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MINISTÉRIO DA DEFESA NACIONAL
AUTORIDADE AERONÁUTICA NACIONAL
Gabinete da Autoridade Aeronáutica Nacional

Special condition for Vertical Take-off-and-Landing Requirements for UAS with a MTOW below 150 Kg.

1. Purpose

This Special Condition prescribes airworthiness standards for the issuance of the type certificate, and changes to the type certificate for Vertical Take-off-and-Landing Requirements for UAS with a MTOW below 150 Kg.

2. Applicability

This Special Condition is applicable to aircraft with vertical lifting elements used to generate powered lift with more than two vertical lifting elements used to provide lift during vertical take-off or landing in addition to the *Alternative Means of compliance for certification of UAS with a MTOW below 150 Kg based on risk Assessment* or to STANAG 4703.

To comply with this special condition, the applicant must present a certification program identifying the applicable and non-applicable requirements for the VTOL particular design features with the correspondent substantiation. In addition to this special condition, the applicant may propose to the AAN alternative or additional requirements and means of compliance (MoC) which ensure the same or higher level of safety. The submitted certification program shall be agreed with the AAN.

3. Definitions:

"limit flight envelope" - means the flight envelope associated with aircraft design limits or protection limits;
"vertiport" means an area of land, water, or structure used or intended to be used for the landing and take-off of VTOL aircraft.
"VTOL aircraft" - An aircraft that uses powered lift to ascend or descend vertically or near vertically.

4. Requirements

The requirements of the special condition for VTOL for Vertical Take-off-and-Landing Requirements for UAS with a MTOW below 150 Kg are provided in a three-column table. The first column is the number of the requirement; the second column presents the description of the requirement;

the third column presents the means of compliance that the applicant should consider to develop the means of evidence to be provided to the AAN in order to show compliance with the requirements.

Reference	Requirement	MoC
VTOL 1.0 - Mass and centre of gravity	VTOL 1.1 - The applicant must determine limits for mass and centre of gravity that provide for the safe operation of the UAS, clearly specifying the condition of the aircraft at the time of determining its empty mass and centre of gravity.	MoC 1 – Documentation (AFM)
	VTOL 1.2 - The applicant must demonstrate that for the most forward limit of the CG, the UAS can take-off vertically; transit to forward flight, perform horizontal flight, transit to landing mode, land vertically, in a safe, stable and controlled way. (in manual direct piloting mode)	MoC 6 – Flight Test
	VTOL 1.3 - The applicant must demonstrate that for the most forward limit of the CG, the UAS can take-off vertically; transit to forward flight, perform horizontal flight, transit to landing mode, land vertically, in a safe, stable and controlled way. (in auto-pilot mode)	MoC 6 – Flight Test
	VTOL 1.4 - The applicant must demonstrate that for the most rearward limit of the CG, the UAS can take-off vertically; transit to forward flight, perform forward flight, transit to landing mode, land vertically, in a safe, stable and controlled way. (in manual direct piloting mode)	MoC 6 – Flight Test
	VTOL 1.5 - The applicant must demonstrate that for the most rearward limit of the CG, the UAS can take-off vertically; transit to forward flight, perform forward flight, transit to landing mode, land vertically, in a safe, stable and controlled way (in auto-pilot mode)	MoC 6 – Flight Test

Reference	Requirement	MoC
VTOL 2.0 - Performance	VTOL 2.1 - The applicant must develop the performance data required by this requirement 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.	MOC 6 - Flight test MOC 2 - Analysis report
	VTOL 2.2 -The applicant must define in the AFM of the UAS the maximum altitude that the UAS is able to take-off and land from a vertiport for which certification is requested.	MoC 1 – Documentation (AFM)
	VTOL 2.3 - The applicant must demonstrate that the UAS is able to land and take-off from a vertiport for which certification is requested to the maximum altitude defined in the AFM.	MoC 6 – Flight Test
VTOL 3.0 - Performance at minimum operating speeds	(a) The hovering ceiling must be determined, over the ranges of weight, altitude and temperature for which certification is requested, with: (1) Take-off power; (2) The UAV in ground effect at a height consistent with normal take-off procedures; and (b) The hovering ceiling determined under subparagraph (a) at maximum weight with a standard atmosphere.	MOC 6 - Flight test MOC 2 - Analysis report
VTOL. 4.0 - Flight Envelopes	The applicant must define in the UAS AFM the normal, operational and limit flight envelope for each flight configuration used in operations. (<u>Note:</u> The flight envelopes' determination must account for the most adverse conditions for each flight configuration.)	MoC 1 – Documentation (AFM)

