

	SPECIAL CONDITION Vertical Take-Off and Landing (VTOL) Aircraft	Doc. No: SC-VTOL-01 Issue: 1 Date: 2 July 2019
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Special Condition for small-category VTOL aircraft

Statement of Issue

The Agency has received a number of requests for the type certification of vertical take-off and landing (VTOL) aircraft, which differ from conventional rotorcraft or fixed-wing aircraft. In the absence of 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 aircraft has been developed. This special condition addresses the unique characteristics of these products and prescribes airworthiness standards for the issuance of the type certificate, and changes to this type certificate, for a person-carrying VTOL aircraft in the small category, with lift/thrust units used to generate powered lift and control.

Note

For ease of interpretation, grey shading has been used in the following special condition to indicate where additions or substitutions have been made to text that is already existing in CS-23 Amdt 5 and blue shading where additions or substitutions have been made based on the comments received in the public consultation of the proposed special condition. The term “Reserved” has been used to indicate where existing text in CS-23 Amdt 5 has not been found appropriate for this special condition.

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PREAMBLE

Why a Special Condition?

EASA has reviewed more than 150 VTOL project configurations, at different stages of maturity, all aiming at addressing a potentially new market. The available data shows that there are a wide variety of configurations with limited common characteristics except for a VTOL capability and distributed propulsion. Despite having design characteristics of aeroplanes, rotorcraft or both, in most cases EASA was not able to classify these new vehicles as being either a conventional aeroplane or a rotorcraft as covered by the existing certification specifications.

Applying either the certification specifications for aeroplane or for rotorcraft, depending on whether they are rather an aeroplane or rather a rotorcraft, and only adding some modifications would not ensure equal treatment. These new types of vehicles are designed to address the same new market – even though not always the same segments. However CS-23 and CS-27 have significant differences, especially in terms of system Safety Objectives and Operational aspects. EASA opinion is that it would not be fair to treat applicants differently based on the regulatory starting point (CS-23 or CS-27) as it would probably favour some configurations, thus preventing potentially innovative concepts to compete on the market.

Instead, EASA favours to use objective based certification requirements, which provide the necessary flexibility to certify innovative state-of-the-art designs and technology, to establish a common set of conditions for the certification of these new concepts. Therefore EASA developed this VTOL Special Condition extensively based on CS-23 Amendment 5, which is also largely harmonised with the FAAs Part 23, integrating elements of CS-27 and new elements where deemed appropriate. Accepted Means of Compliance (AMC) will be developed and, when considered necessary, the most significant ones may be consulted publicly.

The establishment of a common set of conditions will enable a fair competition and clarity for future potential applicants. In addition, it will enable EASA to consider all vehicles with a Certification Basis based on the VTOL Special Condition as “Special Category” aircraft. This classification will provide greater flexibility in the Operational regulatory framework by enabling to tailor requirements to this type of aircraft rather than having to use aeroplane or helicopter regulations.

Applicability

The special condition has been established to prescribe the technical specifications for the type certification of a person-carrying vertical take-off and landing (VTOL) heavier-than-air aircraft in the small category, with lift/thrust units used to generate powered lift and control. The distinction from conventional aeroplanes is based on the VTOL capability of the aircraft while the distinction from conventional rotorcraft is based on the use of distributed propulsion, specifically when more than two lift/thrust units are used to provide lift during vertical take-off or landing. The special condition is intended to be compatible with a remote piloting capability or different levels of autonomy, however these aspects are not currently addressed by this special condition. Flight crew references will be considered “as applicable” when material for remote piloting and autonomy is added.

EASA has decided to set the scope of the VTOL Special Condition up to the CS-27 small rotorcraft limits, with a passenger seating configuration of 9 or less and a maximum certified take-off mass of 3 175 kg (7 000 lbs) or less. This decision has been motivated by several comments received and provides the possibility to align with the CS-23 aeroplane certification levels 1 to 3 and potentially the future UAS Safety Continuum.

Link to type of Operations

In order to be proportionate to the nature and risk of particular activity to be conducted by VTOL aircraft, two certification categories are introduced in this special condition, namely Basic and Enhanced, linked to the intended type of operations. A direct relationship between airworthiness and types of operations already exist, for example when certifying for VFR or IFR operations. Introducing this additional link allows proportionality in safety objectives and enables to apply the highest safety levels of Category Enhanced to protection of third-parties when flying over congested areas and when conducting commercial air transport of passengers. The operational rules can then be built on demonstrated aircraft safety levels and adapted as necessary to local particularities.

VTOL aircraft that are certified in the Category Enhanced would have to meet requirements for continued safe flight and landing, and be able to continue to the original intended destination or a suitable alternate vertiport after a failure. Whereas for Category Basic only controlled emergency landing requirements would have to be met, in a similar manner to a controlled glide or autorotation.

The types of operations that the Category Enhanced aircraft will perform correspond to the highest operational risk to third parties and/or to passenger transport for remuneration. For this reason the most stringent system safety objectives are assigned regardless of the number of occupants. These safety objectives have been established based upon two complementary EASA evaluations which converged on a numerical value of the same order of magnitude.

The first evaluation considered the underlying assumptions of the current certification specifications, in particular CS-25, CS-27/29 and CS-23. The EASA evaluation aligned with the considerations included in FAA AC 23.1309-1E, when referring to Classes of Airplanes, or “Assessment Levels” in the ASTM standards, and the associated upper limit for the average probability per flight hour for catastrophic failure conditions (i.e. $<1.10^{-6}$ for Class I):

“These classes were defined based on the way accident and safety statistics are currently collected. Generally, the classes deal with airplanes of historical equivalent levels of system complexity, type of use, system reliability, and historical divisions of airplanes according to these characteristics. However, these classes could change because of new technologies. The placement of a specific airplane in a class should be done in reference to all of the airplane’s missions and performance characteristics.”

EASA concluded that the levels of system complexity that is introduced by the distributed propulsion and corresponding advanced flight controls is deemed sufficiently unusual and novel that the current CS-23 acceptable means of compliance are no longer considered appropriate for determining the aircraft and system safety objectives.

