Section 3

QCI - DGCA Initiative

Certification Scheme for

Remotely Piloted Aircraft Systems (RPAS)

CERTIFICATION CRITERIA FOR RPAS

CERTIFICATION CRITERIA FOR RPAS

1. Objective

1.1 The objective of this document / certification criteria is to provide the minimum requirements for airworthiness (safety and security) of the RPAS and permission to fly / operate (NPNT and enable the evaluation of RPAS to these specific safety and security requirements and certification of RPAS under this CS for RPAS.

2. Scope

2.1 This Certification Criteria is applicable to RPAS being manufactured by indigenous manufacturers and importers of RPAS in India. For the purpose of ease, indigenous manufacturers, importers and assemblers of RPAS are being termed as manufacturer under this RPAS Certification Scheme.

2.2 This Scheme is applicable to Civil Remotely Piloted Aircraft Systems, which are Remotely Piloted from a Remote Pilot Station.

2.3 Civil RPA is categorized in accordance with max. All-Up-Weight (including payload) as indicated below:

a) Nano: Less than or equal to 250 grams*
b) Micro: Greater than 250 grams and less than or equal to 2 kg.
c) Small: Greater than 2 kg and less than or equal to 25 kg.
d) Medium Greater than 25 kg and less than or equal to 150 kg;
e) Large: Greater than 150 kg

2.4 For the time being this certification is available for Categories of Nano, Micro, Small and Medium. This Certification Criteria is applicable to these four categories of RPAS.

2.5 The large RPAS are currently excluded from this Scheme and could be subsequently included as the Scheme matures and more experience is gained.

3. Normative References

3.1 The referenced documents (refer Annex B) are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

4. Competence Requirements

Remote Pilot: Remote Pilot should meet the training requirements as specified in Para 9 of DGCA CAR, Section 3, Series X, Part I

5. Requirements

5.1 The RPAS shall comply with the requirements as given in Table 1 at Annex A and evaluated as per methods of evaluation described in Table 1.

Annex A

Table 1
Requirements (Technical Criteria) for RPAS

S. No.	Parameter / Characteristics	Compliance Criteria (with Requirements)	Method of Evaluation 1. Verification of records 2. Testing and verification 2.1 On-site testing (Ground) 2.2 Flight testing 2.3 Laboratory test (with appropriate details)	Guidance on method of evaluation
1	**General**			
1.1	Category of RPAS	Nano / Micro / Small / Medium / Large • Nano: Less than or equal to 250 grams* • Micro: Greater than 250 grams and less than or equal to 2 kg Small: Greater than 2 kg and less than or equal to 25 kg • Medium Greater than 25 kg and less than or equal to 150 kg • Large: Greater than 150 kg	Verify the statement submitted by the manufacturer stating the category of the RPAS.	RPAS is categorized in accordance with maximum all up weight (including all compatible payloads) and no additional weight will be permitted. *Applicable for Nano RPAS intended to fly above 50 ft AGL or in controlled airspace.

S. No.	Parameter / Characteristics	Compliance Criteria (with Requirements)	Method of Evaluation 1. Verification of records 2. Testing and verification 2.1 On-site testing (Ground) 2.2 Flight testing 2.3 Laboratory test (with appropriate details)	Guidance on method of evaluation
1.2	Weight	i) Empty weight • Weight without fuel / battery and without payload. • Weight with fuel / battery but no payload.	Report of test by calibrated measurement equipment to be verified by certification body with respect to empty weight of the RPAS.	Manufacturer to weigh the RPAS sample with / without maximum fuel / battery, compatible payloads using calibrated measuring equipment and calibration certificate of the equipment to be submitted. Manufacturer to weigh the RPAS sample with / without fuel / battery but no payload.
		ii) Maximum all up weight • Weight with fuel / battery and with all compatible payloads (Fixed + Variable)	Report of test by calibrated measurement equipment to be verified by certification body with respect to maximum all up weight of the RPAS.	Manufacturer to weigh the RPAS sample with maximum fuel / battery and compatible payloads using calibrated measuring equipment and calibration certificate of the equipment to be submitted. RPAS is categorized in accordance with maximum all up weight (including all compatible payloads) and no additional weight will be permitted.

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		iii) Relevant CG limits for each configuration	Verification of appropriate analysis done by the manufacturers for calculating CG, for all configurations of the RPAS, in the design documents submitted by the manufacturers.	
1.3	Type of RPA	i) Fixed Wing / Rotary Wing	Physical inspection of the RPAS to verify if the RPAS type is as per the declaration of the manufacturer in the submitted design document.	
		ii) Launch and Recovery type	Physical inspection of the launch and recovery system to verify if the launch and recovery system is as per the declaration of the manufacturer in the submitted design document	
1.4	Dimensions	Wing Span / Max Diagonal Length	Measure the wing span / max diagonal length using calibrated measuring instruments and verify with submitted design documents.	Measure dimension of RPA in all configurations. Example: Folded, Ready to Launch, With and Without Payload etc.
1.5	Life of RPA	i) Airframe	Verification of design document determining the life of the airframe.	
		ii) Engine	Verification of design document determining the life of the engine or	

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			Manufacturer to submit OEM documents giving details of life of the engine.	
		iii) Battery	Verification of test reports from an accredited testing laboratory submitted by the manufacturer. Standards to be followed: **IS 16046 (Part 1)**: Secondary Cells and Batteries Containing Alkaline or Other Non-Acid Electrolytes — Safety Requirements for Portable Sealed Secondary Cells and for Batteries Made from Them for Use in Portable Applications: Part 1 Nickel Systems or **IS 16046 (Part 2)**: Secondary Cells and Batteries Containing Alkaline or Other Non-Acid Electrolytes — Safety Requirements for Portable Sealed Secondary Cells and for Batteries Made from Them for Use in Portable	

