University of Colorado at Boulder Unmanned Aircraft Systems Airworthiness Certification Manual

Office of Integrity, Safety and Compliance

Flight Operations

University of Colorado
Boulder

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Manual Approval

This manual bas been approved by the following representatives:

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Part 1: Introduction and Preface

1.1 Manual Structure

This manual applies to all aircraft being operated in affiliation with CU in any capacity.

Airworthiness standards are different depending on the nature of aircraft operations, aircraft type, and aircraft origin.

Aircraft operations fall into one of two categories:

- *Experimental (EX)*. Experimental aircraft are strictly for testing purposes and must be operated only in remote locations. The primary concern with experimental airworthiness certification is that the aircraft does not pose a risk of injury to personnel on the ground or to the NAS at large.
- *Operational (OP)*. Operational aircraft are for any purpose outside of what is covered by experimental aircraft and can be operated anywhere in accordance with FAA regulations, authorizing documents, and the Flight Operations Manual. The primary concern with operational airworthiness certification is that the aircraft is a stable, structurally sound, reliable, well-built aircraft ready to accomplish its mission. An operational aircraft is to be flight-tested under an experimental airworthiness certificate before being issued an operational airworthiness certificate.

Differing aircraft types are as follows:

- *Airplane.* An airplane is a heavier- than-air engine-driven fixed-wing aircraft, that is supported in flight by the dynamic reaction of air against its wings.
- *Glider.* A glider is a heavier-than-air aircraft, that is supported in flight by the dynamic reaction of the air against its lifting surface and whose free flight does not depend principally on an engine.
- *Multirotor*. A multirotor is a rotorcraft with more than two lift-generating rotors.
- *Helicopter*. A rotorcraft that, for its horizontal motion, depends principally on its engine-driven rotors.
- *Airship*. An airship is an engine-driven lighter-than-air aircraft that can be steered. These aircraft are also described as dirigibles, blimps, and zeppelins.

For the sake of airworthiness standards, airplanes and gliders are treated the same, and are collectively referred to as airplanes since they have very similar dynamics.

Airplanes are broken down into two different categories for the purposes of certain airworthiness standards:

- *Normal/transport.* This describes a general-purpose airplane which does not meet the description of *aerobatic*.
- *Aerobatic*. This describes an airplane designed for aerobatic use or is expected to be subjected to moderate turbulence or frequent hard landings.

The possible origins of aircraft are defined as follows:

- *Commercial off-the-shelf, factory-assembled (COTS)*. This describes aircraft that are purchased readily from a commercial manufacturer and are entirely unmodified by the operator. COTS aircraft must be mostly complete and require minimal assembly by the end user. The aircraft must have servos, linkages, and a propulsion system (if applicable) pre-installed. Kits which only include the airframe are not considered COTS. Further, products such as ARF (Almost Ready to Fly) kits that require significant assembly by the end user are not considered COTS. In general, OISC defines COTS aircraft as commercially purchased aircraft of a completion level equal to or better than PNP (Plug and Play) provided the radio system can be purchased commercially.

- *Commercial off-the-shelf, user-assembled (COTS-U).* This describes an aircraft which is assembled primarily of commercial-off-the-shelf components but requires significant user assembly. This describes ARF kits, products containing only an airframe but no electronics, or any other aircraft composed primarily of commercial off-the-shelf components but requires more user assembly than a BNF kit. It is acceptable for some amount of the aircraft to be composed of user-built parts under the following circumstances: (a) the additional user-built parts do not materially change the aircraft's structure, aerodynamics, or weight and balance; (b) the aircraft is built with not more than 5% user-built parts, as measured by part count; and (c) OISC inspects all of the user-built parts. If these three stipulations are not met, the aircraft must be evaluated as an entirely novel (EN) aircraft.
- *Entirely novel (EN)*. This describes aircraft that are not able to be purchased commercially and are constructed by the operator or a contractor of the operator.

In order to determine which section of this manual applies to a given aircraft type, purpose, and origin, make use of the flowchart on the following page:

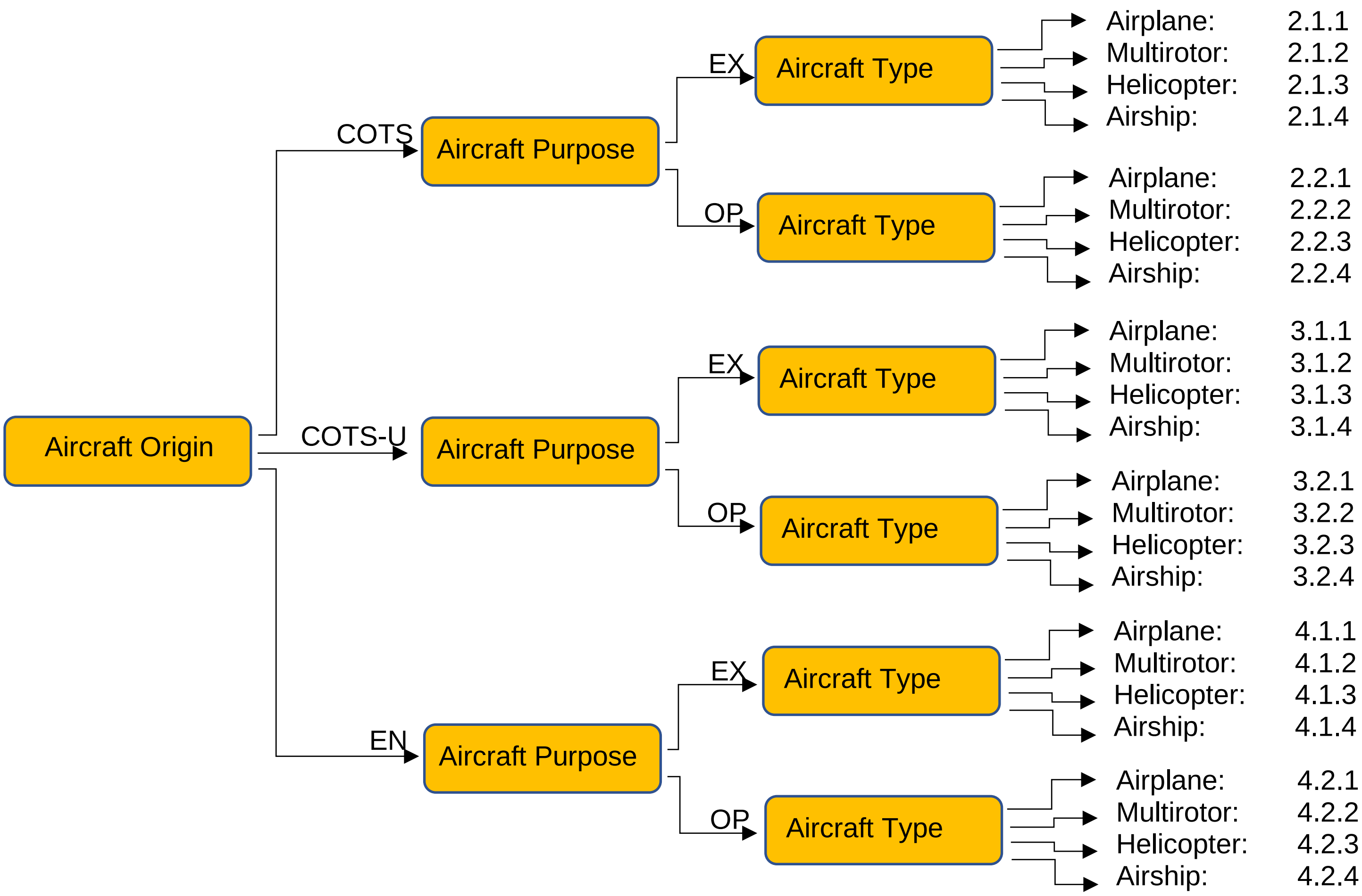


Figure 1-1: Schematic showing relevant parts of manual for certification of different aircraft types and origins

OISC also sets standards for the following:

- Special criteria which are applicable only for specific aircraft systems or use cases. These standards are contained in part 5 of this manual.
- Criteria for certain payloads, standards for which are contained in part 6 of this manual.
- Modified and repaired aircraft, standards for which are contained in part 7 of this manual.
- Flying difficulty, standards for which are contained in part 8 of this manual.

Scoring of aircraft is based on the idea of a *reduced score* and *total reduced score*:

- A reduced score is specific to a category of evaluation. Compute the reduced score by summing the accumulated risk points, dividing by the maximum possible risk points, and multiplying by 100.
- A total reduced score is based on the reduced scores from all relevant categories of evaluation. Compute the total reduced score by summing the accumulated reduced scores, dividing by the maximum possible accumulated reduced score, and multiplying by 100.

1.2 Preface and Purpose

OISC needs consistent and risk-based methods to assess airworthiness of aircraft flown in association with CU. Further, given the extent of airworthiness certification process, it is not appropriate to include this in the airworthiness section of the Flight Operations Manual.

This manual serves to set forth objective, risk-based, rigorous standards for airworthiness certification.

1.3 Enforcement of Airworthiness Stipulations

Any operating limitations that arise from an airworthiness assessment must be included in the airworthiness certification letter. Compliance with operating limitations is mandatory.

The flying difficulty evaluation is used in the Flight Operations Training Manual to inform standards for pilot certification.

1.4 Personnel

Any airworthiness assessment must be made strictly by employees of OISC who have aerospace engineering experience. Specifically, they must have passed the following CU aerospace engineering classes, or an equivalent set of coursework:

- ASEN3111 Aerodynamics, and corresponding prerequisites.
- ASEN3112 Structures, and corresponding prerequisites.
- ASEN3128 Aircraft Dynamics, and corresponding prerequisites.
- ASEN3113 Thermodynamics, and corresponding prerequisites.

An equivalent set of coursework must include formal university training on the following subjects:

- Structures, to include:
  - Mechanics of materials
  - Stress-strain relations and stress transformation
  - Statics
  - Trusses, solved by equilibrium, virtual work, and finite element method
  - Beam theory
  - Torsion
  - Vibration
  - Buckling
- Thermodynamics, to include:
  - Basic thermodynamic relations: ideal gas law, isentropic relations, first and second laws, Carnot cycle, entropy
  - Thermodynamic cycles, including Otto, Diesel, Brayton, Rankine
  - Heat transfer, including heat conduction, radiation, forced and natural convection
- Aerodynamics, to include:
  - Basic incompressible flow relations

    - Incompressible flow as applied to airplanes: thin airfoil theory, Prandtl lifting line theory, and the vortex panel method
    - Basic compressible flow relations for subsonic flow
    - Compressibility corrections
- Dynamics, to include:
    - Solutions for dynamics problems using energy, momentum, and Newton's second law for both translational and rotational cases
    - Kinematic relationships
    - Feedback control systems
- Flight dynamics, to include:
    - Basic equations of motion for an aircraft, including linearization
    - Estimation of airplane stability derivatives, including dimensionalization and transformation
    - Assessment of static stability
    - Formulation of lateral and longitudinal dynamics matricies
    - Determining characteristics of dynamic modes and what aircraft design features effect which dynamic modes
    - Incorporating effect of aircraft controls and feedback control systems to change dynamic handling
- Aircraft design principles, to include:
    - Formulation of whole aircraft drag polar
    - Determining requirements for thrust, power required to fly
    - Determining glide range, climb rate, climb angle, required airspeeds for each
    - Determining range and endurance
    - Calculation of takeoff and landing distance
    - Calculation of turn performance
    - Energy methods for aircraft performance assessment

Further, assessing airworthiness requires that the assessor has the utmost intellectual honestly about their knowledge. If an airworthiness assessor encounters a situation where they believe their knowledge is insufficient to perform the relevant assessment, they must seek assistance from another employee of Flight Operations.

Airworthiness assessment personnel must conduct their inspections and evaluations with the utmost integrity.

In no case will an exception be made that waives any requirements delineated in this section: in no case may a non-OISC employee certify airworthiness, and in no case may anyone without the required aerospace engineering background certify airworthiness.

The DO has the ultimate authority to determine if an individual is fit to serve as an airworthiness evaluator. The DO shall maintain a list of individuals qualified to perform airworthiness evaluations.

1.5 Airworthiness Certification Process and Structure

1.5.1 Airworthiness Certification vs. Type Certification

Under this manual, aircraft are required to possess both a type certificate and an airworthiness certificate. The differences are as follows:

- Type certificate. Issued to original manufacturer of aircraft certifying that a given type of aircraft is airworthy, such as a RAAVEN or Mavic. These must specify the performance limitations, components, etc. of the aircraft type.
- Airworthiness certificate. Issued for a specific aircraft which certifies that the aircraft conforms to its type certificate and is in a condition for safe operation.

1.5.2 Type Certification Process

In assessing the airworthiness of an aircraft type, the following process will take place:

If an experimental airworthiness certificate is sought:

- OISC airworthiness assessor conducts an airworthiness assessment according to the relevant section of this manual, looking for compliance with experimental airworthiness standards.
- OISC conducts or supervises certification flight, or series of certification flights.
- OISC issues airworthiness certificate, including operating limitations. If the aircraft performance and stability characteristics, as determined from flight test, are not commensurate with the calculated/predicted parameters, the airworthiness must be re-evaluated. Similarly, if flight test shows that the aircraft cannot comply with operating limitations, the airworthiness needs to be re-assessed.

If an operational airworthiness certificate is sought:

- OISC airworthiness assessor conducts an airworthiness assessment according to the relevant section of this manual, looking for compliance with experimental airworthiness standards first.
- OISC conducts or supervises certification flight, or series of certification flights.
- OISC issues experimental airworthiness certificate, including operating limitations. If flight testing shows that either the calculated aircraft characteristics are not correct, or that the aircraft cannot comply with operating limitations, the airworthiness must be re-assessed.
- Proponent conducts testing to meet requirements for operational certification with OISC oversight.
- OISC conducts second airworthiness assessment according to the relevant section of the manual, looking for compliance with operational airworthiness standards. This includes a certification flight or series of certification flights performed by a pilot within Flight Operations. This flight must include performing maneuvers which can allow for assessing the requirements set forth in the relevant section of this manual.
- OISC issues operational airworthiness certificate, including operating limitations.

In any case, this manual assigns a risk value based on aircraft parameters. From there, risk points in each category are added up, and the overall total is also found. Depending on the total number of risk points, the aircraft will be placed in one of four categories:

- Risk level 1.
- Risk level 2.
- Risk level 3.
- Unairworthy.

These airworthiness risk scores are used in conjunction with the Flight Operations Risk Matrix to inform the risk in a given operation.

An aircraft is deemed unairworthy if the total risk points exceed the limit, or if the total risk points in a category exceed the limit for that category.

Note that certain risk assessment categories have an option of 'Unairworthy'. This corresponds to 100 risk points for the purposes of computing an airworthiness score.

The proponent must submit a concept of operations (CONOPS) as a part of the type certification process. See section 1.5.9 for more information on what information is required to be contained in the CONOPS.

The general process for obtaining a type certificate for a new aircraft type is as follows:

1. Proponent submits request for new type certificate, complete with CONOPS
2. Flight Operations department performs preliminary analysis to issue an experimental airworthiness certificate.
3. Flight testing is conducted to assess compliance with operational airworthiness certificate standards.
4. Flight Operations Department assess results of flight testing and issues operational airworthiness certificate and assigns pilot difficulty rating.

1.5.3 Individual Aircraft Airworthiness Certification Process and Standards

For an individual aircraft to be certified as airworthy, the following process must take place:

- OISC airworthiness assessor inspects the aircraft to ensure that it conforms to its type certificate. This means that it must meet the specifications delineated in the type certificate, insofar as it (a) has the same dimensions and overall configuration as the type certificate, and (b) is built with the same parts specified in the type certificate.
- OISC airworthiness assessor inspects the aircraft to ensure that it is in a condition for safe operation. This means it must be built with a high degree of craftsmanship and not exhibit any wear/damage outside of the specifications of the type certificate.

OISC expects that aircraft are constructed with a high degree of craftsmanship and compare to manned aircraft in terms of build quality.

Aircraft meets specifications of type certificate in terms of:

- Aerodynamic characteristics, including wing characteristics, vertical and horizontal stabilizer characteristics, fuselage characteristics, propulsion characteristics, .
- Dynamics characteristics, as affected by aircraft weight-and-balance.
- Structural characteristics, including material construction and material grade, structural design (such as beam shape or truss characteristics).
- Components used in constructing the aircraft.
- Build quality: all components must be built to the design specified in the type certificate.
- Any other item noted on the type certificate.

If the aircraft does not meet the specifications of its type certificate, it is unairworthy.

Additionally, any of the following will render an individual aircraft unairworthy:

- Excessively loose components or components which are not mounted properly
- Plastic deformation in any component outside of design specifications
- Any component not built to design specifications
- Aircraft is not built with all required fasteners or adhesive
- Adhesive is cured poorly, or the wrong type of adhesive is used for as given purpose
- Fasters are not tightened properly, or the wrong type of faster is used for the given purpose
- Excessive hangar rash incurred during building
- Built from secondhand components of unacceptable quality
- Built with parts of a lower quality than design specifications call for
- Built from materials of a lower grade than design specifications
- Poorly managed wires within aircraft
- Components mounted in a lopsided manner outside of design specifications
- Unbalanced propeller(s)
- Excessive vibration caused by powerplant
- Any instance where the airworthiness assessor deems, in their expert opinion, that the build quality and craftsmanship is lacking.

1.5.4 OISC Right to Inspect Aircraft

As is delineated in sections 2 through 7 of this manual, some aircraft qualify for immediate airworthiness certification without requiring OISC inspection. However, at the discretion of the Associate Vice Chancellor for Integrity, Safety, and Compliance or any Flight Operations staff, OSIC reserves the right to conduct an airworthiness inspection on any aircraft before certifying it for flight in the NAS.

1.5.5 Certificate Holders

Airworthiness certificates are to be held by the owner/operator of the aircraft in question.

Type certificates are to be held by the manufacturer of the aircraft type.

1.5.6 Certificate Termination and Revocation

Airworthiness certificates are valid if the aircraft meets its approved type design, is in a condition for safe operation, and maintenance (including preventative maintenance) is performed.

A type certificate remains valid if the type certificate holder remains responsible for the continued integrity of the approved aircraft design and remains a focal point for locating and addressing issues that may require corrective action. This requires continued technical capability, or access to technical capability. Technical capability means continued access to people with the necessary formal engineering training necessary to identify, analyze, and resolve aircraft issues.

OISC has the authority to revoke airworthiness certificates if specific and articulable circumstances exist which call into question the airworthiness of the aircraft.

OISC can revoke type certificates if the safety of the aircraft design is in doubt, or if the holder of the type certificate no longer possesses the required technical capability to identify and address issues with the type design.

1.5.7 Airworthiness Directives

Airworthiness directives may be issued by OISC to rectify a safety issue that exists with a particular aircraft type. Compliance with airworthiness directives is mandatory. The aircraft may still be flown if the airworthiness directive permits flight. Airworthiness directives may, depending on the scope of the safety issue, require the following:

- Decreased inspection interval or more rigorous inspections
- Replacement of aircraft components, or shorter permissible lifetimes of aircraft components, or other maintenance more rigorous than originally specified
- Grounding of the aircraft type

Airworthiness directives are issued by the Director of Flight Operations at the recommendation of any Flight Operations employee or the Associate Vice Chancellor of Integrity, Safety, and Compliance.

1.5.8 Airworthiness Risk Spreadsheet

To aid in determining the airworthiness status of the aircraft, this manual is accompanied by an Excel spreadsheet which allows the user to input the accumulated risk points in each category. The required formulae are applied then to determine the airworthiness risk level of a given aircraft.

1.5.9 CONOPS

Proponents are required to submit a concept of operations (CONOPS) for airworthiness certification. The CONOPS must present, in graphical form, the following information:

- Aircraft specifications, to include key parameters such as endurance, maximum takeoff weight, empty weight, major dimensions, and a three-view of the aircraft.

- Aircraft mission and use case: define what the aircraft will do, what data it will collect (if any), etc.
- Flight location: detail the general area in which the operation will take place. This must include features such as population density and proximity to national borders.
    - It is permissible to be broad: if the aircraft will be operated over sparsely populated areas in the United States, that amount of detail will suffice. Precise population density figures are not required.
    - If the typical mission will include flights within 100nm of a national border, this information must be included.
    - If the aircraft is desired to be flown in a foreign country, or within 100nm of territory controlled by a hostile foreign government, this information must be included.
- Flight legal parameters: maximum altitude, airspace class, VLOS/BVLOS
- Weather conditions: detail whether or not the aircraft is intended to fly in any of the following conditions: nighttime flight, flights in precipitation of any intensity, exceptionally cold environments, icing conditions, IMC/BVLOS, or flights in conditions conducive to lightning.
- Personnel required to support the operations: number of crew and crew positions/roles of each. Detail precisely what each crew member is responsible for.
- How the aircraft is launched and recovered. If using an unconventional method for takeoff/recovery, this section is of particular concern.
- How the aircraft is controlled: manual vs. automated flight, means of transmitting information from control station to aircraft
- Layout and feature set of control stations: telemetry data sent to control station (if any), means of manual control, means of automatic control, physical description/photo of control station

If the aircraft will be operated in multiple different mission scenarios that differ substantially from one another, a CONOPS must be submitted for each unique mission scenario.

Some examples of differing scenarios which do and do not require a separate CONOPS to be submitted:

- As an example, if an aircraft will be flown according to the same mission profile in the United States and also near foreign airspace controlled by a hostile government, a CONOPS for each case must be submitted.
- As an example, if an aircraft will be flown in one mission several times for a short duration, and in another mission it will be flown only once for a much longer period of time, multiple CONOPS must be submitted.
- As an example, if an aircraft will be launched/recovered differently in different missions, multiple CONOPS must be submitted.
- As an example, if an aircraft will be flown in several broadly similar missions but with differing altitudes and endurances, a single CONOPS may be submitted reflecting the longest endurance and highest altitudes.

The Flight Operations Department and the Office of Integrity, Safety, and Compliance ultimately has discretion as to whether or not multiple CONOPS need to be submitted.

OISC will carefully evaluate the CONOPS in assessing airworthiness. The CONOPS will affect the following:

- Whether any special airworthiness standards are triggered, such as:
    - Flights in known icing, flights at night, flights in cold environments, etc. contained in section
    - Schedule II airworthiness standards for aircraft with a sufficiently long endurance, sufficiently large MTOW, etc.
    - Enhanced security concerns for flying near hostile foreign airspace
- Whether additional analysis needs to be conducted not covered by existing airworthiness standards
- Whether current OISC policies and flight permissions from civil aviation authorities permit the operation

1.6 Pilot Skill Level Evaluation

OISC will evaluate the required pilot skill for each aircraft type. Part 7 of this manual contains the standards for evaluating the piloting difficulty, which is differentiated based on the category of aircraft in question.

Reference the Flight Operations Training Manual for information regarding the corresponding training and certification requirements for differing aircraft skill levels.

1.7 Airworthiness Analysis Methods and Standards

This section delineates the process of analysis which is to be followed in analyzing aircraft airworthiness.

1.7.1 Methods of Analysis

The following methods of analysis are acceptable for use in assessing compliance with various airworthiness standards:

- Empirical and theoretical equations, such as thin airfoil theory and basic mechanics of materials equations.
- Numerical methods, such as the vortex panel method, Prandtl lifting line theory, and the structural finite element method. It is recommended to implement these methods in an application like MATLAB, as they are not practical to compute by hand.
- Aircraft stability analysis, using linearized equations of motion, and using best practices for estimating stability derivatives delineated in publications such as *Dynamics of Flight* by Etkin and Reid as well as the USAF DATCOM.
- Fluid flow analysis in CFD to evaluate the effects of viscosity, such as parasite drag and stall characteristics. CFD packages that could be useful include Ansys Fluent and Autodesk CFD.
- Structural analysis tools built into CAD packages, such as the structural simulation tool in Autodesk Fusion 360.
- Structural tests by finding modal frequencies from a shaker table test.

- Wind tunnel tests.
- Experimental nondestructive structural testing; evaluation of structural performance by certifying that the structure bears a given load without yielding or excessive deformation.
- Experimental destructive structural testing: evaluation of structural performance by loading the structure until failure and evaluating the load which results in failure.
- Flight test, which must be conducted strictly in a non-operational environment and in a remote area. See section 1.6.2 for when flight testing is an acceptable method of analysis.
- Any other method deemed appropriate for use by the airworthiness assessor based on their best judgement and expertise.

1.7.2 Choosing Method of Analysis

In order to determine which methods of analysis are appropriate for a given situation, the following applies:

- The primary method of analysis is to use mathematical models to predict aircraft performance, along with nondestructive experimentation to assess the aircraft's structure. More complicated numerical models, such as CFD, are not expected to be used in most airworthiness assessments.
- In general, standards relating to phenomena that are difficult to assess on the ground (such as aeroelastic effects and structural modal frequencies) can be assessed in flight, provided that (a) the proponent is aware of and accepts the risk of a hull loss of the aircraft, (b) the flight is conducted in a non-operational environment and in a remote location, and (c) flight testing in the NAS does not risk to other users of the NAS or personnel/property on the ground. If these conditions are not satisfied, a more onerous and detailed analysis must be performed before flight in order to satisfy that there is a low risk of a hull loss of the aircraft, and a low risk of risk of injury/property damage.
- In no case will a flight test will be completed without the airworthiness assessor being satisfied that flying the aircraft does not constitute a risk of injury or property damage.
- At the discretion of the Director of Flight Operations or the Associate Vice Chancellor or Integrity, Safety, and Compliance, any aircraft can be subjected to more onerous airworthiness assessment prior to flight. This could entail more detailed aerodynamic analysis (such as CFD models and wind tunnel tests) as well as more detailed structural tests (such as models within CAD, destructive testing, and shaker tests to find modal frequencies). This discretion is expected to be invoked for aircraft which are (a) particularly heavy, (b) expected to operate beyond visual line of sight or (c) expected to operate over people. That said, this discretion is explicitly reserved to be invoked in any circumstance deemed appropriate by the DO or AVC. Additionally, see section 1.7.5 for stricter airworthiness standards that are invoked as a consequence of the aircraft's weight, speed, endurance, etc.

1.7.3 Unpublished standards

This manual contains extensive and thorough airworthiness standards that are intended to cover a wide array of differing aircraft types and aircraft systems.

If a situation exists in which a novel aircraft or aircraft system which is not covered adequately by these standards is presented for airworthiness evaluation, OISC must develop appropriate standards and publish them in this manual. These standards will be communicated by an Airworthiness Directive.

1.7.4 Approved Manufacturers

Aircraft from approved manufacturers may be eligible for expedited airworthiness certification. The current list of approved manufacturers is:

- Horizon Hobby, including all brands and subsidiaries
- Blackswift Technologies
- DJI
- 3DR
- Yuneec
- Parrot

This list is expected to change with time as new reputable manufacturers are found and existing reputable manufacturers fail to live up to their reputation.

If an airworthiness assessor, during the course of evaluating the airworthiness of an aircraft from a non-approved manufacturer, determines that the build quality is consistently comparable to that of an approved manufacturer, the list of approved manufacturers must be updated to include this new approved manufacturer.

The DO is the final authority as to which manufacturers are approved for expedited airworthiness evaluation and is responsible for maintaining a list of approved manufacturers in this section of this manual.

These aircraft must still be evaluated per any systems and application-specific criteria that might apply.

Aircraft not from approved manufacturers need to undergo a testing campaign in which OISC evaluates the aircraft performance, build quality, and most importantly safety.

1.7.5 Stricter Airworthiness Standards for Certain Aircraft

OISC requires certain aircraft to meet stricter airworthiness standards depending on their capabilities and size. These standards are contained in part 9 of this manual.

Ultimately, these standards are invoked at the discretion of OISC. However, they are generally triggered by aircraft which meet any of the following criteria:

- Maximum takeoff weight greater than 25 lbs
- Endurances greater than 45 minutes when the aircraft is operated in a configuration that maximizes endurance
- Flight altitudes greater than 400 feet AGL
- Flights over densely populated areas

If any of the above standards are triggered, the standards in part 9 of this manual apply.

- Flights within 100 nautical miles of any airspace/territory controlled by a hostile foreign government, or flights within 100 nautical miles of any area of sociopolitical turmoil. In this case, the enhanced security standards in part 10 of this manual.

For aircraft with a maximum takeoff weight greater then 55lbs, destructive structural testing is required. These requirements are delineated in section 9.5.

1.8 Nomenclature and Definitions

1.8.1 Notation Convention

All analysis performed by OISC must conform to standard aerospace engineering notation relevant to aerodynamics, structures, and aircraft dynamics. This common standard allows for OISC staff to easily interpret each other's analysis.

In addition to the nomenclature described in the sections below, some overarching notation conventions are as follows:

$\dot{x}$ First derivative of x with respect to time.

$\ddot{x}$ Second derivative of x with respect to time.

$\vec{x}$ Vector.

$[X]$ Matrix or tensor.

Δx Deviation from trim value of parameter x.

x_{real} Real component of x. Also notated as $real(x)$.

x_{imag} Imaginary component of x. Also notated as $imag(x)$.

While the notation contained here is intended to be as comprehensive as possible, any situation which is not covered by these conventions must use notation as similar as possible.

1.8.1.1 Axes and Reference Frames

There are two primary frames which are used in modeling aircraft performance: the body-fixed frame and the earth inertial frame.

Body frame

The following diagram delineates the body axes:

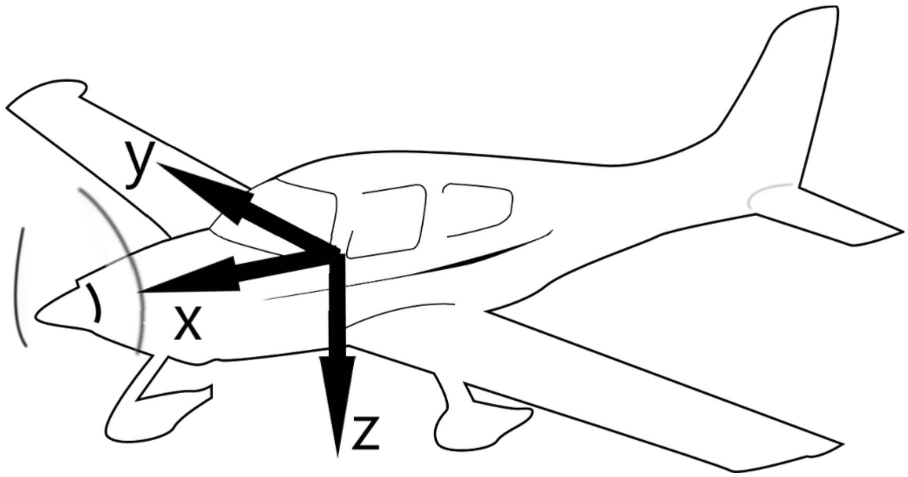


Figure 1-2: Visualization of aircraft axes used in stability analysis

This coordinate frame origin is at the aircraft center of mass. It has the positive x axis through the nose of the aircraft, the positive y axis along the right wing, and the positive z axis straight down, through the bottom of the plane. All axes are mutually orthogonal and fixed to the body. Unless otherwise stated, this body frame is oriented such that there are no off-diagonal elements in the inertia tensor; this is to say it is a principal frame. In this case, this is referred to simply as a body frame. In modeling stability, this body frame is rotated about the $\hat{y}$ axis by an angle ξ such that the relative wind vector lies along the $\hat{x}$ axis. This is commonly referred to as the body stability frame.

Earth inertial frame

In order to express the attitude of the airplane, another frame needs to be specified. This takes the form of the NED frame, in which the $\widehat{N}$ vector points due north, the $\widehat{E}$ vector points due east, and the $\widehat{D}$ vector points down into the earth. There are no mathematical constraints on where the origin of this frame is located, as long as it is fixed to some point on the Earth. For all attitude specification Euler angles to be equal to zero, the $\hat{x}$ axis must be aligned with the $\widehat{N}$ axis, the $\hat{y}$ axis must be aligned with the $\widehat{E}$ axis, and the $\hat{z}$ axis must be aligned with the $\widehat{D}$ axis. See section 1.7.1.2 for more information on notation for attitude specification.

1.8.1.2 Forces, Moments, Angular Rates, Velocity, Attitude Specification

Note that positive directions for forces and translational velocities are along the axes shown above. Positive directions for attitude Euler angles, moments, and angular rates are given by the right-hand rule.

Aerodynamic forces

X Aerodynamic force in $\hat{x}$ direction

Y Aerodynamic force in $\hat{y}$ direction

Z Aerodynamic force in $\hat{z}$ direction

Aerodynamic moments

L Aerodynamic moment about $\hat{x}$ axis

M Aerodynamic moment about $\hat{y}$ axis

N Aerodynamic moment about $\hat{z}$ axis

Angular rates

p Angular rate about $\hat{x}$ axis

q Angular rate about $\hat{y}$ axis

r Angular rate about $\hat{z}$ axis

Translational velocities

u Relative wind velocity along $\hat{x}$ axis

v Relative wind velocity along $\hat{y}$ axis

w Relative wind velocity along $\hat{z}$ axis

$\vec{V} = [u, v, w]^T$ Relative wind velocity vector

$V = |\vec{V}|$ Relative wind velocity vector magnitude (airspeed)

Attitude specification Euler angles

ψ Azimuth angle

θ Elevation angle

ϕ Bank angle

Displacement

x_E Coordinate of aircraft center of mass location relative to NED frame along $\widehat{N}$ axis.

y_E Coordinate of aircraft center of mass location relative to NED frame along $\hat{E}$ axis.

z_E Coordinate of aircraft center of mass location relative to NED frame along $\widehat{D}$ axis.

Miscellaneous angles

$\alpha = \tan^{-1}\frac{w}{u}$ Angle of attack, angle of oncoming airflow relative to body $\hat{x}$ axis, measured in xz plane.

$\beta = \tan^{-1}\frac{v}{V}$ Sideslip angle, angle of oncoming airflow relative to body $\hat{x}$ axis, measured in xy plane

ϵ Downwash angle, characterizes disturbance in airflow about horizontal stabilizer

σ Sidewash angle, characterizes disturbance in airflow about vertical stabilizer

Groupings of aircraft degrees of freedoms

Longitudinal: $u, w, q, \theta, x_E,\ z_E$

Lateral: v, p, r, ϕ, ψ, y_E

V speeds – important reference speeds for identifying aircraft performance and limitations

V_s Stall speed in clean configuration.

V_{s0} Stall speed in landing configuration.

V_x Speed for best angle of climb. Corresponding angle of climb θ.

V_y Speed for best rate of climb. Corresponding rate of climb V_h.

V_{ref} Landing reference speed.

V_A Design maneuvering speed.

V_O Maximum operating maneuvering speed.

V_{NE} Never-exceed speed.

V_{DF} Demonstrated maximum diving speed.

V_H Maximum airspeed in level flight at maximum continuous power.

1.8.1.3 Aerodynamics

Airfoil parameters

α Angle of attack; typically measured as the angle between the chord line of the root of the wing and the oncoming airflow. Absolute angle of attack standard also exists; α defined such that $\alpha = 0$ when lift is zero. Usually designated as α_{abs}.

a_0 Lift curve slope of airfoil. Takes a value of 2π per radian for thin airfoils.

C_l Lift coefficient (2D).

q Dynamic pressure. Can be calculated as $q = \frac{1}{2}\rho u^2$

ρ Air density. Can be found based on standard atmosphere data.

u_∞ Free-stream flow speed. Also referred to as true airspeed.

C_d Drag coefficient (2D).

C_m Airfoil pitching moment coefficient. Note 3D effects are typically ignored. Positive pitching moment acts to pitch the airplane up, which is consistent with the definition of M given previously.

c Chord length.

c_f Skin friction coefficient, a component of 2D drag coefficient.

L' Lift per unit span.

D' Drag per unit span.

M' Pitching moment per unit span.

Full wing/aircraft parameters

a Lift curve slope of full finite wing.

b Wingspan.

S Wing planform area.

AR Wing aspect ratio.

λ Taper ratio. Calculated as $\lambda = C_t/C_r$.

c_t Chord length at wingtip.

c Chord length at wing root.

$\bar{c}$ Mean chord length.

Λ Sweepback angle of quarter chord line.

Γ Dihedral angle. Dihedral (as opposed to anhedral) corresponds to positive Γ.

C_D Drag coefficient (3D).

D Drag force.

M Pitching moment.

L Total aircraft lift.

e Span efficiency factor, which takes a value less than or equal to unity, depending on wing planform geometry. Describes efficiency of wing planform geometry; quantifies how elliptical the lift distribution is.

e_0 Oswald efficiency factor which takes a value less than or equal to unity, and less than the value of e. Dependent on whole aircraft geometry. Describes efficiency of aircraft geometry.

C_L Lift coefficient (3D).

n Load factor.

1.8.1.4 Stability, Dynamics, Control

Static stability parameters

h Nondimensionalized location of CG relative to leading edge of wing at root. Defined as $h = \frac{x_{cg}}{\bar{c}}$.

h_{nw} Nondimensionalized location of neutral point of wing relative to leading edge of wing at root. Defined as $h_{nw} = \frac{x_{nw}}{\bar{c}}$.

h_n Nondimensionalized location of neutral point of whole vehicle relative to leading edge of wing at root. Calculated based on h_{nw} and V_H.

V_H Horizontal tail volume coefficient based on l_t.

$\overline{V_H}$ Horizontal tail volume coefficient based on $\overline{l_t}$.

K_n Static margin; $K_n > 0$ for statically stable airplane.

$C_{m\alpha}$ Stability derivative: nondimensionalized linearized derivative of pitching moment with respect to angle of attack.

$-C_{m\alpha}$ Pitch stiffness; must be positive for statically stable airplane.

l_t Distance of horizontal tail neutral point relative to aircraft CG.

$\overline{l_t}$ Distance of horizontal tail neutral point relative to wing neutral point.

S_t Horizontal tail planform area.

Dynamic stability characterization

ζ Damping ratio.

ω_n Natural frequency.

ω_d Damped frequency.

τ Time constant; time for envelope to change by factor of $1/e$. $\tau > 0$ indicates stability.

T_2 Time for envelope to double in magnitude, or halve in magnitude, depending on stability.

λ Eigenvalue.

$\vec{u}$ Eigenvector.

Longitudinal stability derivatives and parameters

X_u Linearized derivative of $\hat{x}$ aerodynamic force with respect to u.

X_w Linearized derivative of $\hat{x}$ aerodynamic force with respect to w.

Z_u Linearized derivative of $\hat{z}$ aerodynamic force with respect to u.

Z_w Linearized derivative of $\hat{z}$ aerodynamic force with respect to w.

$Z_{\dot{w}}$ Linearized derivative of $\hat{z}$ aerodynamic force with respect to $\dot{w}$.

Z_q Linearized derivative of $\hat{z}$ aerodynamic force with respect to q.

M_u Linearized derivative of $\hat{y}$ aerodynamic moment with respect to u.

M_w Linearized derivative of $\hat{y}$ aerodynamic moment with respect to w. Pitch stiffness.

$M_{\dot{w}}$ Linearized derivative of $\hat{y}$ aerodynamic moment with respect to $\dot{w}$.

M_q Linearized derivative of $\hat{y}$ aerodynamic moment with respect to q. Pitch damping.

m Aircraft mass.

θ_0 Nominal/reference elevation angle.

g Gravitational acceleration.

u_0 Nominal/reference airspeed.

I_y Moment of inertia about $\hat{y}$ axis.

C_{w0} Weight coefficient.

C_{xu} Nondimensional derivative used in constructing X_u.

C_{mu} Nondimensional derivative used in constructing M_u.

$C_{x\alpha}$ Nondimensional derivative used in constructing X_w.

$C_{z\alpha}$ Nondimensional derivative used in constructing Z_w.

$C_{m\alpha}$ Nondimensional derivative used in constructing M_w. Pitch stiffness.

C_{xq} Nondimensional derivative used in constructing X_q.

C_{mq} Nondimensional derivative used in constructing M_q.

$C_{x\dot{\alpha}}$ Nondimensional derivative used in constructing $X_{\dot{w}}$.

$C_{z\dot{\alpha}}$ Nondimensional derivative used in constructing $Z_{\dot{w}}$.

$C_{m\dot{\alpha}}$ Nondimensional derivative used in constructing $M_{\dot{w}}$.

Lateral stability derivatives and parameters

Y_v Linearized derivative of $\hat{y}$ aerodynamic force with respect to v.

Y_p Linearized derivative of $\hat{y}$ aerodynamic force with respect to p.

Y_r Linearized derivative of $\hat{y}$ aerodynamic force with respect to r.

L_v Linearized derivative of $\hat{x}$ aerodynamic moment with respect to v.

L_p Linearized derivative of $\hat{x}$ aerodynamic moment with respect to p.

L_r Linearized derivative of $\hat{x}$ aerodynamic moment with respect to r.

N_v Linearized derivative of $\hat{z}$ aerodynamic moment with respect to v.

N_p Linearized derivative of $\hat{z}$ aerodynamic moment with respect to p.

N_r Linearized derivative of $\hat{z}$ aerodynamic moment with respect to r.

$I_x{}'$ Shorthand moment of inertia. $I_x' = (I_x I_z - I_{zx}^2)/I_z$

$I_z{}'$ Shorthand moment of inertia. $I_z' = (I_x I_z - I_{zx}^2)/I_x$

$I_{zx}{}'$ Shorthand moment of inertia. $I_{zx}' = I_{zx}/(I_x I_z - I_{xz}^2)$

I_x Moment of inertia about $\hat{x}$ axis.

I_z Moment of inertia about $\hat{z}$ axis.

I_{zx} Moment of inertia cross-term; equivalent to I_{xz}.

z_f Height of aerodynamic center of vertical stabilizer above CG.

y_w Spanwise location of wing centroid of lift.

l_f Distance of vertical tail neutral point relative to aircraft CG.

$\overline{l_f}$ Distance of vertical tail neutral point relative to wing neutral point.

V_V Horizontal tail volume coefficient based on l_f.

$\overline{V_V}$ Horizontal tail volume coefficient based on $\overline{l_f}$.

$C_{y\beta}$ Nondimensional derivative used in constructing Y_v.

$C_{l\beta}$ Nondimensional derivative used in constructing L_v. Roll stiffness.

$C_{n\beta}$ Nondimensional derivative used in constructing N_v. Yaw stiffness.

C_{yp} Nondimensional derivative used in constructing Y_p.

C_{lp} Nondimensional derivative used in constructing L_p. Roll damping.

C_{np} Nondimensional derivative used in constructing N_p.

C_{yr} Nondimensional derivative used in constructing Y_r.

C_{lr} Nondimensional derivative used in constructing L_r.

C_{nr} Nondimensional derivative used in constructing N_r. Yaw damping.

Control

δ_a Aileron deflection

δ_r Rudder deflection

δ_e Elevator deflection

δ_p Propulsion setting

X_c Value of X resulting from control. Similar notation for other controlled values.

1.8.1.5 Structures

Basic notation

σ Normal stress.

τ Shear stress.

ϵ Normal strain.

γ Shear strain.

E Modulus of elasticity (Young's modulus).

G Shear modulus.

I Second moment of area.

J Torsional stiffness parameter.

FS Factor of safety, defined as $\sigma_{max}/\sigma_{applied}$ (or similar for shear stress).

ν Poisson's ratio.

Beams

y Distance above neutral axis of beam.

M Bending moment.

V Shear force.

θ, v' Deflection angle. Notation used interchangeably.

v Deflection.

Torsion

$\frac{\partial\phi}{\partial x}$ Twist rate.

ϕ Twist angle.

L Length of torsional specimen.

Stresses

σ_{xx} Normal stress along $\hat{x}$ axis. Similar notation applies to normal strain.

τ_{xy} Shear stress with cut plane normal vector parallel to $\hat{x}$, force parallel to $\hat{y}$. Similar notation applies to shear strain.

σ'_{xx} Transformed normal stress value σ_{xx}. Similar notation for other transformed stresses.

θ Stress transformation angle

θ_p Stress transformation angle corresponding to principal stress.

τ_{max} Maximum in-plane shear stress.

σ_1 First principal stress.

σ_2 Second principal stress. $\sigma_2 < \sigma_1$.

1.8.2 Stability Characterization

1.8.2.1 Basic Stability Characterization

Equilibrium	State in which forces and moments acting on the aircraft sum to zero, and in turn the aircraft does not experience any linear or angular acceleration.
Static Stability	Characterizes aircraft's initial response to a disturbance; is statically stable if initial response is toward equilibrium condition.
Dynamic Stability	Characterizes aircraft's response to a disturbance over time; is dynamically stable if it returns to and stays at equilibrium condition.
Oscillatory	In reference to dynamic stability: aircraft's response involves oscillations. Also referred to as having a second-order response.
Undamped	In reference to dynamic stability: aircraft's response involves oscillations that are constant in magnitude. Corresponds to $\zeta = 0$.
Underdamped	In reference to dynamic stability: aircraft's response involves oscillations that decay in magnitude over time. Corresponds to $0 < \zeta < 1$.
Critically damped	In reference to dynamic stability: aircraft's response returns to equilibrium as quickly as possible without oscillating. Corresponds to $\zeta = 1$.
Overdamped	In reference to dynamic stability: aircraft's response returns to equilibrium without oscillating, but not as quickly as possible. Corresponds to $\zeta > 1$.
Natural frequency	Oscillation frequency of system without control or damping.
Damped frequency	Oscillation frequency of system without control, but with damping.
Envelope	In reference to dynamic stability: exponential curve that either defines or bounds system response.
Pitch stiffness	Describes static stability about y axis.
Roll stiffness	Describes static stability about x axis.
Yaw stiffness	Describes static stability about z axis.
Pitch damping	Describes moment produced which opposes the pitch rate, and in turn limits the maximum pitch rate of the aircraft.
Roll damping	Describes moment produced which opposes the roll rate, and in turn limits the maximum roll rate of the aircraft.
Yaw damping	Describes moment produced which opposes the yaw rate, and in turn

	limits the maximum yaw rate of the aircraft.
Stability derivative	Describes how particular forces and moments acting on an aircraft change as other parameters, such as airspeed, angle of attack, etc. change.
Control derivative	Describes how particular forces and moments acting on an aircraft change with control deflections.
Dynamic mode	A specific way in which the aircraft oscillates. A mode is defined by its natural frequency, damping ratio, stability, and the degrees of freedom along which the aircraft oscillates.
First-order response	System response to a disturbance is constructed only from exponential functions: no oscillations occur.
Jesus bolt/nut	Colloquial name for a bolt or nut which would cause catastrophic loss of the aircraft if it were to fail.

1.8.2.2 Airplane Dynamic Modes

Note: unconventional airplanes or airplanes with artificial stabilization will likely have different modes.

Longitudinal modes

- Phugoid mode – a second-order mode which contains primarily changes in u and w and results in oscillation at a low frequency. This mode is generally stable and is lightly damped. This mode is generally easy to activate in flight.
- Short period mode – a second-order mode which contains primarily changes in q and θ and results in oscillation at a high frequency. This mode is generally stable and is well-damped. This mode is generally difficult to activate in flight.

Lateral modes

- Dutch roll mode – a second-order mode with changes in all lateral degrees of freedom; the oscillation is at a low frequency. This mode is generally easy to activate in flight.
- Roll mode – a first-order mode that has a fast response; contains almost pure rolling motion. This mode is generally stable.
- Spiral mode – a first-order mode that has a slow response. This mode entails slowly growing or slowly decaying values in all lateral degrees of freedom. This mode may be unstable or stable depending on flight conditions and aircraft design.

1.8.3 Miscellaneous Definitions and Acronyms

SLUF	Acronym for steady, level, unaccelerated flight. Describes a condition in which the airplane's altitude and airspeed are constant and is in 1G flight (zero bank angle).
Elastic Deformation	Describes situation in which material is stressed, but is below yield stress so that the material returns exactly to its undeformed configuration when the stress is removed.
Plastic Deformation	Describes situation in which material is stressed, but above yield stress so that the material retains permanent deformation even when the stress is removed.
Proponent	Individual/entity seeking a type certificate or an airworthiness certificate

1.9 General Requirements

There requirements are general enough to apply to any aircraft, and in turn apply to any aircraft type, any origin (COTS, COTS-U, EN), and any aircraft use (experimental or operational).

1.9.1 Load Factor Requirements

Load factor, given in units of g, where $g = 9.81$ ms^{-2}, is defined as $n = \frac{lift}{weight}$.

Note the load factor requirements for varying aircraft types:

Aircraft type	n_{max}	n_{min}
Normal/transport category airplane	3.8	-1.5
High load factor category airplane	6	-3
Rotorcraft	3.5	-1
Airship	1.5	0.5

Figure 1-3: Load factor requirements for various aircraft types

This applies to structural standards only.

1.9.2 Documentation

Each aircraft type certified as airworthy must have the following documentation associated with it, and a copy of this documentation must be submitted in the airworthiness approval process:

- Checklist. This must include specific tasks to be performed for normal operations and emergencies.
- Operating limitations. This must include airspeed limitations, powerplant limitations, weight-and-balance limitations, and any additional relevant operational limitations.
- Pilot’s operating handbook. This must contain both the checklists and operating limitations, and is recommended to include performance data, a description of onboard systems, and a guide for handling, service, and maintenance.

Generally, COTS aircraft have all the required documentation from their manufacturer. If the included documentation does not meet the requirements of this section, OSIC will author a supplement to the existing documentation.

For COTS-M and EN aircraft, OISC will author the documentation, in association with the proponent. OISC is the final authority to accept or reject this documentation.

Required content in each publication is as follows:

- Checklist
  - Normal procedures
  - Abnormal and emergency procedures
  - The checklist must meet the following specifications:
    - Each item is specific, concise, and pertains only to a single step to be completed.
    - The checklist must be comprehensive, thorough, and cover every procedure to be completed when operating the aircraft.
    - A call-and-response format for the checklist is preferred.
    - The checklist must be divided into sections based on the phase of flight that each set of procedures needs to be completed in.
- Operating limitations (as applicable depending on aircraft design)
  - Maximum operating limit speed V_{MO}
  - Flap extended speed limitations V_{FE}
  - Landing gear extended speed V_{LE}
  - Powerplant limitations
    - Reciprocating engines. Require maximum continuous power and takeoff power specifications, including horsepower, torque, RPM, and manifold pressure. Require fuel grade or specification and cylinder head or oil temperatures, and any other parameter for which a limitation has been established by the engine manufacturer that cannot be exceeded during normal operation.
    - Turbine engines. Require horsepower, torque, thrust, RPM, gas temperature, and time for maximum continuous power or thrust, and takeoff power or thrust. Require fuel designation or specification as well as maximum time interval between engine run-ups from idle, run-up power setting and duration at power for ground operation in icing conditions. Further require any other parameter which the engine manufacturer established that cannot be exceeded during normal operation.

        - Regardless of engine type, an ambient temperature limitation must be established.
        - Explanation of powerplant limitations.
    - Weight and balance. This includes limits on gross aircraft weight and center of gravity. Further, the condition of the airplane and items included in the empty weight must be included.
    - Maneuvering flight load factors. The maximum load factor in both the positive and negative direction must be specified.
- Pilot's operating handbook
    - Include checklist and operating limitations.
    - Required performance information:
        - Climb data, including climb rate and climb angle with at different density altitudes.
        - Takeoff and landing distance at varying density altitudes, headwinds, takeoff weights.
        - Stall speeds in various configurations.
        - Climb performance at V_X and V_Y with varying density altitudes, weights. This includes climb performance with a critical loss of thrust on multiengine airplanes in the initial climb configuration.
        - Glide performance in single-engine airplanes following a complete loss of thrust.
        - Cruise performance at various power settings.
        - Maximum demonstrated crosswind performance.
    - The format must conform to the aviation standard for airplane flight manuals:
        - Section 1: General. This includes basic dimensions and a basic description of the aircraft. This may also include nomenclature and unit conversion tables.
        - Section 2: Limitations. This includes limitations pertaining to airspeed, the powerplant, weight and balance, flight limits, and placards.
        - Section 3: Emergency Procedures. The emergency procedures checklists are included here.
        - Section 4: Normal Procedures. The normal procedures checklists are included here.
        - Section 5: Performance. All performance data is included in this section.
        - Section 6: Weight and Balance and Equipment List. This must include a sample weight and balance problem completed using the weight-and-balance data given.
        - Section 7: Systems Description. This must include a through description of all systems such that an advanced pilot can gain an insight into how the pilot works.
        - Section 8: Handling, Service, and Maintenance. This must include maintenance and inspections. This must also include preventative maintenance as well as handling and transportation procedures.
        - Section 9: Supplements. This must include information necessary to safely operate the aircraft with any supplemental or optional features not included on the base model aircraft.

- Section 10: Safety Tips. This section is optional. This section would contain a review of information that enhances the safe operation of the aircraft.
- Additional information can be included at the discretion of the proponent and OISC.

1.10 Manual Revisions

1.10.1 Authority to Amend

This manual shall be amended upon approval from the Director of Flight Operations and the Associate Vice Chancellor for Integrity, Safety, and Compliance.

Approval from the UAS Committee is not required to amend this manual.

1.10.2 Indications of Amended Sections

Any new or amended airworthiness standards will be marked with a change bar. The appendix will contain a section summarizing the changes made between different versions.

Part 2: Standards for Commercial Off-The-Shelf Aircraft

Note that OISC regulates what kinds of components must be installed on Commercial Off-The-Shelf aircraft. For parts except batteries, the aircraft must be flown with OEM parts or OEM-recommended parts unless other parts are certificated as airworthy by OISC.

With regards to batteries, the following definitions apply:

- Smart battery – a battery with any microcontroller onboard to aid in reading out the battery level to a user or to communicate with the aircraft/charger system.
- Standard battery – a battery consisting solely of cells, connectors, and a case. Batteries not meeting this description are qualified as smart batteries.

COTS aircraft which require smart batteries must be flown only with OEM batteries unless third-party batteries are certificated as airworthy by OISC. Aircraft requiring standard batteries may be flown using any suitable battery.

OISC assumes that manufacturers will deliver a product which meets basic craftsmanship standards and are mostly well-designed. If the airworthiness assessor deems that these assumptions are not met, the aircraft will be treated as an entirely novel aircraft under section 4.2.

2.1 Experimental Standards

2.1.1 Standards for Airplanes

Any commercial off-the-shelf aircraft meeting operational airworthiness standards is immediately qualified for an experimental airworthiness certificate. This requires the airplane to be from an approved manufacturer. Reference section 2.2.1 for the operational standards.

For an aircraft not from an approved manufacturer to receive an experimental airworthiness certificate, it must be evaluated per the remainder of this section. The primary concern is that the aircraft does not pose an undue risk to the crew operating it, the NAS, or people/property on the ground. This requires that the aircraft be free of any deficiencies which constitute an egregious safety risk.

The airworthiness status is evaluated based on the reduced risk score:

- Less than 10: risk level 1.
- Between 11 and 21: risk level 2.
- Between 22 and 35: risk level 3.
- Over 35: unairworthy.

2.1.1.1 Structural Standards

The structural standards are characterized by the following areas of concern:

- Wing structure is capable of supporting aircraft mass at a load factor of +3.8 and -1.5.
- Wing torsional rigidity is such that, based on the airworthiness assessor’s expertise, there is minimal risk of aileron reversal in flight.
- Torsional rigidity of the horizontal stabilizer is such that, based on the airworthiness assessor’s experience, there is minimal risk of in-flight elevator reversal.

In order to assess the wing structure, sandbags (or a similar weight which can distribute the force) must be placed on the aircraft wing. The wing must not exhibit excessive elastic deformation, plastically deform, and no part of the wing may break.

All torsional rigidity standards must be evaluated based on manually flexing the relevant controls and using the airworthiness assessor’s expertise to determine if the torsional rigidity is insufficient. Note that OISC accepts the risk that this method of examining torsional rigidity may leave some small risk of control reversal occurring in flight; this is acceptable since all flights will be conducted in a remote environment.

If these standards are not met, the aircraft is unairworthy.

2.1.1.1 (a). Wing/stabilizer structural performance: physical test results at maximum load factor in positive direction. See section 1.8.1 for load factor requirements.

Results from physical test	Load is supported without failure or plastic deformation; maximum deflection angle less than 10 degrees	Load is supported without failure or plastic deformation; maximum deflection angle greater than 10 degrees	Load is supported without failure, but plastic deformation occurs	Structure fails
Risk points	0	25	Unairworthy	Unairworthy

2.1.1.1 (b). Wing/stabilizer structural performance: physical test results at maximum load factor in negative direction. See section 1.8.1 for load factor requirements.

Results from physical test	Load is supported without failure or plastic deformation; maximum deflection angle less than 10 degrees	Load is supported without failure or plastic deformation; maximum deflection angle greater than 10 degrees	Load is supported without failure, but plastic deformation occurs	Structure fails
Risk points	0	25	Unairworthy	Unairworthy

2.1.1.1 (c). Wing/stabilizer structural performance: qualitative torsional rigidity evaluation

Expert qualitative evaluation	Torsional stiffness is better than is required	Torsional stiffness is certainly adequate	Torsional stiffness is likely adequate	Torsional stiffness is likely inadequate
Risk points	0	10	30	Unairworthy

If the reduced score in this category exceeds 27, the aircraft is rendered unairworthy.

2.1.1.2 Stability and Control Standards

The stability and control standards are characterized by the following areas of concern:

- Size of control surfaces is such that the aircraft can be maneuvered effectively and safely.
- Aircraft possesses, based on a qualitative analysis, static stability about all 3 axes.

The evaluation of controllability is to be accomplished based on the airworthiness assessor's expertise. OISC accepts the risk of relying on an individual's expertise in this situation since the flights are to be completed strictly in remote areas.

Static stability about each axis should be evaluated based on:

- Pitch stiffness: the CG must be located at approximately the ¼ chord point on the wing.
- Roll stiffness: presence of design features that produce the dihedral effect, such as: high wing mounting, wing sweep, and dihedral.
- Yaw stiffness: presence of vertical stabilizer with an adequately sized moment arm.

If these standards are not met, the aircraft is unairworthy.

2.1.1.2 (a) Control surface sizing qualitative evaluation

Expert qualitative evaluation	Control surface sizing is larger than is required	Control surface sizing is certainly adequate	Control surface sizing is likely adequate	Control surface sizing is likely inadequate
Risk points	0	10	30	Unairworthy

2.1.1.2 (b) Static stability about each axis

Expert qualitative evaluation	Statically stable about all 3 axes	Stable in pitch, but instable in roll or yaw	Does not possess static pitch stability
Risk points	0	50	Unairworthy

The reduced score in this category may not exceed 40, or the aircraft is unairworthy.

2.1.1.3 Performance Standards

The performance standards are characterized by the following areas of concern:

- Propulsion system is adequate to provide acceptable climb performance, based on the expertise of the airworthiness assessor.
- The aircraft possesses no features that would make stall recovery unduly difficult, such as: wash-in, an unduly aft CG, or blanketing of the horizontal stabilizer.

Both standards are evaluated based on the airworthiness assessor's expertise. OISC accepts the risk that the aerodynamic performance may be lacking, but this is an acceptable level of risk since all flights will be conducted strictly in a remote area.

If these standards are not met, the aircraft is unairworthy.

2.1.1.3 (a) Propulsion system qualitative evaluation

Expert qualitative evaluation	Propulsion system is larger than is necessary	Propulsion system is certainly adequate	Propulsion system is likely adequate	Propulsion system is likely inadequate
Risk points	0	10	30	Unairworthy

2.1.1.3 (b) Stall recovery qualitative evaluation

Expert qualitative evaluation	Stall recovery evaluated as easy with minimal wing drop	Stall recovery evaluated as easy with significant wing drop	Stall recovery evaluated as moderately difficult but very possible	Stall recovery evaluated as difficult
Risk points	0	10	50	Unairworthy

The reduced score in this category may not exceed 40, or the aircraft is rendered unairworthy.

2.1.1.4 Electronics Standards

The electronics standards are characterized by the following areas of concern:

- All current draws are such that there is no risk of creating an in-flight fire: conductors must be appropriately sized, and current draws through a given component are below the manufacturer-recommended current draws.
- Ideally, the radio will use 2.4GHz frequency-hopping technology.

2.1.1.4 (a) Remote control signal reliability: carrier frequency and technology used

Carrier frequency	2.4 GHz spread spectrum with DSMx or similar frequency-hopping features	Legacy carrier frequency without frequency-hopping features
Risk points	0	50

2.1.1.4 (b) Signal reliability: antenna diversity

Diversity features	Antenna diversity on transmitter and receiver	Antenna diversity on transmitter only	Antenna diversity on receiver only	No antenna diversity
Risk points	0	5	20	40

Further, all wire sizes must be specified based on the expected current draw according to the chart on the following page:

Wire size (gauge)	Wire conductor diameter (inches)	Maximum continuous current (amps), power transmission	Maximum continuous current (amps), chassis wiring
0000	0.4600	302	380
000	0.4096	239	328
00	0.3648	190	283
0	0.3249	150	245
1	0.2893	119	211
2	0.2576	94	181
3	0.2294	75	158
4	0.2043	60	135
5	0.1819	47	118
6	0.1620	37	101
7	0.1443	30	89
8	0.1285	24	73
9	0.1144	19	64
10	0.1019	15	55
11	0.0907	12	47
12	0.0808	9.3	41
13	0.0720	7.4	35
14	0.0641	5.9	32
15	0.0571	4.7	28
16	0.0508	3.7	22
17	0.0453	2.9	19
18	0.0403	2.3	16
19	0.0359	1.8	14
20	0.0320	1.5	11
21	0.0285	1.2	9
22	0.0253	0.92	7
23	0.0226	0.729	4.7
24	0.0201	0.577	3.5
25	0.0179	0.457	2.7
26	0.0159	0.361	2.2
27	0.0142	0.288	1.7
28	0.0126	0.226	1.4
29	0.0113	0.182	1.2
30	0.0100	0.142	0.86
31	0.0089	0.113	0.7
32	0.0080	0.091	0.53
33	0.0071	0.072	0.43
34	0.0063	0.056	0.33
35	0.0056	0.044	0.27
36	0.0050	0.035	0.21
37	0.0045	0.0289	0.17
38	0.0040	0.0228	0.13
39	0.0035	0.0175	0.11
40	0.0031	0.0137	0.09

Figure 2-1: Electrical wiring ampacity chart

The following requirements apply for conductor sizing:

- In no case may the current in a wire in the aircraft exceed the table value for the wire of the corresponding diameter/gauge.
- The *chassis wiring* specification applies only to wiring runs of a length less than 3.5 meters.
- The *power transmission* specification has no requirement for wiring run length.

2.1.1.4 (c) Wire gauge size: value of design maximum current in relation to table value for maximum permissible current

Value of $\frac{I_{table}}{I_{design}}$	$\frac{I_{table}}{I_{design}} \geq 1.3$	$\frac{I_{table}}{I_{design}} \geq 1.15$	$\frac{I_{table}}{I_{design}} \geq 1$	$\frac{I_{table}}{I_{design}} < 1$
Risk points	0	5	10	Unairworthy

2.1.1.4 (d) Wiring protection: OISC requires that, wherever a wire is mounted to the airframe, the wire be protected by heat-shrink tubing or a similar means. It is not acceptable to anchor a wire without any protection. Risk points are allocated as follows:

Wire protection standards	Wire protection standards met	Wire protection standards not met
Risk points	0	Unairworthy

The reduced score in this category may not exceed 34, or the aircraft is rendered unairworthy.

2.1.2 Standards for Multirotors

The airworthiness status of a multirotor is based on the total reduced score:

- Less than 8: risk level 1
- Between 9 and 35: risk level 2
- Between 36 and 65: risk level 3
- Greater than 65: unairworthy

2.1.2.1 Overall Design Characteristics

2.1.2.1 (a) Type of stability augmentation system

Stability augmentation system presence and characteristics	Type 1 or type 2 SAS	Type 3 SAS	Type 4 SAS	No SAS
Risk points	0	20	50	95

The various types of stability augmentation system capabilities are defined as follows:

- Type 1: SAS can hold position and altitude when both control sticks are centered, regardless of wind. SAS automatically maintains altitude as pitch and bank are adjusted. Control sticks are used to command altitude rate, yaw rate, pitch angle, and bank angle. The position and altitude are known both a barometric altimeter and/or GPS.
- Type 2: SAS can hold position and altitude when both control sticks are centered, regardless of wind. SAS automatically maintains altitude as pitch and bank are adjusted. Control sticks are used to command altitude rate, yaw rate, pitch angle, and bank angle. The position and altitude are found based on the IMU alone.
- Type 3: SAS can hold altitude and attitude when both control sticks are centered but does not hold position. Control sticks are used to command altitude rate, yaw rate, pitch angle, and bank angle.
- Type 4: SAS is used to allow user to command altitude rate, yaw rate, pitch rate, bank rate. No altitude-hold or position-hold features.
- Types 3 and 4 stability augmentation systems require the aircraft to be trimmable.

OISC does not require experimental multirotors to have a stability augmentation system onboard.

2.1.2.1 (b) Redundancy: number of motors

Number of motors	3	4	5	6 or more
Risk points	50	40	30	0

2.1.2.1 (c) Vibration: fastener securing

Fastener securing	Fasteners secured with two of the approved methods	Fasteners secured with one of the approved methods	Fasteners unsecured; conditions for unsecure fasteners are met	Fasteners unsecured; conditions for unsecure fasteners are not met
Risk points	0	10	80	Unairworthy

Approved fastener securing methods:

- Safety wire
- Nylon locking nuts
- Thread locking compound, such as Loctite
- Castle nut and locking pin
- Split beam nut
- Locking plate or tab washer

Conditions to leave fasteners unsecured: the applicant must demonstrate compliance with the following:

- The aircraft's maximum takeoff weight must not exceed 10 lbs (4.5 kg).
- The aircraft must strictly be flown in daytime VFR conditions and within VLOS.
- The aircraft must never be flown in a crowded environment such that there is a substantial risk of it flying over people. For example, flights over campus would be prohibited since, even if the PIC makes the utmost effort to avoid flights over people, campus is sufficiently congested that, realistically, this is difficult to avoid.
- The applicant must demonstrate that the vibration produced on the aircraft is such that, after 60 minutes of consecutive flights, all fasteners remain firmly anchored.

The reduced score in this category must not exceed 69 or the aircraft is unairworthy.

2.1.2.2 Structures Standards

Motor mounting structure: standards relating to effect of beam structure deflection. The deflection must be so severe such that:

- The propellers interfere with each other
- The propellers interfere with other parts of the aircraft structure

The standards for motor mounting structure deflection delineated previously in this section still apply.

2.1.2.2 (a) Risk points are allotted based on meeting the above standards:

Interference and deflection standards result	Standards met	Standards not met
Risk points	0	Unairworthy

2.1.2.2 (b) Whole aircraft torsional rigidity: maximum twist angle between opposing sides of vehicle during maximum yaw rate maneuver.

Deflection angle θ	$\theta < 2.5^o$	$\theta < 5^o$	$\theta < 7.5^o$	$\theta > 7.5^o$
Risk points	0	20	30	Unairworthy

This requirement describes the torsion which occurs when the aircraft is executing a yaw maneuver. In this configuration, the thrust of one propeller will be changed relative to the adjacent motor. The resulting moment causes the torsion evaluated by this section.

2.1.2.2 (c) Structural vibrations: in-flight oscillations during flight test

$f_{modal,structural}$ in relation to $f_{encountered}$	No structural oscillations encountered in any regime of flight	Structural vibrations occur during flight, but there is no noticeable wear after 10 flights	Structural vibrations cause significant and noticeable wear and damage after 10 flights	Structural vibrations cause component failure in flight
Risk points	0	40	Unairworthy	Unairworthy

This must cover vibrations from varying degrees of motor thrust and various airspeeds. Flight test must reveal whether the structural modal frequencies are such that the aircraft structure will excessively vibrate during flight.

2.1.2.2 (d) Material construction: presence of fibrous materials vulnerable to splitting

Presence of fibrous materials	Only isotropic materials used in aircraft structure	Fibrous materials used with overlapping layers offset by at least 60 degrees	Fibrous materials used but no stress is applied orthogonal to fiber	Fibrous materials used with stress orthogonal to fiber
Risk points	0	5	10	Unairworthy

The reduced risk score in this category may not exceed 20 or the aircraft is rendered unairworthy.

2.1.2.3 Stability, Dynamics, and Control Standards

2.1.2.3 (a) Pitch and bank angle limitation

Pitch and bank limits	Limits are below FOM-defined thresholds	Limits meet FOM-defined threshold	No SAS limits: reliant on pilot to maintain FOM pitch and bank limits
Risk points	0	5	30

This is the only requirement OISC has for experimental certification of multirotors with respect to stability, dynamics, and control since evaluation of these standards is strongly dependent on flight test.

The reduced score in this category may equal 100 and still be airworthy.

2.1.2.4 Electronics Standards

2.1.2.4 (a) Remote control signal reliability: carrier frequency and technology used

Carrier frequency	2.4 GHz spread spectrum with DSMx or similar frequency-hopping features	Legacy carrier frequency without frequency-hopping features
Risk points	0	50

2.1.2.4 (b) Signal reliability: antenna diversity

Diversity features	Antenna diversity on transmitter and receiver	Antenna diversity on transmitter only	Antenna diversity on receiver only	No antenna diversity
Risk points	0	5	20	40

The reduced electronics score may not exceed 90 or the aircraft is rendered unairworthy.

2.1.2.5 Propulsion and Performance Standards

2.1.2.5 (a) Maximum endurance:

Endurance	> 20 mins	> 12 mins	> 5 mins	< 5 mins
Risk points	0	20	40	Unairworthy

This must be found from flight test. This must include adequate reserve. For example, if using LiPo batteries, there must be sufficient voltage remaining to serve as a reserve. This means generally that the cell voltage must be kept above a predefined value. Similarly, for fueled propulsion systems, this endurance must be established with reserve fuel in the tank. The precise amount of reserve required is highly dependent on the aircraft and application, and as such is to be set by the airworthiness assessor.