The second evaluation was based on the Concept of Operations that were provided by applicants and further complemented by market projection analyses. Two concepts of operations were considered: high-density deployment of urban on-demand passenger commercial air transport for intermodal connections and high-density deployment of urban and inter-urban, on-demand passenger commercial air transport.

Both evaluations confirmed that the current system safety objectives for CS-25 and CS-27/29 aircraft should be maintained as a minimum for the commercial air transport operations of passengers as well as for urban air mobility using VTOL aircraft to address the risks to persons on board and on the ground.

For Category Basic, some level of proportionality is provided: The safety objectives are linked to the maximum number of passenger seats for a given configuration, which is similar to the approach in CS-23. The levels have

been aligned with the CS-23 aeroplane certification levels 1 to 3. The corresponding safety objectives, however, have been increased by one level compared to CS-23, due to the higher dependency on systems that are associated with distributed propulsion, VTOL and the possible invalidation of other CS-23 assumptions. This increase realigns the upper level of Category Basic with current CS-27 aircraft and potential UAS Safety Objectives, while some proportionality between the Categories Basic and Enhanced is maintained through a number of other requirements, such as continued safe flight and landing capability. Objectives are also provided in terms of Functional Development Assurance Level (FDAL) so that, for certain system architectures and levels, it is possible that elements with lower Development Assurance Levels can be combined to achieve the top level objective. EASA has included these Safety Objectives in Accepted Means of Compliance. As always EASA will carefully evaluate any alternative proposed means of compliance that is provided by applicants.

Single failure criteria

The overarching principle that any catastrophic failure condition must not result from a single failure is already included in CS-23 and CS-27 acceptable means of compliance for system safety. It has been elevated to the level of the objective as this consideration may have a significant impact on distributed propulsion architectures. The requirement is extended to also include aircraft structures for the Category Enhanced to make best use of the distributed propulsion while retaining proportionality. This takes into account current in-service experience of “critical parts” with the objective being to promote state-of-the-art design practices that are supported by dedicated AMC. This AMC will include considerations on what constitutes single failures in the context of single and multiple load paths.

Bird strike

Adverse in service experience of rotorcraft operations triggered the FAA to establish the Advisory and Rulemaking Committee (ARAC) Rotorcraft Bird Strike Working Group. In service data showed an increase in reported bird strikes with both small and large category rotorcraft. An increase in the number of bird strikes increases the risk of potential serious injuries or fatalities to occupants and substantial damage to rotorcraft. Taking into account the work of the ARAC, requirements for bird strike have been included for Category Basic aircraft with 7 or more passengers and for Category Enhanced aircraft.

Recorders

12 safety recommendations have been addressed to EASA (by 7 accident investigation authorities) recommending that an in-flight recording capability is provided for light aircraft models which are currently outside the scope of the current flight recorder carriage requirements. In addition, new standards (recently introduced in ICAO Annex 6) require the carriage of lightweight flight recorders for light aeroplanes and light helicopters. EASA has issued Notice of Proposed Amendment 2017-03 with a regulatory proposal how to address this issue. In addition, one of the NTSB recommendations on the Most Wanted List is “Expand Use of Recorders to Enhance Transportation Safety”.

VTOL aircraft are expected to introduce novel technologies and conduct new types of operations. It is therefore deemed to be essential for this new category of aircraft to have a requirement for the installation of recorders included in the airworthiness requirements to support occurrences/accident investigation and to maintain an appropriate level of safety by enabling continuing airworthiness action. As most foreseen configurations are anticipated to have advanced flight controls, this data should already be available and therefore the burden on initial aircraft designs is minimised. Additionally EASA has introduced the possibility to transmit and record some data remotely.

SUBPART A – GENERAL

VTOL.2000 Applicability and definitions

- (a) This Special Condition prescribes airworthiness standards for the issuance of the type certificate, and changes to this type certificate, for a person-carrying vertical take-off and landing (VTOL) heavier-than-air aircraft in the small category. This Special Condition is applicable to aircraft with lift/thrust units used to generate powered lift and control and with more than two lift/thrust units used to provide lift during vertical take-off or landing.
- (b) For the purposes of this Special Condition, the following definition applies:
- (1) 'commercial air transport' means an aircraft operation to transport passengers, cargo or mail for remuneration or other valuable consideration;
 - (2) 'congested area' means in relation to a city, town or settlement, any area which is substantially used for residential, commercial or recreational purposes;
 - (3) 'continued safe flight and landing' means an aircraft is capable of continued controlled flight and landing at a vertiport, possibly using emergency procedures, without requiring exceptional piloting skill or strength;
 - (4) 'controlled emergency landing' means an aircraft is capable of performing a controlled landing, possibly using emergency procedures, without requiring exceptional piloting skill or strength. Upon landing, some aircraft damage may occur;
 - (5) 'normal flight envelope' means the flight envelope associated with routine operational and/or prescribed conditions;
 - (6) 'operational flight envelope' means the flight envelope associated with warning onset;
 - (7) 'limit flight envelope' means the flight envelope associated with aircraft design limits or protection limits;
 - (8) 'vertiport' means an area of land, water, or structure used or intended to be used for the landing and take-off of VTOL aircraft.
- (c) This Special Condition applies to aircraft that are not pressurised.
- (d) This Special Condition applies to aircraft with a V_{NO} or $V_{MO} \leq 250$ knots calibrated airspeed (KCAS) or a $M_{MO} \leq 0.6$.

VTOL.2005 Certification of small-category VTOL aircraft

- (a) Certification with this small category Special Condition applies to an aircraft with a passenger seating configuration of 9 or less and a maximum certified take-off mass of 3 175 kg (7 000 lbs) or less.
- (b) The aircraft must be certified in one or both of the following categories:
- (1) Category Enhanced: the aircraft is capable of continued safe flight and landing and meets all applicable requirements. Aircraft intended for operations over congested areas or for Commercial Air Transport operations of passengers must be certified in this category;

- (2) Category Basic: the aircraft is capable of a controlled emergency landing and meets all applicable requirements.