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			Applications: Part 2 Lithium Systems or any other relevant standard / applicable mandatory certification / registration for batteries as mandated by the appropriate regulator or authority having jurisdiction from time to time.	
		iv) Propeller / Rotor	Verification of design document determining the life of the propeller / rotor.	Additionally, validation of design results from manufacturer or through ground / bench tests with test bed values (if any) should also be submitted.
		v) Number of Maximum Permissible Landings	Verification of design document determining the number of maximum permissible landings.	Additionally, validation of design results from manufacturer or through ground / bench tests (if any) should also be submitted.
1.6	Payloads	Compatible Payload Details	Manufacturer to submit a list of all compatible payloads with complete details like weight, specifications, purpose of usage.	No other payload shall be permitted other than those approved by the certification body.
2	**Performance**			

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2.1	Speeds	i) Minimum operating speed – the minimum specified operating speed of RPA at standard sea level conditions shall be at least 10% above the actual stall speed	To be witnessed during flight testing: a) Verify that minimum operating speed is at least 10% more than stall speed by design in the submitted design document. b) OEM should demonstrate stable flight (without stall) at minimum operating speed.	Annexure 1: Guidelines for flight test
		ii) Determine maximum operating speed at standard sea level conditions	To be witnessed during flight testing: Manufacturer to demonstrate flight with maximum speed as submitted in the design document.	Annexure 1: Guidelines for flight test
		iii) Determine that maximum kinetic energy on impact does not exceed 95 KJ at any combination of mass and speed	Verification of analysis submitted by the manufacturer showing maximum kinetic energy on impact does not exceed 95 KJ at any combination of mass and speed.	The calculations to be done for two scenarios: **1.** Emergency Landing Under Control **2.** Complete Loss of Control (Either it is a free fall calculation from 400 ft with zero forward speed or Max forward speed scenario by calculating 1.4 x Vmax)

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2.2	Range	Determine maximum range in still air	Verification of analysis submitted by manufacturer.	To be verified through analysis by taking into account endurance and cruise speed validated during flight tests. Annexure 1: Guidelines for flight test
2.3	Endurance	a) Determine fuel and oil consumption (if applicable)	Verification of manufacturer's test results by witnessing flight testing.	Annexure 1: Guidelines for flight test
		b) Determine rate of discharge of battery (if applicable)	Verification of test reports from an accredited testing laboratory submitted by the manufacturer determining rate of discharge of battery with charge capacity more than 85% at all times.	
		c) Storage Battery design and installation	Physical inspection to be conducted to ascertain and verify the following as per design documents submitted by the manufacturer: 1. Batteries shall be stored in the manner as to prevent deterioration 2. Mechanisms for charging and logging of battery voltages should be provided.	To be verified from design document and relevant user manual

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2.4	Operational altitude	Determine maximum attainable altitude above ground level (AGL)	Manufacturer to declare maximum attainable altitude (AGL) by design and demonstrate restriction of maximum attainable altitude in GCS or firmware. To be verified during flight testing against the design document submitted by the manufacturer.	The maximum permissible altitude in accordance with CAR requirements is 400ft AGL - VLOS.
2.5	Operational envelope	Determine boundaries of operational envelope within which safe flight, in normal and emergency conditions, can be demonstrated under combinations of weight, centre of gravity, altitude, temperature and airspeed	Verification of design document details and comparison with actual flight performance and parameters. In case of medium and above categories of RPA, additionally, operational envelope to be demonstrated during flight test.	The manufacturer to submit documents that describe the rationale behind determination of the operational envelope and explain the method of verification. The RPAS performance to be considered in both, normal and emergency conditions that are defined by the manufacturer. However, the standard / available environmental conditions are only to be considered during certification.

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2.6	Ceiling height	Determine ceiling height over a range of weight, centre of gravity, altitude, temperature and airspeed	Verification of design documents details and comparison with actual flight performance and parameters.	Manufacturer to declare the maximum attainable height above Mean Sea Level by design.
2.7	Propeller speed and pitch for safe operation	a) Determine propeller speed and pitch limits that ensure safe operation under normal operating conditions	Verification of the certificate provided by the manufacturer regarding propeller pitch and speed limits for safe operations.	For detachable propeller blades, test results of blade retention test at a load double the max centrifugal force should be part of the document submitted.
		b) Determine integrity of propeller and its mounting at maximum rpm	Manufacturer to submit design documents determining the integrity of the propeller and its mounting at its maximum rpm or CB to witness bench test to determine the stated requirement.	Manufacturer to submit ground test schedule along with test results at their end.

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2.8	Stability and control	a) Determine that RPA is able to maintain a stable flight without pilot input	To be verified during flight testing: i. Manufacturer to demonstrate stable flight and sensor readings which should be longitudinally, directionally and laterally stable. ii. Similar tests to be carried out in fixed wing drones. Note on Stability: The RPAS should be tested in all its operating modes, both FCS augmented or manual, including the effects of sensors or computational errors must be longitudinally, directionally and laterally stable in any condition normally encountered in service.	Annexure 1: Guidelines for flight test
		b) Determine that pilot is able to control RPA with ease.	To be witnessed during flight: Manufacturer to demonstrate stable flight with minimal pilot inputs.	
3	**Powerplant**			

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3.1	Powerplant (Engine Operated)	a) Determine that fan blade can withstand ultimate load of 1.5 times the centrifugal force resulting from operation	Verification of design analysis and relevant evaluation data of the stated requirement from manufacturer / OEM.	
		b) Determine that engine installation is such that it prevents excessive vibration from any part	Vibration test to be witnessed for verification of test reports submitted by the manufacturer.	Test report to be submitted by manufacturer as per the specifications given in the design document.
		c) Ensure that exhaust is firmly mounted to the structure and free from any obstructions	Ascertain by physical inspection that exhaust is firmly mounted to the structure and free from any obstruction.	
		d) Determine that there is no fuel leak in the system under pressure during operational tests on ground	Physical inspection and witness ground test by manufacturer to demonstrate fuel system integrity under pressure during ground test.	Integrity of fuel system against leakage to be tested with a factor of safety e.g. 1.5 times the operating pressure of the system.
	Powerplant (Battery Operated)	a) Determine that safe cell temperatures and pressures are maintained during charging / discharging cycle	Verification of test reports from an accredited testing laboratory and battery OEM's certificate submitted by the manufacturer.	Ground tests with electronic load matching the operating current profile may be conducted.