Reference	Requirement	MoC
VTOL 5.0 - Take-off	A take-off safety trace must be determined as the area in which there may be a hazard which could result in a risk to personnel, third parties, equipment and/or property. Winds, navigational accuracies, communication latencies, etc. must be considered in the establishment of the take-off safety trace.	MOC 6 - Flight test MOC 2 - Analysis report
VTOL 6.0 - Take-off	When an automatic take-off system is provided it must comply with the following: (a) Once the automatic take-off mode has been engaged, the process is fully automatic and the UAS crew monitors the take-off from the UAS control station, via the command and control data link, but is not required to perform any manual "piloting action", except manual abort, where required, as per provisions of (e). (b) The automatic function will reside in the UAV airborne control laws algorithms and will utilize navigation and flight path tracking inputs in such a manner as not to degrade the overall redundancy or level of safety of the flight control system. When off-board sensors are utilised via data-links, the continued safe flight of the vehicle must be ensured in the event of a loss of that data-link. (c) The automatic system may cause no unsafe sustained oscillations or undue attitude changes or control activity as a result of configuration or power changes or any other disturbance to be expected in normal operation. (d) In case of failure that could adversely affect safe flight or exceedance from predefined limits occurring during the take-off process an automatic abort function shall be provided to land the UAV on the pad up to "Take-off Rejection Point." (e) The automatic take-off system must incorporate a manual abort command. Its control shall be easily accessible to the UAS crew in order to interrupt take-off and either land or hover the UAS up to "take-off rejection point". (f) Specific abort procedure shall be provided in the UAS Flight Manual.	MoC 1 - Documentation (AFM) MOC 6 - Flight test MOC 2 - Analysis report

Reference	Requirement	MoC
VTOL 7.0 - Take-off	(a)The take-off, with take-off power and rpm, at the most critical centre of gravity: (1) May not require exceptional skill from the UAV crew or exceptionally favourable conditions throughout the ranges of altitude from standard sea-level conditions to the maximum altitude for which take-off and landing certification is requested. (2) Must be made in such a manner that no single or complete engine failure will lead to a Catastrophic or Hazardous failure condition. (b) Sub-paragraph (a) must be met throughout the ranges of altitude, temperature and weight for which certification is requested.	MOC 6 - Flight test MOC 2 - Analysis report MOC 3 – Safety analysis
VTOL 8.0 - Climb requirements	The design must comply with minimum climb performance out of ground effect for which certification is requested.	MoC 6 – Flight Test
	Minimum climb performance out of ground effect must be defined in the UAS AFM.	MoC 1 – Documentation (AFM)
VTOL 9.0 - Vertical Climb and descend	The steady rate of vertical climb must be determined at maximum continuous power: (a) At a speed for which certification is requested; (b) From sea level up to an altitude for which certification is requested; (c) At weights and temperatures for which certification is requested.	MOC 6 - Flight test MOC 2 - Analysis report
VTOL 10.0 Climb information	The applicant must define in the UAS AFM the VTOL ceiling in and out of the ground effect.	MoC 1 – Documentation (AFM)

Reference	Requirement	MoC
VTOL 11.0 Landing	The applicant must determine and establish in the UAS AFM, the approach and landing speeds, configurations, and procedures, which allow a UAS pilot of average skill to land within a landing area consistently and without causing damage or injury, and which allow for a safe transition to the balked-landing conditions.	MoC 1 – Documentation (AFM)
VTOL 12.0 Landing	It must be shown that the landing sequence is a reliable, repeatable and predictable safe operation.	MOC 6 - Flight test MOC 2 - Analysis report
VTOL 13.0 Landing	Landing safety trace must be determined as the area in which there may be a hazard which could result in a risk to personnel, third parties, equipment and/or property. Winds, navigational accuracies, communication latencies, etc. must be considered in the establishment of the landing safety trace.	MOC 6 - Flight test MOC 2 - Analysis report