VTOL.2010 Accepted means of compliance

- (a) An applicant must comply with this Special Condition using means of compliance accepted by EASA, which may include consensus standards.
- (b) An applicant requesting EASA to accept a means of compliance must provide the means of compliance to EASA in an acceptable form and manner.

SUBPART B - FLIGHT

VTOL.2100 Mass and centre of gravity

- (a) The applicant must determine limits for mass and centre of gravity that provide for the safe operation of the aircraft.
- (b) The applicant's design must comply with each requirement of this Subpart at critical combinations of mass and centre of gravity within the aircraft's range of loading conditions using acceptable tolerances.
- (c) The condition of the aircraft at the time of determining its empty mass and centre of gravity must be well defined and easily repeatable.

VTOL.2105 Performance data

- (a) Unless otherwise prescribed, an aircraft must meet the performance requirements of this Subpart in:
 - (1) still air and standard atmospheric conditions at sea level for all aircraft; and
 - (2) ambient atmospheric conditions within the operational flight envelope for:
 - (i) reserved.
 - (ii) Category Enhanced.
- (b) Unless otherwise prescribed, the applicant must develop the performance data required by this Subpart for the following conditions:
 - (1) vertiport altitudes from sea level to the maximum certified take-off and landing altitude; and
 - (2) temperatures above and below standard day temperature that are within the range of operating limitations if those temperatures could have a negative effect on performance.
- (c) The procedures used for determining take-off and landing area must be executable consistently by flight crew of average skill in atmospheric conditions expected to be encountered in service.
- (d) Performance data determined in accordance with SC VTOL.2105(b) must account for losses due to atmospheric conditions, cooling needs, installation, downwash considerations, and other demands on power sources.

VTOL.2110 Flight Envelopes

The applicant must determine the normal, operational and limit flight envelope for each flight configuration used in operations. The flight envelopes determination must account for the most adverse conditions for each flight configuration.

VTOL.2115 Take-off performance

- (a) The applicant must determine take-off performance accounting for:
 - (1) operational flight envelope;
 - (2) reserved; and

- (3) obstacle safety margins.
- (b) Reserved.
- (c) Reserved.

VTOL.2120 Climb requirements

The design must comply with minimum climb performance out of ground effect:

- (a) in the normal flight envelope.
- (b) for Category Enhanced:
 - (1) in the operational envelope;
 - (2) reserved.
- (c) reserved.

VTOL.2125 Climb information

- (a) The applicant must determine, as applicable, climb and/or descent performance:
 - (1) in the normal flight envelope;
 - (2) for Category Enhanced, in the operational envelope;
 - (3) reserved.
- (b) The VTOL ceiling in and out of ground effect, if applicable, must be determined within the operational flight envelope.

VTOL.2130 Landing

The applicant must determine the following, at critical combinations of flight parameters within the operational limits:

- (a) the area required to land and come to a stop, assuming approach paths applicable to the aircraft; and
- (b) the approach and landing speeds, configurations, and procedures, which allow a flight crew of average skill to land within the published landing area consistently and without causing damage or injury, and which allow for a safe transition to the balked-landing conditions.

VTOL.2135 Controllability

- (a) The aircraft must be controllable and manoeuvrable, without requiring exceptional piloting skills, alertness, or strength, within the operational flight envelope and must be controllable and manoeuvrable within the limit flight envelope:
 - (1) at all loading conditions for which certification is requested;
 - (2) during all phases of ground or flight operations;
 - (3) reserved;

- (4) during configuration changes;
 - (5) in all degraded flight control system operating modes; and
 - (6) the applicant must demonstrate controllability in wind from zero to a wind limit appropriate for the aircraft type.
- (b) Reserved.
 - (c) Reserved.
 - (d) It must be possible to make a smooth transition from one flight condition to another without danger of exceeding the limit flight envelope.

VTOL.2140 Control forces

- (a) Reserved.
- (b) Reserved.
- (c) Residual control forces must not fatigue or distract the flight crew during normal operations of the aircraft and likely abnormal or emergency operations. The trim control, if installed, must not introduce any undesirable discontinuities in control force gradients.

VTOL.2145 Flying qualities

- (a) Within its flight envelopes, the aircraft must show suitable stability and control feel, in all axes.
- (b) Within its flight envelopes, no aircraft may exhibit any divergent stability characteristic, so as to require exceptional piloting skills, alertness, or strength or otherwise endanger the aircraft and its occupants.

VTOL.2150 Stall characteristics and stall warning

- (a) If part of the lift is generated by a wing, the aircraft must have controllable stall characteristics in straight flight, turning flight, and accelerated turning flight with a clear and distinctive stall warning that provides sufficient margin to prevent inadvertent stalling.
- (b) Reserved.
- (c) Reserved.
- (d) Reserved.
- (e) Reserved.

VTOL.2155 (reserved)

VTOL.2160 Vibration

- (a) Each part of the aircraft must be free from excessive vibration throughout the limit flight envelope.
- (b) Reserved.
- (c) Reserved.

(d) Reserved.

VTOL.2165 | Flight in icing conditions

- (a) An applicant who requests certification for flight in icing conditions must demonstrate that the aircraft can be safely operated in the icing conditions for which certification is requested.
- (b) The applicant must provide a means to detect any icing conditions for which the aircraft is not certified to operate and demonstrate the aircraft's ability to avoid or exit those conditions.
- (c) The applicant must develop an operating limitation to prohibit intentional flight, including take-off and landing, into icing conditions for which the aircraft is not certified to operate.

FLIGHT INFORMATION

VTOL.2170 | Operating Limitations

- (a) The following flight information must be established:
 - (1) operating limitations, procedures and instructions necessary for the safe operation of the aircraft; and
 - (2) essential speeds and performance information.

