL.2510
System separation	VTOL.2255, VTOL.2325, VTOL.2330, VTOL.2500, VTOL.2505, VTOL.2520
System safety	VTOL.2425, VTOL.2430, VTOL.2510
Component identification	VTOL.2340, VTOL.2445, VTOL.2500, VTOL.2505
Fire protection	VTOL.2330
Electrical bonding and protection against static electricity	VTOL.2430, VTOL.2510, VTOL.2515, VTOL.2520
Occupant protection	VTOL.2320
Circuit protective devices	VTOL.2510, VTOL.2525
Accessibility provisions	VTOL.2255, VTOL.2400
Protection of EWIS	VTOL.2255, VTOL.2400, VTOL.2425, VTOL.2510
Flammable fluid fire protection	VTOL.2325
Instructions for Continued Airworthiness (ICA)	VTOL.2625

3. Design and Installation

(a) Electrical Wiring Interconnection Systems (EWIS) includes:

(1) Wires and cables.
(2) Bus bars.
(3) The termination point on electrical devices, including those on relays, interrupters, switches, contactors, terminal blocks, and circuit breakers and other circuit protection devices.
(4) Connectors, including feed-through connectors.
(5) Connector accessories.
(6) Electrical grounding and bonding devices and their associated connections.
(7) Electrical splices.
(8) Materials used to provide additional protection for wires, including wire insulation, wire sleeving, and conduits that have electrical termination for the purpose of bonding.
(9) Shields or braids.
(10)Clamps and other devices used to route and support the wire bundle.
(11)Cable tie devices.
(12)Labels or other means of identification.
(13)Pressure seals.

(b) The definition in subparagraph (a) of this paragraph covers EWIS components inside shelves, panels, racks, junction boxes, distribution panels, and back-planes of equipment racks, including, but not limited to, circuit board back-planes, wire integration units and external wiring of equipment.

(c) Except for the equipment indicated in subparagraph above, EWIS components inside the following equipment, and the external connectors that are part of that equipment, are excluded from the definition in subparagraph (a):

(1) Electrical equipment or avionics that is qualified to environmental conditions and testing procedures when those conditions and procedures are -
 (i) Appropriate for the intended function and operating environment, and
 (ii) Acceptable to the Agency.
(2) Portable electrical devices that are not part of the type design of the aircraft. This includes personal entertainment devices and laptop computers.
(3) Fiber optics.

4. Function and installation

(a) Each EWIS component installed in any area of the aircraft should:

(1) Be of a kind and design appropriate to its intended function.
(2) Be installed according to limitations specified for the EWIS components.
(3) Perform the function for which it was intended without degrading the airworthiness of the aircraft.
(4) Be designed and installed in a way that will minimize mechanical strain (for example bend radius, stand-offs, cable ties etc.).
(5) Comply with AS50881, or any other standard as agreed with EASA.

(b) Selection of wires should consider known characteristics of the wire in relation to each installation and application to minimize the risk of wire damage, including any arc tracking phenomena.

(c) EWIS components located in areas of known moisture accumulation should be protected to minimize any hazardous effects due to moisture.

(d) The design and installation of the wires should allow for a reasonable degree of deformation and stretching without failure.

(e) For High Voltage (HV) EWIS, the following should be given consideration, though this list is not meant to be complete:

(1) Minimize Partial discharge (PD).
PD can be defined as electrical discharges that connect the insulation between conductors or inside voids within the insulation. Refer to SAE AIR7506 for additional guidance on addressing Partial Discharge.

(2) Minimize any Corona effect.
Corona is a form of partial discharge that occurs in gaseous media around conductors which are remote from solid or liquid insulation. Refer to SAE AIR7506 for additional guidance on addressing Corona Effect.

5. System separation

(a) EWIS should be designed and installed with adequate physical separation from other EWIS, aircraft systems and structural elements so that an EWIS component failure will not create a hazardous condition. Unless otherwise stated, for the purposes of this section, adequate physical separation should be achieved by separation distance or by a barrier that provides protection equivalent to that separation distance.
The intent is to a perform a qualitative design assessment. Because each system design and VCA type can be unique, and because manufacturers have differing design standards and installation techniques, no mandatory specific separation distance can be given. Instead, an adequately chosen separation is required so that an EWIS component failure will not create a hazardous condition. Several factors should be considered when determining the separation distance, like for instance:
(1) Electrical characteristics, amount of electrical power, and severity of failure condition of the system functions performed by the signals in the EWIS and adjacent EWIS.
(2) The intended operating environment, including amount of deflection or relative movement possible and the effect of failure of a wire support or other separation means.
(3) Possible EMI, HIRF, or induced lightning effects.
The term “hazardous condition” as used in this document refers to severity of the effects of hazardous and catastrophic failure conditions as defined in MOC VTOL.2510 section 7 (a)(4) and (5). Unlike for a typical safety assessment as per VTOL.2510, here, no probability objectives are required for compliance. The intent of this section, is that the applicant must perform a qualitative design assessment of the installed EWIS and the physical separation to guard against hazardous conditions.

(b) EWIS should be designed and installed so that any electrical interference such as EMI likely to be present in the aircraft will not result in hazardous effects upon the aircraft or its systems.
Electromagnetic interference (EMI) can be introduced into aircraft systems and wiring by coupling between electrical cables or between cables and coaxial lines or other aircraft systems. Function of systems should not be affected by EMI generated by adjacent wire. EMI between wiring which is a source of EMI and wire susceptible to EMI increases in proportion to the length of parallel runs and decreases with greater separation. Wiring of sensitive circuits that may be affected by EMI should be routed away from other wiring interference or provided with sufficient shielding to avoid system malfunctions under operating conditions.

EMI should be limited to negligible levels in wiring related to systems necessary for continued safe flight, landing, and egress.

(c) Wires and cables carrying heavy current (e.g. propulsion system feeder cables, energy storage output lines, or charging interfaces) and their associated EWIS components should be designed and installed to ensure adequate physical separation and electrical isolation, so that damage to essential circuits will be minimized under fault conditions.

(d) EWIS associated with independent aircraft electrical power sources or electrical power sources connected in combination should be designed and installed to ensure adequate physical separation and electrical isolation so that a fault in any one aircraft power source EWIS will not adversely affect any other independent power sources. In addition:

(1) Aircraft independent electrical power sources should not share a common ground terminating location.