Reference	Requirement	MoC
VTOL 14.0 Landing	When an automatic landing system is provided it must comply with the following: (a) Once the automatic landing mode has been engaged, the process is fully automatic and the UAS crew monitors the landing from the UA control station, via the command and control data link, but is not required to perform any manual "piloting action", except manual abort, where required, as per provisions of (e). (b) The automatic function will reside in the UA airborne control laws algorithms and will utilize navigation and flight path tracking inputs in such a manner as not to degrade the overall redundancy or level of safety of the flight control system. When off-board sensors are utilized via data-links, the continued safe flight of the vehicle must be ensured in the event of a loss of that data-link. (c) The automatic system must not cause any unsafe sustained oscillations or undue attitude changes or control activity as a result of configuration or power changes or any other disturbance to be expected in normal operation. (d) In case of failure or exceedance from the predefined limits occurring during the approach, an automatic go around function shall be provided before "Landing Rejection Point." (e) The automatic landing system must incorporate a manual abort command. Its control shall be easily accessible to the UAS crew in order to continue to a safe and stabilized airborne state (e.g. go around or hover) during the landing phase. (f) Specific go around procedure shall be provided in the UAS System Flight Manual.	MOC 6 - Flight test MOC 2 - Analysis report

Reference	Requirement	MoC
VTOL 15.0 - Limiting height-speed envelope	(a) If there is any combination of height and forward speed (including hover) under which a safe landing cannot be made under applicable power failure condition, a limiting height-speed envelope must be established.	MoC 2 - Analysis report MoC 6 - Flight test
VTOL 16.0 - Controllability	The UAS must be controllable and manoeuvrable in piloted mode, without requiring exceptional piloting skills, workload or alertness, within the operational flight envelope and must be controllable and manoeuvrable within the limits of the flight envelope for all phases and phase transitions.	MoC 6 – Flight Test
	The UAS must perform in auto-pilot mode all the operations possible and fly in the same conditions as in piloted mode, performing with at least, the same level of performance, as in piloted mode.	MoC 6 – Flight Test
VTOL 17.0 - Transition flight	It must be possible to make a smooth transition from one flight phase to another without danger of exceeding the operating limitations of the UA, under any probable operating condition, (including, for multi-engine UA, those conditions normally encountered in the sudden failure of any engine). Where applicable, consideration must be given to the transition from take-off and normal flight condition, as well as, to the transition from normal flight condition to landing phase.	MoC 6 – Flight Test
	The applicant must define in the UAS AFM the minimum altitude (above vertiport altitude) at which transition from vertical movement to forward movement is allowed.	MoC 1 – Documentation (AFM)
	The applicant must define in the UAS AFM the minimum altitude (above vertiport altitude) at which transition from forward movement to vertical movement is allowed.	MoC 1 – Documentation (AFM)

Reference	Requirement	MoC
VTOL 18.0 - Stability	Transient response in all axes during transition between different flight conditions and FCS flight modes must be smooth, convergent, and exhibit damping characteristics with minimal overshoot of the intended flight path.	MoC 2 - Model analysis MOC 6 - Flight test
VTOL 19.0 - Stability	In addition to data obtained by computation or modelling, stability analysis must be supported by the results of relevant flight tests.	MoC 2 - Model analysis MOC 6 - Flight test
VTOL 20.0 - Stability	Stability also must be assessed in manual direct piloting conditions (where applicable), taking due account of data-link latencies.	MoC 2 - Model analysis MOC 6 - Flight test
VTOL 30.0 - Stability	Pilot induced oscillation (PIO) tendencies must be safe, with particular consideration to manual direct piloting conditions flight characteristics (where applicable).	MoC 2 - Model analysis MOC 6 - Flight test
VTOL 31.0 - Flying qualities	The UAS must, within its flight envelopes and for all flight stages, show suitable stability and control feel, in all axes.	MoC 6 – Flight Test