SUBPART C -STRUCTURES

VTOL.2200 Structural design envelope

The applicant must determine the structural design envelope, which describes the range and limits of aircraft design and operational parameters for which the applicant will show compliance with the requirements of this Subpart. The applicant must account for all aircraft design and operational parameters that affect structural loads, strength, durability, and aeroelasticity, including:

- (a) structural design airspeeds to be considered when determining the corresponding manoeuvring and gust loads must:
 - (1) if part of the lift is generated by a wing, be sufficiently greater than the stalling speed of the aircraft to safeguard against loss of control in turbulent air, if applicable; and
 - (2) provide sufficient margin for the establishment of practical operational limiting airspeeds.
- (b) flight load conditions to be expected in service;
- (c) mass variations and distributions over the applicable mass and centre of gravity envelope, within the operating limitations;
- (d) loads in response to all designed control inputs; and
- (e) redistribution of loads if deflections under load would significantly change the distribution of external or internal loads.

VTOL.2205 Interaction of systems and structures

For aircraft equipped with systems that affect structural performance, either directly or as a result of failure or malfunction, the applicant must account for the influence and failure conditions of these systems when showing compliance with the requirements of this Subpart.

STRUCTURAL LOADS

VTOL.2210 Structural design loads

- (a) The applicant must:
 - (1) determine structural design loads resulting from likely externally or internally applied pressure, force or moment which may occur in flight, ground and water operations, ground- and water-handling, and while the aircraft is parked or moored;
 - (2) determine the loads required by SC VTOL.2210(a)(1) at all critical combinations of parameters, on and within the boundaries of the structural design envelope; and
 - (3) the magnitude and distribution of these loads must be based on established physical principles within the structural design envelope.

VTOL.2215 Flight load conditions

- (a) Critical flight loads must be established for symmetrical and asymmetrical loading from all combinations of flight parameters and load factors at and within the boundaries of the manoeuvre and gust envelope:
 - (1) at each altitude within the operating limitations, where the effects of compressibility are taken into account when significant;
 - (2) at each mass from the design minimum mass to the design maximum mass; and
 - (3) at any practical but conservative distribution of disposable load within the operating limitations for each altitude and weight.
- (b) Vibration and buffeting must not result in structural damage
 - (1) up to dive speed.
 - (2) within the limit flight envelope.
- (c) Flight loads resulting from a likely failure of an aircraft system, component, or lift/thrust unit must be determined.

VTOL.2220 Ground and water load conditions

The applicant must determine the structural design loads resulting from taxi, take-off, landing, and handling conditions on the applicable surface in normal and adverse attitudes and configurations.

VTOL.2225 Component loading conditions

- (a) The applicant must determine the loads acting upon all relevant structural components, including rotor assemblies, in response to:
 - (1) interaction of systems and structures;
 - (2) structural design loads;
 - (3) flight load conditions;
 - (4) ground and water load conditions; and
 - (5) limit input torque from lift/thrust units at any rotational speed.
- (b) Reserved.

VTOL.2230 Limit and ultimate loads

- (a) Unless special or other factors of safety are necessary to meet the requirements of this Subpart, the applicant must determine:
 - (1) the limit loads, which are equal to the structural design loads;
 - (2) the ultimate loads, which are equal to the limit loads multiplied by a 1.5 factor of safety, unless otherwise provided.
- (b) Some strength specifications are specified in terms of ultimate loads only, when permanent detrimental deformation is acceptable.

STRUCTURAL PERFORMANCE

VTOL.2235 Structural strength

The structure must support

- (a) limit loads without:
 - (1) interference with the safe operation of the aircraft; and
 - (2) detrimental or permanent deformation.
- (b) ultimate loads.

VTOL.2240 Structural Durability

- (a) The applicant must develop and implement inspections or other procedures to prevent structural failures due to foreseeable causes of strength degradation, which could result in serious or fatal injuries, or extended periods of operation with reduced safety margins. Each of the inspections or other procedures developed under SC VTOL.2240 must be included in the Airworthiness Limitations Section of Instructions for Continued Airworthiness required by SC VTOL.2625.
- (b) For Category Enhanced, the procedures developed for compliance with SC VTOL.2240(a) must be capable of detecting structural damage before the damage could result in structural failure.
- (c) Reserved.
- (d) The aircraft must be designed to minimise hazards to the aircraft due to structural damage caused by high-energy fragments from an uncontained lift/thrust unit or rotating-machinery failure.
- (e) For Category Enhanced, provisions for in-service monitoring of parts having an important bearing on safety in operations must be established.

VTOL.2245 Aeroelasticity

- (a) The aircraft must be free from flutter, control reversal, and divergence:
 - (1) at all speeds within and sufficiently beyond the structural design envelope;
 - (2) for any configuration and condition of operation;
 - (3) accounting for critical degrees of freedom; and
 - (4) accounting for any critical failures or malfunctions.
- (b) The applicants' design must account for tolerances for all quantities that affect flutter.

VTOL.2250 Design and construction principles

- (a) Each part, article, and assembly must be designed for the expected operating conditions of the aircraft.
- (b) Design data must adequately define the part, article, or assembly configuration, its design features, and any materials and processes used.

- (c) The suitability of each design detail and part having an important bearing on safety in operations must be determined. For Category Enhanced, a single failure must not have a catastrophic effect upon the aircraft.
- (d) The control system must be free from jamming, excessive friction, and excessive deflection when the aircraft is subjected to expected limit air loads.
- (e) Doors, canopies, and exits must be protected against inadvertent opening in flight, unless shown to create no hazard, when opened in flight.
- (f) The aircraft must be designed to ensure that after a likely bird impact the capability remains to conduct:
 - (1) a controlled emergency landing for Category Basic with a maximum passenger seating configuration of 7 or more; or
 - (2) continued safe flight and landing for Category Enhanced.

VTOL.2255 Protection of structure

- (a) Each part of the aircraft, including small parts such as fasteners, must be protected against deterioration or loss of strength due to any cause likely to occur in the expected operational environment.
- (b) Each part of the aircraft must have adequate provisions for ventilation and drainage.
- (c) For each part that requires maintenance, preventive maintenance, or servicing, the applicant must incorporate a means into the aircraft design to allow such actions to be accomplished.