(2) Aircraft system's static grounds should not share a common ground terminating location with any of the aircraft's independent electrical power sources.

This will help ensure the independence of separate electrical power sources so that a single ground failure will not disable multiple power sources and prevent introduction of unwanted interference into aircraft electrical power systems from other aircraft systems.

6. EWIS Safety Assessment

Applicants should perform a system safety assessment to demonstrate compliance of the EWIS with VTOL.2510. This assessment should be based on a qualitative approach, rather than being a numerical, probability-based quantitative analysis.

A traditional quantitative system safety assessment, focusing on the safety effects of failure conditions, is not considered adequate to properly identify the EWIS failures. Indeed, failure of an electrical wire, regardless of the safety effects of the failure of the associated system, could cause serious physical and functional damage to the aircraft, resulting in hazardous or even catastrophic failure conditions.

The integrated nature of wiring and the potential severity of its failures demand a more structured safety analysis approach than the one traditionally used. Traditional system safety assessments typically evaluate effects of wire failures on system functions. But they do not consider physical wire failure as a cause of the failure of other wires within the EWIS. Traditional assessments look at external factors like e.g. rotor burst, lightning, but not at internal factors, like a single wire chafing or arcing event, as the cause of the failure of functions supported by the EWIS. In order to demonstrate compliance of the EWIS with VTOL.2517, it is expected that those failure modes are addressed at the aircraft level. This means that EWIS failures should be analyzed to determine what effect they could have on the safe operation of the aircraft.

As specified above, the analysis required to demonstrate compliance of the EWIS with VTOL.2510 is based on a qualitative approach. The intent is not to examine each individual wire and its relation to other wires. It is rather to ensure that there are no combinations of failures that could lead to a hazardous condition. However, in case such "top down" analysis process determines that a failure in a given bundle may lead to a catastrophic failure condition, assessing its mitigation may lead to a complete analysis of each wire in the relevant bundle.

When using qualitative analyses to determine compliance with VTOL.2510(a)(1) and (a)(2), the following descriptions of the probability terms have become commonly accepted as aids to engineering judgment:

a. Extremely remote failure conditions.

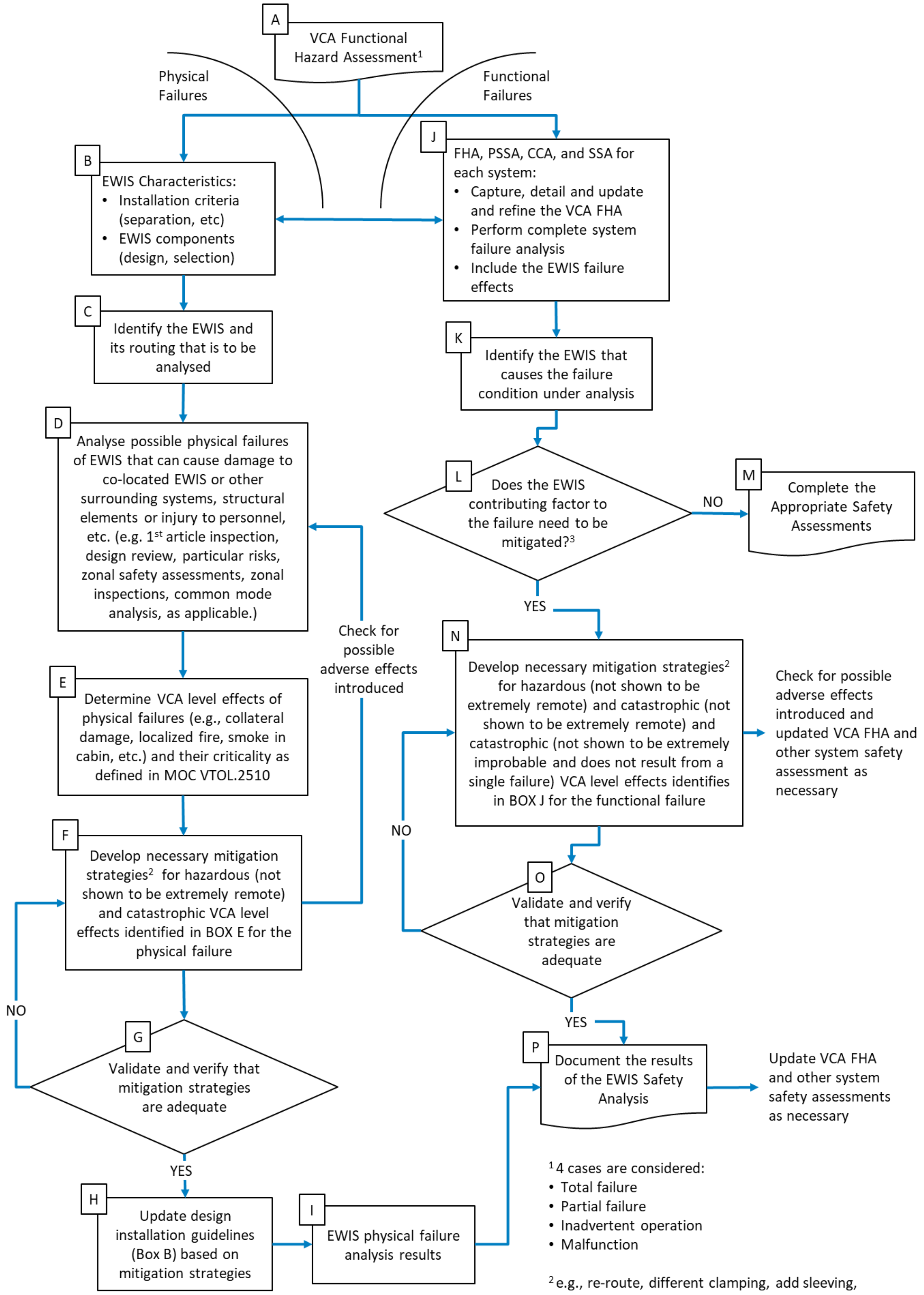
These are failure conditions that are not anticipated to occur to an individual aircraft during its total life, but which may occur a few times when considering the total operational life of all aircraft of the type.

b. Extremely improbable failure conditions.

These are failure conditions so unlikely that they are not anticipated to occur during the entire operational life of all aircraft of one type.