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			Standards to be followed: **IS 16046 (Part 1)**: Secondary Cells and Batteries Containing Alkaline or Other Non-Acid Electrolytes — Safety Requirements for Portable Sealed Secondary Cells and for Batteries Made from Them for Use in Portable Applications: Part 1 Nickel Systems. or **IS 16046 (Part 2)**: Secondary Cells and Batteries Containing Alkaline or Other Non-Acid Electrolytes — Safety Requirements for Portable Sealed Secondary Cells and for Batteries Made from Them for Use in Portable Applications: Part 2 Lithium Systems or any other relevant standard / applicable mandatory certification / registration for batteries as mandated by the appropriate regulator or authority having jurisdiction from time to time.	

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		b) Determine that no explosive or toxic gases are emitted in normal operation	-- *Same as above* –	
		c) Determine that no corrosive fluid is discharged which may damage the surrounding structures / equipment	-- *Same as above* –	
		d) Ensure that motor / motor controller has overcurrent / overheating protection	Witness the test to verify the stated requirement.	Bench test may be performed for the motor / motor controller exceeding it's operating limits.
4	**Structure**			
4.1	Strength requirements	a) Demonstrate that airframe structure shall be able to withstand flight limit loads without failure, malfunction or permanent deformation	Verification of static load test report and design documents as submitted by the manufacturer.	For determination of anticipated flight loads, appropriate standard softwares may be used. Static Structural Analysis may be done with Aircraft Handbook Calculation Methods or Finite Element Methods(FEA) (Software) can also be used.

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				Visual inspection to be conducted on engine / motor mounting and structure after the tests for deformation, if any. Static test to limit load based on maximum all up weight.
		b) Applicant has to provide analysis of the structure showing that a factor of safety of 1.5 has been used	Verification of analysis and design documents as submitted by the manufacturer.	Static Structural Analysis may be done with Aircraft Handbook Calculation Methods or Finite Element Methods(FEA) (Software) can also be used.
		c) Determine that each removable bolt, screw, nut, pin or other fastener whose loss could jeopardize the safe operation of the RPAS, shall incorporate a locking device	Verification of Design Review Analysis Document to establish that Primary Structure Elements (PSEs) have been identified and their drawings have provision of lock nuts or other mechanisms as applicable. Physical verification to be conducted by the inspection agency on sample RPAS.	

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		d) Determine that RPA is free from excessive vibrations under any operational speed and power condition.	Witness the vibration tests and verify the submitted documents.	
		e) Determine that propeller blade clearance is sufficient from structure and/or components, and from ground.	Verification of design documents details and comparison with the RPAS during physical inspection.	
4.2	Shock absorbing mechanism of RPA, if applicable	a) It must be shown that the limit load factors selected for design will not be exceeded.	Verification of design analysis submitted by the manufacturer.	Impact/Static Analysis Report of Landing gear using Finite Element Analysis (FEA) software can also be considered.
		b) The landing gear may not fail, but may yield, in a test showing its reserved energy absorption capacity	Verify the design document and witness the drop test.	Demonstration of safe landing of the aircraft when dropped from a height as determined by the manufacturer and demonstrated accordingly. This should also be reflected in operational limitations to be followed by the operator.

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5	**Material and Construction**			
5.1	Type of material for construction	The suitability and durability of materials used for parts, the failure of which could adversely affect safety, must: a) be established on the basis of experience or tests;	Review of material test reports from accredited testing laboratory to ascertain the compliance criteria. However, in the absence of above documentation the manufacturer may submit appropriate analysis or Finite Element Analysis (FEA) whichever applicable.	Strength experimental analysis approved by ASTM / any other permitted standard) to be carried out for the materials to find out the strength of the material.
		The suitability and durability of materials used for parts, the failure of which could adversely affect safety, must: b) meet approved specifications, which will ensure that strength and other properties assumed in the design data are correct;	Review of material test reports from accredited testing laboratory (as per ISO/IEC 17025) to ascertain the compliance criteria. However, in the absence of above documentation the manufacturer may submit appropriate analysis or Finite Element Analysis (FEA) whichever applicable.	Strength experimental analysis approved by ASTM / any other permitted standard) to be carried out for the materials to find out the strength of the material.

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		The suitability and durability of materials used for parts, the failure of which could adversely affect safety, must: c) take into account the effects of environmental conditions, such as temperature and humidity, expected in service.	Review of material test reports from accredited testing laboratory (as per ISO/IEC 17025) to ascertain the compliance criteria. However, in the absence of above documentation the OEM may submit appropriate analysis.	Strength experimental analysis approved by ASTM / any other permitted standard) to be carried out for the materials to find out the strength of the material.
5.2	Fabrication Method	a) Methods of fabrication used must produce consistently sound structures	Review of QC process specification and/or procedures submitted by the manufacturer for establishing consistency in quality of fabrication. Additionally, physical inspection may be conducted to verify if such processes are in place adequately.	Design document from manufacturer should have description about fabrication and integration procedure in Manufacturing Process Record.
		b) In a fabrication process, such as gluing, spot welding, heat-treating, etc. requires close control, the process must be performed	Review of the approved QC process specification and/or procedures submitted by the manufacturer for establishing consistency in quality of fabrication.	