2.1.2.5 (b) Vibration: propeller balance

Propeller balance characteristics	Negligible vibration: propeller center of gravity within 0.001 inches of propeller axis	Small vibration: propeller center of gravity within 0.005 inches of propeller axis	Moderate or greater vibrations; propeller center of gravity further than 0.005 inches from propeller
Risk points	0	10	Unairworthy

2.1.2.5 (c) Vibration: motor vibration

Vibration characteristics	Negligible vibration: vibration amplitude less than 0.001 inch	Small vibrations: vibration amplitude less than 0.005 inch	Moderate vibrations: vibration amplitude greater than 0.005 inch
Risk points	0	10	Unairworthy

The reduced score in this category may not exceed 20 or the aircraft is rendered unairworthy.

2.1.3 Standards for Helicopters

Any commercial off-the-shelf aircraft meeting operational airworthiness standards is immediately qualified for an experimental airworthiness certificate. This requires the helicopter to be from an approved manufacturer. Reference section 2.2.3 for the operational standards.

For an aircraft not from an approved manufacturer to receive an experimental airworthiness certificate, it must be evaluated per the remainder of this section. The primary concern is that the aircraft does not pose an undue risk to the crew operating it, the NAS, or people/property on the ground. This requires that the aircraft be free of any deficiencies which constitute an egregious safety risk.

The airworthiness statis is found based on the reduced risk score:

- Between 0 and 5: risk level 1
- Between 6 and 12: risk level 2
- Between 13 and 24: risk level 3
- Greater than 24: unairworthy

2.1.3.1 Overall design characteristics

2.1.3.1 (a) Tail rotor ground strike protection. OISC requires that the tail rotor be protected from ground strikes by means of a skid plate mounted such that, as the helicopter is pitched up, the tail skid contacts the ground and clearance between the ground and tail rotor is maintained. Risk points are assessed as follows:

Tail rotor protection	Inapplicable due to design features such as counter rotating rotors or a ducted fan tail rotor	Clearance greater than 1/10 of the rotor radius	Clearance greater than 1/20 of the rotor radius	Clearances less than 1/20 of the rotor radius
Risk points	0	15	30	Unairworthy

2.1.3.1 (b) Rotor clearance: with the least favorable cyclic control and least favorable load factor, the rotor must clear any other part of the aircraft (such as the boom or fuselage) by at least 1% of the rotor diameter. Risk points are assessed as follows:

Clearance as measured by: $\frac{z_{clear}}{d_{rotor}}$	$\frac{z_{clear}}{d_{rotor}} > 0.05$	$\frac{z_{clear}}{d_{rotor}} > 0.025$	$\frac{z_{clear}}{d_{rotor}} > 0.01$	$\frac{z_{clear}}{d_{rotor}} < 0.01$
Risk points	0	15	30	Unairworthy

2.1.3.1 (c) Vibration: fastener securing

Fastener securing	Fasteners secured with two of the approved methods	Fasteners secured with one of the approved methods	Fasteners unsecured; conditions for unsecure fasteners are met	Fasteners unsecured; conditions for unsecure fasteners are not met
Risk points	0	10	80	Unairworthy

Approved fastener securing methods:

- Safety wire
- Nylon locking nuts
- Thread locking compound, such as Loctite
- Castle nut and locking pin
- Split beam nut
- Locking plate or tab washer

Conditions to leave fasteners unsecured: the applicant must demonstrate compliance with the following:

- The aircraft's maximum takeoff weight must not exceed 10 lbs (4.5 kg).
- The aircraft must strictly be flown in daytime VFR conditions and within VLOS.
- The aircraft must never be flown in a crowded environment such that there is a substantial risk of it flying over people. For example, flights over campus would be prohibited since, even if the PIC makes the utmost effort to avoid flights over people, campus is sufficiently congested that, realistically, this is difficult to avoid.
- The applicant must demonstrate that the vibration produced on the aircraft is such that, after 60 minutes of consecutive flights, all fasteners remain firmly anchored.

2.1.3.1 (d) Swashplate motion smoothness: the swashplate must move smoothly up and down the shaft without binding. Since it is typical for the smoothness of motion to degrade with time as lubrication is expelled from the swashplate mechanism, the risk is evaluated based on the amount of time smooth motion can be maintained while running the rotor at maximum RPM.

Time for which smooth motion is maintained	Greater than 90 minutes	Greater than 60 minutes	Greater than 30 minutes	Less than 30 minutes
Risk points	0	25	50	Unairworthy

The maximum flight time must be specified based on the time for which smooth motion can be maintained. The maximum flight time is not to exceed half of the time for which smooth motion is maintained.

2.1.3.1 (e) Build quality evaluation

Build quality	1: Comparable to that of approved manufacturers	2: Overall good quality, but falls short of that of approved manufacturers	3: Overall decent build quality but lacks craftsmanship in some areas	4: Poor build quality
Risk points	0	10	20	Unairworthy

As previously mentioned, an evaluation of manufacturer build quality is reliant on the airworthiness assessor's experience. In order to qualify each degree of build quality, the following guidelines exist:

- Level 1: The airplane is built with tight tolerances, all components in precise alignment with one another, and all components are made of high-quality materials. This also requires that components fit flush to one another. Further, this level describes airplanes in which appropriate materials are used to reinforce the structure, i.e. using a carbon fiber spar in a foam wing as opposed to using an unreinforced foam wing.
- Level 2: This describes an airplane which is built with a decent level of craftsmanship but falls short of level 1 standards. This, for example, could include a foam wing reinforced with a weaker spar, or an airplane made with looser but acceptable tolerances.
- Level 3: the aircraft generally meets level 2 build quality standards but not in all realms. For instance, the tolerances may be acceptable but not the wing reinforcement. To qualify for level 3 scoring, no part of the airplane may meet the description for level 4 build quality.
- Level 4: this describes an aircraft which has excessively loose tolerances, poor alignment between components, low-quality materials, or poor fit between components.

The reduced risk score in this category may not exceed 42, or the aircraft is rendered unairworthy.

2.1.3.2 Propulsion and performance

2.1.3.2 (a). Maximum endurance:

Endurance	> 20 mins	> 12 mins	> 5 mins	< 5 mins
Risk points	0	20	40	Unairworthy

This must be found from flight test. This must include adequate reserve. For example, if using LiPo batteries, there must be sufficient voltage remaining to serve as a reserve. This means generally that the cell voltage must be kept above a predefined value. Similarly, for fueled propulsion systems, this endurance must be established with reserve fuel in the tank. The precise amount of reserve required is highly dependent on the aircraft and application, and as such is to be set by the airworthiness assessor.

2.1.3.2 (b) Vibration: rotor balance

Rotor balance characteristics	Negligible vibration: rotor center of gravity within 0.001 inches of propeller axis	Small vibration: rotor center of gravity within 0.005 inches of propeller axis	Moderate or greater vibrations; rotor center of gravity further than 0.005 inches from propeller
Risk points	0	10	Unairworthy

2.1.3.2 (c) Vibration: motor vibration

Vibration characteristics	Negligible vibration: vibration amplitude less than 0.001 inch	Small vibrations: vibration amplitude less than 0.005 inch	Moderate vibrations: vibration amplitude greater than 0.005 inch
Risk points	0	10	Unairworthy

2.1.3.2 (d) Vibration: damping of propulsion system vibrations

Damping characteristics present	Viscous liquid dampers are used	Rubber vibration isolating devices are used	No vibration damping is present, propeller balance and motor vibration score of 0	No vibration damping is present, nonzero propeller/motor vibration score
Risk points	0	20	20	Unairworthy

The reduced score in this category may not exceed 20 in this category or the aircraft is rendered unairworthy.

2.1.3.3 Electronics

2.1.3.3 (a). Remote control signal reliability: carrier frequency and technology used

Carrier frequency	2.4 GHz spread spectrum with DSMx or similar frequency-hopping features	Legacy carrier frequency without frequency-hopping features
Risk points	0	50

2.1.3.3 (b). Signal reliability: antenna diversity

Diversity features	Antenna diversity on transmitter and receiver	Antenna diversity on transmitter only	Antenna diversity on receiver only	No antenna diversity
Risk points	0	5	20	40

2.1.3.3 (c). ESC current rating in relation to expected maximum current draw through ESC

Value of $\frac{I_{ESC}}{I_{max}}$	$\frac{I_{ESC}}{I_{max}} > 1.5$	$\frac{I_{ESC}}{I_{max}} > 1.25$	$\frac{I_{ESC}}{I_{max}} > 1.1$	$\frac{I_{ESC}}{I_{max}} < 1.1$
Risk points	0	5	15	Unairworthy

Note: this may be inapplicable depending on the method of propulsion used in the airplane.

2.1.3.3 (d). Receiver power source

Configuration	Receiver powered from independent battery and independent BEC	Receiver powered by main flight battery, but through independent BEC	Receiver powered from BEC integrated into ESC
Risk points	0	10	30

2.1.3.3 (e). Auxiliary device power source

Configuration	Powered from independent battery and independent BEC	Powered by main flight battery, but through independent BEC	Powered from BEC integrated into ESC, or powered directly from receiver
Risk points	0	10	30

This includes aircraft lights, autopilots, sensors, etc. This category may be inapplicable depending on whether the aircraft has any auxiliary devices.

Further, all wire sizes must be specified based on the expected current draw according to the chart on the following page:

Wire size (gauge)	Wire conductor diameter (inches)	Maximum continuous current (amps), power transmission	Maximum continuous current (amps), chassis wiring
0000	0.4600	302	380
000	0.4096	239	328
00	0.3648	190	283
0	0.3249	150	245
1	0.2893	119	211
2	0.2576	94	181
3	0.2294	75	158
4	0.2043	60	135
5	0.1819	47	118
6	0.1620	37	101
7	0.1443	30	89
8	0.1285	24	73
9	0.1144	19	64
10	0.1019	15	55
11	0.0907	12	47
12	0.0808	9.3	41
13	0.0720	7.4	35
14	0.0641	5.9	32
15	0.0571	4.7	28
16	0.0508	3.7	22
17	0.0453	2.9	19
18	0.0403	2.3	16
19	0.0359	1.8	14
20	0.0320	1.5	11
21	0.0285	1.2	9
22	0.0253	0.92	7
23	0.0226	0.729	4.7
24	0.0201	0.577	3.5
25	0.0179	0.457	2.7
26	0.0159	0.361	2.2
27	0.0142	0.288	1.7
28	0.0126	0.226	1.4
29	0.0113	0.182	1.2
30	0.0100	0.142	0.86
31	0.0089	0.113	0.7
32	0.0080	0.091	0.53
33	0.0071	0.072	0.43
34	0.0063	0.056	0.33
35	0.0056	0.044	0.27
36	0.0050	0.035	0.21
37	0.0045	0.0289	0.17
38	0.0040	0.0228	0.13
39	0.0035	0.0175	0.11
40	0.0031	0.0137	0.09

Figure 2-2: Electrical wiring ampacity chart

The following requirements apply for conductor sizing:

- In no case may the current in a wire in the aircraft exceed the table value for the wire of the corresponding diameter/gauge.
- The *chassis wiring* specification applies only to wiring runs of a length less than 3.5 meters.
- The *power transmission* specification has no requirement for wiring run length.

2.1.3.3 (f). Wire gauge size: value of design maximum current in relation to table value for maximum permissible current

Value of $\frac{I_{table}}{I_{design}}$	$\frac{I_{table}}{I_{design}} \geq 1.3$	$\frac{I_{table}}{I_{design}} \geq 1.15$	$\frac{I_{table}}{I_{design}} \geq 1$	$\frac{I_{table}}{I_{design}} < 1$
Risk points	0	5	10	Unairworthy

Additionally, the following requirements apply for wiring:

- All wiring runs must be of a minimal length without the wires cluttering the interior of the airplane.
- Long wiring runs must not be accomplished by connecting multiple extension wires. If multiple lengths of wire are needed, they must be soldered together and secured with heat shrink tubing.

2.1.3.3 (g). Long wiring runs: minimal lengths

Wiring length	Wire runs are of a minimal length without cluttering the interior of the airplane.	Wiring length standards are not met.
Risk points	0	Unairworthy

2.1.3.3 (h). Long wiring runs: connection method between wire lengths

Wiring connections	Long wire runs use a single cable, or multiple cables with soldered joints.	Long wiring connection standards are not met.
Risk points	0	Unairworthy

2.1.3.3 (i). Wiring protection: OISC requires that, wherever a wire is mounted to the airframe, the wire be protected by heat-shrink tubing or a similar means. It is not acceptable to anchor a wire without any protection. Risk points are allocated as follows:

Wire protection standards	Wire protection standards met	Wire protection standards not met
Risk points	0	Unairworthy

The reduced risk score in this category may not exceed 24 or the aircraft is rendered unairworthy.

2.1.3.4 Structures

2.1.3.4 (a). Material construction: presence of fibrous materials vulnerable to splitting

Presence of fibrous materials	Only isotropic materials used in aircraft structure	Fibrous materials used with overlapping layers offset by at least 60 degrees	Fibrous materials used but no stress is applied orthogonal to fiber	Fibrous materials used with stress orthogonal to fiber
Risk points	0	5	10	Unairworthy

2.1.4 Standards for Airships

The airworthiness status is found based on the reduced risk score:

- Between 0 and 5: risk level 1
- Between 6 10: risk level 2
- Between 11 and 19: risk level 3
- Greater than 19: unairworthy

2.1.4.1 Overall design characteristics

2.1.4.1 (a). Type of airship

Airship type	Rigid airship	Semi-rigid airship	Non-rigid airship
Risk points	0	15	30

The definitions for each type of airship are below:

- Rigid airship – an airship with an internal structure which supports the envelope and maintains the external shape of the airship independent of the pressure within the airship.
- Semi-rigid airship – an airship with a stiff (or semi-stiff) keel or truss supports the airship along its lower length. The external shape of the envelope is maintained by air pressure.
- Non-rigid airship – an airship which requires air pressure to maintain the external shape of the envelope and obtains most of its strength and stiffness from the pressurized envelope.

2.1.4.1 (b). Lifting gas

Lifting gas risk level	Risk level 1 gas	Risk level 2 gas	Risk level 3 gas	Risk level 4 gas
Risk points	0	30	80	Unairworthy

The following list details the kinds of lifting gas and the associated risk levels:

- Risk level 1 gasses
  - Helium
  - Ammonia
  - Neon
  - Nitrogen
  - Any non-flammable, non-toxic, cold gas
- Risk level 2 gasses
  - Hot air
  - Water vapor
  - Vacuum
  - Any hot, non-flammable, non-toxic gas or gasses which require low pressures
- Risk level 3 gasses
  - Hydrogen
  - Methane
  - Acetylene
  - Coal gas
  - Any flammable non-toxic gas
- Risk level 4 gasses
  - Plasma
  - Hydrogen cyanide
  - Hydrogen fluoride
  - Any excessively hot or toxic gas

Lifting gas safety features: OISC requires the airship to be equipped with certain safety features depending on the type of lifting gas. These requirements are detailed below:

- Flammable gasses
  - This applies to hydrogen, methane, acetylene, and coal gas or any other flammable gas.
  - The chief concern is that the lifting gas could ignite.
  - No airship will be certified as airworthy which uses flammable gas without the following:
    - Design features to ensure no ignition sources exist within 20cm of the envelope containing the lifting gas.
    - A plan for rigorous inspection of the aircraft before and after flight to locate any leaks.
    - Safety plan to mitigate fire risk during flight, gas filling, and gas removal approved by OISC and a local fire department.
- Hot gasses
  - This applies to hot air, water vapor, and any other gas which is heated to a temperature above atmospheric temperature to function.
  - The chief concern is that the heat could soften any materials used in constructing the airship, potentially causing loss of pressure or structural failure.

  - No airship will be certified as airworthy which uses hot gasses without the following:
    - Design features to closely regulate the gas temperature and alert the crew if the temperature is outside of acceptable ranges.
    - Analysis to show that the chosen materials can withstand the heat of these gasses without decreasing stiffness or strength material parameters to the point of causing excessive deformation or material failure.
    - Design features to ensure that any heating apparatuses cannot ignite the structure of the airship itself.
- Gasses which can diffuse through common skin materials
  - This applies to hydrogen, helium, and any other generally monoatomic gas which can easily diffuse through common skin materials.
  - The chief concern is that the gas can diffuse through the skin of the aircraft and the pressure can be lost over time, which could reduce the lift force generated over time.
  - No airship will be certified as airworthy which uses gasses prone to diffusion through skin without the following:
    - Design features to closely monitor the pressure inside the airship and to alert the crew if the pressure drops too low.
    - Selection of skin material to minimize gaseous diffusion through the skin.
    - Precise determination of the permissible flight time considering gaseous diffusion phenomena.
- Vacuum
  - This applies to situations where a near-vacuum is used to provide the lifting force.
  - The chief concern is ensuring that the structure can safely support a vacuum and has adequate fatigue life to support repeated flights.
  - No airship will be certified as airworthy which relies on a vacuum without the following:
    - Demonstration from proponent that the structure possesses at least a 1.25 factor of safety against yielding at standard sea level external conditions and zero-pressure internal conditions.
    - Determination of pressurization-depressurization cycles which the aircraft can undergo before fatigue renders the structure unairworthy.

2.1.4.1 (c). Risk points for gas-specific safety features

Gas-specific safety standards	Standards met	Standards not met
Risk points	0	Unairworthy

2.1.4.1 (d). Lifting gas venting: all airships must be equipped with a means to quickly vent lifting gas in the event of an emergency. This must be capable of, at minimum, quickly venting both a small fraction of the gas to allow the airship to sink, and quickly venting all or most of the lifting gas.

Gas venting standards	Standards met	Standards not met
Risk points	0	Unairworthy

The reduced risk score in this category may not exceed 33 or the aircraft is rendered unairworthy.

2.1.4.2 Dynamics and handling

2.1.4.2 (a). Pitch control: the aircraft's pitch must be able to be controlled both at zero airspeed and at nonzero airspeed.

Pitch control	Pitch control standards met	Standards not met
Risk points	0	Unairworthy

2.1.4.2 (b). Altitude control: the airship must be able to maintain altitude as the buoyancy of the airship changes. It further must be able to make corrections to altitude to aid in landing. To that, OISC requires two types of altitude control, unless the applicant can demonstrate that another solution accomplishes both goals:

- A system to account for changes in atmospheric conditions, changes in density of the lifting gas, or other large-scale phenomena that would change the trim altitude of the airship by tens to hundreds of meters. An example of a means to comply with this requirement would be a ballonet, changing the pressure, temperature, or amount of lifting gas in the bag, or using ballast such as water which can be jettisoned.
- A system to produce small changes in altitude, such as those required for takeoff and landing. OSIC recommends a system in which thrust is produced in the vertical direction.

Altitude control requirements	Requirements met	Requirements not met
Risk points	0	Unairworthy

2.1.4.2 (c). Yaw control: the aircraft's yaw must be able to be controlled both at zero airspeed and at nonzero airspeed.

Yaw control	Yaw control standards met	Standards not met
Risk points	0	Unairworthy

The reduced risk score in this category may not exceed 0 as all standards are binary, i.e. the aircraft is airworthy or not.

2.1.4.3 Structures

2.1.4.3 (a). Puncture resistance: the applicant must demonstrate that the airship bag will not puncture when exposed to routine puncture risk items such as rocks, dust, precipitation, sharp edges on equipment, etc. The bag must also not be punctured by the structure in the event of a hard landing (2G).

Puncture resistance standards	Standards met	Standards not met
Risk points	0	Unairworthy

2.1.4.3 (b). Envelope skin UV protection: the applicant must specify a total amount of time for which the envelope can be exposed to the UV light without causing damage to the envelope which may result in leaks. The applicant must also specify inspection procedures to locate any UV damage prior to each flight.

UV exposure standards	Standards met	Standards not met
Risk points	0	Unairworthy

2.1.4.3 (c). Material construction: presence of fibrous materials vulnerable to splitting

Presence of fibrous materials	Only isotropic materials used in aircraft structure	Fibrous materials used with overlapping layers offset by at least 60 degrees	Fibrous materials used but no stress is applied orthogonal to fiber	Fibrous materials used with stress orthogonal to fiber
Risk points	0	5	10	Unairworthy

The reduced risk score in this category may not exceed 13 or the aircraft is rendered unairworthy.

2.1.4.4 Performance and propulsion

2.1.4.4 (a). Maximum endurance

Endurance, minutes	> 90 minutes	> 60 minutes	> 30 minutes	< 30 minutes
Risk points	0	15	30	Unairworthy

2.1.4.4 (b). Absolute ceiling, density altitude

Absolute ceiling z_{abs}, m	$z_{abs} > 5500$ m	$z_{abs} > 4400$ m	$z_{abs} > 3200$ m	$z_{abs} < 2100$ m
Risk points	0	20	40	Unairworthy

The reduced risk score in this category may not exceed 35 or the aircraft is rendered unairworthy.

2.1.4.5 Electronics

2.1.4.5 (a). Remote control signal reliability: carrier frequency and technology used

Carrier frequency	2.4 GHz spread spectrum with DSMx or similar frequency-hopping features	Legacy carrier frequency without frequency-hopping features
Risk points	0	50

2.1.4.5 (b). Signal reliability: antenna diversity

Diversity features	Antenna diversity on transmitter and receiver	Antenna diversity on transmitter only	Antenna diversity on receiver only	No antenna diversity
Risk points	0	5	20	40

2.1.4.5 (c). ESC current rating in relation to expected maximum current draw through ESC

Value of $\frac{I_{ESC}}{I_{max}}$	$\frac{I_{ESC}}{I_{max}} > 1.5$	$\frac{I_{ESC}}{I_{max}} > 1.25$	$\frac{I_{ESC}}{I_{max}} > 1.1$	$\frac{I_{ESC}}{I_{max}} < 1.1$
Risk points	0	5	15	Unairworthy

Further, all wire sizes must be specified based on the expected current draw according to the chart on the following page:

Wire size (gauge)	Wire conductor diameter (inches)	Maximum continuous current (amps), power transmission	Maximum continuous current (amps), chassis wiring
0000	0.4600	302	380
000	0.4096	239	328
00	0.3648	190	283
0	0.3249	150	245
1	0.2893	119	211
2	0.2576	94	181
3	0.2294	75	158
4	0.2043	60	135
5	0.1819	47	118
6	0.1620	37	101
7	0.1443	30	89
8	0.1285	24	73
9	0.1144	19	64
10	0.1019	15	55
11	0.0907	12	47
12	0.0808	9.3	41
13	0.0720	7.4	35
14	0.0641	5.9	32
15	0.0571	4.7	28
16	0.0508	3.7	22
17	0.0453	2.9	19
18	0.0403	2.3	16
19	0.0359	1.8	14
20	0.0320	1.5	11
21	0.0285	1.2	9
22	0.0253	0.92	7
23	0.0226	0.729	4.7
24	0.0201	0.577	3.5
25	0.0179	0.457	2.7
26	0.0159	0.361	2.2
27	0.0142	0.288	1.7
28	0.0126	0.226	1.4
29	0.0113	0.182	1.2
30	0.0100	0.142	0.86
31	0.0089	0.113	0.7
32	0.0080	0.091	0.53
33	0.0071	0.072	0.43
34	0.0063	0.056	0.33
35	0.0056	0.044	0.27
36	0.0050	0.035	0.21
37	0.0045	0.0289	0.17
38	0.0040	0.0228	0.13
39	0.0035	0.0175	0.11
40	0.0031	0.0137	0.09

Figure 2-3: Electrical wiring ampacity chart

The following requirements apply for conductor sizing:

- In no case may the current in a wire in the aircraft exceed the table value for the wire of the corresponding diameter/gauge.
- The *chassis wiring* specification applies only to wiring runs of a length less than 3.5 meters.
- The *power transmission* specification has no requirement for wiring run length.

2.1.4.5 (d). Wire gauge size: value of design maximum current in relation to table value for maximum permissible current

Value of $\frac{I_{table}}{I_{design}}$	$\frac{I_{table}}{I_{design}} \geq 1.3$	$\frac{I_{table}}{I_{design}} \geq 1.15$	$\frac{I_{table}}{I_{design}} \geq 1$	$\frac{I_{table}}{I_{design}} < 1$
Risk points	0	5	10	Unairworthy

Additionally, the following requirements apply for wiring:

- All wiring runs must be of a minimal length without the wires cluttering the interior of the airplane.
- Long wiring runs must not be accomplished by connecting multiple extension wires. If multiple lengths of wire are needed, they must be soldered together and secured with heat shrink tubing.

2.1.4.5 (e). Long wiring runs: minimal lengths

Wiring length	Wire runs are of a minimal length without cluttering the interior of the airplane.	Wiring length standards are not met.
Risk points	0	Unairworthy

2.1.4.5 (f). Long wiring runs: connection method between wire lengths

Wiring connections	Long wire runs use a single cable, or multiple cables with soldered joints.	Long wiring connection standards are not met.
Risk points	0	Unairworthy

2.1.4.5 (g). Wiring protection: OISC requires that, wherever a wire is mounted to the airframe, the wire be protected by heat-shrink tubing or a similar means. It is not acceptable to anchor a wire without any protection. Risk points are allocated as follows:

Wire protection standards	Wire protection standards met	Wire protection standards not met
Risk points	0	Unairworthy

The reduced risk score in this category may not exceed 16 or the aircraft is rendered unairworthy.

2.2 Operational Standards

Note that the type certificate for all unmodified commercial off-the-shelf aircraft must include any OEM-provided modifications to the aircraft.

2.2.1 Standards for Airplanes

Airplanes from approved manufacturers qualify for immediate operational airworthiness certification.

These criteria contained in this section apply to unmodified commercial off-the-shelf airplanes not from approved manufacturers. The systems and application-specific criteria contained in section 5.1 also apply depending on the aircraft application.

The manufacturer's build quality must be evaluated during the type certification of the airplane. This is evaluated against build quality of reputable manufacturers and is ultimately determined by the airworthiness assessor.

2.2.1.1 Build Quality

2.2.1.1 (a). Build quality evaluation

Build quality	1: Comparable to that of approved manufacturers	2: Overall good quality, but falls short of that of approved manufacturers	3: Overall decent build quality but lacks craftsmanship in some areas	4: Poor build quality
Risk points	0	10	20	Unairworthy

As previously mentioned, an evaluation of manufacturer build quality is reliant on the airworthiness assessor's experience. In order to qualify each degree of build quality, the following guidelines exist:

- Level 1: The airplane is built with tight tolerances, all components in precise alignment with one another, and all components are made of high-quality materials. This also requires that components fit flush to one another. Further, this level describes airplanes in which appropriate materials are used to reinforce the structure, i.e. using a carbon fiber spar in a foam wing as opposed to using an unreinforced foam wing.
- Level 2: This describes an airplane which is built with a decent level of craftsmanship but falls short of level 1 standards. This, for example, could include a foam wing reinforced with a weaker spar, or an airplane made with looser but acceptable tolerances.
- Level 3: the aircraft generally meets level 2 build quality standards but not in all realms. For instance, the tolerances may be acceptable but not the wing reinforcement. To qualify for level 3 scoring, no part of the airplane may meet the description for level 4 build quality.
- Level 4: this describes an aircraft which has excessively loose tolerances, poor alignment between components, low-quality materials, or poor fit between components.

In order to certify a non-preapproved manufacturer's aircraft as operationally airworthy, flight test must be conducted under an experimental airworthiness certificate to investigate the following:

- Basic aircraft stability and control
- Aeroelasticity and in-flight oscillations
- Stall handling
- Structural performance with high in-flight load factors
- Aircraft endurance

2.2.1.2 Stability and Control Evaluation

2.2.1.2 (a). Longitudinal modal stability Cooper-Harper

Cooper-Harper score	$CH \leq 2$	$CH \leq 4$	$CH \leq 6$	$CH > 6$
Risk points	0	5	10	Unairworthy

2.2.1.2 (b). Longitudinal control authority stability Cooper-Harper

Cooper-Harper score	$CH \leq 2$	$CH \leq 4$	$CH \leq 6$	$CH > 6$
Risk points	0	5	10	Unairworthy

2.2.1.2 (c). Lateral modal stability Cooper-Harper

Cooper-Harper score	$CH \leq 2$	$CH \leq 4$	$CH \leq 6$	$CH > 6$
Risk points	0	5	10	Unairworthy

2.2.1.2 (d). Lateral control authority stability Cooper-Harper

Cooper-Harper score	$CH \leq 2$	$CH \leq 4$	$CH \leq 6$	$CH > 6$
Risk points	0	5	10	Unairworthy

Note that these criteria are to be evaluated in flight test. If the flight test reveals any deficiencies in the area of stability and control, the aircraft must be evaluated as per the relevant part of section 4.2.

2.2.1.2 (e). Tendency to drop a wing during stall

Stall behavior	Wing drop less than 15 degrees	Wing drop less than 30 degrees	Wing drop more than 30 degrees
Risk points	0	20	40

2.2.1.2 (f). Capability of elevator to break stall

Stall behavior	Down elevator use breaks the stall with ease	Down elevator is mostly effective in breaking a stall	Recovering from stall is difficult and down elevator control is ineffective
Risk points	0	40	Unairworthy

2.2.1.3 Structural Evaluation

2.2.1.3 (a). In-flight structural oscillations

Oscillatory behavior	No structural oscillations occur during any flight regime	Structural oscillations occur but only at extreme flight regimes that are not encountered during normal flight	Structural oscillations occur during normal flight regime, but no structural damage occurs	Structural oscillations occur with noticeable structural damage
Risk points	0	5	10	Unairworthy

2.2.1.3 (b). Structural performance at high load factor (75-degree banked turn)

Structural behavior	No structural damage occurs as a result of this maneuver	Noticeable structural damage occurs after this maneuver
Risk points	0	Unairworthy

2.2.1.3 (c). Structural performance at low load factor (top of parabola maneuver)

Structural behavior	No structural damage occurs as a result of this maneuver	Noticeable structural damage occurs after this maneuver
Risk points	0	Unairworthy

2.2.1.3 (d). Wing/stabilizer structural performance: physical test results at maximum load factor in positive direction. See section 1.8.1 for load factor requirements.

Results from physical test	Load is supported without failure or plastic deformation; maximum deflection angle less than 10 degrees	Load is supported without failure or plastic deformation; maximum deflection angle greater than 10 degrees	Load is supported without failure, but plastic deformation occurs	Structure fails
Risk points	0	25	Unairworthy	Unairworthy

2.2.1.3 (e). Wing/stabilizer structural performance: physical test results at maximum load factor in negative direction. See section 1.8.1 for load factor requirements.

Results from physical test	Load is supported without failure or plastic deformation; maximum deflection angle less than 10 degrees	Load is supported without failure or plastic deformation; maximum deflection angle greater than 10 degrees	Load is supported without failure, but plastic deformation occurs	Structure fails
Risk points	0	25	Unairworthy	Unairworthy

2.2.1.3 (f). Wing/stabilizer structural performance: qualitative torsional rigidity evaluation based on flight test

Flight test results	No indications of control reversal even at extremes of speed envelope	Control reversal signs only occur at extremely high speeds	Control reversal signs occur only at high speeds	Control reversal occurs during typical flight speed regime
Risk points	0	10	30	Unairworthy

2.2.1.4 Performance

2.2.1.4 (a). Climb performance evaluation from flight test

Pilot qualitative evaluation	Propulsion system provides for excellent climb rate and climb angle	Propulsion system provides good performance for climb rate and angle	Propulsion system provides acceptable performance	Propulsion system provides inadequate performance
Risk points	0	10	30	Unairworthy

The aircraft endurance must be measured and published in the airworthiness certificate. If this endurance is so short that a safe go-around cannot be completed, the aircraft is unairworthy.

2.2.1.4 (b). Maximum endurance:

Endurance	> 15 mins	> 10 mins	> 5 mins	< 5 mins
Risk points	0	20	40	Unairworthy

This must be found from flight test. This must include adequate reserve. For example, if using LiPo batteries, there must be sufficient voltage remaining to serve as a reserve. This means generally that the cell voltage must be kept above a predefined value. Similarly, for fueled propulsion systems, this endurance must be established with reserve fuel in the tank. The precise amount of reserve required is highly dependent on the aircraft and application, and as such is to be set by the airworthiness assessor.

2.2.1.5 Electronics

The electronics standards are characterized by the following areas of concern:

- All current draws are such that there is no risk of creating an in-flight fire: conductors must be appropriately sized, and current draws through a given component are below the manufacturer-recommended current draws.
- Ideally, the radio will use 2.4GHz frequency-hopping technology.

2.2.1.5 (a). Remote control signal reliability: carrier frequency and technology used

Carrier frequency	2.4 GHz spread spectrum with DSMx or similar frequency-hopping features	Legacy carrier frequency without frequency-hopping features
Risk points	0	50

2.2.1.5 (b). Signal reliability: antenna diversity

Diversity features	Antenna diversity on transmitter and receiver	Antenna diversity on transmitter only	Antenna diversity on receiver only	No antenna diversity
Risk points	0	5	20	40

Further, all wire sizes must be specified based on the expected current draw according to the chart on the following page:

Wire size (gauge)	Wire conductor diameter (inches)	Maximum continuous current (amps), power transmission	Maximum continuous current (amps), chassis wiring
0000	0.4600	302	380
000	0.4096	239	328
00	0.3648	190	283
0	0.3249	150	245
1	0.2893	119	211
2	0.2576	94	181
3	0.2294	75	158
4	0.2043	60	135
5	0.1819	47	118
6	0.1620	37	101
7	0.1443	30	89
8	0.1285	24	73
9	0.1144	19	64
10	0.1019	15	55
11	0.0907	12	47
12	0.0808	9.3	41
13	0.0720	7.4	35
14	0.0641	5.9	32
15	0.0571	4.7	28
16	0.0508	3.7	22
17	0.0453	2.9	19
18	0.0403	2.3	16
19	0.0359	1.8	14
20	0.0320	1.5	11
21	0.0285	1.2	9
22	0.0253	0.92	7
23	0.0226	0.729	4.7
24	0.0201	0.577	3.5
25	0.0179	0.457	2.7
26	0.0159	0.361	2.2
27	0.0142	0.288	1.7
28	0.0126	0.226	1.4
29	0.0113	0.182	1.2
30	0.0100	0.142	0.86
31	0.0089	0.113	0.7
32	0.0080	0.091	0.53
33	0.0071	0.072	0.43
34	0.0063	0.056	0.33
35	0.0056	0.044	0.27
36	0.0050	0.035	0.21
37	0.0045	0.0289	0.17
38	0.0040	0.0228	0.13
39	0.0035	0.0175	0.11
40	0.0031	0.0137	0.09

Figure 2-4: Electrical wiring ampacity chart

The following requirements apply for conductor sizing:

- In no case may the current in a wire in the aircraft exceed the table value for the wire of the corresponding diameter/gauge.
- The *chassis wiring* specification applies only to wiring runs of a length less than 3.5 meters.
- The *power transmission* specification has no requirement for wiring run length.

2.2.1.5 (c). Wire gauge size: value of design maximum current in relation to table value for maximum permissible current

Value of $\frac{I_{table}}{I_{design}}$	$\frac{I_{table}}{I_{design}} \geq 1.3$	$\frac{I_{table}}{I_{design}} \geq 1.15$	$\frac{I_{table}}{I_{design}} \geq 1$	$\frac{I_{table}}{I_{design}} < 1$
Risk points	0	5	10	Unairworthy

2.2.1.5 (d). Wiring protection: OISC requires that, wherever a wire is mounted to the airframe, the wire be protected by heat-shrink tubing or a similar means. It is not acceptable to anchor a wire without any protection. Risk points are allocated as follows:

Wire protection standards	Wire protection standards met	Wire protection standards not met
Risk points	0	Unairworthy

2.2.2 Standards for Multirotors

Multirotors from approved manufacturers specified in section 1.7.4 qualify for immediate operational certification. Multirotors from other manufacturers must meet certification requirements delineated in the rest of this section.

The airworthiness status is determined based on the reduced risk score:

- 7 or below: risk level 1
- Between 8 and 20: risk level 2
- Between 21 and 37: risk level 3
- 38 or greater: unairworthy

2.2.2.1 Overall Design Characteristics

2.2.2.1 (a). Type of stability augmentation system

Stability augmentation system presence and characteristics	Type 1 SAS	Type 2 SAS	Type 3 SAS	Type 4 SAS
Risk points	0	20	50	95

The various types of stability augmentation system capabilities are defined as follows:

- Type 1: SAS can hold position and altitude when both control sticks are centered, regardless of wind. SAS automatically maintains altitude as pitch and bank are adjusted. Control sticks are used to command altitude rate, yaw rate, pitch angle, and bank angle. The position and altitude are known both a barometric altimeter and/or GPS.
- Type 2: SAS can hold position and altitude when both control sticks are centered, regardless of wind. SAS automatically maintains altitude as pitch and bank are adjusted. Control sticks are used to command altitude rate, yaw rate, pitch angle, and bank angle. The position and altitude are found based on the IMU alone.
- Type 3: SAS can hold altitude and attitude when both control sticks are centered but does not hold position. Control sticks are used to command altitude rate, yaw rate, pitch angle, and bank angle.
- Type 4: SAS is used to allow user to command altitude rate, yaw rate, pitch rate, bank rate. No altitude-hold or position-hold features.
- Types 3 and 4 stability augmentation systems require the aircraft to be trimmable.

2.2.2.1 (b). Redundancy: number of motors

Number of motors	3	4	5	6 or more
Risk points	50	40	30	0

2.2.2.1 (c). Vibration: fastener securing

Fastener securing	Fasteners secured with two of the approved methods	Fasteners secured with one of the approved methods	Fasteners unsecured; conditions for unsecure fasteners are met	Fasteners unsecured; conditions for unsecure fasteners are not met
Risk points	0	10	80	Unairworthy

Approved fastener securing methods:

- Safety wire
- Nylon locking nuts
- Thread locking compound, such as Loctite

- Castle nut and locking pin
- Split beam nut
- Locking plate or tab washer

Conditions to leave fasteners unsecured: the applicant must demonstrate compliance with the following:

- The aircraft's maximum takeoff weight must not exceed 10 lbs (4.5 kg).
- The aircraft must strictly be flown in daytime VFR conditions and within VLOS.
- The aircraft must never be flown in a crowded environment such that there is a substantial risk of it flying over people. For example, flights over campus would be prohibited since, even if the PIC makes the utmost effort to avoid flights over people, campus is sufficiently congested that, realistically, this is difficult to avoid.
- The applicant must demonstrate that the vibration produced on the aircraft is such that, after 60 minutes of consecutive flights, all fasteners remain firmly anchored.

The reduced score in this category may not exceed 70, or the aircraft is unairworthy.

2.2.2.2 Structures Standards

2.2.2.2 (a). Whole aircraft torsional rigidity: maximum twist angle between opposing sides of vehicle during maximum yaw rate maneuver.

Deflection angle θ	$\theta < 2.5^o$	$\theta < 5^o$	$\theta < 7.5^o$	$\theta > 7.5^o$
Risk points	0	20	30	Unairworthy

This requirement describes the torsion which occurs when the aircraft is executing a yaw maneuver. In this configuration, the thrust of one propeller will be changed relative to the adjacent motor. The resulting moment causes the torsion evaluated by this section.

2.2.2.2 (b). Fatigue life: cycles until failure of motor mount arms due to changes in thrust during flight

Cycles	> 10000	> 5000	> 1000	< 100
Risk points	0	10	20	Unairworthy

2.2.2.2 (c). Fatigue life: cycles until failure of motor mount arms due to motor vibrations

Cycles	> 10000	> 5000	> 1000	< 100
Risk points	0	10	20	Unairworthy

2.2.2.2 (d). Structural vibrations: in-flight oscillations during flight test

$f_{modal,structural}$ in relation to $f_{encountered}$	No structural oscillations encountered in any regime of flight	Structural vibrations occur during flight, but there is no noticeable wear after 10 flights	Structural vibrations cause significant and noticeable wear and damage after 10 flights	Structural vibrations cause component failure in flight
Risk points	0	40	Unairworthy	Unairworthy

This must cover vibrations from varying degrees of motor thrust and various airspeeds. Flight test must reveal whether the structural modal frequencies are such that the aircraft structure will excessively vibrate during flight.

2.2.2.2 (e). Material construction: presence of fibrous materials vulnerable to splitting

Presence of fibrous materials	Only isotropic materials used in aircraft structure	Fibrous materials used with overlapping layers offset by at least 60 degrees	Fibrous materials used but no stress is applied orthogonal to fiber	Fibrous materials used with stress orthogonal to fiber
Risk points	0	5	10	Unairworthy

The reduced score in this category may not exceed 25, or the aircraft is unairworthy.

2.2.2.3 Stability, Dynamics, and Control Standards

2.2.2.3 (a). Position-hold performance: maximum deviation from target position in any direction in smooth air

Deviation	< 10cm	< 20cm	< 30cm	> 30cm
Risk points	0	5	10	Unairworthy

2.2.2.3 (b). Position-hold performance: position hold Cooper-Harper score

Cooper-Harper score	2 or better	4 or better	6 or better	Worse than 6
Risk points	0	15	40	Unairworthy

2.2.2.3 (c). Attitude-hold performance: maximum angular deviation from target attitude in either direction (pitch or roll)

Deviation	$< 2^o$	$< 4^o$	$< 6^o$	$> 6^o$
Risk points	0	20	40	Unairworthy

2.2.2.3 (d). Attitude-hold performance: attitude-hold Cooper-Harper score

Cooper-Harper score	2 or better	4 or better	6 or better	Worse than 6
Risk points	0	15	40	Unairworthy

2.2.2.3 (e). Disturbance rejection: position-hold performance: maximum deviation from target position in any direction in light turbulence

Deviation	< 15cm	< 30cm	< 45cm	> 45cm
Risk points	0	10	20	90

2.2.2.3 (f). Disturbance tracking: position-hold performance: Cooper-Harper score in light turbulence

Cooper-Harper score	2 or better	4 or better	6 or better	Worse than 6
Risk points	0	15	40	Unairworthy

2.2.2.3 (g). Control tracking: aircraft stability augmentation response to control inputs

Response characteristics	Critically or over-damped	Well-damped	Lightly damped	Extremely lightly damped
Risk points	0	10	40	60

2.2.2.3 (h). Control tracking: aircraft stability augmentation response to control inputs Cooper-Harper score

Cooper-Harper score	2 or better	4 or better	6 or better	Worse than 6
Risk points	0	15	40	Unairworthy

2.2.2.3 (i). Altitude-hold capabilities during forward/transverse flight: altitude deviation

Altitude hold deviation	< 10cm	< 20cm	< 30cm	> 30cm
Risk points	0	5	10	60

2.2.2.3 (j). Altitude-hold capabilities during forward/transverse flight: Cooper-Harper score

Cooper-Harper score	2 or better	4 or better	6 or better	Worse than 6
Risk points	0	15	40	Unairworthy

2.2.2.3 (k). Pitch and bank angle limitation

Pitch and bank limits	Limits are below FOM-defined thresholds	Limits meet FOM-defined threshold	No SAS limits: reliant on pilot to maintain FOM pitch and bank limits
Risk points	0	5	30

2.2.2.3 (l). Maintaining attitude limits: Cooper-Harper score

Cooper-Harper score	2 or better	4 or better	6 or better	Worse than 6
Risk points	0	15	40	Unairworthy

2.2.2.3 (m). Control precision: takeoff/landing precision test

Precision	$\pm$10cm or better	$\pm$20cm or better	$\pm$35cm or better	$\pm$35cm or worse
Risk points	0	15	40	Unairworthy

For this test, the pilot must take the aircraft off from a helipad, fly it to 10 feet in altitude without inputting any other control inputs, and land it again. The difference in the takeoff location of the center of the aircraft and landing location of the center of the aircraft is to be measured.

2.2.2.3 (n). Control precision: Cooper-Harper score for landing on precise location

Cooper-Harper score	2 or better	4 or better	6 or better	Worse than 6
Risk points	0	15	40	Unairworthy

This is based on the following test: the aircraft is to be landed on a square pad with a side length not exceeding 1.2 times the maximum diagonal length between propellers. The pilot is to land on the middle of this pad and rate the difficulty of doing so.

2.2.2.3 (o). Control precision: azimuth hold ability

Azimuth variation test results	±2m or better	±4m or better	±8m or better	Worse than ±8m
Risk points	0	15	40	Unairworthy

This is to be assessed by a physical test: from a safe altitude, the aircraft must be aligned to a given azimuth, flown forward 35 meters without any lateral commands. It then must be flown directly backward to the start location. The difference in position measured in the direction perpendicular to the target azimuth must be measured. See the diagram below:

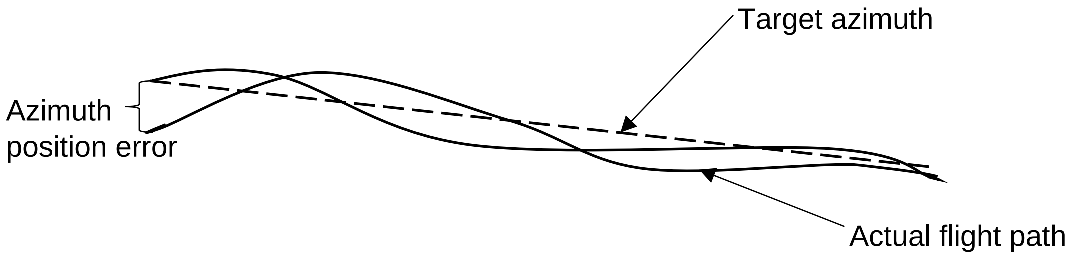


Figure 2-5: Azimuth tracking visualization

2.2.2.3 (p). Control precision: azimuth hold ability Cooper-Harper score

Cooper-Harper score	2 or better	4 or better	6 or better	Worse than 6
Risk points	0	15	40	Unairworthy

This is based on the pilot's workload during the test delineated in the previous standard.

The reduced score in this category may not exceed 38, or the aircraft is unairworthy.

2.2.2.4 Electronics Standards

2.2.2.4 (a). Remote control signal reliability: carrier frequency and technology used

Carrier frequency	2.4 GHz spread spectrum with DSMx or similar frequency-hopping features	Legacy carrier frequency without frequency-hopping features
Risk points	0	50

2.2.2.4 (b). Signal reliability: antenna diversity

Diversity features	Antenna diversity on transmitter and receiver	Antenna diversity on transmitter only	Antenna diversity on receiver only	No antenna diversity
Risk points	0	5	20	40

2.2.2.4 (c). ESC current rating in relation to expected maximum current draw through ESC

Value of $\frac{I_{ESC}}{I_{max}}$	$\frac{I_{ESC}}{I_{max}} > 1.5$	$\frac{I_{ESC}}{I_{max}} > 1.25$	$\frac{I_{ESC}}{I_{max}} > 1.1$	$\frac{I_{ESC}}{I_{max}} < 1.1$
Risk points	0	5	15	Unairworthy

Note: this may be inapplicable depending on the method of propulsion used in the aircraft.

2.2.2.4 (d). Receiver power source

Configuration	Receiver powered from independent battery and independent BEC	Receiver powered by main flight battery, but through independent BEC	Receiver powered from BEC integrated into ESC
Risk points	0	10	30

2.2.2.4 (e). Auxiliary device power source

Configuration	Powered from independent battery and independent BEC	Powered by main flight battery, but through independent BEC	Powered from BEC integrated into ESC, or powered directly from receiver
Risk points	0	10	30

This includes aircraft lights, autopilots, sensors, etc. This category may be inapplicable depending on whether the aircraft has any auxiliary devices.

Further, all wire sizes must be specified based on the expected current draw according to the chart on the following page:

Wire size (gauge)	Wire conductor diameter (inches)	Maximum continuous current (amps), power transmission	Maximum continuous current (amps), chassis wiring
0000	0.4600	302	380
000	0.4096	239	328
00	0.3648	190	283
0	0.3249	150	245
1	0.2893	119	211
2	0.2576	94	181
3	0.2294	75	158
4	0.2043	60	135
5	0.1819	47	118
6	0.1620	37	101
7	0.1443	30	89
8	0.1285	24	73
9	0.1144	19	64
10	0.1019	15	55
11	0.0907	12	47
12	0.0808	9.3	41
13	0.0720	7.4	35
14	0.0641	5.9	32
15	0.0571	4.7	28
16	0.0508	3.7	22
17	0.0453	2.9	19
18	0.0403	2.3	16
19	0.0359	1.8	14
20	0.0320	1.5	11
21	0.0285	1.2	9
22	0.0253	0.92	7
23	0.0226	0.729	4.7
24	0.0201	0.577	3.5
25	0.0179	0.457	2.7
26	0.0159	0.361	2.2
27	0.0142	0.288	1.7
28	0.0126	0.226	1.4
29	0.0113	0.182	1.2
30	0.0100	0.142	0.86
31	0.0089	0.113	0.7
32	0.0080	0.091	0.53
33	0.0071	0.072	0.43
34	0.0063	0.056	0.33
35	0.0056	0.044	0.27
36	0.0050	0.035	0.21
37	0.0045	0.0289	0.17
38	0.0040	0.0228	0.13
39	0.0035	0.0175	0.11
40	0.0031	0.0137	0.09

Figure 2-6: Electrical wiring ampacity chart

The following requirements apply for conductor sizing:

- In no case may the current in a wire in the aircraft exceed the table value for the wire of the corresponding diameter/gauge.
- The *chassis wiring* specification applies only to wiring runs of a length less than 3.5 meters.
- The *power transmission* specification has no requirement for wiring run length.

2.2.2.4 (f). Wire gauge size: value of design maximum current in relation to table value for maximum permissible current

Value of $\frac{I_{table}}{I_{design}}$	$\frac{I_{table}}{I_{design}} \geq 1.3$	$\frac{I_{table}}{I_{design}} \geq 1.15$	$\frac{I_{table}}{I_{design}} \geq 1$	$\frac{I_{table}}{I_{design}} < 1$
Risk points	0	5	10	Unairworthy

Additionally, the following requirements apply for wiring:

- All wiring runs must be of a minimal length without the wires cluttering the interior of the airplane.
- Long wiring runs must not be accomplished by connecting multiple extension wires. If multiple lengths of wire are needed, they must be soldered together and secured with heat shrink tubing.

2.2.2.4 (g). Long wiring runs: minimal lengths

Wiring length	Wire runs are of a minimal length without cluttering the interior of the airplane.	Wiring length standards are not met.
Risk points	0	Unairworthy

2.2.2.4 (h). Long wiring runs: connection method between wire lengths

Wiring connections	Long wire runs use a single cable, or multiple cables with soldered joints.	Long wiring connection standards are not met.
Risk points	0	Unairworthy

2.2.2.4 (i). Wiring protection: OISC requires that, wherever a wire is mounted to the airframe, the wire be protected by heat-shrink tubing or a similar means. It is not acceptable to anchor a wire without any protection. Risk points are allocated as follows:

Wire protection standards	Wire protection standards met	Wire protection standards not met
Risk points	0	Unairworthy

The reduced score in this category may not exceed 24, or the aircraft is unairworthy.

2.2.2.5 Propulsion and Performance Standards

2.2.2.5 (a). Service ceiling – altitude at which climb rate reduces to 1.5 m/s (300 fpm) in standard atmospheric conditions

Value of Z_{svc}	$Z_{svc} \geq 5000$ m	$3500 < Z_{svc} \leq 5000$ m	$1500 \leq Z_{svc} \leq 3500$ m	$Z_{svc} < 1500$ m
Risk points	0	5	10	50

2.2.2.5 (b). Maximum rate of climb, evaluated at standard sea level

Value of V_h	$V_h > 6$ m/s	$4 \leq V_h \leq 6$ m/s	$1 \leq V_h < 4$ m/s	$V_h < 1$ m/s
Risk points	0	5	15	Unairworthy

2.2.2.5 (c). Mean time between powerplant failure when recommended maintenance schedule is followed:

Time between failure	> 100 flight hours	> 50 flight hours	>25 flight hours	< 25 flight hours
Risk points	0	20	40	Unairworthy

Meeting this criterion should be established by referencing manufacturer specifications for expected powerplant longevity.

2.2.2.5 (d). Maximum endurance:

Endurance	> 20 mins	> 12 mins	> 5 mins	< 5 mins
Risk points	0	20	40	Unairworthy

This must be found from flight test. This must include adequate reserve. For example, if using LiPo batteries, there must be sufficient voltage remaining to serve as a reserve. This means generally that the cell voltage must be kept above a predefined value. Similarly, for fueled propulsion systems, this endurance must be established with reserve fuel in the tank. The precise amount of reserve required is highly dependent on the aircraft and application, and as such is to be set by the airworthiness assessor.

2.2.2.5 (e). Vibration: propeller balance

Propeller balance characteristics	Negligible vibration: propeller center of gravity within 0.001 inches of propeller axis	Small vibration: propeller center of gravity within 0.005 inches of propeller axis	Moderate or greater vibrations; propeller center of gravity further than 0.005 inches from propeller
Risk points	0	10	Unairworthy

2.2.2.5 (f). Vibration: motor vibration

Vibration characteristics	Negligible vibration: vibration amplitude less than 0.001 inch	Small vibrations: vibration amplitude less than 0.005 inch	Moderate vibrations: vibration amplitude greater than 0.005 inch
Risk points	0	10	Unairworthy

2.2.2.5 (g). Vibration: damping of propulsion system vibrations

Damping characteristics present	Viscous liquid dampers are used	Rubber vibration isolating devices are used	No vibration damping is present, propeller balance and motor vibration score of 0	No vibration damping is present, nonzero propeller/motor vibration score
Risk points	0	10	20	Unairworthy

The reduced score in this category may not exceed 22, or the aircraft is unairworthy.

2.2.3 Standards for Helicopters

Helicopters from approved manufacturers qualify for immediate operational airworthiness certification.

Helicopters from non-approved manufacturers must be evaluated per the remainder of this section.

The airworthiness status is found based on the reduced risk score:

- Between 0 and 10: risk level 1
- Between 11 and 20: risk level 2
- Between 21 and 32: risk level 3
- Greater than 32: unairworthy

2.2.3.1 Overall design

2.2.3.1 (a). Build quality evaluation

Build quality	1: Comparable to that of approved manufacturers	2: Overall good quality, but falls short of that of approved manufacturers	3: Overall decent build quality but lacks craftsmanship in some areas	4: Poor build quality
Risk points	0	10	20	Unairworthy

As previously mentioned, an evaluation of manufacturer build quality is reliant on the airworthiness assessor’s experience. In order to qualify each degree of build quality, the following guidelines exist:

- Level 1: The airplane is built with tight tolerances, all components in precise alignment with one another, and all components are made of high-quality materials. This also requires that components fit flush to one another. Further, this level describes airplanes in which appropriate materials are used to reinforce the structure, i.e. using a carbon fiber spar in a foam wing as opposed to using an unreinforced foam wing.
- Level 2: This describes an airplane which is built with a decent level of craftsmanship but falls short of level 1 standards. This, for example, could include a foam wing reinforced with a weaker spar, or an airplane made with looser but acceptable tolerances.
- Level 3: the aircraft generally meets level 2 build quality standards but not in all realms. For instance, the tolerances may be acceptable but not the wing reinforcement. To qualify for level 3 scoring, no part of the airplane may meet the description for level 4 build quality.
- Level 4: this describes an aircraft which has excessively loose tolerances, poor alignment between components, low-quality materials, or poor fit between components.

2.2.3.1 (b). Tail rotor ground strike protection. OISC requires that the tail rotor be protected from ground strikes by means of a skid plate mounted such that, as the helicopter is pitched up, the tail skid contacts the ground and clearance between the ground and tail rotor is maintained. Risk points are assessed as follows:

Tail rotor protection	Inapplicable due to design features such as counter rotating rotors or a ducted fan tail rotor	Clearance greater than 1/10 of the rotor radius	Clearance greater than 1/20 of the rotor radius	Clearances less than 1/20 of the rotor radius
Risk points	0	15	30	Unairworthy

Note: if the rotors intermesh, the applicant must demonstrate that there is no risk of the rotors striking each other.

2.2.3.1 (c). Tail rotor placement: the applicant must show that the tail rotor is located such that yaw control can be maintained in normal flight without requiring exceptional pilot skill or exceptionally favorable conditions. This is evaluated based on the worst-case Cooper-Harper score for maintaining a heading in any normal flight regime.

Cooper-Harper score CH	$CH < 3$	$CH \leq 4$	$CH \leq 6$	$CH > 6$
Risk points	0	10	20	Unairworthy

2.2.3.1 (d). Rotor clearance: with the least favorable cyclic control and least favorable load factor, the rotor must clear any other part of the aircraft (such as the boom or fuselage) by at least 1% of the rotor diameter. Risk points are assessed as follows:

Clearance as measured by: $\frac{z_{clear}}{d_{rotor}}$	$\frac{z_{clear}}{d_{rotor}} > 0.05$	$\frac{z_{clear}}{d_{rotor}} > 0.025$	$\frac{z_{clear}}{d_{rotor}} > 0.01$	$\frac{z_{clear}}{d_{rotor}} < 0.01$
Risk points	0	15	30	Unairworthy

2.2.3.1 (e). Vibration: fastener securing

Fastener securing	Fasteners secured with two of the approved methods	Fasteners secured with one of the approved methods	Fasteners unsecured; conditions for unsecure fasteners are met	Fasteners unsecured; conditions for unsecure fasteners are not met
Risk points	0	10	80	Unairworthy

Approved fastener securing methods:

- Safety wire
- Nylon locking nuts
- Thread locking compound, such as Loctite
- Castle nut and locking pin
- Split beam nut
- Locking plate or tab washer

Conditions to leave fasteners unsecured: the applicant must demonstrate compliance with the following:

- The aircraft's maximum takeoff weight must not exceed 10 lbs (4.5 kg).
- The aircraft must strictly be flown in daytime VFR conditions and within VLOS.
- The aircraft must never be flown in a crowded environment such that there is a substantial risk of it flying over people. For example, flights over campus would be prohibited since, even if the PIC makes the utmost effort to avoid flights over people, campus is sufficiently congested that, realistically, this is difficult to avoid.
- The applicant must demonstrate that the vibration produced on the aircraft is such that, after 60 minutes of consecutive flights, all fasteners remain firmly anchored.

2.2.3.1 (f). Redundancy: number of motors

Number of motors	2 or more	1
Risk points	0	30

Jesus bolts. Any bolts or nut on the aircraft which would cause complete loss of the aircraft in the event of failure must meet the following criteria:

- Safety factor against yielding not less than 2 with MTOW, maximum rotor thrust, and maximum load factor.
- Two methods to prevent the bolt/nut from loosening over time. The approved methods are listed below:
  - Thread locking compound, such as Loctite
  - Safety wire
  - Castle nut and locking pin
- The applicant must delineate an inspection and maintenance schedule for any of these bolts/nuts.

2.2.3.1 (g). Risk points are allocated for Jesus bolts as follows:

Safety factor	$FS \geq 3$	$FS \geq 2.5$	$FS \geq 2$	$FS < 2$
Risk points	0	15	30	Unairworthy

2.2.3.1 (h). Other standards for Jesus bolts:

Other standards met?	Met	Not met
Risk points	0	Unairworthy

The reduced risk score in this category may not exceed 33 or the aircraft is rendered unairworthy.

2.2.3.2 Swashplate

2.2.3.2 (a). Servo sizing: servo torque in relation to minimum required torque

Value of $\frac{\tau}{\tau_{req}}$	$\frac{\tau}{\tau_{req}} > 2$	$\frac{\tau}{\tau_{req}} > 1.5$	$\frac{\tau}{\tau_{req}} > 1$	$\frac{\tau}{\tau_{req}} < 1$
Risk points	0	15	30	Unairworthy

The required torque is computed as follows: at the maximum rotor RPM and maximum angle of incidence of the propeller, the pitching moment about the joint which supports the rotor must be computed. The support reaction by the joint which is used to alter the rotor angle of incidence must then be computed. Then the actuation torque is found based on the length of the servo arm. Twice this torque is the minimum required torque.

2.2.3.2 (b). Swashplate motion smoothness: the swashplate must move smoothly up and down the shaft without binding. Since it is typical for the smoothness of motion to degrade with time as lubrication is expelled from the swashplate mechanism, the risk is evaluated based on the amount of time smooth motion can be maintained while running the rotor at maximum RPM.

Time for which smooth motion is maintained	Greater than 90 minutes	Greater than 60 minutes	Greater than 30 minutes	Less than 30 minutes
Risk points	0	25	50	Unairworthy

The maximum flight time must be specified based on the time for which smooth motion can be maintained. The maximum flight time is not to exceed half of the time for which smooth motion is maintained.

The reduced risk score in this category may not exceed 40 or the aircraft is rendered unairworthy.

2.2.3.3 Performance and Propulsion

2.2.3.3 (a). Climb gradient at V_y, standard sea level, all engines operative, maximum weight

Climb gradient	1:3 or better	1:4 or better	1:5 or better	Less than 1:6
Risk points	0	15	30	Unairworthy

2.2.3.3 (b). Climb gradient at V_y, standard sea level, one engine inoperative, maximum weight

Climb gradient	1:14 or better	1:16 or better	1:18 or better	Less than 1:20
Risk points	0	15	30	Unairworthy

2.2.3.3 (c). Mean time between powerplant failure when recommended maintenance schedule is followed:

Time between failure	> 100 flight hours	> 50 flight hours	>25 flight hours	< 25 flight hours
Risk points	0	20	40	Unairworthy

Meeting this criterion should be established by referencing manufacturer specifications for expected powerplant longevity.

2.2.3.3 (d). Maximum endurance:

Endurance	> 20 mins	> 12 mins	> 5 mins	< 5 mins
Risk points	0	20	40	Unairworthy

This must be found from flight test. This must include adequate reserve. For example, if using LiPo batteries, there must be sufficient voltage remaining to serve as a reserve. This means generally that the cell voltage must be kept above a predefined value. Similarly, for fueled propulsion systems, this endurance must be established with reserve fuel in the tank. The precise amount of reserve required is highly dependent on the aircraft and application, and as such is to be set by the airworthiness assessor.

2.2.3.3 (e). Vibration: rotor balance

Rotor balance characteristics	Negligible vibration: rotor center of gravity within 0.001 inches of propeller axis	Small vibration: rotor center of gravity within 0.005 inches of propeller axis	Moderate or greater vibrations; rotor center of gravity further than 0.005 inches from propeller
Risk points	0	10	Unairworthy

2.2.3.3 (f). Vibration: motor vibration

Vibration characteristics	Negligible vibration: vibration amplitude less than 0.001 inch	Small vibrations: vibration amplitude less than 0.005 inch	Moderate vibrations: vibration amplitude greater than 0.005 inch
Risk points	0	10	Unairworthy

2.2.3.3 (g). Vibration: damping of propulsion system vibrations

Damping characteristics present	Viscous liquid dampers are used	Rubber vibration isolating devices are used	No vibration damping is present, propeller balance and motor vibration score of 0	No vibration damping is present, nonzero propeller/motor vibration score
Risk points	0	20	20	Unairworthy

The reduced risk score in this category may not exceed 26 or the aircraft is rendered unairworthy.

2.2.3.4 Electronics

2.2.3.4 (a). Remote control signal reliability: carrier frequency and technology used

Carrier frequency	2.4 GHz spread spectrum with DSMx or similar frequency-hopping features	Legacy carrier frequency without frequency-hopping features
Risk points	0	50

2.2.3.4 (b). Signal reliability: antenna diversity

Diversity features	Antenna diversity on transmitter and receiver	Antenna diversity on transmitter only	Antenna diversity on receiver only	No antenna diversity
Risk points	0	5	20	40

2.2.3.4 (c). ESC current rating in relation to expected maximum current draw through ESC

Value of $\frac{I_{ESC}}{I_{max}}$	$\frac{I_{ESC}}{I_{max}} > 1.5$	$\frac{I_{ESC}}{I_{max}} > 1.25$	$\frac{I_{ESC}}{I_{max}} > 1.1$	$\frac{I_{ESC}}{I_{max}} < 1.1$
Risk points	0	5	15	Unairworthy

Note: this may be inapplicable depending on the method of propulsion used in the airplane.

2.2.3.4 (d). Receiver power source

Configuration	Receiver powered from independent battery and independent BEC	Receiver powered by main flight battery, but through independent BEC	Receiver powered from BEC integrated into ESC
Risk points	0	10	30

2.2.3.4 (e). Auxiliary device power source

Configuration	Powered from independent battery and independent BEC	Powered by main flight battery, but through independent BEC	Powered from BEC integrated into ESC, or powered directly from receiver
Risk points	0	10	30

This includes aircraft lights, autopilots, sensors, etc. This category may be inapplicable depending on whether the aircraft has any auxiliary devices.

Further, all wire sizes must be specified based on the expected current draw according to the chart on the following page:

Wire size (gauge)	Wire conductor diameter (inches)	Maximum continuous current (amps), power transmission	Maximum continuous current (amps), chassis wiring
0000	0.4600	302	380
000	0.4096	239	328
00	0.3648	190	283
0	0.3249	150	245
1	0.2893	119	211
2	0.2576	94	181
3	0.2294	75	158
4	0.2043	60	135
5	0.1819	47	118
6	0.1620	37	101
7	0.1443	30	89
8	0.1285	24	73
9	0.1144	19	64
10	0.1019	15	55
11	0.0907	12	47
12	0.0808	9.3	41
13	0.0720	7.4	35
14	0.0641	5.9	32
15	0.0571	4.7	28
16	0.0508	3.7	22
17	0.0453	2.9	19
18	0.0403	2.3	16
19	0.0359	1.8	14
20	0.0320	1.5	11
21	0.0285	1.2	9
22	0.0253	0.92	7
23	0.0226	0.729	4.7
24	0.0201	0.577	3.5
25	0.0179	0.457	2.7
26	0.0159	0.361	2.2
27	0.0142	0.288	1.7
28	0.0126	0.226	1.4
29	0.0113	0.182	1.2
30	0.0100	0.142	0.86
31	0.0089	0.113	0.7
32	0.0080	0.091	0.53
33	0.0071	0.072	0.43
34	0.0063	0.056	0.33
35	0.0056	0.044	0.27
36	0.0050	0.035	0.21
37	0.0045	0.0289	0.17
38	0.0040	0.0228	0.13
39	0.0035	0.0175	0.11
40	0.0031	0.0137	0.09

Figure 2-7: Electrical wiring ampacity chart

The following requirements apply for conductor sizing:

- In no case may the current in a wire in the aircraft exceed the table value for the wire of the corresponding diameter/gauge.
- The *chassis wiring* specification applies only to wiring runs of a length less than 3.5 meters.
- The *power transmission* specification has no requirement for wiring run length.

2.2.3.4 (f). Wire gauge size: value of design maximum current in relation to table value for maximum permissible current

Value of $\frac{I_{table}}{I_{design}}$	$\frac{I_{table}}{I_{design}} \geq 1.3$	$\frac{I_{table}}{I_{design}} \geq 1.15$	$\frac{I_{table}}{I_{design}} \geq 1$	$\frac{I_{table}}{I_{design}} < 1$
Risk points	0	5	10	Unairworthy

Additionally, the following requirements apply for wiring:

- All wiring runs must be of a minimal length without the wires cluttering the interior of the airplane.
- Long wiring runs must not be accomplished by connecting multiple extension wires. If multiple lengths of wire are needed, they must be soldered together and secured with heat shrink tubing.

2.2.3.4 (g). Long wiring runs: minimal lengths

Wiring length	Wire runs are of a minimal length without cluttering the interior of the airplane.	Wiring length standards are not met.
Risk points	0	Unairworthy

2.2.3.4 (h). Long wiring runs: connection method between wire lengths

Wiring connections	Long wire runs use a single cable, or multiple cables with soldered joints.	Long wiring connection standards are not met.
Risk points	0	Unairworthy

2.2.3.4 (i). Wiring protection: OISC requires that, wherever a wire is mounted to the airframe, the wire be protected by heat-shrink tubing or a similar means. It is not acceptable to anchor a wire without any protection. Risk points are allocated as follows:

Wire protection standards	Wire protection standards met	Wire protection standards not met
Risk points	0	Unairworthy

The reduced score in this category may not exceed 24 or the aircraft is rendered unairworthy.

2.2.3.5 Structures

2.2.3.5 (a). Fatigue life: cycles until failure of motor mount mechanism due to changes in thrust during flight

Cycles	> 10000	> 5000	> 1000	< 100
Risk points	0	10	20	Unairworthy

2.2.3.5 (b). Fatigue life: cycles until failure of motor mount mechanism due to motor vibrations

Cycles	> 10000	> 5000	> 1000	< 100
Risk points	0	10	20	Unairworthy

2.2.3.5 (c). Structural vibrations: in-flight oscillations during flight test

$f_{modal,structural}$ in relation to $f_{encountered}$	No structural oscillations encountered in any regime of flight	Structural vibrations occur during flight, but there is no noticeable wear after 10 flights	Structural vibrations cause significant and noticeable wear and damage after 10 flights	Structural vibrations cause component failure in flight
Risk points	0	40	Unairworthy	Unairworthy

This must cover vibrations from varying degrees of motor thrust and various airspeeds. Flight test must reveal whether the structural modal frequencies are such that the aircraft structure will excessively vibrate during flight.

2.2.3.5 (d). Material construction: presence of fibrous materials vulnerable to splitting

Presence of fibrous materials	Only isotropic materials used in aircraft structure	Fibrous materials used with overlapping layers offset by at least 60 degrees	Fibrous materials used but no stress is applied orthogonal to fiber	Fibrous materials used with stress orthogonal to fiber
Risk points	0	5	10	Unairworthy

2.2.3.5 (e). Rotor structures: minimum factor of safety of main rotor at maximum thrust, MTOW, maximum load factor

Value of FS	$FS > 1.5$	$FS > 1.5$	$FS > 1.15$	$FS < 1.15$
Risk points	0	20	40	Unairworthy

Rotor structures: the following rotor structures standards also apply:

- The rotor must possess sufficient torsional stiffness to not deform excessively to compromise the lift generated by the rotor.
- The rotor must possess sufficient beam bending stiffness to not deform excessively to compromise the lift generated by the rotor or cause interference with other parts of the aircraft structure.