The following flow chart serves as a guidance to analyse the impact on the aircraft FHAs. The flow chart has two main streams, one for functional failures and one for physical failures. For the physical failure analysis, the following is applicable:

a. Only single common cause events or failures need to be addressed during the physical failure analysis as described in this MoC and shown on the left-hand side of Flowchart 1. Multiple common cause events or failures need not be addressed.
b. In relation to physical effects, it should be assumed that wires are carrying electrical energy and that, in the case of an EWIS failure, this energy may result in hazardous or catastrophic effects directly or when combined with other factors, for example fuel, oxygen, hydraulic fluid, or damage by passengers, These failures may result in fire, smoke, emission of toxic gases, damage to co-located systems and structural elements or injury to personnel. This analysis considers all EWIS from all systems (autopilot, auto throttle, PA system, IFE systems, etc.) regardless of the system criticality.



[1] 4 cases are considered:
- Total failure
- Partial failure
- Inadvertent operation
- Malfunction

[2] e.g., re-route, different clamping, add sleeving, add barrier, etc

[3] Contributin means the EWIS causes the failure in whole or in part

Note: VTOL.2510(a)(3) is not considered applicable for the EWIS. The EWIS safety assessment consists in a holistic qualitative analysis at aircraft level. It complements the quantitative approach already used to demonstrate compliance of related systems and equipment with VTOL.2510. Extending such qualitative analysis to address also Major failure conditions of the EWIS would lead to a level of complexity that is not deemed commensurate with the safety benefit that could be potentially obtained.

7. Component identification

EWIS components should be labelled or otherwise identified using a consistent method that facilitates identification of the EWIS component, its function, and its design limitations, if any.

8. Fire protection

(a) EWIS components that are located in designated fire zones and are necessary during emergency procedures should be at least fire resistant.

(b) Insulation on electrical wire and electrical cable, and materials used to provide additional protection for the wire and cable, installed in any area of the aircraft, should be self-extinguishing when tested in accordance with the applicable portions of Appendix F of CS 25.

9. Electrical bonding and protection against static electricity

On aircraft having grounded electrical systems, electrical bonding provided by EWIS components should provide an electrical return path capable of carrying both normal and fault currents without creating a shock hazard or damage to the EWIS components, other aircraft system components, or aircraft structure.

10. Occupant protection

All occupants should be protected from hazards of the electrical systems. The accessible EWIS should be readily identifiable and visible to the occupants and rescue personnel, especially during egress situations and meet the requirements of VTOL.2320.

11. Circuit protective devices

Electrical wires and cables should be designed and installed so they are compatible with the circuit protection devices that ensure compliance with VTOL.2525, and VTOL.2510, so that a fire or smoke hazard cannot be created under temporary or continuous fault conditions.

12. Accessibility provisions

Access to EWIS should be provided to allow for inspection and replacement of any EWIS component as necessary for continued airworthiness.

13. Protection of EWIS

(a) EWIS should be designed and installed to minimize damage and risk of damage to EWIS by movement of people in the aircraft during all phases of flight, maintenance, and servicing.

(b) EWIS should be designed and installed to minimize damage and risk of damage to EWIS by items carried onto the aircraft by passengers or cabin crew.

14. Flammable fluid fire protection

EWIS components located in each area where flammable fluid or vapors might escape by leakage of a fluid system should be considered as a potential ignition source and meet the requirements of VTOL.2325.

15. Instructions for Continued Airworthiness (ICA)

The applicant should prepare ICA in accordance with VTOL.2625 to address all maintenance, replacement, and operational aspects of the EWIS, for example task reference, task type, task interval, zone, task descriptions/procedure etc. This should include all components that make up the system.

MOC VTOL.2555 Installation of flight recorders

> **Note:**
>
> The following text fully replaces MOC VTOL.2555 in Doc. No. MOC SC-VTOL Issue 2, dated 12 May 2021.
>
> Changes and additions are highlighted in blue colour for the reader's convenience.

This MOC is applicable to each recorder installed to comply with VTOL.2555:

(a) Definitions:

Flight recorders are either crash-protected flight recorders, covered by EUROCAE ED-112() or lightweight flight recorders, covered by EUROCAE ED-155().

As defined by ICAO Annex 6, crash-protected flight recorders comprise one or more of the following:

(1) a flight data recorder (FDR),
(2) a cockpit voice recorder (CVR),
(3) an airborne image recorder (AIR),
(4) a data link recorder (DLR).

Lightweight flight recorders comprise one or more of the following:

(1) an aircraft data recording system (ADRS),
(2) a cockpit audio recording system (CARS),
(3) an airborne image recording system (AIRS),
(4) a data link recording system (DLRS).

(b) General:

The recorder should have an ETSO authorisation against one of the following ETSOs or a later equivalent:

(1) ETSO-C123b; or
(2) ETSO-C124b; or
(3) ETSO-C176a; or
(4) ETSO-C177a; or

(5) ETSO-2C197

(c) Recorder installation:

The flight recorder system should be installed in accordance with the recommendations made in EUROCAE Document ED-155 Section 2-5.

The container of the recording medium should be located and mounted so as to minimise the probability of the container rupturing, or the recording medium being destroyed as a result of impact with the Earth's surface or of heat damage caused by a post-impact fire.

The structural provisions within the aircraft for the mounting of the recorder should be able to withstand the loads resulting from severe vibration (such as those resulting from rotor imbalance). In addition, the strength of the local attachments should be able to withstand the crash safety loads in CS 27.561(b)(3).

(d) Minimum Dimensions for the Memory Module ~~Recorder identification~~:

The sum of the height, width and depth of the robust memory module shall be 12 cm or greater. Each of these major dimensions shall be at least 2 cm or greater.

(e) Recorder characteristics:

The recorder and its installation should:

(1) Permit quick downloading of the flight parameters without having to remove the recorder;

(2) should provide an aural or visual means for pre-flight checking of the recorder for proper recording of data in the storage medium;

(3) If the recorder has a recording duration of less than 25 hours, have an automatic means to stop the recording within 10 minutes after the crash impact;

(4) If the recorder has a recording duration of less than 25 hours, have a means for the flight crew to stop the recording upon completion of the flight in such a way that re-enabling the recording is only possible by a dedicated manual action.