S. No.	Parameter / Characteristics	Compliance Criteria (with Requirements)	Method of Evaluation 1. Verification of records 2. Testing and verification 2.1 On-site testing (Ground) 2.2 Flight testing 2.3 Laboratory test (with appropriate details)	Guidance on method of evaluation
		according to an approved process specification.	Additionally, physical inspection may be conducted to verify if such processes are in place adequately.	
		c) Fabrication method must be substantiated by a test program	Review of the test program, QC process specification and / or procedures submitted by the manufacturer.	
5.3	Means of protection against deterioration or loss of strength in operation due to any cause i.e. weathering, corrosion and abrasion.	a) Effect of in-service wear on the loading of critical components should be determined	By design review or analysis followed by physical inspection after ground and flight tests.	Manufacturer to identify critical components for anticipated in-service wear.
		b) Effect of temperature and moisture should be determined in computing the material design values	Verification of test reports from accredited testing laboratory ***For Temperature:*** Verification of test reports from an accredited testing lab submitted by the manufacturer for temperature range of -10°C and +50°C, as per **IS 9000 Part 2 & 3 or equivalent standard**	Specimen / Coupon Tests

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			For Humidity: Verification of test reports from an accredited testing lab submitted by the manufacturer for 90% Relative Humidity at +40°C, as per **IS 9000 Part 4** or **IEC 60068–2–78 or equivalent standard**	
5.4	Fire resistant identification plate on RPA for inscribing UIN.	a) Determination of ID plate material which should be fire resistant	Review of the declared material type of the ID plate and supported by test reports from accredited testing laboratories. In case the manufacturer is using certified fire-resistant materials, then a certificate and/or appropriate test report certifying the same from the material manufacturer may be accepted.	
		b) Determine location of ID plate along with its secure fixing on RPA	The Location of ID Plate Manufacturer has to be mentioned in the Detailed Drawing. Ascertain by physical inspection the location of the fire-resistant identification	

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			plate and whether it is securely fixed on RPA.	
6	**Data Link**			
6.1	Type of data link used for communication (C2 data link, frequency band etc.)	a) Determine full functioning of data link communication	*1. Verify the documents submitted by the manufacturer.* i. OEM to submit ETA copy and associated test reports as applicable. *2. Witness the test of verification as per below compliance.* i) To be verified during a distance communication test from all possible azimuth angles against the data submitted by the OEM/ Manufacturer ii) C2-Data Link capability vs performance comparison through test cases need to be demonstrated by OEM (Verification (functional) of Manufacturer's Specifications on Stability & Control,	Data link loss is declared if the link is lost for more than 10 seconds. Annexure 1: Guidelines for flight test.

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			Redundancy (Single or dual channel) and Back Up, if any) iii) Manufacturer to demonstrate the contingencies implemented including return to home functionality when data link is lost or other applicable contingencies.	
		b) Demonstration of system to alert the remote pilot with aural and visual signal, for any loss of command and control data link	*1. Verify the description of the same in documents (flight manual) submitted by the manufacturer.* *2. Witness the test of verification as per below compliance.* Manufacturer to demonstrate by flight whether aural and visual signal during loss of command and control data link is implemented satisfactorily to alert the RPA Pilot.	Annexure 1: Guidelines for flight test

S. No.	Parameter / Characteristics	Compliance Criteria (with Requirements)	Method of Evaluation 1. Verification of records 2. Testing and verification 2.1 On-site testing (Ground) 2.2 Flight testing 2.3 Laboratory test (with appropriate details)	Guidance on method of evaluation
		c) Determine that communication range is sufficient to have a permanent connection with the RPA	*1. Verify the documents submitted by the manufacturer.* *2. Witness the test of verification as per below compliance.* i) Manufacturer to demonstrate communication range between the RPA and C2 Data Link for positive, negative and boundary case distances from the GCS for having permanent connection in an environment free from interference. ii) Similar test to be performed under various battery /power conditions	Annexure 1: Guidelines for flight test
		d) Determine that when data link is lost or in other contingencies, the RPA follows a predefined path to ensure safe end of flight within the required area restrictions	*1. Verify the documents submitted by the manufacturer.* i) The same should be described in detail in the RPA flight manual. Flight manual submitted by the manufacturer to be reviewed.	Data link loss is declared if the link is lost for more than 10 seconds. Annexure 1: Guidelines for flight test

S. No.	Parameter / Characteristics	Compliance Criteria (with Requirements)	Method of Evaluation 1. Verification of records 2. Testing and verification 2.1 On-site testing (Ground) 2.2 Flight testing 2.3 Laboratory test (with appropriate details)	Guidance on method of evaluation
			ii) Manufacturer to provide description of function performed in case of link loss in RPA Flight Manual iii) CB to assess the sufficiency by verifying the RPA manual in each audit. *2. Witness the test of verification as per below compliance.* i) Manufacturer to demonstrate the contingencies implemented including return to home functionality when data link is lost or other applicable contingencies.	
		e) Determine the capability of system to inform remote pilot by means of a warning signal in the event of data link loss	*1. Verify the description of the same in documents (flight manual) submitted by the manufacturer.* *2. Witness the test of verification as per below compliance.*	Annexure 1: Guidelines for flight test

S. No.	Parameter / Characteristics	Compliance Criteria (with Requirements)	Method of Evaluation 1. Verification of records 2. Testing and verification 2.1 On-site testing (Ground) 2.2 Flight testing 2.3 Laboratory test (with appropriate details)	Guidance on method of evaluation
			i) Manufacturer to demonstrate by flight whether aural and visual signal during loss of data link is implemented satisfactorily to alert the RPA Pilot.	
		f) A command and control data link loss strategy must be established, approved and presented in the RPA Flight Manual	*1. Verify the documents submitted by the manufacturer.* i) Manufacturer to provide description of function performed in case of link loss in RPA Flight Manual and CB to assess the sufficiency. CB will verify RPA manual in each audit *2. Witness the test of verification as per below compliance.* i) Manufacturer to demonstrate the contingencies implemented when command control data link is lost	
7	**Digital Sky Platform - No Permission No Take-off (NPNT)**			