2.2.3.5 (f). Rotor stiffness risk points

Standards met	Met	Not met
Risk points	0	Unairworthy

The reduced risk score may not exceed 22 or the aircraft is rendered unairworthy.

2.2.3.6 Dynamics and Handling

2.2.3.6 (a). Position-hold performance: position hold Cooper-Harper score

Cooper-Harper score	2 or better	4 or better	6 or better	Worse than 6
Risk points	0	15	40	Unairworthy

2.2.3.6 (b). Attitude-hold performance: attitude-hold Cooper-Harper score

Cooper-Harper score	2 or better	4 or better	6 or better	Worse than 6
Risk points	0	15	40	Unairworthy

2.2.3.6 (c). Disturbance tracking: position-hold performance: Cooper-Harper score in light turbulence

Cooper-Harper score	2 or better	4 or better	6 or better	Worse than 6
Risk points	0	15	40	Unairworthy

2.2.3.6 (d). Maintaining attitude limits: Cooper-Harper score

Cooper-Harper score	2 or better	4 or better	6 or better	Worse than 6
Risk points	0	15	40	Unairworthy

2.2.3.6 (e). Control precision: Cooper-Harper score for landing on precise location

Cooper-Harper score	2 or better	4 or better	6 or better	Worse than 6
Risk points	0	15	40	Unairworthy

This is based on the following test: the aircraft is to be landed on a square pad with a side length not exceeding 1.2 times the maximum diagonal length between propellers. The pilot is to land on the middle of this pad and rate the difficulty of doing so.

2.2.3.6 (f). Control precision: azimuth hold ability Cooper-Harper score

Cooper-Harper score	2 or better	4 or better	6 or better	Worse than 6
Risk points	0	15	40	Unairworthy

This is based on the pilot's workload during the test delineated in the previous standard.

2.2.3.6 (g). Dynamic rollover: critical rollover angle

Critical angle θ	$\theta > 15^o$	$\theta > 10^o$	$\theta > 5^o$	$\theta < 5^o$
Risk points	0	15	30	Unairworthy

2.2.3.6 (h). Static stability: static yaw stability in forward flight

Static stability	Statically stable	Neutrally stable or unstable
Risk points	0	80

2.2.3.6 (i). Static stability: static roll stability in forward flight

Static stability	Statically stable	Neutrally stable or unstable
Risk points	0	80

2.2.3.6 (j). Static stability: static pitch stability in forward flight

Static stability	Statically stable	Neutrally stable or unstable
Risk points	0	80

2.2.3.6 (k). Dynamic stability: growth of oscillations in pitch (hover)

Absolute value of time constant τ	$\tau > 1$ sec	$\tau > 0.6$ sec	$\tau > 0.1$ sec	$\tau < 0.1$ sec
Risk points	0	20	40	Unairworthy

2.2.3.6 (l). Dynamic stability: growth of oscillations in roll (hover)

Absolute value of time constant τ	$\tau > 1$ sec	$\tau > 0.6$ sec	$\tau > 0.1$ sec	$\tau < 0.1$ sec
Risk points	0	20	40	Unairworthy

2.2.3.6 (m). Dynamic stability: growth of oscillations in yaw (hover)

Absolute value of time constant τ	$\tau > 1$ sec	$\tau > 0.6$ sec	$\tau > 0.1$ sec	$\tau < 0.1$ sec
Risk points	0	20	40	Unairworthy

The reduced risk score in this category may not exceed 51 or the aircraft is rendered unairworthy.

2.2.4 Standards for Airships

The airworthiness status is found based on the reduced risk score:

- Between 0 and 5: risk level 1
- Between 6 and 11: risk level 2
- Between 12 and 23: risk level 3
- Greater than 23: unairworthy

2.2.4.1 Overall design characteristics

2.2.4.1 (a). Type of airship

Airship type	Rigid airship	Semi-rigid airship	Non-rigid airship
Risk points	0	15	30

The definitions for each type of airship are below:

- Rigid airship – an airship with an internal structure which supports the envelope and maintains the external shape of the airship independent of the pressure within the airship.
- Semi-rigid airship – an airship with a stiff (or semi-stiff) keel or truss supports the airship along its lower length. The external shape of the envelope is maintained by air pressure.
- Non-rigid airship – an airship which requires air pressure to maintain the external shape of the envelope and obtains most of its strength and stiffness from the pressurized envelope.

2.2.4.1 (b). Lifting gas

Lifting gas risk level	Risk level 1 gas	Risk level 2 gas	Risk level 3 gas	Risk level 4 gas
Risk points	0	30	80	Unairworthy

The following list details the kinds of lifting gas and the associated risk levels:

- Risk level 1 gasses
  - Helium
  - Ammonia
  - Neon
  - Nitrogen
  - Any non-flammable, non-toxic, cold gas
- Risk level 2 gasses
  - Hot air
  - Water vapor
  - Vacuum
  - Any hot, non-flammable, non-toxic gas or gasses which require low pressures
- Risk level 3 gasses
  - Hydrogen
  - Methane
  - Acetylene
  - Coal gas
  - Any flammable non-toxic gas
- Risk level 4 gasses
  - Plasma
  - Hydrogen cyanide
  - Hydrogen fluoride
  - Any excessively hot or toxic gas

Lifting gas safety features: OISC requires the airship to be equipped with certain safety features depending on the type of lifting gas. These requirements are detailed below:

- Flammable gasses
  - This applies to hydrogen, methane, acetylene, and coal gas or any other flammable gas.
  - The chief concern is that the lifting gas could ignite.
  - No airship will be certified as airworthy which uses flammable gas without the following:
    - Design features to ensure no ignition sources exist within 20cm of the envelope containing the lifting gas.
    - A plan for rigorous inspection of the aircraft before and after flight to locate any leaks.
    - Safety plan to mitigate fire risk during flight, gas filling, and gas removal approved by OISC and a local fire department.
- Hot gasses

- This applies to hot air, water vapor, and any other gas which is heated to a temperature above atmospheric temperature to function.
    - The chief concern is that the heat could soften any materials used in constructing the airship, potentially causing loss of pressure or structural failure.
    - No airship will be certified as airworthy which uses hot gasses without the following:
        - Design features to closely regulate the gas temperature and alert the crew if the temperature is outside of acceptable ranges.
        - Analysis to show that the chosen materials can withstand the heat of these gasses without decreasing stiffness or strength material parameters to the point of causing excessive deformation or material failure.
        - Design features to ensure that any heating apparatuses cannot ignite the structure of the airship itself.
- Gasses which can diffuse through common skin materials
    - This applies to hydrogen, helium, and any other generally monoatomic gas which can easily diffuse through common skin materials.
    - The chief concern is that the gas can diffuse through the skin of the aircraft and the pressure can be lost over time, which could reduce the lift force generated over time.
    - No airship will be certified as airworthy which uses gasses prone to diffusion through skin without the following:
        - Design features to closely monitor the pressure inside the airship and to alert the crew if the pressure drops too low.
        - Selection of skin material to minimize gaseous diffusion through the skin.
        - Precise determination of the permissible flight time considering gaseous diffusion phenomena.
- Vacuum
    - This applies to situations where a near-vacuum is used to provide the lifting force.
    - The chief concern is ensuring that the structure can safely support a vacuum and has adequate fatigue life to support repeated flights.
    - No airship will be certified as airworthy which relies on a vacuum without the following:
        - Demonstration from proponent that the structure possesses at least a 1.25 factor of safety against yielding at standard sea level external conditions and zero-pressure internal conditions.
        - Determination of pressurization-depressurization cycles which the aircraft can undergo before fatigue renders the structure unairworthy.

2.2.4.1 (c). Risk points for gas-specific safety features

Gas-specific safety standards	Standards met	Standards not met
Risk points	0	Unairworthy

2.2.4.1 (d). Lifting gas venting: all airships must be equipped with a means to quickly vent lifting gas in the event of an emergency. This must be capable of, at minimum, quickly venting both a small fraction of the gas to allow the airship to sink, and quickly venting all or most of the lifting gas.

Gas venting standards	Standards met	Standards not met
Risk points	0	Unairworthy

The reduced risk score in this category may not exceed 33 or the aircraft is rendered unairworthy.

2.2.4.2 Dynamics and handling

2.2.4.2 (a). Dynamic yaw stability: during forward flight, no unstable yaw oscillations may develop. The dynamic yaw stability is assessed by the following table:

Dynamic yaw response characteristics	First-order response	Well damped second-order response ($\zeta > 0.5$)	Lightly damped second-order response ($\zeta < 0.5$)	Unstable first or second-order response
Risk points	0	15	50	Unairworthy

2.2.4.2 (b). Pitch control: the aircraft's pitch must be able to be controlled both at zero airspeed and at nonzero airspeed.

Pitch control	Pitch control standards met	Standards not met
Risk points	0	Unairworthy

2.2.4.2 (c). Yaw control: the airship's yaw must be able to be controlled both at zero airspeed and at nonzero airspeed. At any airspeed from zero to V_H, the airship must be able to generate a yawing moment such that a standard-rate 3-degree per second turn, at minimum, can be established. This is evaluated by the following table:

Yaw rate*	> 5 deg/s	> 4 deg/s	> 3 deg/s	< 3 deg/s
Risk points	0	5	10	Unairworthy

*Note that, for the purposes of assessing the effectiveness of the yaw controls, the yaw rate at maximum control deflection at airspeeds from 0 to V_H. The minimum value in that set is the yaw rate used for this standard.

2.2.4.2 (d). Altitude control: the airship must be able to maintain altitude as the buoyancy of the airship changes. It further must be able to make corrections to altitude to aid in landing. To that, OISC requires two types of altitude control, unless the applicant can demonstrate that another solution accomplishes both goals:

- A system to account for changes in atmospheric conditions, changes in density of the lifting gas, or other large-scale phenomena that would change the trim altitude of the

airship by tens to hundreds of meters. An example of a means to comply with this requirement would be a ballonet, changing the pressure, temperature, or amount of lifting gas in the bag, or using ballast such as water which can be jettisoned.
- A system to produce small changes in altitude, such as those required for takeoff and landing. OSIC recommends a system in which thrust is produced in the vertical direction.

Altitude control requirements	Requirements met	Requirements not met
Risk points	0	Unairworthy

The reduced risk score in this category may not exceed 15 or the aircraft is unairworthy.

2.2.4.3 Structures

2.2.4.3 (a). Structural vibrations: in-flight oscillations during flight test

$f_{modal,structural}$ in relation to $f_{encountered}$	No structural oscillations encountered in any regime of flight	Structural vibrations occur during flight, but there is no noticeable wear after 10 flights	Structural vibrations cause significant and noticeable wear and damage after 10 flights	Structural vibrations cause component failure in flight
Risk points	0	40	Unairworthy	Unairworthy

This must cover vibrations from varying degrees of motor thrust and various airspeeds. Flight test must reveal whether the structural modal frequencies are such that the aircraft structure will excessively vibrate during flight.

2.2.4.3 (b). Material construction: presence of fibrous materials vulnerable to splitting

Presence of fibrous materials	Only isotropic materials used in aircraft structure	Fibrous materials used with overlapping layers offset by at least 60 degrees	Fibrous materials used but no stress is applied orthogonal to fiber	Fibrous materials used with stress orthogonal to fiber
Risk points	0	5	10	Unairworthy

2.2.4.3 (c). Puncture resistance: the applicant must demonstrate that the airship bag will not puncture when exposed to routine puncture risk items such as rocks, dust, precipitation, sharp edges on equipment, etc. The bag must also not be punctured by the structure in the event of a hard landing (2G).

Puncture resistance standards	Standards met	Standards not met
Risk points	0	Unairworthy

2.2.4.3 (d). Envelope skin UV protection: the applicant must specify a total amount of time for which the envelope can be exposed to the UV light without causing damage to the envelope which may result in leaks. The applicant must also specify inspection procedures to locate any UV damage prior to each flight.

UV exposure standards	Standards met	Standards not met
Risk points	0	Unairworthy

The reduced risk score in this category may not exceed 13 or the aircraft is unairworthy.

2.2.4.4 Performance and propulsion

2.2.4.4 (a). Absolute ceiling, density altitude

Absolute ceiling z_{abs}, m	$z_{abs} > 5500$ m	$z_{abs} > 4400$ m	$z_{abs} > 3200$ m	$z_{abs} < 2100$ m
Risk points	0	20	40	Unairworthy

2.2.4.4 (b). Maximum true airspeed developed at standard sea level

Maximum true airspeed u_{∞}, m/s	$u_{\infty} > 3$ m/s	$u_{\infty} > 2$ m/s	$u_{\infty} > 1$m/s	$u_{\infty} < 1$ m/s
Risk points	0	15	30	Unairworthy

The aircraft may be certified for flights in winds not to exceed half of the maximum airspeed the airship can develop.

2.2.4.4 (c). Climb performance: maximum rate of climb at standard sea level

Climb rate, m/s	> 2 m/s	> 1.5 m/s	> 1 m/s	< 1 m/s
Risk points	0	15	30	Unairworthy

2.2.4.4 (d). Descent performance: maximum rate of descent at service ceiling without gas venting

Descent rate, m/s	> 1.5 m/s	> 1 m/s	> 0.5 m/s	< 0.5 m/s
Risk points	0	15	30	Unairworthy

2.2.4.4 (e). Maximum endurance

Endurance, minutes	> 90 minutes	> 60 minutes	> 30 minutes	< 30 minutes
Risk points	0	15	30	Unairworthy

The reduced risk score in this category may not exceed 32 or the aircraft is rendered unairworthy.

2.2.4.5 Electronics

2.2.4.5 (a). Remote control signal reliability: carrier frequency and technology used

Carrier frequency	2.4 GHz spread spectrum with DSMx or similar frequency-hopping features	Legacy carrier frequency without frequency-hopping features
Risk points	0	50

2.2.4.5 (b). Signal reliability: antenna diversity

Diversity features	Antenna diversity on transmitter and receiver	Antenna diversity on transmitter only	Antenna diversity on receiver only	No antenna diversity
Risk points	0	5	20	40

2.2.4.5 (c). ESC current rating in relation to expected maximum current draw through ESC

Value of $\frac{I_{ESC}}{I_{max}}$	$\frac{I_{ESC}}{I_{max}} > 1.5$	$\frac{I_{ESC}}{I_{max}} > 1.25$	$\frac{I_{ESC}}{I_{max}} > 1.1$	$\frac{I_{ESC}}{I_{max}} < 1.1$
Risk points	0	5	15	Unairworthy

Note: this may be inapplicable depending on the method of propulsion used in the airplane.

2.2.4.5 (d). Receiver power source

Configuration	Receiver powered from independent battery and independent BEC	Receiver powered by main flight battery, but through independent BEC	Receiver powered from BEC integrated into ESC
Risk points	0	10	30

2.2.4.5 (e). Auxiliary device power source

Configuration	Powered from independent battery and independent BEC	Powered by main flight battery, but through independent BEC	Powered from BEC integrated into ESC, or powered directly from receiver
Risk points	0	10	30

This includes aircraft lights, autopilots, sensors, etc. This category may be inapplicable depending on whether the aircraft has any auxiliary devices.

Further, all wire sizes must be specified based on the expected current draw according to the chart on the following page:

Wire size (gauge)	Wire conductor diameter (inches)	Maximum continuous current (amps), power transmission	Maximum continuous current (amps), chassis wiring
0000	0.4600	302	380
000	0.4096	239	328
00	0.3648	190	283
0	0.3249	150	245
1	0.2893	119	211
2	0.2576	94	181
3	0.2294	75	158
4	0.2043	60	135
5	0.1819	47	118
6	0.1620	37	101
7	0.1443	30	89
8	0.1285	24	73
9	0.1144	19	64
10	0.1019	15	55
11	0.0907	12	47
12	0.0808	9.3	41
13	0.0720	7.4	35
14	0.0641	5.9	32
15	0.0571	4.7	28
16	0.0508	3.7	22
17	0.0453	2.9	19
18	0.0403	2.3	16
19	0.0359	1.8	14
20	0.0320	1.5	11
21	0.0285	1.2	9
22	0.0253	0.92	7
23	0.0226	0.729	4.7
24	0.0201	0.577	3.5
25	0.0179	0.457	2.7
26	0.0159	0.361	2.2
27	0.0142	0.288	1.7
28	0.0126	0.226	1.4
29	0.0113	0.182	1.2
30	0.0100	0.142	0.86
31	0.0089	0.113	0.7
32	0.0080	0.091	0.53
33	0.0071	0.072	0.43
34	0.0063	0.056	0.33
35	0.0056	0.044	0.27
36	0.0050	0.035	0.21
37	0.0045	0.0289	0.17
38	0.0040	0.0228	0.13
39	0.0035	0.0175	0.11
40	0.0031	0.0137	0.09

Figure 2-8: Electrical wiring ampacity chart

The following requirements apply for conductor sizing:

- In no case may the current in a wire in the aircraft exceed the table value for the wire of the corresponding diameter/gauge.
- The *chassis wiring* specification applies only to wiring runs of a length less than 3.5 meters.
- The *power transmission* specification has no requirement for wiring run length.

2.2.4.5 (f). Wire gauge size: value of design maximum current in relation to table value for maximum

permissible current

Value of $\frac{I_{table}}{I_{design}}$	$\frac{I_{table}}{I_{design}} \geq 1.3$	$\frac{I_{table}}{I_{design}} \geq 1.15$	$\frac{I_{table}}{I_{design}} \geq 1$	$\frac{I_{table}}{I_{design}} < 1$
Risk points	0	5	10	Unairworthy

Additionally, the following requirements apply for wiring:

- All wiring runs must be of a minimal length without the wires cluttering the interior of the airplane.
- Long wiring runs must not be accomplished by connecting multiple extension wires. If multiple lengths of wire are needed, they must be soldered together and secured with heat shrink tubing.

2.2.4.5 (g). Long wiring runs: minimal lengths

Wiring length	Wire runs are of a minimal length without cluttering the interior of the airplane.	Wiring length standards are not met.
Risk points	0	Unairworthy

2.2.4.5 (h). Long wiring runs: connection method between wire lengths

Wiring connections	Long wire runs use a single cable, or multiple cables with soldered joints.	Long wiring connection standards are not met.
Risk points	0	Unairworthy

2.2.4.5 (i). Wiring protection: OISC requires that, wherever a wire is mounted to the airframe, the wire be protected by heat-shrink tubing or a similar means. It is not acceptable to anchor a wire without any protection. Risk points are allocated as follows:

Wire protection standards	Wire protection standards met	Wire protection standards not met
Risk points	0	Unairworthy

The reduced risk score in this category may not exceed 24 or the aircraft is rendered unairworthy.

Part 3: Standards for User-Assembled Commercial Off-The-Shelf Aircraft

OISC assumes that manufacturers will deliver a product which meets basic craftsmanship standards and are mostly well-designed. If the airworthiness assessor deems that these assumptions are not met, the aircraft will be treated as an entirely novel aircraft under section 4.2.

3.1 Experimental Standards

3.1.1 Standards for Airplanes

Any commercial off-the-shelf aircraft meeting operational airworthiness standards is immediately qualified for an experimental airworthiness certificate. This requires the airplane to be from an approved manufacturer. Reference section 2.2.1 for the operational standards.

For an aircraft not from an approved manufacturer to receive an experimental airworthiness certificate, it must be evaluated per the remainder of this section. The primary concern is that the aircraft does not pose an undue risk to the crew operating it, the NAS, or people/property on the ground. This requires that the aircraft be free of any deficiencies which constitute an egregious safety risk.

Based on the total reduced score, the airworthiness status is assessed:

- Below 10: risk level 1
- Between 11 and 20: risk level 2
- Between 21 and 40: risk level 3
- Above 40: unairworthy

3.1.1.1 Structural Standards

The structural standards are characterized by the following areas of concern:

- Wing structure is capable of supporting aircraft mass at a load factor of +3.8 and -1.5.
- Wing torsional rigidity is such that, based on the airworthiness assessor's expertise, there is minimal risk of aileron reversal in flight.
- Torsional rigidity of the horizontal stabilizer is such that, based on the airworthiness assessor's experience, there is minimal risk of in-flight elevator reversal.

If these standards are not met, the aircraft is unairworthy.

3.1.1.1 (a). Wing/stabilizer structural performance: physical test results at maximum load factor in positive direction. See section 1.8.1 for load factor requirements.

Results from physical test	Load is supported without failure or plastic deformation; maximum deflection angle less than 10 degrees	Load is supported without failure or plastic deformation; maximum deflection angle greater than 10 degrees	Load is supported without failure, but plastic deformation occurs	Structure fails
Risk points	0	25	Unairworthy	Unairworthy

3.1.1.1 (b). Wing/stabilizer structural performance: physical test results at maximum load factor in negative direction. See section 1.8.1 for load factor requirements.

Results from physical test	Load is supported without failure or plastic deformation; maximum deflection angle less than 10 degrees	Load is supported without failure or plastic deformation; maximum deflection angle greater than 10 degrees	Load is supported without failure, but plastic deformation occurs	Structure fails
Risk points	0	25	Unairworthy	Unairworthy

3.1.1.1 (c). Wing/stabilizer structural performance: qualitative torsional rigidity evaluation

Expert qualitative evaluation	Torsional stiffness is better than is required	Torsional stiffness is certainly adequate	Torsional stiffness is likely adequate	Torsional stiffness is likely inadequate
Risk points	0	10	30	Unairworthy

If the structures reduced score exceeds 27, the aircraft is unairworthy.

3.1.1.2 Stability and Control Standards

The stability and control standards are characterized by the following areas of concern:

- Size of control surfaces is such that the aircraft can be maneuvered effectively and safely.
- Aircraft possesses, based on a qualitative analysis, static stability about all 3 axes.
- Servo size

If these standards are not met, the aircraft is unairworthy.

3.1.1.2 (a). Control surface sizing qualitative evaluation

Expert qualitative evaluation	Control surface sizing is larger than is required	Control surface sizing is certainly adequate	Control surface sizing is likely adequate	Control surface sizing is likely inadequate
Risk points	0	10	30	Unairworthy

3.1.1.2 (b). Static stability about each axis

Expert qualitative evaluation	Statically stable about all 3 axes	Stable in pitch, but instable in roll or yaw	Does not possess static pitch stability
Risk points	0	50	Unairworthy

3.1.1.2 (c). Qualitative servo size/torque evaluation

Expert qualitative evaluation	Servo size is much greater than is required	Servo size is certainly adequate	Servo size is likely adequate	Servo size is likely inadequate
Risk points	0	10	30	Unairworthy

If the stability and control reduced score exceeds 37, the aircraft is unairworthy.

3.1.1.3 Performance Standards

The performance standards are characterized by the following areas of concern:

- Propulsion system is adequate to provide acceptable climb performance, based on the expertise of the airworthiness assessor.
- The aircraft possesses no features that would make stall recovery unduly difficult, such as: wash-in, an unduly aft CG, or blanketing of the horizontal stabilizer.

If these standards are not met, the aircraft is unairworthy.

3.1.1.3 (a) Propulsion system qualitative evaluation

Expert qualitative evaluation	Propulsion system is larger than is necessary	Propulsion system is certainly adequate	Propulsion system is likely adequate	Propulsion system is likely inadequate
Risk points	0	10	30	Unairworthy

3.1.1.3 (b) Stall recovery qualitative evaluation

Expert qualitative evaluation	Stall recovery evaluated as easy with minimal wing drop	Stall recovery evaluated as easy with significant wing drop	Stall recovery evaluated as moderately difficult but very possible	Stall recovery evaluated as difficult
Risk points	0	10	50	Unairworthy

If the performance reduced score exceeds 40, the aircraft is unairworthy.

3.1.1.4 Electronics Standards

The electronics standards are characterized by the following areas of concern:

- All current draws are such that there is no risk of creating an in-flight fire: conductors must be appropriately sized, and current draws through a given component are below the manufacturer-recommended current draws.
- The radio system is appropriate: it is of an acceptable quality and ideally features technology, such as frequency-hopping features, to maximize reliability.

3.1.1.4 (a). Remote control signal reliability: carrier frequency and technology used

Carrier frequency	2.4 GHz spread spectrum with DSMx or similar frequency-hopping features	Legacy carrier frequency without frequency-hopping features
Risk points	0	50

3.1.1.4 (b). Signal reliability: antenna diversity

Diversity features	Antenna diversity on transmitter and receiver	Antenna diversity on transmitter only	Antenna diversity on receiver only	No antenna diversity
Risk points	0	5	20	40

Further, all wire sizes must be specified based on the expected current draw according to the chart on the following page:

Wire size (gauge)	Wire conductor diameter (inches)	Maximum continuous current (amps), power transmission	Maximum continuous current (amps), chassis wiring
0000	0.4600	302	380
000	0.4096	239	328
00	0.3648	190	283
0	0.3249	150	245
1	0.2893	119	211
2	0.2576	94	181
3	0.2294	75	158
4	0.2043	60	135
5	0.1819	47	118
6	0.1620	37	101
7	0.1443	30	89
8	0.1285	24	73
9	0.1144	19	64
10	0.1019	15	55
11	0.0907	12	47
12	0.0808	9.3	41
13	0.0720	7.4	35
14	0.0641	5.9	32
15	0.0571	4.7	28
16	0.0508	3.7	22
17	0.0453	2.9	19
18	0.0403	2.3	16
19	0.0359	1.8	14
20	0.0320	1.5	11
21	0.0285	1.2	9
22	0.0253	0.92	7
23	0.0226	0.729	4.7
24	0.0201	0.577	3.5
25	0.0179	0.457	2.7
26	0.0159	0.361	2.2
27	0.0142	0.288	1.7
28	0.0126	0.226	1.4
29	0.0113	0.182	1.2
30	0.0100	0.142	0.86
31	0.0089	0.113	0.7
32	0.0080	0.091	0.53
33	0.0071	0.072	0.43
34	0.0063	0.056	0.33
35	0.0056	0.044	0.27
36	0.0050	0.035	0.21
37	0.0045	0.0289	0.17
38	0.0040	0.0228	0.13
39	0.0035	0.0175	0.11
40	0.0031	0.0137	0.09

Figure 3-1: Electrical wiring ampacity chart

The following requirements apply for conductor sizing:

- In no case may the current in a wire in the aircraft exceed the table value for the wire of the corresponding diameter/gauge.
- The *chassis wiring* specification applies only to wiring runs of a length less than 3.5 meters.
- The *power transmission* specification has no requirement for wiring run length.

3.1.1.4 (c). Wire gauge size: value of design maximum current in relation to table value for maximum permissible current

Value of $\frac{I_{table}}{I_{design}}$	$\frac{I_{table}}{I_{design}} \geq 1.3$	$\frac{I_{table}}{I_{design}} \geq 1.15$	$\frac{I_{table}}{I_{design}} \geq 1$	$\frac{I_{table}}{I_{design}} < 1$
Risk points	0	5	10	Unairworthy

3.1.1.4 (d). Wiring protection: OISC requires that, wherever a wire is mounted to the airframe, the wire be protected by heat-shrink tubing or a similar means. It is not acceptable to anchor a wire without any protection. Risk points are allocated as follows:

Wire protection standards	Wire protection standards met	Wire protection standards not met
Risk points	0	Unairworthy

If the electronics reduced score exceeds 53, the aircraft is unairworthy.

3.1.2 Standards for Multirotors

The airworthiness status of the aircraft is found based on the reduced risk score:

- Less than 12: risk level 1
- Between 13 and 30: risk level 2
- Between 31 and 62: risk level 3
- Greater than 62: unairworthy

3.1.2.1 Overall Design Characteristics

3.1.2.1 (a). Type of stability augmentation system

Stability augmentation system presence and characteristics	Type 1 or type 2 SAS	Type 3 SAS	Type 4 SAS	No SAS
Risk points	0	20	50	95

The various types of stability augmentation system capabilities are defined as follows:

- Type 1: SAS can hold position and altitude when both control sticks are centered, regardless of wind. SAS automatically maintains altitude as pitch and bank are adjusted. Control sticks are used to command altitude rate, yaw rate, pitch angle, and bank angle. The position and altitude are known both a barometric altimeter and/or GPS.
- Type 2: SAS can hold position and altitude when both control sticks are centered, regardless of wind. SAS automatically maintains altitude as pitch and bank are adjusted. Control sticks are used to command altitude rate, yaw rate, pitch angle, and bank angle. The position and altitude are found based on the IMU alone.
- Type 3: SAS can hold altitude and attitude when both control sticks are centered but does not hold position. Control sticks are used to command altitude rate, yaw rate, pitch angle, and bank angle.
- Type 4: SAS is used to allow user to command altitude rate, yaw rate, pitch rate, bank rate. No altitude-hold or position-hold features.
- Types 3 and 4 stability augmentation systems require the aircraft to be trimmable.

OISC does not require experimental multirotors to have a stability augmentation system onboard.

3.1.2.1 (b). Redundancy: number of motors

Number of motors	3	4	5	6 or more
Risk points	50	40	30	0

3.1.2.1 (c). Vibration: fastener securing

Fastener securing	Fasteners secured with two of the approved methods	Fasteners secured with one of the approved methods	Fasteners unsecured; conditions for unsecure fasteners are met	Fasteners unsecured; conditions for unsecure fasteners are not met
Risk points	0	10	80	Unairworthy

Approved fastener securing methods:

- Safety wire
- Nylon locking nuts
- Thread locking compound, such as Loctite
- Castle nut and locking pin
- Split beam nut
- Locking plate or tab washer

Conditions to leave fasteners unsecured: the applicant must demonstrate compliance with the following:

- The aircraft's maximum takeoff weight must not exceed 10 lbs (4.5 kg).
- The aircraft must strictly be flown in daytime VFR conditions and within VLOS.
- The aircraft must never be flown in a crowded environment such that there is a substantial risk of it flying over people. For example, flights over campus would be prohibited since, even if the PIC makes the utmost effort to avoid flights over people, campus is sufficiently congested that, realistically, this is difficult to avoid.
- The applicant must demonstrate that the vibration produced on the aircraft is such that, after 60 minutes of consecutive flights, all fasteners remain firmly anchored.

If the reduced score in this category exceeds 69, the aircraft is unairworthy.

3.1.2.2 Structures Standards

Motor mounting structure: standards relating to effect of beam structure deflection. The deflection must be so severe such that:

- The propellers interfere with each other
- The propellers interfere with other parts of the aircraft structure

The standards for motor mounting structure deflection delineated previously in this section still apply.

3.1.2.2 (a). Risk points are allotted based on meeting the above standards:

Interference and deflection standards result	Standards met	Standards not met
Risk points	0	Unairworthy

3.1.2.2 (b). Whole aircraft torsional rigidity: maximum twist angle between opposing sides of vehicle during maximum yaw rate maneuver.

Deflection angle θ	$\theta < 2.5^o$	$\theta < 5^o$	$\theta < 7.5^o$	$\theta > 7.5^o$
Risk points	0	20	30	Unairworthy

This requirement describes the torsion which occurs when the aircraft is executing a yaw maneuver. In this configuration, the thrust of one propeller will be changed relative to the adjacent motor. The resulting moment causes the torsion evaluated by this section.

3.1.2.2 (c). Structural vibrations: in-flight oscillations during flight test

$f_{modal,structural}$ in relation to $f_{encountered}$	No structural oscillations encountered in any regime of flight	Structural vibrations occur during flight, but there is no noticeable wear after 10 flights	Structural vibrations cause significant and noticeable wear and damage after 10 flights	Structural vibrations cause component failure in flight
Risk points	0	40	Unairworthy	Unairworthy

This must cover vibrations from varying degrees of motor thrust and various airspeeds. Flight test must reveal whether the structural modal frequencies are such that the aircraft structure will excessively vibrate during flight.

3.1.2.2 (d). Material construction: presence of fibrous materials vulnerable to splitting

Presence of fibrous materials	Only isotropic materials used in aircraft structure	Fibrous materials used with overlapping layers offset by at least 60 degrees	Fibrous materials used but no stress is applied orthogonal to fiber	Fibrous materials used with stress orthogonal to fiber
Risk points	0	5	10	Unairworthy

If the reduced score in this category exceeds 20, the aircraft is unairworthy.

3.1.2.3 Stability, Dynamics, and Control Standards

3.1.2.3 (a). Pitch and bank angle limitation

Pitch and bank limits	Limits are below FOM-defined thresholds	Limits meet FOM-defined threshold	No SAS limits: reliant on pilot to maintain FOM pitch and bank limits
Risk points	0	5	30

This is the only requirement OISC has for experimental certification of multirotors with respect to stability, dynamics, and control since evaluation of these standards is strongly dependent on flight test.

3.1.2.4 Electronics Standards

3.1.2.4 (a). Remote control signal reliability: carrier frequency and technology used

Carrier frequency	2.4 GHz spread spectrum with DSMx or similar frequency-hopping features	Legacy carrier frequency without frequency-hopping features
Risk points	0	50

3.1.2.4 (b). Signal reliability: antenna diversity

Diversity features	Antenna diversity on transmitter and receiver	Antenna diversity on transmitter only	Antenna diversity on receiver only	No antenna diversity
Risk points	0	5	20	40

The reduced score in this category may not exceed 100 or the aircraft is unairworthy.

3.1.2.5 Propulsion and Performance Standards

3.1.2.5 (a). Maximum endurance:

Endurance	> 20 mins	> 12 mins	> 5 mins	< 5 mins
Risk points	0	20	40	Unairworthy

This must be found from flight test. This must include adequate reserve. For example, if using LiPo batteries, there must be sufficient voltage remaining to serve as a reserve. This means generally that the cell voltage must be kept above a predefined value. Similarly, for fueled propulsion systems, this endurance must be established with reserve fuel in the tank. The precise amount of reserve required is highly dependent on the aircraft and application, and as such is to be set by the airworthiness assessor.

3.1.2.5 (b). Vibration: propeller balance

Propeller balance characteristics	Negligible vibration: propeller center of gravity within 0.001 inches of propeller axis	Small vibration: propeller center of gravity within 0.005 inches of propeller axis	Moderate or greater vibrations; propeller center of gravity further than 0.005 inches from propeller
Risk points	0	10	Unairworthy

3.1.2.5 (c). Vibration: motor vibration

Vibration characteristics	Negligible vibration: vibration amplitude less than 0.001 inch	Small vibrations: vibration amplitude less than 0.005 inch	Moderate vibrations: vibration amplitude greater than 0.005 inch
Risk points	0	10	Unairworthy

The reduced score in this category may not exceed 20 or the aircraft is unairworthy

3.1.3 Standards for Helicopters

Any commercial off-the-shelf aircraft meeting operational airworthiness standards is immediately qualified for an experimental airworthiness certificate. This requires the airplane to be from an approved manufacturer. Reference section 3.2.3 for the operational standards.

For an aircraft not from an approved manufacturer to receive an experimental airworthiness certificate, it must be evaluated per the remainder of this section. The primary concern is that the aircraft does not pose an undue risk to the crew operating it, the NAS, or people/property on the ground. This requires that the aircraft be free of any deficiencies which constitute an egregious safety risk.

The airworthiness status is found based on the reduced risk score:

- Between 0 and 5: risk level 1
- Between 6 and 15: risk level 2
- Between 16 and 27: risk level 3
- Greater than 27: unairworthy

3.1.3.1 Overall design

3.1.3.1 (a). Build quality evaluation

Build quality	1: Comparable to that of approved manufacturers	2: Overall good quality, but falls short of that of approved manufacturers	3: Overall decent build quality but lacks craftsmanship in some areas	4: Poor build quality
Risk points	0	10	20	Unairworthy

As previously mentioned, an evaluation of manufacturer build quality is reliant on the airworthiness assessor’s experience. In order to qualify each degree of build quality, the following guidelines exist:

- Level 1: The airplane is built with tight tolerances, all components in precise alignment with one another, and all components are made of high-quality materials. This also requires that components fit flush to one another. Further, this level describes airplanes in which appropriate materials are used to reinforce the structure, i.e. using a carbon fiber spar in a foam wing as opposed to using an unreinforced foam wing.
- Level 2: This describes an airplane which is built with a decent level of craftsmanship but falls short of level 1 standards. This, for example, could include a foam wing reinforced with a weaker spar, or an airplane made with looser but acceptable tolerances.
- Level 3: the aircraft generally meets level 2 build quality standards but not in all realms. For instance, the tolerances may be acceptable but not the wing reinforcement. To qualify for level 3 scoring, no part of the airplane may meet the description for level 4 build quality.
- Level 4: this describes an aircraft which has excessively loose tolerances, poor alignment between components, low-quality materials, or poor fit between components.

3.1.3.1 (b). Tail rotor ground strike protection. OISC requires that the tail rotor be protected from ground strikes by means of a skid plate mounted such that, as the helicopter is pitched up, the tail skid contacts the ground and clearance between the ground and tail rotor is maintained. Risk points are assessed as follows:

Tail rotor protection	Inapplicable due to design features such as counter rotating rotors or a ducted fan tail rotor	Clearance greater than 1/10 of the rotor radius	Clearance greater than 1/20 of the rotor radius	Clearances less than 1/20 of the rotor radius
Risk points	0	15	30	Unairworthy

3.1.3.1 (c). Tail rotor placement: the applicant must show that the tail rotor is located such that yaw control can be maintained in normal flight without requiring exceptional pilot skill or exceptionally favorable conditions. This is evaluated based on the worst-case Cooper-Harper score for maintaining a heading in any normal flight regime.

Cooper-Harper score CH	$CH < 3$	$CH \leq 4$	$CH \leq 6$	$CH > 6$
Risk points	0	10	20	Unairworthy

3.1.3.1 (d). Rotor clearance: with the least favorable cyclic control and least favorable load factor, the rotor must clear any other part of the aircraft (such as the boom or fuselage) by at least 1% of the rotor diameter. Risk points are assessed as follows:

Clearance as measured by: $\frac{z_{clear}}{d_{rotor}}$	$\frac{z_{clear}}{d_{rotor}} > 0.05$	$\frac{z_{clear}}{d_{rotor}} > 0.025$	$\frac{z_{clear}}{d_{rotor}} > 0.01$	$\frac{z_{clear}}{d_{rotor}} < 0.01$
Risk points	0	15	30	Unairworthy

3.1.3.1 (e). Vibration: fastener securing

Fastener securing	Fasteners secured with two of the approved methods	Fasteners secured with one of the approved methods	Fasteners unsecured; conditions for unsecure fasteners are met	Fasteners unsecured; conditions for unsecure fasteners are not met
Risk points	0	10	80	Unairworthy

Approved fastener securing methods:

- Safety wire
- Nylon locking nuts
- Thread locking compound, such as Loctite

- Castle nut and locking pin
- Split beam nut
- Locking plate or tab washer

Conditions to leave fasteners unsecured: the applicant must demonstrate compliance with the following:

- The aircraft's maximum takeoff weight must not exceed 10 lbs (4.5 kg).
- The aircraft must strictly be flown in daytime VFR conditions and within VLOS.
- The aircraft must never be flown in a crowded environment such that there is a substantial risk of it flying over people. For example, flights over campus would be prohibited since, even if the PIC makes the utmost effort to avoid flights over people, campus is sufficiently congested that, realistically, this is difficult to avoid.
- The applicant must demonstrate that the vibration produced on the aircraft is such that, after 60 minutes of consecutive flights, all fasteners remain firmly anchored.

Jesus bolts. Any bolts or nut on the aircraft which would cause complete loss of the aircraft in the event of failure must meet the following criteria:

- Safety factor against yielding not less than 2 with MTOW, maximum rotor thrust, and maximum load factor.
- Two methods to prevent the bolt/nut from loosening over time. The approved methods are listed below:
    - Thread locking compound, such as Loctite
    - Safety wire
    - Castle nut and locking pin
- The applicant must delineate an inspection and maintenance schedule for any of these bolts/nuts.

3.1.3.1 (f). Risk points are allocated for Jesus bolts as follows:

Safety factor	$FS \geq 3$	$FS \geq 2.5$	$FS \geq 2$	$FS < 2$
Risk points	0	15	30	Unairworthy

3.1.3.1 (g). Other standards for Jesus bolts:

Other standards met?	Met	Not met
Risk points	0	Unairworthy

The reduced risk score in this category may not exceed 30 or the aircraft is rendered unairworthy.

3.1.3.2 Swashplate Mechanisms

3.1.3.2 (a). Swashplate motion smoothness: the swashplate must move smoothly up and down the shaft without binding. Since it is typical for the smoothness of motion to degrade with time as lubrication is expelled from the swashplate mechanism, the risk is evaluated based on the amount of time smooth motion can be maintained while running the rotor at maximum RPM.

Time for which smooth motion is maintained	Greater than 90 minutes	Greater than 60 minutes	Greater than 30 minutes	Less than 30 minutes
Risk points	0	25	50	Unairworthy

The maximum flight time must be specified based on the time for which smooth motion can be maintained. The maximum flight time is not to exceed half of the time for which smooth motion is maintained.

3.1.3.3 Propulsion and performance

3.1.3.3 (a). Maximum endurance:

Endurance	> 20 mins	> 12 mins	> 5 mins	< 5 mins
Risk points	0	20	40	Unairworthy

This must be found from flight test. This must include adequate reserve. For example, if using LiPo batteries, there must be sufficient voltage remaining to serve as a reserve. This means generally that the cell voltage must be kept above a predefined value. Similarly, for fueled propulsion systems, this endurance must be established with reserve fuel in the tank. The precise amount of reserve required is highly dependent on the aircraft and application, and as such is to be set by the airworthiness assessor.

3.1.3.3 (b). Vibration: rotor balance

Rotor balance characteristics	Negligible vibration: rotor center of gravity within 0.001 inches of propeller axis	Small vibration: rotor center of gravity within 0.005 inches of propeller axis	Moderate or greater vibrations; rotor center of gravity further than 0.005 inches from propeller
Risk points	0	10	Unairworthy

3.1.3.3 (c). Vibration: motor vibration

Vibration characteristics	Negligible vibration: vibration amplitude less than 0.001 inch	Small vibrations: vibration amplitude less than 0.005 inch	Moderate vibrations: vibration amplitude greater than 0.005 inch
Risk points	0	10	Unairworthy

3.1.3.3 (d). Vibration: damping of propulsion system vibrations

Damping characteristics present	Viscous liquid dampers are used	Rubber vibration isolating devices are used	No vibration damping is present, propeller balance and motor vibration score of 0	No vibration damping is present, nonzero propeller/motor vibration score
Risk points	0	20	20	Unairworthy

The reduced risk score in this category may not exceed 20 or the aircraft is rendered unairworthy.

3.1.3.4 Electronics

3.1.3.4 (a). Remote control signal reliability: carrier frequency and technology used

Carrier frequency	2.4 GHz spread spectrum with DSMx or similar frequency-hopping features	Legacy carrier frequency without frequency-hopping features
Risk points	0	50

3.1.3.4 (b). Signal reliability: antenna diversity

Diversity features	Antenna diversity on transmitter and receiver	Antenna diversity on transmitter only	Antenna diversity on receiver only	No antenna diversity
Risk points	0	5	20	40

3.1.3.4 (c). ESC current rating in relation to expected maximum current draw through ESC

Value of $\frac{I_{ESC}}{I_{max}}$	$\frac{I_{ESC}}{I_{max}} > 1.5$	$\frac{I_{ESC}}{I_{max}} > 1.25$	$\frac{I_{ESC}}{I_{max}} > 1.1$	$\frac{I_{ESC}}{I_{max}} < 1.1$
Risk points	0	5	15	Unairworthy

Note: this may be inapplicable depending on the method of propulsion used in the airplane.

3.1.3.4 (d). Receiver power source

Configuration	Receiver powered from independent battery and independent BEC	Receiver powered by main flight battery, but through independent BEC	Receiver powered from BEC integrated into ESC
Risk points	0	10	30

3.1.3.4 (e). Auxiliary device power source

Configuration	Powered from independent battery and independent BEC	Powered by main flight battery, but through independent BEC	Powered from BEC integrated into ESC, or powered directly from receiver
Risk points	0	10	30

This includes aircraft lights, autopilots, sensors, etc. This category may be inapplicable depending on whether the aircraft has any auxiliary devices.

Further, all wire sizes must be specified based on the expected current draw according to the chart on the following page:

Wire size (gauge)	Wire conductor diameter (inches)	Maximum continuous current (amps), power transmission	Maximum continuous current (amps), chassis wiring
0000	0.4600	302	380
000	0.4096	239	328
00	0.3648	190	283
0	0.3249	150	245
1	0.2893	119	211
2	0.2576	94	181
3	0.2294	75	158
4	0.2043	60	135
5	0.1819	47	118
6	0.1620	37	101
7	0.1443	30	89
8	0.1285	24	73
9	0.1144	19	64
10	0.1019	15	55
11	0.0907	12	47
12	0.0808	9.3	41
13	0.0720	7.4	35
14	0.0641	5.9	32
15	0.0571	4.7	28
16	0.0508	3.7	22
17	0.0453	2.9	19
18	0.0403	2.3	16
19	0.0359	1.8	14
20	0.0320	1.5	11
21	0.0285	1.2	9
22	0.0253	0.92	7
23	0.0226	0.729	4.7
24	0.0201	0.577	3.5
25	0.0179	0.457	2.7
26	0.0159	0.361	2.2
27	0.0142	0.288	1.7
28	0.0126	0.226	1.4
29	0.0113	0.182	1.2
30	0.0100	0.142	0.86
31	0.0089	0.113	0.7
32	0.0080	0.091	0.53
33	0.0071	0.072	0.43
34	0.0063	0.056	0.33
35	0.0056	0.044	0.27
36	0.0050	0.035	0.21
37	0.0045	0.0289	0.17
38	0.0040	0.0228	0.13
39	0.0035	0.0175	0.11
40	0.0031	0.0137	0.09

Figure 3-2: Electrical wiring ampacity chart

The following requirements apply for conductor sizing:

- In no case may the current in a wire in the aircraft exceed the table value for the wire of the corresponding diameter/gauge.
- The *chassis wiring* specification applies only to wiring runs of a length less than 3.5 meters.
- The *power transmission* specification has no requirement for wiring run length.

3.1.3.4 (f). Wire gauge size: value of design maximum current in relation to table value for maximum permissible current

Value of $\frac{I_{table}}{I_{design}}$	$\frac{I_{table}}{I_{design}} \geq 1.3$	$\frac{I_{table}}{I_{design}} \geq 1.15$	$\frac{I_{table}}{I_{design}} \geq 1$	$\frac{I_{table}}{I_{design}} < 1$
Risk points	0	5	10	Unairworthy

Additionally, the following requirements apply for wiring:

- All wiring runs must be of a minimal length without the wires cluttering the interior of the airplane.
- Long wiring runs must not be accomplished by connecting multiple extension wires. If multiple lengths of wire are needed, they must be soldered together and secured with heat shrink tubing.

3.1.3.4 (g). Long wiring runs: minimal lengths

Wiring length	Wire runs are of a minimal length without cluttering the interior of the airplane.	Wiring length standards are not met.
Risk points	0	Unairworthy

3.1.3.4 (h). Long wiring runs: connection method between wire lengths

Wiring connections	Long wire runs use a single cable, or multiple cables with soldered joints.	Long wiring connection standards are not met.
Risk points	0	Unairworthy

3.1.3.4 (i). Wiring protection: OISC requires that, wherever a wire is mounted to the airframe, the wire be protected by heat-shrink tubing or a similar means. It is not acceptable to anchor a wire without any protection. Risk points are allocated as follows:

Wire protection standards	Wire protection standards met	Wire protection standards not met
Risk points	0	Unairworthy

The reduced risk score in this category may not exceed 24 or the aircraft is rendered unairworthy.

3.1.3.5 Structures

3.1.3.5 (a). Material construction: presence of fibrous materials vulnerable to splitting

Presence of fibrous materials	Only isotropic materials used in aircraft structure	Fibrous materials used with overlapping layers offset by at least 60 degrees	Fibrous materials used but no stress is applied orthogonal to fiber	Fibrous materials used with stress orthogonal to fiber
Risk points	0	5	10	Unairworthy

3.1.4 Standards for Airships

The airworthiness status is found based on the reduced risk score:

- Between 0 and 5: risk level 1
- Between 6 and 10: risk level 2
- Between 11 and 18: risk level 3
- Greater than 18: unairworthy

3.1.4.1 Overall design characteristics

3.1.4.1 (a). Type of airship

Airship type	Rigid airship	Semi-rigid airship	Non-rigid airship
Risk points	0	15	30

The definitions for each type of airship are below:

- Rigid airship – an airship with an internal structure which supports the envelope and maintains the external shape of the airship independent of the pressure within the airship.
- Semi-rigid airship – an airship with a stiff (or semi-stiff) keel or truss supports the airship along its lower length. The external shape of the envelope is maintained by air pressure.
- Non-rigid airship – an airship which requires air pressure to maintain the external shape of the envelope and obtains most of its strength and stiffness from the pressurized envelope.

3.1.4.1 (b). Lifting gas

Lifting gas risk level	Risk level 1 gas	Risk level 2 gas	Risk level 3 gas	Risk level 4 gas
Risk points	0	30	80	Unairworthy

The following list details the kinds of lifting gas and the associated risk levels:

- Risk level 1 gasses
  - Helium
  - Ammonia
  - Neon
  - Nitrogen
  - Any non-flammable, non-toxic, cold gas
- Risk level 2 gasses
  - Hot air
  - Water vapor
  - Vacuum
  - Any hot, non-flammable, non-toxic gas or gasses which require low pressures
- Risk level 3 gasses
  - Hydrogen
  - Methane
  - Acetylene
  - Coal gas
  - Any flammable non-toxic gas
- Risk level 4 gasses
  - Plasma
  - Hydrogen cyanide
  - Hydrogen fluoride
  - Any excessively hot or toxic gas

Lifting gas safety features: OISC requires the airship to be equipped with certain safety features depending on the type of lifting gas. These requirements are detailed below:

- Flammable gasses
  - This applies to hydrogen, methane, acetylene, and coal gas or any other flammable gas.
  - The chief concern is that the lifting gas could ignite.
  - No airship will be certified as airworthy which uses flammable gas without the following:
    - Design features to ensure no ignition sources exist within 20cm of the envelope containing the lifting gas.
    - A plan for rigorous inspection of the aircraft before and after flight to locate any leaks.
    - Safety plan to mitigate fire risk during flight, gas filling, and gas removal approved by OISC and a local fire department.
- Hot gasses

    - This applies to hot air, water vapor, and any other gas which is heated to a temperature above atmospheric temperature to function.
    - The chief concern is that the heat could soften any materials used in constructing the airship, potentially causing loss of pressure or structural failure.
    - No airship will be certified as airworthy which uses hot gasses without the following:
        - Design features to closely regulate the gas temperature and alert the crew if the temperature is outside of acceptable ranges.
        - Analysis to show that the chosen materials can withstand the heat of these gasses without decreasing stiffness or strength material parameters to the point of causing excessive deformation or material failure.
        - Design features to ensure that any heating apparatuses cannot ignite the structure of the airship itself.
- Gasses which can diffuse through common skin materials
    - This applies to hydrogen, helium, and any other generally monoatomic gas which can easily diffuse through common skin materials.
    - The chief concern is that the gas can diffuse through the skin of the aircraft and the pressure can be lost over time, which could reduce the lift force generated over time.
    - No airship will be certified as airworthy which uses gasses prone to diffusion through skin without the following:
        - Design features to closely monitor the pressure inside the airship and to alert the crew if the pressure drops too low.
        - Selection of skin material to minimize gaseous diffusion through the skin.
        - Precise determination of the permissible flight time considering gaseous diffusion phenomena.
- Vacuum
    - This applies to situations where a near-vacuum is used to provide the lifting force.
    - The chief concern is ensuring that the structure can safely support a vacuum and has adequate fatigue life to support repeated flights.
    - No airship will be certified as airworthy which relies on a vacuum without the following:
        - Demonstration from proponent that the structure possesses at least a 1.25 factor of safety against yielding at standard sea level external conditions and zero-pressure internal conditions.
        - Determination of pressurization-depressurization cycles which the aircraft can undergo before fatigue renders the structure unairworthy.

3.1.4.1 (c). Risk points for gas-specific safety features

Gas-specific safety standards	Standards met	Standards not met
Risk points	0	Unairworthy

3.1.4.1 (d). Lifting gas venting: all airships must be equipped with a means to quickly vent lifting gas in the event of an emergency. This must be capable of, at minimum, quickly venting both a small fraction of the gas to allow the airship to sink, and quickly venting all or most of the lifting gas.

Gas venting standards	Standards met	Standards not met
Risk points	0	Unairworthy

3.1.4.1 (e). Build quality evaluation

Build quality	1: Comparable to that of approved manufacturers	2: Overall good quality, but falls short of that of approved manufacturers	3: Overall decent build quality but lacks craftsmanship in some areas	4: Poor build quality
Risk points	0	10	20	Unairworthy

As previously mentioned, an evaluation of manufacturer build quality is reliant on the airworthiness assessor's experience. In order to qualify each degree of build quality, the following guidelines exist:

- Level 1: The airplane is built with tight tolerances, all components in precise alignment with one another, and all components are made of high-quality materials. This also requires that components fit flush to one another. Further, this level describes airplanes in which appropriate materials are used to reinforce the structure, i.e. using a carbon fiber spar in a foam wing as opposed to using an unreinforced foam wing.
- Level 2: This describes an airplane which is built with a decent level of craftsmanship but falls short of level 1 standards. This, for example, could include a foam wing reinforced with a weaker spar, or an airplane made with looser but acceptable tolerances.
- Level 3: the aircraft generally meets level 2 build quality standards but not in all realms. For instance, the tolerances may be acceptable but not the wing reinforcement. To qualify for level 3 scoring, no part of the airplane may meet the description for level 4 build quality.
- Level 4: this describes an aircraft which has excessively loose tolerances, poor alignment between components, low-quality materials, or poor fit between components.

The reduced risk score in this category may not exceed 30 or the aircraft is rendered unairworthy.

3.1.4.2 Dynamics and handling

3.1.4.2 (a). Pitch control: the aircraft's pitch must be able to be controlled both at zero airspeed and at nonzero airspeed.

Pitch control	Pitch control standards met	Standards not met
Risk points	0	Unairworthy

3.1.4.2 (b). Altitude control: the airship must be able to maintain altitude as the buoyancy of the airship changes. It further must be able to make corrections to altitude to aid in landing. To that, OISC requires two types of altitude control, unless the applicant can demonstrate that another solution accomplishes both goals:

- A system to account for changes in atmospheric conditions, changes in density of the lifting gas, or other large-scale phenomena that would change the trim altitude of the airship by tens to hundreds of meters. An example of a means to comply with this requirement would be a ballonet, changing the pressure, temperature, or amount of lifting gas in the bag, or using ballast such as water which can be jettisoned.
- A system to produce small changes in altitude, such as those required for takeoff and landing. OSIC recommends a system in which thrust is produced in the vertical direction.

Altitude control requirements	Requirements met	Requirements not met
Risk points	0	Unairworthy

3.1.4.2 (c). Yaw control: the aircraft's yaw must be able to be controlled both at zero airspeed and at nonzero airspeed.

Yaw control	Yaw control standards met	Standards not met
Risk points	0	Unairworthy

The reduced risk score in this category may not exceed 0 since the criteria in this category are binary.

3.1.4.3 Structures

3.1.4.3 (a). Puncture resistance: the applicant must demonstrate that the airship bag will not puncture when exposed to routine puncture risk items such as rocks, dust, precipitation, sharp edges on equipment, etc. The bag must also not be punctured by the structure in the event of a hard landing (2G).

Puncture resistance standards	Standards met	Standards not met
Risk points	0	Unairworthy

3.1.4.3 (b). Envelope skin UV protection: the applicant must specify a total amount of time for which the envelope can be exposed to the UV light without causing damage to the envelope which may result in leaks. The applicant must also specify inspection procedures to locate any UV damage prior to each flight.

UV exposure standards	Standards met	Standards not met
Risk points	0	Unairworthy

3.1.4.3 (c). Material construction: presence of fibrous materials vulnerable to splitting

Presence of fibrous materials	Only isotropic materials used in aircraft structure	Fibrous materials used with overlapping layers offset by at least 60 degrees	Fibrous materials used but no stress is applied orthogonal to fiber	Fibrous materials used with stress orthogonal to fiber
Risk points	0	5	10	Unairworthy

The reduced risk score in this category may not exceed 3 or the aircraft is rendered unairworthy.

3.1.4.4 Performance and propulsion

3.1.4.4 (a). Maximum endurance

Endurance, minutes	> 90 minutes	> 60 minutes	> 30 minutes	< 30 minutes
Risk points	0	15	30	Unairworthy

3.1.4.4 (b). Absolute ceiling, density altitude

Absolute ceiling z_{abs}, m	$z_{abs} > 5500$ m	$z_{abs} > 4400$ m	$z_{abs} > 3200$ m	$z_{abs} < 2100$ m
Risk points	0	20	40	Unairworthy

The reduced risk score in this category may not exceed 35 or the aircraft is rendered unairworthy.

3.1.4.5 Electronics

3.1.4.5 (a). Remote control signal reliability: carrier frequency and technology used

Carrier frequency	2.4 GHz spread spectrum with DSMx or similar frequency-hopping features	Legacy carrier frequency without frequency-hopping features
Risk points	0	50

3.1.4.5 (b). Signal reliability: antenna diversity

Diversity features	Antenna diversity on transmitter and receiver	Antenna diversity on transmitter only	Antenna diversity on receiver only	No antenna diversity
Risk points	0	5	20	40

3.1.4.5 (c). ESC current rating in relation to expected maximum current draw through ESC

Value of $\frac{I_{ESC}}{I_{max}}$	$\frac{I_{ESC}}{I_{max}} > 1.5$	$\frac{I_{ESC}}{I_{max}} > 1.25$	$\frac{I_{ESC}}{I_{max}} > 1.1$	$\frac{I_{ESC}}{I_{max}} < 1.1$
Risk points	0	5	15	Unairworthy

Further, all wire sizes must be specified based on the expected current draw according to the chart on the following page:

Wire size (gauge)	Wire conductor diameter (inches)	Maximum continuous current (amps), power transmission	Maximum continuous current (amps), chassis wiring
0000	0.4600	302	380
000	0.4096	239	328
00	0.3648	190	283
0	0.3249	150	245
1	0.2893	119	211
2	0.2576	94	181
3	0.2294	75	158
4	0.2043	60	135
5	0.1819	47	118
6	0.1620	37	101
7	0.1443	30	89
8	0.1285	24	73
9	0.1144	19	64
10	0.1019	15	55
11	0.0907	12	47
12	0.0808	9.3	41
13	0.0720	7.4	35
14	0.0641	5.9	32
15	0.0571	4.7	28
16	0.0508	3.7	22
17	0.0453	2.9	19
18	0.0403	2.3	16
19	0.0359	1.8	14
20	0.0320	1.5	11
21	0.0285	1.2	9
22	0.0253	0.92	7
23	0.0226	0.729	4.7
24	0.0201	0.577	3.5
25	0.0179	0.457	2.7
26	0.0159	0.361	2.2
27	0.0142	0.288	1.7
28	0.0126	0.226	1.4
29	0.0113	0.182	1.2
30	0.0100	0.142	0.86
31	0.0089	0.113	0.7
32	0.0080	0.091	0.53
33	0.0071	0.072	0.43
34	0.0063	0.056	0.33
35	0.0056	0.044	0.27
36	0.0050	0.035	0.21
37	0.0045	0.0289	0.17
38	0.0040	0.0228	0.13
39	0.0035	0.0175	0.11
40	0.0031	0.0137	0.09

Figure 3-3: Electrical wiring ampacity chart

The following requirements apply for conductor sizing:

- In no case may the current in a wire in the aircraft exceed the table value for the wire of the corresponding diameter/gauge.
- The *chassis wiring* specification applies only to wiring runs of a length less than 3.5 meters.
- The *power transmission* specification has no requirement for wiring run length.

3.1.4.5 (d). Wire gauge size: value of design maximum current in relation to table value for maximum permissible current

Value of $\frac{I_{table}}{I_{design}}$	$\frac{I_{table}}{I_{design}} \geq 1.3$	$\frac{I_{table}}{I_{design}} \geq 1.15$	$\frac{I_{table}}{I_{design}} \geq 1$	$\frac{I_{table}}{I_{design}} < 1$
Risk points	0	5	10	Unairworthy

Additionally, the following requirements apply for wiring:

- All wiring runs must be of a minimal length without the wires cluttering the interior of the airplane.
- Long wiring runs must not be accomplished by connecting multiple extension wires. If multiple lengths of wire are needed, they must be soldered together and secured with heat shrink tubing.

3.1.4.5 (e). Long wiring runs: minimal lengths

Wiring length	Wire runs are of a minimal length without cluttering the interior of the airplane.	Wiring length standards are not met.
Risk points	0	Unairworthy

3.1.4.5 (f). Long wiring runs: connection method between wire lengths

Wiring connections	Long wire runs use a single cable, or multiple cables with soldered joints.	Long wiring connection standards are not met.
Risk points	0	Unairworthy

3.1.4.5 (g). Wiring protection: OISC requires that, wherever a wire is mounted to the airframe, the wire be protected by heat-shrink tubing or a similar means. It is not acceptable to anchor a wire without any protection. Risk points are allocated as follows:

Wire protection standards	Wire protection standards met	Wire protection standards not met
Risk points	0	Unairworthy

The reduced risk score in this category may not exceed 24 or the aircraft is rendered unairworthy.

3.2 Operational Standards

3.2.1 Standards for Airplanes

There are several different standards that apply:

- Standards for ARF or kit airplanes. This includes commercial off-the-shelf kits which include the airframe and manufacturer-recommended configurations for electronics and other accessories.
- Standards for airframe-only kits. This includes commercial off-the-shelf kits which do not come with any manufacturer-recommended configurations for electronics or other accessories. In this case, the end user is expected to provide the appropriate servos, propulsion system, and electronics.

In general, OISC assumes that the airframe design is adequate in the areas of stability, aerodynamic performance, and structures. However, OISC reserves the right to assess the airframe as an entirely novel aircraft per section 4.2 of this manual in the following circumstances:

- The manufacturer of the airframe is of a questionable reputation, or there is reason to believe that the quality of the airframe is in question.
- The sizing of key aerodynamic surfaces, such as the vertical/horizontal stabilizer or control surfaces, is believed to be inadequate to provide acceptable stability and control of the aircraft according to the airworthiness assessor's expertise.
- The structure is of questionable effectiveness, as evidenced by the materials used, size of key structural elements, and overall structure design.
- The Director of Flight Operations recommends that the aircraft be treated as an entirely novel aircraft.

3.2.1.1 Standards for ARF Airplanes

The standards for ARF airplanes are characterized by ensuring that the airplane is built according to the manufacturer's standards, and that the electronics meet the manufacturer's recommended specifications.

Build quality standards

- The aircraft must be built strictly according to the manufacturer's recommended build process.
- All parts must fit as designed: flush joints must be flush to one another; orthogonal joints must be orthogonal. Parts must not misfit such that unwanted aerodynamic features are introduced, such as unwanted geometric twist or unwanted dihedral. All tolerances must be within manufacturer-determined acceptable ranges.
- All adhesive and fasteners must be applied in all areas that require adhesive or fasteners. All adhesive and fasteners used must be appropriate to the application. For

example, if CA is used despite a manufacturer's recommendation to use epoxy, the adhesive would not be appropriate.

- The propulsion system must meet or exceed manufacturer specifications. This requires the engine/motor/powerplant size to meet or exceed manufacturer specifications, and that the quality of the propulsion system meets or exceeds the manufacturer's recommended parts. This also requires that the propeller and ESC, if applicable, are appropriately sized. Further, the battery or fuel tank specifications must meet or exceed the manufacturer's specifications.
- All servos must be sized to meet or exceed manufacturer-recommended servo sizes and torque ratings. All servos must meet or exceed the build quality of the manufacturer-recommended parts.
- The radio system reliability must be evaluated as per the following risk point tables.

3.2.1.1 (a). Build quality risk points

Build quality	Build quality standards met	Build quality standards not met
Risk points	0	Unairworthy

3.2.1.1 (b). Remote control signal reliability: carrier frequency and technology used

Carrier frequency	2.4 GHz spread spectrum with DSMx or similar frequency-hopping features	Legacy carrier frequency without frequency-hopping features
Risk points	0	50

3.2.1.1 (c). Signal reliability: antenna diversity

Diversity features	Antenna diversity on transmitter and receiver	Antenna diversity on transmitter only	Antenna diversity on receiver only	No antenna diversity
Risk points	0	5	20	40

The airworthiness status is found based off the reduced risk score:

- Between 0 and 2: risk level 1
- Between 3 and 20: risk level 2
- Between 21 and 37: risk level 3
- Greater than 37: unairworthy

3.2.1.2 Standards for Airframe-Only Kits

The standards for airframe-only kits are characterized by ensuring that the user's choice of electronics, propulsion system, and other accessories is adequate, that the airframe assembly is completed with an adequate degree of craftsmanship, that the propulsion system chosen meets performance standards, and that the airframe is mated to other components in an acceptable manner.

The airworthiness status is found based on the reduced risk score:

- Between 0 and 5: risk level 1
- Between 6 and 15: risk level 2
- Between 16 and 20: risk level 3
- Greater than 20: unairworthy

3.2.1.2 (a) Build quality

Build quality standards

- The aircraft must be built strictly according to the manufacturer's recommended build process.
- All parts must fit as designed: flush joints must be flush to one another; orthogonal joints must be orthogonal. Parts must not misfit such that unwanted aerodynamic features are introduced, such as unwanted geometric twist or unwanted dihedral. All tolerances must be within manufacturer-determined acceptable ranges.
- All adhesive and fasteners must be applied in all areas that require adhesive or fasteners. All adhesive and fasteners used must be appropriate to the application. For example, if CA is used despite a manufacturer's recommendation to use epoxy, the adhesive would not be appropriate.
- All servos must be sized to meet or exceed manufacturer-recommended servo sizes and torque ratings. All servos must meet or exceed the build quality of the manufacturer-recommended parts.
- The radio system, electronics, and propulsion system reliability and performance must be evaluated as per the following risk point tables.

3.2.1.2 (a) (a). Build quality risk points

Build quality	Build quality standards met	Build quality standards not met
Risk points	0	Unairworthy

3.2.1.2 (b) Electronics Standards

3.2.1.2 (b) (a) Servo sizing: Servo torque in relation to required torque

Value of $\frac{\tau_{servo}}{\tau_{required}}$	$\frac{\tau_{servo}}{\tau_{required}} > 3$	$\frac{\tau_{servo}}{\tau_{required}} > 2.25$	$\frac{\tau_{servo}}{\tau_{required}} > 1.5$	$\frac{\tau_{servo}}{\tau_{required}} < 1.5$
Risk points	0	10	20	Unairworthy

The required torque must be computed based on the known control hinge moments and the linkage geometry. The required torque is the torque that needs to be applied to the servo arm to (a) overcome the control hinge moment, and (b) provide adequate angular acceleration of the control surface. So, the required torque will be considerably higher than that which is simply required to overcome the control hinge moment.

3.2.1.2 (b) (b) Remote control signal reliability: carrier frequency and technology used

Carrier frequency	2.4 GHz spread spectrum with DSMx or similar frequency-hopping features	Legacy carrier frequency without frequency-hopping features
Risk points	0	50

3.2.1.2 (b) (c) Signal reliability: antenna diversity

Diversity features	Antenna diversity on transmitter and receiver	Antenna diversity on transmitter only	Antenna diversity on receiver only	No antenna diversity
Risk points	0	5	20	40

3.2.1.2 (b) (d) ESC current rating in relation to expected maximum current draw through ESC

Value of $\frac{I_{ESC}}{I_{max}}$	$\frac{I_{ESC}}{I_{max}} > 1.5$	$\frac{I_{ESC}}{I_{max}} > 1.25$	$\frac{I_{ESC}}{I_{max}} > 1.1$	$\frac{I_{ESC}}{I_{max}} < 1.1$
Risk points	0	5	15	Unairworthy

Note: this may be inapplicable depending on the method of propulsion used in the airplane.

3.2.1.2 (b) (e) Receiver power source

Configuration	Receiver powered from independent battery and independent BEC	Receiver powered by main flight battery, but through independent BEC	Receiver powered from BEC integrated into ESC
Risk points	0	10	30

3.2.1.2 (b) (f) Auxiliary device power source

Configuration	Powered from independent battery and independent BEC	Powered by main flight battery, but through independent BEC	Powered from BEC integrated into ESC, or powered directly from receiver
Risk points	0	10	30

This includes aircraft lights, autopilots, sensors, etc. This category may be inapplicable depending on whether the aircraft has any auxiliary devices.

Further, all wire sizes must be specified based on the expected current draw according to the chart on the following page:

Wire size (gauge)	Wire conductor diameter (inches)	Maximum continuous current (amps), power transmission	Maximum continuous current (amps), chassis wiring
0000	0.4600	302	380
000	0.4096	239	328
00	0.3648	190	283
0	0.3249	150	245
1	0.2893	119	211
2	0.2576	94	181
3	0.2294	75	158
4	0.2043	60	135
5	0.1819	47	118
6	0.1620	37	101
7	0.1443	30	89
8	0.1285	24	73
9	0.1144	19	64
10	0.1019	15	55
11	0.0907	12	47
12	0.0808	9.3	41
13	0.0720	7.4	35
14	0.0641	5.9	32
15	0.0571	4.7	28
16	0.0508	3.7	22
17	0.0453	2.9	19
18	0.0403	2.3	16
19	0.0359	1.8	14
20	0.0320	1.5	11
21	0.0285	1.2	9
22	0.0253	0.92	7
23	0.0226	0.729	4.7
24	0.0201	0.577	3.5
25	0.0179	0.457	2.7
26	0.0159	0.361	2.2
27	0.0142	0.288	1.7
28	0.0126	0.226	1.4
29	0.0113	0.182	1.2
30	0.0100	0.142	0.86
31	0.0089	0.113	0.7
32	0.0080	0.091	0.53
33	0.0071	0.072	0.43
34	0.0063	0.056	0.33
35	0.0056	0.044	0.27
36	0.0050	0.035	0.21
37	0.0045	0.0289	0.17
38	0.0040	0.0228	0.13
39	0.0035	0.0175	0.11
40	0.0031	0.0137	0.09

Figure 3-4: Electrical wiring ampacity chart

The following requirements apply for conductor sizing:

- In no case may the current in a wire in the aircraft exceed the table value for the wire of the corresponding diameter/gauge.
- The *chassis wiring* specification applies only to wiring runs of a length less than 3.5 meters.
- The *power transmission* specification has no requirement for wiring run length.