Reference	Requirement	MoC
VTOL 32.0 - Stall characteristics and stall warning	If part of the lift is generated by a wing, the UAS must have controllable stall characteristics in straight flight, turning flight, and accelerated turning flight so that in piloted mode the UAS does not enter inadvertent stalling in those conditions.	MoC 6 – Flight Test
	If part of the lift is generated by a wing, the UAS must have an auto-pilot that is able to manage stall characteristics in straight flight, turning flight, and accelerated turning flight, so that the UAS in auto-pilot mode does not enter inadvertent stalling in those conditions.	MoC 6 – Flight Test
VTOL 33.0 - Vibration	The vibrations inherent to the operation of the UAS in vertical take-off and landing and in transition modes must be shown to be able to be coped with, without demanding excessive workload from the pilot (in piloted mode)	MoC 6 – Flight Test
	The auto-pilot must be shown to be able to cope with the UAS vibrations for all stages of flight.	MoC 6 – Flight Test
VTOL 34.0 - Propulsion system – Mass balance	- The vertical lifting element(s) must be mass balanced as necessary to- (1) Prevent excessive vibration; and (2) Prevent flutter at any speed. - The structural integrity of the mass balance installation must be substantiated	MoC1 -Description of requirements compatibility MoC2 – Analyses MoC5 - Ground test MoC 6- Flight test

Reference	Requirement	MoC
VTOL 35.0 - Propulsion system - Vertical lifting elements clearance	There must be enough clearance between the vertical lifting element(s) and other parts of the structure to prevent the vertical lifting element(s) from striking any part of the structure during any operating condition.	MoC1 -Description of requirements compatibility MoC2 – Analyses MoC5 - Ground test MoC 6- Flight test
VTOL 36.0 - Propulsion system- Ground resonance prevention means	(a) The UAV may have no dangerous tendency to oscillate on the ground with the vertical lifting element(s) turning. (b) The reliability of the means for preventing ground resonance must be shown either by analysis and tests, or reliable service experience, or by showing through analysis or tests that malfunction or failure of a single means will not cause ground resonance. (c) The probable range of variations, during service, of the damping action of the ground resonance prevention means must be established and must be investigated during the test required by (a)	MoC1 -Description of requirements compatibility MoC2 – Analyses MoC5 - Ground test MoC 6- Flight test
VTOL 37.0 - Flight in icing conditions	The applicant must include in the AFM an operating limitation to prohibit intentional flight, including take-off and landing, into icing conditions.	MoC 1 – Documentation (AFM)

Reference	Requirement	MoC
VTOL 38.0 - Operating Limitations	The applicant must include in the AFM operating limitations for: • Maximum vertical speed; • Minimum transition altitude; • Maximum transition horizontal speed; • Minimum horizontal speed in horizontal mode; • Maximum horizontal speed in vertical mode; • Minimum hover altitude. • Minimum and maximum operating temperatures for the phases of vertical take-off and landing; • Maximum altitude of Vertiport from/to which the UAS can operate. • Maximum horizontal speed of the vertiport for take-off (if applicable); • Maximum horizontal speed of the vertiport for landing (if applicable); • Maximum allowed side wind on vertiport for take-off; • Maximum allowed side wind on vertiport for landing.	MoC 1 – Documentation (AFM)

Reference	Requirement	MoC
VTOL 39.0 - Structural design envelope	The applicant must determine the structural design envelope, which describes the range and limits of the UAS design and operational parameters for all flight phases including vertical take-off and landing. The applicant must account for all UAS design and operational parameters that affect structural loads, strength, durability, and aeroelasticity.	MoC 2. Expected an analysis (qualitative) in the structural report, with a presentation of the design flight envelope and discussion of the structural design conditions and necessary limitations.
	The applicant must include in the AFM any limitation that derives from the structural design envelope for each flight phase.	MoC 1 – Documentation (AFM)
VTOL 40.0 - Interaction of systems and structures	The applicant must demonstrate that the UAS is safe in case of failure of systems during the phases of vertical take-off and landing and hover. (e.g. Gimbal that breaks loose, vertical engine failure, loss of link during these phases, Interference problems, other).	MoC 2 – Structural report MoC 3 – Safety assessment (FHA for these phases) MoC 6 for loss of link.