(f) Flight Parameters and audio recording:

The recorder, or the combination of recorders installed to comply with VTOL.2555, should:

(1) Record the parameters required to accurately determine the flight path and speed well as any information provided to the crew and necessary for the safe operation of the aircraft. The minimum list of flight parameters to be recorded is provided in paragraphs (k) to (m). All recorded parameter values should be accurately time-stamped according to a common time reference and be recorded at a rate not below 4 Hz for the parameters listed in (k) and at a rate to be agreed by the competent authority for the other ones;

(2) Simultaneously record, on separate channels and with reference to a timescale:

(i) for aircraft intended for multi-crew or VEMS operations,

– the aural environment of the cockpit (using an area microphone);

– the interphone between crew members;

(ii) radio-communications with air traffic service units as required.

(g) Evaluation of recordings

The following acceptable means of compliance with SC VTOL.2555 (a) and (e) is provided to demonstrate that the performance of the installed flight recorder system is acceptable with regard to data recording. Inspections of the recordings that are part of the instructions for continued airworthiness are not within the scope of this paragraph.

(1) A recording made during a flight should be evaluated to confirm that the recording of the data required by Regulation (EU) No 965/2012 is acceptable during all phases of flight where this data should be recorded. In the case of image recordings, refer to Section III-6.4 of ED-155.

(2) The evaluation of the recordings from the flight should include:

(iii) checking the correct functioning of the automatic start-and-stop function of the flight recorder system; and

(iv) if the recorder is fitted with a built-in-test feature, checking the absence of faults that may affect the performance of the recorder.

(3) The evaluation of the recordings should be documented in an evaluation report.

(4) The performance of the flight recorder system with regard to data recording should be considered to be acceptable only if sub-paragraphs (g)(1) and (g)(2) of this MOC were satisfactorily addressed.

(5) It is accepted that by implementing emergency procedures (i.e. for smoke/fire isolation) the power supply to the recorder is cut off.

(h) Image and audio recordings of the flight crew area

If there are no compartments to physically segregate the flight crew from the passengers, the term 'flight crew compartment' in SC VTOL.2555 should be understood as the area including:

(1) the flight crew seat(s),

(2) windshield and windows used by the flight crew to get an external view while seated,

(3) aircraft instruments and controls, and

(4) circuit breakers accessible by the flight crew while seated.

(i) Instructions for continued airworthiness (ICA):

(1) When developing the ICA for the recorder systems, the applicant should address all the failures that may affect their correct functioning or the quality of the recorded information.

Note: 'Recorder systems' designates the recorders and their dedicated equipment (e.g. dedicated sensors or transducers, dedicated data busses, dedicated power source…).

(2) Examples of failures (indicative and non-exhaustive list):

(i) Loss of the recording function or of the acquisition function of the recorder;

(ii) Failure of a means to detect a crash impact (for the purpose of stopping the recording after a crash impact, or for the purpose of deploying the recorder if it is deployable);

(iii) Failure of any power source dedicated to the recorder (e.g. dedicated battery);

(iv) Failure of the start-and-stop function;

(v) Failure of a sensor dedicated to the recorder system;

(vi) For flight parameters recording, when any required parameter is missing, or is not correctly recorded;

(vii) For audio recording (if applicable):

(viii) Any required audio signal is missing, or is recorded with an audio quality that is rated ‘poor’ (refer to the example of audio quality rating provided in Section 9 of AMC 25.1459);

(ix) Failure of a transducer or amplifier dedicated to the recorder system (e.g. failure of the cockpit area microphone).

(3) The ICA should include the procedures to be followed for retrieving the data required to be recorded by the flight recorder when it is undamaged.

In addition, if the flight recorder records some required flight parameters as digital data, the ICA should include a document that presents the information necessary to retrieve the raw binary data of these flight parameters from a recording file and to convert this data into engineering units and textual interpretations. If the flight recorder records some required flight parameters by means of images, the ICA should include a document that presents the information necessary to read the flight parameter values from the recorded images.

(j) Data transmission & ground recording: [Reserved]

(k) The following flight parameters should as a minimum be recorded with a recording resolution at least as high as specified in the applicable version of EUROCAE Documents ED-155 or ED-112. In the absence of a relevant resolution for parameters that are not specified by these standards (e.g., electrical energy), the resolution need to be submitted to the competent authority for acceptance:

(1) Relative ~~T~~ time count;

(2) Pitch ~~Al~~ attitude or pitch rate;

(3) roll attitude or roll rate;

(4) Heading (magnetic or true) or yaw rate;

(5) Latitude;

(6) Longitude;

(7) positioning system: estimated error (if available);

(8) pressure altitude or GNSS altitude;

(9) time;

(10) Groundspeed;

(11) GNSS or inertial T track (if available);

(12) Normal acceleration;

(13) Longitudinal acceleration (body axis);

(14) Lateral acceleration;

(15) remaining usable amount of fuel/energy as displayed to the crew;

(16) amount of fuel/energy necessary to complete the remaining part of the flight as displayed to the crew.

(l) In addition, the parameters characterizing the information that is required to be provided to the crew, as listed below, should be recorded:

(1) control limit as defined by VTOL.2300 (a)(3);

(2) if installed, trim system information that is required for safe operation as defined by VTOL.2300(b)(2);

(3) indication means for fire or smoke awareness as defined by SC VTOL.2325(b)(1);

(4) information related to the lift/thrust configuration as defined by SC VTOL.2445(e);

(5) any additional lift/thrust system information necessary for the safe operation of the aircraft as defined by SC VTOL.2445(c);

(6) system operating parameters provided to the crew and required to operate the aircraft including warnings, cautions, and normal indications as defined by SC VTOL.2605(b);

(7) Information concerning an unsafe system operating condition as defined by SC VTOL.2605(c);

(8) flight, navigation, and lift/thrust system information provided to the crew members to monitor the parameters and trends and limitations, as needed to operate the aircraft as defined by SC VTOL.2615(a).

The applicant should provide a matrix showing which recorded parameters addresses each of the paragraph above.

(m) If the VTOL aircraft has datalink communication capabilities, data link communication messages to and from the aircraft required by airspace usage or operational requirements should be recorded.

(n) Any novel or unique design or operational characteristics of the aircraft should be evaluated to determine if any dedicated parameters must be recorded on the flight data recorder in addition to, or in place of, the parameters that are required by the existing requirements.

(o) If the flight recorder is used to record a flight parameter as required by the applicable operating rules by means of images, the image source must be installed to provide images with a quality sufficient for reading the values of this flight parameter during all phases of the flight.