3.2.1.2 (b) (g) Wire gauge size: value of design maximum current in relation to table value for maximum permissible current

Value of $\frac{I_{table}}{I_{design}}$	$\frac{I_{table}}{I_{design}} \geq 1.3$	$\frac{I_{table}}{I_{design}} \geq 1.15$	$\frac{I_{table}}{I_{design}} \geq 1$	$\frac{I_{table}}{I_{design}} < 1$
Risk points	0	5	10	Unairworthy

Additionally, the following requirements apply for wiring:

- All wiring runs must be of a minimal length without the wires cluttering the interior of the airplane.
- Long wiring runs must not be accomplished by connecting multiple extension wires. If multiple lengths of wire are needed, they must be soldered together and secured with heat shrink tubing.

3.2.1.2 (b) (h) Long wiring runs: minimal lengths

Wiring length	Wire runs are of a minimal length without cluttering the interior of the airplane.	Wiring length standards are not met.
Risk points	0	Unairworthy

3.2.1.2 (b) (i) Long wiring runs: connection method between wire lengths

Wiring connections	Long wire runs use a single cable, or multiple cables with soldered joints.	Long wiring connection standards are not met.
Risk points	0	Unairworthy

3.2.1.2 (b) (j) Wiring protection: OISC requires that, wherever a wire is mounted to the airframe, the wire be protected by heat-shrink tubing or a similar means. It is not acceptable to anchor a wire without any protection. Risk points are allocated as follows:

Wire protection standards	Wire protection standards met	Wire protection standards not met
Risk points	0	Unairworthy

The reduced risk category may not exceed 23 or the aircraft is rendered unairworthy.

3.2.1.2 (c) Propulsion Standards

The following aspects of the propulsion system are evaluated:

- Reliability, including expected mean time between failure and performance in multiple load factor scenarios.
- Maximum endurance. The goal is not for the aircraft to meet any specific performance requirement, but that the endurance is sufficient for a safe flight, accounting for multiple go-arounds.

3.2.1.2 (c) (a). Mean time between powerplant failure when recommended maintenance schedule is followed:

Time between failure	> 100 flight hours	> 50 flight hours	>25 flight hours	< 25 flight hours
Risk points	0	20	40	Unairworthy

Meeting this criterion should be established by referencing manufacturer specifications for expected powerplant longevity.

3.2.1.2 (c) (b). Minimum load factor in which the powerplant can still function nominally:

Value of n_{min}	$n_{min} < -2$	$n_{min} < -1$	$n_{min} < 0.5$	$n_{min} > 0.5$
Risk points	0	20	40	Unairworthy

Meeting this criterion should be established by referencing manufacturer specifications for expected powerplant performance.

3.2.1.2 (c) (c). Maximum endurance:

Endurance	> 15 mins	> 10 mins	> 5 mins	< 5 mins
Risk points	0	20	40	Unairworthy

This must be found from flight test. This must include adequate reserve. For example, if using LiPo batteries, there must be sufficient voltage remaining to serve as a reserve. This means generally that the cell voltage must be kept above a predefined value. Similarly, for fueled propulsion systems, this endurance must be established with reserve fuel in the tank. The precise amount of reserve required is highly dependent on the aircraft and application, and as such is to be set by the airworthiness assessor.

3.2.1.2 (c) (d). Propulsion reliability: number of engines

Engine configuration	Glider	Single engine	Multiengine
Risk points	20	20	0

Note that multiengine airplanes must conform to standards for multiengine airplanes contained in later in this section.

Additionally, if the aircraft is equipped with a reciprocating engine or a turbine engine, the transmitter must be configured such that the engine can be turned off outright from the ground.

The reduced risk score in this category may not exceed 44 or the aircraft is rendered unairworthy.

3.2.1.2 (d) Performance Standards

3.2.1.2 (d) (a) Maximum rate of climb, evaluated at standard sea level

Value of V_h	$V_h > 13$ m/s	$7 \leq V_h \leq 13$ m/s	$2.5 \leq V_h < 7$ m/s	$V_h < 2.5$ m/s
Risk points	0	5	15	Unairworthy

3.2.1.2 (d) (b) Maximum climb angle, evaluated at standard sea level

Value of θ	$\theta > 9^0$	$6.5 \leq \theta \leq 9^o$	$4.75 \leq \theta < 6.5^o$	$\theta < 4.75^o$
Risk points	0	5	10	Unairworthy

3.2.1.2 (d) (c) Climb angle in landing configuration, evaluated at standard sea level

Value of θ	$\theta > 4.5^o$	$3 \leq \theta < 4.5^o$	$1.7 \leq \theta < 3^o$	$\theta < 1.7^o$
Risk points	0	5	10	Unairworthy

3.2.1.2 (d) (d) Service ceiling – altitude at which climb rate reduces to 1.5 m/s (300 fpm)

Value of Z_{svc}	$Z_{svc} > 5500$ m	$3500 < Z_{svc} \leq 5500$ m	$1500 \leq Z_{svc} \leq 3500$ m	$Z_{svc} < 1500$ m
Risk points	0	5	10	50

The reduced score in this category may not exceed 13, or the aircraft is rendered unairworthy.

3.2.1.3 Standards Applicable to All User-Assembled Airplanes

In order to certify any user-assembled COTS aircraft as operationally airworthy, flight test must be conducted under an experimental airworthiness certificate to investigate the following:

- Basic aircraft stability and control
- Aeroelasticity and in-flight oscillations
- Stall handling
- Structural performance with high in-flight load factors

The airworthiness status is found based on the reduced risk score:

- Between 0 and 5: risk level 1
- Between 6 and 10: risk level 2
- Between 11 and 23: risk level 3
- Greater than 23: unairworthy

3.2.1.3 (a) Stability and Control Evaluation

3.2.1.3 (a) (a). Longitudinal modal stability Cooper-Harper

Cooper-Harper score	$CH \leq 2$	$CH \leq 4$	$CH \leq 6$	$CH > 6$
Risk points	0	5	10	Unairworthy

3.2.1.3 (a) (b). Longitudinal control authority stability Cooper-Harper

Cooper-Harper score	$CH \leq 2$	$CH \leq 4$	$CH \leq 6$	$CH > 6$
Risk points	0	5	10	Unairworthy

3.2.1.3 (a) (c). Lateral modal stability Cooper-Harper

Cooper-Harper score	$CH \leq 2$	$CH \leq 4$	$CH \leq 6$	$CH > 6$
Risk points	0	5	10	Unairworthy

3.2.1.3 (a) (d). Lateral control authority stability Cooper-Harper

Cooper-Harper score	$CH \leq 2$	$CH \leq 4$	$CH \leq 6$	$CH > 6$
Risk points	0	5	10	Unairworthy

Note that these criteria are to be evaluated in flight test. If the flight test reveals any deficiencies in the area of stability and control, the aircraft must be evaluated as per the relevant part of section 4.2.

If the reduced score in this category exceeds 10, the aircraft is unairworthy.

3.2.1.3 (b) Structural Evaluation

3.2.1.3 (b) (a). In-flight structural oscillations

Oscillatory behavior	No structural oscillations occur during any flight regime	Structural oscillations occur but only at extreme flight regimes that are not encountered during normal flight	Structural oscillations occur during normal flight regime, but no structural damage occurs	Structural oscillations occur with noticeable structural damage
Risk points	0	5	10	Unairworthy

3.2.1.3 (b) (b). Structural performance at high load factor (75-degree banked turn)

Structural behavior	No structural damage occurs as a result of this maneuver	Noticeable structural damage occurs after this maneuver
Risk points	0	Unairworthy

3.2.1.3 (b) (c). Structural performance at low load factor (top of parabola maneuver)

Structural behavior	No structural damage occurs as a result of this maneuver	Noticeable structural damage occurs after this maneuver
Risk points	0	Unairworthy

The reduced score in this category my not exceed 3, or the aircraft is rendered unairworthy.

3.2.1.3 (c) Stall handling

3.2.1.3 (c) (a). Tendency to drop a wing during stall

Stall behavior	Wing drop less than 15 degrees	Wing drop less than 30 degrees	Wing drop more than 30 degrees
Risk points	0	20	40

3.2.1.3 (c) (b). Capability of elevator to break stall

Stall behavior	Down elevator use breaks the stall with ease	Down elevator is mostly effective in breaking a stall	Recovering from stall is difficult and down elevator control is ineffective
Risk points	0	40	Unairworthy

The reduced score in this category may not exceed 57, or the aircraft is rendered unairworthy.

3.2.2 Standards for Multirotors

3.2.2.1 Standards for ARF Multirotors

The standards for ARF multirotors are characterized by ensuring that the aircraft is built according to the manufacturer's standards, and that the electronics and propulsion system meet the manufacturer's recommended specifications.

Build quality standards

- The aircraft must be built strictly according to the manufacturer's recommended build process.
- All parts must fit as designed: flush joints must be flush to one another; orthogonal joints must be orthogonal. Parts must not misfit such that unwanted aerodynamic features are introduced. All tolerances must be within manufacturer-determined acceptable ranges.
- All adhesive and fasteners must be applied in all areas that require adhesive or fasteners. All adhesive and fasteners used must be appropriate to the application. For example, if CA is used despite a manufacturer's recommendation to use epoxy, the adhesive would not be appropriate.
- The propulsion system must meet or exceed manufacturer specifications. This requires the engine/motor/powerplant size to meet or exceed manufacturer specifications, and that the quality of the propulsion system meets or exceeds the manufacturer's recommended parts. This also requires that the propeller and ESC, if applicable, are appropriately sized. Further, the battery or fuel tank specifications must meet or exceed the manufacturer's specifications.
- All servos must be sized to meet or exceed manufacturer-recommended servo sizes and torque ratings. All servos must meet or exceed the build quality of the manufacturer-recommended parts.
- The radio system reliability must be evaluated as per the following risk point tables.

3.2.2.1 (a). Build quality risk points

Build quality	Build quality standards met	Build quality standards not met
Risk points	0	Unairworthy

3.2.2.1 (b). Remote control signal reliability: carrier frequency and technology used

Carrier frequency	2.4 GHz spread spectrum with DSMx or similar frequency-hopping features	Legacy carrier frequency without frequency-hopping features
Risk points	0	50

3.2.2.1 (c). Signal reliability: antenna diversity

Diversity features	Antenna diversity on transmitter and receiver	Antenna diversity on transmitter only	Antenna diversity on receiver only	No antenna diversity
Risk points	0	5	20	40

The airworthiness status is found based on the reduced score in this category:

- Between 0 and 2: risk level 1
- Between 3 and 20: risk level 2
- Between 21 and 37: risk level 3
- Greater than 37: unairworthy

3.2.2.2 Standards for Airframe-Only Kits

The standards for airframe-only kits are characterized by ensuring that the user's choice of electronics, propulsion system, and other accessories is adequate, that the airframe assembly is completed with an adequate degree of craftsmanship, that the propulsion system chosen meets performance standards, and that the airframe is mated to other components in an acceptable manner.

The airworthiness status of the aircraft is determined based on the reduced risk score:

- Between 0 and 10: risk level 1
- Between 11 and 20: risk level 2
- Between 21 and 28: risk level 3
- Above 28: unairworthy

3.2.2.2 (a) Build quality

Build quality standards

- The aircraft must be built strictly according to the manufacturer's recommended build process.
- All parts must fit as designed: flush joints must be flush to one another; orthogonal joints must be orthogonal. Parts must not misfit such that unwanted aerodynamic features are introduced, such as unwanted geometric twist or unwanted dihedral. All tolerances must be within manufacturer-determined acceptable ranges.
- All adhesive and fasteners must be applied in all areas that require adhesive or fasteners. All adhesive and fasteners used must be appropriate to the application. For example, if CA is used despite a manufacturer's recommendation to use epoxy, the adhesive would not be appropriate.

- All servos must be sized to meet or exceed manufacturer-recommended servo sizes and torque ratings. All servos must meet or exceed the build quality of the manufacturer-recommended parts.
- The radio system, electronics, and propulsion system reliability and performance must be evaluated as per the following risk point tables.

3.2.2.2 (a) (a). Build quality risk points

Build quality	Build quality standards met	Build quality standards not met
Risk points	0	Unairworthy

3.2.2.2 (b) Overall Design Characteristics

OISC evaluates the overall design of a multirotor based on the following:

- Presence and type of stability augmentation system: OISC requires a stability augmentation system to be present on any operationally certified multirotor due to the inherently unstable nature of multirotors
- Interference between propellers and propeller discs
- Number of motors

3.2.2.2 (b) (a). Type of stability augmentation system

Stability augmentation system presence and characteristics	Type 1 SAS	Type 2 SAS	Type 3 SAS	Type 4 SAS
Risk points	0	20	50	95

The various types of stability augmentation system capabilities are defined as follows:

- Type 1: SAS can hold position and altitude when both control sticks are centered, regardless of wind. SAS automatically maintains altitude as pitch and bank are adjusted. Control sticks are used to command altitude rate, yaw rate, pitch angle, and bank angle. The position and altitude are known both a barometric altimeter and/or GPS.
- Type 2: SAS can hold position and altitude when both control sticks are centered, regardless of wind. SAS automatically maintains altitude as pitch and bank are adjusted. Control sticks are used to command altitude rate, yaw rate, pitch angle, and bank angle. The position and altitude are found based on the IMU alone.
- Type 3: SAS can hold altitude and attitude when both control sticks are centered but does not hold position. Control sticks are used to command altitude rate, yaw rate, pitch angle, and bank angle.
- Type 4: SAS is used to allow user to command altitude rate, yaw rate, pitch rate, bank rate. No altitude-hold or position-hold features.
- Types 3 and 4 stability augmentation systems require the aircraft to be trimmable.

3.2.2.2 (b) (b). Propeller interference

Propeller interference characteristics	Minimum straight-line distance between propeller discs at least 2cm	Minimum straight-line distance between propeller discs less than 2cm, but do not interfere	Propeller discs interfere, but propellers are prevented from interfering by gearing or belts	Propeller discs interfere, and no mechanism is present to prevent propellers from interfering
Risk points	0	5	20	Unairworthy

The definition of *propeller discs* and *propellers*, for the sake of this airworthiness standard, are shown below:

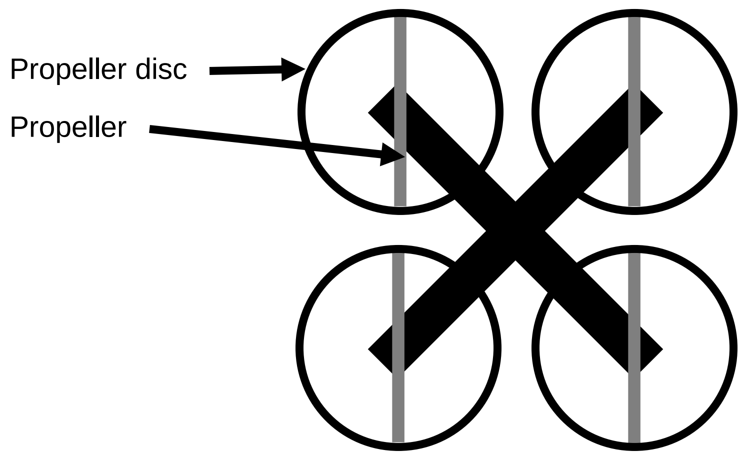


Figure 3-5: Propeller and propeller geometry diagram

3.2.2.2 (b) (c). Redundancy: number of motors

Number of motors	3	4	5	6 or more
Risk points	50	40	30	0

3.2.2.2 (b) (d). Vibration: fastener securing

Fastener securing	Fasteners secured with two of the approved methods	Fasteners secured with one of the approved methods	Fasteners unsecured; conditions for unsecure fasteners are met	Fasteners unsecured; conditions for unsecure fasteners are not met
Risk points	0	10	80	Unairworthy

Approved fastener securing methods:

- Safety wire
- Nylon locking nuts
- Thread locking compound, such as Loctite
- Castle nut and locking pin
- Split beam nut
- Locking plate or tab washer

Conditions to leave fasteners unsecured: the applicant must demonstrate compliance with the following:

- The aircraft's maximum takeoff weight must not exceed 10 lbs (4.5 kg).
- The aircraft must strictly be flown in daytime VFR conditions and within VLOS.
- The aircraft must never be flown in a crowded environment such that there is a substantial risk of it flying over people. For example, flights over campus would be prohibited since, even if the PIC makes the utmost effort to avoid flights over people, campus is sufficiently congested that, realistically, this is difficult to avoid.
- The applicant must demonstrate that the vibration produced on the aircraft is such that, after 60 minutes of consecutive flights, all fasteners remain firmly anchored.

The reduced score may not exceed 55 in this category or the aircraft is unairworthy.

3.2.2.2 (c) Structures Standards

3.2.2.2 (c) (a). Whole aircraft torsional rigidity: maximum twist angle between opposing sides of vehicle during maximum yaw rate maneuver.

Deflection angle θ	$\theta < 2.5^o$	$\theta < 5^o$	$\theta < 7.5^o$	$\theta > 7.5^o$
Risk points	0	20	30	Unairworthy

This requirement describes the torsion which occurs when the aircraft is executing a yaw maneuver. In this configuration, the thrust of one propeller will be changed relative to the adjacent motor. The resulting moment causes the torsion evaluated by this section.

3.2.2.2 (c) (b). Fatigue life: cycles until failure of motor mount arms due to changes in thrust during flight

Cycles	> 10000	> 5000	> 1000	< 100
Risk points	0	10	20	Unairworthy

3.2.2.2 (c) (c). Fatigue life: cycles until failure of motor mount arms due to motor vibrations

Cycles	> 10000	> 5000	> 1000	< 100
Risk points	0	10	20	Unairworthy

3.2.2.2 (c) (d). Structural vibrations: in-flight oscillations during flight test

$f_{modal,structural}$ in relation to $f_{encountered}$	No structural oscillations encountered in any regime of flight	Structural vibrations occur during flight, but there is no noticeable wear after 10 flights	Structural vibrations cause significant and noticeable wear and damage after 10 flights	Structural vibrations cause component failure in flight
Risk points	0	40	Unairworthy	Unairworthy

This must cover vibrations from varying degrees of motor thrust and various airspeeds. Flight test must reveal whether the structural modal frequencies are such that the aircraft structure will excessively vibrate during flight.

3.2.2.2 (c) (e). Material construction: presence of fibrous materials vulnerable to splitting

Presence of fibrous materials	Only isotropic materials used in aircraft structure	Fibrous materials used with overlapping layers offset by at least 60 degrees	Fibrous materials used but no stress is applied orthogonal to fiber	Fibrous materials used with stress orthogonal to fiber
Risk points	0	5	10	Unairworthy

The reduced score in this category may not exceed 24 or the aircraft is rendered unairworthy.

3.2.2.2 (d) Dynamics, Stability, and Control Standards

3.2.2.2 (d) (a). Position-hold performance: maximum deviation from target position in any direction in smooth air

Deviation	$< 10\text{cm}$	$< 20\text{cm}$	$< 30\text{cm}$	$> 30\text{cm}$
Risk points	0	5	10	Unairworthy

3.2.2.2 (d) (b). Position-hold performance: position hold Cooper-Harper score

Cooper-Harper score	2 or better	4 or better	6 or better	Worse than 6
Risk points	0	15	40	Unairworthy

3.2.2.2 (d) (c). Attitude-hold performance: maximum angular deviation from target attitude in either direction (pitch or roll)

Deviation	$< 2^o$	$< 4^o$	$< 6^o$	$> 6^o$
Risk points	0	20	40	Unairworthy

3.2.2.2 (d) (d). Attitude-hold performance: attitude-hold Cooper-Harper score

Cooper-Harper score	2 or better	4 or better	6 or better	Worse than 6
Risk points	0	15	40	Unairworthy

3.2.2.2 (d) (e). Disturbance rejection: position-hold performance: maximum deviation from target position in any direction in light turbulence

Deviation	< 15cm	< 30cm	< 45cm	> 45cm
Risk points	0	10	20	90

3.2.2.2 (d) (f). Disturbance tracking: position-hold performance: Cooper-Harper score in light turbulence

Cooper-Harper score	2 or better	4 or better	6 or better	Worse than 6
Risk points	0	15	40	Unairworthy

3.2.2.2 (d) (g). Control tracking: aircraft stability augmentation response to control inputs

Response characteristics	Critically or over-damped	Well-damped	Lightly damped	Extremely lightly damped
Risk points	0	10	40	60

3.2.2.2 (d) (h). Control tracking: aircraft stability augmentation response to control inputs Cooper-Harper score

Cooper-Harper score	2 or better	4 or better	6 or better	Worse than 6
Risk points	0	15	40	Unairworthy

3.2.2.2 (d) (i). Altitude-hold capabilities during forward/transverse flight: altitude deviation

Altitude hold deviation	< 10cm	< 20cm	< 30cm	> 30cm
Risk points	0	5	10	60

3.2.2.2 (d) (j). Altitude-hold capabilities during forward/transverse flight: altitude deviation

Cooper-Harper score	2 or better	4 or better	6 or better	Worse than 6
Risk points	0	15	40	Unairworthy

3.2.2.2 (d) (k). Pitch and bank angle limitation

Pitch and bank limits	Limits are below FOM-defined thresholds	Limits meet FOM-defined threshold	No SAS limits: reliant on pilot to maintain FOM pitch and bank limits
Risk points	0	5	30

3.2.2.2 (d) (l). Maintaining attitude limits: Cooper-Harper score

Cooper-Harper score	2 or better	4 or better	6 or better	Worse than 6
Risk points	0	15	40	Unairworthy

3.2.2.2 (d) (m). Control precision: takeoff/landing precision test

Precision	± 10cm or better	± 20cm or better	± 35cm or better	± 35cm or worse
Risk points	0	15	40	Unairworthy

For this test, the pilot must take the aircraft off from a helipad, fly it to 10 feet in altitude without inputting any other control inputs, and land it again. The difference in the takeoff location of the center of the aircraft and landing location of the center of the aircraft is to be measured.

3.2.2.2 (d) (n). Control precision: Cooper-Harper score for landing on precise location

Cooper-Harper score	2 or better	4 or better	6 or better	Worse than 6
Risk points	0	15	40	Unairworthy

This is based on the following test: the aircraft is to be landed on a square pad with a side length not exceeding 1.2 times the maximum diagonal length between propellers. The pilot is to land on the middle of this pad and rate the difficulty of doing so.

3.2.2.2 (d) (o). Control precision: azimuth hold ability

Azimuth variation test results	± 2m or better	± 4m or better	± 8m or better	Worse than ± 8m
Risk points	0	15	40	Unairworthy

This is to be assessed by a physical test: from a safe altitude, the aircraft must be aligned to a given azimuth, flown forward 35 meters without any lateral commands. It then must be flown directly backward to the start location. The difference in position measured in the direction perpendicular to the target azimuth must be measured. See the diagram below:

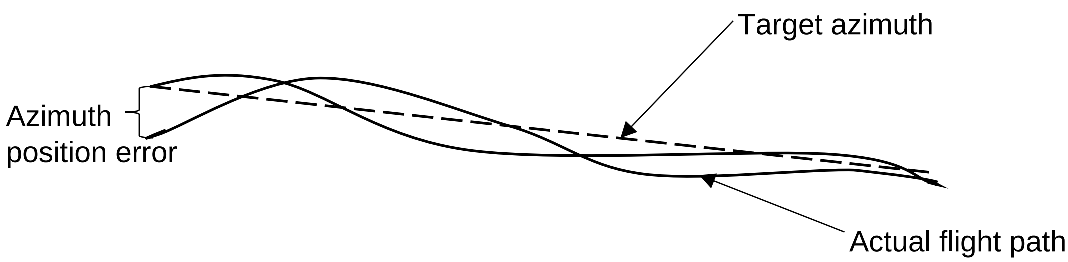


Figure 3-6: Azimuth tracking visualization

3.2.2.2 (d) (p). Control precision: azimuth hold ability Cooper-Harper score

Cooper-Harper score	2 or better	4 or better	6 or better	Worse than 6
Risk points	0	15	40	Unairworthy

This is based on the pilot's workload during the test delineated in the previous standard.

The reduced score in this category may not exceed 38 or the aircraft is rendered unairworthy.

3.2.2.2 (e) Propulsion and Performance Standards

3.2.2.2 (e) (a). Service ceiling – altitude at which climb rate reduces to 1.5 m/s (300 fpm) in standard atmospheric conditions

Value of Z_{svc}	$Z_{svc} \geq 5000$ m	$3500 < Z_{svc} \leq 5000$ m	$1500 \leq Z_{svc} \leq 3500$ m	$Z_{svc} < 1500$ m
Risk points	0	5	10	50

3.2.2.2 (e) (b). Maximum rate of climb, evaluated at standard sea level

Value of V_h	$V_h > 6$ m/s	$4 \leq V_h \leq 6$ m/s	$1 \leq V_h < 4$ m/s	$V_h < 1$ m/s
Risk points	0	5	15	Unairworthy

3.2.2.2 (e) (c). Mean time between powerplant failure when recommended maintenance schedule is followed:

Time between failure	> 100 flight hours	> 50 flight hours	>25 flight hours	< 25 flight hours
Risk points	0	20	40	Unairworthy

Meeting this criterion should be established by referencing manufacturer specifications for expected powerplant longevity.

3.2.2.2 (e) (d). Maximum endurance:

Endurance	> 20 mins	> 12 mins	> 5 mins	< 5 mins
Risk points	0	20	40	Unairworthy

This must be found from flight test. This must include adequate reserve. For example, if using LiPo batteries, there must be sufficient voltage remaining to serve as a reserve. This means generally that the cell voltage must be kept above a predefined value. Similarly, for fueled propulsion systems, this endurance must be established with reserve fuel in the tank. The precise amount of reserve required is highly dependent on the aircraft and application, and as such is to be set by the airworthiness assessor.

3.2.2.2 (e) (e). Vibration: propeller balance

Propeller balance characteristics	Negligible vibration: propeller center of gravity within 0.001 inches of propeller axis	Small vibration: propeller center of gravity within 0.005 inches of propeller axis	Moderate or greater vibrations; propeller center of gravity further than 0.005 inches from propeller
Risk points	0	10	Unairworthy

3.2.2.2 (e) (f). Vibration: motor vibration

Vibration characteristics	Negligible vibration: vibration amplitude less than 0.001 inch	Small vibrations: vibration amplitude less than 0.005 inch	Moderate vibrations: vibration amplitude greater than 0.005 inch
Risk points	0	10	Unairworthy

3.2.2.2 (e) (g). Vibration: damping of propulsion system vibrations

Damping characteristics present	Viscous liquid dampers are used	Rubber vibration isolating devices are used	No vibration damping is present, propeller balance and motor vibration score of 0	No vibration damping is present, nonzero propeller/motor vibration score
Risk points	0	20	20	Unairworthy

The maximum score in this category is 22, or the aircraft is rendered unairworthy.

3.2.3 Standards for Helicopters

3.2.3.1 Standards for ARF Helicopters

The standards for ARF helicopters are characterized by ensuring that the aircraft is built according to the manufacturer's standards, and that the electronics and propulsion system meet the manufacturer's recommended specifications.

Build quality standards

- The aircraft must be built strictly according to the manufacturer's recommended build process.
- All parts must fit as designed: flush joints must be flush to one another; orthogonal joints must be orthogonal. Parts must not misfit such that unwanted aerodynamic features are introduced. All tolerances must be within manufacturer-determined acceptable ranges.
- All adhesive and fasteners must be applied in all areas that require adhesive or fasteners. All adhesive and fasteners used must be appropriate to the application. For example, if CA is used despite a manufacturer's recommendation to use epoxy, the adhesive would not be appropriate.
- The propulsion system must meet or exceed manufacturer specifications. This requires the engine/motor/powerplant size to meet or exceed manufacturer specifications, and that the quality of the propulsion system meets or exceeds the manufacturer's recommended parts. This also requires that the propeller and ESC, if applicable, are appropriately sized. Further, the battery or fuel tank specifications must meet or exceed the manufacturer's specifications.
- All servos must be sized to meet or exceed manufacturer-recommended servo sizes and torque ratings. All servos must meet or exceed the build quality of the manufacturer-recommended parts.
- The radio system reliability must be evaluated as per the following risk point tables.

3.2.3.1 (a). Build quality risk points

Build quality	Build quality standards met	Build quality standards not met
Risk points	0	Unairworthy

3.2.3.1 (b). Remote control signal reliability: carrier frequency and technology used

Carrier frequency	2.4 GHz spread spectrum with DSMx or similar frequency-hopping features	Legacy carrier frequency without frequency-hopping features
Risk points	0	50

3.2.3.1 (c). Signal reliability: antenna diversity

Diversity features	Antenna diversity on transmitter and receiver	Antenna diversity on transmitter only	Antenna diversity on receiver only	No antenna diversity
Risk points	0	5	20	40

The airworthiness status is based on the reduced risk score:

- Between 0 and 2: risk level 1
- Between 3 and 10: risk level 2
- Between 11 and 32: risk level 3
- Greater than 32: unairworthy

3.2.3.2 Standards for Airframe-Only Kits

The airworthiness status is based on the reduced risk score:

- Between 0 and 10: risk level 1
- Between 11 and 20: risk level 2
- Between 21 and 32: risk level 3
- Greater than 32: unairworthy

3.2.3.2 (a) Overall design characteristics

Build quality standards

- The aircraft must be built strictly according to the manufacturer's recommended build process.
- All parts must fit as designed: flush joints must be flush to one another; orthogonal joints must be orthogonal. Parts must not misfit such that unwanted aerodynamic features are introduced. All tolerances must be within manufacturer-determined acceptable ranges.
- All adhesive and fasteners must be applied in all areas that require adhesive or fasteners. All adhesive and fasteners used must be appropriate to the application. For example, if CA is used despite a manufacturer's recommendation to use epoxy, the adhesive would not be appropriate.

- The propulsion system must meet or exceed manufacturer specifications. This requires the engine/motor/powerplant size to meet or exceed manufacturer specifications, and that the quality of the propulsion system meets or exceeds the manufacturer's recommended parts. This also requires that the propeller and ESC, if applicable, are appropriately sized. Further, the battery or fuel tank specifications must meet or exceed the manufacturer's specifications.
- All servos must be sized to meet or exceed manufacturer-recommended servo sizes and torque ratings. All servos must meet or exceed the build quality of the manufacturer-recommended parts.
- The radio system reliability must be evaluated as per the following risk point tables.

3.2.3.2 (a) (a). Build quality risk points

Build quality	Build quality standards met	Build quality standards not met
Risk points	0	Unairworthy

3.2.3.2 (a) (b). Tail rotor ground strike protection. OISC requires that the tail rotor be protected from ground strikes by means of a skid plate mounted such that, as the helicopter is pitched up, the tail skid contacts the ground and clearance between the ground and tail rotor is maintained. Risk points are assessed as follows:

Tail rotor protection	Inapplicable due to design features such as counter rotating rotors or a ducted fan tail rotor	Clearance greater than 1/10 of the rotor radius	Clearance greater than 1/20 of the rotor radius	Clearances less than 1/20 of the rotor radius
Risk points	0	15	30	Unairworthy

Note: if the rotors intermesh, the applicant must demonstrate that there is no risk of the rotors striking each other.

3.2.3.2 (a) (c). Tail rotor placement: the applicant must show that the tail rotor is located such that yaw control can be maintained in normal flight without requiring exceptional pilot skill or exceptionally favorable conditions. This is evaluated based on the worst-case Cooper-Harper score for maintaining a heading in any normal flight regime.

Cooper-Harper score CH	$CH < 3$	$CH \leq 4$	$CH \leq 6$	$CH > 6$
Risk points	0	10	20	Unairworthy

3.2.3.2 (a) (d). Rotor clearance: with the least favorable cyclic control and least favorable load factor, the rotor must clear any other part of the aircraft (such as the boom or fuselage) by at least 1% of the rotor diameter. Risk points are assessed as follows:

Clearance as measured by: $\frac{z_{clear}}{d_{rotor}}$	$\frac{z_{clear}}{d_{rotor}} > 0.05$	$\frac{z_{clear}}{d_{rotor}} > 0.025$	$\frac{z_{clear}}{d_{rotor}} > 0.01$	$\frac{z_{clear}}{d_{rotor}} < 0.01$
Risk points	0	15	30	Unairworthy

3.2.3.2 (a) (e). Vibration: fastener securing

Fastener securing	Fasteners secured with two of the approved methods	Fasteners secured with one of the approved methods	Fasteners unsecured; conditions for unsecure fasteners are met	Fasteners unsecured; conditions for unsecure fasteners are not met
Risk points	0	10	80	Unairworthy

Approved fastener securing methods:

- Safety wire
- Nylon locking nuts
- Thread locking compound, such as Loctite
- Castle nut and locking pin
- Split beam nut
- Locking plate or tab washer

Conditions to leave fasteners unsecured: the applicant must demonstrate compliance with the following:

- The aircraft's maximum takeoff weight must not exceed 10 lbs (4.5 kg).
- The aircraft must strictly be flown in daytime VFR conditions and within VLOS.
- The aircraft must never be flown in a crowded environment such that there is a substantial risk of it flying over people. For example, flights over campus would be prohibited since, even if the PIC makes the utmost effort to avoid flights over people, campus is sufficiently congested that, realistically, this is difficult to avoid.
- The applicant must demonstrate that the vibration produced on the aircraft is such that, after 60 minutes of consecutive flights, all fasteners remain firmly anchored.

3.2.3.2 (a) (f). Redundancy: number of motors

Number of motors	2 or more	1
Risk points	0	30

3.2.3.2 (a) (g). Jesus bolts. Any bolts or nut on the aircraft which would cause complete loss of the aircraft in the event of failure must meet the following criteria:

- Safety factor against yielding not less than 2 with MTOW, maximum rotor thrust, and maximum load factor.
- Two methods to prevent the bolt/nut from loosening over time. The approved methods are listed below:
  - Thread locking compound, such as Loctite
  - Safety wire
  - Castle nut and locking pin
- The applicant must delineate an inspection and maintenance schedule for any of these bolts/nuts.

3.2.3.2 (a) (h). Risk points are allocated for Jesus bolts as follows:

Safety factor	$FS \geq 3$	$FS \geq 2.5$	$FS \geq 2$	$FS < 2$
Risk points	0	15	30	Unairworthy

3.2.3.2 (a) (i). Other standards for Jesus bolts:

Other standards met?	Met	Not met
Risk points	0	Unairworthy

The reduced risk score may not exceed 30 or the aircraft is rendered unairworthy.

3.2.3.2 (b) Swashplate mechanism

3.2.3.2 (b) (a). Servo sizing: servo torque in relation to minimum required torque

Value of $\frac{\tau}{\tau_{req}}$	$\frac{\tau}{\tau_{req}} > 2$	$\frac{\tau}{\tau_{req}} > 1.5$	$\frac{\tau}{\tau_{req}} > 1$	$\frac{\tau}{\tau_{req}} < 1$
Risk points	0	15	30	Unairworthy

The required torque is computed as follows: at the maximum rotor RPM and maximum angle of incidence of the propeller, the pitching moment about the joint which supports the rotor must be computed. The support reaction by the joint which is used to alter the rotor angle of incidence must then be computed. Then the actuation torque is found based on the length of the servo arm. Twice this torque is the minimum required torque.

The design of the swashplate assembly must be built according to best practices, such as:

- Using an anti-rotation device to prevent the lower swashplate from rotating
- An adequate safety factor is used in swashplate system, as assessed by the risk points table below
- Adequate tolerances and balance

The manufacturer of the swashplate system must provide a rigorous inspection and maintenance schedule to guide continuing airworthiness inspections and maintenance. This must include:

- Inspection and replacement intervals for all components of the swashplate
- Requirements for maintaining adequate lubrication on all components
- Specifications for the requited tightness of all bolts and fasteners
- Specific guidance for a preflight inspection

3.2.3.2 (b) (b). Swashplate motion smoothness: the swashplate must move smoothly up and down the shaft without binding. Since it is typical for the smoothness of motion to degrade with time as lubrication is expelled from the swashplate mechanism, the risk is evaluated based on the amount of time smooth motion can be maintained while running the rotor at maximum RPM.

Time for which smooth motion is maintained	Greater than 90 minutes	Greater than 60 minutes	Greater than 30 minutes	Less than 30 minutes
Risk points	0	25	50	Unairworthy

The maximum flight time must be specified based on the time for which smooth motion can be maintained. The maximum flight time is not to exceed half of the time for which smooth motion is maintained.

The reduced risk score in this category may not exceed 40 or the aircraft is rendered unairworthy.

3.2.3.2 (c) Performance and propulsion system

3.2.3.2 (c) (a). Climb gradient at V_y, standard sea level, all engines operative, maximum weight

Climb gradient	1:3 or better	1:4 or better	1:5 or better	Less than 1:6
Risk points	0	15	30	Unairworthy

3.2.3.2 (c) (b). Climb gradient at V_y, standard sea level, one engine inoperative, maximum weight

Climb gradient	1:14 or better	1:16 or better	1:18 or better	Less than 1:20
Risk points	0	15	30	Unairworthy

3.2.3.2 (c) (c). Mean time between powerplant failure when recommended maintenance schedule is followed:

Time between failure	> 100 flight hours	> 50 flight hours	>25 flight hours	< 25 flight hours
Risk points	0	20	40	Unairworthy

Meeting this criterion should be established by referencing manufacturer specifications for expected powerplant longevity.

3.2.3.2 (c) (d). Maximum endurance:

Endurance	> 20 mins	> 12 mins	> 5 mins	< 5 mins
Risk points	0	20	40	Unairworthy

This must be found from flight test. This must include adequate reserve. For example, if using LiPo batteries, there must be sufficient voltage remaining to serve as a reserve. This means generally that the cell voltage must be kept above a predefined value. Similarly, for fueled propulsion systems, this endurance must be established with reserve fuel in the tank. The precise amount of reserve required is highly dependent on the aircraft and application, and as such is to be set by the airworthiness assessor.

3.2.3.2 (c) (e). Vibration: rotor balance

Rotor balance characteristics	Negligible vibration: rotor center of gravity within 0.001 inches of propeller axis	Small vibration: rotor center of gravity within 0.005 inches of propeller axis	Moderate or greater vibrations; rotor center of gravity further than 0.005 inches from propeller
Risk points	0	10	Unairworthy

3.2.3.2 (c) (f). Vibration: motor vibration

Vibration characteristics	Negligible vibration: vibration amplitude less than 0.001 inch	Small vibrations: vibration amplitude less than 0.005 inch	Moderate vibrations: vibration amplitude greater than 0.005 inch
Risk points	0	10	Unairworthy

3.2.3.2 (c) (g). Vibration: damping of propulsion system vibrations

Damping characteristics present	Viscous liquid dampers are used	Rubber vibration isolating devices are used	No vibration damping is present, propeller balance and motor vibration score of 0	No vibration damping is present, nonzero propeller/motor vibration score
Risk points	0	20	20	Unairworthy

The reduced risk score in this category may not exceed 26 or the aircraft is rendered unairworthy.

3.2.3.2 (d) Electronics

3.2.3.2 (d) (a). Remote control signal reliability: carrier frequency and technology used

Carrier frequency	2.4 GHz spread spectrum with DSMx or similar frequency-hopping features	Legacy carrier frequency without frequency-hopping features
Risk points	0	50

3.2.3.2 (d) (b). Signal reliability: antenna diversity

Diversity features	Antenna diversity on transmitter and receiver	Antenna diversity on transmitter only	Antenna diversity on receiver only	No antenna diversity
Risk points	0	5	20	40

3.2.3.2 (d) (c). ESC current rating in relation to expected maximum current draw through ESC

Value of $\frac{I_{ESC}}{I_{max}}$	$\frac{I_{ESC}}{I_{max}} > 1.5$	$\frac{I_{ESC}}{I_{max}} > 1.25$	$\frac{I_{ESC}}{I_{max}} > 1.1$	$\frac{I_{ESC}}{I_{max}} < 1.1$
Risk points	0	5	15	Unairworthy

Note: this may be inapplicable depending on the method of propulsion used in the airplane.

3.2.3.2 (d) (d). Receiver power source

Configuration	Receiver powered from independent battery and independent BEC	Receiver powered by main flight battery, but through independent BEC	Receiver powered from BEC integrated into ESC
Risk points	0	10	30

3.2.3.2 (d) (e). Auxiliary device power source

Configuration	Powered from independent battery and independent BEC	Powered by main flight battery, but through independent BEC	Powered from BEC integrated into ESC, or powered directly from receiver
Risk points	0	10	30

This includes aircraft lights, autopilots, sensors, etc. This category may be inapplicable depending on whether the aircraft has any auxiliary devices.

Further, all wire sizes must be specified based on the expected current draw according to the chart on the following page:

Wire size (gauge)	Wire conductor diameter (inches)	Maximum continuous current (amps), power transmission	Maximum continuous current (amps), chassis wiring
0000	0.4600	302	380
000	0.4096	239	328
00	0.3648	190	283
0	0.3249	150	245
1	0.2893	119	211
2	0.2576	94	181
3	0.2294	75	158
4	0.2043	60	135
5	0.1819	47	118
6	0.1620	37	101
7	0.1443	30	89
8	0.1285	24	73
9	0.1144	19	64
10	0.1019	15	55
11	0.0907	12	47
12	0.0808	9.3	41
13	0.0720	7.4	35
14	0.0641	5.9	32
15	0.0571	4.7	28
16	0.0508	3.7	22
17	0.0453	2.9	19
18	0.0403	2.3	16
19	0.0359	1.8	14
20	0.0320	1.5	11
21	0.0285	1.2	9
22	0.0253	0.92	7
23	0.0226	0.729	4.7
24	0.0201	0.577	3.5
25	0.0179	0.457	2.7
26	0.0159	0.361	2.2
27	0.0142	0.288	1.7
28	0.0126	0.226	1.4
29	0.0113	0.182	1.2
30	0.0100	0.142	0.86
31	0.0089	0.113	0.7
32	0.0080	0.091	0.53
33	0.0071	0.072	0.43
34	0.0063	0.056	0.33
35	0.0056	0.044	0.27
36	0.0050	0.035	0.21
37	0.0045	0.0289	0.17
38	0.0040	0.0228	0.13
39	0.0035	0.0175	0.11
40	0.0031	0.0137	0.09

Figure 3-6: Electrical wiring ampacity chart

The following requirements apply for conductor sizing:

- In no case may the current in a wire in the aircraft exceed the table value for the wire of the corresponding diameter/gauge.
- The *chassis wiring* specification applies only to wiring runs of a length less than 3.5 meters.
- The *power transmission* specification has no requirement for wiring run length.

3.2.3.2 (d) (f). Wire gauge size: value of design maximum current in relation to table value for maximum permissible current

Value of $\frac{I_{table}}{I_{design}}$	$\frac{I_{table}}{I_{design}} \geq 1.3$	$\frac{I_{table}}{I_{design}} \geq 1.15$	$\frac{I_{table}}{I_{design}} \geq 1$	$\frac{I_{table}}{I_{design}} < 1$
Risk points	0	5	10	Unairworthy

Additionally, the following requirements apply for wiring:

- All wiring runs must be of a minimal length without the wires cluttering the interior of the airplane.
- Long wiring runs must not be accomplished by connecting multiple extension wires. If multiple lengths of wire are needed, they must be soldered together and secured with heat shrink tubing.

3.2.3.2 (d) (g). Long wiring runs: minimal lengths

Wiring length	Wire runs are of a minimal length without cluttering the interior of the airplane.	Wiring length standards are not met.
Risk points	0	Unairworthy

3.2.3.2 (d) (h). Long wiring runs: connection method between wire lengths

Wiring connections	Long wire runs use a single cable, or multiple cables with soldered joints.	Long wiring connection standards are not met.
Risk points	0	Unairworthy

3.2.3.2 (d) (i). Wiring protection: OISC requires that, wherever a wire is mounted to the airframe, the wire be protected by heat-shrink tubing or a similar means. It is not acceptable to anchor a wire without any protection. Risk points are allocated as follows:

Wire protection standards	Wire protection standards met	Wire protection standards not met
Risk points	0	Unairworthy

The reduced risk score may not exceed 24 or the aircraft is rendered unairworthy.

3.2.3.2 (e) Structures

3.2.3.2 (e) (a). Rotor mounting structure: minimum safety factor against yielding at full thrust and maximum takeoff weight

Value of FS	$FS > 1.5$	$FS > 1.25$	$FS > 1.1$	$FS < 1.1$
Risk points	0	5	10	Unairworthy

3.2.3.2 (e) (b). Tail boom structure: maximum deflection of beam structure at full tail rotor thrust and maximum takeoff weight

Deflection v	$v < 3\text{mm}$	$v < 5\text{mm}$	$v < 10\text{mm}$	$v > 10\text{mm}$
Risk points	0	20	30	Unairworthy

3.2.3.2 (e) (c). Tail boom structure: maximum deflection angle of beam structure at full tail rotor thrust and maximum takeoff weight

Deflection angle θ	$\theta < 2.5^o$	$\theta < 5^o$	$\theta < 7.5^o$	$\theta > 7.5^o$
Risk points	0	20	30	Unairworthy

3.2.3.2 (e) (d). Landing gear structure: minimum safety factor against yielding

Value of FS	$FS > 2.5$	$FS > 2.25$	$FS > 2.1$	$FS < 2.1$
Risk points	0	5	10	Unairworthy

Landing gear deflection: the following standards apply for the deflection of landing gear during a 2-g landing on a smooth, level surface:

- The landing gear must not deflect so much that the tail rotor risks touching the ground
- The landing gear must not deflect asymmetrically to change the attitude of the aircraft which could cause the rotor to impact the ground.

3.2.3.2 (e) (e). Structural vibrations: in-flight oscillations during flight test

$f_{modal,structural}$ in relation to $f_{encountered}$	No structural oscillations encountered in any regime of flight	Structural vibrations occur during flight, but there is no noticeable wear after 10 flights	Structural vibrations cause significant and noticeable wear and damage after 10 flights	Structural vibrations cause component failure in flight
Risk points	0	40	Unairworthy	Unairworthy

This must cover vibrations from varying degrees of motor thrust and various airspeeds. Flight test must reveal whether the structural modal frequencies are such that the aircraft structure will excessively vibrate during flight.

3.2.3.2 (e) (f). Material construction: presence of fibrous materials vulnerable to splitting

Presence of fibrous materials	Only isotropic materials used in aircraft structure	Fibrous materials used with overlapping layers offset by at least 60 degrees	Fibrous materials used but no stress is applied orthogonal to fiber	Fibrous materials used with stress orthogonal to fiber
Risk points	0	5	10	Unairworthy

The reduced risk score in this category may not exceed 22 or the aircraft is unairworthy.

3.2.3.2 (f) Dynamics and handling

3.2.3.2 (f) (a). Position-hold performance: position hold Cooper-Harper score

Cooper-Harper score	2 or better	4 or better	6 or better	Worse than 6
Risk points	0	15	40	Unairworthy

3.2.3.2 (f) (b). Attitude-hold performance: attitude-hold Cooper-Harper score

Cooper-Harper score	2 or better	4 or better	6 or better	Worse than 6
Risk points	0	15	40	Unairworthy

3.2.3.2 (f) (c). Disturbance tracking: position-hold performance: Cooper-Harper score in light turbulence

Cooper-Harper score	2 or better	4 or better	6 or better	Worse than 6
Risk points	0	15	40	Unairworthy

3.2.3.2 (f) (d). Maintaining attitude limits: Cooper-Harper score

Cooper-Harper score	2 or better	4 or better	6 or better	Worse than 6
Risk points	0	15	40	Unairworthy

3.2.3.2 (f) (e). Control precision: Cooper-Harper score for landing on precise location

Cooper-Harper score	2 or better	4 or better	6 or better	Worse than 6
Risk points	0	15	40	Unairworthy

This is based on the following test: the aircraft is to be landed on a square pad with a side length not exceeding 1.2 times the maximum diagonal length between propellers. The pilot is to land on the middle of this pad and rate the difficulty of doing so.

3.2.3.2 (f) (f). Control precision: azimuth hold ability Cooper-Harper score

Cooper-Harper score	2 or better	4 or better	6 or better	Worse than 6
Risk points	0	15	40	Unairworthy

This is based on the pilot's workload during the test delineated in the previous standard.

3.2.3.2 (f) (g). Dynamic rollover: critical rollover angle

Critical angle θ	$\theta > 15^o$	$\theta > 10^o$	$\theta > 5^o$	$\theta < 5^o$
Risk points	0	15	30	Unairworthy

3.2.3.2 (f) (h). Static stability: static yaw stability in forward flight

Static stability	Statically stable	Neutrally stable or unstable
Risk points	0	80

3.2.3.2 (f) (i). Static stability: static roll stability in forward flight

Static stability	Statically stable	Neutrally stable or unstable
Risk points	0	80

3.2.3.2 (f) (j). Static stability: static pitch stability in forward flight

Static stability	Statically stable	Neutrally stable or unstable
Risk points	0	80

3.2.3.2 (f) (k). Dynamic stability: growth of oscillations in pitch (hover)

Absolute value of time constant τ	$\tau > 1$ sec	$\tau > 0.6$ sec	$\tau > 0.1$ sec	$\tau < 0.1$ sec
Risk points	0	20	40	Unairworthy

3.2.3.2 (f) (l). Dynamic stability: growth of oscillations in roll (hover)

Absolute value of time constant τ	$\tau > 1$ sec	$\tau > 0.6$ sec	$\tau > 0.1$ sec	$\tau < 0.1$ sec
Risk points	0	20	40	Unairworthy

3.2.3.2 (f) (m). Dynamic stability: growth of oscillations in yaw (hover)

Absolute value of time constant τ	$\tau > 1$ sec	$\tau > 0.6$ sec	$\tau > 0.1$ sec	$\tau < 0.1$ sec
Risk points	0	20	40	Unairworthy

The reduced score in this category may not exceed 51 or the aircraft is rendered unairworthy.

3.2.4 Standards for Airships

Given the current consumer market for airships as of writing this manual, no distinction is made between ARF and airframe-only kits; all kits which require user assembly are to be evaluated using this section.

The airworthiness status is found based on the reduced risk score:

- Between 0 and 5: risk level 1
- Between 6 and 10: risk level 2
- Between 11 and 23: risk level 3
- Greater than 23: unairworthy

3.2.4.1 Overall design characteristics

3.2.4.1 (a). Type of airship

Airship type	Rigid airship	Semi-rigid airship	Non-rigid airship
Risk points	0	15	30

The definitions for each type of airship are below:

- Rigid airship – an airship with an internal structure which supports the envelope and maintains the external shape of the airship independent of the pressure within the airship.
- Semi-rigid airship – an airship with a stiff (or semi-stiff) keel or truss supports the airship along its lower length. The external shape of the envelope is maintained by air pressure.
- Non-rigid airship – an airship which requires air pressure to maintain the external shape of the envelope and obtains most of its strength and stiffness from the pressurized envelope.

3.2.4.1 (b). Lifting gas

Lifting gas risk level	Risk level 1 gas	Risk level 2 gas	Risk level 3 gas	Risk level 4 gas
Risk points	0	30	80	Unairworthy

The following list details the kinds of lifting gas and the associated risk levels:

- Risk level 1 gasses
  - Helium
  - Ammonia
  - Neon
  - Nitrogen
  - Any non-flammable, non-toxic, cold gas
- Risk level 2 gasses
  - Hot air
  - Water vapor
  - Vacuum
  - Any hot, non-flammable, non-toxic gas or gasses which require low pressures
- Risk level 3 gasses
  - Hydrogen
  - Methane
  - Acetylene
  - Coal gas
  - Any flammable non-toxic gas
- Risk level 4 gasses
  - Plasma
  - Hydrogen cyanide
  - Hydrogen fluoride
  - Any excessively hot or toxic gas

Lifting gas safety features: OISC requires the airship to be equipped with certain safety features depending on the type of lifting gas. These requirements are detailed below:

- Flammable gasses
    - This applies to hydrogen, methane, acetylene, and coal gas or any other flammable gas.
    - The chief concern is that the lifting gas could ignite.
    - No airship will be certified as airworthy which uses flammable gas without the following:
        - Design features to ensure no ignition sources exist within 20cm of the envelope containing the lifting gas.
        - A plan for rigorous inspection of the aircraft before and after flight to locate any leaks.
        - Safety plan to mitigate fire risk during flight, gas filling, and gas removal approved by OISC and a local fire department.
- Hot gasses
    - This applies to hot air, water vapor, and any other gas which is heated to a temperature above atmospheric temperature to function.
    - The chief concern is that the heat could soften any materials used in constructing the airship, potentially causing loss of pressure or structural failure.
    - No airship will be certified as airworthy which uses hot gasses without the following:
        - Design features to closely regulate the gas temperature and alert the crew if the temperature is outside of acceptable ranges.
        - Analysis to show that the chosen materials can withstand the heat of these gasses without decreasing stiffness or strength material parameters to the point of causing excessive deformation or material failure.
        - Design features to ensure that any heating apparatuses cannot ignite the structure of the airship itself.
- Gasses which can diffuse through common skin materials
    - This applies to hydrogen, helium, and any other generally monoatomic gas which can easily diffuse through common skin materials.
    - The chief concern is that the gas can diffuse through the skin of the aircraft and the pressure can be lost over time, which could reduce the lift force generated over time.
    - No airship will be certified as airworthy which uses gasses prone to diffusion through skin without the following:
        - Design features to closely monitor the pressure inside the airship and to alert the crew if the pressure drops too low.
        - Selection of skin material to minimize gaseous diffusion through the skin.
        - Precise determination of the permissible flight time considering gaseous diffusion phenomena.
- Vacuum
    - This applies to situations where a near-vacuum is used to provide the lifting force.
    - The chief concern is ensuring that the structure can safely support a vacuum and has adequate fatigue life to support repeated flights.

- No airship will be certified as airworthy which relies on a vacuum without the following:
    - Demonstration from proponent that the structure possesses at least a 1.25 factor of safety against yielding at standard sea level external conditions and zero-pressure internal conditions.
    - Determination of pressurization-depressurization cycles which the aircraft can undergo before fatigue renders the structure unairworthy.

3.2.4.1 (c). Risk points for gas-specific safety features

Gas-specific safety standards	Standards met	Standards not met
Risk points	0	Unairworthy

3.2.4.1 (d). Lifting gas venting: all airships must be equipped with a means to quickly vent lifting gas in the event of an emergency. This must be capable of, at minimum, quickly venting both a small fraction of the gas to allow the airship to sink, and quickly venting all or most of the lifting gas.

Gas venting standards	Standards met	Standards not met
Risk points	0	Unairworthy

3.2.4.1 (e). Build quality evaluation

Build quality	1: Comparable to that of approved manufacturers	2: Overall good quality, but falls short of that of approved manufacturers	3: Overall decent build quality but lacks craftsmanship in some areas	4: Poor build quality
Risk points	0	10	20	Unairworthy

As previously mentioned, an evaluation of manufacturer build quality is reliant on the airworthiness assessor's experience. In order to qualify each degree of build quality, the following guidelines exist:

- Level 1: The airplane is built with tight tolerances, all components in precise alignment with one another, and all components are made of high-quality materials. This also requires that components fit flush to one another. Further, this level describes airplanes in which appropriate materials are used to reinforce the structure, i.e. using a carbon fiber spar in a foam wing as opposed to using an unreinforced foam wing.
- Level 2: This describes an airplane which is built with a decent level of craftsmanship but falls short of level 1 standards. This, for example, could include a foam wing reinforced with a weaker spar, or an airplane made with looser but acceptable tolerances.
- Level 3: the aircraft generally meets level 2 build quality standards but not in all realms. For instance, the tolerances may be acceptable but not the wing reinforcement. To qualify for level 3 scoring, no part of the airplane may meet the description for level 4 build quality.

- Level 4: this describes an aircraft which has excessively loose tolerances, poor alignment between components, low-quality materials, or poor fit between components.

The reduced risk score in this category may not exceed 30 or the aircraft is rendered unairworthy.

3.2.4.2 Dynamics and handling

3.2.4.2 (a). Dynamic yaw stability: during forward flight, no unstable yaw oscillations may develop. The dynamic yaw stability is assessed by the following table:

Dynamic yaw response characteristics	First-order response	Well damped second-order response ($\zeta > 0.5$)	Lightly damped second-order response ($\zeta < 0.5$)	Unstable first or second-order response
Risk points	0	15	50	Unairworthy

3.2.4.2 (b). Pitch control: the aircraft's pitch must be able to be controlled both at zero airspeed and at nonzero airspeed.

Pitch control	Pitch control standards met	Standards not met
Risk points	0	Unairworthy

3.2.4.2 (c). Yaw control: the airship's yaw must be able to be controlled both at zero airspeed and at nonzero airspeed. At any airspeed from zero to V_H, the airship must be able to generate a yawing moment such that a standard-rate 3-degree per second turn, at minimum, can be established. This is evaluated by the following table:

Yaw rate*	> 5 deg/s	> 4 deg/s	> 3 deg/s	< 3 deg/s
Risk points	0	5	10	Unairworthy

*Note that, for the purposes of assessing the effectiveness of the yaw controls, the yaw rate at maximum control deflection at airspeeds from 0 to V_H. The minimum value in that set is the yaw rate used for this standard.

3.2.4.2 (d). Altitude control: the airship must be able to maintain altitude as the buoyancy of the airship changes. It further must be able to make corrections to altitude to aid in landing. To that, OISC requires two types of altitude control, unless the applicant can demonstrate that another solution accomplishes both goals:

- A system to account for changes in atmospheric conditions, changes in density of the lifting gas, or other large-scale phenomena that would change the trim altitude of the airship by tens to hundreds of meters. An example of a means to comply with this requirement would be a ballonet, changing the pressure, temperature, or amount of lifting gas in the bag, or using ballast such as water which can be jettisoned.
- A system to produce small changes in altitude, such as those required for takeoff and landing. OSIC recommends a system in which thrust is produced in the vertical direction.

Altitude control requirements	Requirements met	Requirements not met
Risk points	0	Unairworthy

The reduced risk score in this category may not exceed 15 or the aircraft is unairworthy.

3.2.4.3 Structures

3.2.4.3 (a). Structural vibrations: in-flight oscillations during flight test

$f_{modal,structural}$ in relation to $f_{encountered}$	No structural oscillations encountered in any regime of flight	Structural vibrations occur during flight, but there is no noticeable wear after 10 flights	Structural vibrations cause significant and noticeable wear and damage after 10 flights	Structural vibrations cause component failure in flight
Risk points	0	40	Unairworthy	Unairworthy

This must cover vibrations from varying degrees of motor thrust and various airspeeds. Flight test must reveal whether the structural modal frequencies are such that the aircraft structure will excessively vibrate during flight.

3.2.4.3 (b). Material construction: presence of fibrous materials vulnerable to splitting

Presence of fibrous materials	Only isotropic materials used in aircraft structure	Fibrous materials used with overlapping layers offset by at least 60 degrees	Fibrous materials used but no stress is applied orthogonal to fiber	Fibrous materials used with stress orthogonal to fiber
Risk points	0	5	10	Unairworthy

3.2.4.3 (c). Puncture resistance: the applicant must demonstrate that the airship bag will not puncture when exposed to routine puncture risk items such as rocks, dust, precipitation, sharp edges on equipment, etc. The bag must also not be punctured by the structure in the event of a hard landing (2G).

Puncture resistance standards	Standards met	Standards not met
Risk points	0	Unairworthy

3.2.4.3 (d). Envelope skin UV protection: the applicant must specify a total amount of time for which the envelope can be exposed to the UV light without causing damage to the envelope which may result in leaks. The applicant must also specify inspection procedures to locate any UV damage prior to each flight.

UV exposure standards	Standards met	Standards not met
Risk points	0	Unairworthy

The reduced risk score in this category may not exceed 13 or the aircraft is unairworthy.

3.2.4.4 Performance and propulsion

3.2.4.4 (a). Absolute ceiling, density altitude

Absolute ceiling z_{abs}, m	$z_{abs} > 5500$ m	$z_{abs} > 4400$ m	$z_{abs} > 3200$ m	$z_{abs} < 2100$ m
Risk points	0	20	40	Unairworthy

3.2.4.4 (b). Maximum true airspeed developed at standard sea level

Maximum true airspeed u_∞, m/s	$u_\infty > 3$ m/s	$u_\infty > 2$ m/s	$u_\infty > 1$m/s	$u_\infty < 1$ m/s
Risk points	0	15	30	Unairworthy

The aircraft may be certified for flights in winds not to exceed half of the maximum airspeed the airship can develop.

3.2.4.4 (c). Climb performance: maximum rate of climb at standard sea level

Climb rate, m/s	> 2 m/s	> 1.5 m/s	> 1 m/s	< 1 m/s
Risk points	0	15	30	Unairworthy

3.2.4.4 (d). Descent performance: maximum rate of descent at service ceiling without gas venting

Descent rate, m/s	> 1.5 m/s	> 1 m/s	> 0.5 m/s	< 0.5 m/s
Risk points	0	15	30	Unairworthy

3.2.4.4 (e). Maximum endurance

Endurance, minutes	> 90 minutes	> 60 minutes	> 30 minutes	< 30 minutes
Risk points	0	15	30	Unairworthy

The reduced risk score in this category may not exceed 32 or the aircraft is rendered unairworthy.

3.2.4.5 Electronics

3.2.4.5 (a). Remote control signal reliability: carrier frequency and technology used

Carrier frequency	2.4 GHz spread spectrum with DSMx or similar frequency-hopping features	Legacy carrier frequency without frequency-hopping features
Risk points	0	50

3.2.4.5 (b). Signal reliability: antenna diversity

Diversity features	Antenna diversity on transmitter and receiver	Antenna diversity on transmitter only	Antenna diversity on receiver only	No antenna diversity
Risk points	0	5	20	40

3.2.4.5 (c). ESC current rating in relation to expected maximum current draw through ESC

Value of $\frac{I_{ESC}}{I_{max}}$	$\frac{I_{ESC}}{I_{max}} > 1.5$	$\frac{I_{ESC}}{I_{max}} > 1.25$	$\frac{I_{ESC}}{I_{max}} > 1.1$	$\frac{I_{ESC}}{I_{max}} < 1.1$
Risk points	0	5	15	Unairworthy

Note: this may be inapplicable depending on the method of propulsion used in the airplane.

3.2.4.5 (d). Receiver power source

Configuration	Receiver powered from independent battery and independent BEC	Receiver powered by main flight battery, but through independent BEC	Receiver powered from BEC integrated into ESC
Risk points	0	10	30

3.2.4.5 (e). Auxiliary device power source

Configuration	Powered from independent battery and independent BEC	Powered by main flight battery, but through independent BEC	Powered from BEC integrated into ESC, or powered directly from receiver
Risk points	0	10	30

This includes aircraft lights, autopilots, sensors, etc. This category may be inapplicable depending on whether the aircraft has any auxiliary devices.

Further, all wire sizes must be specified based on the expected current draw according to the chart on the following page:

Wire size (gauge)	Wire conductor diameter (inches)	Maximum continuous current (amps), power transmission	Maximum continuous current (amps), chassis wiring
0000	0.4600	302	380
000	0.4096	239	328
00	0.3648	190	283
0	0.3249	150	245
1	0.2893	119	211
2	0.2576	94	181
3	0.2294	75	158
4	0.2043	60	135
5	0.1819	47	118
6	0.1620	37	101
7	0.1443	30	89
8	0.1285	24	73
9	0.1144	19	64
10	0.1019	15	55
11	0.0907	12	47
12	0.0808	9.3	41
13	0.0720	7.4	35
14	0.0641	5.9	32
15	0.0571	4.7	28
16	0.0508	3.7	22
17	0.0453	2.9	19
18	0.0403	2.3	16
19	0.0359	1.8	14
20	0.0320	1.5	11
21	0.0285	1.2	9
22	0.0253	0.92	7
23	0.0226	0.729	4.7
24	0.0201	0.577	3.5
25	0.0179	0.457	2.7
26	0.0159	0.361	2.2
27	0.0142	0.288	1.7
28	0.0126	0.226	1.4
29	0.0113	0.182	1.2
30	0.0100	0.142	0.86
31	0.0089	0.113	0.7
32	0.0080	0.091	0.53
33	0.0071	0.072	0.43
34	0.0063	0.056	0.33
35	0.0056	0.044	0.27
36	0.0050	0.035	0.21
37	0.0045	0.0289	0.17
38	0.0040	0.0228	0.13
39	0.0035	0.0175	0.11
40	0.0031	0.0137	0.09

Figure 3-6: Electrical wiring ampacity chart

The following requirements apply for conductor sizing:

- In no case may the current in a wire in the aircraft exceed the table value for the wire of the corresponding diameter/gauge.
- The *chassis wiring* specification applies only to wiring runs of a length less than 3.5 meters.
- The *power transmission* specification has no requirement for wiring run length.

3.2.4.5 (f). Wire gauge size: value of design maximum current in relation to table value for maximum permissible current

Value of $\frac{I_{table}}{I_{design}}$	$\frac{I_{table}}{I_{design}} \geq 1.3$	$\frac{I_{table}}{I_{design}} \geq 1.15$	$\frac{I_{table}}{I_{design}} \geq 1$	$\frac{I_{table}}{I_{design}} < 1$
Risk points	0	5	10	Unairworthy

Additionally, the following requirements apply for wiring:

- All wiring runs must be of a minimal length without the wires cluttering the interior of the airplane.
- Long wiring runs must not be accomplished by connecting multiple extension wires. If multiple lengths of wire are needed, they must be soldered together and secured with heat shrink tubing.

3.2.4.5 (g). Long wiring runs: minimal lengths

Wiring length	Wire runs are of a minimal length without cluttering the interior of the airplane.	Wiring length standards are not met.
Risk points	0	Unairworthy

3.2.4.5 (h). Long wiring runs: connection method between wire lengths

Wiring connections	Long wire runs use a single cable, or multiple cables with soldered joints.	Long wiring connection standards are not met.
Risk points	0	Unairworthy

3.2.4.5 (i). Wiring protection: OISC requires that, wherever a wire is mounted to the airframe, the wire be protected by heat-shrink tubing or a similar means. It is not acceptable to anchor a wire without any protection. Risk points are allocated as follows:

Wire protection standards	Wire protection standards met	Wire protection standards not met
Risk points	0	Unairworthy

The reduced risk score in this category may not exceed 24 or the aircraft is rendered unairworthy.

Part 4: Standards for Completely Novel Aircraft

In addition to the standards delineated in this section, the following restrictions apply to component lifetimes. This must be included in an airworthiness certificate, and it is incumbent on the operator to adhere to these guidelines. There are several stages of inspection and replacement schedules:

- A-check. Short check completed relatively often.
- B-check. More detailed check completed more rarely.
- Replacement. Component will be replaced after a specified number of flight hours, cycles, or amount of time.
- Fly until failure. Component need not be replaced or inspected until it fails.

Note: this section contains typical maintenance intervals for various aircraft components. Airworthiness assessors may change the inspection and replacement intervals/procedures depending on the circumstances.

Motors, direct drive

An A-check consists of:

- Ensure the motor turns freely and does not bind
- Ensure casing and shaft are not deformed
- Ensure motor is sufficiently lubricated
- Ensure bearings, bushings, and washers are not overly worn
- Check condition of windings and magnets
- Replace any component which shows excessive wear.

A B-check consists of:

- All A-check items
- Re-grease motor
- Replace all bearings

Inspection and replacement schedule

Check	A	B	A	Replace motor outright
Flight hours	10	10	10	10
Number of flights	7	7	7	7
Time	8 months	8 months	8 months	8 months

Figure 4-1: Direct-drive motor inspection and repair schedule

Use the minimum figure specifying the inspection interval (flight hours, number of flights, time).

Motors, geared

An A-check consists of:

- Ensure the motor turns freely and does not bind
- Ensure casing and shaft are not deformed
- Ensure motor is sufficiently lubricated
- Ensure gears are sufficiently lubricated
- Ensure gear casing is not overly worn
- Ensure bearings, bushings, and washers are not overly worn
- Check condition of windings and magnets
- Replace any component which shows excessive wear.

A B-check consists of:

- All A-check items
- Re-grease motor
- Re-grease gears
- Replace all bearings

Inspection and replacement schedule

Check	A	B	A	Replace motor outright
Flight hours	5	5	5	5
Number of flights	3	3	3	3
Time	8 months	8 months	8 months	8 months

Figure 4-2: Geared motor inspection and repair schedule

Use the minimum figure specifying the inspection interval (flight hours, number of flights, time).

Servo, single servo actuating a given mechanism

An A-check consists of:

- Ensure servo turns freely and does not bind
- Ensure servo can move through its entire range
- Ensure servo horn is in good condition and is not deformed, holes are not excessively worn, spline is not worn, and servo axis moves with servo horn without backlash.
- Ensure servo drivetrain is sufficiently lubricated

A B-check consists of:

- All A-check items
- Replace and re-grease gears within servo

- Replace servo horn

Inspection and replacement schedule

Check	A	B	A	Replace servo outright
Flight hours	15	15	15	15
Number of flights	8	8	8	8
Time	8 months	8 months	8 months	8 months

Figure 4-3: Servo inspection and repair schedule

Servo, two or more servos actuating a given mechanism

Note: for this category to be applicable, each servo must be independently capable of actuating the mechanism. Further:

- One servo must be able to actuate the mechanism, accounting for the resistance of a broken servo, while remaining within the manufacturer specifications for servo load.
- One servo must be able to actuate the mechanism while providing the same or comparable performance to the case where both servos are operational

In this case, the servo may be flown until failure. If the stipulations above are not met, the standards for a single servo apply.