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7.1	Firmware tamper avoidance	a) Protection of onboard computer firmware from tampering (software) *RPAS should not function if firmware is changed by any procedure other than authorized update procedure.*	*1. Verify the documents submitted by the manufacturer.* *2. Witness the test of verification as per below compliance.* **A. Verification of Secure Boot:** Manufacturer to produce a certificate of compliance indicating compliance with all conditions mentioned below: ***i) Flight Module Security Implementation*** a) Flight Module should have 'Level 0 or 'Level 1' compliance as defined in the DGCA RPAS Guidance Manual. b) Flight modules should follow the communication requirement (if applicable) for multiple chips or module design.	

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			c) RFM should have a root of trust mechanism implemented (using, for example, TPM or TEE for Level 1 compliance) which is used to sign the data generated inside the RFM. d) The verification key of the root of trust will be submitted to DigitalSky. (This key will also be used for verifying the origin of logs generated by the RFM). ***ii) Calculation of Checksums*** a) Manufacturer to submit checksums of the firmware to the CB and these checksums may be called 'registered checksums'. b) Code part and data part checksums to be calculated separately to enable updating of data/parameters in the future easily.	

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			c) All checksums should be calculated using a Secure Hash Algorithm (SHA2 or SHA3). d) Registered checksums should be stored securely in the flight module such that they cannot be updated without the authorisation of the manufacturer. e) These registered checksums may be digitally signed by the CB and be submitted to DigitalSky. ***iii) Power on Self-Test (POST)*** a. Manufacturers should implement a Power On Self-Test (POST). b) It should include calculation of checksums of the firmware (code and data part) and the checksum should be matched with the registered checksum stored in the flight module which was supplied at the time of certification.	

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			c) The result of the POST should be logged. d) Mismatch of checksum should prevent the RPAS from booting and be logged. ***iv) Testing of Firmware protection (software)*** a) Attempt modifying the firmware (code and data) in an unauthorised manner. The firmware update should fail. In case the firmware gets updated in an unauthorised manner, then verify that RPAS fails the POST and does not arm even with a valid permission artefact. Test to be conducted in presence of the CB.	

S. No.	Parameter / Characteristics	Compliance Criteria (with Requirements)	Method of Evaluation 1. Verification of records 2. Testing and verification 2.1 On-site testing (Ground) 2.2 Flight testing 2.3 Laboratory test (with appropriate details)	Guidance on method of evaluation
		b) Safety and security of firmware update	*1. Verify the certificates submitted by the manufacturer for ensuring safety and security of the firmware.* *2. Witness the firmware update process as per the process explained below.* **A. Secure Upgrade Test:** i) The update should be permitted only if it is signed by the manufacturer's digital certificate. ii) RPAS should be able to verify the authenticity of the update by verifying it with the public key of the manufacturer. iii) Firmware change should be recorded in the logs.	

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			iv) After the RPAS is upgraded, the registered checksum should be updated in the flight module securely. v) The checksums of the updated firmware (code and data) to be digitally signed by the CB.	
		c) Secure change of flight parameters	*1. Verify the documents submitted by the manufacturer citing the process for instituting a change in any given parameter.* *2. Witness the test for the change process as detailed below.* **A. Testing of Parameter Update:** i) RPAS should be able to verify the authenticity of the update by verifying it with the public key of the manufacturer. ii) Change should be recorded in the logs.	1. Manufacturers should update parameters that do not affect compliance conditions using a Manufacturer's Standard Operating Procedure. For e.g: Using GCS, APIs, etc. 2. If a manufacturer needs to update parameters that affect compliance conditions, the update should be permitted only if it is part of a firmware update and signed by the manufacturer's digital certificate.

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			iii) After the RPAS is upgraded, the registered checksum should be updated in the flight module securely. iv) The checksums of the updated firmware (code and data) to be digitally signed by the CB. v) Try to update the parameters that affect compliance conditions using the manufacturer's standard operating procedure. The parameter should remain unaffected. vi) Try to update the parameters in the firmware that affect compliance conditions using an invalid digital signature. The update should fail.	
7.2	Hardware Tamper Avoidance	a) Protection of onboard computer from tampering (physical)	*1. Verify the documents submitted by the manufacturer explaining the tamper protection mechanism along with its justification*	1. The onboard computer and its ports (USB, UART, bus, etc.) should not be accessible to unauthorised user.

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			2. Witness the test for the tamper protection as detailed below. **<u>A. Hardware Tamper Detection and Response:</u>** i) Verify the physical presence of tamper prevention, detection and response mechanisms by inspection of the RPAS. ii) Replace crucial flight-critical components using unauthorised procedure and check if RPAS is arming. Physical tampering should be detected by RPAS and use of unauthorised flight critical components should be logged. iii) In case of unauthorised replacement of an electronically paired, flight-critical component, the RPAS should not arm.	2. Manufacturers may electronically pair crucial flight-critical components like radio, GPS, etc. with the flight controller and detect the use of unauthorised components. 3. In case a flight-critical component cannot be electronically paired, the manufacturer should take utmost care of using hardware protection mechanisms and appropriate design elements to minimise the tampering of the same.

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			iv) In case of non-electronically paired, flight-critical components, verify by visual inspection if the manufacturer has implemented hardware protection mechanisms and designed RPAS in a way to minimise tampering.	
		b) Mechanism to replace crucial hardware like radio modules, GPS and flight controller	*1. Verify the documents submitted by the manufacturer explaining the process of replacement* *2. Witness the test for the integrity of the hardware* **A. Testing of Secure Hardware Change:** i) In case of unauthorised replacement of an electronically paired, flight-critical component, the RPAS should not arm. ii) In case of non-electronically paired, flight-critical components, verify by visual inspection if the manufacturer has implemented hardware protection	1. SOP for hardware change should also include verifying authenticity and functional integrity of the new component being introduced. 2. Manufacturers should uniquely pair either electronically or non-electronically be appropriate marking with a unique flight controller and record the same. 3. Manufacturer should establish Standard Operating Procedure to replace hardware and should only enable the same via an authorised person.