VTOL.2260 Materials and processes

- (a) The applicant must determine the suitability and durability of materials used for parts, articles, and assemblies, the failure of which could prevent continued safe flight and landing for Category Enhanced, or a controlled emergency landing for Category Basic, accounting for the effects of likely environmental conditions expected in service.
- (b) The methods and processes of fabrication and assembly used must produce consistently sound structures. If a fabrication process requires close control to reach this objective, the applicant must define the process with an approved process specification as part of the design data.
- (c) Except as provided for in SC VTOL.2260(f) and (g), the applicant must select design values that ensure material strength with probabilities that account for the criticality of the structural element. Design values must account for the probability of structural failure due to material variability.
- (d) If material strength properties are required, a determination of those properties must be based on sufficient tests of material meeting specifications to establish design values on a statistical basis.
- (e) If environmental effects are significant on a critical component or structure under normal operating conditions, the applicant must determine those effects.
- (f) Design values, greater than the minimums specified by SC VTOL.2260, may be used, where only guaranteed minimum values are normally allowed, if a specimen of each individual item is tested before use to determine that the actual strength properties of that particular item will equal or exceed those used in the design.
- (g) An applicant may use other material design values if specifically approved by EASA.

VTOL.2265 Special factors of safety

- (a) The applicant must determine a special factor of safety for each critical design value for each part, article, or assembly for which that critical design value is uncertain, and for each part, article, or assembly that is:
 - (1) likely to deteriorate in service before normal replacement; or
 - (2) subject to appreciable variability because of uncertainties in manufacturing processes or inspection methods.
- (b) The applicant must determine a special factor of safety using quality controls and specifications that account for each:
 - (1) type of application;
 - (2) inspection method;
 - (3) structural test requirement;
 - (4) sampling percentage; and
 - (5) process and material control.
- (c) The applicant must multiply the highest pertinent special factor of safety in the design for each part of the structure by each limit load and ultimate load, or ultimate load only, if there is no corresponding limit load, such as occurs with emergency condition loading.

STRUCTURAL OCCUPANT PROTECTION**VTOL.2270 Emergency conditions**

- (a) The aircraft, even when damaged in an emergency landing, must protect each occupant against injury that would preclude egress when:
 - (1) properly using safety equipment and features provided for in the design;
 - (2) the occupant experiences ultimate static inertia loads likely to occur in an emergency landing; and
 - (3) items of mass, including lift/thrust unit or auxiliary power units (APUs), within or adjacent to the cabin, that could injure an occupant, experience ultimate static inertia loads likely to occur in an emergency landing.
- (b) The emergency landing conditions specified in SC VTOL.2270(a) must:
 - (1) include dynamic conditions that are likely to occur in an emergency landing; and
 - (2) not generate loads experienced by the occupants, which exceed established human-injury criteria for human tolerance due to restraint or contact with objects in the aircraft.
- (c) The aircraft must provide protection for all occupants, accounting for likely flight, ground, and emergency landing conditions.
- (d) Each occupant protection system must perform its intended function and not create a hazard that could cause a secondary injury to an occupant. The occupant protection system must not prevent occupant egress or interfere with the operation of the aircraft when not in use.

- (e) Each baggage and cargo compartment must:
- (1) be designed for its maximum loading and for the critical load distributions at the maximum load factors corresponding to the flight and ground load conditions determined under this **Special Condition**;
 - (2) have a means to prevent the contents of the compartment from becoming a hazard by impacting occupants or shifting;
 - (3) protect controls, wiring, lines, equipment, or accessories whose damage or failure would prevent **continued safe flight and landing for Category Enhanced**, **or a controlled emergency landing for Category Basic**; and
 - (4) **be designed so that a fire does not preclude continued safe flight and landing for Category Enhanced**, **or a controlled emergency landing for Category Basic**.

SUBPART D –DESIGN AND CONSTRUCTION

VTOL.2300 Flight control systems

- (a) The flight control systems must be designed to:
- (1) operate easily, smoothly, and positively enough to allow proper performance of their functions;
 - (2) protect against likely hazards;
 - (3) allow flight crew to be aware of the control limits.
- (b) Trim systems, if installed, must be designed to:
- (1) protect against inadvertent, incorrect, or abrupt trim operation;
 - (2) provide information that is required for safe operation.

VTOL.2305 Landing gear systems

- (a) The landing gear must be designed to:
- (1) provide stable support and control to the aircraft during surface operation; and
 - (2) account for likely system failures and likely operation environment (including anticipated limitation exceedances and emergency procedures).
- (b) The aircraft must have a reliable means of stopping the aircraft with sufficient kinetic energy absorption to account for landing and take-off, in all approved conditions, and of holding the aircraft in position when parked.
- (c) For aircraft that have a system that actuates the landing gear, there must be:
- (1) a positive means to keep the landing gear in the landing position; and
 - (2) an alternative means available to bring the landing gear in the landing position when a non-deployed system position would be a hazard.

VTOL.2310 Flotation

- (a) If certification for intended operations on water is requested, the aircraft must:
- (1) provide buoyancy of 80 % in excess of the buoyancy required to support the maximum weight of the aircraft in fresh water; and
 - (2) have sufficient margin so that the aircraft will stay afloat at rest in calm water without capsizing in case of a likely float or hull flooding.
- (b) If certification for emergency flotation is requested, the aircraft must :
- (1) be equipped with an approved emergency flotation system;
 - (2) have flotation units of the emergency flotation system and their attachments to the aircraft capable of withstanding the applicable water loads; and
 - (3) be shown to maintain its intended floating attitude in the sea conditions selected by the applicant.

- (c) If certification for ditching is requested, the aircraft must :
- (1) be equipped with an approved emergency flotation system that does not rely on manual activation;
 - (2) withstand the applicable water loads; and
 - (3) be shown to have a safe water entry and to maintain its intended floating attitude in the sea conditions selected by the applicant.