4.1 Experimental Standards

4.1.1 Standards for Airplanes

The airworthiness status is found based on the reduced risk score:

- Between 0 and 5: risk level 1
- Between 6 and 15: risk level 2
- Between 16 and 26: risk level 3
- Greater than 26: unairworthy

4.1.1.1 Dynamics and Handling Requirements

The following characteristics are assessed:

- Static stability about all 3 axes
- Dynamic mode characteristics of each of the standard 5 modes: phugoid, short period, Dutch roll, roll, and spiral.

4.1.1.1 (a). Static pitch stability/pitch stiffness

Value of $C_{m\alpha}$	$C_{m\alpha} < 2$	$C_{m\alpha} < 1$	$C_{m\alpha} < 0$	$C_{m\alpha} \geq 0$
Risk points	0	5	20	80

Introduce an angle of attack disturbance with the elevator and note the initial reaction of the aircraft. Ensure this is commensurate with expectations based on the value of $C_{m\alpha}$.

4.1.1.1 (b). Gust sensitivity/static roll stability/roll stiffness

Value of $C_{l\beta}$	$C_{l\beta} < -0.12$	$C_{l\beta} < -0.06$	$C_{l\beta} < 0$	$C_{l\beta} \geq 0$
Risk points	0	5	20	80

Introduce a sideslip disturbance with the rudder and note the initial reaction of the aircraft. Ensure this is commensurate with expectations based on the value of $C_{l\beta}$.

4.1.1.1 (c). Static yaw stability/yaw stiffness

Value of $C_{n\beta}$	$C_{n\beta} \geq 0.085$	$C_{n\beta} \geq 0.05$	$C_{n\beta} > 0$	$C_{n\beta} \leq 0$
Risk points	0	5	40	80

Introduce a sideslip disturbance with the rudder and note the initial reaction of the aircraft. Ensure this is commensurate with expectations based on the value of $C_{n\beta}$.

4.1.1.1 (d). Phugoid mode characteristics

Damping ratio	$\zeta \geq 0.04$	$0 \leq \zeta < 0.04$	$T_2 > 25$ seconds	$T_2 \leq 25$ seconds
Risk points	0	10	20	50

In-flight test of mode: introduce a pitch rate disturbance using the elevator or using the combination of control inputs calculated in the experimental certification process. Verify that the resulting motion of the aircraft is commensurate with expectations.

4.1.1.1 (e). Short period mode characteristics

Damping ratio	$\zeta > 0.35$	$\zeta > 0.25$	$\zeta > 0.15$	$\zeta < 0.15$
Risk points	0	5	10	30

In-flight test of mode: introduce a disturbance using the combination of control inputs calculated in the experimental certification process. If the short-period mode is expected to be unstable, this should only be done at the PIC's discretion and at a high altitude. Verify that the resulting motion of the aircraft is commensurate with expectations.

4.1.1.1 (f). Dutch roll mode characteristics

Damping ratio	$\zeta > 0.4$	$\zeta > 0.19$	$\zeta > 0.08$	$\zeta < 0.08$
Risk points	0	10	20	50

In-flight test of mode: introduce a sideslip disturbance using the rudder or using the combination of control inputs calculated from the airplane analysis application. Verify that the resulting motion of the aircraft is commensurate with expectations.

4.1.1.1 (g). Spiral mode characteristics

Doubling time	$T_2 \geq 0$ seconds	$T_2 < -8$ seconds	$-8 < T_2 < -4$ seconds	$-4 < T_2 < 0$ seconds
Risk points	0	5	10	50

In-flight test of mode: introduce a disturbance according to calculations from the airplane analysis app. Verify that the resulting motion of the aircraft is commensurate with expectations.

4.1.1.1 (h). Roll mode characteristics

Time constant	$\tau < 1.4$ seconds, $\tau > 0$	$\tau < 3$ seconds, $\tau > 0$	$\tau > 3$ seconds	$\tau < 0$ seconds
Risk points	0	5	20	50

In-flight test of mode: introduce a disturbance according to calculations from the airplane analysis app. Verify that the resulting aircraft motion is commensurate with expectations.

Additionally, controllability must be evaluated qualitatively based on the airworthiness assessor's expertise. Based on the control surface planform size, deflection, and moment arms, the airworthiness assessor must evaluate:

- Pitch control authority

- Roll control authority
- Yaw control authority

If the control authority is in doubt, the aircraft must be evaluated per the relevant section of 4.2.

The reduced risk score in this category may not exceed 38 or the aircraft is rendered unairworthy.

4.1.1.2 Aerodynamic Performance Requirements

4.1.1.2 (a). Landing reference speed (evaluate at angle of attack of 6 degrees, maximum landing weight)

Value of V_{ref}	$V_{ref} < 10$ m/s	$10 \leq V_{ref} <$ 14 m/s	$14 \leq V_{ref} < 20$ m/s	$V_{ref} \geq 20$ m/s
Risk points	0	10	20	50

4.1.1.2 (b). Maximum rate of climb, evaluated at standard sea level

Value of V_h	$V_h > 13$ m/s	$7 \leq V_h \leq 13$ m/s	$2.5 \leq V_h < 7$ m/s	$V_h < 2.5$ m/s
Risk points	0	5	15	Unairworthy

4.1.1.2 (c). Maximum climb angle, evaluated at standard sea level

Value of θ	$\theta > 9^0$	$6.5 \leq \theta \leq 9^o$	$4.75 \leq \theta < 6.5^o$	$\theta < 4.75^o$
Risk points	0	5	10	Unairworthy

4.1.1.2 (d). Climb angle in landing configuration, evaluated at standard sea level

Value of θ	$\theta > 4.5^o$	$3 \leq \theta < 4.5^o$	$1.7 \leq \theta < 3^o$	$\theta < 1.7^o$
Risk points	0	5	10	Unairworthy

4.1.1.2 (e). Service ceiling – altitude at which climb rate reduces to 1.5 m/s (300 fpm)

Value of Z_{svc}	$Z_{svc} > 5500$ m	$3500 < Z_{svc} \leq$ 5500 m	$1500 \leq Z_{svc} \leq$ 3500 m	$Z_{svc} < 1500$ m
Risk points	0	5	10	50

Additionally, the airworthiness assessor must qualitatively evaluate the aircraft for any features which would make stall recovery unduly difficult:

- Exceptionally aft CG
- Aerodynamic twist on wing – wash-in
- Blanketing of horizontal stabilizer/elevator

If this is in doubt, the aircraft must be evaluated per the relevant section of 4.2.

The reduced risk score in this category may not exceed 16 or the aircraft is rendered unairworthy.

4.1.1.3 Structural Requirements

4.1.1.3 (a). Wing/stabilizer structural performance: physical test results at maximum load factor in positive direction. See section 1.9.1 for load factor requirements.

Results from physical test	Load is supported without failure or plastic deformation; maximum deflection angle less than 10 degrees	Load is supported without failure or plastic deformation; maximum deflection angle greater than 10 degrees	Load is supported without failure, but plastic deformation occurs	Structure fails
Risk points	0	25	Unairworthy	Unairworthy

4.1.1.3 (b). Wing/stabilizer structural performance: physical test results at maximum load factor in negative direction. See section 1.8.1 for load factor requirements.

Results from physical test	Load is supported without failure or plastic deformation; maximum deflection angle less than 10 degrees	Load is supported without failure or plastic deformation; maximum deflection angle greater than 10 degrees	Load is supported without failure, but plastic deformation occurs	Structure fails
Risk points	0	25	Unairworthy	Unairworthy

The reduced risk score in this category may not exceed 25 or the aircraft is rendered unairworthy.

4.1.1.4 Electronics Standards

4.1.1.4 (a). Servo sizing: Servo torque in relation to required torque

Value of $\frac{\tau_{servo}}{\tau_{required}}$	$\frac{\tau_{servo}}{\tau_{required}} > 3$	$\frac{\tau_{servo}}{\tau_{required}} > 2.25$	$\frac{\tau_{servo}}{\tau_{required}} > 1.5$	$\frac{\tau_{servo}}{\tau_{required}} < 1.5$
Risk points	0	10	20	Unairworthy

The required torque must be computed based on the known control hinge moments and the linkage geometry. The required torque is the torque that needs to be applied to the servo arm to (a) overcome the control hinge moment, and (b) provide adequate angular acceleration of the control surface. So, the required torque will be considerably higher than that which is simply required to overcome the control hinge moment.

4.1.1.4 (b). Remote control signal reliability: carrier frequency and technology used

Carrier frequency	2.4 GHz spread spectrum with DSMx or similar frequency-hopping features	Legacy carrier frequency without frequency-hopping features
Risk points	0	50

4.1.1.4 (c). Signal reliability: antenna diversity

Diversity features	Antenna diversity on transmitter and receiver	Antenna diversity on transmitter only	Antenna diversity on receiver only	No antenna diversity
Risk points	0	5	20	40

4.1.1.4 (d). ESC current rating in relation to expected maximum current draw through ESC

Value of $\frac{I_{ESC}}{I_{max}}$	$\frac{I_{ESC}}{I_{max}} > 1.5$	$\frac{I_{ESC}}{I_{max}} > 1.25$	$\frac{I_{ESC}}{I_{max}} > 1.1$	$\frac{I_{ESC}}{I_{max}} < 1.1$
Risk points	0	5	15	Unairworthy

4.1.1.4 (e). Wiring protection: OISC requires that, wherever a wire is mounted to the airframe, the wire be protected by heat-shrink tubing or a similar means. It is not acceptable to anchor a wire without any protection. Risk points are allocated as follows:

Wire protection standards	Wire protection standards met	Wire protection standards not met

Risk points	0	Unairworthy

The reduced risk score in this category may not exceed 27 or the aircraft is rendered unairworthy.

4.1.2 Standards for Multirotors

The airworthiness status is found based on the reduced risk score:

- Between 0 and 20: risk level 1
- Between 21 and 35: risk level 2
- Between 36 and 57: risk level 3
- Greater than 57: unairworthy

4.1.2.1 Overall Design Characteristics

4.1.2.1 (a). Type of stability augmentation system

Stability augmentation system presence and characteristics	Type 1 or type 2 SAS	Type 3 SAS	Type 4 SAS	No SAS
Risk points	0	20	50	95

The various types of stability augmentation system capabilities are defined as follows:

- Type 1: SAS can hold position and altitude when both control sticks are centered, regardless of wind. SAS automatically maintains altitude as pitch and bank are adjusted. Control sticks are used to command altitude rate, yaw rate, pitch angle, and bank angle. The position and altitude are known both a barometric altimeter and/or GPS.
- Type 2: SAS can hold position and altitude when both control sticks are centered, regardless of wind. SAS automatically maintains altitude as pitch and bank are adjusted. Control sticks are used to command altitude rate, yaw rate, pitch angle, and bank angle. The position and altitude are found based on the IMU alone.
- Type 3: SAS can hold altitude and attitude when both control sticks are centered but does not hold position. Control sticks are used to command altitude rate, yaw rate, pitch angle, and bank angle.
- Type 4: SAS is used to allow user to command altitude rate, yaw rate, pitch rate, bank rate. No altitude-hold or position-hold features.
- Types 3 and 4 stability augmentation systems require the aircraft to be trimmable.

OISC does not require experimental multirotors to have a stability augmentation system onboard.

4.1.2.1 (b). Redundancy: number of motors

Number of motors	3	4	5	6 or more
Risk points	50	40	30	0

4.1.2.1 (c). Vibration: fastener securing

Fastener securing	Fasteners secured with two of the approved methods	Fasteners secured with one of the approved methods	Fasteners unsecured; conditions for unsecure fasteners are met	Fasteners unsecured; conditions for unsecure fasteners are not met
Risk points	0	10	80	Unairworthy

Approved fastener securing methods:

- Safety wire
- Nylon locking nuts
- Thread locking compound, such as Loctite
- Castle nut and locking pin
- Split beam nut
- Locking plate or tab washer

Conditions to leave fasteners unsecured: the applicant must demonstrate compliance with the following:

- The aircraft's maximum takeoff weight must not exceed 10 lbs (4.5 kg).
- The aircraft must strictly be flown in daytime VFR conditions and within VLOS.
- The aircraft must never be flown in a crowded environment such that there is a substantial risk of it flying over people. For example, flights over campus would be prohibited since, even if the PIC makes the utmost effort to avoid flights over people, campus is sufficiently congested that, realistically, this is difficult to avoid.
- The applicant must demonstrate that the vibration produced on the aircraft is such that, after 60 minutes of consecutive flights, all fasteners remain firmly anchored.

The reduced score in this category may not exceed 69 or the aircraft is rendered unairworthy.

4.1.2.2 Structures Standards

Motor mounting structure: standards relating to effect of beam structure deflection. The deflection must be so severe such that:

- The propellers interfere with each other
- The propellers interfere with other parts of the aircraft structure

The standards for motor mounting structure deflection delineated previously in this section still apply.

4.1.2.2 (a). Risk points are allotted based on meeting the above standards:

Interference and deflection standards result	Standards met	Standards not met
Risk points	0	Unairworthy

4.1.2.2 (b). Whole aircraft torsional rigidity: maximum twist angle between opposing sides of vehicle during maximum yaw rate maneuver.

Deflection angle θ	$\theta < 2.5^o$	$\theta < 5^o$	$\theta < 7.5^o$	$\theta > 7.5^o$
Risk points	0	20	30	Unairworthy

This requirement describes the torsion which occurs when the aircraft is executing a yaw maneuver. In this configuration, the thrust of one propeller will be changed relative to the adjacent motor. The resulting moment causes the torsion evaluated by this section.

4.1.2.2 (c). Structural vibrations: in-flight oscillations during flight test

$f_{modal,structural}$ in relation to $f_{encountered}$	No structural oscillations encountered in any regime of flight	Structural vibrations occur during flight, but there is no noticeable wear after 10 flights	Structural vibrations cause significant and noticeable wear and damage after 10 flights	Structural vibrations cause component failure in flight
Risk points	0	40	Unairworthy	Unairworthy

This must cover vibrations from varying degrees of motor thrust and various airspeeds. Flight test must reveal whether the structural modal frequencies are such that the aircraft structure will excessively vibrate during flight.

4.1.2.2 (d). Material construction: presence of fibrous materials vulnerable to splitting

Presence of fibrous materials	Only isotropic materials used in aircraft structure	Fibrous materials used with overlapping layers offset by at least 60 degrees	Fibrous materials used but no stress is applied orthogonal to fiber	Fibrous materials used with stress orthogonal to fiber
Risk points	0	5	10	Unairworthy

The reduced score in this category must not exceed 20, or the aircraft is unairworthy.

4.1.2.3 Stability, Dynamics, and Control Standards

4.1.2.3 (a). Pitch and bank angle limitation

Pitch and bank limits	Limits are below FOM-defined thresholds	Limits meet FOM-defined threshold	No SAS limits: reliant on pilot to maintain FOM pitch and bank limits
Risk points	0	5	30

This is the only requirement OISC has for experimental certification of multirotors with respect to stability, dynamics, and control since evaluation of these standards is strongly dependent on flight test.

4.1.2.4 Electronics Standards

4.1.2.4 (a). Remote control signal reliability: carrier frequency and technology used

Carrier frequency	2.4 GHz spread spectrum with DSMx or similar frequency-hopping features	Legacy carrier frequency without frequency-hopping features
Risk points	0	50

4.1.2.4 (b). Signal reliability: antenna diversity

Diversity features	Antenna diversity on transmitter and receiver	Antenna diversity on transmitter only	Antenna diversity on receiver only	No antenna diversity
Risk points	0	5	20	40

The reduced score in this category may not exceed 78 or the aircraft is rendered unairworthy.

4.1.2.5 Propulsion and Performance Standards

4.1.2.5 (a). Maximum endurance:

Endurance	> 20 mins	> 12 mins	> 5 mins	< 5 mins
Risk points	0	20	40	Unairworthy

This must be found from flight test. This must include adequate reserve. For example, if using LiPo batteries, there must be sufficient voltage remaining to serve as a reserve. This means generally that the cell voltage must be kept above a predefined value. Similarly, for fueled propulsion systems, this endurance must be established with reserve fuel in the tank. The precise amount of reserve required is highly dependent on the aircraft and application, and as such is to be set by the airworthiness assessor.

4.1.2.5 (b). Vibration: propeller balance

Propeller balance characteristics	Negligible vibration: propeller center of gravity within 0.001 inches of propeller axis	Small vibration: propeller center of gravity within 0.005 inches of propeller axis	Moderate or greater vibrations; propeller center of gravity further than 0.005 inches from propeller
Risk points	0	10	Unairworthy

4.1.2.5 (c). Vibration: motor vibration

Vibration characteristics	Negligible vibration: vibration amplitude less than 0.001 inch	Small vibrations: vibration amplitude less than 0.005 inch	Moderate vibrations: vibration amplitude greater than 0.005 inch
Risk points	0	10	Unairworthy

The reduced risk score in this category may not exceed 20 or the aircraft is rendered unairworthy.

4.1.3 Standards for Helicopters

The airworthiness status is based on the reduced score:

- Between 0 and 7: risk level 1
- Between 8 and 15: risk level 2
- Between 16 and 33: risk level 3
- Greater than 33: unairworthy

4.1.3.1 Overall design characteristics

4.1.3.1 (a). Tail rotor ground strike protection. OISC requires that the tail rotor be protected from ground strikes by means of a skid plate mounted such that, as the helicopter is pitched up, the tail skid contacts the ground and clearance between the ground and tail rotor is maintained. Risk points are assessed as follows:

Tail rotor protection	Inapplicable due to design features such as counter rotating rotors or a ducted fan tail rotor	Clearance greater than 1/10 of the rotor radius	Clearance greater than 1/20 of the rotor radius	Clearances less than 1/20 of the rotor radius
Risk points	0	15	30	Unairworthy

4.1.3.1 (b). Rotor clearance: with the least favorable cyclic control and least favorable load factor, the rotor must clear any other part of the aircraft (such as the boom or fuselage) by at least 1% of the rotor diameter. Risk points are assessed as follows:

Clearance as measured by: $\frac{z_{clear}}{d_{rotor}}$	$\frac{z_{clear}}{d_{rotor}} > 0.05$	$\frac{z_{clear}}{d_{rotor}} > 0.025$	$\frac{z_{clear}}{d_{rotor}} > 0.01$	$\frac{z_{clear}}{d_{rotor}} < 0.01$
Risk points	0	15	30	Unairworthy

4.1.3.1 (c). Vibration: fastener securing

Fastener securing	Fasteners secured with two of the approved methods	Fasteners secured with one of the approved methods	Fasteners unsecured; conditions for unsecure fasteners are met	Fasteners unsecured; conditions for unsecure fasteners are not met
Risk points	0	10	80	Unairworthy

Approved fastener securing methods:

- Safety wire
- Nylon locking nuts
- Thread locking compound, such as Loctite
- Castle nut and locking pin
- Split beam nut
- Locking plate or tab washer

Conditions to leave fasteners unsecured: the applicant must demonstrate compliance with the following:

- The aircraft’s maximum takeoff weight must not exceed 10 lbs (4.5 kg).
- The aircraft must strictly be flown in daytime VFR conditions and within VLOS.

- The aircraft must never be flown in a crowded environment such that there is a substantial risk of it flying over people. For example, flights over campus would be prohibited since, even if the PIC makes the utmost effort to avoid flights over people, campus is sufficiently congested that, realistically, this is difficult to avoid.
- The applicant must demonstrate that the vibration produced on the aircraft is such that, after 60 minutes of consecutive flights, all fasteners remain firmly anchored.

Jesus bolts. Any bolts or nut on the aircraft which would cause complete loss of the aircraft in the event of failure must meet the following criteria:

- Safety factor against yielding not less than 2 with MTOW, maximum rotor thrust, and maximum load factor.
- Two methods to prevent the bolt/nut from loosening over time. The approved methods are listed below:
    - Thread locking compound, such as Loctite
    - Safety wire
    - Castle nut and locking pin
- The applicant must delineate an inspection and maintenance schedule for any of these bolts/nuts.

4.1.3.1 (d). Risk points are allocated for Jesus bolts as follows:

Safety factor	$FS \geq 3$	$FS \geq 2.5$	$FS \geq 2$	$FS < 2$
Risk points	0	15	30	Unairworthy

4.1.3.1 (e). Other standards for Jesus bolts:

Other standards met?	Met	Not met
Risk points	0	Unairworthy

The reduced score in this category may not exceed 34 or the aircraft is rendered unairworthy.

4.1.3.2 Swashplate mechanisms

4.1.3.2 (a). Servo sizing: servo torque in relation to minimum required torque

Value of $\frac{\tau}{\tau_{req}}$	$\frac{\tau}{\tau_{req}} > 2$	$\frac{\tau}{\tau_{req}} > 1.5$	$\frac{\tau}{\tau_{req}} > 1$	$\frac{\tau}{\tau_{req}} < 1$
Risk points	0	15	30	Unairworthy

The required torque is computed as follows: at the maximum rotor RPM and maximum angle of incidence of the propeller, the pitching moment about the joint which supports the rotor must be computed. The support reaction by the joint which is used to alter the rotor angle of incidence must then be computed. Then the actuation torque is found based on the length of the servo arm. Twice this torque is the minimum required torque.

The design of the swashplate assembly must be built according to best practices, such as:

- Using an anti-rotation device to prevent the lower swashplate from rotating
- An adequate safety factor is used in swashplate system, as assessed by the risk points table below
- Adequate tolerances and balance

4.1.3.2 (b). Worst-case tolerance in any component in the swashplate system

Tolerance	± 0.001 inch or better	± 0.005 inch or better	± 0.01 inch or better	Worse than ± 0.01 inch
Risk points	0	5	20	Unairworthy

4.1.3.2 (c). Location of swashplate center of gravity in relation to swashplate axis of rotation

Difference in location	< 0.001 inch	< 0.003 inch	< 0.005 inch	> 0.005 inch
Risk points	0	20	40	Unairworthy

4.1.3.2 (d). Minimum safety factor in swashplate system

Value of FS	$FS > 1.5$	$FS > 1.25$	$FS > 1.1$	$FS < 1.1$
Risk points	0	20	40	Unairworthy

The manufacturer of the swashplate system must provide a rigorous inspection and maintenance schedule to guide continuing airworthiness inspections and maintenance. This must include:

- Inspection and replacement intervals for all components of the swashplate
- Requirements for maintaining adequate lubrication on all components
- Specifications for the requited tightness of all bolts and fasteners
- Specific guidance for a preflight inspection

4.1.3.2 (e). Swashplate motion smoothness: the swashplate must move smoothly up and down the shaft without binding. Since it is typical for the smoothness of motion to degrade with time as lubrication is expelled from the swashplate mechanism, the risk is evaluated based on the amount of time smooth motion can be maintained while running the rotor at maximum RPM.

Time for which smooth motion is maintained	Greater than 90 minutes	Greater than 60 minutes	Greater than 30 minutes	Less than 30 minutes
Risk points	0	25	50	Unairworthy

The maximum flight time must be specified based on the time for which smooth motion can be maintained. The maximum flight time is not to exceed half of the time for which smooth motion is maintained.

The reduced score in this category may not exceed 35 or the aircraft is rendered unairworthy.

4.1.3.3 Performance and propulsion

4.1.3.3 (a). Climb gradient at V_y, standard sea level, all engines operative, maximum weight

Climb gradient	1:3 or better	1:4 or better	1:5 or better	Less than 1:6
Risk points	0	15	30	Unairworthy

4.1.3.3 (b). Climb gradient at V_y, standard sea level, one engine inoperative, maximum weight

Climb gradient	1:14 or better	1:16 or better	1:18 or better	Less than 1:20
Risk points	0	15	30	Unairworthy

4.1.3.3 (c). Maximum endurance:

Endurance	> 20 mins	> 12 mins	> 5 mins	< 5 mins
Risk points	0	20	40	Unairworthy

This must be found from flight test. This must include adequate reserve. For example, if using LiPo batteries, there must be sufficient voltage remaining to serve as a reserve. This means generally that the cell voltage must be kept above a predefined value. Similarly, for fueled propulsion systems, this endurance must be established with reserve fuel in the tank. The precise amount of reserve required is highly dependent on the aircraft and application, and as such is to be set by the airworthiness assessor.

4.1.3.3 (d). Vibration: propeller balance

Propeller balance characteristics	Negligible vibration: propeller center of gravity within 0.001 inches of propeller axis	Small vibration: propeller center of gravity within 0.005 inches of propeller axis	Moderate or greater vibrations; propeller center of gravity further than 0.005 inches from propeller
Risk points	0	10	Unairworthy

4.1.3.3 (e). Vibration: motor vibration

Vibration characteristics	Negligible vibration: vibration amplitude less than 0.001 inch	Small vibrations: vibration amplitude less than 0.005 inch	Moderate vibrations: vibration amplitude greater than 0.005 inch
Risk points	0	10	Unairworthy

4.1.3.3 (f). Vibration: damping of propulsion system vibrations

Damping characteristics present	Viscous liquid dampers are used	Rubber vibration isolating devices are used	No vibration damping is present, propeller balance and motor vibration score of 0	No vibration damping is present, nonzero propeller/motor vibration score
Risk points	0	20	20	Unairworthy

The reduced risk score in this category may not exceed 23 or the aircraft is rendered unairworthy.

4.1.3.4 Electronics

4.1.3.4 (a). Remote control signal reliability: carrier frequency and technology used

Carrier frequency	2.4 GHz spread spectrum with DSMx or similar frequency-hopping features	Legacy carrier frequency without frequency-hopping features
Risk points	0	50

4.1.3.4 (b). Signal reliability: antenna diversity

Diversity features	Antenna diversity on transmitter and receiver	Antenna diversity on transmitter only	Antenna diversity on receiver only	No antenna diversity
Risk points	0	5	20	40

4.1.3.4 (c). ESC current rating in relation to expected maximum current draw through ESC

Value of $\frac{I_{ESC}}{I_{max}}$	$\frac{I_{ESC}}{I_{max}} > 1.5$	$\frac{I_{ESC}}{I_{max}} > 1.25$	$\frac{I_{ESC}}{I_{max}} > 1.1$	$\frac{I_{ESC}}{I_{max}} < 1.1$
Risk points	0	5	15	Unairworthy

Note: this may be inapplicable depending on the method of propulsion used in the airplane.

4.1.3.4 (d). Receiver power source

Configuration	Receiver powered from independent battery and independent BEC	Receiver powered by main flight battery, but through independent BEC	Receiver powered from BEC integrated into ESC
Risk points	0	10	30

4.1.3.4 (e). Auxiliary device power source

Configuration	Powered from independent battery and independent BEC	Powered by main flight battery, but through independent BEC	Powered from BEC integrated into ESC, or powered directly from receiver
Risk points	0	10	30

This includes aircraft lights, autopilots, sensors, etc. This category may be inapplicable depending on whether the aircraft has any auxiliary devices.

Further, all wire sizes must be specified based on the expected current draw according to the chart on the following page:

Wire size (gauge)	Wire conductor diameter (inches)	Maximum continuous current (amps), power transmission	Maximum continuous current (amps), chassis wiring
0000	0.4600	302	380
000	0.4096	239	328
00	0.3648	190	283
0	0.3249	150	245
1	0.2893	119	211
2	0.2576	94	181
3	0.2294	75	158
4	0.2043	60	135
5	0.1819	47	118
6	0.1620	37	101
7	0.1443	30	89
8	0.1285	24	73
9	0.1144	19	64
10	0.1019	15	55
11	0.0907	12	47
12	0.0808	9.3	41
13	0.0720	7.4	35
14	0.0641	5.9	32
15	0.0571	4.7	28
16	0.0508	3.7	22
17	0.0453	2.9	19
18	0.0403	2.3	16
19	0.0359	1.8	14
20	0.0320	1.5	11
21	0.0285	1.2	9
22	0.0253	0.92	7
23	0.0226	0.729	4.7
24	0.0201	0.577	3.5
25	0.0179	0.457	2.7
26	0.0159	0.361	2.2
27	0.0142	0.288	1.7
28	0.0126	0.226	1.4
29	0.0113	0.182	1.2
30	0.0100	0.142	0.86
31	0.0089	0.113	0.7
32	0.0080	0.091	0.53
33	0.0071	0.072	0.43
34	0.0063	0.056	0.33
35	0.0056	0.044	0.27
36	0.0050	0.035	0.21
37	0.0045	0.0289	0.17
38	0.0040	0.0228	0.13
39	0.0035	0.0175	0.11
40	0.0031	0.0137	0.09

Figure 4-4: Electrical wiring ampacity chart

The following requirements apply for conductor sizing:

- In no case may the current in a wire in the aircraft exceed the table value for the wire of the corresponding diameter/gauge.
- The *chassis wiring* specification applies only to wiring runs of a length less than 3.5 meters.
- The *power transmission* specification has no requirement for wiring run length.

4.1.3.4 (f). Wire gauge size: value of design maximum current in relation to table value for maximum permissible current

Value of $\frac{I_{table}}{I_{design}}$	$\frac{I_{table}}{I_{design}} \geq 1.3$	$\frac{I_{table}}{I_{design}} \geq 1.15$	$\frac{I_{table}}{I_{design}} \geq 1$	$\frac{I_{table}}{I_{design}} < 1$
Risk points	0	5	10	Unairworthy

Additionally, the following requirements apply for wiring:

- All wiring runs must be of a minimal length without the wires cluttering the interior of the airplane.
- Long wiring runs must not be accomplished by connecting multiple extension wires. If multiple lengths of wire are needed, they must be soldered together and secured with heat shrink tubing.

4.1.3.4 (g). Long wiring runs: minimal lengths

Wiring length	Wire runs are of a minimal length without cluttering the interior of the airplane.	Wiring length standards are not met.
Risk points	0	Unairworthy

4.1.3.4 (h). Long wiring runs: connection method between wire lengths

Wiring connections	Long wire runs use a single cable, or multiple cables with soldered joints.	Long wiring connection standards are not met.
Risk points	0	Unairworthy

4.1.3.4 (i). Wiring protection: OISC requires that, wherever a wire is mounted to the airframe, the wire be protected by heat-shrink tubing or a similar means. It is not acceptable to anchor a wire without any protection. Risk points are allocated as follows:

Wire protection standards	Wire protection standards met	Wire protection standards not met
Risk points	0	Unairworthy

The reduced risk score in this category may not exceed 24 or the aircraft is rendered unairworthy.

4.1.3.5 Structures

4.1.3.5 (a). Rotor mounting structure: minimum safety factor against yielding at full thrust and maximum takeoff weight

Value of FS	$FS > 1.5$	$FS > 1.25$	$FS > 1.1$	$FS < 1.1$
Risk points	0	5	10	Unairworthy

4.1.3.5 (b). Tail boom structure: maximum deflection of beam structure at full tail rotor thrust and maximum takeoff weight

Deflection v	$v < 3\text{mm}$	$v < 5\text{mm}$	$v < 10\text{mm}$	$v > 10\text{mm}$
Risk points	0	20	30	Unairworthy

4.1.3.5 (c). Tail boom structure: maximum deflection angle of beam structure at full tail rotor thrust and maximum takeoff weight

Deflection angle θ	$\theta < 2.5^o$	$\theta < 5^o$	$\theta < 7.5^o$	$\theta > 7.5^o$
Risk points	0	20	30	Unairworthy

4.1.3.5 (d). Landing gear structure: minimum safety factor against yielding

Value of FS	$FS > 2.5$	$FS > 2.25$	$FS > 2.1$	$FS < 2.1$
Risk points	0	5	10	Unairworthy

Landing gear deflection: the following standards apply for the deflection of landing gear during a 2-g landing on a smooth, level surface:

- The landing gear must not deflect so much that the tail rotor risks touching the ground
- The landing gear must not deflect asymmetrically to change the attitude of the aircraft which could cause the rotor to impact the ground.

4.1.3.5 (e). Material construction: presence of fibrous materials vulnerable to splitting

Presence of fibrous materials	Only isotropic materials used in aircraft structure	Fibrous materials used with overlapping layers offset by at least 60 degrees	Fibrous materials used but no stress is applied orthogonal to fiber	Fibrous materials used with stress orthogonal to fiber
Risk points	0	5	10	Unairworthy

4.1.3.5 (f). Rotor structures: minimum factor of safety of main rotor at maximum thrust, MTOW, maximum load factor

Value of FS	$FS > 1.5$	$FS > 1.5$	$FS > 1.15$	$FS < 1.15$
Risk points	0	20	40	Unairworthy

Rotor structures: the following rotor structures standards also apply:

- The rotor must possess sufficient torsional stiffness to not deform excessively to compromise the lift generated by the rotor.
- The rotor must possess sufficient beam bending stiffness to not deform excessively to compromise the lift generated by the rotor or cause interference with other parts of the aircraft structure.

4.1.3.5 (g). Rotor stiffness risk points

Standards met	Met	Not met
Risk points	0	Unairworthy

The reduced risk score in this category may not exceed 19 or the aircraft is rendered unairworthy.

4.1.3.6 Dynamics and handling

4.1.3.6 (a). Dynamic rollover: critical rollover angle

Critical angle θ	$\theta > 15^o$	$\theta > 10^o$	$\theta > 5^o$	$\theta < 5^o$
Risk points	0	15	30	Unairworthy

4.1.3.6 (b). Static stability: static yaw stability in forward flight

Static stability	Statically stable	Neutrally stable or unstable
Risk points	0	80

4.1.3.6 (c). Static stability: static roll stability in forward flight

Static stability	Statically stable	Neutrally stable or unstable
Risk points	0	80

4.1.3.6 (d). Static stability: static pitch stability in forward flight

Static stability	Statically stable	Neutrally stable or unstable
Risk points	0	80

4.1.3.6 (e). Dynamic stability: growth of oscillations in pitch (hover)

Absolute value of time constant τ	$\tau > 1$ sec	$\tau > 0.6$ sec	$\tau > 0.1$ sec	$\tau < 0.1$ sec
Risk points	0	20	40	Unairworthy

4.1.3.6 (f). Dynamic stability: growth of oscillations in roll (hover)

Absolute value of time constant τ	$\tau > 1$ sec	$\tau > 0.6$ sec	$\tau > 0.1$ sec	$\tau < 0.1$ sec
Risk points	0	20	40	Unairworthy

4.1.3.6 (g). Dynamic stability: growth of oscillations in yaw (hover)

Absolute value of time constant τ	$\tau > 1$ sec	$\tau > 0.6$ sec	$\tau > 0.1$ sec	$\tau < 0.1$ sec
Risk points	0	20	40	Unairworthy

The reduced risk score in this category may not exceed 61 or the aircraft is rendered unairworthy.

4.1.4 Standards for Airships

The airworthiness status is found based on the reduced risk score:

- Between 0 and 5: risk level 1
- Between 5 and 10: risk level 2
- Between 11 and 20: risk level 3
- Greater than 20: unairworthy

4.1.4.1 Overall design characteristics

4.1.4.1 (a). Type of airship

Airship type	Rigid airship	Semi-rigid airship	Non-rigid airship
Risk points	0	15	30

The definitions for each type of airship are below:

- Rigid airship – an airship with an internal structure which supports the envelope and maintains the external shape of the airship independent of the pressure within the airship.
- Semi-rigid airship – an airship with a stiff (or semi-stiff) keel or truss supports the airship along its lower length. The external shape of the envelope is maintained by air pressure.
- Non-rigid airship – an airship which requires air pressure to maintain the external shape of the envelope and obtains most of its strength and stiffness from the pressurized envelope.

4.1.4.1 (b). Lifting gas

Lifting gas risk level	Risk level 1 gas	Risk level 2 gas	Risk level 3 gas	Risk level 4 gas
Risk points	0	30	80	Unairworthy

The following list details the kinds of lifting gas and the associated risk levels:

- Risk level 1 gasses
  - Helium
  - Ammonia
  - Neon
  - Nitrogen
  - Any non-flammable, non-toxic, cold gas
- Risk level 2 gasses
  - Hot air
  - Water vapor
  - Vacuum
  - Any hot, non-flammable, non-toxic gas or gasses which require low pressures
- Risk level 3 gasses
  - Hydrogen
  - Methane
  - Acetylene
  - Coal gas
  - Any flammable non-toxic gas
- Risk level 4 gasses
  - Plasma
  - Hydrogen cyanide
  - Hydrogen fluoride
  - Any excessively hot or toxic gas

Lifting gas safety features: OISC requires the airship to be equipped with certain safety features depending on the type of lifting gas. These requirements are detailed below:

- Flammable gasses
  - This applies to hydrogen, methane, acetylene, and coal gas or any other flammable gas.
  - The chief concern is that the lifting gas could ignite.
  - No airship will be certified as airworthy which uses flammable gas without the following:
    - Design features to ensure no ignition sources exist within 20cm of the envelope containing the lifting gas.
    - A plan for rigorous inspection of the aircraft before and after flight to locate any leaks.
    - Safety plan to mitigate fire risk during flight, gas filling, and gas removal approved by OISC and a local fire department.
- Hot gasses
  - This applies to hot air, water vapor, and any other gas which is heated to a temperature above atmospheric temperature to function.
  - The chief concern is that the heat could soften any materials used in constructing the airship, potentially causing loss of pressure or structural failure.
  - No airship will be certified as airworthy which uses hot gasses without the following:
    - Design features to closely regulate the gas temperature and alert the crew if the temperature is outside of acceptable ranges.
    - Analysis to show that the chosen materials can withstand the heat of these gasses without decreasing stiffness or strength material parameters to the point of causing excessive deformation or material failure.
    - Design features to ensure that any heating apparatuses cannot ignite the structure of the airship itself.
- Gasses which can diffuse through common skin materials
  - This applies to hydrogen, helium, and any other generally monoatomic gas which can easily diffuse through common skin materials.
  - The chief concern is that the gas can diffuse through the skin of the aircraft and the pressure can be lost over time, which could reduce the lift force generated over time.
  - No airship will be certified as airworthy which uses gasses prone to diffusion through skin without the following:
    - Design features to closely monitor the pressure inside the airship and to alert the crew if the pressure drops too low.
    - Selection of skin material to minimize gaseous diffusion through the skin.
    - Precise determination of the permissible flight time considering gaseous diffusion phenomena.
- Vacuum
  - This applies to situations where a near-vacuum is used to provide the lifting force.
  - The chief concern is ensuring that the structure can safely support a vacuum and has adequate fatigue life to support repeated flights.

- No airship will be certified as airworthy which relies on a vacuum without the following:
  - Demonstration from proponent that the structure possesses at least a 1.25 factor of safety against yielding at standard sea level external conditions and zero-pressure internal conditions.
  - Determination of pressurization-depressurization cycles which the aircraft can undergo before fatigue renders the structure unairworthy.

4.1.4.1 (c). Risk points for gas-specific safety features

Gas-specific safety standards	Standards met	Standards not met
Risk points	0	Unairworthy

4.1.4.1 (d). Lifting gas venting: all airships must be equipped with a means to quickly vent lifting gas in the event of an emergency. This must be capable of, at minimum, quickly venting both a small fraction of the gas to allow the airship to sink, and quickly venting all or most of the lifting gas.

Gas venting standards	Standards met	Standards not met
Risk points	0	Unairworthy

The reduced risk score in this category may not exceed 33 or the aircraft is rendered unairworthy.

4.1.4.2 Stability and Control

4.1.4.2 (a). Moment balance in pitch: resting pitch angle

Pitch angle absolute value	$\|\theta\| < 1^o$	$\|\theta\| < 2^o$	$\|\theta\| < 5^o$	$\|\theta\| > 5^o$
Risk points	0	15	40	Unairworthy

This assumes that the desired nominal pitch angle is zero. However, if the design calls for a nonzero nominal pitch angle, this standard should be based on the error of the actual resting pitch angle vs. the desired resting pitch angle.

4.1.4.2 (b). Moment balance in roll: resting roll angle error

Pitch angle absolute value	$\|\phi\| < 1^o$	$\|\phi\| < 2^o$	$\|\phi\| < 5^o$	$\|\phi\| > 5^o$
Risk points	0	15	40	Unairworthy

This assumes that the desired nominal roll angle is zero. However, if the design calls for a nonzero nominal roll angle, this standard should be based on the error of the actual resting roll angle vs. the desired resting roll angle.

4.1.4.2 (c). Static stability in pitch, zero airspeed: the center of buoyancy must be located relative to the center of mass of the airship such that, when the pitch is perturbed at zero airspeed, the airship reacts such that it has static pitch stiffness.

Static pitch stiffness	Stable	Unstable or neutrally stable
Risk points	0	Unairworthy

4.1.4.2 (d). Static stability in roll: the center of buoyancy must be located relative to the center of mass of the airship such that, when the roll is perturbed at any airspeed between 0 and V_H, the airship reacts such that it has static roll stiffness.

Static roll stiffness	Stable	Unstable or neutrally stable
Risk points	0	Unairworthy

4.1.4.2 (e). Static yaw stability, nonzero airspeed: during forward flight, the airship must produce a yawing moment response to a sideslip to counteract the sideslip.

Static yaw stiffness	Stable	Unstable or neutrally stable
Risk points	0	Unairworthy

4.1.4.2 (f). Pitch control: the aircraft's pitch must be able to be controlled both at zero airspeed and at nonzero airspeed.

Pitch control	Pitch control standards met	Standards not met
Risk points	0	Unairworthy

4.1.4.2 (g). Altitude control: the airship must be able to maintain altitude as the buoyancy of the airship changes. It further must be able to make corrections to altitude to aid in landing. To that, OISC requires two types of altitude control, unless the applicant can demonstrate that another solution accomplishes both goals:

- A system to account for changes in atmospheric conditions, changes in density of the lifting gas, or other large-scale phenomena that would change the trim altitude of the airship by tens to hundreds of meters. An example of a means to comply with this requirement would be a ballonet, changing the pressure, temperature, or amount of lifting gas in the bag, or using ballast such as water which can be jettisoned.
- A system to produce small changes in altitude, such as those required for takeoff and landing. OSIC recommends a system in which thrust is produced in the vertical direction.

Altitude control requirements	Requirements met	Requirements not met
Risk points	0	Unairworthy

The reduced risk score in this category may not exceed 11 or the aircraft is rendered unairworthy.

4.1.4.3 Structures

Note that these standards are general and apply to any airship. Structural standards specific to rigid, non-rigid, and semi-rigid airships are contained in section 5.4.

4.1.4.3 (a). Safety factor of skin

Value of FS	$FS > 1.5$	$FS > 1.25$	$FS > 1.05$	$FS < 1.05$
Risk points	0	5	15	Unairworthy

This is to be evaluated at maximum internal pressure and 90% of the standard atmosphere pressure at the design absolute ceiling.

OISC recommends maintaining the internal pressure slightly above the outside pressure such that a leak in the skin would not be catastrophic.

4.1.4.3 (b). Material construction: presence of fibrous materials vulnerable to splitting

Presence of fibrous materials	Only isotropic materials used in aircraft structure	Fibrous materials used with overlapping layers offset by at least 60 degrees	Fibrous materials used but no stress is applied orthogonal to fiber	Fibrous materials used with stress orthogonal to fiber
Risk points	0	5	10	Unairworthy

4.1.4.3 (c). Minimum safety factor in gondola mount

Value of FS	$FS > 1.5$	$FS > 1.25$	$FS > 1.15$	$FS < 1.15$
Risk points	0	5	15	Unairworthy

This safety factor must be calculated based on the maximum expected G load in flight and the load that may need to be supported in a hard (2G) landing.

4.1.4.3 (d). Puncture resistance: the applicant must demonstrate that the airship bag will not puncture when exposed to routine puncture risk items such as rocks, dust, precipitation, sharp edges on equipment, etc. The bag must also not be punctured by the structure in the event of a hard landing (2G).

Puncture resistance standards	Standards met	Standards not met
Risk points	0	Unairworthy

4.1.4.3 (e). Motor mount: minimum safety factor in motor mounting structure

Value of FS	$FS > 1.5$	$FS > 1.25$	$FS > 1.15$	$FS < 1.15$
Risk points	0	5	15	Unairworthy

4.1.4.3 (f). Landing gear: minimum safety factor in landing gear structure at MTOW and hard (2G) landing

Value of FS	$FS > 1.5$	$FS > 1.35$	$FS > 1.25$	$FS < 1.25$
Risk points	0	5	15	Unairworthy

4.1.4.3 (g). Landing gear other standards: the landing gear must also meet the following other standards:

- The landing gear must be able to swivel to account for the change in azimuth of the airship in response to the wind as it is secured to the ground.
- Some means of mooring the airship must be included which secures the airship to the ground when it is not flying.

Landing gear other standards	Standard met	Standards not met
Risk points	0	Unairworthy

The reduced risk score in this category may not exceed 10 or the aircraft is rendered unairworthy.

4.1.4.4 Performance and Propulsion

4.1.4.4 (a). Absolute ceiling, density altitude

Absolute ceiling z_{abs}, m	$z_{abs} > 5500$ m	$z_{abs} > 4400$ m	$z_{abs} > 3200$ m	$z_{abs} < 2100$ m
Risk points	0	20	40	Unairworthy

4.1.4.4 (b). Climb performance: maximum rate of climb at standard sea level

Climb rate, m/s	> 2 m/s	> 1.5 m/s	> 1 m/s	< 1 m/s
Risk points	0	15	30	Unairworthy

4.1.4.4 (c). Descent performance: maximum rate of descent at service ceiling without gas venting

Descent rate, m/s	> 1.5 m/s	> 1 m/s	> 0.5 m/s	< 0.5 m/s
Risk points	0	15	30	Unairworthy

4.1.4.4 (d). Vibration: propeller balance

Propeller balance characteristics	Negligible vibration: propeller center of gravity within 0.001 inches of propeller axis	Small vibration: propeller center of gravity within 0.005 inches of propeller axis	Moderate or greater vibrations; propeller center of gravity further than 0.005 inches from propeller
Risk points	0	10	Unairworthy

4.1.4.4 (e). Vibration: motor vibration

Vibration characteristics	Negligible vibration: vibration amplitude less than 0.001 inch	Small vibrations: vibration amplitude less than 0.005 inch	Moderate vibrations: vibration amplitude greater than 0.005 inch
Risk points	0	10	Unairworthy

4.1.4.4 (f). Vibration: damping of propulsion system vibrations

Damping characteristics present	Viscous liquid dampers are used	Rubber vibration isolating devices are used	No vibration damping is present, propeller balance and motor vibration score of 0	No vibration damping is present, nonzero propeller/motor vibration score
Risk points	0	20	20	Unairworthy

The reduced risk score in this category may not exceed 23 or the aircraft is rendered unairworthy.

4.1.4.5 Electronics

4.1.4.5 (a). Remote control signal reliability: carrier frequency and technology used

Carrier frequency	2.4 GHz spread spectrum with DSMx or similar frequency-hopping features	Legacy carrier frequency without frequency-hopping features
Risk points	0	50

4.1.4.5 (b). Signal reliability: antenna diversity

Diversity features	Antenna diversity on transmitter and receiver	Antenna diversity on transmitter only	Antenna diversity on receiver only	No antenna diversity
Risk points	0	5	20	40

4.1.4.5 (c). ESC current rating in relation to expected maximum current draw through ESC

Value of $\frac{I_{ESC}}{I_{max}}$	$\frac{I_{ESC}}{I_{max}} > 1.5$	$\frac{I_{ESC}}{I_{max}} > 1.25$	$\frac{I_{ESC}}{I_{max}} > 1.1$	$\frac{I_{ESC}}{I_{max}} < 1.1$
Risk points	0	5	15	Unairworthy

Note: this may be inapplicable depending on the method of propulsion used in the airplane.

4.1.4.5 (d). Receiver power source

Configuration	Receiver powered from independent battery and independent BEC	Receiver powered by main flight battery, but through independent BEC	Receiver powered from BEC integrated into ESC
Risk points	0	10	30

4.1.4.5 (e). Auxiliary device power source

Configuration	Powered from independent battery and independent BEC	Powered by main flight battery, but through independent BEC	Powered from BEC integrated into ESC, or powered directly from receiver
Risk points	0	10	30

This includes aircraft lights, autopilots, sensors, etc. This category may be inapplicable depending on whether the aircraft has any auxiliary devices.

Further, all wire sizes must be specified based on the expected current draw according to the chart on the following page:

Wire size (gauge)	Wire conductor diameter (inches)	Maximum continuous current (amps), power transmission	Maximum continuous current (amps), chassis wiring
0000	0.4600	302	380
000	0.4096	239	328
00	0.3648	190	283
0	0.3249	150	245
1	0.2893	119	211
2	0.2576	94	181
3	0.2294	75	158
4	0.2043	60	135
5	0.1819	47	118
6	0.1620	37	101
7	0.1443	30	89
8	0.1285	24	73
9	0.1144	19	64
10	0.1019	15	55
11	0.0907	12	47
12	0.0808	9.3	41
13	0.0720	7.4	35
14	0.0641	5.9	32
15	0.0571	4.7	28
16	0.0508	3.7	22
17	0.0453	2.9	19
18	0.0403	2.3	16
19	0.0359	1.8	14
20	0.0320	1.5	11
21	0.0285	1.2	9
22	0.0253	0.92	7
23	0.0226	0.729	4.7
24	0.0201	0.577	3.5
25	0.0179	0.457	2.7
26	0.0159	0.361	2.2
27	0.0142	0.288	1.7
28	0.0126	0.226	1.4
29	0.0113	0.182	1.2
30	0.0100	0.142	0.86
31	0.0089	0.113	0.7
32	0.0080	0.091	0.53
33	0.0071	0.072	0.43
34	0.0063	0.056	0.33
35	0.0056	0.044	0.27
36	0.0050	0.035	0.21
37	0.0045	0.0289	0.17
38	0.0040	0.0228	0.13
39	0.0035	0.0175	0.11
40	0.0031	0.0137	0.09

Figure 4-5: Electrical wiring ampacity chart

The following requirements apply for conductor sizing:

- In no case may the current in a wire in the aircraft exceed the table value for the wire of the corresponding diameter/gauge.
- The *chassis wiring* specification applies only to wiring runs of a length less than 3.5 meters.
- The *power transmission* specification has no requirement for wiring run length.

4.1.4.5 (f). Wire gauge size: value of design maximum current in relation to table value for maximum permissible current

Value of $\frac{I_{table}}{I_{design}}$	$\frac{I_{table}}{I_{design}} \geq 1.3$	$\frac{I_{table}}{I_{design}} \geq 1.15$	$\frac{I_{table}}{I_{design}} \geq 1$	$\frac{I_{table}}{I_{design}} < 1$
Risk points	0	5	10	Unairworthy

Additionally, the following requirements apply for wiring:

- All wiring runs must be of a minimal length without the wires cluttering the interior of the airplane.
- Long wiring runs must not be accomplished by connecting multiple extension wires. If multiple lengths of wire are needed, they must be soldered together and secured with heat shrink tubing.

4.1.4.5 (g). Long wiring runs: minimal lengths

Wiring length	Wire runs are of a minimal length without cluttering the interior of the airplane.	Wiring length standards are not met.
Risk points	0	Unairworthy

4.1.4.5 (h). Long wiring runs: connection method between wire lengths

Wiring connections	Long wire runs use a single cable, or multiple cables with soldered joints.	Long wiring connection standards are not met.
Risk points	0	Unairworthy

4.1.4.5 (i). Wiring protection: OISC requires that, wherever a wire is mounted to the airframe, the wire be protected by heat-shrink tubing or a similar means. It is not acceptable to anchor a wire without any protection. Risk points are allocated as follows:

Wire protection standards	Wire protection standards met	Wire protection standards not met
Risk points	0	Unairworthy

The reduced score in this category may not exceed 24 or the aircraft is rendered unairworthy.

4.2 Operational Standards

For all operational standards, the requirements must be verified by both (a) analysis performed by OISC, and (b) documented flight tests. Flights must be conducted under an experimental airworthiness certificate. For OISC to verify the flight data, either (a) the aircraft must be equipped with sensors and dataloggers to capture the required data, or (b) an OISC airworthiness assessor must be present for flight tests.

4.2.1 Standards for Airplanes

Note that, while the intent of this section is to be as comprehensive as possible with the stipulations for airworthiness, the airworthiness inspector has the right to conduct additional tests and demand that the aircraft meet additional standards, so long as the criteria for passing these tests is clearly delineated before conducting them. These tests, along with the circumstances that warranted them, should then be added to this manual.

The airworthiness status is found based on the reduced total score:

- Less than 10: risk level 1
- Between 11 and 22: risk level 2
- Between 23 and 38: risk level 3
- Greater than 38: unairworthy

4.2.1.1 Dynamics and Handling Requirements

The following categories are assessed:

- Static stability in relation to stiffness about the pitch, roll, and yaw axes. Static stability is desired.
- Dynamic stability of all lateral modes.
- Dynamic stability of all longitudinal modes.
- In relation to dynamic stability, one unstable or insufficiently well-damped mode does not render the aircraft unairworthy. An aircraft which is severely unstable about multiple axes will be rendered unairworthy, along with an aircraft that is unstable in modes that are expected to commonly occur during normal flight.
- Note regarding dynamic stability:
    - If the aircraft is not equipped with an autopilot or stability augmentation system, only the natural dynamics need to be evaluated.
    - If the aircraft is equipped with an autopilot or stability augmentation system, the artificial dynamics score needs to be evaluated in addition to the automation reliability score.
    - If the automation reliability score is greater than 5, the aircraft must also meet airworthiness requirements with its natural dynamics.
- Control authority: maximum pitch and roll rates. A sluggish aircraft that lacks sufficient control authority for safe normal flight will be unairworthy. An aircraft with very sharp and

fast handling will contain as a stipulation in its airworthiness certificate that it should be flown by an experienced pilot or feature a dual rate setting to reduce the maximum pitch/roll rates.

- Crosswind handling characteristics.

Note: if the aircraft is equipped with artificial stabilization or an autopilot, see 4.2.1.4 to evaluate the reliability of the automation. In this case, the dynamics score is based on the artificial dynamic characteristics. Due to the possibility of introducing new modes, which can be significantly different than the natural dynamics modes, the artificial dynamics must be evaluated per a different set of requirements contained in 4.2.1.4.

The natural dynamics characteristics should be computed before operational certification. In the certification flight, it is not expected that precise dynamics characteristics be measured, but maneuvers should be performed to show that the calculated dynamics characteristics are at least qualitatively correct, i.e. that a mode is stable or lightly damped. If the flight test shows similar results to the calculations, the calculated values are assumed to be valid. If the flight test disagrees with the calculations, the results from the flight test should be used to assess the dynamics. In this case, the airworthiness assessor should categorize the performance within the risk analysis framework in this section based on their expertise. Note that all flight tests to validate a calculated stability characteristic are specific to a given airspeed, flight configuration (i.e. level, climb, descent, load factor), and weight/balance configuration. Take care to replicate the conditions used in the calculations in the flight test.

This section assumes that the airplane has the five standard dynamic modes: short period, phugoid, Dutch roll, spiral, roll. If the aircraft does not have these five modes, the dynamics evaluation for augmented dynamics should be used since it is more general.

4.2.1.1 (a). Phugoid mode characteristics

Damping ratio	$\zeta \geq 0.04$	$0 \leq \zeta < 0.04$	$T_2 > 25$ seconds	$T_2 \leq 25$ seconds
Risk points	0	10	20	50

In-flight test of mode: introduce a pitch rate disturbance using the elevator or using the combination of control inputs calculated in the experimental certification process. Verify that the resulting motion of the aircraft is commensurate with expectations.

4.2.1.1 (b). Short period mode characteristics

Damping ratio	$\zeta > 0.35$	$\zeta > 0.25$	$\zeta > 0.15$	$\zeta < 0.15$
Risk points	0	5	10	30

In-flight test of mode: introduce a disturbance using the combination of control inputs calculated in the experimental certification process. If the short-period mode is expected to be unstable, this should only be done at the PIC's discretion and at a high altitude. Verify that the resulting motion of the aircraft is commensurate with expectations.

4.2.1.1 (c). Dutch roll mode characteristics

Damping ratio	$\zeta > 0.4$	$\zeta > 0.19$	$\zeta > 0.08$	$\zeta < 0.08$
Risk points	0	10	20	50

In-flight test of mode: introduce a sideslip disturbance using the rudder or using the combination of control inputs calculated from the airplane analysis application. Verify that the resulting motion of the aircraft is commensurate with expectations.

4.2.1.1 (d). Spiral mode characteristics

Doubling time	$T_2 \geq 0$ seconds	$T_2 < -8$ seconds	$-8 < T_2 < -4$ seconds	$-4 < T_2 < 0$ seconds
Risk points	0	5	10	50

In-flight test of mode: introduce a disturbance according to calculations from the airplane analysis app. Verify that the resulting motion of the aircraft is commensurate with expectations.

4.2.1.1 (e). Roll mode characteristics

Time constant	$\tau < 1.4$ seconds, $\tau > 0$	$\tau < 3$ seconds, $\tau > 0$	$\tau > 3$ seconds	$\tau < 0$ seconds
Risk points	0	5	20	50

In-flight test of mode: introduce a disturbance according to calculations from the airplane analysis app. Verify that the resulting aircraft motion is commensurate with expectations.

4.2.1.1 (f). Static pitch stability/pitch stiffness

Value of $C_{m\alpha}$	$C_{m\alpha} < 2$	$C_{m\alpha} < 1$	$C_{m\alpha} < 0$	$C_{m\alpha} \geq 0$
Risk points	0	5	20	Unairworthy

Introduce an angle of attack disturbance with the elevator and note the initial reaction of the aircraft. Ensure this is commensurate with expectations based on the value of $C_{m\alpha}$.

4.2.1.1 (g). Gust sensitivity/static roll stability/roll stiffness

Value of $C_{l\beta}$	$C_{l\beta} < -0.12$	$C_{l\beta} < -0.06$	$C_{l\beta} < 0$	$C_{l\beta} \geq 0$
Risk points	0	5	20	80

Introduce a sideslip disturbance with the rudder and note the initial reaction of the aircraft. Ensure this is commensurate with expectations based on the value of $C_{l\beta}$.

4.2.1.1 (h). Static yaw stability/yaw stiffness

Value of $C_{n\beta}$	$C_{n\beta} \geq 0.085$	$C_{n\beta} \geq 0.05$	$C_{n\beta} > 0$	$C_{n\beta} \leq 0$
Risk points	0	5	40	Unairworthy

Introduce a sideslip disturbance with the rudder and note the initial reaction of the aircraft. Ensure this is commensurate with expectations based on the value of $C_{n\beta}$.

4.2.1.1 (i). Time to roll from -30 to +60 degrees at reference approach speed and approach configuration

Value of t_{roll}, seconds	$t_{roll} < 4$	$4 \leq t_{roll} < 7$	$7 \leq t_{roll} < 10$	$t_{roll} > 10$
PIC control authority evaluation	Excellent or sensitive; $CH \leq 2$	Good; $CH \leq 4$	Adequate; $CH \leq 6$	Inadequate; $CH > 6$
Risk points	10	0	50	Unairworthy

From a state at which the roll rate is zero and the bank is 30 degrees, introduce full aileron deflection and record the time to roll to 60 degrees bank in the opposite direction.

4.2.1.1 (j). Time to roll from -30 to +60 degrees at cruise speed and clean configuration

Value of t_{roll}, seconds	$t_{roll} < 1$	$1 \leq t_{roll} < 4$	$4 \leq t_{roll} < 7$	$t_{roll} > 7$
PIC control authority evaluation	Excellent or sensitive; $CH \leq 2$	Good; $CH \leq 4$	Adequate; $CH \leq 6$	Inadequate; $CH > 6$
Risk points	10	0	50	Unairworthy

From a state at which the roll rate is zero and the bank is 30 degrees, introduce full aileron deflection and record the time to roll to 60 degrees bank in the opposite direction.

4.2.1.1 (k). Pitch control authority, down elevator: value of $\dot{q}_{init}$, initial time rate of change of pitch rate with maximum up-elevator deflection at approach speed.

Value of $\dot{q}_{init}$, degrees/second squared	$\dot{q}_{init} < 250$	$\dot{q}_{init} < 350$	$\dot{q}_{init} < 450$	$\dot{q}_{init} > 450$
PIC control authority evaluation	Inadequate; Cooper-Harper ≥ 6	Acceptable; Cooper-Harper ≥ 4	Good; Cooper-Harper ≥ 2	Sensitive; Cooper-Harper ≥ 5
Risk points	Unairworthy	20	0	50

Introduce full down elevator and note the resulting motion. Ensure it is commensurate with the calculated value of $\dot{q}_{init}$.

4.2.1.1 (l). Pitch control authority, up elevator: value of $\dot{q}_{init}$, initial time rate of change of pitch rate with maximum down-elevator deflection at approach speed.

Value of $\dot{q}_{init}$, degrees/second squared	$\dot{q}_{init} < 1000$	$\dot{q}_{init} < 1200$	$\dot{q}_{init} < 1600$	$\dot{q}_{init} > 1600$
PIC control authority evaluation	Inadequate; Cooper-Harper ≥ 6	Acceptable; Cooper-Harper ≥ 4	Good; Cooper-Harper ≥ 2	Sensitive; Cooper-Harper ≥ 5
Risk points	Unairworthy	0	20	50

Introduce full up elevator and note the resulting motion. Ensure it is commensurate with the calculated value of $\dot{q}_{init}$.

4.2.1.1 (m). Elevator control authority: CG range as a fraction of mean chord length for which static stability and balanced pitching moments can be maintained.

Value of $h_{max} - h_{min}$	$h_{max} - h_{min} > 0.3$	$h_{max} - h_{min} > 0.2$	$h_{max} - h_{min} > 0.1$	$h_{max} - h_{min} \leq 0.1$
Risk points	0	10	20	30

Generally, the absolute forward CG limit will be dictated by the maximum lift that the elevator can exert in the negative direction. The absolute aft limit will be set by the need to maintain static pitch stability. This, however, does not guarantee favorable handling characteristics at the extremes of this range. In turn, flight test will need to be completed to determine the CG location range in which favorable handling characteristics can be maintained.

Note regarding control authority: as a part of the certification process, the airworthiness assessor should generate a recommended controls setup, including dual rates and exponentials. The goal is to adjust dual rates and exponentials to reach the maximum possible Cooper-Harper rating for control authority and control sensitivity. These recommended settings must be published in the type certificate for the airplane.

4.2.1.1 (n). Crosswind handling – maximum demonstrated crosswind component, expressed as a fraction of reference approach speed at maximum

Demonstrated maximum crosswind component divided by landing speed	$\frac{V_{cross}}{V_{REF}} > 0.25$	$\frac{V_{cross}}{V_{REF}} > 0.2$	$\frac{V_{cross}}{V_{REF}} > 0.15$	$\frac{V_{cross}}{V_{REF}} < 0.1$
Risk points	0	10	20	Unairworthy

4.2.1.1 (o). Crosswind handling – Cooper-Harper score for crosswind handling

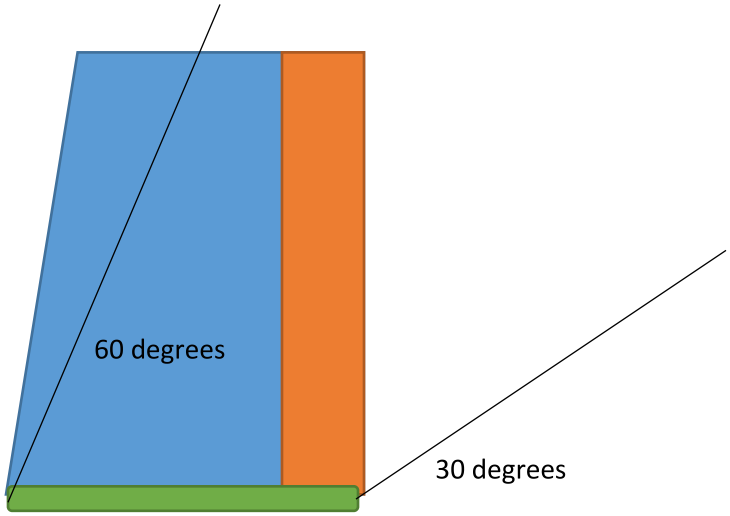
Cooper-Harper score CH	$CH < 3$	$CH \leq 4$	$CH \leq 6$	$CH > 6$
Risk points	0	10	20	Unairworthy

4.2.1.1 (p). Rudder control authority: Cooper-Harper score for rudder ability to counteract engine torque effect. This test should be conducted based on the pilot skill/concentration required to maintain centerline during takeoff at full power. This must also be rated based on crosswind handling.

Cooper-Harper score CH	$CH < 3$	$CH \leq 4$	$CH \leq 6$	$CH > 6$
Risk points	0	10	20	Unairworthy

4.2.1.1 (q). Spin recovery: this is evaluated based on the method described below:

Draw a line at a 60-degree angle and a 30-degree angle at the leading and trailing edge respectively of the horizontal stabilizer. Determine the fraction of the rudder area blanketed in the horizontal stabilizer in this case.



The fraction of the rudder blanketed by the horizontal stabilizer is used to assess risk points with S_{rb} representing the blanketed area of the rudder and S_r representing the total area of the rudder:

4.2.1.1 (r).

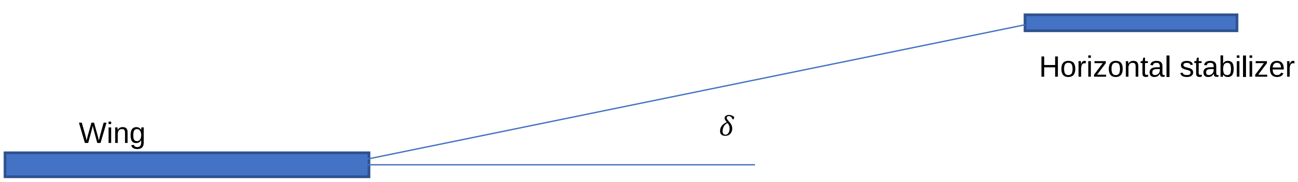
Value of $\frac{S_{rb}}{S_r}$	$\frac{S_{rb}}{S_r} < 0.3$	$\frac{S_{rb}}{S_r} < 0.6$	$\frac{S_{rb}}{S_r} < 0.9$	$\frac{S_{rb}}{S_r} > 0.9$
Risk points	0	15	40	80

If the aircraft's empennage geometry is such that $\frac{S_{rb}}{S_r} > 0.9$, the POH must include a warning that spin recovery is difficult or impossible.

Note that the stalled horizontal stabilizer may not be the only body which has a turbulent wake which could render the rudder ineffective. The analysis of the blanketed area must include the effects of other bodies, such as the fuselage or a stalled wing.

4.2.1.1 (s). Deep stall vulnerability: in order to determine if the aircraft is at risk for deep stalls, the following analysis needs to be completed.

The angle between the trailing edge of the wing and the leading edge of the horizontal stabilizer must be measured relative to the wing chord. This geometry is shown below:



4.2.1.1 (t). The value of δ is used to assess the risk of deep stall:

Value of δ (degrees)	$\delta < 10$	$\delta < 20$	$\delta < 30$	$\delta > 30$
Risk points	0	15	40	80

The results of this analysis must be verified by flight test. If the airplane's empennage geometry is such that an unaccelerated stall is unduly difficult to recover from, the airplane's difficulty level is automatically elevated to difficulty level 3.

The reduced dynamics airworthiness score may not exceed 55, otherwise the aircraft is unairworthy.

4.2.1.2 Aerodynamic Performance Requirements

The following categories are assessed:

- Landing reference speed
- Climb rate and angle
- Service ceiling
- Turn radius
- Demonstrated maximum dive speed
- Qualitative stall behavior
- Required landing distance

All performance measures are to be calculated at standard sea level and in a clean configuration at maximum takeoff weight, unless otherwise noted.

4.2.1.2 (a). Landing reference speed (evaluate at angle of attack of 6 degrees, maximum landing weight)

Value of V_{ref}	$V_{ref} < 10$ m/s	$10 \leq V_{ref} < 14$ m/s	$14 \leq V_{ref} < 20$ m/s	$V_{ref} \geq 20$ m/s
Risk points	0	10	20	50

Flight test: conduct a normal approach and landing (3-degree glideslope, roughly 1-degree nose-up pitch) and evaluate the speed.

For all criteria pertaining to climb rate, the flight test should reference the calculated climb rate for the density altitude present during the test. If the calculation matches observation, the rest of the results pertaining to climb rate are deemed valid. If the calculation is significantly inaccurate, adjust the drag terms in the calculations until they match the experiment. The corresponding values for other items pertaining to climb rate are then assumed to be valid.

4.2.1.2 (b). Maximum rate of climb, evaluated at standard sea level

Value of V_h	$V_h > 13$ m/s	$7 \leq V_h \leq 13$ m/s	$2.5 \leq V_h < 7$ m/s	$V_h < 2.5$ m/s
Risk points	0	5	15	Unairworthy

4.2.1.2 (c). Maximum climb angle, evaluated at standard sea level

Value of θ	$\theta > 9^0$	$6.5 \leq \theta \leq 9^o$	$4.75 \leq \theta < 6.5^o$	$\theta < 4.75^o$
Risk points	0	5	10	Unairworthy

4.2.1.2 (d). Climb angle in landing configuration, evaluated at standard sea level

Value of θ	$\theta > 4.5^o$	$3 \leq \theta < 4.5^o$	$1.7 \leq \theta < 3^o$	$\theta < 1.7^o$
Risk points	0	5	10	Unairworthy

4.2.1.2 (e). Service ceiling – altitude at which climb rate reduces to 1.5 m/s (300 fpm) in standard atmospheric conditions

Value of Z_{svc}	$Z_{svc} > 5500$ m	$3500 < Z_{svc} \leq 5500$ m	$1500 \leq Z_{svc} \leq 3500$ m	$Z_{svc} < 1500$ m
Risk points	0	5	10	50

4.2.1.2 (f). Minimum turn radius at 60-degree bank ($n = 2$)

Value of r	$r < 10$ m	$10 \leq r < 20$ m	$20 \leq r \leq 40$ m	$r > 40$ m
Risk points	0	5	10	50

Flight test: perform a 60-degree bank turn, and estimate the turning radius based on terrain/objects in the area with known dimensions.

4.2.1.2 (g). Demonstrated maximum dive speed V_{DF}: this must only be evaluated if the aircraft is not equipped with a system to provide immediate readouts of airspeed to the pilot. This must be evaluated in relation to maximum speed stipulations that exist within the flight rules, designated as V_{reg}.