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			mechanisms and designed RPAS in a way to detect hardware change. iii) In case of secure hardware change, validate SOP by the manufacturer for completeness. iv) In case of secure hardware change, check if the change is logged (to log both secure and insecure hardware change).	4. Every change of hardware should be recorded by the manufacturer and documents should be available to the CB or DGCA for inspection and surveillance. 5. It should also be noted that if any component which forms the RPAS's internal id (which is attached to UIN) is replaced, then the RPAS should undergo a fresh registration and acquire a new UIN

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7.3	NPNT	Compliance to NPNT technical specification	*1. Verify the documents submitted by the manufacturer* i) Check that there is no path to bypass NPNT functionality. To be done by scrutiny of design and comparison with the implementation. *2. Witness the test for NPNT as the protocol defined below:* i) Check if RPAS is armed only when all conditions in the permission artefact like presence of UUID, presence of UIN, valid location, valid time are met. ii) Check if RPAS returns invalid permission message with appropriate reason in case of permission artefact is expired or location is not permitted.	

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			iii) Check if RTH is triggered in case of location or time violations. iv) Check if time and location breach is logged. v) Verify the frequency of check for comparing RPS location and RPAS time with permission artefact/geofence. vi) Verify that logs are generated and signed in a secure manner and also verify that storage and transport of logs to DigitalSky is secured. vii) Verify that there is appropriate secure provisioning of keys. viii) Verify if logs can be retrieved during accidents using any specialised equipment.	

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8	**Instruments / Equipment**			
8.1	a) Global Navigation Satellite System (GNSS) receivers b) Flashing anti-collision strobe lights c) Actuators d) Servo controllers e) Other RPA components	Determine the following: i) Adequate source of electrical energy, where electrical energy is necessary for operation of RPA ii) Wiring is installed in such a manner that operation of any equipment will not adversely affect the simultaneous operation of any other equipment iii) Wiring lay out is according to the wiring diagram iv) All wiring is suitable for the current and voltage going through v) No kinks in the wiring exist	Verification of design documents submitted by the manufacturer and physical inspection to be conducted: 1) Manufacturer to submit component and wireframe diagram illustrating that compliance criteria has been met. 2) Visual Inspection to be performed to ascertain that the RPAS is built as per the component and wireframe diagram to meet the compliance criteria as per information provided Other standards (if applicable): IS 616 or IS 13252.	1. Internal wiring shall be routed, supported, clamped or secured in a manner that reduces the likelihood of excessive strain on wire and on terminal connections; loosening of terminal connections; and damage of conductor insulation. 2. For soldered terminations in safety critical circuits, the conductor shall be positioned or fixed so that reliance is not placed upon the soldering alone to maintain the conductor in position. 3. An external terminal for charging shall be designed to prevent an inadvertent shorting and misalignment and a reverse polarity connection when connected to the charger. 4. For battery packs that are intended for removal from the UAS for external charging or replacement with a charged

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		vi) Wiring routing is not along the sharp edges vii) Soldering connections between cables are not there viii) All equipment are connected with adequately secured connections to prevent loosening during vibrations ix) Minimum operating current x) Maximum operating current		battery pack 5. The external terminal for charging shall be designed to prevent inadvertent shorting, a reverse polarity connection, misalignment, or access by the user.
	f) Geo-fencing capability	Determine whether Geo-fencing capability has been implemented	To be verified during flight testing: Manufacturer to demonstrate the implementation of Geo-fencing capability and document the functionality in RPAS Flight Manual	Manufacturer should be able to demonstrate that the RPA Pilot should be able to define a Geo-fence from the RPA GCS and should be able to demonstrate that the RPA does not breach the Geo-fence during flight

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				Only applicable for RPAS intending to operating in controlled airspace
	g) Autonomous Flight Termination System or Return Home (RH) option	Determine whether Autonomous Flight Termination System or Return Home (RH) option has been implemented	To be verified during flight testing: Manufacturer to demonstrate with flight the implementation of Autonomous Flight Termination System or Return Home (RH) option and document the functionality about the same in RPAS Flight Manual	
	h) SSR transponder (Mode 'C' or 'S') or ADS-B OUT equipment.	Determine whether RPA has SSR transponder (Mode 'C' or 'S') or ADS-B OUT equipment.	Manufacturer to declare if RPAS has SSR transponder (Mode 'C' or 'S') or ADS-B OUT equipment. 1. If present, the presence of the same to be verified in the submitted design document. i. OEM to submit ETA copy and associated test reports as applicable. 2. Witness the demonstration	Only applicable for RPAS intending to operating in controlled airspace

S. No.	Parameter / Characteristics	Compliance Criteria (with Requirements)	Method of Evaluation 1. Verification of records 2. Testing and verification 2.1 On-site testing (Ground) 2.2 Flight testing 2.3 Laboratory test (with appropriate details)	Guidance on method of evaluation
			i. of the appropriate equipment by the manufacturer of the functionality. ii. CB to document the evidence of the functionality.	
	i) Detect and Avoid capability	Determine whether Detect and Avoid capability option has been implemented	To be verified during flight testing: Manufacturer to demonstrate with flight the implementation of Detect and Avoid capability option and document the functionality in RPAS Flight Manual.	Only applicable for RPAS intending to operating in controlled airspace
	j) Flight controller with flight data logging capability	Determine whether RPA has flight controller with flight data logging capability	Manufacturer to declare if RPA has Flight controller with flight data logging capability and show the presence of the same in Design Document. Presence of flight data logging to be verified after conducting flight testing.	
	k) Barometric equipment with capability for remote subscale setting	Determine whether RPA has Barometric equipment with capability for remote subscale setting	OEM to declare if RPA has Barometric equipment with capability for remote subscale setting and show the presence of the same in Design Document	Only applicable for RPAS intending to operating in controlled airspace