MOC VTOL.2545 Pressurised system elements

Note:

Following consideration of the comments received during its public consultation, the following text is now proposed to replace the proposed MOC VTOL.2545 in Doc. No. MOC-4 SC-VTOL Issue 1, dated 18 Dec 2023.

The requirement VTOL.2545 applies to both hydraulic systems, and pneumatic and pressurisation systems, as well as their components/elements.

(a) As far as hydraulic systems are concerned, these may include (but are not limited to): landing gear extension/retraction mechanisms, brakes, steering, movable surfaces actuation systems using hydraulic fluid as control and/or energy storage means.

Compliance with VTOL.2545 for hydraulic systems and components may be achieved by showing compliance with the following certification specifications: CS 23.1435 (a) (1) amdt. 4, CS 23.1435 (a) (2) amdt. 4, CS 23.1435 (a) (4) amdt. 4, CS 29.1435 (a) (4) amdt. 11, CS 29.1435 (a) (5) amdt. 11, CS 29.1435 (a) (6) amdt. 11, CS 23.1435 (b) amdt. 4.

Appropriate guidance for establishing the burst pressure for each hydraulic system component may be found in CS 25.1435 (a) (1) or SAE AS5440.

(b) Compliance with VTOL.2545 for pneumatic/pressurisation systems may be achieved by showing compliance with CS 23.1438 amdt. 4 - *Pressurisation and pneumatic systems.*

(1) The following definitions could help an applicant to determine which components belong to pneumatic or pressurization systems.

(i) Pneumatic System: All of the elements of the system that convey gas and/or control pressure and temperature from compressed gas sources to provide a conditioned gas mass flow or provide energy for heating or to perform mechanical work.

(ii) Pressurization System: All elements comprising the system that controls the air pressure of the aircraft pressurized zones. Pressurization system elements include for example the out-flow valves and pressure relief valves. This MOC does not apply to the structural parts of the pressurized cabin. For unpressurised vessel, only the coefficients proposed for the pneumatic parts are applicable.

(2) The burst pressure test requirement for pneumatic and pressurization system elements has been used to demonstrate that high pressure air will be contained within the system or element. The element is not required to function during or after the burst pressure test, but pressurized air must be contained within the element or system. The proof pressure test is used to demonstrate that pneumatic and pressurization system elements can function after a higher-than-normal pressure (1.5 times the maximum normal operating pressure) is introduced into the element or system.

MOC – SUBPART G –FLIGHT CREW INTERFACE AND OTHER INFORMATION

MOC VTOL.2605 Installation and operation information

Note:

The following subparagraph is added to the MOC VTOL.2605 in Doc. No. MOC SC-VTOL Issue 2, dated 12 May 2021.

Changes and additions are highlighted in blue colour for the reader's convenience.

(b) ((5) The identification of unsafe system operating condition (USOC) may be performed according to the process defined in appendix "X2. IDENTIFICATION AND MITIGATION OF UNSAFE SYSTEM OPERATING CONDITIONS" of F3061/F3061M - 24a Standard Specification for Systems and Equipment in Aircraft.

MOC VTOL.2615 (a) Air Data Systems

1. Purpose

This MOC describes an accepted means for showing compliance with VTOL.2615 (a) for Air Data Systems (ADS), in line with VTOL.2500(b) and VTOL.2510. It is intended to supplement the engineering and operational judgment that forms the basis of any compliance demonstration.

2) Terminology and Applicability

Air Data Systems intend to provide flight parameters characterized by the aircraft position and movement relative to the air. These parameters are provided to the crew to fly the aircraft and to various systems, including but not limited to: flight control system, avionics equipment (e.g. transponder) or other aircraft systems. A typical list of ADS output parameters are:

- Pressure-altitude (baro-corrected or not),
- Calibrated and True Airspeed (CAS and TAS),
- Barometric vertical speed,
- Angles of attack (AoA) and of sideslip (AoS)
- Static and/or total temperature (SAT / TAT).

These parameters are typically derived from local measurements obtained from various probes, sensing for example the static pressure, the total pressure and the temperature. Alternate measurement means might also be used, such as optical measurement. The performance of air data parameters displayed to the crew might also be improved by using other sensors such as inertial measurement units. In such a case, the performance of the information provided to the crew or other systems is the one described for air data parameters in this MOC.

This MOC mainly addresses the pressure-altitude and the calibrated airspeed that are provided to the crew. The applicant is expected to address the specific requirements related to each parameter and to each consumer system connected to the ADS using the standard development process. It builds on practices in place on other categories of aircraft, while adapting them to the specific flight envelope of the eVTOL aircraft.

3) Related Documents

Additional information may be found in the following references. Later amendments may be used.

(a) EASA CS-23 Amendment 4: Book 1 CS 23.1311, CS 23.1323, CS 23.1325, CS 23.1545, and Book 2

Flight Test Guide for certification of CS–23 Aeroplanes (FTG) paragraphs 289, 303, 304.

(b) EASA CS-25 Amendment 26 and subsequent, CS 25.1323, CS 25.1325, CS 25.1545 and their AMCs.

(c) EASA CS-27 Amendment 6 and subsequent, CS 27.1323, CS 27.1325, CS 27.1545 and FAA AC 27-1B, paragraphs 27.1323, 27.1325, 27.1543A, 27.1545A.

(d) EASA CS-29 Amendment 6 and subsequent, CS 29.1323, CS 29.1325, CS-29.1545, FAA AC 29.1323, 29.1323A, AC 29.1543.

(e) EUROCAE ED-241 Minimum Operational Performance Specification for Altimetry Function

(f) SAE AS8002B Air Data Computer – Minimum Performance Standard

(g) SAE AS8006A Minimum Performance Standard for Pitot and Pitot-Static Probes

(h) EASA CS-ACNS Issue 5, Subpart E, Appendix A - Altimetry System Error Components

These references are offered for additional guidance but are not in themselves acceptable means of compliance with SC-VTOL. Some of their content may not be applicable due to the design or operational use of the VTOL ADS or be too demanding depending on the VTOL category. However, they contain useful information, either by themselves or by referring to FAA advisory circulars and RTCA and SAE documents.

4) Definitions

(a) 'Instrument' means a device using an internal mechanism to show visually or aurally the attitude, altitude, or operation of an aircraft or aircraft part. It includes electronic devices for automatically controlling an aircraft in flight. (CS-Definitions)

(b) Airspeeds

(1) In this MOC, the term airspeed refers to the airspeed component on the aircraft longitudinal axis.