Value of $\frac{V_{DF}}{V_{reg}}$	$\frac{V_{DF}}{V_{reg}} < 0.9$	$\frac{V_{DF}}{V_{reg}} \leq 1$	$\frac{V_{DF}}{V_{reg}} > 1$	$\frac{V_{DF}}{V_{reg}} > 1.1$
Risk points	0	2.5	5	10

Flight test: in minimal wind conditions, perform a full-power dive and find the groundspeed during the dive. If this attains a nonzero risk score, the airworthiness certificate must indicate that it is easy to exceed the maximum speed restrictions contained within the flight rules, and that PICs of the aircraft need to be trained to carefully manage airspeed.

Note that, in flight test, the stall speeds are evaluated with varying configurations. The stall speed requirements must be evaluated using the worst case encountered during flight testing. Further, the type certificate must specify stall handling characteristics with varying configurations.

4.2.1.2 (h). Stall handling – wing drop

Stall behavior	Wing stalls at root first; no significant wingtip drop	30-degree or less wingtip drop	60-degree or less wingtip drop	More than 60 degrees of wingtip drop
Risk points	0	5	10	20

Flight test: perform a stall from a level attitude and observe wing drop. Note the stall behavior on the airworthiness certificate. Note the stall handling characteristics on the airworthiness certificate.

4.2.1.2 (i). Stall handing – Cooper Harper score during stall

Cooper-Harper score CH	$CH < 3$	$CH \leq 4$	$CH \leq 6$	$CH > 6$
Risk points	0	10	20	Unairworthy

4.2.1.2 (j). Stall speed in landing configuration

Stall speed V_{SO}	$V_{SO} < 6.5$ m/s	$6.5 \leq V_{SO} < 11$ m/s	$11 \leq V_{SO} \leq 15.5$ m/s	$V_{SO} > 15.5$ m/s
Risk points	0	10	20	50

4.2.1.2 (k). Required landing distance on design landing surface, including flare

This is defined as the distance traveled by the aircraft from reaching an altitude of one wingspan above the ground to coming to rest at the end of the ground roll.

Required landing distance d	$d < 35$ m	$d < 70$ m	$d < 100$ m	$d > 100$ m
Risk score	0	20	40	80

4.2.1.2 (l). Required landing distance on design landing surface, rollout only

Required landing distance d	$d < 20$ m	$d < 55$ m	$d < 75$ m	$d > 75$ m
Risk score	0	20	40	80

4.2.1.2 (m). Aerodynamic blanketing: fuselage and wing effects on reducing control authority of tail surfaces

Blanketing effects	No blanketing occurs at any usable angle of attack	Blanketing occurs only at very low angles of attack that can only be encountered at extremely high-speed flight	Blanketing occurs to make stall recovery difficult or impossible
Risk score	0	20	Unairworthy

The aerodynamic performance score must not exceed 40, otherwise the aircraft is rendered unairworthy.

4.2.1.3 Structural Requirements

The following categories are evaluated:

- Minimum safety factor
- Maximum load factor
- Wing torsional rigidity/aileron reversal speed
- Structural modal frequencies in relation to expected excitation frequencies
- Fatigue life of key structural components

Note regarding structural analysis: determining some structural parameters, such as the number of cycles until failure requires a good estimate of the stress in a component. Given the complexity a typical airplane structure, and the often-nonlinear nature of materials such as wood and carbon fiber, finding this stress accurately can be difficult. In circumstances such as these, the airworthiness assessor should certify the aircraft only for a certain number of flights, and the aircraft must be submitted for airworthiness assessment again after this period is over. The airworthiness assessor must then inspect the aircraft for signs of plastic deformation and fatigue and determine if the aircraft can continue to be airworthy.

4.2.1.3 (a). Wing/stabilizer structural performance: physical test results at maximum load factor in positive direction. See section 1.8.1 for load factor requirements.

Results from physical test	Load is supported without failure or plastic deformation; maximum deflection angle less than 10 degrees	Load is supported without failure or plastic deformation; maximum deflection angle greater than 10 degrees	Load is supported without failure, but plastic deformation occurs	Structure fails
Risk points	0	25	Unairworthy	Unairworthy

4.2.1.3 (b). Wing/stabilizer structural performance: physical test results at maximum load factor in negative direction. See section 1.8.1 for load factor requirements.

Results from physical test	Load is supported without failure or plastic deformation; maximum deflection angle less than 10 degrees	Load is supported without failure or plastic deformation; maximum deflection angle greater than 10 degrees	Load is supported without failure, but plastic deformation occurs	Structure fails
Risk points	0	25	Unairworthy	Unairworthy

4.2.1.3 (c). Wing torsional rigidity: aileron reversal speed V_R in relation to maximum demonstrated dive speed V_{DF}.

V_{DF} in relation to V_R	$V_R > 1.5V_{DF}$	$V_R > 1.35V_{DF}$	$V_R \geq 1.1V_{DF}$	$V_R < 1.1V_{DF}$
Risk points	0	10	20	Unairworthy

Note that no airplane should be accepted as operationally airworthy with $V_R < 1.1V_{DF}$. Further, it is not acceptable for V_{NE} to be specified such that $V_R > 1.1V_{NE}$ unless the aircraft has an airspeed readout available instantaneously for the pilot. In cases where this requirement is not met, the aircraft performance and/or wing torsional rigidity must be modified such that $V_R > 1.1V_{DF}$. If an instantaneous readout of airspeed is available to the pilot, V_{NE} must be specified such that $V_{NE} \leq 0.9V_R$.

4.2.1.3 (d). Structural modal frequencies and in-flight oscillations.

$f_{modal,structural}$ in relation to $f_{encountered}$	No structural oscillations encountered in any regime of flight	Structural vibrations occur during flight, but there is no noticeable wear after 10 flights	Structural vibrations cause significant and noticeable wear and damage after 10 flights	Structural vibrations cause component failure in flight
Risk points	0	40	Unairworthy	Unairworthy

This includes flutter. To minimize flutter, OISC highly recommends that all control surfaces are dynamically balanced and that hinge line gaps are sealed. However, any effective method to control flutter is acceptable.

4.2.1.3 (e). Number of flight cycles until failure of wing spar due to fatigue.

Cycles	> 10000	> 5000	> 1000	< 100
Risk points	0	10	20	Unairworthy

Note: this can be modeled reasonably accurately using Euler-Bernoulli beam theory.

4.2.1.3 (f). Number of flight cycles until failure of horizontal stabilizer spar due to fatigue.

Cycles	> 10000	> 5000	> 1000	< 100
Risk points	0	10	20	Unairworthy

Note: this can be modeled reasonably accurately using Euler-Bernoulli beam theory.

4.2.1.3 (g). Number of flight cycles until failure of fuselage structure due to fatigue.

Cycles	> 10000	> 5000	> 1000	< 100
Risk points	0	10	20	Unairworthy

Note: this can be modeled reasonably accurately as a 3D truss or as a Euler-Bernoulli beam, depending on the nature of the fuselage.

Note: the airworthiness assessor must specify the aircraft as airworthy for a given number of flights cycles. This should be based on the minimum number of cycles until fatigue failures for key components (wing spar, horizontal stabilizer spar, etc.), and best estimates for the number of structural cycles per flight cycle. The number of flights for which the aircraft is certified as airworthy should be a factor of 10 lower than the predicted value, in order to account for inexact modeling and the possibility for greater stresses on the structure than the calculations assume. When the number of cycles flown reaches the number of cycles the aircraft is certified for, the proponent can ask OISC to consider certifying the aircraft for more cycles, if the structure is in good condition.

Further, it is possible for aircraft that would be unairworthy due to fatigue load concerns to be certified as airworthy under certain circumstances. All the following must apply for this to be considered:

- A plan is in place to carefully manage the loads that the aircraft encounters during flight. This must be formulated by both OISC and the operator and include specific procedures to be followed to limit the load on the structure, which must be substantiated by rigorous engineering reasoning. This should include procedures such as flying only on days with calm winds and minimal turbulence, and limiting the load factor the airplane is subjected to by means of a live readout of applied load factor.
- Rigorous structural inspection after every three flights which is to be conducted by an OISC airworthiness assessor.
- Plan for airframe components which the airworthiness assessor identifies as a concern from a fatigue life perspective to be discarded and not incorporated into any future airframe.

4.2.1.3 (h). Material construction: presence of fibrous materials vulnerable to splitting

Presence of fibrous materials	Only isotropic materials used in aircraft structure	Fibrous materials used with overlapping layers offset by at least 60 degrees	Fibrous materials used but no stress is applied orthogonal to fiber	Fibrous materials used with stress orthogonal to fiber
Risk points	0	5	10	Unairworthy

The reduced structures score may not exceed 24, otherwise the aircraft is rendered unairworthy.

4.2.1.3 Propulsion Standards

The following aspects of the propulsion system are evaluated:

- Reliability, including expected mean time between failure and performance in multiple load factor scenarios.
- Maximum endurance. The goal is not for the aircraft to meet any specific performance requirement, but that the endurance is sufficient for a safe flight, accounting for multiple go-arounds.

4.2.1.3 (a). Mean time between powerplant failure when recommended maintenance schedule is followed:

Time between failure	> 100 flight hours	> 50 flight hours	>25 flight hours	< 25 flight hours
Risk points	0	20	40	Unairworthy

Meeting this criterion should be established by referencing manufacturer specifications for expected powerplant longevity.

4.2.1.3 (b). Minimum load factor in which the powerplant can still function nominally:

Value of n_{min}	$n_{min} < -2$	$n_{min} < -1$	$n_{min} < 0.5$	$n_{min} > 0.5$
Risk points	0	20	40	Unairworthy

Meeting this criterion should be established by referencing manufacturer specifications for expected powerplant performance.

4.2.1.3 (c). Maximum endurance:

Endurance	> 15 mins	> 10 mins	> 5 mins	< 5 mins
Risk points	0	20	40	Unairworthy

This must be found from flight test. This must include adequate reserve. For example, if using LiPo batteries, there must be sufficient voltage remaining to serve as a reserve. This means generally that the cell voltage must be kept above a predefined value. Similarly, for fueled propulsion systems, this endurance must be established with reserve fuel in the tank. The precise amount of reserve required is highly dependent on the aircraft and application, and as such is to be set by the airworthiness assessor.

4.2.1.3 (d). Propulsion reliability: number of engines

Engine configuration	Glider	Single engine	Multiengine
Risk points	20	20	0

Note that multiengine airplanes must conform to standards for multiengine airplanes contained in section 4.2.1.5.

Additionally, if the aircraft is equipped with a reciprocating engine or a turbine engine, the transmitter must be configured such that the engine can be turned off outright from the ground.

The reduced propulsion score may not exceed 44, or the aircraft is rendered unairworthy.

4.2.1.4 Electronics Standards

4.2.1.4 (a). Servo sizing: Servo torque in relation to required torque

Value of $\frac{\tau_{servo}}{\tau_{required}}$	$\frac{\tau_{servo}}{\tau_{required}} > 3$	$\frac{\tau_{servo}}{\tau_{required}} > 2.25$	$\frac{\tau_{servo}}{\tau_{required}} > 1.5$	$\frac{\tau_{servo}}{\tau_{required}} < 1.5$
Risk points	0	10	20	Unairworthy

The required torque must be computed based on the known control hinge moments and the linkage geometry. The required torque is the torque that needs to be applied to the servo arm to (a) overcome the control hinge moment, and (b) provide adequate angular acceleration of the control surface. So, the required torque will be considerably higher than that which is simply required to overcome the control hinge moment.

4.2.1.4 (b). Remote control signal reliability: carrier frequency and technology used

Carrier frequency	2.4 GHz spread spectrum with DSMx or similar frequency-hopping features	Legacy carrier frequency without frequency-hopping features
Risk points	0	50

4.2.1.4 (c). Signal reliability: antenna diversity

Diversity features	Antenna diversity on transmitter and receiver	Antenna diversity on transmitter only	Antenna diversity on receiver only	No antenna diversity
Risk points	0	5	20	40

4.2.1.4 (d). ESC current rating in relation to expected maximum current draw through ESC

Value of $\frac{I_{ESC}}{I_{max}}$	$\frac{I_{ESC}}{I_{max}} > 1.5$	$\frac{I_{ESC}}{I_{max}} > 1.25$	$\frac{I_{ESC}}{I_{max}} > 1.1$	$\frac{I_{ESC}}{I_{max}} < 1.1$
Risk points	0	5	15	Unairworthy

Note: this may be inapplicable depending on the method of propulsion used in the airplane.

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4.2.1.4 (e). Receiver power source

Configuration	Receiver powered from independent battery and independent BEC	Receiver powered by main flight battery, but through independent BEC	Receiver powered from BEC integrated into ESC
Risk points	0	10	30

4.2.1.4 (f). Auxiliary device power source

Configuration	Powered from independent battery and independent BEC	Powered by main flight battery, but through independent BEC	Powered from BEC integrated into ESC, or powered directly from receiver
Risk points	0	10	30

This includes aircraft lights, autopilots, sensors, etc. This category may be inapplicable depending on whether the aircraft has any auxiliary devices.

Further, all wire sizes must be specified based on the expected current draw according to the chart on the following page:

Wire size (gauge)	Wire conductor diameter (inches)	Maximum continuous current (amps), power transmission	Maximum continuous current (amps), chassis wiring
0000	0.4600	302	380
000	0.4096	239	328
00	0.3648	190	283
0	0.3249	150	245
1	0.2893	119	211
2	0.2576	94	181
3	0.2294	75	158
4	0.2043	60	135
5	0.1819	47	118
6	0.1620	37	101
7	0.1443	30	89
8	0.1285	24	73
9	0.1144	19	64
10	0.1019	15	55
11	0.0907	12	47
12	0.0808	9.3	41
13	0.0720	7.4	35
14	0.0641	5.9	32
15	0.0571	4.7	28
16	0.0508	3.7	22
17	0.0453	2.9	19
18	0.0403	2.3	16
19	0.0359	1.8	14
20	0.0320	1.5	11
21	0.0285	1.2	9
22	0.0253	0.92	7
23	0.0226	0.729	4.7
24	0.0201	0.577	3.5
25	0.0179	0.457	2.7
26	0.0159	0.361	2.2
27	0.0142	0.288	1.7
28	0.0126	0.226	1.4
29	0.0113	0.182	1.2
30	0.0100	0.142	0.86
31	0.0089	0.113	0.7
32	0.0080	0.091	0.53
33	0.0071	0.072	0.43
34	0.0063	0.056	0.33
35	0.0056	0.044	0.27
36	0.0050	0.035	0.21
37	0.0045	0.0289	0.17
38	0.0040	0.0228	0.13
39	0.0035	0.0175	0.11
40	0.0031	0.0137	0.09

Figure 4-6: Electrical wiring ampacity chart

The following requirements apply for conductor sizing:

- In no case may the current in a wire in the aircraft exceed the table value for the wire of the corresponding diameter/gauge.
- The *chassis wiring* specification applies only to wiring runs of a length less than 3.5 meters.
- The *power transmission* specification has no requirement for wiring run length.

4.2.1.4 (g). Wire gauge size: value of design maximum current in relation to table value for maximum permissible current

Value of $\frac{I_{table}}{I_{design}}$	$\frac{I_{table}}{I_{design}} \geq 1.3$	$\frac{I_{table}}{I_{design}} \geq 1.15$	$\frac{I_{table}}{I_{design}} \geq 1$	$\frac{I_{table}}{I_{design}} < 1$
Risk points	0	5	10	Unairworthy

Additionally, the following requirements apply for wiring:

- All wiring runs must be of a minimal length without the wires cluttering the interior of the airplane.
- Long wiring runs must not be accomplished by connecting multiple extension wires. If multiple lengths of wire are needed, they must be soldered together and secured with heat shrink tubing.

4.2.1.4 (h). Long wiring runs: minimal lengths

Wiring length	Wire runs are of a minimal length without cluttering the interior of the airplane.	Wiring length standards are not met.
Risk points	0	Unairworthy

4.2.1.4 (i). Long wiring runs: connection method between wire lengths

Wiring connections	Long wire runs use a single cable, or multiple cables with soldered joints.	Long wiring connection standards are not met.
Risk points	0	Unairworthy

4.2.1.4 (j). Wiring protection: OISC requires that, wherever a wire is mounted to the airframe, the wire be protected by heat-shrink tubing or a similar means. It is not acceptable to anchor a wire without any protection. Risk points are allocated as follows:

Wire protection standards	Wire protection standards met	Wire protection standards not met
Risk points	0	Unairworthy

The reduced electronics score may not exceed 30, or the aircraft is rendered unairworthy.

4.2.1.5 Documentation

OISC expects that aircraft novel aircraft have comprehensive documentation to enable pilots to operate the aircraft as safely as possible.

OISC requires that all aircraft types be certified with the following documentation:

- Checklist, including normal and emergency computers
- Operating limitations
- Pilot's operating handbook

Note that specific requirements for the content of each document are in section 1.8.2.

4.2.2 Standards for Multirotors

The airworthiness status is based on the reduced risk score:

- Less than 8: risk level 1
- Between 9 and 20: risk level 2
- Between 21 and 32: risk level 3
- Over 32: unairworthy

4.2.2.1 POH Performance Requirements

The POH for the multirotor must contain the following performance information specific to multirotors, based not on exceptional skill or exceptionally favorable atmospheric conditions, and at varying density altitudes, weights, and wind conditions:

- Power required to hover (outside of ground effect)
- Fuel flow or battery current required to hover (outside of ground effect)
- Time and fuel to climb

The requirements for POH content in section 1.8.2 also apply.

4.2.2.2 Overall Design Characteristics

OISC evaluates the overall design of a multirotor based on the following:

- Presence and type of stability augmentation system: OISC requires a stability augmentation system to be present on any operationally certified multirotor due to the inherently unstable nature of multirotors
- Interference between propellers and propeller discs
- Number of motors

4.2.2.2 (a). Type of stability augmentation system

Stability augmentation system presence and characteristics	Type 1 SAS	Type 2 SAS	Type 3 SAS	Type 4 SAS
Risk points	0	20	50	95

The various types of stability augmentation system capabilities are defined as follows:

- Type 1: SAS can hold position and altitude when both control sticks are centered, regardless of wind. SAS automatically maintains altitude as pitch and bank are adjusted. Control sticks are used to command altitude rate, yaw rate, pitch angle, and bank angle. The position and altitude are known both a barometric altimeter and/or GPS.
- Type 2: SAS can hold position and altitude when both control sticks are centered, regardless of wind. SAS automatically maintains altitude as pitch and bank are adjusted. Control sticks are used to command altitude rate, yaw rate, pitch angle, and bank angle. The position and altitude are found based on the IMU alone.
- Type 3: SAS can hold altitude and attitude when both control sticks are centered but does not hold position. Control sticks are used to command altitude rate, yaw rate, pitch angle, and bank angle.
- Type 4: SAS is used to allow user to command altitude rate, yaw rate, pitch rate, bank rate. No altitude-hold or position-hold features.
- Types 3 and 4 stability augmentation systems require the aircraft to be trimmable.

4.2.2.2 (b). Propeller interference

Propeller interference characteristics	Minimum straight-line distance between propeller discs at least 2cm	Minimum straight-line distance between propeller discs less than 2cm, but do not interfere	Propeller discs interfere, but propellers are prevented from interfering by gearing or belts	Propeller discs interfere, and no mechanism is present to prevent propellers from interfering
Risk points	0	5	20	Unairworthy

The definition of *propeller discs* and *propellers*, for the sake of this airworthiness standard, are shown below:

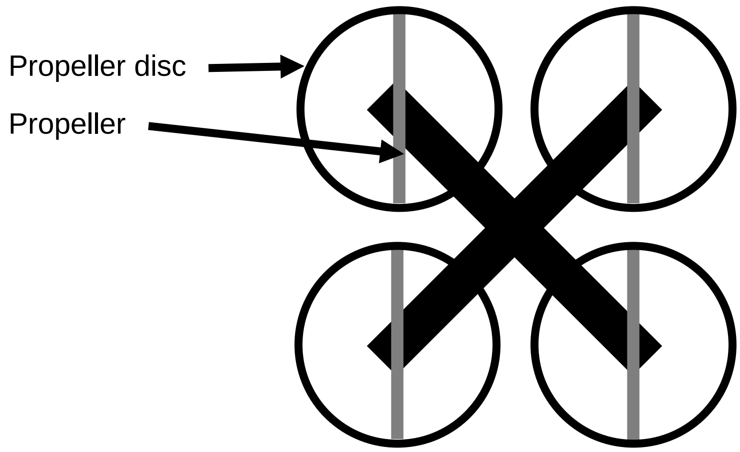

Figure 4-6: Propeller and propeller geometry diagram

4.2.2.2 (c). Redundancy: number of motors

Number of motors	3	4	5	6 or more
Risk points	50	40	30	0

4.2.2.2 (d). Vibration: fastener securing

Fastener securing	Fasteners secured with two of the approved methods	Fasteners secured with one of the approved methods	Fasteners unsecured; conditions for unsecure fasteners are met	Fasteners unsecured; conditions for unsecure fasteners are not met
Risk points	0	10	80	Unairworthy

Approved fastener securing methods:

- Safety wire
- Nylon locking nuts
- Thread locking compound, such as Loctite
- Castle nut and locking pin
- Split beam nut
- Locking plate or tab washer

Conditions to leave fasteners unsecured: the applicant must demonstrate compliance with the following:

- The aircraft's maximum takeoff weight must not exceed 10 lbs (4.5 kg).
- The aircraft must strictly be flown in daytime VFR conditions and within VLOS.

- The aircraft must never be flown in a crowded environment such that there is a substantial risk of it flying over people. For example, flights over campus would be prohibited since, even if the PIC makes the utmost effort to avoid flights over people, campus is sufficiently congested that, realistically, this is difficult to avoid.
- The applicant must demonstrate that the vibration produced on the aircraft is such that, after 60 minutes of consecutive flights, all fasteners remain firmly anchored.

The reduced score in this category may not exceed 55 or the aircraft is rendered unairworthy.

4.2.2.3 Structures Standards

4.2.2.3 (a). Motor mounting structure: minimum safety factor against yielding at full thrust and maximum takeoff weight

Value of FS	$FS > 1.5$	$FS > 1.25$	$FS > 1.1$	$FS < 1.1$
Risk points	0	5	10	Unairworthy

4.2.2.3 (b). Motor mounting structure: maximum deflection of beam structure at full thrust and maximum takeoff weight

Deflection v	$v < 3\text{mm}$	$v < 5\text{mm}$	$v < 10\text{mm}$	$v > 10\text{mm}$
Risk points	0	20	30	Unairworthy

4.2.2.3 (c). Motor mounting structure: maximum deflection angle of beam structure at full thrust and maximum takeoff weight

Deflection angle θ	$\theta < 2.5^o$	$\theta < 5^o$	$\theta < 7.5^o$	$\theta > 7.5^o$
Risk points	0	20	30	Unairworthy

Motor mounting structure: standards relating to effect of beam structure deflection. The deflection must be so severe such that:

- The propellers interfere with each other
- The propellers interfere with other parts of the aircraft structure

The standards for motor mounting structure deflection delineated previously in this section still apply.

4.2.2.3 (d). Risk points are allotted based on meeting the above standards:

Interference and deflection standards result	Standards met	Standards not met
Risk points	0	Unairworthy

4.2.2.3 (e). Landing gear structure: minimum safety factor against yielding

Value of FS	$FS > 2.5$	$FS > 2.25$	$FS > 2.1$	$FS < 2.1$
Risk points	0	5	10	Unairworthy

Landing gear deflection: the following standards apply for the deflection of landing gear during a 2-g landing on a smooth, level surface:

- The landing gear must not deflect so much that any of the propellers risk touching the ground
- The landing gear must not deflect asymmetrically so as to change the attitude of the aircraft which could cause the propeller to impact the ground.

4.2.2.3 (f). Whole aircraft torsional rigidity: maximum twist angle between opposing sides of vehicle during maximum yaw rate maneuver.

Deflection angle θ	$\theta < 2.5^o$	$\theta < 5^o$	$\theta < 7.5^o$	$\theta > 7.5^o$
Risk points	0	20	30	Unairworthy

This requirement describes the torsion which occurs when the aircraft is executing a yaw maneuver. In this configuration, the thrust of one propeller will be changed relative to the adjacent motor. The resulting moment causes the torsion evaluated by this section.

4.2.2.3 (g). Fatigue life: cycles until failure of motor mount arms due to changes in thrust during flight

Cycles	> 10000	> 5000	> 1000	< 100
Risk points	0	10	20	Unairworthy

4.2.2.3 (h). Fatigue life: cycles until failure of motor mount arms due to motor vibrations

Cycles	> 10000	> 5000	> 1000	< 100
Risk points	0	10	20	Unairworthy

4.2.2.3 (i). Structural vibrations: in-flight oscillations during flight test

$f_{modal,structural}$ in relation to $f_{encountered}$	No structural oscillations encountered in any regime of flight	Structural vibrations occur during flight, but there is no noticeable wear after 10 flights	Structural vibrations cause significant and noticeable wear and damage after 10 flights	Structural vibrations cause component failure in flight
Risk points	0	40	Unairworthy	Unairworthy

This must cover vibrations from varying degrees of motor thrust and various airspeeds. Flight test must reveal whether the structural modal frequencies are such that the aircraft structure will excessively vibrate during flight.

4.2.2.3 (j). Material construction: presence of fibrous materials vulnerable to splitting

Presence of fibrous materials	Only isotropic materials used in aircraft structure	Fibrous materials used with overlapping layers offset by at least 60 degrees	Fibrous materials used but no stress is applied orthogonal to fiber	Fibrous materials used with stress orthogonal to fiber
Risk points	0	5	10	Unairworthy

The reduced score in this category exceeds 20, the aircraft is unairworthy.

4.2.2.4 Stability, Dynamics, and Control Standards

4.2.2.4 (a). Position-hold performance: maximum deviation from target position in any direction in smooth air

Deviation	$< 10\text{cm}$	$< 20\text{cm}$	$< 30\text{cm}$	$> 30\text{cm}$
Risk points	0	5	10	Unairworthy

4.2.2.4 (b). Position-hold performance: position hold Cooper-Harper score

Cooper-Harper score	2 or better	4 or better	6 or better	Worse than 6
Risk points	0	15	40	Unairworthy

4.2.2.4 (c). Attitude-hold performance: maximum angular deviation from target attitude in either direction (pitch or roll)

Deviation	$< 2^o$	$< 4^o$	$< 6^o$	$> 6^o$
Risk points	0	20	40	Unairworthy

4.2.2.4 (d). Attitude-hold performance: attitude-hold Cooper-Harper score

Cooper-Harper score	2 or better	4 or better	6 or better	Worse than 6
Risk points	0	15	40	Unairworthy

4.2.2.4 (e). Disturbance rejection: position-hold performance: maximum deviation from target position in any direction in light turbulence

Deviation	< 15cm	< 30cm	< 45cm	> 45cm
Risk points	0	10	20	90

4.2.2.4 (f). Disturbance tracking: position-hold performance: Cooper-Harper score in light turbulence

Cooper-Harper score	2 or better	4 or better	6 or better	Worse than 6
Risk points	0	15	40	Unairworthy

4.2.2.4 (g). Control tracking: aircraft stability augmentation response to control inputs

Response characteristics	Critically or over-damped	Well-damped	Lightly damped	Extremely lightly damped
Risk points	0	10	40	60

4.2.2.4 (h). Control tracking: aircraft stability augmentation response to control inputs Cooper-Harper score

Cooper-Harper score	2 or better	4 or better	6 or better	Worse than 6
Risk points	0	15	40	Unairworthy

4.2.2.4 (i). Altitude-hold capabilities during forward/transverse flight: altitude deviation

Altitude hold deviation	< 10cm	< 20cm	< 30cm	> 30cm
Risk points	0	5	10	60

4.2.2.4 (j). Altitude-hold capabilities during forward/transverse flight: altitude deviation

Cooper-Harper score	2 or better	4 or better	6 or better	Worse than 6
Risk points	0	15	40	Unairworthy

4.2.2.4 (k). Pitch and bank angle limitation

Pitch and bank limits	Limits are below FOM-defined thresholds	Limits meet FOM-defined threshold	No SAS limits: reliant on pilot to maintain FOM pitch and bank limits
Risk points	0	5	30

4.2.2.4 (l). Maintaining attitude limits: Cooper-Harper score

Cooper-Harper score	2 or better	4 or better	6 or better	Worse than 6
Risk points	0	15	40	Unairworthy

4.2.2.4 (m). Control precision: takeoff/landing precision test

Precision	$\pm$10cm or better	$\pm$20cm or better	$\pm$35cm or better	$\pm$35cm or worse
Risk points	0	15	40	Unairworthy

For this test, the pilot must take the aircraft off from a helipad, fly it to 10 feet in altitude without inputting any other control inputs, and land it again. The difference in the takeoff location of the center of the aircraft and landing location of the center of the aircraft is to be measured.

4.2.2.4 (n). Control precision: Cooper-Harper score for landing on precise location

Cooper-Harper score	2 or better	4 or better	6 or better	Worse than 6
Risk points	0	15	40	Unairworthy

This is based on the following test: the aircraft is to be landed on a square pad with a side length not exceeding 1.2 times the maximum diagonal length between propellers. The pilot is to land on the middle of this pad and rate the difficulty of doing so.

4.2.2.4 (o). Control precision: azimuth hold ability

Azimuth variation test results	±2m or better	±4m or better	±8m or better	Worse than ±8m
Risk points	0	15	40	Unairworthy

This is to be assessed by a physical test: from a safe altitude, the aircraft must be aligned to a given azimuth, flown forward 35 meters without any lateral commands. It then must be flown directly backward to the start location. The difference in position measured in the direction perpendicular to the target azimuth must be measured. See the diagram below:

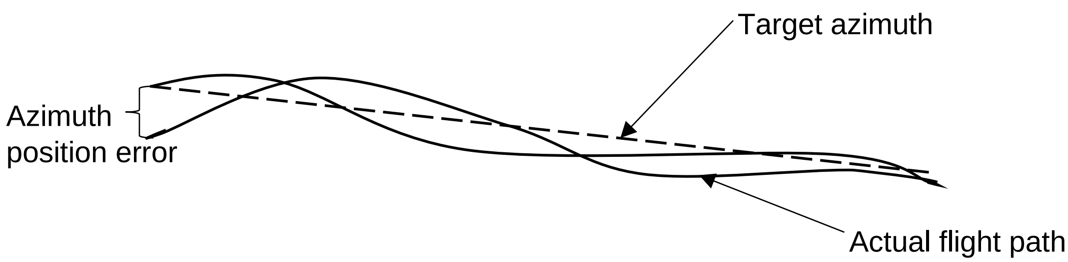

Figure 4-7: Azimuth tracking visualization

4.2.2.4 (p). Control precision: azimuth hold ability Cooper-Harper score

Cooper-Harper score	2 or better	4 or better	6 or better	Worse than 6
Risk points	0	15	40	Unairworthy

This is based on the pilot's workload during the test delineated in the previous standard.

The maximum reduced score in this category must not exceed 38, or the aircraft is unairworthy.

4.2.2.5 Electronics Standards

4.2.2.5 (a). Remote control signal reliability: carrier frequency and technology used

Carrier frequency	2.4 GHz spread spectrum with DSMx or similar frequency-hopping features	Legacy carrier frequency without frequency-hopping features
Risk points	0	50

4.2.2.5 (b). Signal reliability: antenna diversity

Diversity features	Antenna diversity on transmitter and receiver	Antenna diversity on transmitter only	Antenna diversity on receiver only	No antenna diversity
Risk points	0	5	20	40

4.2.2.5 (c). ESC current rating in relation to expected maximum current draw through ESC

Value of $\frac{I_{ESC}}{I_{max}}$	$\frac{I_{ESC}}{I_{max}} > 1.5$	$\frac{I_{ESC}}{I_{max}} > 1.25$	$\frac{I_{ESC}}{I_{max}} > 1.1$	$\frac{I_{ESC}}{I_{max}} < 1.1$
Risk points	0	5	15	Unairworthy

Note: this may be inapplicable depending on the method of propulsion used in the airplane.

4.2.2.5 (d). Receiver power source

Configuration	Receiver powered from independent battery and independent BEC	Receiver powered by main flight battery, but through independent BEC	Receiver powered from BEC integrated into ESC
Risk points	0	10	30

4.2.2.5 (e). Auxiliary device power source

Configuration	Powered from independent battery and independent BEC	Powered by main flight battery, but through independent BEC	Powered from BEC integrated into ESC, or powered directly from receiver
Risk points	0	10	30

This includes aircraft lights, autopilots, sensors, etc. This category may be inapplicable depending on whether the aircraft has any auxiliary devices.

Further, all wire sizes must be specified based on the expected current draw according to the chart on the following page:

Wire size (gauge)	Wire conductor diameter (inches)	Maximum continuous current (amps), power transmission	Maximum continuous current (amps), chassis wiring
0000	0.4600	302	380
000	0.4096	239	328
00	0.3648	190	283
0	0.3249	150	245
1	0.2893	119	211
2	0.2576	94	181
3	0.2294	75	158
4	0.2043	60	135
5	0.1819	47	118
6	0.1620	37	101
7	0.1443	30	89
8	0.1285	24	73
9	0.1144	19	64
10	0.1019	15	55
11	0.0907	12	47
12	0.0808	9.3	41
13	0.0720	7.4	35
14	0.0641	5.9	32
15	0.0571	4.7	28
16	0.0508	3.7	22
17	0.0453	2.9	19
18	0.0403	2.3	16
19	0.0359	1.8	14
20	0.0320	1.5	11
21	0.0285	1.2	9
22	0.0253	0.92	7
23	0.0226	0.729	4.7
24	0.0201	0.577	3.5
25	0.0179	0.457	2.7
26	0.0159	0.361	2.2
27	0.0142	0.288	1.7
28	0.0126	0.226	1.4
29	0.0113	0.182	1.2
30	0.0100	0.142	0.86
31	0.0089	0.113	0.7
32	0.0080	0.091	0.53
33	0.0071	0.072	0.43
34	0.0063	0.056	0.33
35	0.0056	0.044	0.27
36	0.0050	0.035	0.21
37	0.0045	0.0289	0.17
38	0.0040	0.0228	0.13
39	0.0035	0.0175	0.11
40	0.0031	0.0137	0.09

Figure 4-8: Electrical wiring ampacity chart

The following requirements apply for conductor sizing:

- In no case may the current in a wire in the aircraft exceed the table value for the wire of the corresponding diameter/gauge.
- The *chassis wiring* specification applies only to wiring runs of a length less than 3.5 meters.
- The *power transmission* specification has no requirement for wiring run length.

4.2.2.5 (f). Wire gauge size: value of design maximum current in relation to table value for maximum permissible current

Value of $\frac{I_{table}}{I_{design}}$	$\frac{I_{table}}{I_{design}} \geq 1.3$	$\frac{I_{table}}{I_{design}} \geq 1.15$	$\frac{I_{table}}{I_{design}} \geq 1$	$\frac{I_{table}}{I_{design}} < 1$
Risk points	0	5	10	Unairworthy

Additionally, the following requirements apply for wiring:

- All wiring runs must be of a minimal length without the wires cluttering the interior of the airplane.
- Long wiring runs must not be accomplished by connecting multiple extension wires. If multiple lengths of wire are needed, they must be soldered together and secured with heat shrink tubing.

4.2.2.5 (g). Long wiring runs: minimal lengths

Wiring length	Wire runs are of a minimal length without cluttering the interior of the airplane.	Wiring length standards are not met.
Risk points	0	Unairworthy

4.2.2.5 (h). Long wiring runs: connection method between wire lengths

Wiring connections	Long wire runs use a single cable, or multiple cables with soldered joints.	Long wiring connection standards are not met.
Risk points	0	Unairworthy

4.2.2.5 (i). Wiring protection: OISC requires that, wherever a wire is mounted to the airframe, the wire be protected by heat-shrink tubing or a similar means. It is not acceptable to anchor a wire without any protection. Risk points are allocated as follows:

Wire protection standards	Wire protection standards met	Wire protection standards not met
Risk points	0	Unairworthy

The reduced score in this category must not exceed 24 or the aircraft is rendered unairworthy.

4.2.2.6 Propulsion and Performance Standards

4.2.2.6 (a). Service ceiling – altitude at which climb rate reduces to 1.5 m/s (300 fpm) in standard atmospheric conditions

Value of Z_{svc}	$Z_{svc} \geq 5000$ m	$3500 < Z_{svc} \leq 5000$ m	$1500 \leq Z_{svc} \leq 3500$ m	$Z_{svc} < 1500$ m
Risk points	0	5	10	50

4.2.2.6 (b). Maximum rate of climb, evaluated at standard sea level

Value of V_h	$V_h > 6$ m/s	$4 \leq V_h \leq 6$ m/s	$1 \leq V_h < 4$ m/s	$V_h < 1$ m/s
Risk points	0	5	15	Unairworthy

4.2.2.6 (c). Mean time between powerplant failure when recommended maintenance schedule is followed:

Time between failure	> 100 flight hours	> 50 flight hours	>25 flight hours	< 25 flight hours
Risk points	0	20	40	Unairworthy

Meeting this criterion should be established by referencing manufacturer specifications for expected powerplant longevity.

4.2.2.6 (d). Maximum endurance:

Endurance	> 20 mins	> 12 mins	> 5 mins	< 5 mins
Risk points	0	20	40	Unairworthy

This must be found from flight test. This must include adequate reserve. For example, if using LiPo batteries, there must be sufficient voltage remaining to serve as a reserve. This means generally that the cell voltage must be kept above a predefined value. Similarly, for fueled propulsion systems, this endurance must be established with reserve fuel in the tank. The precise amount of reserve required is highly dependent on the aircraft and application, and as such is to be set by the airworthiness assessor.

4.2.2.6 (e). Vibration: propeller balance

Propeller balance characteristics	Negligible vibration: propeller center of gravity within 0.001 inches of propeller axis	Small vibration: propeller center of gravity within 0.005 inches of propeller axis	Moderate or greater vibrations; propeller center of gravity further than 0.005 inches from propeller
Risk points	0	10	Unairworthy

4.2.2.6 (f). Vibration: motor vibration

Vibration characteristics	Negligible vibration: vibration amplitude less than 0.001 inch	Small vibrations: vibration amplitude less than 0.005 inch	Moderate vibrations: vibration amplitude greater than 0.005 inch
Risk points	0	10	Unairworthy

4.2.2.6 (g). Vibration: damping of propulsion system vibrations

Damping characteristics present	Viscous liquid dampers are used	Rubber vibration isolating devices are used	No vibration damping is present, propeller balance and motor vibration score of 0	No vibration damping is present, nonzero propeller/motor vibration score
Risk points	0	20	20	Unairworthy

The maximum score in this category is 22, or the aircraft is rendered unairworthy.

4.2.3 Standards for Helicopters

The airworthiness status is found based on the reduced risk score:

- Between 0 and 7: risk level 1
- Between 8 and 18: risk level 2
- Between 19 and 26: risk level 3
- Greater than 26: unairworthy

4.2.3.1 Required POH Content

Autorotation. The applicant must determine the glide ratio and airspeed to minimize the descent rate of the aircraft in the event of a full loss of power and publish this information in the POH.

Power requirements. The applicant must determine the power required to maintain steady hover for altitudes at and below the hovering ceiling at a range of aircraft weights from the operating empty weight to the maximum takeoff weight.

Height-velocity diagram: the applicant must furnish a diagram specifying the safe and unsafe operating regimes.

Hovering ceiling: the hovering ceiling must be established to avoid a vortex-ring state. The proponent must also publish procedures for exiting a vortex ring state.

4.2.3.1 (a). POH content requirements

Content	Content requirements met	Content requirements not met
Risk points	0	Unairworthy

4.2.3.2 Overall Design Characteristics

4.2.3.2 (a). Low rotor speed: the aircraft must be designed to innately be difficult to enter a low rotor rotation rate state. Further, the aircraft must be equipped with a means to alert the pilot of a low rotor speed state. This limit must be triggered during any situation which may result in rotors speeds so low that safety is compromised. The precise speed is to be determined by the applicant.

Low rotor speed standards	Standards met	Standards not met
Risk points	0	Unairworthy

4.2.3.2 (b). Tail rotor ground strike protection. OISC requires that the tail rotor be protected from ground strikes by means of a skid plate mounted such that, as the helicopter is pitched up, the tail skid contacts the ground and clearance between the ground and tail rotor is maintained. Risk points are assessed as follows:

Tail rotor protection	Inapplicable due to design features such as counter rotating rotors or a ducted fan tail rotor	Clearance greater than 1/10 of the rotor radius	Clearance greater than 1/20 of the rotor radius	Clearances less than 1/20 of the rotor radius
Risk points	0	15	30	Unairworthy

Note: if the rotors intermesh, the applicant must demonstrate that there is no risk of the rotors striking each other.

4.2.3.2 (c). Tail rotor placement: the applicant must show that the tail rotor is located such that yaw control can be maintained in normal flight without requiring exceptional pilot skill or exceptionally favorable conditions. This is evaluated based on the worst-case Cooper-Harper score for maintaining a heading in any normal flight regime.

Cooper-Harper score CH	$CH < 3$	$CH \leq 4$	$CH \leq 6$	$CH > 6$
Risk points	0	10	20	Unairworthy

4.2.3.2 (d). Rotor clearance: with the least favorable cyclic control and least favorable load factor, the rotor must clear any other part of the aircraft (such as the boom or fuselage) by at least 1% of the rotor diameter. Risk points are assessed as follows:

Clearance as measured by: $\frac{z_{clear}}{d_{rotor}}$	$\frac{z_{clear}}{d_{rotor}} > 0.05$	$\frac{z_{clear}}{d_{rotor}} > 0.025$	$\frac{z_{clear}}{d_{rotor}} > 0.01$	$\frac{z_{clear}}{d_{rotor}} < 0.01$
Risk points	0	15	30	Unairworthy

4.2.3.2 (e). Vibration: fastener securing

Fastener securing	Fasteners secured with two of the approved methods	Fasteners secured with one of the approved methods	Fasteners unsecured; conditions for unsecure fasteners are met	Fasteners unsecured; conditions for unsecure fasteners are not met
Risk points	0	10	80	Unairworthy

Approved fastener securing methods:

- Safety wire
- Nylon locking nuts
- Thread locking compound, such as Loctite
- Castle nut and locking pin
- Split beam nut
- Locking plate or tab washer

Conditions to leave fasteners unsecured: the applicant must demonstrate compliance with the following:

- The aircraft's maximum takeoff weight must not exceed 10 lbs (4.5 kg).
- The aircraft must strictly be flown in daytime VFR conditions and within VLOS.
- The aircraft must never be flown in a crowded environment such that there is a substantial risk of it flying over people. For example, flights over campus would be prohibited since, even if the PIC makes the utmost effort to avoid flights over people, campus is sufficiently congested that, realistically, this is difficult to avoid.
- The applicant must demonstrate that the vibration produced on the aircraft is such that, after 60 minutes of consecutive flights, all fasteners remain firmly anchored.

4.2.3.2 (f). Redundancy: number of motors

Number of motors	2 or more	1
Risk points	0	30

Jesus bolts. Any bolts or nut on the aircraft which would cause complete loss of the aircraft in the event of failure must meet the following criteria:

- Safety factor against yielding not less than 2 with MTOW, maximum rotor thrust, and maximum load factor.
- Two methods to prevent the bolt/nut from loosening over time. The approved methods are listed below:
    - Thread locking compound, such as Loctite
    - Safety wire
    - Castle nut and locking pin
- The applicant must delineate an inspection and maintenance schedule for any of these bolts/nuts.

4.2.3.2 (g). Risk points are allocated for Jesus bolts as follows:

Safety factor	$FS \geq 3$	$FS \geq 2.5$	$FS \geq 2$	$FS < 2$
Risk points	0	15	30	Unairworthy

4.2.3.2 (h). Other standards for Jesus bolts:

Other standards met?	Met	Not met
Risk points	0	Unairworthy

4.2.3.2 (i). Autorotation capability: glide ratio during autorotation.

Glide ratio	Greater than 6	Greater than 4	Greater than 2	Worse than 2
Risk points	0	5	10	Unairworthy

Note: it is expected that this will be measured through flight test.

The reduced score in this category ma not exceed 29, or the aircraft is rendered unairworthy.

4.2.3.3 Swashplate Mechanisms

4.2.3.3 (a). Servo sizing: servo torque in relation to minimum required torque

Value of $\frac{\tau}{\tau_{req}}$	$\frac{\tau}{\tau_{req}} > 2$	$\frac{\tau}{\tau_{req}} > 1.5$	$\frac{\tau}{\tau_{req}} > 1$	$\frac{\tau}{\tau_{req}} < 1$
Risk points	0	15	30	Unairworthy

The required torque is computed as follows: at the maximum rotor RPM and maximum angle of incidence of the propeller, the pitching moment about the joint which supports the rotor must be computed. The support reaction by the joint which is used to alter the rotor angle of incidence must then be computed. Then the actuation torque is found based on the length of the servo arm. Twice this torque is the minimum required torque.

The design of the swashplate assembly must be built according to best practices, such as:

- Using an anti-rotation device to prevent the lower swashplate from rotating

- An adequate safety factor is used in swashplate system, as assessed by the risk points table below
- Adequate tolerances and balance

4.2.3.3 (b). Worst-case tolerance in any component in the swashplate system

Tolerance	± 0.001 inch or better	± 0.005 inch or better	± 0.01 inch or better	Worse than ± 0.01 inch
Risk points	0	5	20	Unairworthy

4.2.3.3 (c). Location of swashplate center of gravity in relation to swashplate axis of rotation

Difference in location	< 0.001 inch	< 0.003 inch	< 0.005 inch	> 0.005 inch
Risk points	0	20	40	Unairworthy

4.2.3.3 (d). Minimum safety factor in swashplate system

Value of FS	$FS > 1.5$	$FS > 1.25$	$FS > 1.1$	$FS < 1.1$
Risk points	0	20	40	Unairworthy

The manufacturer of the swashplate system must provide a rigorous inspection and maintenance schedule to guide continuing airworthiness inspections and maintenance. This must include:

- Inspection and replacement intervals for all components of the swashplate
- Requirements for maintaining adequate lubrication on all components
- Specifications for the requited tightness of all bolts and fasteners
- Specific guidance for a preflight inspection

4.2.3.3 (e). Swashplate motion smoothness: the swashplate must move smoothly up and down the shaft without binding. Since it is typical for the smoothness of motion to degrade with time as lubrication is expelled from the swashplate mechanism, the risk is evaluated based on the amount of time smooth motion can be maintained while running the rotor at maximum RPM.

Time for which smooth motion is maintained	Greater than 90 minutes	Greater than 60 minutes	Greater than 30 minutes	Less than 30 minutes
Risk points	0	25	50	Unairworthy

The maximum flight time must be specified based on the time for which smooth motion can be maintained. The maximum flight time is not to exceed half of the time for which smooth motion is maintained.

The reduced score in this category may not exceed 36 or the aircraft is rendered unairworthy.

4.2.3.4 Performance and Propulsion System

4.2.3.4 (a). Climb gradient at V_y, standard sea level, all engines operative, maximum weight

Climb gradient	1:3 or better	1:4 or better	1:5 or better	Less than 1:6
Risk points	0	15	30	Unairworthy

4.2.3.4 (b). Climb gradient at V_y, standard sea level, one engine inoperative, maximum weight

Climb gradient	1:14 or better	1:16 or better	1:18 or better	Less than 1:20
Risk points	0	15	30	Unairworthy

4.2.3.4 (c). Mean time between powerplant failure when recommended maintenance schedule is followed:

Time between failure	> 100 flight hours	> 50 flight hours	>25 flight hours	< 25 flight hours
Risk points	0	20	40	Unairworthy

Meeting this criterion should be established by referencing manufacturer specifications for expected powerplant longevity.

4.2.3.4 (d). Maximum endurance:

Endurance	> 20 mins	> 12 mins	> 5 mins	< 5 mins
Risk points	0	20	40	Unairworthy

This must be found from flight test. This must include adequate reserve. For example, if using LiPo batteries, there must be sufficient voltage remaining to serve as a reserve. This means generally that the cell voltage must be kept above a predefined value. Similarly, for fueled propulsion systems, this endurance must be established with reserve fuel in the tank. The precise amount of reserve required is highly dependent on the aircraft and application, and as such is to be set by the airworthiness assessor.

4.2.3.4 (e). Vibration: propeller balance

Propeller balance characteristics	Negligible vibration: propeller center of gravity within 0.001 inches of propeller axis	Small vibration: propeller center of gravity within 0.005 inches of propeller axis	Moderate or greater vibrations; propeller center of gravity further than 0.005 inches from propeller
Risk points	0	10	Unairworthy

4.2.3.4 (f). Vibration: motor vibration

Vibration characteristics	Negligible vibration: vibration amplitude less than 0.001 inch	Small vibrations: vibration amplitude less than 0.005 inch	Moderate vibrations: vibration amplitude greater than 0.005 inch
Risk points	0	10	Unairworthy

4.2.3.4 (g). Vibration: damping of propulsion system vibrations

Damping characteristics present	Viscous liquid dampers are used	Rubber vibration isolating devices are used	No vibration damping is present, propeller balance and motor vibration score of 0	No vibration damping is present, nonzero propeller/motor vibration score
Risk points	0	20	20	Unairworthy

The reduced score in this category may not exceed 26 or the aircraft is rendered unairworthy.

4.2.3.5 Electronics

4.2.3.5 (a). Remote control signal reliability: carrier frequency and technology used

Carrier frequency	2.4 GHz spread spectrum with DSMx or similar frequency-hopping features	Legacy carrier frequency without frequency-hopping features
Risk points	0	50

4.2.3.5 (b). Signal reliability: antenna diversity

Diversity features	Antenna diversity on transmitter and receiver	Antenna diversity on transmitter only	Antenna diversity on receiver only	No antenna diversity
Risk points	0	5	20	40

4.2.3.5 (c). ESC current rating in relation to expected maximum current draw through ESC

Value of $\frac{I_{ESC}}{I_{max}}$	$\frac{I_{ESC}}{I_{max}} > 1.5$	$\frac{I_{ESC}}{I_{max}} > 1.25$	$\frac{I_{ESC}}{I_{max}} > 1.1$	$\frac{I_{ESC}}{I_{max}} < 1.1$
Risk points	0	5	15	Unairworthy

Note: this may be inapplicable depending on the method of propulsion used in the airplane.

4.2.3.5 (d). Receiver power source

Configuration	Receiver powered from independent battery and independent BEC	Receiver powered by main flight battery, but through independent BEC	Receiver powered from BEC integrated into ESC
Risk points	0	10	30

4.2.3.5 (e). Auxiliary device power source

Configuration	Powered from independent battery and independent BEC	Powered by main flight battery, but through independent BEC	Powered from BEC integrated into ESC, or powered directly from receiver
Risk points	0	10	30

This includes aircraft lights, autopilots, sensors, etc. This category may be inapplicable depending on whether the aircraft has any auxiliary devices.

Further, all wire sizes must be specified based on the expected current draw according to the chart on the following page:

Wire size (gauge)	Wire conductor diameter (inches)	Maximum continuous current (amps), power transmission	Maximum continuous current (amps), chassis wiring
0000	0.4600	302	380
000	0.4096	239	328
00	0.3648	190	283
0	0.3249	150	245
1	0.2893	119	211
2	0.2576	94	181
3	0.2294	75	158
4	0.2043	60	135
5	0.1819	47	118
6	0.1620	37	101
7	0.1443	30	89
8	0.1285	24	73
9	0.1144	19	64
10	0.1019	15	55
11	0.0907	12	47
12	0.0808	9.3	41
13	0.0720	7.4	35
14	0.0641	5.9	32
15	0.0571	4.7	28
16	0.0508	3.7	22
17	0.0453	2.9	19
18	0.0403	2.3	16
19	0.0359	1.8	14
20	0.0320	1.5	11
21	0.0285	1.2	9
22	0.0253	0.92	7
23	0.0226	0.729	4.7
24	0.0201	0.577	3.5
25	0.0179	0.457	2.7
26	0.0159	0.361	2.2
27	0.0142	0.288	1.7
28	0.0126	0.226	1.4
29	0.0113	0.182	1.2
30	0.0100	0.142	0.86
31	0.0089	0.113	0.7
32	0.0080	0.091	0.53
33	0.0071	0.072	0.43
34	0.0063	0.056	0.33
35	0.0056	0.044	0.27
36	0.0050	0.035	0.21
37	0.0045	0.0289	0.17
38	0.0040	0.0228	0.13
39	0.0035	0.0175	0.11
40	0.0031	0.0137	0.09

Figure 4-9: Electrical wiring ampacity chart

The following requirements apply for conductor sizing:

- In no case may the current in a wire in the aircraft exceed the table value for the wire of the corresponding diameter/gauge.
- The *chassis wiring* specification applies only to wiring runs of a length less than 3.5 meters.
- The *power transmission* specification has no requirement for wiring run length.

4.2.3.5 (f). Wire gauge size: value of design maximum current in relation to table value for maximum permissible current

Value of $\frac{I_{table}}{I_{design}}$	$\frac{I_{table}}{I_{design}} \geq 1.3$	$\frac{I_{table}}{I_{design}} \geq 1.15$	$\frac{I_{table}}{I_{design}} \geq 1$	$\frac{I_{table}}{I_{design}} < 1$
Risk points	0	5	10	Unairworthy

Additionally, the following requirements apply for wiring:

- All wiring runs must be of a minimal length without the wires cluttering the interior of the airplane.
- Long wiring runs must not be accomplished by connecting multiple extension wires. If multiple lengths of wire are needed, they must be soldered together and secured with heat shrink tubing.

4.2.3.5 (g). Long wiring runs: minimal lengths

Wiring length	Wire runs are of a minimal length without cluttering the interior of the airplane.	Wiring length standards are not met.
Risk points	0	Unairworthy

4.2.3.5 (h). Long wiring runs: connection method between wire lengths

Wiring connections	Long wire runs use a single cable, or multiple cables with soldered joints.	Long wiring connection standards are not met.
Risk points	0	Unairworthy

4.2.3.5 (i). Wiring protection: OISC requires that, wherever a wire is mounted to the airframe, the wire be protected by heat-shrink tubing or a similar means. It is not acceptable to anchor a wire without any protection. Risk points are allocated as follows:

Wire protection standards	Wire protection standards met	Wire protection standards not met
Risk points	0	Unairworthy

The reduced score in this category may not exceed 24 or the aircraft is rendered unairworthy.

4.2.3.6 Structures

4.2.3.6 (a). Rotor mounting structure: minimum safety factor against yielding at full thrust and maximum takeoff weight

Value of FS	$FS > 1.5$	$FS > 1.25$	$FS > 1.1$	$FS < 1.1$
Risk points	0	5	10	Unairworthy

4.2.3.6 (b). Tail boom structure: maximum deflection of beam structure at full tail rotor thrust and maximum takeoff weight

Deflection v	$v < 3$mm	$v < 5$mm	$v < 10$mm	$v > 10$mm
Risk points	0	20	30	Unairworthy

4.2.3.6 (c). Tail boom structure: maximum deflection angle of beam structure at full tail rotor thrust and maximum takeoff weight

Deflection angle θ	$\theta < 2.5^o$	$\theta < 5^o$	$\theta < 7.5^o$	$\theta > 7.5^o$
Risk points	0	20	30	Unairworthy

4.2.3.6 (d). Landing gear structure: minimum safety factor against yielding

Value of FS	$FS > 2.5$	$FS > 2.25$	$FS > 2.1$	$FS < 2.1$
Risk points	0	5	10	Unairworthy

Landing gear deflection: the following standards apply for the deflection of landing gear during a 2-g landing on a smooth, level surface:

- The landing gear must not deflect so much that the tail rotor risks touching the ground
- The landing gear must not deflect asymmetrically to change the attitude of the aircraft which could cause the rotor to impact the ground.

4.2.3.6 (e). Fatigue life: cycles until failure of motor mount mechanism due to changes in thrust during flight

Cycles	> 10000	> 5000	> 1000	< 100
Risk points	0	10	20	Unairworthy

4.2.3.6 (f). Fatigue life: cycles until failure of motor mount mechanism due to motor vibrations

Cycles	> 10000	> 5000	> 1000	< 100
Risk points	0	10	20	Unairworthy

4.2.3.6 (g). Structural vibrations: in-flight oscillations during flight test

$f_{modal,structural}$ in relation to $f_{encountered}$	No structural oscillations encountered in any regime of flight	Structural vibrations occur during flight, but there is no noticeable wear after 10 flights	Structural vibrations cause significant and noticeable wear and damage after 10 flights	Structural vibrations cause component failure in flight
Risk points	0	40	Unairworthy	Unairworthy

This must cover vibrations from varying degrees of motor thrust and various airspeeds. Flight test must reveal whether the structural modal frequencies are such that the aircraft structure will excessively vibrate during flight.

4.2.3.6 (h). Material construction: presence of fibrous materials vulnerable to splitting

Presence of fibrous materials	Only isotropic materials used in aircraft structure	Fibrous materials used with overlapping layers offset by at least 60 degrees	Fibrous materials used but no stress is applied orthogonal to fiber	Fibrous materials used with stress orthogonal to fiber
Risk points	0	5	10	Unairworthy

4.2.3.6 (i). Rotor structures: minimum factor of safety of main rotor at maximum thrust, MTOW, maximum load factor

Value of FS	$FS > 1.5$	$FS > 1.5$	$FS > 1.15$	$FS < 1.15$
Risk points	0	20	40	Unairworthy

Rotor structures: the following rotor structures standards also apply:

- The rotor must possess sufficient torsional stiffness to not deform excessively to compromise the lift generated by the rotor.
- The rotor must possess sufficient beam bending stiffness to not deform excessively to compromise the lift generated by the rotor or cause interference with other parts of the aircraft structure.

4.2.3.6 (j). Rotor stiffness risk points

Standards met	Met	Not met
Risk points	0	Unairworthy

The reduced risk score in this category may not exceed 21 or the aircraft is rendered unairworthy.

4.2.3.7 Dynamics and Handling

4.2.3.7 (a). Position-hold performance: position hold Cooper-Harper score

Cooper-Harper score	2 or better	4 or better	6 or better	Worse than 6
Risk points	0	15	40	Unairworthy

4.2.3.7 (b). Attitude-hold performance: attitude-hold Cooper-Harper score

Cooper-Harper score	2 or better	4 or better	6 or better	Worse than 6
Risk points	0	15	40	Unairworthy

4.2.3.7 (c). Disturbance tracking: position-hold performance: Cooper-Harper score in light turbulence

Cooper-Harper score	2 or better	4 or better	6 or better	Worse than 6
Risk points	0	15	40	Unairworthy

4.2.3.7 (d). Maintaining attitude limits: Cooper-Harper score

Cooper-Harper score	2 or better	4 or better	6 or better	Worse than 6
Risk points	0	15	40	Unairworthy

4.2.3.7 (e). Control precision: Cooper-Harper score for landing on precise location

Cooper-Harper score	2 or better	4 or better	6 or better	Worse than 6
Risk points	0	15	40	Unairworthy

This is based on the following test: the aircraft is to be landed on a square pad with a side length not exceeding 1.2 times the maximum diagonal length between propellers. The pilot is to land on the middle of this pad and rate the difficulty of doing so.

4.2.3.7 (f). Control precision: azimuth hold ability Cooper-Harper score

Cooper-Harper score	2 or better	4 or better	6 or better	Worse than 6
Risk points	0	15	40	Unairworthy

This is based on the pilot's workload during the test delineated in the previous standard.

4.2.3.7 (g). Dynamic rollover: critical rollover angle

Critical angle θ	$\theta > 15^o$	$\theta > 10^o$	$\theta > 5^o$	$\theta < 5^o$
Risk points	0	15	30	Unairworthy

4.2.3.7 (h). Static stability: static yaw stability in forward flight

Static stability	Statically stable	Neutrally stable or unstable
Risk points	0	80

4.2.3.7 (i). Static stability: static roll stability in forward flight

Static stability	Statically stable	Neutrally stable or unstable
Risk points	0	80

4.2.3.7 (j). Static stability: static pitch stability in forward flight

Static stability	Statically stable	Neutrally stable or unstable
Risk points	0	80

4.2.3.7 (k). Dynamic stability: growth of oscillations in pitch (hover)

Absolute value of time constant τ	$\tau > 1$ sec	$\tau > 0.6$ sec	$\tau > 0.1$ sec	$\tau < 0.1$ sec
Risk points	0	20	40	Unairworthy

4.2.3.7 (l). Dynamic stability: growth of oscillations in roll (hover)

Absolute value of time constant τ	$\tau > 1$ sec	$\tau > 0.6$ sec	$\tau > 0.1$ sec	$\tau < 0.1$ sec
Risk points	0	20	40	Unairworthy

4.2.3.7 (m). Dynamic stability: growth of oscillations in yaw (hover)

Absolute value of time constant τ	$\tau > 1$ sec	$\tau > 0.6$ sec	$\tau > 0.1$ sec	$\tau < 0.1$ sec
Risk points	0	20	40	Unairworthy

The reduced score in this category may not exceed 51 or the aircraft is rendered unairworthy.

4.2.4 Standards for Airships

The airworthiness status is found based on the reduced risk score:

- Between 0 and 5: risk level 1
- Between 6 and 10: risk level 2
- Between 11 and 22: risk level 3
- Greater than 22: unairworthy

4.2.4.1 Overall design characteristics

4.2.4.1 (a). Type of airship

Airship type	Rigid airship	Semi-rigid airship	Non-rigid airship
Risk points	0	15	30

The definitions for each type of airship are below:

- Rigid airship – an airship with an internal structure which supports the envelope and maintains the external shape of the airship independent of the pressure within the airship.
- Semi-rigid airship – an airship with a stiff (or semi-stiff) keel or truss supports the airship along its lower length. The external shape of the envelope is maintained by air pressure.
- Non-rigid airship – an airship which requires air pressure to maintain the external shape of the envelope and obtains most of its strength and stiffness from the pressurized envelope.

4.2.4.1 (b). Lifting gas

Lifting gas risk level	Risk level 1 gas	Risk level 2 gas	Risk level 3 gas	Risk level 4 gas
Risk points	0	30	80	Unairworthy

The following list details the kinds of lifting gas and the associated risk levels:

- Risk level 1 gasses
    - Helium
    - Ammonia
    - Neon
    - Nitrogen

    - Any non-flammable, non-toxic, cold gas
- Risk level 2 gasses
    - Hot air
    - Water vapor
    - Vacuum
    - Any hot, non-flammable, non-toxic gas or gasses which require low pressures
- Risk level 3 gasses
    - Hydrogen
    - Methane
    - Acetylene
    - Coal gas
    - Any flammable non-toxic gas
- Risk level 4 gasses
    - Plasma
    - Hydrogen cyanide
    - Hydrogen fluoride
    - Any excessively hot or toxic gas

Lifting gas safety features: OISC requires the airship to be equipped with certain safety features depending on the type of lifting gas. These requirements are detailed below:

- Flammable gasses
    - This applies to hydrogen, methane, acetylene, and coal gas or any other flammable gas.
    - The chief concern is that the lifting gas could ignite.
    - No airship will be certified as airworthy which uses flammable gas without the following:
        - Design features to ensure no ignition sources exist within 20cm of the envelope containing the lifting gas.
        - A plan for rigorous inspection of the aircraft before and after flight to locate any leaks.
        - Safety plan to mitigate fire risk during flight, gas filling, and gas removal approved by OISC and a local fire department.
- Hot gasses
    - This applies to hot air, water vapor, and any other gas which is heated to a temperature above atmospheric temperature to function.
    - The chief concern is that the heat could soften any materials used in constructing the airship, potentially causing loss of pressure or structural failure.
    - No airship will be certified as airworthy which uses hot gasses without the following:
        - Design features to closely regulate the gas temperature and alert the crew if the temperature is outside of acceptable ranges.
        - Analysis to show that the chosen materials can withstand the heat of these gasses without decreasing stiffness or strength material parameters to the point of causing excessive deformation or material failure.

        - Design features to ensure that any heating apparatuses cannot ignite the structure of the airship itself.
- Gasses which can diffuse through common skin materials
    - This applies to hydrogen, helium, and any other generally monoatomic gas which can easily diffuse through common skin materials.
    - The chief concern is that the gas can diffuse through the skin of the aircraft and the pressure can be lost over time, which could reduce the lift force generated over time.
    - No airship will be certified as airworthy which uses gasses prone to diffusion through skin without the following:
        - Design features to closely monitor the pressure inside the airship and to alert the crew if the pressure drops too low.
        - Selection of skin material to minimize gaseous diffusion through the skin.
        - Precise determination of the permissible flight time considering gaseous diffusion phenomena.
- Vacuum
    - This applies to situations where a near-vacuum is used to provide the lifting force.
    - The chief concern is ensuring that the structure can safely support a vacuum and has adequate fatigue life to support repeated flights.
    - No airship will be certified as airworthy which relies on a vacuum without the following:
        - Demonstration from proponent that the structure possesses at least a 1.25 factor of safety against yielding at standard sea level external conditions and zero-pressure internal conditions.
        - Determination of pressurization-depressurization cycles which the aircraft can undergo before fatigue renders the structure unairworthy.

4.2.4.1 (c). Risk points for gas-specific safety features

Gas-specific safety standards	Standards met	Standards not met
Risk points	0	Unairworthy

4.2.4.1 (d). Lifting gas venting: all airships must be equipped with a means to quickly vent lifting gas in the event of an emergency. This must be capable of, at minimum, quickly venting both a small fraction of the gas to allow the airship to sink, and quickly venting all or most of the lifting gas.

Gas venting standards	Standards met	Standards not met
Risk points	0	Unairworthy

The reduced risk score in this category may not exceed 33 or the aircraft is rendered unairworthy.

4.2.4.2 Stability and Control

4.2.4.2 (a). Moment balance in pitch: resting pitch angle

Pitch angle absolute value	$\|\theta\| < 1^o$	$\|\theta\| < 2^o$	$\|\theta\| < 5^o$	$\|\theta\| > 5^o$
Risk points	0	15	40	Unairworthy

This assumes that the desired nominal pitch angle is zero. However, if the design calls for a nonzero nominal pitch angle, this standard should be based on the error of the actual resting pitch angle vs. the desired resting pitch angle.

4.2.4.2 (b). Moment balance in roll: resting roll angle error

Pitch angle absolute value	$\|\phi\| < 1^o$	$\|\phi\| < 2^o$	$\|\phi\| < 5^o$	$\|\phi\| > 5^o$
Risk points	0	15	40	Unairworthy

This assumes that the desired nominal roll angle is zero. However, if the design calls for a nonzero nominal roll angle, this standard should be based on the error of the actual resting roll angle vs. the desired resting roll angle.

4.2.4.2 (c). Static stability in pitch, zero airspeed: the center of buoyancy must be located relative to the center of mass of the airship such that, when the pitch is perturbed at zero airspeed, the airship reacts such that it has static pitch stiffness.

Static pitch stiffness	Stable	Unstable or neutrally stable
Risk points	0	Unairworthy

4.2.4.2 (d). Static stability in roll: the center of buoyancy must be located relative to the center of mass of the airship such that, when the roll is perturbed at any airspeed between 0 and V_H, the airship reacts such that it has static roll stiffness.

Static roll stiffness	Stable	Unstable or neutrally stable
Risk points	0	Unairworthy

4.2.4.2 (e). Static yaw stability, nonzero airspeed: during forward flight, the airship must produce a yawing moment response to a sideslip to counteract the sideslip.

Static yaw stiffness	Stable	Unstable or neutrally stable
Risk points	0	Unairworthy

4.2.4.2 (f). Dynamic yaw stability: during forward flight, no unstable yaw oscillations may develop. The dynamic yaw stability is assessed by the following table:

Dynamic yaw response characteristics	First-order response	Well damped second-order response ($\zeta > 0.5$)	Lightly damped second-order response ($\zeta < 0.5$)	Unstable first or second-order response
Risk points	0	15	50	Unairworthy

4.2.4.2 (g). Static pitch stability: critical speed in relation to maximum airspeed that can be developed by propulsion system

Value of $\frac{V_{crit}}{V_H}$	$\frac{V_{crit}}{V_H} > 1.5$	$\frac{V_{crit}}{V_H} > 1.3$	$\frac{V_{crit}}{V_H} > 1.1$	$\frac{V_{crit}}{V_H} < 1.1$
Risk points	0	20	35	Unairworthy

4.2.4.2 (h). Pitch control: the aircraft's pitch must be able to be controlled both at zero airspeed and at nonzero airspeed.

Pitch control	Pitch control standards met	Standards not met
Risk points	0	Unairworthy

4.2.4.2 (i). Yaw control: the airship's yaw must be able to be controlled both at zero airspeed and at nonzero airspeed. At any airspeed from zero to V_H, the airship must be able to generate a yawing moment such that a standard-rate 3-degree per second turn, at minimum, can be established. This is evaluated by the following table:

Yaw rate*	> 5 deg/s	> 4 deg/s	> 3 deg/s	< 3 deg/s
Risk points	0	5	10	Unairworthy

*Note that, for the purposes of assessing the effectiveness of the yaw controls, the yaw rate at maximum control deflection at airspeeds from 0 to V_H. The minimum value in that set is the yaw rate used for this standard.

4.2.4.2 (j). Altitude control: the airship must be able to maintain altitude as the buoyancy of the airship changes. It further must be able to make corrections to altitude to aid in landing. To that, OISC requires two types of altitude control, unless the applicant can demonstrate that another solution accomplishes both goals:

- A system to account for changes in atmospheric conditions, changes in density of the lifting gas, or other large-scale phenomena that would change the trim altitude of the airship by tens to hundreds of meters. An example of a means to comply with this requirement would be a ballonet, changing the pressure, temperature, or amount of lifting gas in the bag, or using ballast such as water which can be jettisoned.
- A system to produce small changes in altitude, such as those required for takeoff and landing. OSIC recommends a system in which thrust is produced in the vertical direction.