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	l) RFID and GSM Sim Card	Determine whether RPA has provision for RFID and GSM SIM Card	Verify from design documents, whether the manufacturer has implemented RFID and GSM SIM card or verify if the manufacturer has made provisions to implement the same.	1. Independent tamper proof hardware in the RPA (air) unit should be implemented on the RPAS 2. Software dashboard to be provided to regulators/ CB for real time tracking 3. Maintenance of data base for a period of 3 months from the date of flight. 4. This is applicable to categories 'Small' and higher categories (above 2 Kg).
9	**Qualification Testing**			
9.1	Environmental tests	Determine that instruments and equipment withstand the following: a) Effects of voltage spikes from power source;	***If RPA is powered from an external source:*** Verification of test reports from an accredited testing lab submitted by the manufacturer for Surge Immunity as per **ANSI/IEEE C62.41 / IEC 61000-4-5 / IS 14700 or equivalent standard.**	

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			If RPA powered from on-board source: Review of design analysis report submitted by the manufacturer detailing the nominal voltage range of the electrical power supply on-board the RPA.	
		Determine that instruments and equipment withstand the following: b) Susceptibility to HIRF;	***If RPA is intended to be operated in environment with HIRF:*** Verification of test reports from an accredited testing lab submitted by the manufacturer for Radiated Immunity as per **IEC 61000-4-3 equivalent standard.** ***Else, not applicable***	As a safety feature, manufacturer should ensure bonding of the components and grounding them properly to the airframe.
		Determine that instruments and equipment withstand the following: c) Temperature and humidity variations;	***For Temperature:*** Verification of test reports from an accredited testing lab submitted by the manufacturer for temperature, as per **IS 9000 Part 2 & 3 or equivalent standard** ***For Humidity:***	Tests should be carried out across the full operational environmental range (temperature and humidity) of the RPA as specified in RPA manual. RPA should be kept in serviceable condition (not storage) during the test. At a minimum, tests should be carried out for temperature ranges of 0 to 50 deg C and 90% RH at 40 deg C.

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			Verification of test reports from an accredited testing lab submitted by the manufacturer for humidity, as per **IS 9000 Part 4** or **IEC 60068–2–78 or equivalent standard**	
		Determine that instruments and equipment withstand the following: d) Shock resistant, etc.	Verification of test reports from an accredited testing lab submitted by the manufacturer for shock resistance, as per **IEC 60068-2-27 or equivalent standard**	
		Determine that instruments and equipment withstand the following: e) Ingress Protection (IP) Certification	In case the manufacturer has defined IP Certification, the same should be validated.	
9.2	EMI / EMC test	Determine that each electrical instrument and equipment is protected against EMI coming from the operational environment to ensure normal operation.	Verification of test reports from an accredited testing lab submitted by the manufacturer for Radiated Immunity, as per applicable Parts and Clauses of **IEC 61000 / IS 14700 or equivalent standard**	

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9.3	Software	a) Determine impact of loss of function and malfunction of RPA	Risk analysis statement to by submitted by manufacturer and accepted by Certification Body	IEC Standard for FMEA to be determined or SAE ARP4761 - System Safety Assessment to be reviewed.
		b) Determine that sufficient independence exists between software components with respect to both function and design	To verify and approve the statement of independence to be issued by the manufacturer.	
9.4	Hardware	a) Determination of hardware design life cycle through established quality control procedure,	To verify and approve documents submitted by the manufacturer declaring hardware design life cycle including appropriate analysis and Internal Quality Assurance Procedure.	Conformance to be verified as per the provisions of **ISO 9001 - Management Systems.** Manufacturers are required to follow the procedures in ISO 9001. They may not necessarily be ISO 9001 certified.
		b) Component performance and reliability to be monitored on a continuous basis.	Manufacturers should demonstrate the component performance, monitoring process effectiveness and document the same in the RPAS Maintenance Manual.	Monitoring of component performance and reliability subsequent to certification would be the responsibility of the manufacturer.
10	**Documentation**			

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10.1	RPA Flight manual	RPA flight manual should contain the following information: 1) Limitations / operating conditions/ operating envelope 2) Normal Procedures, pre-flight checklist, etc. 3) Emergency procedures 4) Performance (at various combination of weight, altitude, temperature and wind conditions) 5) Any other relevant information required for safe operation of RPA	The certification body to review the submitted flight manual and approve the content for its applicability.	
10.2	RPA Maintenance Manual	RPA maintenance manual should consist of the following:	The certification body to review the submitted maintenance manual and approve the content for its applicability.	

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		1) Maintenance procedures of the RPA. 2) Continuous Monitoring process for RPA components		
10.3	RPA Log book	RPA log book should consist of the following: 1) Provision to maintain RPA Operation Logs 2) Provision to maintain RPA Maintenance Logs	The certification body to review the submitted log book and approve the content for its applicability.	
10.4	Other design documents	1. Analysis reports	Verify for appropriateness the version-controlled documents to be submitted along with application that are duly approved by the authorised signatory.	All analysis reports as required for substantiation. Reports should have document number, rev no, release date, preparer/ reviewer / approver.
		2. Test reports	Verify for appropriateness the version-controlled documents to be submitted	All test reports as required for substantiation. Reports should have