OCCUPANT SYSTEM DESIGN PROTECTION

VTOL.2315 Means of egress and emergency exits

- (a) The aircraft must be designed to:
- (1) Facilitate rapid and safe evacuation of the aircraft in conditions likely to occur following an emergency landing, including on water if an emergency flotation system is included.
 - (2) Have means of egress (openings, exits or emergency exits) that can be readily located and opened from the inside and outside. The means of opening must be simple and obvious. If an emergency flotation system is included, the means of egress must be above the water in the intended floating attitude. Additionally, if certification for ditching is requested, the means of egress must be usable in all stable floating attitudes.
 - (3) Have easy access to emergency exits when present.
- (b) Reserved.

VTOL.2320 Occupant physical environment

- (a) The aircraft must be designed to:
- (1) allow clear communication between the flight crew and passengers;
 - (2) protect the occupants against serious injury due to hazards originating from high energy, associated with systems and equipment, including while embarking and disembarking; and
 - (3) protect the occupants against serious injury due to breakage of windshields, windows, and canopies.
- (b) Reserved.
- (c) The aircraft must provide each occupant with air at a breathable pressure, free of hazardous concentrations of gases, vapours and smoke during normal operations and likely failures.
- (d) Reserved.
- (e) If an oxygen system is installed in the aircraft, it must:
- (1) effectively provide oxygen to each user to prevent the effects of hypoxia; and
 - (2) be free from hazards in itself, in its method of operation, and its effect upon other components.

FIRE AND HIGH ENERGY PROTECTION

VTOL.2325 Fire Protection

- (a) The aircraft must be designed to minimise the risk of fire initiation due to:
- (1) anticipated heat or energy dissipation or system failures or overheat that are expected to generate heat sufficient to ignite a fire;
 - (2) ignition of flammable fluids, gases or vapours; and
 - (3) fire-propagating or -initiating system characteristics (e.g. oxygen systems).
 - (4) a survivable emergency landing.
- (b) The aircraft must be designed to minimise the risk of fire propagation by:
- (1) providing adequate fire or smoke awareness and extinguishing means when practical;
 - (2) application of self-extinguishing, flame-resistant, or fireproof materials that are adequate to the application, location and certification level; or
 - (3) specifying and designing designated fire zones that meet the specifications of SC VTOL.2330.

VTOL.2330 Fire Protection in designated fire zones

- (a) Flight critical systems, lift/thrust unit mounting, and other structures within or adjacent to designated fire zones must be capable of withstanding the effects of a fire.
- (b) A fire or other release of stored energy in a designated fire zone must not preclude continued safe flight and landing for Category Enhanced, or a controlled emergency landing for Category Basic.
- (c) Terminals, equipment, and electrical cables used during emergency procedures must be fire-resistant.

VTOL.2335 Lightning Protection

Unless it is shown that exposure to lightning is unlikely, the aircraft must be protected against catastrophic effects of lightning.

VTOL.2340 Design and construction information

The following design and construction information must be established:

- (a) operating limitations, procedures and instructions necessary for the safe operation of the aircraft;
- (b) the need for instrument markings or placards;
- (c) any additional information necessary for the safe operation of the aircraft; and
- (d) inspections or maintenance to assure continued safe operation.

SUBPART E –LIFT/THRUST SYSTEM INSTALLATION

VTOL.2400 Lift/thrust system installation

- (a) For the purpose of this Subpart, the aircraft lift/thrust system installation must include each component that is necessary for lift/thrust, affects lift/thrust safety, or provides auxiliary power to the aircraft.
- (b) Each aircraft engine, propeller and auxiliary power unit (APU) must be type certified, or meet accepted specifications.
- (c) The applicant must construct and arrange each lift/thrust system installation to account for:
 - (1) all likely operating conditions, including foreign object threats;
 - (2) sufficient clearance of moving parts to other aircraft parts and their surroundings;
 - (3) likely hazards in operation, including hazards to ground personnel; and
 - (4) vibration and fatigue.
- (d) Hazardous accumulations of fluids, vapours or gases must be isolated from the aircraft and personnel compartments and must be safely contained or discharged.
- (e) Installations of lift/thrust system components that deviate from the component limitations or installation instructions must be shown to be safe.
- (f) For the purposes of this Subpart, 'energy' means any type of energy for the lift/thrust unit, including, for example, fuels or any kind of electric current.

VTOL.2405 (reserved)

VTOL.2410 (reserved)

VTOL.2415 Lift/thrust system installation ice protection

- (a) The aircraft and lift/thrust system installation design must prevent any accumulation or shedding of ice or snow that would adversely affect lift/thrust system operation.
- (b) Reserved.

VTOL.2420 (reserved)

VTOL.2425 Lift/thrust system operational characteristics

- (a) The installed lift/thrust system must operate without any hazardous characteristics during normal and emergency operation within the range of operation limitations for the aircraft and lift/thrust system installation.
- (b) If the safety benefits outweighs the hazard, the design must allow the shutdown and restart of a lift/thrust unit in flight within an established envelope.

VTOL.2430 Lift/thrust system installation, energy storage and distribution systems

- (a) Each system must:
- (1) be designed to provide independence between multiple energy storage and supply systems so that a failure, including fire, of any one component in one system will not result in the loss of energy storage or supply of another system.
 - (2) be designed to prevent catastrophic events due to lightning strikes taking into account direct and indirect effects for aircraft unless it is shown that exposure to lightning is unlikely.
 - (3) provide energy to the lift/thrust system installation with adequate margins to ensure safe functioning under all permitted and likely operating conditions, and accounting for likely component failures.
 - (4) provide the relevant information established in SC VTOL.2445 to the flight crew and provide uninterrupted supply of that energy when the system is correctly operated, accounting for likely energy fluctuations.
 - (5) provide a means to safely remove or isolate the energy stored within the system.
 - (6) be designed to retain the energy under all likely operating conditions and minimise hazards to the occupants and people on the ground during any survivable emergency landing. For Category Enhanced, failure due to overload of the landing system must be taken into account.
 - (7) prevent hazardous contamination of the energy supplied to each lift/thrust unit installation.
- (b) Each storage system must:
- (1) withstand the loads under likely operating conditions without failure, accounting for installation;
 - (2) be isolated from personnel compartments and protected from likely hazards;
 - (3) be designed to prevent significant loss of stored energy due to energy transfer or venting under likely operating conditions;
 - (4) provide energy for a sufficient reserve based on a standard flight; and
 - (5) be capable of jettisoning energy safely if this functionality is provided.
- (c) Each energy-storage-refilling or -recharging system must be designed to:
- (1) prevent improper refilling or recharging;
 - (2) prevent contamination of the stored energy during likely operating conditions; and
 - (3) prevent the occurrence of any hazard to the aircraft or to persons during refilling or recharging.
- (d) Likely errors during ground handling of the aircraft must not lead to a hazardous loss of stored energy.