(2) 'Calibrated airspeed' means indicated airspeed of an aircraft, corrected for position and instrument error. Calibrated airspeed is equal to true airspeed in standard atmosphere at sea level. (CS-Definitions)

(3) 'Equivalent airspeed' means the calibrated airspeed of an aircraft corrected for adiabatic compressible flow for the particular altitude. Equivalent airspeed is equal to calibrated airspeed in standard atmosphere at sea level. (CS-Definitions)

(4) 'Indicated airspeed' means the speed of an aircraft as shown on its Pitot static airspeed indicator calibrated to reflect standard atmosphere adiabatic compressible flow at sea level uncorrected for airspeed system errors. (CS-Definitions)

(5) 'True airspeed' means the airspeed of an aircraft relative to undisturbed air. True airspeed is equal to equivalent airspeed multiplied by $(\rho_o/\rho)^{1/2}$. (CS-Definitions)

(c) Errors

(1) 'Position Error': Position error is the total-pressure (Pitot) and static-pressure errors of the Pitot-static installation. By proper design, the total pressure error may be reduced to the point where it is insignificant for most flight conditions. NASA Reference Publication 1046 (see subparagraph g) gives various design considerations. The static pressure error is more difficult to measure and can be quite large.

(2) 'Instrument Error': Instrument errors are errors inherent in the instrument for mechanical instruments. These errors are the result of manufacturing tolerances, hysteresis, temperature changes, friction, and inertia of moving parts. For electronic instruments, these errors are due to errors in the electronic element which convert Pitot-static pressures into electronic signals. Instrument errors are determined for inflight conditions in steady state conditions. Ground run system calibrations may require the consideration of internal instrument dynamics as would be affected by take-off acceleration.

(3) 'System Error': System error is the combination of position error and instrument error.

(d) Temperatures

(1) 'Static Air Temperature': The temperature of the air outside an aircraft is measured and indicated within the cockpit or used, together with outputs from the Pitot Static System, as an input to aircraft equipment, e.g. Air Data Computer (ADC).

(2) 'Total Air Temperature (TAT)': If temperature is measured by means of a sensor positioned in the airflow, kinetic heating will result, raising the temperature measured above the OAT. The temperature measured in this way is known as the Total Air Temperature (TAT) and is used in ADCs to calculate True Airspeed (TAS). Careful design and siting of the TAT probe is necessary to ensure accurate measurement of TAT.

(e) 'System Calibration': the air data system is calibrated to address the guidance in sections 7 and 8 of this MOC and to establish an air data reference which is used in demonstrating compliance with other applicable regulations.

5) Acronyms

Acronyms	Definition
ACAS	Airborne Collision Avoidance System
ADC	Air Data Computer
ADS	Air Data System
AoA	Angle of attack
AoS	Angle of sideslip
CAS	Calibrated airspeed
CFP	Critical Failure for Performance (See MOC VTOL.2115)
EAS	Equivalent airspeed
FCS	Flight Control System
FDR	Flight Data Recorder
FGS	Flight Guidance System
FMS	Flight Management System
HUD	Head-Up Display
IAS	Indicated Air Speed
ICA	Instruction for Continued Airworthiness
LDP	Landing Decision Point (See MOC VTOL.2130)
MOC	Means of Compliance
OAT	Outside Air Temperature
SAT	Static Air Temperature
TAS	True airspeed
TAT	Total Air Temperature
TAWS	Terrain Avoidance and Warning System
V_D	Maximum Design speed (See MOC VTOL.2200)
V_{NE}	Never-exceed speed (See MOC VTOL.2200)
V_{TOSS}	Take-off Safety Speed (See MOC VTOL.2115)

Acronyms	Definition
ACAS	Airborne Collision Avoidance System
ADC	Air Data Computer
ADS	Air Data System
TDP	Take-off Decision Point (See MOC VTOL.2115)

6) System Description

The applicant should provide a clear, detailed, and comprehensive description of the ADS and its interfaces. The description should encompass –but not be limited to– the aspects listed below. It should include diagrams and images to illustrate the descriptions.

(a) Functions performed by the system.
(b) Architecture, including equipment hosting the ADS functions, their interfaces, their locations, as well as all the other equipment and functions with which the ADS is interacting/interfaced. In particular and when applicable, the protection against icing such as probe heating should be included.
(c) Modes of operation, including their objective, the flight procedures they support, the inputs they are using, the outputs they are producing, reversion conditions, the related indications to the flight crew.
(d) Cockpit interface and figuration of the flight parameters derived from the air data system, including all the controls and displays for the flight crew.
(e) Alerts, including their classification, their visual, aural, and tactile components, and their inhibitions.
(f) Interfaces with other functions/systems, e.g., sensors, FMS, Flight guidance and autopilot, FCS, maintenance, flight recorder, power supply, ACAS, Transponder, TAWS, envelope protection…
(g) A list of all air data parameters, together with the systems which use these parameters and their required accuracy and severity in case of erroneous value, should be provided.
(h) Monitoring within the ADS or in consumer systems.
(i) Consolidation and selection of data, e.g. elaboration of local and global values, selection, voting, blending, fault detection.
(j) Degraded conditions, e.g., failure within the ADS or in the heating system, failure of other functions/systems, electrical bus failures, ...
(k) Calibration,
(l) Self-test and maintenance.

7) System Design and Development – General considerations

(a) The applicant should develop the ADS in accordance with:
  (1) MOC VTOL.2510 regarding safety and development assurance aspects.
  (2) MOC 3 VTOL.2500(b) “airworthiness security in the category enhanced”, when certification for Category Enhanced is sought.
(b) The applicant should design the ADS in accordance with:
  (2) MOC VTOL.2205 “interaction of systems and structures” for taking into account its effects on structures.
  (3) MOC 1 VTOL.2500(b) “intended function of systems and equipment” so that it is qualified for the operating and environmental conditions for which the aircraft is certified.
  (4) MOC 2 VTOL.2500(b) “electromagnetic compatibility”.
  (5) MOC VTOL.2515 “electrical and electronic system lightning protection”.
  (6) MOC VTOL.2520 “high-intensity radiated fields protection”.