Reference	Requirement	MoC
VTOL 41.0 - Structural design loads	The applicant must determine structural design loads resulting from the likely external conditions under which the UAS is expected to operate. Namely, the following are to be considered: Ground operations; Water operations; Ground and water handling; Parked/moored; Horizontal flight; Climb/descend; Vertical Flight / Hover;	MoC 2. Expected an analysis in the structural report.
VTOL 42.0 - Flight load conditions	Flight loads resulting from a likely failure of an aircraft system, component, or vertical lifting element(s) must be determined.	MoC 2 -Assumptions and analysis of the design loads in-flight
VTOL 43.0 - structures and materials- Loads VTOL	(a) Unless otherwise provided, the specified air, ground, and water loads must be placed in equilibrium with inertia forces, considering each item of mass in the UA. These loads must be distributed to closely approximate or conservatively represent actual conditions. (b) If deflection under load would significantly change the distribution of external or internal loads, this redistribution must be considered.	MoC 2- A description of the rationale for the design loads margins to be included in Design Criteria

Reference	Requirement	MoC
VTOL 44.0 - Structures and materials - Proof of Structure	(a) Compliance with the strength and deformation requirements of this paragraph must be shown for each critical loading condition accounting for the environment to which the structure will be exposed in operation. Structural analysis (static or fatigue) may be used only if the structure conforms to those structures for which experience has shown this method to be reliable. In other cases, substantiating tests must be made. (b) Proof of compliance with the strength requirements of this paragraph must include - (1) Dynamic and endurance tests of vertical lifting element(s) (as required); (2) Limit load tests of the control system, including control surfaces; (3) Operation tests of control system; (4) Flight stress measurement tests; (5) Landing gear drop tests; and (6) Any additional tests required for new or unusual design features.	MoC 2- A description of the rationale for the design loads margins to be included in Design Criteria
VTOL 45.0 - Structures and materials - Proof of Structure - Design limitations	The following values and limitations must be established to show compliance with the structural requirements of this paragraph: (a) The design maximum weight. (b) The vertical lift element rpm ranges power-on and (where applicable) power-off. (c) The maximum forward speeds for each vertical lifting element rpm within the ranges determined in sub-paragraph (b). (d) The maximum rearward and sideward flight speeds (where applicable) (e) The center of gravity limits corresponding to the limitations determined in sub-paragraphs (b), (c), and (d). (f) The rotational speed ratios between powerplant and each connected rotating component. (g) The positive and negative manoeuvring load factors.	MoC 2- A description of the rationale for the design loads margins to be included in Design Criteria

Reference	Requirement	MoC
VTOL 46.0 – Loads - Gust loads	The UA must be designed to withstand loads at each critical airspeed including hovering. Gust values should be determined by rational analysis of the intended use of the UA, considering the design operational altitude level and the cruise speed (consistent with the design usage spectrum). In absence of an alternative compelling rationale, the following should be used; the loads resulting from a vertical gust of 9.1 m/s (30 ft/s) Potential limitations may be established, where applicable, and documented in operating manuals, taking due account of the design usage spectrum.	MoC 1 – Documentation (AFM) MoC 2 -Assumptions and analysis of the design loads in-flight
VTOL 47.0 - Ground loading conditions and assumptions	(a) For specified landing conditions, a design maximum weight must be used that is not less than the maximum weight. Vertical lifting element(s) lift may be assumed to act through the centre of gravity throughout the landing impact. This lift may not exceed two-thirds of the design maximum weight. (b) Unless otherwise prescribed, for each specified landing condition, the UA must be designed for a limit load factor of not less than the limit inertia load factor.	MoC2 - Analysis report