Altitude control requirements	Requirements met	Requirements not met
Risk points	0	Unairworthy

The reduced risk score in this category may not exceed 18 or the aircraft is rendered unairworthy.

4.2.4.3 Structures

Note that these standards are general and apply to any airship. Structural standards specific to rigid, non-rigid, and semi-rigid airships are contained in section 5.4.

4.2.4.3 (a). Safety factor of skin

Value of FS	$FS > 1.5$	$FS > 1.25$	$FS > 1.05$	$FS < 1.05$
Risk points	0	5	15	Unairworthy

This is to be evaluated at maximum internal pressure and 90% of the standard atmosphere pressure at the design absolute ceiling.

OISC recommends maintaining the internal pressure slightly above the outside pressure such that a leak in the skin would not be catastrophic.

4.2.4.3 (b). Structural vibrations: in-flight oscillations during flight test

$f_{modal,structural}$ in relation to $f_{encountered}$	No structural oscillations encountered in any regime of flight	Structural vibrations occur during flight, but there is no noticeable wear after 10 flights	Structural vibrations cause significant and noticeable wear and damage after 10 flights	Structural vibrations cause component failure in flight
Risk points	0	40	Unairworthy	Unairworthy

This must cover vibrations from varying degrees of motor thrust and various airspeeds. Flight test must reveal whether the structural modal frequencies are such that the aircraft structure will excessively vibrate during flight.

4.2.4.3 (c). Material construction: presence of fibrous materials vulnerable to splitting

Presence of fibrous materials	Only isotropic materials used in aircraft structure	Fibrous materials used with overlapping layers offset by at least 60 degrees	Fibrous materials used but no stress is applied orthogonal to fiber	Fibrous materials used with stress orthogonal to fiber
Risk points	0	5	10	Unairworthy

4.2.4.3 (d). Minimum safety factor in gondola mount

Value of FS	$FS > 1.5$	$FS > 1.25$	$FS > 1.15$	$FS < 1.15$
Risk points	0	5	15	Unairworthy

This safety factor must be calculated based on the maximum expected G load in flight and the load that may need to be supported in a hard (2G) landing.

4.2.4.3 (e). Puncture resistance: the applicant must demonstrate that the airship bag will not puncture when exposed to routine puncture risk items such as rocks, dust, precipitation, sharp edges on equipment, etc. The bag must also not be punctured by the structure in the event of a hard landing (2G).

Puncture resistance standards	Standards met	Standards not met
Risk points	0	Unairworthy

4.2.4.3 (f). Envelope skin UV protection: the applicant must specify a total amount of time for which the envelope can be exposed to the UV light without causing damage to the envelope which may result in leaks. The applicant must also specify inspection procedures to locate any UV damage prior to each flight.

UV exposure standards	Standards met	Standards not met
Risk points	0	Unairworthy

4.2.4.3 (g). Motor mount: minimum safety factor in motor mounting structure

Value of FS	$FS > 1.5$	$FS > 1.25$	$FS > 1.15$	$FS < 1.15$
Risk points	0	5	15	Unairworthy

4.2.4.3 (h). Motor mount: all motor mounts must meet the following criteria:

- The motors must mount to a rigid part of the airship. For example, on a non-rigid airship, it is not acceptable to mount motors to the bag when no rigid connection exists between the bag and other rigid parts of the airship.
- The motor mount may not excessively deform when subjected to full thrust.
- The motor mount must feature some means of vibration control.

Motor mount other standards	Standards met	Standards not met
Risk points	0	Unairworthy

4.2.4.3 (i). Landing gear: minimum safety factor in landing gear structure at MTOW and hard (2G) landing

Value of FS	$FS > 1.5$	$FS > 1.35$	$FS > 1.25$	$FS < 1.25$
Risk points	0	5	15	Unairworthy

4.2.4.3 (j). Landing gear other standards: the landing gear must also meet the following other standards:

- The landing gear must be able to swivel to account for the change in azimuth of the airship in response to the wind as it is secured to the ground.
- Some means of mooring the airship must be included which secures the airship to the ground when it is not flying.

Landing gear other standards	Standard met	Standards not met
Risk points	0	Unairworthy

The reduced risk score in this category may not exceed 11 or the aircraft is rendered unairworthy.

4.2.4.4 Performance and Propulsion

4.2.4.4 (a). Absolute ceiling, density altitude

Absolute ceiling z_{abs}, m	$z_{abs} > 5500$ m	$z_{abs} > 4400$ m	$z_{abs} > 3200$ m	$z_{abs} < 2100$ m
Risk points	0	20	40	Unairworthy

4.2.4.4 (b). Maximum true airspeed developed at standard sea level

Maximum true airspeed u_{∞}, m/s	$u_{\infty} > 3$ m/s	$u_{\infty} > 2$ m/s	$u_{\infty} > 1$m/s	$u_{\infty} < 1$ m/s
Risk points	0	15	30	Unairworthy

The aircraft may be certified for flights in winds not to exceed half of the maximum airspeed the airship can develop.

4.2.4.4 (c). Climb performance: maximum rate of climb at standard sea level

Climb rate, m/s	> 2 m/s	> 1.5 m/s	> 1 m/s	< 1 m/s
Risk points	0	15	30	Unairworthy

4.2.4.4 (d). Descent performance: maximum rate of descent at service ceiling without gas venting

Descent rate, m/s	> 1.5 m/s	> 1 m/s	> 0.5 m/s	< 0.5 m/s
Risk points	0	15	30	Unairworthy

4.2.4.4 (e). Maximum endurance

Endurance, minutes	> 90 minutes	> 60 minutes	> 30 minutes	< 30 minutes
Risk points	0	15	30	Unairworthy

4.2.4.4 (f). Vibration: propeller balance

Propeller balance characteristics	Negligible vibration: propeller center of gravity within 0.001 inches of propeller axis	Small vibration: propeller center of gravity within 0.005 inches of propeller axis	Moderate or greater vibrations; propeller center of gravity further than 0.005 inches from propeller
Risk points	0	10	Unairworthy

4.2.4.4 (g). Vibration: motor vibration

Vibration characteristics	Negligible vibration: vibration amplitude less than 0.001 inch	Small vibrations: vibration amplitude less than 0.005 inch	Moderate vibrations: vibration amplitude greater than 0.005 inch
Risk points	0	10	Unairworthy

4.2.4.4 (h). Vibration: damping of propulsion system vibrations

Damping characteristics present	Viscous liquid dampers are used	Rubber vibration isolating devices are used	No vibration damping is present, propeller balance and motor vibration score of 0	No vibration damping is present, nonzero propeller/motor vibration score
Risk points	0	20	20	Unairworthy

The reduced score in this category may not exceed 25 or the aircraft is rendered unairworthy.

4.2.4.5 Electronics

4.2.4.5 (a). Remote control signal reliability: carrier frequency and technology used

Carrier frequency	2.4 GHz spread spectrum with DSMx or similar frequency-hopping features	Legacy carrier frequency without frequency-hopping features
Risk points	0	50

4.2.4.5 (b). Signal reliability: antenna diversity

Diversity features	Antenna diversity on transmitter and receiver	Antenna diversity on transmitter only	Antenna diversity on receiver only	No antenna diversity
Risk points	0	5	20	40

4.2.4.5 (c). ESC current rating in relation to expected maximum current draw through ESC

Value of $\frac{I_{ESC}}{I_{max}}$	$\frac{I_{ESC}}{I_{max}} > 1.5$	$\frac{I_{ESC}}{I_{max}} > 1.25$	$\frac{I_{ESC}}{I_{max}} > 1.1$	$\frac{I_{ESC}}{I_{max}} < 1.1$
Risk points	0	5	15	Unairworthy

Note: this may be inapplicable depending on the method of propulsion used in the airplane.

4.2.4.5 (d). Receiver power source

Configuration	Receiver powered from independent battery and independent BEC	Receiver powered by main flight battery, but through independent BEC	Receiver powered from BEC integrated into ESC
Risk points	0	10	30

4.2.4.5 (e). Auxiliary device power source

Configuration	Powered from independent battery and independent BEC	Powered by main flight battery, but through independent BEC	Powered from BEC integrated into ESC, or powered directly from receiver
Risk points	0	10	30

This includes aircraft lights, autopilots, sensors, etc. This category may be inapplicable depending on whether the aircraft has any auxiliary devices.

Further, all wire sizes must be specified based on the expected current draw according to the chart on the following page:

Wire size (gauge)	Wire conductor diameter (inches)	Maximum continuous current (amps), power transmission	Maximum continuous current (amps), chassis wiring
0000	0.4600	302	380
000	0.4096	239	328
00	0.3648	190	283
0	0.3249	150	245
1	0.2893	119	211
2	0.2576	94	181
3	0.2294	75	158
4	0.2043	60	135
5	0.1819	47	118
6	0.1620	37	101
7	0.1443	30	89
8	0.1285	24	73
9	0.1144	19	64
10	0.1019	15	55
11	0.0907	12	47
12	0.0808	9.3	41
13	0.0720	7.4	35
14	0.0641	5.9	32
15	0.0571	4.7	28
16	0.0508	3.7	22
17	0.0453	2.9	19
18	0.0403	2.3	16
19	0.0359	1.8	14
20	0.0320	1.5	11
21	0.0285	1.2	9
22	0.0253	0.92	7
23	0.0226	0.729	4.7
24	0.0201	0.577	3.5
25	0.0179	0.457	2.7
26	0.0159	0.361	2.2
27	0.0142	0.288	1.7
28	0.0126	0.226	1.4
29	0.0113	0.182	1.2
30	0.0100	0.142	0.86
31	0.0089	0.113	0.7
32	0.0080	0.091	0.53
33	0.0071	0.072	0.43
34	0.0063	0.056	0.33
35	0.0056	0.044	0.27
36	0.0050	0.035	0.21
37	0.0045	0.0289	0.17
38	0.0040	0.0228	0.13
39	0.0035	0.0175	0.11
40	0.0031	0.0137	0.09

Figure 4-10: Electrical wiring ampacity chart

The following requirements apply for conductor sizing:

- In no case may the current in a wire in the aircraft exceed the table value for the wire of the corresponding diameter/gauge.
- The *chassis wiring* specification applies only to wiring runs of a length less than 3.5 meters.
- The *power transmission* specification has no requirement for wiring run length.

4.2.4.5 (f). Wire gauge size: value of design maximum current in relation to table value for maximum permissible current

Value of $\frac{I_{table}}{I_{design}}$	$\frac{I_{table}}{I_{design}} \geq 1.3$	$\frac{I_{table}}{I_{design}} \geq 1.15$	$\frac{I_{table}}{I_{design}} \geq 1$	$\frac{I_{table}}{I_{design}} < 1$
Risk points	0	5	10	Unairworthy

Additionally, the following requirements apply for wiring:

- All wiring runs must be of a minimal length without the wires cluttering the interior of the airplane.
- Long wiring runs must not be accomplished by connecting multiple extension wires. If multiple lengths of wire are needed, they must be soldered together and secured with heat shrink tubing.

4.2.4.5 (g). Long wiring runs: minimal lengths

Wiring length	Wire runs are of a minimal length without cluttering the interior of the airplane.	Wiring length standards are not met.
Risk points	0	Unairworthy

4.2.4.5 (h). Long wiring runs: connection method between wire lengths

Wiring connections	Long wire runs use a single cable, or multiple cables with soldered joints.	Long wiring connection standards are not met.
Risk points	0	Unairworthy

4.2.4.5 (i). Wiring protection: OISC requires that, wherever a wire is mounted to the airframe, the wire be protected by heat-shrink tubing or a similar means. It is not acceptable to anchor a wire without any protection. Risk points are allocated as follows:

Wire protection standards	Wire protection standards met	Wire protection standards not met
Risk points	0	Unairworthy

The reduced score in this category may not exceed 24 or the aircraft is rendered unairworthy.

Part 5: Systems and Application-Specific Criteria

Since all systems and application-specific criteria are reliant on flight testing to verify compliance with these standards, these criteria only apply to operational certification and are inapplicable to experimental certification.

Under an experimental airworthiness certificate, any testing that is needed to assess compliance with systems and application-specific criteria may be conducted, providing that the daytime VMC-only conditions for experimental flights are met.

5.1 Standards for Airplanes

There are several categories contained in this section that might be relevant depending on the aircraft design and purpose. These include:

- Automation reliability for aircraft equipped with autopilots or artificial stabilization.
- Alternate dynamics characteristics, which applies to airplanes with artificial stabilization or airplanes with nonstandard dynamic modes
- Aircraft to be flown at night
- Aircraft to be flown in precipitation
- Aircraft to be flown in cold environments
- Multiengine airplanes
- Aircraft to be flown in environments where incidental exposure to icing conditions is expected
- Aircraft to be certified for extended flight in icing conditions

These categories are only to be evaluated upon request from the proponent. The aircraft will be certified as unairworthy for any systems and application-specific criterion unless the proponent requests an airworthiness evaluation for that criterion.

5.1.1 Aircraft equipped with artificial stabilization and autopilots: automation reliability

This category assesses the following:

- Automation reliability insofar as the number of redundant sensors, flight computers, state estimation accuracy, state estimation mounting security.

The artificial dynamics should be evaluated based on flight tests alone; there is no expectation to calculate the characteristics of the airplane’s artificial dynamics. Again, in flight testing, the airworthiness assessor should categorize the aircraft stability against the framework in this chapter based on their experience.

5.1.1 (a). Artificial stabilization reliability – minimum number redundant state-estimation sensors.

Number of redundant sensors	≥ 4	3	2	1
Risk points	1	5	20	50

5.1.1 (b). Artificial stabilization reliability – number of redundant flight computers.

Number of redundant flight computers	≥ 3	2	1
Risk points	1	10	20

5.1.1 (c). Accuracy of state estimation: demonstrated worst-case accuracy of any IMU state-estimation sensor in normal operation.

Accuracy	$\leq 1\%$	$\leq 5\%$	$< 10\%$	$\geq 10\%$
Risk points	1	10	20	50

5.1.1 (d). Accuracy of state estimation: demonstrated worst-case accuracy of airspeed measurement.

Accuracy	$\pm 1\%$ or better	$\pm 5\%$ or better	$\pm 10\%$ or better	Worse than $\pm 10\%$
Risk points	1	10	20	50

5.1.1 (e). Latency: worst-case time between a physical change in a parameter and that change being recognized by the onboard software.

Latency	≤ 150 ms	≤ 250 ms	≤ 350 ms	> 350 ms
Risk points	1	5	15	30

5.1.1 (f). State estimation sensor mounting security: maximum flex in any direction. Note: this is referencing loose mounting and not deformation under load.

Flex	$\leq 1^o$	$\leq 2^o$	$\leq 3^o$	$> 3^o$
Risk points	1	5	15	30

5.1.1 (g). State estimation mounting security: maximum flex in any direction under maximum load expected in normal flight.

Flex	$\leq 1^o$	$\leq 2^o$	$\leq 3^o$	$> 3^o$
Risk points	1	5	15	30

The total automation reliability score calculated by adding up all automation reliability risk points and dividing by the maximum possible automation reliability risk.

The airworthiness results are computed from the reduced score:

- Less than 10: risk level 1
- Between 11 and 25: risk level 2
- Between 26 and 65: risk level 3
- Greater than 65: unairworthy

5.1.2 Nonstandard dynamics: artificially augmented dynamics, nonstandard dynamic modes

Note: this applies to artificial dynamics, as modified by an autopilot or stability augmentation system, and for airplanes with nonstandard dynamic modes.

Further note that the standards for stability of aircraft with augmented dynamics characteristics are higher since it is possible to use artificial stabilization to produce an airplane with very desirable handling qualities.

The following definitions apply:

- Easy-to-activate dynamic modes: this describes a mode that is expected to be encountered in normal flight. This includes modes activated easily by changes in airspeed or sideslip angle, for example.
- Difficult-to-activate dynamic modes: this describes a mode that is not expected to be encountered in normal flight. This includes modes activated easily by a specific and unlikely to be encountered combination of state variables, for example.

5.1.2 (a). Easy-to-activate oscillatory dynamic modes (such as Dutch roll and phugoid). Repeat for each relevant dynamic mode.

Damping ratio ζ / damped frequency ω_d	Slow	Moderate	Fast
Lightly damped	25	45	75
Moderately damped	15	35	65
Well-damped	0	25	55

Since this standard is evaluated with flight test as opposed to calculations on the ground, the mode characteristics are qualitative as opposed to quantitative. What qualifies as a fast mode depends on the aircraft type; for instance, certain modes will be faster or slower depending on the trim airspeed u_0. So, the airworthiness assessor must use their best judgement in qualifying a mode's damping ratio and frequency.

5.1.2 (b). Easy-to-activate first-order dynamic modes. Repeat for each relevant dynamic mode.

Time constant τ	Stable, fast	Stable, slow	Unstable, slow	Unstable, fast
Risk points	0	10	20	Unairworthy

Since this standard is evaluated with flight test as opposed to calculations on the ground, the mode characteristics are qualitative as opposed to quantitative. The airworthiness assessor must use their best judgement for what constitutes a slow or fast mode.

5.1.2 (c). Difficult-to-activate oscillatory dynamic modes (such as short period). Repeat for each relevant dynamic mode.

Damping ratio / damped frequency	Slow	Moderate	Fast
Lightly damped	20	35	50
Moderately damped	10	25	40
Well-damped	0	15	30

Since this standard is evaluated with flight test as opposed to calculations on the ground, the mode characteristics are qualitative as opposed to quantitative. What qualifies as a fast mode depends on the aircraft type; for instance, certain modes will be faster or slower depending on the trim airspeed u_0. So, the airworthiness assessor must use their best judgement in qualifying a mode's damping ratio and frequency.

5.1.2 (d). Difficult-to-activate first-order dynamic modes. Repeat for each relevant dynamic mode.

Time constant τ	Stable, fast	Stable, slow	Unstable, slow	Unstable, fast
Risk points	0	5	10	25

Since this standard is evaluated with flight test as opposed to calculations on the ground, the mode characteristics are qualitative as opposed to quantitative. The airworthiness assessor must use their best judgement for what constitutes a slow or fast mode.

5.1.2 (e). Static pitch stability

Pitch stability	Stable	Unstable/neutrally stable
Risk points	0	50

Test method: introduce a pitch disturbance using the elevator and note the initial reaction of the airplane.

5.1.2 (f). Static roll stability

Roll stability	Stable	Unstable/neutrally stable
Risk points	0	50

Test method: introduce a sideslip disturbance using the rudder and note the initial reaction of the airplane.

5.1.2 (g). Static yaw stability

Yaw stability	Stable	Unstable/neutrally stable
Risk points	0	50

Test method: introduce a sideslip disturbance using the rudder and note the initial reaction of the airplane.

5.1.2 (h). Maximum roll rate

Value of p_{max}	$p_{max} < 20^o$/s	$20 \leq p_{max} \leq 100^o$/s	$100 < p_{max} \leq 200^o$/s	$p_{max} > 200^o$/s
Risk points	Unairworthy	0	20	50

Introduce full aileron in either direction, and note the resulting motion. Ensure it is commensurate with the value of p_{max} calculated in the aircraft analysis application.

5.1.2 (i). Initial roll acceleration at reference approach speed with maximum aileron deflection

Value of $\dot{p}_{init}$, degrees/second squared	$\dot{p}_{init} < 3500$	$\dot{p}_{init} < 4500$	$\dot{p}_{init} < 5500$	$\dot{p}_{init} > 5500$
PIC control authority evaluation	Inadequate; Cooper-Harper ≥ 6	Acceptable; Cooper-Harper ≥ 4	Good; Cooper-Harper ≥ 2	Sensitive; Cooper-Harper ≥ 5
Risk points	Unairworthy	20	0	50

Introduce full aileron in either direction and note the resulting notion. Ensure it is commensurate with the calculated value of $\dot{p}_{init}$.

5.1.2 (j). Pitch control authority, down elevator: value of $\dot{q}_{init}$, initial time rate of change of pitch rate with maximum up-elevator deflection at approach speed.

Value of $\dot{q}_{init}$, degrees/second squared	$\dot{q}_{init} < 250$	$\dot{q}_{init} < 350$	$\dot{q}_{init} < 450$	$\dot{q}_{init} > 450$
PIC control authority evaluation	Inadequate; Cooper-Harper ≥ 6	Acceptable; Cooper-Harper ≥ 4	Good; Cooper-Harper ≥ 2	Sensitive; Cooper-Harper ≥ 5
Risk points	Unairworthy	20	0	50

Introduce full down elevator and note the resulting motion. Ensure it is commensurate with the calculated value of $\dot{q}_{init}$.

5.1.2 (k). Pitch control authority, up elevator: value of $\dot{q}_{init}$, initial time rate of change of pitch rate with maximum down-elevator deflection at approach speed.

Value of $\dot{q}_{init}$, degrees/second squared	$\dot{q}_{init} < 1000$	$\dot{q}_{init} < 1200$	$\dot{q}_{init} < 1600$	$\dot{q}_{init} > 1600$
PIC control authority evaluation	Inadequate; Cooper-Harper ≥ 6	Acceptable; Cooper-Harper ≥ 4	Good; Cooper-Harper ≥ 2	Sensitive; Cooper-Harper ≥ 5
Risk points	Unairworthy	0	20	50

Introduce full up elevator and note the resulting motion. Ensure it is commensurate with the calculated value of $\dot{q}_{init}$.

5.1.2 (l). Elevator control authority: CG range as a fraction of mean chord length for which static stability and balanced pitching moments can be maintained.

Value of $h_{max} - h_{min}$	$h_{max} - h_{min} > 0.3$	$h_{max} - h_{min} > 0.2$	$h_{max} - h_{min} > 0.1$	$h_{max} - h_{min} \leq 0.1$
Risk points	0	10	20	30

Note regarding control authority: as a part of the certification process, the airworthiness assessor should generate a recommended controls setup, including dual rates and exponentials. The goal is to adjust dual rates and exponentials to reach the maximum possible Cooper-Harper rating for control authority and control sensitivity. These recommended settings must be published in the type certificate for the airplane.

5.1.2 (m). Crosswind handling – maximum demonstrated crosswind component, expressed as a fraction of reference approach speed at maximum landing weight

Demonstrated maximum crosswind component divided by landing speed	$\frac{V_{cross}}{V_{REF}} > 0.25$	$\frac{V_{cross}}{V_{REF}} > 0.2$	$\frac{V_{cross}}{V_{REF}} > 0.15$	$\frac{V_{cross}}{V_{REF}} < 0.1$
Risk points	0	10	20	Unairworthy

5.1.2 (n). Crosswind handling – Cooper-Harper score for crosswind handling

Cooper-Harper score CH	$CH < 3$	$CH \leq 4$	$CH \leq 6$	$CH > 6$
Risk points	0	10	20	Unairworthy

5.1.2 (o). Crosswind handling – Cooper-Harper score for rudder control authority

Cooper-Harper score CH	$CH < 3$	$CH \leq 4$	$CH \leq 6$	$CH > 6$
Risk points	0	10	20	Unairworthy

The airworthiness status is computed based on the reduced score and the application:

- Nonstandard dynamic modes
    - Less than 20: risk level 1
    - Between 21 and 40: risk level 2
    - Between 41 and 60: risk level 3
    - Greater than 60: unairworthy
- Stability augmentation
    - Less than 10: risk level 1
    - Between 11 and 30: risk level 2
    - Between 31 and 45: risk level 3
    - Greater than 45: unairworthy

Note that the maximum acceptable dynamics score for artificially stabilized airplanes is less than that for airplanes with nonstandard dynamic modes since the goal of artificial stabilization is to enhance stability.

If the maximum acceptable dynamics score is exceeded, the aircraft does not meet airworthiness requirements for dynamics.

5.1.3 Aircraft to be flown at night

Note that both COA nighttime stipulations and Part 107 nighttime waivers have the same requirements for aircraft lighting. These stipulations include the requirement for the beacon to be visible at 3 statute miles unless safety dictates that this distance be reduced. In the cases when safety requires a shorter visibility distance requirement, the visibility must be maximized within the constraints of safety.

5.1.3 (a). Beacon visibility

Visibility	Less than 3 statute miles	3 statute miles or greater
Risk points	Unairworthy	0

This must be tested with physical experimentation.

The beacon light bust be configured such that it is visible regardless of the airplane's attitude.

The three-statute visibility requirement can generally be accomplished by using a roughly 15-watt bulb.

5.1.3 (b). Additional lighting requirements

Navigation lights are present	Yes, visible from at least 3 statute miles	Yes, visible from at least 1 statute mile	No
Risk points	0	10	Unairworthy

Note that navigation lights must be mounted such that the red navigation light is on the port wingtip, and the green navigation light is mounted on the starboard wingtip.

If other flight rules have different lighting requirements, the airworthiness assessment must be adjusted to be commensurate with the flight rules.

In addition to the FAA-required beacon and navigation lights, OISC strongly recommends that the aircraft be equipped with strobe lights. Further, OISC recommends that the aircraft either be equipped with landing lights or are landed in a well-lit location.

Further, OISC strongly recommends that nighttime aircraft missions are first flown in a daytime environment, and the landing is extensively practiced. If an autopilot is to be used, the automatic landing should be configured during the daytime and that the autopilot configuration remains completely unchanged to ensure that the nighttime landing is completed safely.

The airworthiness status is found based on the reduced risk score:

- Less than 10: risk level 1
- Equal to 10: risk level 2
- Greater than 10: unairworthy

5.1.4 Aircraft to be flown in precipitation

Waterproofing requirements

- When the exterior of the aircraft is subjected to heavy precipitation, no water should enter the interior of the aircraft to damage the electronics.
- Any waterproofing features must not be soluble in water or degrade over time with exposure to water.

In order to assess compliance with waterproofing standards, the following experimentation must be conducted:

- Aircraft must be fully assembled and powered on
- Use a water spray to simulate heavy precipitation
- Spray the aircraft from all angles and for at least thirty minutes

5.1.4 (a). The risk points are found based on the rest results:

Test results	No water enters interior of airplane	Water enters interior of airplane and shows noticeable residue	Water enters interior of airplane and pools	Electronics fail during test
Risk points	0	50	Unairworthy for operations in precipitation.	Unairworthy for operations in precipitation.

Further, aircraft to be flown in precipitation need to be inspected for corrosion and water damage after every 5 hours during which the aircraft has flown in precipitation.

Further, all materials used on the aircraft must be tested for water solubility. In order to do this, each material must be immersed in water for a minimum of 1 hour to ensure that water damage is not a concern. If prolonged exposure to water causes material degradation, the aircraft is unairworthy for the purposes of flights in precipitation. Manners of material degradation is delineated below:

- Disintegration of material
- Delamination of layers within a material
- Greater than 5% change in elastic modulus, shear modulus, or Poisson ratio of material
- Greater than 5% change in yield stress and ultimate stress for both the shear and normal stress cases

5.1.4 (b). The following table quantifies risk points for the above list of material degradation conditions that may render an aircraft unairworthy for flights in precipitation:

Condition	No material degradation conditions met	Any of the material degradation conditions are met
Risk points	0	Unairworthy for operations in precipitation.

The airworthiness status is found based on the reduced score:

- Less than 25: risk level 1
- Less than 55: risk level 2
- Greater than 55: unairworthy

5.1.5 Aircraft to be flown in cold environments

Cold environments are defined as environments where the historical average temperature for the time of operation is below 10^oC.

Depending on the aircraft, concerns in the following areas might be applicable:

- Battery performance degradation
- Elastic material performance degradation
- Potential for fuel to freeze or develop into a gel-like substance

Evaluate only each category that is applicable. Each category requires physical experimentation in order to certify the aircraft.

Battery performance degradation

- Place the batteries in freezer for 10 hours prior to experimentation
- Fly with cold batteries in 2-minute increments. Check to ensure the aircraft is not underpowered and check the battery voltage after each flight.
- The flight time should be certified such that the minimum voltage the battery reaches is 5% higher than the nominal battery cell voltage. For a LiPo, the nominal cell voltage is 3.7V so the minimum acceptable discharge voltage in cold environments is 3.85V. Airworthiness assessors are permitted to set the minimum discharge voltage to a higher value.
- If the results of the test are in doubt, the airworthiness assessor must specify procedures to be carried out by the operator in the cold-weather environment and how the results of those tests affect operating limitations.
- A higher C rating battery must be used for cold-weather environments than is used for temperate environments.
- The battery must be insulated in order to minimize heat loss from the battery. This is particularly important if the battery is exposed to the propwash or the airflow around the airplane.
- The battery must be warmed prior to flight.
- Batteries used in cold weather environments must be marked as having been subjected to cold environments, and the number of cycles they are subjected to in the cold environment must be documented.

Elastic material performance degradation

- Any elastic materials must be frozen for ten hours prior to flight.
- If after freezing they cannot be used for their intended purpose, the aircraft is unairworthy for the purposes of cold-weather operation.
- The aircraft must be flown in ten-minute increments, and the elastic material inspected between flights.
- From this, the airworthiness assessor must specify a useful life for all elastic parts.
- If the elastic cannot last more than 60 minutes, the aircraft is unairworthy. The useful life of an elastic material must be 1/3 of the time which it takes for the elastic to fail.

Fuel viscosity change

- The fuel must be frozen before flight for at least ten hours.
- If the fuel becomes solid, the aircraft is unairworthy for the purposes of cold-weather operation.
- If the fuel remains liquid, it is to be tested in the engine. If the engine cannot run for thirty minutes at a minimum, it is unairworthy for cold-weather operations.
- If the engine shows signs of excessive wear during or after the test, the aircraft is unairworthy for the purposes of cold-weather operations.
- All engine tests are intended to be performed on a test stand with an adequately large fuel tank. It is not relevant as to whether the design tank size of provides for a flight time commensurate with the required time to demonstrate normal engine operation. This section simply evaluates the ability of the engine and fuel to operate in cold environments.

5.1.5 (a). Battery performance degradation: maximum flight time in cold weather environments

Endurance	> 10 mins	> 7 mins	> 3 mins	< 3 mins
Risk points	0	20	40	Unairworthy for flights in cold environments

5.1.5 (b). Elastic material performance degradation

Elastic material performance	No elastic material used in airplane	Elastic material is present and can be used for 20 minutes and meet standards delineated in this section	Elastic material is present and cannot be used for 20 minutes	Elastic material fails in cold weather
Risk points	0	10	Unairworthy for flights in cold environments	Unairworthy for flights in cold environments

5.1.5 (c). Fuel viscosity change

Fuel performance degradation	No change in fuel and engine performance in cold environments	Fuel remains liquid and engine can run for a minimum of 30 minutes	Fuel remains liquid, but engine cannot be run for 30 minutes	Fuel forms into a gel or solid in cold environments
Risk points	0	20	Unairworthy for flights in cold environments	Unairworthy for flights in cold environments

The airworthiness status us found based on the reduced risk score:

- Less than 12: risk level 1
- Between 12 and 20: risk level 2
- Between 21 and 30: risk level 3
- Over 30: unairworthy

5.1.6 Aircraft to be flown in icing conditions – incidental exposure

Note that, as of the drafting of this manual in May 2020, there are several operations that CU has conducted in which icing conditions were encountered:

- S2 NIGHTFOX mission
- Datahawk flights in arctic environments
- Pilatus flights in Alaska

In each of these situations, the aircraft flew strictly in VMC but encountered icing, nonetheless. In turn, OISC needs to set standards for aircraft that are flown in environments where icing is a possibility.

This section applies to aircraft to be flown in situations where icing is possible, but extended operations in icing conditions are not expected. Under this certification scheme, the aircraft must leave icing conditions as soon as they are encountered.

The following analysis must be completed, and the following features must be included:

- Analysis must be completed to characterize airframe icing, including:
    - Where ice will accumulate, how quickly, and in what conditions
    - Icing effects on lift and stall speed
    - Icing effects on drag and ability of propulsion system to propel aircraft at speeds needed to maintain level flight
    - Expected performance changes as ice accumulates must be included in the performance section of the POH.
    - Note: ANSYS CFD packages can analyze aircraft icing, albeit at the expense of significant time and computational resources.

- Structural effects of ice shedding. This includes the effects of ice shedding from propellers and the effects of ice shedding from other flight surfaces, such as wings.
- Detection system for ice. The aircraft must be equipped with sufficient ice detection sensors that can alert the flight crew at the earliest signs of ice accumulation on any part of the airframe.
- Ice effects on air data sensors. This analysis must investigate if, how, and to what extent air data measurements will be affected by ice buildup.
- Ideal maneuvers for exiting icing conditions. The aircraft further must be certified with a recommended procedure for the flight crew to execute if they encounter icing conditions. This procedure need not require that the flight crew land if ice accumulation diminishes after exiting the icing environments. However, this procedure must guide the flight crew in exiting the icing situation with minimal risk

For an aircraft to be certified as airworthy for flights into possible icing conditions, the following standards apply:

5.1.6 (a). Change in stall speed in clean configuration with 5-minute icing condition exposure:

Stall airspeed change	$< 10\%$	$< 25\%$	$< 35\%$	$\geq 35\%$
Risk points	0	5	10	Unairworthy for flight in possible icing conditions

5.1.6 (b). Change in maximum airspeed the propulsion system is capable of sustaining in SLUF flight with 5-minute icing condition exposure:

Maximum airspeed change	$< 10\%$	$< 25\%$	$< 35\%$	$\geq 35\%$
Risk points	0	5	10	Unairworthy for flight in possible icing conditions

5.1.6 (c). Stall speed in clean configuration relative to maximum airspeed after 5-minute icing encounter:

Value of $\frac{V_H}{V_S}$	$\frac{V_H}{V_S} > 2.5$	$\frac{V_H}{V_S} > 2$	$\frac{V_H}{V_S} > 1.5$	$\frac{V_H}{V_S} < 1.5$
Risk points	0	5	10	Unairworthy for flight in possible icing conditions

5.1.6 (d). Flight-critical structural damage that occurs from ice shedding (including from propellers, wing, horizontal stabilizer, vertical stabilizer, and all other flight surfaces):

Damage	No flight-critical structural damage	Flight-critical structural damage
Risk points	0	Unairworthy for flight in possible icing conditions

5.1.6 (e). Ice detection system: ability to accurately detect ice accumulation on all surfaces where icing may be encountered:

Detection ability	Accurately identifies ice accumulation and lack of ice accumulation in at least 99% of cases	Accurately identifies ice accumulation and lack of ice accumulation in at least 85% of cases	Accurately identifies ice accumulation and lack of ice accumulation in at least 75% of cases	Accurately identifies ice accumulation and lack of ice accumulation in less than 75% of cases
Risk points	0	20	40	Unairworthy for flight in possible icing conditions

5.1.6 (f). Ice effects on air data sensors:

Effect on sensors	Angle of attack, static pressure, total pressure accuracy unaffected by ice accumulation	Angle of attack, static pressure, total pressure accuracy affected by less than 5%	Angle of attack, static pressure, total pressure accuracy affected by less than 10%	Angle of attack, static pressure, total pressure accuracy affected by more than 10%
Risk points	0	20	40	Unairworthy for flight in possible icing conditions

5.1.6 (g). Icing condition exit strategy

Existence and thoroughness of icing condition exit strategy	Strategy exists and is through, specific, and comprehensive	Strategy exists but is insufficiently thorough, specific, and comprehensive, or does not exist
Risk points	0	Unairworthy for flight in possible icing conditions

The airworthiness status is found based on the reduced score:

- Less than or equal to 5: risk level 1
- Between 6 and 10: risk level 2
- Between 11 and 20: risk level 3
- Greater than 20: unairworthy

5.1.7 Aircraft to be flown in icing conditions – extended flight in icing conditions

This section applies to aircraft that are to be certified for extended flight in icing conditions.

The following analysis needs to be conducted for aircraft certified for extended flight in icing conditions, and the following features need to be included:

- Analysis must be completed to characterize airframe icing, including:
    - Where ice will accumulate, how quickly, and in what conditions
    - Icing effects on lift and stall speed
    - Icing effects on drag and ability of propulsion system to propel aircraft at speeds needed to maintain level flight
    - Expected performance changes as ice accumulates must be included in the performance section of the POH.
    - Note: ANSYS CFD packages can analyze aircraft icing, albeit at the expense of significant time and computational resources.
- Aircraft must be equipped with adequate protection from ice shedding from propellers. If any flight-critical structural damage occurs as a result of shedding ice, the aircraft is unairworthy.
- De-ice system. The aircraft must be able to remove ice from all flight-critical areas in which it might accumulate, including the wing, horizontal and vertical stabilizers, air data probes, propellers, and inlets.
- Anti-ice system to prevent ice buildup in icing conditions
- Ice detection system. The aircraft must be equipped with an ice detection system which can alert the flight crew at the earliest sign of ice accumulation.
- Ice effects on air data sensors. This analysis must investigate if, how, and to what extent air data measurements will be affected by ice buildup.
- Ground de-ice and anti-ice procedures. This entails recommended practices for removing ice on the ground and mitigating ice accumulation prior to takeoff. This must include recommended substances to be used for de-icing and anti-ice purposes. It further must include the holdover time for which the ground de-ice and anti-ice efforts are effective. Further, the specifications must note a minimum acceptable holdover time. Note: the FAA publishes recommended holdover time for various temperatures, aircraft construction, and temperatures for every winter season.

5.1.7 (a). Change in stall speed in clean configuration with 5-minute icing condition exposure:

Stall airspeed change	$< 10\%$	$< 25\%$	$< 35\%$	$\geq 35\%$
Risk points	0	5	10	Unairworthy for flight in possible icing conditions

5.1.7 (b). Change in maximum airspeed the propulsion system is capable of sustaining in SLUF flight with 5-minute icing condition exposure:

Maximum airspeed change	$< 10\%$	$< 25\%$	$< 35\%$	$\geq 35\%$
Risk points	0	5	10	Unairworthy for flight in possible icing conditions

5.1.7 (c). Stall speed in clean configuration relative to maximum airspeed after 5-minute icing encounter:

Value of $\frac{V_H}{V_S}$	$\frac{V_H}{V_S} > 2.5$	$\frac{V_H}{V_S} > 2$	$\frac{V_H}{V_S} > 1.5$	$\frac{V_H}{V_S} < 1.5$
Risk points	0	5	10	Unairworthy for flight in possible icing conditions

5.1.7 (d). Flight-critical structural damage that occurs from ice shedding (including from propellers, wing, horizontal stabilizer, vertical stabilizer, and all other flight surfaces):

Damage	No flight-critical structural damage	Flight-critical structural damage
Risk points	0	Unairworthy for flight in possible icing conditions

5.1.7 (e). De-ice system effectiveness. Maximum ice accumulation that de-ice system can effectively remove:

Maximum ice thickness t	$t > 1$ cm	$t > 5$ mm	$t > 1.5$ mm	$t < 1.5$ mm
Risk points	0	10	20	Unairworthy for flight in possible icing conditions

5.1.7 (f). Anti-ice system effectiveness. Maximum ice buildup during icing conditions with anti-ice system active:

Maximum ice thickness t	$t < 1$ mm	$t < 2$ mm	$t < 3$ mm	$t \geq 3$ mm
Risk points	0	10	20	Unairworthy for flight in possible icing conditions

5.1.7 (g). Stall speed in clean configuration relative to maximum airspeed in icing conditions with anti-ice system active:

Value of $\frac{V_H}{V_S}$	$\frac{V_H}{V_S} > 2.5$	$\frac{V_H}{V_S} > 2.25$	$\frac{V_H}{V_S} > 2$	$\frac{V_H}{V_S} < 2$
Risk points	0	5	10	Unairworthy for flight in possible icing conditions

5.1.7 (h). Ice detection system: ability to accurately detect ice accumulation on all surfaces where icing may be encountered:

Detection ability	Accurately identifies ice accumulation and lack of ice accumulation in at least 99% of cases	Accurately identifies ice accumulation and lack of ice accumulation in at least 85% of cases	Accurately identifies ice accumulation and lack of ice accumulation in at least 75% of cases	Accurately identifies ice accumulation and lack of ice accumulation in less than 75% of cases
Risk points	0	20	40	Unairworthy for flight in possible icing conditions

5.1.7 (i). Ice effects on air data sensors:

Effect on sensors	Angle of attack, static pressure, total pressure accuracy unaffected by ice accumulation	Angle of attack, static pressure, total pressure accuracy affected by less than 5%	Angle of attack, static pressure, total pressure accuracy affected by less than 10%	Angle of attack, static pressure, total pressure accuracy affected by more than 10%
Risk points	0	20	40	Unairworthy for flight in possible icing conditions

Ground anti-ice and de-ice procedures: the following must be included for the aircraft to be certified as airworthy:

- Acceptable de-ice and anti-ice fluids to use
- Recommended method of applying said fluids, including fluid temperature
- Holdover time for various fluids and outside temperatures, determined based on considering aircraft material construction.
- Minimum acceptable hold over time

The airworthiness status if found based on the reduced score:

- Less than or equal to 5: risk level 1
- Between 6 and 12: risk level 2
- Between 13 and 22: risk level 3
- Greater than 22: unairworthy

5.1.8 Multiengine airplanes

5.1.8 (a). Climb angle at MTOW in standard sea level conditions with critical loss of thrust

Climb angle θ	$\theta > 1.5^o$	$\theta > 1^o$	$\theta > 0.5^o$	$\theta < 0.5^o$
Risk points	0	15	30	Unairworthy

5.1.8 (b). Minimum control speed with critical loss of thrust in relation to V_s

Relation between V_{MCA} and V_s	$V_{MCA} > 1.30\ V_s$	$V_{MCA} > 1.20\ V_s$	$V_{MCA} > 1.10\ V_s$	$V_{MCA} < 1.10\ V_s$
Risk points	0	15	30	Unairworthy

The airworthiness status is found from the reduced risk score:

- Between 0 and 10: risk level 1
- Between 11 and 20: risk level 2
- Between 21 and 30: risk level 3
- Above 30: unairworthy

5.1.9 Fueled aircraft

The fuel tank must be located such that:

- The fuel tank will not touch the ground upon landing the aircraft
- There is adequate clearance between the fuel tank and propeller discs
- In the event of propeller structural failure, the fuel tanks are adequately protected from shrapnel
- All wiring is routed away from the fuel tank to minimize the chances of an ignition of fuel vapors in the event of malfunction of the wiring
- The aircraft's stability augmentation system can handle the differing center of gravity caused by fuel sloshing in the fuel tank
- Reliability and accuracy of fuel gauge

5.1.9 (a). Clearance between fuel tank and ground on smooth, level surface

Clearance	$>$ 15 cm	$>$ 10 cm	$>$ 5 cm	$<$ 5 cm
Risk points	0	10	30	Unairworthy

If the aircraft features sprung landing gear, this standard must be evaluated at the point where the distance is the smallest.

5.1.9 (b). Clearance between fuel tank and propeller discs

Clearance	$>$ 3 cm	$>$ 2 cm	$>$ 1 cm	$<$ 1 cm
Risk points	0	10	30	Unairworthy

Fuel tank protection: OISC requires adequate fuel tank protection in certain circumstances:

- If the aircraft is to be flown strictly VLOS and at a distance from the control station such that, in the event of a fuel tank fire, the fire can be extinguished by the ground crew within 90 seconds of the fire starting. This may be accomplished by any of the following methods: (a) keeping the aircraft close enough to the landed at the location of the ground crew within 90 seconds, (b) flying the aircraft at a distance such that it can be landed at a location away from the control station and reached by the crew within 90 seconds either on foot or using a vehicle.
- If the aircraft is flown BVLOS or the 90-second criterion cannot be realistically met, the following fuel tank protection standards apply: the fuel tank must be positioned and

protected such that, in normal flight, there is negligible risk of the fuel tank becoming punctured. OISC recommends the following fuel tank protections:

- The fuel tank must be located such that shrapnel from the propulsion system is not likely to impact the fuel tank in the event of a structural failure of any component of the propulsion system.
- The fuel tank should feature some protection such as Kevlar, ballistic foam, or some other protection that OISC deems appropriate to prevent rupture of the fuel tank by shrapnel.
- The fuel tank must be oriented such that, if a puncture were to form in any location on the fuel tank, fuel would not leak onto any potential ignition source.
- OISC requires that the fuel tank meet the following crashworthiness requirements, in that the fuel tank does not rupture under the following loads:
    - 4G upward
    - 16G forward
    - 8G sideward
    - 20G downward
    - 1.5G rearward

5.1.9 (c). Fuel tank protection risk points

Fuel tank protection standards	Standards met	Standards not met
Risk points	0	Unairworthy

Wire routing: the following standards apply for wire routing in proximity to the fuel system, which reply regardless of the current carried by the wire or the potential difference the wire is at relative to chassis ground:

- No wires may pass through the fuel tank, including for the purpose of measuring the level of fuel in the tank.
    - Fuel gauges are required in certain circumstances. OISC expects that this will be accomplished by using a float-type device which actuates a sensor located outside of the fuel tank.
- No wires pay pass within 5 cm of any part of the fuel system where fuel vapors could be present, including fuel filling ports and joints between various components in the fuel system

5.1.9 (d). Wire routing risk points:

Wire routing standards	Wire routing standards met	Wire routing standards not met
Risk points	0	Unairworthy

5.1.9 (e). Fuel slosh and aircraft stability/controllability:

- The aircraft stability, including the stability augmentation system if applicable, must be flight-tested at a level of fuel where the fuel sloshing could result in the maximum change in center of gravity
- The aircraft must be free of undesirable flight characteristics due to fuel sloshing, as assessed by the following risk points table:

Flight characteristics	Flight characteristics are comparable to that of a rigid-body aircraft	Some undesirable flight characteristics introduced, such as well-damped oscillation	Substantial undesirable flight characteristics introduced, such as moderately damped oscillation	Significant undesirable flight characteristics introduced, such as lightly damped oscillations
Risk points	0	15	40	Unairworthy

5.1.9 (f). Fuel hose routing: the fuel hoses must be positioned and protected such that friction between the hose and the aircraft structure cannot gradually wear through the tubing. This means that:

- The fuel tubing may not be routed across any sharp corners
- The tubing may not be routed across rough or sharp materials
- The tubing must be bent according to manufacturer specifications

Tubing standards	Tubing standards met	Tubing standards not met
Risk points	0	Unairworthy

5.1.9 (g). Fuel gauge reliability: all aircraft with a maximum takeoff weight over 15 pounds and powered by a fueled propulsion system must have fuel gauges which meet the following specifications:

- The gauges can accurately identify the quantity of usable onboard the aircraft fuel during steady, level, unaccelerated flight.
- The accuracy standards apply to all fuel levels; the fuel gauges must be accurate at all ranges of usable fuel, from empty to full fuel.
- The accuracy of the fuel gauge is assessed as follows:

Accuracy of fuel gauge	$\pm 3\%$ or better	$\pm 5\%$ or better	$\pm 10\%$ or better	Worse than $\pm 10\%$
Risk points	0	10	20	Unairworthy

Except for pressurized fuel systems, the fuel tanks must be vented to allow for air to enter the fuel tanks as fuel is burned. The fuel vent(s) must be positioned such that there is a minimal risk of the vents being clogged by ice or foreign object debris.

5.1.9 (h). Fuel vent risk points

Fuel vent standards	Fuel vent standards met	Fuel vent standards not met
Risk points	0	Unairworthy

The airworthiness status is assessed based on the reduced risk score:

- Between 0 and 5: risk level 1
- Between 5 and 10: risk level 2
- Between 10 and 20: risk level 3
- Over 20: unairworthy

5.1.10 Aircraft to be flown in IMC or BVLOS

OISC requires more stringent standards to be met for aircraft that are to be flown in IMC or BVLOS. The airworthiness standards delineated here are in addition to any requirements which might arise from the flight rules which authorize these operations.

Automation: the aircraft must be equipped with an autopilot. The autopilot must meet the standards delineated in this section.

5.1.10 (a). Automation: autopilot presence

Autopilot presence	Autopilot is present	No autopilot
Risk points	0	Unairworthy for IMC/BVLOS operations

5.1.10 (b). Automation reliability: risk score from section 5.1.1:

Risk level	Risk level 1	Risk level 2	Risk level 3 or greater
Risk points	0	50	Unairworthy for IMC/BVLOS operations

5.1.10 (c). Position estimation accuracy: nominal accuracy of lateral/longitudinal position estimation

Accuracy	$\pm$3m or better	$\pm$5m or better	$\pm$7m or better	Worse than $\pm$7m
Risk points	0	25	50	Unairworthy for IMC/BVLOS operations

Equipment: the aircraft must be equipped with the following equipment:

- Altimeter: if using a pressure-based altimeter, the altimeter must be able to be calibrated to account for nonstandard atmospheric conditions.
- Airspeed indicator.
- Engine monitoring instrumentation appropriate to the type of propulsion used.
- Fuel/battery remaining gauges.
- Position indicator for landing gear, flaps (if applicable).
- Attitude indicator.
- Directional gyro/heading indicator.
- Suitable avionics to navigate the aircraft as required.
- Suitable transmission system to provide telemetry for all the above data to the crew on the ground.

5.1.10 (d). Equipment standards:

Equipment standards met	Standards met	Standards not met
Risk points	0	Unairworthy for IMC/BVLOS operations

5.1.10 (e). Radio range: smallest range of any radio system installed on the aircraft

Range	> 5km	> 4km	> 3km	< 3km
Risk points	0	25	50	Unairworthy for IMC/ BVLOS operations

This must be based on maximum realistic atmospheric attenuation and other phenomena which would degrade radio communications. Further, the maximum range of any radio system must be 1.5 times the expected maximum distance between the aircraft and control station.

5.1.10 (f). Redundancy: redundant power systems. OISC requires that any aircraft equipped to fly BVLOS feature two independent power systems. One of these power systems may be the main flight battery or a generator from a fueled propulsion system, but a backup battery must be installed to power all flight-critical aircraft systems in the event of failure of the main power supply.

Power redundancy requirements met	Requirements met	Requirements not met
Risk points	0	Unairworthy for IMC/BVLOS operations

Redundancy: OISC requires that all the following measurements be made with a triple-redundant system:

- Airspeed, including three pitot tubes and three pressure differential sensors.
- Altitude. It is acceptable to use multiple methods of measuring altitude, such as GPS and pressure sensing. For example, it is acceptable to have two pressure altimeter and one GPS altimeter.
- Attitude: three sensors/sensor packages to measure attitude are required.
- Heading: three sensors to measure heading are required.

The data from the each of the three sensors must be intercompared. If there is a discrepancy between the data on any of the sensors, there must be a means of alerting the crew.

5.1.10 (g). Sensor redundancy standards:

Redundant sensors	Greater than 3	3	Less than 3
Risk points	0	15	Unairworthy for IMC/BVLOS operations

5.1.10 (h). GPS technology used

Technology	WAAS or similar augmentation	Standard
Risk points	0	15

5.1.10 (i). GPS geofencing. The aircraft must be equipped with a means to restrict the aircraft to only flying within the lateral areas and altitudes authorized for IMC or BVLOS operation.

Geofencing feature applied?	Applied	Not applied
Risk points	0	Unairworthy for IMC/BVLOS operations

The airworthiness status is based on the reduced risk score:

- Between 0 and 10: risk level 1
- Between 11 and 20: risk level 2
- Between 21 and 25: risk level 3
- Greater than 25: unairworthy for flights BVLOS/in IMC

5.1.11 Aircraft to be flown in aerial chase operations

UAS control placement. If the UAS control station is located inside the manned chase aircraft, the UAS control station must be located such that the following requirements are met:

- The UAS control station must not obstruct the flight controls of the chase aircraft
- The UAS control station must not obstruct the manned pilot’s view of the flight instruments, avionics, radio, transponder, trim system, flap actuator, landing gear

actuator, or any other aircraft system that the manned PIC deems necessary for safe flight.

- The UAS control station must not restrict the manned pilot's access to manipulate the flight instruments, avionics, radio, transponder, trim system, flap actuator, landing gear actuator, or any other aircraft system that the manned PIC deems necessary for safe flight.
- The UAS control station, and the location of the seat for the UAS crew must be located and have weights such that the chase aircraft's maximum takeoff weight and CG limits are not exceeded.

5.1.11 (a). Risk points for UAS control station are assessed as follows:

UAS control location within aircraft	Inapplicable as UAS control station is located on the ground	In-aircraft UAS control station placement meets requirements	In-aircraft UAS control station placement meets
Risk points	0	0	Unairworthy for aerial chase operations

UAS control station power draw. If the UAS control station requires power from the chase aircraft, the following standards must be met:

- The risk points must be assessed based on the power draw per the table below. The power may not exceed 75% of the excess power generated by the airplane's alternator/generator system.
- The PIC of the manned aircraft must have a switch to immediately disconnect the power supply from the manned aircraft.
- The UAS control station must have a backup power source to allow for enough time to land the aircraft in the event of power failure from the manned aircraft.

5.1.11 (b). Power draw as a fraction of excess generated power:

Power draw	Inapplicable as no power from aircraft is required	50% of excess generated power or less	75% of excess generated power or less	Exceeds 75% of excess generated power
Risk points	0	15	30	Unairworthy for aerial chase operations

5.1.11 (c). Power disconnect and backup power standards:

Standards met	Met	Not met
Risk points	0	Unairworthy for aerial chase operations

UAS control station electronic interference with manned aircraft systems. The UAS may not transmit on frequencies which would interfere with any of the following aircraft systems:

- Communication radios
- Navigation radios
- Transponder
- Automatic dependent surveillance broadcast (ADS-B)
- GPS
- WiFi or Bluetooth connections between avionics and electronic flight bag systems
- Any other system the manned aircraft PIC deems essential for safe flight

The applicant must demonstrate that:

- Their radio systems meet all requirements laid out by the FCC or, if flying internationally, the appropriate government authority.
- Their radio systems do not interfere with aircraft systems delineated above.

5.1.11 (d). Radio systems risk points:

Radio interference standards met	Met	Not met
Risk points	0	Unairworthy for aerial chase operations

5.1.11 (e). Manned aircraft collision avoidance: presence of onboard systems to prevent loss of separation between chase aircraft and UAS

Method to maintain separation	UAS automatically makes evasive maneuver if separation with manned aircraft may be lost	Reliant on crew of each aircraft to maintain separation with alert for low separation presented to both crews	Reliant on crew of each aircraft to maintain separation with alert for low separation presented to UAS crew only	Reliant on crew of each aircraft to visually maintain separation
Risk points	0	30	70	95

5.1.11 (f). Crew communications between manned crew and UAS crew

Crew communication system	Crew co-located in cockpit and can speak over aircraft intercom	2-way radio communication which does not require push-to-talk	2-way communication which requires push-to-talk
Risk points	0	20	40

5.1.11 (g). Crew communication: manned sterile cockpit procedures. Any communication between the UAS crew and between the UAS crew and manned aircraft crew must conform to sterile cockpit procedures observed in the manned aircraft. This means that these communication systems must conform to the following standards:

- At any time that the manned aircraft PIC determines that sterile cockpit procedures must be observed, the UAS crew communication system must be configurable such that the manned aircraft crew cannot hear chatter between the UAS crew.
- During times which the manned aircraft crew is observing sterile cockpit procedures, there must be a means for the UAS crew to interject to communicate any flight-critical information to the manned crew. The previous requirement to ensure the manned crew is not exposed to general unmanned crew chatter still applies.

Sterile cockpit standards	Standards met	Standards not met
Risk points	0	Unairworthy

The airworthiness status is found based on the reduced risk score:

- Less than 5: risk level 1
- Between 6 and 15: risk level 2
- Between 16 and 22: risk level 3
- Greater than 26: unairworthy for aerial chase operations

5.1.12 Aircraft to be flown in conditions conducive to lightning

This applies to aircraft operating in conditions which are at an elevated risk of lightning. This includes flights within 10 miles of thunderstorms, flights in precipitation, flights such that the outside air temperature is 0 ± 5 degrees Centigrade, altitudes between 5000 and 15000 feet MSL.

This section contains guidelines for how to make an aircraft safe for operations in this environment. The guidelines are not mandatory to implement.

- Wire shielding: all wire bundles with more than 3 conductors should be shielded with a conductive sleeve.
- Ground straps: the common electrical ground must be connected to the aircraft chassis, which is defined as a any major metallic component of the aircraft structure.
- If the airplane is constructed of nonconductive materials, the exterior of the aircraft should be coated in a conductive material (such as an aluminum foil or mesh) so as to form a Faraday cage around the aircraft.
- Static wicks should be placed long the trailing edges of the aircraft to dissipate any electrical charges that build up during flight. It is recommended that these static wicks have a resistance of 2-600 MΩ.
- For any electronic system which, if failed, would result in immediate flight termination, the following standards should to be met:
    - The power delivery circuitry must ensure that the voltage and current are limited to values such that no damage is done to the electronics.

- If, even given the precautions in the power delivery circuitry, there is a risk of failure of any critical systems, then two backup systems are required.

These standards are to be interpreted as recommendations and not hard requirements. Ultimately, whether or not the aircraft is airworthy is determined by demonstration. The applicant must fly their aircraft in a location far from people and in weather conditions conducive to lightning.

The aircraft will be rendered airworthy if:

- All of the aircraft's functionality is maintained during the flight
- No electronic components are damaged after the flight
- No backup systems are needed to safely execute the flight.

5.1.12 (a). Results from flight test

Standards met?	Standards met	Standards not met
Risk points	0	Unairworthy

5.2 Standards for Multirotors

These categories are only to be evaluated upon request from the proponent. The aircraft will be certified as unairworthy for any systems and application-specific criterion unless the proponent requests an airworthiness evaluation for that criterion.

5.2.1 Aircraft to be flown at night

Note that both COA nighttime stipulations and Part 107 nighttime waivers have the same requirements for aircraft lighting. These stipulations include the requirement for the beacon to be visible at 3 statute miles unless safety dictates that this distance be reduced. In the cases when safety requires a shorter visibility distance requirement, the visibility must be maximized within the constraints of safety.

5.2.1 (a). Beacon visibility

Visibility	Less than 3 statute miles	3 statute miles or greater
Risk points	Unairworthy	0

This must be tested with physical experimentation.

The beacon light bust be configured such that it is visible regardless of the airplane's attitude.

The three-statute visibility requirement can generally be accomplished by using a roughly 15-watt bulb.

5.2.1 (b). Additional lighting requirements

Navigation lights are present	Yes, visible from at least 3 statute miles	Yes, visible from at least 1 statute mile	No
Risk points	0	10	Unairworthy

Note that navigation lights must be mounted such that the red navigation light is on the port wingtip, and the green navigation light is mounted on the starboard wingtip.

If other flight rules have different lighting requirements, the airworthiness assessment must be adjusted to be commensurate with the flight rules.

In addition to the FAA-required beacon and navigation lights, OISC strongly recommends that the aircraft be equipped with strobe lights. Further, OISC recommends that the aircraft either be equipped with landing lights or are landed in a well-lit location.

Further, OISC strongly recommends that nighttime aircraft missions are first flown in a daytime environment, and the landing is extensively practiced. If an autopilot is to be used, the automatic landing should be configured during the daytime and that the autopilot configuration remains completely unchanged to ensure that the nighttime landing is completed safely.

The airworthiness status is found based on the reduced risk score:

- Between 0 and 5: risk level 1
- Between 6 and 10: risk level 2
- Above 10: unairworthy for purpose of night flight

5.2.2 Aircraft to be flown in precipitation

Waterproofing requirements

- When the exterior of the aircraft is subjected to heavy precipitation, no water should enter the interior of the aircraft to damage the electronics.
- Any waterproofing features must not be soluble in water or degrade over time with exposure to water.

In order to assess compliance with waterproofing standards, the following experimentation must be conducted:

- Aircraft must be fully assembled and powered on
- Use a water spray to simulate heavy precipitation
- Spray the aircraft from all angles and for at least thirty minutes

5.2.2 (a). The risk points are found based on the rest results:

Test results	No water enters interior of airplane	Water enters interior of airplane and shows noticeable residue	Water enters interior of airplane and pools	Electronics fail during test
Risk points	0	50	Unairworthy for operations in precipitation.	Unairworthy for operations in precipitation.

Further, aircraft to be flown in precipitation need to be inspected for corrosion and water damage after every 5 hours during which the aircraft has flown in precipitation.

Further, all materials used on the aircraft must be tested for water solubility. In order to do this, each material must be immersed in water for a minimum of 1 hour to ensure that water damage is not a concern. If prolonged exposure to water causes material degradation, the aircraft is unairworthy for the purposes of flights in precipitation. Manners of material degradation is delineated below:

- Disintegration of material
- Delamination of layers within a material
- Greater than 5% change in elastic modulus, shear modulus, or Poisson ratio of material
- Greater than 5% change in yield stress and ultimate stress for both the shear and normal stress cases

5.2.2 (b). The following table quantifies risk points for the above list of material degradation conditions that may render an aircraft unairworthy for flights in precipitation:

Condition	No material degradation conditions met	Any of the material degradation conditions are met
Risk points	0	Unairworthy for operations in precipitation.

The airworthiness status is based on the reduced risk score:

- 0: risk level 1
- 25: risk level 2
- Above 25: unairworthy for flights in precipitation

5.2.3 Aircraft to be flown in cold environments

Cold environments are defined as environments where the historical average temperature for the time of operation is below 10^{o}C.

Depending on the aircraft, concerns in the following areas might be applicable:

- Battery performance degradation
- Elastic material performance degradation
- Potential for fuel to freeze or develop into a gel-like substance

Evaluate only each category that is applicable. Each category requires physical experimentation in order to certify the aircraft.

Battery performance degradation

- Place the batteries in freezer for 10 hours prior to experimentation
- Fly with cold batteries in 2-minute increments. Check to ensure the aircraft is not underpowered and check the battery voltage after each flight.
- The flight time should be certified such that the minimum voltage the battery reaches is 5% higher than the nominal battery cell voltage. For a LiPo, the nominal cell voltage is 3.7V so the minimum acceptable discharge voltage in cold environments is 3.85V. Airworthiness assessors are permitted to set the minimum discharge voltage to a higher value.
- If the results of the test are in doubt, the airworthiness assessor must specify procedures to be carried out by the operator in the cold-weather environment and how the results of those tests affect operating limitations.
- A higher C rating battery must be used for cold-weather environments than is used for temperate environments.
- The battery must be insulated in order to minimize heat loss from the battery. This is particularly important if the battery is exposed to the propwash or the airflow around the airplane.
- The battery must be warmed prior to flight.
- Batteries used in cold weather environments must be marked as having been subjected to cold environments, and the number of cycles they are subjected to in the cold environment must be documented.

Elastic material performance degradation

- Any elastic materials must be frozen for ten hours prior to flight.
- If after freezing they cannot be used for their intended purpose, the aircraft is unairworthy for the purposes of cold-weather operation.
- The aircraft must be flown in ten-minute increments, and the elastic material inspected between flights.
- From this, the airworthiness assessor must specify a useful life for all elastic parts.
- If the elastic cannot last more than 60 minutes, the aircraft is unairworthy. The useful life of an elastic material must be 1/3 of the time which it takes for the elastic to fail.

Fuel viscosity change

- The fuel must be frozen before flight for at least ten hours.
- If the fuel becomes solid, the aircraft is unairworthy for the purposes of cold-weather operation.
- If the fuel remains liquid, it is to be tested in the engine. If the engine cannot run for thirty minutes at a minimum, it is unairworthy for cold-weather operations.
- If the engine shows signs of excessive wear during or after the test, the aircraft is unairworthy for the purposes of cold-weather operations.
- All engine tests are intended to be performed on a test stand with an adequately large fuel tank. It is not relevant as to whether the design tank size of provides for a flight time commensurate with the required time to demonstrate normal engine operation. This section simply evaluates the ability of the engine and fuel to operate in cold environments.

5.2.3 (a). Battery performance degradation: maximum flight time in cold weather environments

Endurance	> 10 mins	> 7 mins	> 3 mins	< 3 mins
Risk points	0	20	40	Unairworthy for flights in cold environments

5.2.3 (b). Elastic material performance degradation

Elastic material performance	No elastic material used in airplane	Elastic material is present and can be used for 20 minutes and meet standards delineated in this section	Elastic material is present and cannot be used for 20 minutes	Elastic material fails in cold weather
Risk points	0	10	Unairworthy for flights in cold environments	Unairworthy for flights in cold environments

5.2.3 (c). Fuel viscosity change

Fuel performance degradation	No change in fuel and engine performance in cold environments	Fuel remains liquid and engine can run for a minimum of 30 minutes	Fuel remains liquid, but engine cannot be run for 30 minutes	Fuel forms into a gel or solid in cold environments
Risk points	0	20	Unairworthy for flights in cold environments	Unairworthy for flights in cold environments

The airworthiness status us found based on the reduced risk score:

- Less than 12: risk level 1
- Between 12 and 20: risk level 2
- Between 21 and 30: risk level 3
- Over 30: unairworthy

5.2.4 Aircraft to be flown in icing conditions – incidental exposure

Note that, as of the drafting of this manual in May 2020, there are several operations that CU has conducted in which icing conditions were encountered:

- S2 NIGHTFOX mission
- Datahawk flights in arctic environments
- Pilatus flights in Alaska

In each of these situations, the aircraft flew strictly in VMC but encountered icing, nonetheless. In turn, OISC needs to set standards for aircraft that are flown in environments where icing is a possibility.

This section applies to aircraft to be flown in situations where icing is possible, but extended operations in icing conditions are not expected. Under this certification scheme, the aircraft must leave icing conditions as soon as they are encountered.

No multirotor is permitted to fly in continuous icing conditions.

The following analysis must be completed, and the following features must be included:

- Analysis must be completed to characterize airframe icing, including:
    - Where ice will accumulate, how quickly, and in what conditions
    - Icing effects on lift and stall speed
    - Icing effects on drag and ability of propulsion system to propel aircraft at speeds needed to maintain level flight
    - Expected performance changes as ice accumulates must be included in the performance section of the POH.
    - Note: ANSYS CFD packages can analyze aircraft icing, albeit at the expense of significant time and computational resources.

- Structural effects of ice shedding. This includes the effects of ice shedding from propellers and the effects of ice shedding from other flight surfaces, such as wings.
- Detection system for ice. The aircraft must be equipped with sufficient ice detection sensors that can alert the flight crew at the earliest signs of ice accumulation on any part of the airframe.
- Ice effects on air data sensors. This analysis must investigate if, how, and to what extent air data measurements will be affected by ice buildup.
- Ideal maneuvers for exiting icing conditions. The aircraft further must be certified with a recommended procedure for the flight crew to execute if they encounter icing conditions. This procedure need not require that the flight crew land if ice accumulation diminishes after exiting the icing environments. However, this procedure must guide the flight crew in exiting the icing situation with minimal risk

For an aircraft to be certified as airworthy for flights into possible icing conditions, the following standards apply:

5.2.4 (a). Change in required propulsion power to maintain level flight with 5-minute icing counter

Change in required power	$< 20\%$	$< 35\%$	$< 50\%$	$\geq 50\%$
Risk points	0	5	10	Unairworthy for flight in possible icing conditions

5.2.4 (b). Flight-critical structural damage that occurs from ice shedding (including from propellers, wing, horizontal stabilizer, vertical stabilizer, and all other flight surfaces):

Damage	No flight-critical structural damage	Flight-critical structural damage
Risk points	0	Unairworthy for flight in possible icing conditions

5.2.4 (c). Ice detection system: ability to accurately detect ice accumulation on all surfaces where icing may be encountered:

Detection ability	Accurately identifies ice accumulation and lack of ice accumulation in at least 99% of cases	Accurately identifies ice accumulation and lack of ice accumulation in at least 85% of cases	Accurately identifies ice accumulation and lack of ice accumulation in at least 75% of cases	Accurately identifies ice accumulation and lack of ice accumulation in less than 75% of cases
Risk points	0	20	40	Unairworthy for flight in possible icing conditions

5.2.4 (d). Ice effects on air data sensors:

Effect on sensors	Angle of attack, static pressure, total pressure accuracy unaffected by ice accumulation	Angle of attack, static pressure, total pressure accuracy affected by less than 5%	Angle of attack, static pressure, total pressure accuracy affected by less than 10%	Angle of attack, static pressure, total pressure accuracy affected by more than 10%
Risk points	0	20	40	Unairworthy for flight in possible icing conditions

5.2.4 (e). Icing condition exit strategy

Existence and thoroughness of icing condition exit strategy	Strategy exists and is through, specific, and comprehensive	Strategy exists but is insufficiently thorough, specific, and comprehensive, or does not exist
Risk points	0	Unairworthy for flight in possible icing conditions

The airworthiness status is determined based on the reduced risk score:

- Less than 5: risk level 1
- Between 6 and 12: risk level 2
- Between 13 and 20: risk level 3
- 21 or greater: unairworthy for flight in incidental icing environments

5.2.5 Aircraft with variable-pitch rotors

5.2.5 (a). Servo sizing: servo torque in relation to minimum required torque

Value of $\frac{\tau}{\tau_{req}}$	$\frac{\tau}{\tau_{req}} > 2$	$\frac{\tau}{\tau_{req}} > 1.5$	$\frac{\tau}{\tau_{req}} > 1$	$\frac{\tau}{\tau_{req}} < 1$
Risk points	0	15	30	Unairworthy

The required torque is computed as follows: at the maximum rotor RPM and maximum angle of incidence of the propeller, the pitching moment about the joint which supports the rotor must be computed. The support reaction by the joint which is used to alter the rotor angle of incidence must then be computed. Then the actuation torque is found based on the length of the servo arm. Twice this torque is the minimum required torque.

The design of the swashplate assembly must be built according to best practices, such as:

- Using an anti-rotation device to prevent the lower swashplate from rotating
- An adequate safety factor is used in swashplate system, as assessed by the risk points table below
- Adequate tolerances and balance

5.2.5 (b). Worst-case tolerance in any component in the swashplate system

Tolerance	± 0.001 inch or better	± 0.005 inch or better	± 0.01 inch or better	Worse than ± 0.01 inch
Risk points	0	5	20	Unairworthy

5.2.5 (c). Location of swashplate center of gravity in relation to swashplate axis of rotation

Difference in location	< 0.001 inch	< 0.003 inch	< 0.005 inch	> 0.005 inch
Risk points	0	20	40	Unairworthy

5.2.5 (d). Minimum safety factor in swashplate system

Value of FS	$FS > 1.5$	$FS > 1.25$	$FS > 1.1$	$FS < 1.1$
Risk points	0	20	40	Unairworthy

The manufacturer of the swashplate system must provide a rigorous inspection and maintenance schedule to guide continuing airworthiness inspections and maintenance. This must include:

- Inspection and replacement intervals for all components of the swashplate
- Requirements for maintaining adequate lubrication on all components
- Specifications for the requited tightness of all bolts and fasteners
- Specific guidance for a preflight inspection

5.2.5 (e). Swashplate motion smoothness: the swashplate must move smoothly up and down the shaft without binding. Since it is typical for the smoothness of motion to degrade with time as lubrication is expelled from the swashplate mechanism, the risk is evaluated based on the amount of time smooth motion can be maintained while running the rotor at maximum RPM.