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			along with application that are duly approved by the authorised signatory.	document number, rev no, release date, preparer/reviewer/approver
		3. Detailed drawings	Verify for appropriateness the version-controlled documents to be submitted along with application that are duly approved by the authorised signatory.	The manufacturer should establish a procedure for version control of design documents. Assembly level drawing showing parts list. Drawings should have document number, rev no, release date, preparer/reviewer/approver
		4. Consolidated hardware and software independently verified and validated reports	Verify for appropriateness the version-controlled documents to be submitted along with application that are duly approved by the authorised signatory.	
		5. Material procurement record	Verify for appropriateness the version-controlled documents to be submitted along with application that are duly approved by the authorised signatory.	
		6. Manufacturing process records	Verify for appropriateness the version-controlled documents to be submitted along with application that are duly approved by the authorised signatory.	May include manufacturing process root cards and process records

Annex B

Normative References

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

1. BS EN 61000-3-3:2013, Electromagnetic compatibility (EMC). Limits. Limitation of voltage changes, voltage fluctuations and flicker in public low-voltage supply systems, for equipment with rated current ≤ 16 A per phase and not subject to conditional connection.

2. BS EN 61000-4-6:2014, Electromagnetic compatibility (EMC). Testing and measurement techniques. Immunity to conducted disturbances, induced by radio-frequency fields.

3. BIS IS 14599: 1999(R2014), Automotive Vehicles - Performance Requirements (Measurement of Power, SFC, Opacity) Of Positive and Compression Ignition Engines - Method of Test.

4. Civil Aviation Regulations, Section 3 – Air Transport Series X Part I Issue I, Dated 27 August 2018.

5. 14 CFR 35 - Airworthiness Standards: Propellers, Code of Federal Regulations (annual edition), Federal Aviation Administration.

6. DGCA RPAS Guidance Manual, Revision 2 - 2020.

7. IEC 61000-3-3:2013+AMD1:2017 CSV, Consolidated version, Electromagnetic compatibility (EMC) - Part 3-3: Limits - Limitation of voltage changes, voltage fluctuations and flicker in public low-voltage supply systems, for equipment with rated current ≤ 16 A per phase and not subject to conditional connection.

8. IEC 60068-2-6:2007, Environmental testing - Part 2-6: Tests - Test Fc: Vibration (sinusoidal).

9. IEC 61000-4-6:2013, Electromagnetic compatibility (EMC) - Part 4-6: Testing and measurement techniques - Immunity to conducted disturbances, induced by radio-frequency fields.

10. IEC CISPR 24, Information technology equipment – Immunity characteristics – Limits and methods of measurement.

11. IEC 60947-5-1:1990 (read in conjunction with IEC 947-1), Low-voltage switchgear and control gear. Part 5: Control circuit devices and switching elements - Section One: Electromechanical control circuit devices.

12. IEC 60529:1989, Degrees of protection provided by enclosures (IP Code).

13. ISO 12405-4:2018, Electrically propelled road vehicles —Test specification for lithium-ion traction battery packs and systems — Part 4: Performance testing.

14. ISO/IEC 17025, General requirements for the competence of testing and calibration laboratories.

15. IS 616:2017/IEC 60065:2014 - Audio, Video and similar electronic apparatus- Safety requirements.

16. IS 9002-10-1: Equipment for Environmental Tests for Electronic and Electrical Items, Part 10: Shock Test Machine, Section 1: Free Fall Type.

17. IS 14700-4-1: Electromagnetic Compatibility (EMC), Part 4: Testing and Measurement Techniques, Section 1: Overview of IEC 61000-4 Series.

18. IS 9002-6: Equipment for Environmental Tests for Electronic and Electrical Items, Part VI: Constant Relative Humidity Chamber (non-injection type).

19. IS 9000-16: Basic environmental testing procedures for electronic and electrical items 16 Driving rain test

20. IS 9000-4: Basic Environmental Testing Procedures for Electronic and Electrical Items, Part 4: Damp hear (Steady state).

21. IS 9000-11: Basic environmental testing procedures for electronic and electrical items, Part 11: Salt mist test.

22. IS 4691: 1985, Rotating electrical Machines Part 5 Degrees of protection provided by enclosure for rotating electrical machinery.

23. IS 12063: 1987, Classification of Degrees of Protection Provided by Enclosures of Electrical Equipment.

24. IS 13947: Part 1: 1993, Low-voltage Switchgear and Control gear - Part 1: General Rules

25. IS 14599: Automotive Vehicles - Performance Requirements (Measurement of Power, SFC, Opacity) of Positive and Compression Ignition Engines - Method of Test

26. IS 16046 (Part 1):2018 / IEC 62133-1:2017 Secondary Cells and Batteries Containing Alkaline or Other Non-Acid Electrolytes — Safety Requirements for Portable Sealed Secondary Cells and for Batteries Made from Them for Use in Portable Applications Part 1 Nickel Systems

27. IS 16046 (Part 2):2018 / IEC 62133-2:2017 Secondary Cells and Batteries Containing Alkaline or Other Non-Acid Electrolytes — Safety Requirements for Portable Sealed Secondary Cells and for Batteries Made from Them for Use in Portable Applications Part 2 Lithium Systems.

28. IS 6303-4: Primary Batteries, Part 4: Safety of Lithium Batteries.

29. IS 10000-2: Methods of tests for internal combustion engines, Part 2: Standard reference conditions.

30. JSS 50101: 1996, Environmental Test methods for Service Electronic Components (Group Class 5999).

31. JSS 55555 – Antifungal Test – Electronics.

32. MIL-STD-810 Testing, Environmental Engineering Considerations and Laboratory Tests, Vibration Testing Category 8 – Aircraft – Propeller.

33. NATO STANDARD AEP-83 Light Unmanned Aircraft Systems Airworthiness Requirements, Edition B Version 1 November 2016.

34. UK-CAA Policy for Light UAV Systems by D. R. Haddon, C. J. Whittaker Design & Production Standards Division, Civil Aviation Authority, UK.