(7) MOC VTOL.2600 “flight crew compartment” as regards controls, indications, alerts, and behaviour.
(8) MOC VTOL.250(f) Aircraft capability after bird impact
(9) MOC VTOL.2605 “installation and operating information” as regards its indications and alerts.
(10) VTOL.2610 “instrument markings, control markings and placards” as regards its controls and instruments.
(11) VTOL.2615 “flight, navigation, and lift/thrust system instruments” as regards the provided information.
(12) MOC 5 VTOL.2500 (b) Flight guidance systems VTOL

(c) The applicant should record adequate ADS parameters in accordance with MOC VTOL.2555.
(d) The applicant should also address icing requirements as defined in SC VTOL.2165, as applicable.

8) Performance requirement for air data parameters used as primary flight data - Airspeed

(a) Each airspeed indicating instrument should be approved and should be calibrated to indicate true airspeed (at sea-level with a standard atmosphere) with a minimum practicable instrument calibration error when the corresponding Pitot and static pressures are applied.
(b) Each system should be calibrated to determine system error excluding airspeed instrument error. This calibration should be determined:
    (1) In level flight at speeds from 30 knots or 80% of the take-off safety speed (V_{TOSS}), whichever is lower, up to V_{NE};
    (2) During take-off and landing, with repeatable and readable indications permitting the performance of the approved take-off and landing paths; and
    (3) With the lift/thrust system settings corresponding to the values determined in the establishment of the approved take-off and landing paths assuming that a Critical Failure for Performance (CFP) occurs just beyond the Take-off Decision Point (TDP) or just before the Landing Decision Point (LDP).
(c) The indication should
    (1) allow consistent definition of the take-off and landing decision point if the TDP/LDP is defined based on airspeed indication; and
    (2) be such that the system error, excluding the airspeed instrument calibration error, should not exceed –
        (i) 3% or 9.3 km/h (5 knots), whichever is greater, in level flight at speeds from 9.3 km/h (5 knots) below V_{TOSS};
        (ii) 19 km/h (10 knots) in climb at speeds from 19 km/h (10 knots) below V_{TOSS} or landing reference speed (V_{REF}) (whichever is the lowest) to 19 km/h (10 knots) above the Final Take-off Speed (VFTO), unless a more stringent accuracy is required to accommodate the aircraft speed range and the crew ability to distinguish the various critical speeds.
(d) If the aircraft can stall, from 9.3 km/h (5 knots) below take-off safety speed to the speed at which stall warning begins, the IAS should change perceptibly with CAS and in the same sense, and at speeds below stall warning speed the IAS should not change in an incorrect sense. A rate of change of IAS with CAS greater than 0. 75 between 9.3 km/h (5 knots) below V_{TOSS} to stall warning speed has been accepted in the past.
(e) From V_{NE} to V_{NE} + ⅔ (V_D – V_{NE}), the IAS should change perceptibly with CAS and in the same sense, and at higher speeds up to V_D the IAS should not change in an incorrect sense. A rate of change of IAS with CAS greater than 0. 5 has been accepted in the past. The demonstration may be based on measurements

performed during the aeroelasticity demonstration (see MOC VTOL.2245(d)), or by analysis based on Computation Fluid Dynamics and/or on the airspeed sensor performance.

(f) Each system should be arranged, so far as practicable, to prevent malfunction or serious error due to the entry of moisture, dirt, or other substances. The design and installation of the Pitot system should be such that positive drainage of moisture is provided, chafing of the tubing and excessive distortion at bends is avoided, and the lag and the possibility of moisture blockage in the tubing should be kept to an acceptable minimum.

(g) Where duplicate airspeed indicators are required, their respective Pitot tubes should be far enough apart to avoid damage to both tubes in a collision with a bird.

(h) The definition characteristic speeds of the VTOL aircraft (e.g., V_{TOSS}, V_{REF}, …) should take into account the accuracy of the IAS. When IAS is not directly computed from measurement of the movement of the air mass around the VTOL aircraft (e.g. blended with inertial measurement), additional margins or limitations should be considered for wind variations along the take-off or landing trajectory.

9) Performance requirement for air data parameters used as primary flight data – Baro-altitude

(a) Each instrument with static air case connections should be vented to the outside atmosphere through an appropriate piping system.

(b) Each static port should be designed and located so that:
  (1) the static pressure system performance is least affected by airflow variation, or by moisture or other foreign matter, and
  (2) the correlation between air pressure in the static pressure system and true ambient atmospheric static pressure is not changed when the aircraft is exposed to icing conditions.

(c) The design and installation of the static pressure system should be such that –
  (1) Positive drainage of moisture is provided; chafing of the tubing and excessive distortion or restriction at bends in the tubing is avoided; and the materials used are durable, suitable for the purpose intended, and protected against corrosion; and
  (2) It is airtight except for the port into the atmosphere. A proof test should be conducted to demonstrate the integrity of the static pressure system in the following manner: Evacuate the static pressure system to a pressure differential of approximately 33.86 HPa, (1 inch of mercury) or to a reading on the altimeter, 305 m (1 000 ft) above the aircraft elevation at the time of the test. Without additional pumping for a period of 1 minute, the loss of indicated altitude should not exceed 30 m (100 ft) on the altimeter.

(d) Each pressure altimeter should be approved and should be calibrated to indicate pressure altitude in a standard atmosphere, with a minimum practicable calibration error when the corresponding static pressures are applied.

(e) Each system should be designed and installed so that the error in indicated pressure altitude, at sea-level, with a standard atmosphere, excluding instrument calibration error, does not result in an error of more than ±9 m (±30 ft) at 185 km/h (100 knots) or less and of more than ±9 m (±30 ft) per 185 km/h (100 knots) speed above 185 km/h (100 knots). This condition should apply for the appropriate lift/thrust system settings in the approved speed range.

10) Control, Indicating and Alerting Means

(a) The means provided to the flight crew to interact with the ADS, if any, such as source selection or setting of bugs/alert should enable the flight crew to safely perform their tasks associated with the intended function of the system.

(b) The visual components of the indications and alerts related to the ADS should be positioned in the flight crew field of view in accordance with their intended use and safety implications (e.g., optimum field of view for flight parameters and for caution and warning alerts).

(c) Means should be provided to permit the flight crew to cope with ADS component failures. In particular, the failure of one or several probes, of their heating systems or of ADS computers should be indicated in a way that support the timely recovery of correct parameters. In case such a recovery cannot be achieved, the indication should permit the crew to conduct the corresponding contingency procedure.