Reference	Requirement	MoC
VTOL 48.0 - Vertical lifting element(s) structure	(a) Each vertical lifting assembly (including but not limited to assembly of rotating components which may include the vertical lifting element(s)) must be designed as prescribed in this paragraph. (b) The vertical lifting element structure must be designed to withstand the manoeuvring load factor and the design gust loading conditions. (1) Critical flight loads. (2) Loads occurring under normal conditions. For this condition, the vertical lifting element rpm must be selected to include the effects of altitude. (c) The vertical lifting element structure must be designed to withstand loads simulating - (1) For the vertical lifting elements, the impact force of each lifting element surface against its stop during ground operation; and (2) Any other critical condition expected in normal operation. (d) Each vertical lifting element structure must be designed to withstand the limit torque at any rotational speed including zero. In addition - (1) The limit torque need not be greater than the torque defined by a torque limiting device (where provided), and may not be less than the greater of - (i) The maximum torque likely to be transmitted to the vertical lifting element structure in either direction; and (ii) The limit engine torque (2) The limit torque must be distributed to the vertical lifting element surfaces in a rational manner.	MoC2 - Analysis report MoC 6- Flight test

Reference	Requirement	MoC
VTOL 49.0 - Fuselage, landing gear, and vertical lifting element structures	(a) Each fuselage, landing gear, and vertical lifting element structure must be designed as prescribed in this paragraph. Resultant vertical lifting element forces may be represented as a single force applied at the vertical lifting element hub attachment point. (b) Each structure must be designed to withstand the applicable flight and ground loads. (d) Each engine mount and adjacent fuselage structure must be designed to withstand the loads occurring under accelerated flight and landing conditions, including engine torque.	MoC2 - Analysis report MoC 6- Flight test
VTOL 50.0 - Component loading conditions	VTOL 50.1 - The UAS must have incorporated means to detect failures in the vertical lifting elements and to transmit that information to the UAS pilot.	MoC 1 – Design feature
	VTOL 50.2 - The status of the vertical lifting elements must be made available for the pilot in order to allow evaluation if the transition to vertical movement is possible.	MoC 1 – Design feature
	VTOL 50.3 - The applicant must define in the UAS AFM the procedures for operation when vertical lifting elements for the cases of vertical take-off and landing. (For piloted mode)	MoC 3 – Safety Assessment MoC 1 – Documentation (AFM)
	VTOL 50.4 - The applicant must define in the UAS AFM how the UAS deals with vertical lifting elements failures when failure occurs in the horizontal flight phase, auto vertical take-off and auto vertical landing. (For auto-pilot mode)	MoC 3 – Safety Assessment MoC 1 – Documentation (AFM)

Reference	Requirement	MoC
VTOL 51.0 - Design and construction principles	The applicant must include in the AFM a pre-flight inspection and pre-flight ground-test to the vertical lifting elements to ensure its/their proper functioning prior to the flight. Note: The test must include, at least: ▪ Verification of free rotation of vertical lifting elements; ▪ Verification that the engine generates the required lift, with rise to altitude of 0,5 m; ▪ Maintain 0,5 m altitude for 1 minute; ▪ Descend to ground; ▪ Check of vertical engine parameters; ▪ Test to the advisory indications of vertical engine malfunction.	MoC 1 – Documentation (AFM)
	The applicant must include in the AFM a pre-flight inspection and pre-flight ground-test to the systems responsible for transiting from vertical to horizontal movement to ensure its/their proper functioning prior to the flight. Note: The test must include, at least: ▪ Verification on ground of free movement of any moving part; ▪ Verification on ground that all moving parts are adequately responding to the inputs from the pilot for transiting from vertical to horizontal; ▪ Verification on ground that all moving parts are adequately responding to the inputs from the pilot for transiting from horizontal to vertical;	MoC 1 – Documentation (AFM)
VTOL 52.0 - Flight control systems	The UAS flight control systems must be designed to operate easily, smoothly, and positively enough to allow proper performance of their functions for the horizontal flight phase and for the vertical flight phases and transitions.	MoC 1 – Design feature MoC 6 – Flight Test