VTOL.2435 Lift/thrust installation support systems

- (a) Reserved.
- (b) Reserved.
- (c) Reserved.

- (d) Reserved.
- (e) Reserved.
- (f) Likely foreign object damage that would be hazardous to the lift/thrust unit must be prevented.
- (g) The flight crew must be aware of the lift/thrust configuration.
- (h) Reserved.

VTOL.2440 Lift/thrust system installation fire protection

There must be means to isolate and mitigate hazards to the aircraft in the event of a lift/thrust system fire or overheat in operation.

VTOL.2445 Lift/thrust system installation information

The following lift/thrust system installation information must be established:

- (a) Operating limitations, procedures and instructions necessary for the safe operation of the aircraft;
- (b) the need for instrument markings or placards;
- (c) any additional information necessary for the safe operation of the aircraft;
- (d) inspections or maintenance to assure continued safe operation;
- (e) information related to the lift/thrust configuration;
- (f) techniques and associated limitations for lift/thrust unit starting and stopping; and
- (g) energy level information to support energy management, including consideration of a likely component failure within the system.

SUBPART F –SYSTEMS AND EQUIPMENT

VTOL.2500 General requirements on systems and equipment function

- (a) Requirements SC VTOL.2500, SC VTOL.2505 and SC VTOL.2510 are general requirements applicable to systems and equipment installed in the aircraft, and should not be used to supersede any other specific SC VTOL requirement.
- (b) Equipment and systems required to comply with type certification requirements, airspace requirements or operating rules, or whose improper functioning would lead to a hazard, must be designed and installed so that they perform their intended function throughout the operating and environmental limits for which the aircraft is certified.

VTOL.2505 General requirements on equipment installation

- (a) Each item of installed equipment must be installed according to limitations specified for that equipment.
- (b) Reserved.

VTOL.2510 Equipment, systems, and installations

- (a) The equipment and systems identified in SC VTOL.2500, considered separately and in relation to other systems, must be designed and installed such that:
 - (1) each catastrophic failure condition is extremely improbable and does not result from a single failure;
 - (2) each hazardous failure condition is extremely remote; and
 - (3) each major failure condition is remote.
- (b) The operation of equipment and systems not covered by SC VTOL.2500 must not cause a hazard to the aircraft or its occupants throughout the operating and environmental limits for which the aircraft is certified.
- (c) For Category Enhanced, provisions for in-service monitoring of equipment and systems which failure may have hazardous or catastrophic consequences must be established.

VTOL.2515 Electrical and electronic system lightning protection

Unless it is shown that exposure to lightning is unlikely:

- (a) each electrical or electronic system that performs a function, the failure of which would prevent continued safe flight and landing for Category Enhanced, or a controlled emergency landing for Category Basic, must be designed and installed such that:
 - (1) the function at the aircraft level is not adversely affected during and after the time the aircraft is exposed to lightning; and

- (2) the system recovers normal operation of that function in a timely manner after the aircraft is exposed to lightning unless the system's recovery conflicts with other operational or functional requirements of the system.
- (b) each electrical and electronic system that performs a function, the failure of which would reduce the capability of the aircraft or the ability of the flight crew to respond to an adverse operating condition, must be designed and installed such that the system recovers normal operation of that function in a timely manner after the aircraft is exposed to lightning.

VTOL.2520 High-intensity radiated fields (HIRF) protection

- (a) Each electrical and electronic system that perform a function, the failure of which would prevent continued safe flight and landing for Category Enhanced, or a controlled emergency landing for Category Basic, must be designed and installed such that:
 - (1) the function at the aircraft level is not adversely affected during and after the time the aircraft is exposed to the HIRF environment; and
 - (2) the system recovers normal operation of that function in a timely manner after the aircraft is exposed to the HIRF environment, unless the system's recovery conflicts with other operational or functional requirements of the system.
- (b) Each electrical and electronic system that performs a function, the failure of which would reduce the capability of the aircraft or the ability of the flight crew to respond to an adverse operating condition, must be designed and installed such that the system recovers normal operation of that function in a timely manner after the aircraft is exposed to the HIRF environment.

VTOL.2525 System power generation, energy storage, and distribution

The power generation, energy storage, and distribution for any system, as applicable, must be designed and installed to:

- (a) supply the power required for operation of connected loads during all intended operating conditions;
- (b) reserved;
- (c) reserved.

VTOL.2530 External and cockpit lighting

- (a) All lights must be designed and installed to minimise any adverse effects on the performance of flight crew duties.
- (b) Any position and anti-collision lights, if required by operational rules, must have the intensities, flash rate, colours, fields of coverage, and other characteristics to provide sufficient time for another aircraft to avoid a collision.
- (c) Any position lights, if required by operational rules, must include a red light on the left side of the aircraft, a green light on the right side of the aircraft, spaced laterally as far apart as practicable, and a white light facing aft, located on an aft portion of the aircraft fuselage or on the wing tips.

- (d) Taxi and landing lights, if required, must be designed and installed so they provide sufficient light for night operations.
- (e) If certification for intended operations on water is requested, riding lights must provide a white light visible in clear atmospheric conditions.

VTOL.2535 Safety equipment

Safety and survival equipment, required by the operating rules, must be reliable, readily accessible, easily identifiable, and clearly marked to identify its method of operation.

VTOL.2540 (reserved)

VTOL.2545 Pressurised systems elements

Pressurised systems must withstand appropriate proof and burst pressures.