11) Air data sensors – common mode sources

(a) Environmental considerations
The air data sensors, which are mounted on the external surfaces of the aircraft, should be qualified to the relevant environmentally qualification standards.
For ice and rain, the air data sensors should also be qualified to the most severe environmental qualification requirements defined to address VTOL.2165. Typically, these sensors could include, but are not limited to, Pitot probes, static probes, angle of attack (AOA) vanes, side slip angle probes, temperature probes, and multi-function probes (containing more than one function, e.g. Pitot and static pressure measurement, AoA, etc). The environmental qualification of the air data sensors is however not addressed in this MoC. Applicants not seeking certification for flight in icing conditions should consider EUROCAE document ED-314, which provides in Chapter 7 compliance methodology to ADS flight instrument external probe icing qualification for inadvertent icing approval.
It is to be noted that environmental qualification alone is not sufficient to satisfy the intent of this MoC.

(b) Other common mode sources
Other potential common mode sources should be considered with respect to the air data sensors. As these are external probes, they are potentially subject to external threats. At least the following should be considered:

(1) Maintenance errors
(2) Bird strike,
(3) Sand projection,
(4) Volcanic ashes,
(5) Obstruction caused by insects,
(6) Development Errors

12) Air data equipment (excluding sensors)

(a) Erroneous air data may be generated by any equipment/function which forms part of the chain between the sensor and the end user. The applicant should review the complete system design and provide a quantitative assessment, as part of a system safety analysis, related to the likelihood of each individual equipment/function providing erroneous air data.

(b) A qualitative assessment should also be performed to address common mode failures and errors.

(c) Since the effect of potential development errors, common mode errors and failures in the air data equipment may also ultimately lead to erroneous air data, the applicant should:

(1) identify every occurrence of such potential common modes (see EUROCAE ED-135/SAE ARP4761A section 4.4.3 (Common Mode Error Analysis));
(2) identify the mitigation means or techniques provided to protect against the effects of the potential common modes.

(d) The common mode and system safety analysis should follow the guidance given in EUROCAE ED-135/SAE ARP4761 and should be presented to the Agency. They may be performed at any stage of the development process. However, due to the potential impact on the system architectures and installation, these analyses should be performed and discussed with EASA early in the development process.

13) The effects of erroneous air data on aircraft systems

(a) Common Mode sources such as environmental conditions may simultaneously affect more than one external air data sensor. This may cause processing of erroneous air data parameters (with the same values) by aircraft systems, in particular flight control, and resulting in the display of erroneous air data values to the crew. The applicant should provide mitigations to minimize the effects at aircraft level and maximize the detection of those effects by the crew.

(b) The failure effects on all the aircraft systems due to erroneous air data should be identified and analysed, and their failure classification determined. The applicant should provide a list of air data parameters, including their contribution towards the failure classification.

(c) The consequences of erroneous data from two sensors of the same type should not result in a Catastrophic failure. For more than two sensors of the same type, the consequences of erroneous data should be minimized as far as practicable. The use of independent sources of information, analytical redundancy or model-based fault detection and isolation techniques should be considered.

(d) Erroneous air data may result in unusual indications and/or alerts being generated by multiple systems. The effects of erroneous air data on consumer systems should be considered, together with how these effects are presented to the crew.

(e) The systems listed below should be analysed individually, and in combination, to determine the effects and failure classification due to erroneous air data. The analysis method should be presented to the Agency together with any assumptions/mitigations.

(f) When conducting the analysis, the applicant should define the threshold(s) at which erroneous data change severity depending on the effects on the systems, e.g., the error in pressure-altitude resulting in a catastrophic effect for navigation might be smaller than the error resulting in a catastrophic effect for flight controls. The applicant should make sure that detection or mitigation means are appropriate for the thresholds and persistency/confirmation times of all ADS user systems.

(g) A list of affected systems should also result from an analysis of the air data system design submitted in Paragraph 6 and should include all systems and/or equipment that use, process, and/or display information based upon air data, such as, but not limited to:

(1) Flight Deck Displays
(2) Flight Control System
(3) Lift/Thrust System
(4) Automatic Flight Guidance System
(5) Stall Warning System
(6) Airborne Collision Avoidance System (ACAS)
(7) Terrain Awareness Warning System (TAWS)
(8) Predictive Windshear System (PWS)
(9) Navigation Function
(10) Energy storage and distribution System
(11) Landing Gear System (including extension/retraction, steering, braking, door locking, control and monitoring)

(12)Environmental Control System, when present
(13)On Ground/In Flight Determination System
(14)Ice Protection System

14) Effects of coexistence of air data parameters from different sources

(a) Air data parameters obtained from the Air Data System may coexist with other air data derived from other sources. For example, back-up air data parameters may feed one or more primary flight displays, while air data parameters from the ADS are in use by other aircraft systems.
(b) This coexistence of air data parameters needs to be assessed for impacts at the aircraft level. An analysis should be carried out to identify those cases in which such coexistence triggers an effect at the aircraft level which is not consistent with the expected behaviour, if back-up air data parameters were also used by other aircraft systems.
(c) Such effects may include, but are not limited to, the triggering of alerts, activation of protection modes or inhibition of functions.

15) Human factor considerations

(a) A demonstration of erroneous air data coming from one air data system (or two air data systems if identical sensor and equipment are used) should be conducted to ensure easy and unambiguous identification of the failure. This may be accomplished using a suitably representative simulation tool.
(b) When two or more air data systems are present, the demonstration should also consider the effects of simultaneous and identical erroneous air data.
(c) The flight deck effects should assist the crew in determining the appropriate action to take. The application of the crew actions should not result in excessive increase in crew's workload and should not require exceptional piloting skill and alertness.

16) Limitations, Procedures, Instructions

(a) The applicant should record the ADS maintenance instructions and mandatory maintenance tasks in the Instruction for Continued Airworthiness (ICA), if any, in accordance with SC VTOL.2625 "instructions for continued airworthiness".
(b) In cases where erroneous air data may be detected by the crew by reference to other independent aircraft systems or reference to outside cues, the applicant should ensure crew procedures are provided in accordance with VTOL.2620 to direct the crew to take appropriate action.
(c) In cases where erroneous air data is detected by aircraft systems, care must be taken to ensure crew procedures are assessed at aircraft-level to ensure that the crew is not overloaded by multiple system-level warnings.