Reference	Requirement	MoC
	The UAS flight control systems must be designed to protect the UAS against likely hazards;	MoC 1 – Design feature MoC 1 – Documentation (AFM)
	<u>If Trim Systems Exist:</u> The UAS flight control systems must be designed to allow pilots to be aware of the control limits during all flight phases.	MoC 1 – Design feature MoC 1 – Documentation (AFM) MoC 6 – Flight Test
	<u>If Trim Systems Exist:</u> The UAS must be designed to ensure that inadvertent, incorrect or abrupt trim operation will not cause a hazard in any flight phase including transition.	MoC 3 – Safety Assessment MoC 1 – Design feature
	<u>If Trim Systems Exist:</u> The UAS must be designed to provide to the pilot information of any malfunction in the trimming systems that is required for safe operation in any flight phase including transition.	MoC 3 – Safety Assessment MoC 1 – Design feature MoC 5 – ground test to the information provided.

Reference	Requirement	MoC
VTOL 53.0 - Landing gear systems	The landing gear must be designed to provide stable support and control to the aircraft during surface operation.	MoC 5 – ground test
	The landing gear must be designed to account for likely system failures and likely operation environment (including anticipated limitation exceedances and emergency procedures)	MoC 3 – Safety Assessment
	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.	MoC 3 – Safety Assessment MoC 1 – Design feature MoC 5 – ground test

VTOL 54.0 - Landing impact at the maximum design weight	Taking into account the specific design usage spectrum, the worst combination of loads corresponding to all the reasonably possible scenarios of impact in the landing phase must be determined. For conventional landing gear configurations, the following limit drop test is recommended. Note: Other drop test may be submitted by the applicant to AAN for consideration for conventional landing gear or other configurations. Recommended Limit drop test The limit drop test must be conducted as follows: (a) The drop height must be 0.20 m (8 inches) from the lowest point of the landing gear to the ground; or (b) If considered, the UAV lifting must be introduced into the drop test by appropriate energy absorbing devices or by the use of an effective mass. (c) Each landing gear unit must be tested in the attitude simulating the landing condition that is most critical from the standpoint of the energy to be absorbed by it. (d) When an effective mass is used in showing compliance with sub-paragraph (b) the following formula may be used instead of more rational computations: $$W_e = W\frac{h+(1-L)d}{h+d}$$ $$n = n_j\frac{W_e}{W} + L$$ where:	MoC 2- Assumptions and analysis of the design loads on-ground

Reference	Requirement	MoC
	We = the effective weight to be used in the drop test. W=WM for main gear units, equal to the static reaction on the particular unit with the UAV in the most critical attitude. A rational method may be used in computing a main gear static reaction, taking into consideration the moment arm between the main wheel reaction and the UAV centre of gravity. W=WN for nose gear units, equal to the vertical component of the static reaction that would exist at the nose wheel, assuming that the mass of the UAV acts at the centre of gravity and exerts a force of 1.0 g downward and 0.25 g forward. W=WT for tail wheel units equal to whichever of the following is critical: (1) The static weight on the tail wheel with the UAV resting on all wheels; or (2) The vertical component of the ground reaction that would occur at the tail wheel, assuming that the mass of the UAV acts at the centre of gravity and exerts a force of 1 g downward with the UAV in the maximum nose-up attitude considered in the nose-up landing conditions. h = specified free drop height. L = ratio of assumed vertical lifting elements to the UAV weight. d = deflection under impact of the tyre (at the proper inflation pressure) plus the vertical component of the axle travel relative to the drop mass. n = limit inertia load factor. nj = the load factor developed, during impact, on the mass used in the drop test (i.e., the acceleration dv/dt in g recorded in the drop test plus 1.0).	

5. References:

EASA (2019) Special Condition for small-category VTOL aircraft, Doc. No: SC-VTOL-01. (Available at: https://www.easa.europa.eu/document-library/product-certification-consultations/special-condition-vtol. (Assessed: 8 May 2020).

DRAFT AEP-89 Unmanned Aerial Vehicle (UAV) Systems Airworthiness Requirements (USAR) for Light Vertical Take-Off and Landing (VTOL) Aircraft. . (Available at: www.defense.gouv.fr. (Assessed: 8 May 2020).