VTOL.2550 (reserved)

VTOL.2555 Installation of recorders

The aircraft must be equipped with a recorder or recorders that:

- (a) is installed so as to ensure accurate and intelligible recording and appropriate safeguarding of the data supportive for accident investigation, considering conditions encountered during crash, water immersion or fire;
- (b) is powered by the most reliable power source and remains powered for as long as possible without jeopardising service to essential or emergency loads and emergency operation of the aircraft;
- (c) includes features to facilitate the localisation of a memory medium after an accident;
- (d) is installed so that it automatically records when the aircraft is capable of moving under its own power; and
- (e) records in an accepted format;
- (f) alternatively some data may be transmitted and recorded remotely.

SUBPART G –FLIGHT CREW INTERFACE AND OTHER INFORMATION

VTOL.2600 Flight crew compartment

- (a) The flight crew compartment arrangement, including flight crew view, and its equipment must allow the flight crew to perform their duties within the flight envelopes of the aircraft, without excessive concentration, skill, alertness, or fatigue.
- (b) The applicant must install flight, navigation, surveillance, and lift/thrust system installation controls and displays so that a qualified flight crew can monitor and perform defined tasks associated with the intended functions of systems and equipment. The system and equipment design must account for flight crew errors, which could result in additional hazards.
- (c) For Category Enhanced, the flight crew interface design must allow for continued safe flight and landing after the loss of vision through any one of the windshield panels.

VTOL.2605 Installation and operation information

- (a) Each item of installed equipment related to the flight crew interface must be labelled, if applicable, as for its identification, function, or operating limitations, or any combination of these factors.
- (b) There must be a discernible means of providing system operating parameters required to operate the aircraft including warnings, cautions, and normal indications, to the responsible crew member.
- (c) Information concerning an unsafe system operating condition must be provided in a timely manner to the crew member responsible for taking corrective action. The information must be clear enough to avoid likely crew member errors.
- (d) Information related to safety equipment must be easily identifiable and its method of operation must be clearly marked.

VTOL.2610 Instrument markings, control markings and placards

- (a) Each aircraft must display in a conspicuous manner any placard and instrument marking necessary for operation.
- (b) The design must clearly indicate the function of each cockpit control, other than primary flight controls.
- (c) The applicant must include instrument marking and placard information in the Aircraft Flight Manual.

VTOL.2615 Flight, navigation, and lift/thrust system instruments

- (a) Installed systems must provide the flight crew member who sets or monitors parameters for the flight, navigation, and lift/thrust system the information necessary to do so during each phase of flight. This information must:
 - (1) be presented in a manner that the crew members can monitor the parameters and trends, as needed to operate the aircraft; and
 - (2) include limitations, unless the limitation cannot be exceeded in all intended operations.

- (b) Indication systems that integrate the display of flight or lift/thrust system parameters required to safely operate the aircraft, or required by the operating rules, must:
 - (1) not inhibit the primary display of flight or lift/thrust system parameters needed by any flight crew member in any normal mode of operation;
 - (2) reserved.

VTOL.2620 Aircraft Flight Manual

The applicant must provide an aircraft flight manual that must be delivered with each aircraft and contains the following information:

- (a) operating limitations and procedures;
- (b) performance information;
- (c) loading information;
- (d) instrument marking and placard information; and
- (e) any other information necessary for the safe operation of the aircraft.

VTOL.2625 Instructions for Continued Airworthiness

- (a) The applicant must prepare Instructions for Continued Airworthiness that are appropriate for the certification level and performance level of the aircraft.
- (b) If Instructions for Continued Airworthiness are not supplied by the manufacturer of an appliance or product installed in the aircraft, the Instructions for Continued Airworthiness for the aircraft must include the information essential to the continued airworthiness of the aircraft.
- (c) The Instructions for Continued Airworthiness must contain a Section titled 'Airworthiness limitations' that is segregated and clearly distinguishable from the rest of the document. This Section must set forth each mandatory maintenance action required for type certification. This Section must contain a legible statement in a prominent location that reads: 'The Airworthiness limitations Section is approved and variations must also be approved'.
- (d) The applicant must develop and implement procedures to prevent structural failures due to foreseeable causes of strength degradation, which could result in serious or fatal injuries, loss of the aircraft, or extended periods of operation with reduced safety margins. The Instructions for Continued Airworthiness must include procedures developed under SC VTOL.2255.

AMC VTOL.2510 Equipment, systems, and installations *(partial)*

For Category Enhanced, failure conditions that would prevent continued safe flight and landing of the aircraft are considered catastrophic.

For Category Basic, failure conditions that would prevent a controlled emergency landing of the aircraft are considered catastrophic.

The table below provides the relationship between failure condition classifications and quantitative safety objectives/Function Development Assurance Levels (FDAL) for an aircraft with flight crew on board.

The safety objectives for each failure condition are:

		Failure Condition Classifications			
Maximum Passenger Seating Configuration		Minor	Major	Hazardous	Catastrophic
Category Enhanced	-	$\leq 10^{-3}$ FDAL D	$\leq 10^{-5}$ FDAL C	$\leq 10^{-7}$ FDAL B	$\leq 10^{-9}$ FDAL A
Category Basic	7 to 9 passengers	$\leq 10^{-3}$ FDAL D	$\leq 10^{-5}$ FDAL C	$\leq 10^{-7}$ FDAL B	$\leq 10^{-9}$ FDAL A
	2 to 6 passengers (see note A)	$\leq 10^{-3}$ FDAL D	$\leq 10^{-5}$ FDAL C	$\leq 10^{-7}$ FDAL C	$\leq 10^{-8}$ FDAL B
	0 to 1 passenger (see note A)	$\leq 10^{-3}$ FDAL D	$\leq 10^{-5}$ FDAL C	$\leq 10^{-6}$ FDAL C	$\leq 10^{-7}$ FDAL C

[Quantitative safety objectives are expressed per flight hour]

note A: No considerations of the system architecture for a DAL reduction are acceptable.