Time for which smooth motion is maintained	Greater than 90 minutes	Greater than 60 minutes	Greater than 30 minutes	Less than 30 minutes
Risk points	0	25	50	Unairworthy

The maximum flight time must be specified based on the time for which smooth motion can be maintained. The maximum flight time is not to exceed half of the time for which smooth motion is maintained.

5.2.5 (f). Rotor speed: on variable pitch rotors, the rotor speeds are generally intended to be the same across all rotors. This assesses the relative error between the angular rates of each rotor.

Relative error	$\pm 0.05\%$ or better	$\pm 0.1\%$ or better	$\pm 0.5\%$ or better	$\pm 0.5\%$ orworse
Risk points	0	30	60	Unairworthy

This error must be assessed based on measuring the actual rotation rate of each rotor.

The airworthiness status is found based on the reduced risk score:

- Between 0 and 12: risk level 1
- Between 13 and 30: risk level 2
- Between 31 and 40: risk level 3
- Greater than 40: unairworthy

5.2.6 Fueled aircraft

The fuel tank must be located such that:

- The fuel tank will not touch the ground upon landing the aircraft
- There is adequate clearance between the fuel tank and propeller discs
- In the event of propeller structural failure, the fuel tanks are adequately protected from shrapnel
- All wiring is routed away from the fuel tank to minimize the chances of an ignition of fuel vapors in the event of malfunction of the wiring
- The aircraft’s stability augmentation system can handle the differing center of gravity caused by fuel sloshing in the fuel tank
- Reliability and accuracy of fuel gauge

5.2.6 (a). Clearance between fuel tank and ground on smooth, level surface

Clearance	> 15 cm	> 10 cm	> 5 cm	< 5 cm
Risk points	0	10	30	Unairworthy

If the aircraft features sprung landing gear, this standard must be evaluated at the point where the distance is the smallest.

5.2.6 (b). Clearance between fuel tank and propeller discs

Clearance	> 3 cm	> 2 cm	> 1 cm	< 1 cm
Risk points	0	10	30	Unairworthy

Fuel tank protection: OISC requires adequate fuel tank protection in certain circumstances:

- If the aircraft is to be flown strictly VLOS and at a distance from the control station such that, in the event of a fuel tank fire, the fire can be extinguished by the ground crew within 90 seconds of the fire starting. This may be accomplished by any of the following methods: (a) keeping the aircraft close enough to the landed at the location of the ground crew within 90 seconds, (b) flying the aircraft at a distance such that it can be landed at a location away from the control station and reached by the crew within 90 seconds either on foot or using a vehicle.
- If the aircraft is flown BVLOS or the 90-second criterion cannot be realistically met, the following fuel tank protection standards apply: the fuel tank must be positioned and protected such that, in normal flight, there is negligible risk of the fuel tank becoming punctured. OISC recommends the following fuel tank protections:
    - The fuel tank must be located such that shrapnel from the propulsion system is not likely to impact the fuel tank in the event of a structural failure of any component of the propulsion system.
    - The fuel tank should feature some protection such as Kevlar, ballistic foam, or some other protection that OISC deems appropriate to prevent rupture of the fuel tank by shrapnel.
    - The fuel tank must be oriented such that, if a puncture were to form in any location on the fuel tank, fuel would not leak onto any potential ignition source.
    - OISC requires that the fuel tank meet the following crashworthiness requirements, in that the fuel tank does not rupture under the following loads:
        - 4G upward
        - 16G forward
        - 8G sideward
        - 20G downward
        - 1.5G rearward

5.2.6 (c). Fuel tank protection risk points

Fuel tank protection standards	Standards met	Standards not met
Risk points	0	Unairworthy

Wire routing: the following standards apply for wire routing in proximity to the fuel system, which reply regardless of the current carried by the wire or the potential difference the wire is at relative to chassis ground:

- No wires may pass through the fuel tank, including for the purpose of measuring the level of fuel in the tank.
    - Fuel gauges are required in certain circumstances. OISC expects that this will be accomplished by using a float-type device which actuates a sensor located outside of the fuel tank.
- No wires pay pass within 5 cm of any part of the fuel system where fuel vapors could be present, including fuel filling ports and joints between various components in the fuel system

5.2.6 (d). Wire routing risk points:

Wire routing standards	Wire routing standards met	Wire routing standards not met
Risk points	0	Unairworthy

5.2.6 (e). Fuel slosh and aircraft stability/controllability:

- The aircraft stability, including the stability augmentation system if applicable, must be flight-tested at a level of fuel where the fuel sloshing could result in the maximum change in center of gravity
- The aircraft must be free of undesirable flight characteristics due to fuel sloshing, as assessed by the following risk points table:

Flight characteristics	Flight characteristics are comparable to that of a rigid-body aircraft	Some undesirable flight characteristics introduced, such as well-damped oscillation	Substantial undesirable flight characteristics introduced, such as moderately damped oscillation	Significant undesirable flight characteristics introduced, such as lightly damped oscillations
Risk points	0	15	40	Unairworthy

5.2.6 (f). Fuel hose routing: the fuel hoses must be positioned and protected such that friction between the hose and the aircraft structure cannot gradually wear through the tubing. This means that:

- The fuel tubing may not be routed across any sharp corners
- The tubing may not be routed across rough or sharp materials
- The tubing must be bent according to manufacturer specifications

Tubing standards	Tubing standards met	Tubing standards not met
Risk points	0	Unairworthy

5.2.6 (g). Fuel gauge reliability: all aircraft with a maximum takeoff weight over 15 pounds and powered by a fueled propulsion system must have fuel gauges which meet the following specifications:

- The gauges can accurately identify the quantity of usable onboard the aircraft fuel during steady, level, unaccelerated flight.
- The accuracy standards apply to all fuel levels; the fuel gauges must be accurate at all ranges of usable fuel, from empty to full fuel.
- The accuracy of the fuel gauge is assessed as follows:

Accuracy of fuel gauge	$\pm 3\%$ or better	$\pm 5\%$ or better	$\pm 10\%$ or better	Worse than $\pm 10\%$
Risk points	0	10	20	Unairworthy

Except for pressurized fuel systems, the fuel tanks must be vented to allow for air to enter the fuel tanks as fuel is burned. The fuel vent(s) must be positioned such that there is a minimal risk of the vents being clogged by ice or foreign object debris.

5.2.6 (h). Fuel vent risk points

Fuel vent standards	Fuel vent standards met	Fuel vent standards not met
Risk points	0	Unairworthy

The airworthiness status is assessed based on the reduced risk score:

- Between 0 and 5: risk level 1
- Between 5 and 10: risk level 2
- Between 10 and 20: risk level 3
- Over 20: unairworthy

5.2.7 Clutch systems

The following categories are assessed:

- Clutch alignment in angular and linear directions
- Clutch sizing to ensure to prevent engine stall at low torque settings
- Torque in relation to manufacturer-specified torque
- RPM in relation to manufacturer-specified RPM

5.2.7 (a). Clutch alignment – angular: angular misalignment between shaft axes

Misalignment angle θ	$\theta < 0.01^0$	$\theta < 0.05^0$	$\theta < 0.1^0$	$\theta \geq 0.1^0$
Risk points	0	20	40	Unairworthy

5.2.7 (b). Clutch alignment – linear: linear misalignment between shaft axes

Misalignment distance s	$s < 0.001$ inch	$s < 0.005$ inch	$s < 0.01$	$s \geq 0.01$
Risk points	0	20	40	Unairworthy

5.2.7 (c). Clutch sizing: engine stall

Engine stall status	Engine does not stall at any power setting	Engine stalls at some power setting with normal load
Risk points	0	Unairworthy

5.2.7 (d). Clutch sizing: maximum design torque through clutch vs. manufacturer-specified maximum torque

Value of $\frac{\tau_{design}}{\tau_{spec}}$	$\frac{\tau_{design}}{\tau_{spec}} < 0.8$	$\frac{\tau_{design}}{\tau_{spec}} < 0.9$	$\frac{\tau_{design}}{\tau_{spec}} < 1$	$\frac{\tau_{design}}{\tau_{spec}} \geq 1$
Risk points	0	15	30	Unairworthy

5.2.7 (e). Clutch sizing: maximum design RPM through clutch vs. manufacturer-specified maximum RPM

Value of $\frac{\omega_{design}}{\omega_{spec}}$	$\frac{\omega_{design}}{\omega_{spec}} < 0.8$	$\frac{\omega_{design}}{\omega_{spec}} < 0.9$	$\frac{\omega_{design}}{\omega_{spec}} < 1$	$\frac{\omega_{design}}{\omega_{spec}} \geq 1$
Risk points	0	15	30	Unairworthy

The airworthiness status is found based on the reduced risk score:

- Between 0 and 10: risk level 1
- Between 11 and 20: risk level 2
- Between 21 and 28: risk level 3
- Greater than 28: unairworthy

5.2.8 Aircraft to be flown in IMC or BVLOS

OISC requires more stringent standards to be met for aircraft that are to be flown in IMC or BVLOS. The airworthiness standards delineated here are in addition to any requirements which might arise from the flight rules which authorize these operations.

Automation: the aircraft must be equipped with an autopilot. The autopilot must meet the standards delineated in this section.

5.2.8 (a). Automation: autopilot presence

Autopilot presence	Autopilot is present	No autopilot
Risk points	0	Unairworthy for IMC/BVLOS operations

5.2.8 (b). Automation reliability: risk score from section 5.1.1:

Risk level	Risk level 1	Risk level 2	Risk level 3 or greater
Risk points	0	50	Unairworthy for IMC/BVLOS operations

5.2.8 (c). Position estimation accuracy: nominal accuracy of lateral/longitudinal position estimation

Accuracy	±3m or better	±5m or better	±7m or better	Worse than ±7m
Risk points	0	25	50	Unairworthy for IMC/BVLOS operations

Equipment: the aircraft must be equipped with the following equipment:

- Altimeter: if using a pressure-based altimeter, the altimeter must be able to be calibrated to account for nonstandard atmospheric conditions.
- Airspeed indicator.
- Engine monitoring instrumentation appropriate to the type of propulsion used.
- Fuel/battery remaining gauges.
- Position indicator for landing gear (if applicable).
- Attitude indicator.
- Directional gyro/heading indicator.
- Suitable avionics to navigate the aircraft as required.
- Suitable transmission system to provide telemetry for all the above data to the crew on the ground.

5.2.8 (d). Equipment standards:

Equipment standards met	Standards met	Standards not met
Risk points	0	Unairworthy for IMC/BVLOS operations

5.2.8 (e). Radio range: smallest range of any radio system installed on the aircraft

Range	> 5km	> 4km	> 3km	< 3km
Risk points	0	25	50	Unairworthy for IMC/ BVLOS operations

This must be based on maximum realistic atmospheric attenuation and other phenomena which would degrade radio communications. Further, the maximum range of any radio system must be 1.5 times the expected maximum distance between the aircraft and control station.

5.2.8 (f). Redundancy: redundant power systems. OISC requires that any aircraft equipped to fly BVLOS feature two independent power systems. One of these power systems may be the main flight battery or a generator from a fueled propulsion system, but a backup battery must be installed to power all flight-critical aircraft systems in the event of failure of the main power supply.

Power redundancy requirements met	Requirements met	Requirements not met
Risk points	0	Unairworthy for IMC/BVLOS operations

Redundancy: OISC requires that all the following measurements be made with a triple-redundant system:

- Airspeed, including three pitot tubes and three pressure differential sensors.
- Altitude. It is acceptable to use multiple methods of measuring altitude, such as GPS and pressure sensing. For example, it is acceptable to have two pressure altimeter and one GPS altimeter.
- Attitude: three sensors/sensor packages to measure attitude are required.
- Heading: three sensors to measure heading are required.

The data from the each of the three sensors must be intercompared. If there is a discrepancy between the data on any of the sensors, there must be a means of alerting the crew.

5.2.8 (g). Sensor redundancy standards:

Redundant sensors	Greater than 3	3	Less than 3
Risk points	0	15	Unairworthy for IMC/BVLOS operations

5.2.8 (h). GPS technology used

Technology	WAAS or similar augmentation	Standard
Risk points	0	15

5.2.9 (i). GPS geofencing. The aircraft must be equipped with a means to restrict the aircraft to only flying within the lateral areas and altitudes authorized for IMC or BVLOS operation.

Geofencing feature applied?	Applied	Not applied
Risk points	0	Unairworthy for IMC/BVLOS operations

The airworthiness status is based on the reduced risk score:

- Between 0 and 10: risk level 1
- Between 11 and 20: risk level 2

- Between 21 and 25: risk level 3
- Greater than 25: unairworthy for flights BVLOS/in IMC

5.2.9 Aircraft to be flown in aerial chase operations

UAS control placement. If the UAS control station is located inside the manned chase aircraft, the UAS control station must be located such that the following requirements are met:

- The UAS control station must not obstruct the flight controls of the chase aircraft
- The UAS control station must not obstruct the manned pilot's view of the flight instruments, avionics, radio, transponder, trim system, flap actuator, landing gear actuator, or any other aircraft system that the manned PIC deems necessary for safe flight.
- The UAS control station must not restrict the manned pilot's access to manipulate the flight instruments, avionics, radio, transponder, trim system, flap actuator, landing gear actuator, or any other aircraft system that the manned PIC deems necessary for safe flight.
- The UAS control station, and the location of the seat for the UAS crew must be located and have weights such that the chase aircraft's maximum takeoff weight and CG limits are not exceeded.

5.2.9 (a). Risk points for UAS control station are assessed as follows:

UAS control location within aircraft	Inapplicable as UAS control station is located on the ground	In-aircraft UAS control station placement meets requirements	In-aircraft UAS control station placement meets
Risk points	0	0	Unairworthy for aerial chase operations

UAS control station power draw. If the UAS control station requires power from the chase aircraft, the following standards must be met:

- The risk points must be assessed based on the power draw per the table below. The power may not exceed 75% of the excess power generated by the airplane's alternator/generator system.
- The PIC of the manned aircraft must have a switch to immediately disconnect the power supply from the manned aircraft.
- The UAS control station must have a backup power source to allow for enough time to land the aircraft in the event of power failure from the manned aircraft.

5.2.9 (b). Power draw as a fraction of excess generated power:

Power draw	Inapplicable as no power from aircraft is required	50% of excess generated power or less	75% of excess generated power or less	Exceeds 75% of excess generated power
Risk points	0	15	30	Unairworthy for aerial chase operations

5.2.9 (c). Power disconnect and backup power standards:

Standards met	Met	Not met
Risk points	0	Unairworthy for aerial chase operations

UAS control station electronic interference with manned aircraft systems. The UAS may not transmit on frequencies which would interfere with any of the following aircraft systems:

- Communication radios
- Navigation radios
- Transponder
- Automatic dependent surveillance broadcast (ADS-B)
- GPS
- WiFi or Bluetooth connections between avionics and electronic flight bag systems
- Any other system the manned aircraft PIC deems essential for safe flight

The applicant must demonstrate that:

- Their radio systems meet all requirements laid out by the FCC or, if flying internationally, the appropriate government authority.
- Their radio systems do not interfere with aircraft systems delineated above.

5.2.9 (d). Radio systems risk points:

Radio interference standards met	Met	Not met
Risk points	0	Unairworthy for aerial chase operations

5.2.9 (e). Manned aircraft collision avoidance: presence of onboard systems to prevent loss of separation between chase aircraft and UAS

Method to maintain separation	UAS automatically makes evasive maneuver if separation with manned aircraft may be lost	Reliant on crew of each aircraft to maintain separation with alert for low separation presented to both crews	Reliant on crew of each aircraft to maintain separation with alert for low separation presented to UAS crew only	Reliant on crew of each aircraft to visually maintain separation
Risk points	0	30	70	95

5.2.9 (f). Crew communications between manned crew and UAS crew

Crew communication system	Crew co-located in cockpit and can speak over aircraft intercom	2-way radio communication which does not require push-to-talk	2-way communication which requires push-to-talk
Risk points	0	20	40

5.2.9 (g). Crew communication: manned sterile cockpit procedures. Any communication between the UAS crew and between the UAS crew and manned aircraft crew must conform to sterile cockpit procedures observed in the manned aircraft. This means that these communication systems must conform to the following standards:

- At any time that the manned aircraft PIC determines that sterile cockpit procedures must be observed, the UAS crew communication system must be configurable such that the manned aircraft crew cannot hear chatter between the UAS crew.
- During times which the manned aircraft crew is observing sterile cockpit procedures, there must be a means for the UAS crew to interject to communicate any flight-critical information to the manned crew. The previous requirement to ensure the manned crew is not exposed to general unmanned crew chatter still applies.

Sterile cockpit standards	Standards met	Standards not met
Risk points	0	Unairworthy

The airworthiness status is found based on the reduced risk score:

- Less than 5: risk level 1
- Between 6 and 15: risk level 2
- Between 16 and 22: risk level 3
- Greater than 26: unairworthy for aerial chase operations

5.2.10 Aircraft equipped with artificial stabilization and autopilots: automation reliability

This category assesses the following:

- Automation reliability insofar as the number of redundant sensors, flight computers, state estimation accuracy, state estimation mounting security.

The artificial dynamics should be evaluated based on flight tests alone; there is no expectation to calculate the characteristics of the airplane's artificial dynamics. Again, in flight testing, the airworthiness assessor should categorize the aircraft stability against the framework in this chapter based on their experience.

5.2.10 (a). Artificial stabilization reliability – minimum number redundant state-estimation sensors.

Number of redundant sensors	≥ 4	3	2	1
Risk points	1	5	20	50

5.2.10 (b). Artificial stabilization reliability – number of redundant flight computers.

Number of redundant flight computers	≥ 3	2	1
Risk points	1	10	20

5.2.10 (c). Accuracy of state estimation: demonstrated worst-case accuracy of any IMU state-estimation sensor in normal operation.

Accuracy	$\leq 1\%$	$\leq 5\%$	$< 10\%$	$\geq 10\%$
Risk points	1	10	20	50

5.2.10 (d). Accuracy of state estimation: demonstrated worst-case accuracy of airspeed measurement.

Accuracy	$\pm 1\%$ or better	$\pm 5\%$ or better	$\pm 10\%$ or better	Worse than $\pm 10\%$
Risk points	1	10	20	50

5.2.10 (e). Latency: worst-case time between a physical change in a parameter and that change being recognized by the onboard software.

Latency	≤ 150 ms	≤ 250 ms	≤ 350 ms	> 350 ms
Risk points	1	5	15	30

5.2.10 (f). State estimation sensor mounting security: maximum flex in any direction. Note: this is referencing loose mounting and not deformation under load.

Flex	$\leq 1^o$	$\leq 2^o$	$\leq 3^o$	$> 3^o$
Risk points	1	5	15	30

5.2.10 (g). State estimation mounting security: maximum flex in any direction under maximum load expected in normal flight.

Flex	$\leq 1^o$	$\leq 2^o$	$\leq 3^o$	$> 3^o$
Risk points	1	5	15	30

The total automation reliability score calculated by adding up all automation reliability risk points and dividing by the maximum possible automation reliability risk.

The airworthiness results are computed from the reduced score:

- Less than 10: risk level 1
- Between 11 and 25: risk level 2
- Between 26 and 65: risk level 3
- Greater than 65: unairworthy

5.2.11 Aircraft to be flown in conditions conducive to lightning

This applies to aircraft operating in conditions which are at an elevated risk of lightning. This includes flights within 10 miles of thunderstorms, flights in precipitation, flights such that the outside air temperature is 0 ± 5 degrees Centigrade, altitudes between 5000 and 15000 feet MSL.

This section contains guidelines for how to make an aircraft safe for operations in this environment. The guidelines are not mandatory to implement.

- Wire shielding: all wire bundles with more than 3 conductors should be shielded with a conductive sleeve.
- Ground straps: the common electrical ground must be connected to the aircraft chassis, which is defined as a any major metallic component of the aircraft structure.

- If the airplane is constructed of nonconductive materials, the exterior of the aircraft should be coated in a conductive material (such as an aluminum foil or mesh) so as to form a Faraday cage around the aircraft.
- Static wicks should be placed long the trailing edges of the aircraft to dissipate any electrical charges that build up during flight. It is recommended that these static wicks have a resistance of 2-600 MΩ.
- For any electronic system which, if failed, would result in immediate flight termination, the following standards should to be met:
    - The power delivery circuitry must ensure that the voltage and current are limited to values such that no damage is done to the electronics.
    - If, even given the precautions in the power delivery circuitry, there is a risk of failure of any critical systems, then two backup systems are required.

These standards are to be interpreted as recommendations and not hard requirements. Ultimately, whether or not the aircraft is airworthy is determined by demonstration. The applicant must fly their aircraft in a location far from people and in weather conditions conducive to lightning.

The aircraft will be rendered airworthy if:

- All of the aircraft's functionality is maintained during the flight
- No electronic components are damaged after the flight
- No backup systems are needed to safely execute the flight.

5.1.12 (a). Results from flight test

Standards met?	Standards met	Standards not met
Risk points	0	Unairworthy

5.3 Standards for Helicopters

These categories are only to be evaluated upon request from the proponent. The aircraft will be certified as unairworthy for any systems and application-specific criterion unless the proponent requests an airworthiness evaluation for that criterion.

5.3.1 Aircraft to be flown at night

Note that both COA nighttime stipulations and Part 107 nighttime waivers have the same requirements for aircraft lighting. These stipulations include the requirement for the beacon to be visible at 3 statute miles unless safety dictates that this distance be reduced. In the cases when safety requires a shorter visibility distance requirement, the visibility must be maximized within the constraints of safety.

5.3.1 (a). Beacon visibility

Visibility	Less than 3 statute miles	3 statute miles or greater
Risk points	Unairworthy	0

This must be tested with physical experimentation.

The beacon light(s) bust be configured such that it is visible regardless of the airplane's attitude.

The three-statute visibility requirement can generally be accomplished by using a roughly 15-watt bulb.

5.3.1 (b). Additional lighting requirements

Navigation lights are present	Yes, visible from at least 3 statute miles	Yes, visible from at least 1 statute mile	No
Risk points	0	10	Unairworthy

Note that navigation lights must be mounted such that the red navigation light is on the port side of the aircraft, and the green navigation light is mounted on the starboard side of the aircraft.

If other flight rules have different lighting requirements, the airworthiness assessment must be adjusted to be commensurate with the flight rules.

In addition to the FAA-required beacon and navigation lights, OISC strongly recommends that the aircraft be equipped with strobe lights. Further, OISC recommends that the aircraft either be equipped with landing lights or are landed in a well-lit location.

Further, OISC strongly recommends that nighttime aircraft missions are first flown in a daytime environment, and the landing is extensively practiced. If an autopilot is to be used, the automatic landing should be configured during the daytime and that the autopilot configuration remains completely unchanged to ensure that the nighttime landing is completed safely.

The airworthiness status is found based on the reduced risk score:

- Between 0 and 5: risk level 1
- Between 6 and 10: risk level 2
- Above 10: unairworthy for purpose of night flight

5.2.2 Aircraft to be flown in precipitation

Waterproofing requirements

- When the exterior of the aircraft is subjected to heavy precipitation, no water should enter the interior of the aircraft to damage the electronics.

- Any waterproofing features must not be soluble in water or degrade over time with exposure to water.

In order to assess compliance with waterproofing standards, the following experimentation must be conducted:

- Aircraft must be fully assembled and powered on
- Use a water spray to simulate heavy precipitation
- Spray the aircraft from all angles and for at least thirty minutes

5.2.2 (a). The risk points are found based on the rest results:

Test results	No water enters interior of airplane	Water enters interior of airplane and shows noticeable residue	Water enters interior of airplane and pools	Electronics fail during test
Risk points	0	50	Unairworthy for operations in precipitation.	Unairworthy for operations in precipitation.

Further, aircraft to be flown in precipitation need to be inspected for corrosion and water damage after every 5 hours during which the aircraft has flown in precipitation.

Further, all materials used on the aircraft must be tested for water solubility. In order to do this, each material must be immersed in water for a minimum of 1 hour to ensure that water damage is not a concern. If prolonged exposure to water causes material degradation, the aircraft is unairworthy for the purposes of flights in precipitation. Manners of material degradation is delineated below:

- Disintegration of material
- Delamination of layers within a material
- Greater than 5% change in elastic modulus, shear modulus, or Poisson ratio of material
- Greater than 5% change in yield stress and ultimate stress for both the shear and normal stress cases

5.2.2 (b). The following table quantifies risk points for the above list of material degradation conditions that may render an aircraft unairworthy for flights in precipitation:

Condition	No material degradation conditions met	Any of the material degradation conditions are met
Risk points	0	Unairworthy for operations in precipitation.

The airworthiness status is based on the reduced risk score:

- 0: risk level 1
- 25: risk level 2
- Above 25: unairworthy for flights in precipitation

5.3.3 Aircraft to be flown in cold environments

Cold environments are defined as environments where the historical average temperature for the time of operation is below 10^{o}C.

Depending on the aircraft, concerns in the following areas might be applicable:

- Battery performance degradation
- Elastic material performance degradation
- Potential for fuel to freeze or develop into a gel-like substance

Evaluate only each category that is applicable. Each category requires physical experimentation in order to certify the aircraft.

Battery performance degradation

- Place the batteries in freezer for 10 hours prior to experimentation
- Fly with cold batteries in 2-minute increments. Check to ensure the aircraft is not underpowered and check the battery voltage after each flight.
- The flight time should be certified such that the minimum voltage the battery reaches is 5% higher than the nominal battery cell voltage. For a LiPo, the nominal cell voltage is 3.7V so the minimum acceptable discharge voltage in cold environments is 3.85V. Airworthiness assessors are permitted to set the minimum discharge voltage to a higher value.
- If the results of the test are in doubt, the airworthiness assessor must specify procedures to be carried out by the operator in the cold-weather environment and how the results of those tests affect operating limitations.
- A higher C rating battery must be used for cold-weather environments than is used for temperate environments.
- The battery must be insulated in order to minimize heat loss from the battery. This is particularly important if the battery is exposed to the propwash or the airflow around the airplane.
- The battery must be warmed prior to flight.

- Batteries used in cold weather environments must be marked as having been subjected to cold environments, and the number of cycles they are subjected to in the cold environment must be documented.

Elastic material performance degradation

- Any elastic materials must be frozen for ten hours prior to flight.
- If after freezing they cannot be used for their intended purpose, the aircraft is unairworthy for the purposes of cold-weather operation.
- The aircraft must be flown in ten-minute increments, and the elastic material inspected between flights.
- From this, the airworthiness assessor must specify a useful life for all elastic parts.
- If the elastic cannot last more than 60 minutes, the aircraft is unairworthy. The useful life of an elastic material must be 1/3 of the time which it takes for the elastic to fail.

Fuel viscosity change

- The fuel must be frozen before flight for at least ten hours.
- If the fuel becomes solid, the aircraft is unairworthy for the purposes of cold-weather operation.
- If the fuel remains liquid, it is to be tested in the engine. If the engine cannot run for thirty minutes at a minimum, it is unairworthy for cold-weather operations.
- If the engine shows signs of excessive wear during or after the test, the aircraft is unairworthy for the purposes of cold-weather operations.
- All engine tests are intended to be performed on a test stand with an adequately large fuel tank. It is not relevant as to whether the design tank size of provides for a flight time commensurate with the required time to demonstrate normal engine operation. This section simply evaluates the ability of the engine and fuel to operate in cold environments.

5.3.3 (a). Battery performance degradation: maximum flight time in cold weather environments

Endurance	> 10 mins	> 7 mins	> 3 mins	< 3 mins
Risk points	0	20	40	Unairworthy for flights in cold environments

5.3.3 (b). Elastic material performance degradation

Elastic material performance	No elastic material used in airplane	Elastic material is present and can be used for 20 minutes and meet standards delineated in this section	Elastic material is present and cannot be used for 20 minutes	Elastic material fails in cold weather
Risk points	0	10	Unairworthy for flights in cold environments	Unairworthy for flights in cold environments

5.3.3 (c). Fuel viscosity change

Fuel performance degradation	No change in fuel and engine performance in cold environments	Fuel remains liquid and engine can run for a minimum of 30 minutes	Fuel remains liquid, but engine cannot be run for 30 minutes	Fuel forms into a gel or solid in cold environments
Risk points	0	20	Unairworthy for flights in cold environments	Unairworthy for flights in cold environments

The airworthiness status us found based on the reduced risk score:

- Less than 12: risk level 1
- Between 12 and 20: risk level 2
- Between 21 and 30: risk level 3
- Over 30: unairworthy

5.3.4 Aircraft to be flown in icing conditions – incidental exposure

Note that, as of the drafting of this manual in May 2020, there are several operations that CU has conducted in which icing conditions were encountered:

- S2 NIGHTFOX mission
- Datahawk flights in arctic environments
- Pilatus flights in Alaska

In each of these situations, the aircraft flew strictly in VMC but encountered icing, nonetheless. In turn, OISC needs to set standards for aircraft that are flown in environments where icing is a possibility.

This section applies to aircraft to be flown in situations where icing is possible, but extended operations in icing conditions are not expected. Under this certification scheme, the aircraft must leave icing conditions as soon as they are encountered.

No multirotor is permitted to fly in continuous icing conditions.

The following analysis must be completed, and the following features must be included:

- Analysis must be completed to characterize airframe icing, including:
    - Where ice will accumulate, how quickly, and in what conditions
    - Icing effects on lift and stall speed
    - Icing effects on drag and ability of propulsion system to propel aircraft at speeds needed to maintain level flight
    - Expected performance changes as ice accumulates must be included in the performance section of the POH.
    - Note: ANSYS CFD packages can analyze aircraft icing, albeit at the expense of significant time and computational resources.
- Structural effects of ice shedding. This includes the effects of ice shedding from propellers and the effects of ice shedding from other flight surfaces, such as wings.
- Detection system for ice. The aircraft must be equipped with sufficient ice detection sensors that can alert the flight crew at the earliest signs of ice accumulation on any part of the airframe.
- Ice effects on air data sensors. This analysis must investigate if, how, and to what extent air data measurements will be affected by ice buildup.
- Ideal maneuvers for exiting icing conditions. The aircraft further must be certified with a recommended procedure for the flight crew to execute if they encounter icing conditions. This procedure need not require that the flight crew land if ice accumulation diminishes after exiting the icing environments. However, this procedure must guide the flight crew in exiting the icing situation with minimal risk

For an aircraft to be certified as airworthy for flights into possible icing conditions, the following standards apply:

5.3.4 (a). Change in required propulsion power to maintain level flight with 5-minute icing counter

Change in required power	$< 20\%$	$< 35\%$	$< 50\%$	$\geq 50\%$
Risk points	0	5	10	Unairworthy for flight in possible icing conditions

5.3.4 (b). Flight-critical structural damage that occurs from ice shedding (including from propellers, wing, horizontal stabilizer, vertical stabilizer, and all other flight surfaces):

Damage	No flight-critical structural damage	Flight-critical structural damage
Risk points	0	Unairworthy for flight in possible icing conditions

5.3.4 (c). Ice detection system: ability to accurately detect ice accumulation on all surfaces where icing may be encountered:

Detection ability	Accurately identifies ice accumulation and lack of ice accumulation in at least 99% of cases	Accurately identifies ice accumulation and lack of ice accumulation in at least 85% of cases	Accurately identifies ice accumulation and lack of ice accumulation in at least 75% of cases	Accurately identifies ice accumulation and lack of ice accumulation in less than 75% of cases
Risk points	0	20	40	Unairworthy for flight in possible icing conditions

5.3.4 (d). Ice effects on air data sensors:

Effect on sensors	Angle of attack, static pressure, total pressure accuracy unaffected by ice accumulation	Angle of attack, static pressure, total pressure accuracy affected by less than 5%	Angle of attack, static pressure, total pressure accuracy affected by less than 10%	Angle of attack, static pressure, total pressure accuracy affected by more than 10%
Risk points	0	20	40	Unairworthy for flight in possible icing conditions

5.3.4 (e). Icing condition exit strategy

Existence and thoroughness of icing condition exit strategy	Strategy exists and is through, specific, and comprehensive	Strategy exists but is insufficiently thorough, specific, and comprehensive, or does not exist
Risk points	0	Unairworthy for flight in possible icing conditions

The airworthiness status is determined based on the reduced risk score:

- Less than 5: risk level 1
- Between 6 and 12: risk level 2
- Between 13 and 20: risk level 3
- 21 or greater: unairworthy for flight in incidental icing environments

5.3.5 Fueled aircraft

The fuel tank must be located such that:

- The fuel tank will not touch the ground upon landing the aircraft
- There is adequate clearance between the fuel tank and propeller discs
- In the event of propeller structural failure, the fuel tanks are adequately protected from shrapnel
- All wiring is routed away from the fuel tank to minimize the chances of an ignition of fuel vapors in the event of malfunction of the wiring
- The aircraft's stability augmentation system can handle the differing center of gravity caused by fuel sloshing in the fuel tank
- Reliability and accuracy of fuel gauge

5.3.5 (a). Clearance between fuel tank and ground on smooth, level surface

Clearance	> 15 cm	> 10 cm	> 5 cm	< 5 cm
Risk points	0	10	30	Unairworthy

If the aircraft features sprung landing gear, this standard must be evaluated at the point where the distance is the smallest.

5.3.5 (b). Clearance between fuel tank and rotor discs (including main and tail rotors)

Clearance	> 3 cm	> 2 cm	> 1 cm	< 1 cm
Risk points	0	10	30	Unairworthy

Fuel tank protection: OISC requires adequate fuel tank protection in certain circumstances:

- If the aircraft is to be flown strictly VLOS and at a distance from the control station such that, in the event of a fuel tank fire, the fire can be extinguished by the ground crew within 90 seconds of the fire starting. This may be accomplished by any of the following methods: (a) keeping the aircraft close enough to the landed at the location of the ground crew within 90 seconds, (b) flying the aircraft at a distance such that it can be landed at a location away from the control station and reached by the crew within 90 seconds either on foot or using a vehicle.
- If the aircraft is flown BVLOS or the 90-second criterion cannot be realistically met, the following fuel tank protection standards apply: the fuel tank must be positioned and protected such that, in normal flight, there is negligible risk of the fuel tank becoming punctured. OISC recommends the following fuel tank protections:
    - The fuel tank must be located such that shrapnel from the propulsion system is not likely to impact the fuel tank in the event of a structural failure of any component of the propulsion system.
    - The fuel tank should feature some protection such as Kevlar, ballistic foam, or some other protection that OISC deems appropriate to prevent rupture of the fuel tank by shrapnel.
    - The fuel tank must be oriented such that, if a puncture were to form in any location on the fuel tank, fuel would not leak onto any potential ignition source.
    - OISC requires that the fuel tank meet the following crashworthiness requirements, in that the fuel tank does not rupture under the following loads:
        - 4G upward
        - 16G forward
        - 8G sideward
        - 20G downward
        - 1.5G rearward

5.3.5 (c). Fuel tank protection risk points

Fuel tank protection standards	Standards met	Standards not met
Risk points	0	Unairworthy

5.3.5 (d). Wire routing: the following standards apply for wire routing in proximity to the fuel system, which reply regardless of the current carried by the wire or the potential difference the wire is at relative to chassis ground:

- No wires may pass through the fuel tank, including for the purpose of measuring the level of fuel in the tank.
    - Fuel gauges are required in certain circumstances. OISC expects that this will be accomplished by using a float-type device which actuates a sensor located outside of the fuel tank.
- No wires pay pass within 5 cm of any part of the fuel system where fuel vapors could be present, including fuel filling ports and joints between various components in the fuel system

Wire routing risk points:

Wire routing standards	Wire routing standards met	Wire routing standards not met
Risk points	0	Unairworthy

5.3.5 (e). Fuel slosh and aircraft stability/controllability:

- The aircraft stability, including the stability augmentation system if applicable, must be flight-tested at a level of fuel where the fuel sloshing could result in the maximum change in center of gravity
- The aircraft must be free of undesirable flight characteristics due to fuel sloshing, as assessed by the following risk points table:

Flight characteristics	Flight characteristics are comparable to that of a rigid-body aircraft	Some undesirable flight characteristics introduced, such as well-damped oscillation	Substantial undesirable flight characteristics introduced, such as moderately damped oscillation	Significant undesirable flight characteristics introduced, such as lightly damped oscillations
Risk points	0	15	40	Unairworthy

5.3.5 (f). Fuel hose routing: the fuel hoses must be positioned and protected such that friction between the hose and the aircraft structure cannot gradually wear through the tubing. This means that:

- The fuel tubing may not be routed across any sharp corners
- The tubing may not be routed across rough or sharp materials
- The tubing must be bent according to manufacturer specifications

Tubing standards	Tubing standards met	Tubing standards not met
Risk points	0	Unairworthy

5.3.5 (g). Fuel gauge reliability: all aircraft with a maximum takeoff weight over 15 pounds and powered by a fueled propulsion system must have fuel gauges which meet the following specifications:

- The gauges can accurately identify the quantity of usable onboard the aircraft fuel during steady, level, unaccelerated flight.
- The accuracy standards apply to all fuel levels; the fuel gauges must be accurate at all ranges of usable fuel, from empty to full fuel.

- The accuracy of the fuel gauge is assessed as follows:

Accuracy of fuel gauge	$\pm 3\%$ or better	$\pm 5\%$ or better	$\pm 10\%$ or better	Worse than $\pm 10\%$
Risk points	0	10	20	Unairworthy

Except for pressurized fuel systems, the fuel tanks must be vented to allow for air to enter the fuel tanks as fuel is burned. The fuel vent(s) must be positioned such that there is a minimal risk of the vents being clogged by ice or foreign object debris.

5.3.5 (h). Fuel vent risk points

Fuel vent standards	Fuel vent standards met	Fuel vent standards not met
Risk points	0	Unairworthy

The airworthiness status is assessed based on the reduced risk score:

- Between 0 and 5: risk level 1
- Between 5 and 10: risk level 2
- Between 10 and 20: risk level 3
- Over 20: unairworthy

5.3.6 Clutch systems

The following categories are assessed:

- Clutch alignment in angular and linear directions
- Clutch sizing to ensure to prevent engine stall at low torque settings
- Torque in relation to manufacturer-specified torque
- RPM in relation to manufacturer-specified RPM

5.3.6 (a). Clutch alignment – angular: angular misalignment between shaft axes

Misalignment angle θ	$\theta < 0.01^0$	$\theta < 0.05^0$	$\theta < 0.1^0$	$\theta \geq 0.1^0$
Risk points	0	20	40	Unairworthy

5.3.6 (b). Clutch alignment – linear: linear misalignment between shaft axes

Misalignment distance s	$s < 0.001$ inch	$s < 0.005$ inch	$s < 0.01$	$s \geq 0.01$
Risk points	0	20	40	Unairworthy

5.3.6 (c). Clutch sizing: engine stall

Engine stall status	Engine does not stall at any power setting	Engine stalls at some power setting with normal load
Risk points	0	Unairworthy

5.3.6 (d). Clutch sizing: maximum design torque through clutch vs. manufacturer-specified maximum torque

Value of $\frac{\tau_{design}}{\tau_{spec}}$	$\frac{\tau_{design}}{\tau_{spec}} < 0.8$	$\frac{\tau_{design}}{\tau_{spec}} < 0.9$	$\frac{\tau_{design}}{\tau_{spec}} < 1$	$\frac{\tau_{design}}{\tau_{spec}} \geq 1$
Risk points	0	15	30	Unairworthy

5.3.6 (e). Clutch sizing: maximum design RPM through clutch vs. manufacturer-specified maximum RPM

Value of $\frac{\omega_{design}}{\omega_{spec}}$	$\frac{\omega_{design}}{\omega_{spec}} < 0.8$	$\frac{\omega_{design}}{\omega_{spec}} < 0.9$	$\frac{\omega_{design}}{\omega_{spec}} < 1$	$\frac{\omega_{design}}{\omega_{spec}} \geq 1$
Risk points	0	15	30	Unairworthy

The airworthiness status is found based on the reduced risk score:

- Between 0 and 10: risk level 1
- Between 11 and 20: risk level 2
- Between 21 and 28: risk level 3
- Greater than 28: unairworthy

5.3.7 Aircraft to be flown in IMC or BVLOS

OISC requires more stringent standards to be met for aircraft that are to be flown in IMC or BVLOS. The airworthiness standards delineated here are in addition to any requirements which might arise from the flight rules which authorize these operations.

Automation: the aircraft must be equipped with an autopilot. The autopilot must meet the standards delineated in this section.

5.3.7 (a). Automation: autopilot presence

Autopilot presence	Autopilot is present	No autopilot
Risk points	0	Unairworthy for IMC/BVLOS operations

5.3.7 (b). Automation reliability: risk score from section 5.3.9:

Risk level	Risk level 1	Risk level 2	Risk level 3 or greater
Risk points	0	50	Unairworthy for IMC/BVLOS operations

5.3.7 (c). Position estimation accuracy: nominal accuracy of lateral/longitudinal position estimation

Accuracy	$\pm$3m or better	$\pm$5m or better	$\pm$7m or better	Worse than $\pm$7m
Risk points	0	25	50	Unairworthy for IMC/BVLOS operations

Equipment: the aircraft must be equipped with the following equipment:

- Altimeter: if using a pressure-based altimeter, the altimeter must be able to be calibrated to account for nonstandard atmospheric conditions.
- Airspeed indicator.
- Engine monitoring instrumentation appropriate to the type of propulsion used.
- Fuel/battery remaining gauges.
- Position indicator for landing gear (if applicable).
- Attitude indicator.
- Directional gyro/heading indicator.
- Suitable avionics to navigate the aircraft as required.
- Suitable transmission system to provide telemetry for all the above data to the crew on the ground.

5.3.7 (d). Equipment standards:

Equipment standards met	Standards met	Standards not met
Risk points	0	Unairworthy for IMC/BVLOS operations

5.3.7 (e). Radio range: smallest range of any radio system installed on the aircraft

Range	$>$ 5km	$>$ 4km	$>$ 3km	$<$ 3km
Risk points	0	25	50	Unairworthy for IMC/ BVLOS operations

This must be based on maximum realistic atmospheric attenuation and other phenomena which would degrade radio communications. Further, the maximum range of any radio system must be 1.5 times the expected maximum distance between the aircraft and control station.

5.3.7 (f). Redundancy: redundant power systems. OISC requires that any aircraft equipped to fly BVLOS feature two independent power systems. One of these power systems may be the main flight battery or a generator from a fueled propulsion system, but a backup battery must be installed to power all flight-critical aircraft systems in the event of failure of the main power supply.

Power redundancy requirements met	Requirements met	Requirements not met
Risk points	0	Unairworthy for IMC/BVLOS operations

Redundancy: OISC requires that all the following measurements be made with a triple-redundant system:

- Airspeed, including three pitot tubes and three pressure differential sensors.
- Altitude. It is acceptable to use multiple methods of measuring altitude, such as GPS and pressure sensing. For example, it is acceptable to have two pressure altimeter and one GPS altimeter.
- Attitude: three sensors/sensor packages to measure attitude are required.
- Heading: three sensors to measure heading are required.

The data from the each of the three sensors must be intercompared. If there is a discrepancy between the data on any of the sensors, there must be a means of alerting the crew.

5.3.7 (g). Sensor redundancy standards:

Redundant sensors	Greater than 3	3	Less than 3
Risk points	0	15	Unairworthy for IMC/BVLOS operations

5.3.7 (h). GPS technology used

Technology	WAAS or similar augmentation	Standard
Risk points	0	15

5.3.7 (i). GPS geofencing. The aircraft must be equipped with a means to restrict the aircraft to only flying within the lateral areas and altitudes authorized for IMC or BVLOS operation.

Geofencing feature applied?	Applied	Not applied
Risk points	0	Unairworthy for IMC/BVLOS operations

The airworthiness status is based on the reduced risk score:

- Between 0 and 10: risk level 1
- Between 11 and 20: risk level 2

- Between 21 and 25: risk level 3
- Greater than 25: unairworthy for flights BVLOS/in IMC

5.2.8 Aircraft to be flown in aerial chase operations

UAS control placement. If the UAS control station is located inside the manned chase aircraft, the UAS control station must be located such that the following requirements are met:

- The UAS control station must not obstruct the flight controls of the chase aircraft
- The UAS control station must not obstruct the manned pilot's view of the flight instruments, avionics, radio, transponder, trim system, flap actuator, landing gear actuator, or any other aircraft system that the manned PIC deems necessary for safe flight.
- The UAS control station must not restrict the manned pilot's access to manipulate the flight instruments, avionics, radio, transponder, trim system, flap actuator, landing gear actuator, or any other aircraft system that the manned PIC deems necessary for safe flight.
- The UAS control station, and the location of the seat for the UAS crew must be located and have weights such that the chase aircraft's maximum takeoff weight and CG limits are not exceeded.

5.2.8 (a). Risk points for UAS control station are assessed as follows:

UAS control location within aircraft	Inapplicable as UAS control station is located on the ground	In-aircraft UAS control station placement meets requirements	In-aircraft UAS control station placement meets
Risk points	0	0	Unairworthy for aerial chase operations

5.2.8 (b). UAS control station power draw. If the UAS control station requires power from the chase aircraft, the following standards must be met:

- The risk points must be assessed based on the power draw per the table below. The power may not exceed 75% of the excess power generated by the airplane's alternator/generator system.
- The PIC of the manned aircraft must have a switch to immediately disconnect the power supply from the manned aircraft.
- The UAS control station must have a backup power source to allow for enough time to land the aircraft in the event of power failure from the manned aircraft.

Power draw as a fraction of excess generated power:

Power draw	Inapplicable as no power from aircraft is required	50% of excess generated power or less	75% of excess generated power or less	Exceeds 75% of excess generated power
Risk points	0	15	30	Unairworthy for aerial chase operations

5.2.8 (c). Power disconnect and backup power standards:

Standards met	Met	Not met
Risk points	0	Unairworthy for aerial chase operations

UAS control station electronic interference with manned aircraft systems. The UAS may not transmit on frequencies which would interfere with any of the following aircraft systems:

- Communication radios
- Navigation radios
- Transponder
- Automatic dependent surveillance broadcast (ADS-B)
- GPS
- WiFi or Bluetooth connections between avionics and electronic flight bag systems
- Any other system the manned aircraft PIC deems essential for safe flight

The applicant must demonstrate that:

- Their radio systems meet all requirements laid out by the FCC or, if flying internationally, the appropriate government authority.
- Their radio systems do not interfere with aircraft systems delineated above.

5.2.8 (d). Radio systems risk points:

Radio interference standards met	Met	Not met
Risk points	0	Unairworthy for aerial chase operations

5.2.8 (e). Manned aircraft collision avoidance: presence of onboard systems to prevent loss of separation between chase aircraft and UAS

Method to maintain separation	UAS automatically makes evasive maneuver if separation with manned aircraft may be lost	Reliant on crew of each aircraft to maintain separation with alert for low separation presented to both crews	Reliant on crew of each aircraft to maintain separation with alert for low separation presented to UAS crew only	Reliant on crew of each aircraft to visually maintain separation
Risk points	0	30	70	95

5.2.8 (f). Crew communications between manned crew and UAS crew

Crew communication system	Crew co-located in cockpit and can speak over aircraft intercom	2-way radio communication which does not require push-to-talk	2-way communication which requires push-to-talk
Risk points	0	20	40

5.2.8 (g). Crew communication: manned sterile cockpit procedures. Any communication between the UAS crew and between the UAS crew and manned aircraft crew must conform to sterile cockpit procedures observed in the manned aircraft. This means that these communication systems must conform to the following standards:

- At any time that the manned aircraft PIC determines that sterile cockpit procedures must be observed, the UAS crew communication system must be configurable such that the manned aircraft crew cannot hear chatter between the UAS crew.
- During times which the manned aircraft crew is observing sterile cockpit procedures, there must be a means for the UAS crew to interject to communicate any flight-critical information to the manned crew. The previous requirement to ensure the manned crew is not exposed to general unmanned crew chatter still applies.

Sterile cockpit standards	Standards met	Standards not met
Risk points	0	Unairworthy

The airworthiness status is found based on the reduced risk score:

- Less than 5: risk level 1
- Between 6 and 15: risk level 2
- Between 16 and 22: risk level 3
- Greater than 26: unairworthy for aerial chase operations

5.3.9 Aircraft equipped with artificial stabilization and autopilots: automation reliability

This category assesses the following:

- Automation reliability insofar as the number of redundant sensors, flight computers, state estimation accuracy, state estimation mounting security.

The artificial dynamics should be evaluated based on flight tests alone; there is no expectation to calculate the characteristics of the airplane's artificial dynamics. Again, in flight testing, the airworthiness assessor should categorize the aircraft stability against the framework in this chapter based on their experience.

5.3.9 (a). Artificial stabilization reliability – minimum number redundant state-estimation sensors.

Number of redundant sensors	≥ 4	3	2	1
Risk points	1	5	20	50

5.3.9 (b). Artificial stabilization reliability – number of redundant flight computers.

Number of redundant flight computers	≥ 3	2	1
Risk points	1	10	20

5.3.9 (c). Accuracy of state estimation: demonstrated worst-case accuracy of any IMU state-estimation sensor in normal operation.

Accuracy	$\leq 1\%$	$\leq 5\%$	$< 10\%$	$\geq 10\%$
Risk points	1	10	20	50

5.3.9 (d). Accuracy of state estimation: demonstrated worst-case accuracy of airspeed measurement.

Accuracy	$\pm 1\%$ or better	$\pm 5\%$ or better	$\pm 10\%$ or better	Worse than $\pm 10\%$
Risk points	1	10	20	50

5.3.9 (e). Latency: worst-case time between a physical change in a parameter and that change being recognized by the onboard software.

Latency	≤ 150 ms	≤ 250 ms	≤ 350 ms	> 350 ms
Risk points	1	5	15	30

5.3.9 (f). State estimation sensor mounting security: maximum flex in any direction. Note: this is referencing loose mounting and not deformation under load.

Flex	$\leq 1^o$	$\leq 2^o$	$\leq 3^o$	$> 3^o$
Risk points	1	5	15	30

5.3.9 (g). State estimation mounting security: maximum flex in any direction under maximum load expected in normal flight.

Flex	$\leq 1^o$	$\leq 2^o$	$\leq 3^o$	$> 3^o$
Risk points	1	5	15	30

The total automation reliability score calculated by adding up all automation reliability risk points and dividing by the maximum possible automation reliability risk.

The airworthiness results are computed from the reduced score:

- Less than 10: risk level 1
- Between 11 and 25: risk level 2
- Between 26 and 65: risk level 3
- Greater than 65: unairworthy

5.3.10 Aircraft equipped with stability augmentation system

5.3.10 (a). Automation reliability score

Score	1	2	3	Unairworthy
Risk points	0	20	40	Unairworthy

5.3.10 (b). Position-hold performance: maximum deviation from target position in any direction in smooth air

Deviation	< 10cm	< 20cm	< 30cm	> 30cm
Risk points	0	5	10	Unairworthy

5.3.10 (c). Position-hold performance: position hold Cooper-Harper score

Cooper-Harper score	2 or better	4 or better	6 or better	Worse than 6
Risk points	0	15	40	Unairworthy

5.3.10 (d). Attitude-hold performance: maximum angular deviation from target attitude in either direction (pitch or roll)

Deviation	$< 2^o$	$< 4^o$	$< 6^o$	$> 6^o$
Risk points	0	20	40	Unairworthy

5.3.10 (e). Attitude-hold performance: attitude-hold Cooper-Harper score

Cooper-Harper score	2 or better	4 or better	6 or better	Worse than 6
Risk points	0	15	40	Unairworthy

5.3.10 (f). Disturbance rejection: position-hold performance: maximum deviation from target position in any direction in light turbulence

Deviation	< 15cm	< 30cm	< 45cm	> 45cm
Risk points	0	10	20	90

5.3.10 (g). Disturbance tracking: position-hold performance: Cooper-Harper score in light turbulence

Cooper-Harper score	2 or better	4 or better	6 or better	Worse than 6
Risk points	0	15	40	Unairworthy

5.3.10 (h). Control tracking: aircraft stability augmentation response to control inputs

Response characteristics	Critically or over-damped	Well-damped	Lightly damped	Extremely lightly damped
Risk points	0	10	40	60

5.3.10 (i). Control tracking: aircraft stability augmentation response to control inputs Cooper-Harper score

Cooper-Harper score	2 or better	4 or better	6 or better	Worse than 6
Risk points	0	15	40	Unairworthy

5.3.10 (j). Altitude-hold capabilities during forward/transverse flight: altitude deviation

Altitude hold deviation	< 10cm	< 20cm	< 30cm	> 30cm
Risk points	0	5	10	60

5.3.10 (k). Altitude-hold capabilities during forward/transverse flight: altitude deviation

Cooper-Harper score	2 or better	4 or better	6 or better	Worse than 6
Risk points	0	15	40	Unairworthy

5.3.10 (l). Pitch and bank angle limitation

Pitch and bank limits	Limits are below FOM-defined thresholds	Limits meet FOM-defined threshold	No SAS limits: reliant on pilot to maintain FOM pitch and bank limits
Risk points	0	5	30

5.3.10 (m). Maintaining attitude limits: Cooper-Harper score

Cooper-Harper score	2 or better	4 or better	6 or better	Worse than 6
Risk points	0	15	40	Unairworthy

5.3.10 (n). Control precision: takeoff/landing precision test

Precision	± 10cm or better	± 20cm or better	± 35cm or better	± 35cm or worse
Risk points	0	15	40	Unairworthy

For this test, the pilot must take the aircraft off from a helipad, fly it to 10 feet in altitude without inputting any other control inputs, and land it again. The difference in the takeoff location of the center of the aircraft and landing location of the center of the aircraft is to be measured.

5.3.10 (o). Control precision: Cooper-Harper score for landing on precise location

Cooper-Harper score	2 or better	4 or better	6 or better	Worse than 6
Risk points	0	15	40	Unairworthy

This is based on the following test: the aircraft is to be landed on a square pad with a side length not exceeding 1.2 times the maximum diagonal length between propellers. The pilot is to land on the middle of this pad and rate the difficulty of doing so.

5.3.10 (p). Control precision: azimuth hold ability

Azimuth variation test results	± 2m or better	± 4m or better	± 8m or better	Worse than ± 8m
Risk points	0	15	40	Unairworthy

This is to be assessed by a physical test: from a safe altitude, the aircraft must be aligned to a given azimuth, flown forward 35 meters without any lateral commands. It then must be flown directly backward to the start location. The difference in position measured in the direction perpendicular to the target azimuth must be measured. See the diagram below:

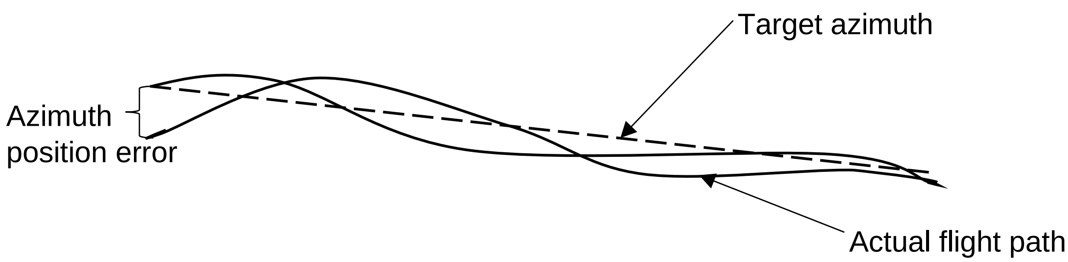

Figure 5-1: Azimuth tracking visualization

5.3.10 (q). Control precision: azimuth hold ability Cooper-Harper score

Cooper-Harper score	2 or better	4 or better	6 or better	Worse than 6
Risk points	0	15	40	Unairworthy

This is based on the pilot's workload during the test delineated in the previous standard.

The airworthiness status is based on the reduced risk score:

- Between 0 and 10: risk level 1
- Between 11 and 20: risk level 2
- Between 21 and 38: risk level 3
- Above 38: unairworthy

5.3.11 Aircraft to be flown in conditions conducive to lightning

This applies to aircraft operating in conditions which are at an elevated risk of lightning. This includes flights within 10 miles of thunderstorms, flights in precipitation, flights such that the outside air temperature is 0 ± 5 degrees Centigrade, altitudes between 5000 and 15000 feet MSL.

This section contains guidelines for how to make an aircraft safe for operations in this environment. The guidelines are not mandatory to implement.

- Wire shielding: all wire bundles with more than 3 conductors should be shielded with a conductive sleeve.

- Ground straps: the common electrical ground must be connected to the aircraft chassis, which is defined as a any major metallic component of the aircraft structure.
- If the airplane is constructed of nonconductive materials, the exterior of the aircraft should be coated in a conductive material (such as an aluminum foil or mesh) so as to form a Faraday cage around the aircraft.
- Static wicks should be placed long the trailing edges of the aircraft to dissipate any electrical charges that build up during flight. It is recommended that these static wicks have a resistance of 2-600 MΩ.
- For any electronic system which, if failed, would result in immediate flight termination, the following standards should to be met:
    - The power delivery circuitry must ensure that the voltage and current are limited to values such that no damage is done to the electronics.
    - If, even given the precautions in the power delivery circuitry, there is a risk of failure of any critical systems, then two backup systems are required.

These standards are to be interpreted as recommendations and not hard requirements. Ultimately, whether or not the aircraft is airworthy is determined by demonstration. The applicant must fly their aircraft in a location far from people and in weather conditions conducive to lightning.

The aircraft will be rendered airworthy if:

- All of the aircraft’s functionality is maintained during the flight
- No electronic components are damaged after the flight
- No backup systems are needed to safely execute the flight.

5.1.12 (a). Results from flight test

Standards met?	Standards met	Standards not met
Risk points	0	Unairworthy

5.4 Standards for Airships

These categories are only to be evaluated upon request from the proponent. The aircraft will be certified as unairworthy for any systems and application-specific criterion unless the proponent requests an airworthiness evaluation for that criterion.

5.4.1 Aircraft to be flown at night

Note that both COA nighttime stipulations and Part 107 nighttime waivers have the same requirements for aircraft lighting. These stipulations include the requirement for the beacon to be visible at 3 statute miles unless safety dictates that this distance be reduced. In the cases when safety requires a shorter visibility distance requirement, the visibility must be maximized within the constraints of safety.

5.4.1 (a). Beacon visibility

Visibility	Less than 3 statute miles	3 statute miles or greater
Risk points	Unairworthy	0

This must be tested with physical experimentation.

The beacon light bust be configured such that it is visible regardless of the airplane's attitude.

The three-statute visibility requirement can generally be accomplished by using a roughly 15-watt bulb.

5.4.1 (b). Additional lighting requirements

Navigation lights are present	Yes, visible from at least 3 statute miles	Yes, visible from at least 1 statute mile	No
Risk points	0	10	Unairworthy

Note that navigation lights must be mounted such that the red navigation light is on the port wingtip, and the green navigation light is mounted on the starboard wingtip.

If other flight rules have different lighting requirements, the airworthiness assessment must be adjusted to be commensurate with the flight rules.

In addition to the FAA-required beacon and navigation lights, OISC strongly recommends that the aircraft be equipped with strobe lights. Further, OISC recommends that the aircraft either be equipped with landing lights or are landed in a well-lit location.

Further, OISC strongly recommends that nighttime aircraft missions are first flown in a daytime environment, and the landing is extensively practiced. If an autopilot is to be used, the automatic landing should be configured during the daytime and that the autopilot configuration remains completely unchanged to ensure that the nighttime landing is completed safely.

The airworthiness status is found based on the reduced risk score:

- Between 0 and 5: risk level 1
- Between 6 and 10: risk level 2
- Above 10: unairworthy for purpose of night flight

5.4.2 Aircraft to be flown in precipitation

Waterproofing requirements

- When the exterior of the aircraft is subjected to heavy precipitation, no water should enter the interior of the aircraft to damage the electronics.

- Any waterproofing features must not be soluble in water or degrade over time with exposure to water.

In order to assess compliance with waterproofing standards, the following experimentation must be conducted:

- Aircraft must be fully assembled and powered on
- Use a water spray to simulate heavy precipitation
- Spray the aircraft from all angles and for at least thirty minutes

5.4.2 (a). The risk points are found based on the rest results:

Test results	No water enters interior of aircraft	Water enters interior of aircraft and shows noticeable residue	Water enters interior of aircraft and pools	Electronics fail during test
Risk points	0	50	Unairworthy for operations in precipitation.	Unairworthy for operations in precipitation.

Further, aircraft to be flown in precipitation need to be inspected for corrosion and water damage after every 5 hours during which the aircraft has flown in precipitation.

Further, all materials used on the aircraft must be tested for water solubility. In order to do this, each material must be immersed in water for a minimum of 1 hour to ensure that water damage is not a concern. If prolonged exposure to water causes material degradation, the aircraft is unairworthy for the purposes of flights in precipitation. Manners of material degradation is delineated below:

- Disintegration of material
- Delamination of layers within a material
- Greater than 5% change in elastic modulus, shear modulus, or Poisson ratio of material
- Greater than 5% change in yield stress and ultimate stress for both the shear and normal stress cases

5.4.2 (b). The following table quantifies risk points for the above list of material degradation conditions that may render an aircraft unairworthy for flights in precipitation:

Condition	No material degradation conditions met	Any of the material degradation conditions are met
Risk points	0	Unairworthy for operations in precipitation.

The airworthiness status is based on the reduced risk score:

- 0: risk level 1
- 25: risk level 2
- Above 25: unairworthy for flights in precipitation

5.4.3 Aircraft to be flown in cold environments

Cold environments are defined as environments where the historical average temperature for the time of operation is below 10^{o}C.

Depending on the aircraft, concerns in the following areas might be applicable:

- Battery performance degradation
- Elastic material performance degradation
- Potential for fuel to freeze or develop into a gel-like substance

Evaluate only each category that is applicable. Each category requires physical experimentation in order to certify the aircraft.

Battery performance degradation

- Place the batteries in freezer for 10 hours prior to experimentation
- Fly with cold batteries in 2-minute increments. Check to ensure the aircraft is not underpowered and check the battery voltage after each flight.
- The flight time should be certified such that the minimum voltage the battery reaches is 5% higher than the nominal battery cell voltage. For a LiPo, the nominal cell voltage is 3.7V so the minimum acceptable discharge voltage in cold environments is 3.85V. Airworthiness assessors are permitted to set the minimum discharge voltage to a higher value.
- If the results of the test are in doubt, the airworthiness assessor must specify procedures to be carried out by the operator in the cold-weather environment and how the results of those tests affect operating limitations.
- A higher C rating battery must be used for cold-weather environments than is used for temperate environments.
- The battery must be insulated in order to minimize heat loss from the battery. This is particularly important if the battery is exposed to the propwash or the airflow around the airplane.
- The battery must be warmed prior to flight.

- Batteries used in cold weather environments must be marked as having been subjected to cold environments, and the number of cycles they are subjected to in the cold environment must be documented.

Elastic material performance degradation

- Any elastic materials must be frozen for ten hours prior to flight.
- If after freezing they cannot be used for their intended purpose, the aircraft is unairworthy for the purposes of cold-weather operation.
- The aircraft must be flown in ten-minute increments, and the elastic material inspected between flights.
- From this, the airworthiness assessor must specify a useful life for all elastic parts.
- If the elastic cannot last more than 60 minutes, the aircraft is unairworthy. The useful life of an elastic material must be 1/3 of the time which it takes for the elastic to fail.
- Any thermal effects which would change the size of the bag must be such that no leaks can form.

Fuel viscosity change

- The fuel must be frozen before flight for at least ten hours.
- If the fuel becomes solid, the aircraft is unairworthy for the purposes of cold-weather operation.
- If the fuel remains liquid, it is to be tested in the engine. If the engine cannot run for thirty minutes at a minimum, it is unairworthy for cold-weather operations.
- If the engine shows signs of excessive wear during or after the test, the aircraft is unairworthy for the purposes of cold-weather operations.
- All engine tests are intended to be performed on a test stand with an adequately large fuel tank. It is not relevant as to whether the design tank size of provides for a flight time commensurate with the required time to demonstrate normal engine operation. This section simply evaluates the ability of the engine and fuel to operate in cold environments.

5.4.3 (a). Battery performance degradation: maximum flight time in cold weather environments

Endurance	> 10 mins	> 7 mins	> 3 mins	< 3 mins
Risk points	0	20	40	Unairworthy for flights in cold environments

5.4.3 (b). Elastic material performance degradation

Elastic material performance	No elastic material used in airplane	Elastic material is present and can be used for 20 minutes and meet standards delineated in this section	Elastic material is present and cannot be used for 20 minutes	Elastic material fails in cold weather
Risk points	0	10	Unairworthy for flights in cold environments	Unairworthy for flights in cold environments

5.4.3 (c). Fuel viscosity change

Fuel performance degradation	No change in fuel and engine performance in cold environments	Fuel remains liquid and engine can run for a minimum of 30 minutes	Fuel remains liquid, but engine cannot be run for 30 minutes	Fuel forms into a gel or solid in cold environments
Risk points	0	20	Unairworthy for flights in cold environments	Unairworthy for flights in cold environments

The airworthiness status us found based on the reduced risk score:

- Less than 12: risk level 1
- Between 12 and 20: risk level 2
- Between 21 and 30: risk level 3
- Over 30: unairworthy

5.4.4 Aircraft to be flown in icing conditions – incidental exposure

Note that, as of the drafting of this manual in May 2020, there are several operations that CU has conducted in which icing conditions were encountered:

- S2 NIGHTFOX mission
- Datahawk flights in arctic environments
- Pilatus flights in Alaska

In each of these situations, the aircraft flew strictly in VMC but encountered icing, nonetheless. In turn, OISC needs to set standards for aircraft that are flown in environments where icing is a possibility.

This section applies to aircraft to be flown in situations where icing is possible, but extended operations in icing conditions are not expected. Under this certification scheme, the aircraft must leave icing conditions as soon as they are encountered.

No multirotor is permitted to fly in continuous icing conditions.

The following analysis must be completed, and the following features must be included:

- Analysis must be completed to characterize airframe icing, including:
    - Where ice will accumulate, how quickly, and in what conditions
    - Icing effects on lift and stall speed
    - Icing effects on drag and ability of propulsion system to propel aircraft at speeds needed to maintain level flight
    - Expected performance changes as ice accumulates must be included in the performance section of the POH.
    - Expected mass of ice accumulated in 5-minute icing encounter. The applicant must prove that the accumulated mass of ice does not exceed the lifting capacity of the airship.
    - Note: ANSYS CFD packages can analyze aircraft icing, albeit at the expense of significant time and computational resources.
- Structural effects of ice shedding. This includes the effects of ice shedding from propellers and the effects of ice shedding from other flight surfaces, such as wings.
- Detection system for ice. The aircraft must be equipped with sufficient ice detection sensors that can alert the flight crew at the earliest signs of ice accumulation on any part of the airframe.
- Ice effects on air data sensors. This analysis must investigate if, how, and to what extent air data measurements will be affected by ice buildup.
- Ideal maneuvers for exiting icing conditions. The aircraft further must be certified with a recommended procedure for the flight crew to execute if they encounter icing conditions. This procedure need not require that the flight crew land if ice accumulation diminishes after exiting the icing environments. However, this procedure must guide the flight crew in exiting the icing situation with minimal risk

For an aircraft to be certified as airworthy for flights into possible icing conditions, the following standards apply:

5.4.4 (a). Expected 5-minute ice accumulation mass in relation to maximum lifting capacity of airship

Total percentage of lifting capacity used with ice accumulated and MTOW	$< 85\%$	$< 90\%$	$< 95\%$	$> 95\%$
Risk points	0	15	40	Unairworthy

5.4.4 (b). Flight-critical structural damage that occurs from ice shedding (including from propellers, wing, horizontal stabilizer, vertical stabilizer, and all other flight surfaces):

Damage	No flight-critical structural damage	Flight-critical structural damage
Risk points	0	Unairworthy for flight in possible icing conditions

5.4.4 (c). Ice detection system: ability to accurately detect ice accumulation on all surfaces where icing may be encountered:

Detection ability	Accurately identifies ice accumulation and lack of ice accumulation in at least 99% of cases	Accurately identifies ice accumulation and lack of ice accumulation in at least 85% of cases	Accurately identifies ice accumulation and lack of ice accumulation in at least 75% of cases	Accurately identifies ice accumulation and lack of ice accumulation in less than 75% of cases
Risk points	0	20	40	Unairworthy for flight in possible icing conditions

5.4.4 (d). Ice effects on air data sensors:

Effect on sensors	Angle of attack, static pressure, total pressure accuracy unaffected by ice accumulation	Angle of attack, static pressure, total pressure accuracy affected by less than 5%	Angle of attack, static pressure, total pressure accuracy affected by less than 10%	Angle of attack, static pressure, total pressure accuracy affected by more than 10%
Risk points	0	20	40	Unairworthy for flight in possible icing conditions

5.4.4 (e). Icing condition exit strategy

Existence and thoroughness of icing condition exit strategy	Strategy exists and is through, specific, and comprehensive	Strategy exists but is insufficiently thorough, specific, and comprehensive, or does not exist
Risk points	0	Unairworthy for flight in possible icing conditions

The airworthiness status is determined based on the reduced risk score:

- Less than 5: risk level 1
- Between 6 and 12: risk level 2
- Between 13 and 24: risk level 3
- 25 or greater: unairworthy for flight in incidental icing environments

5.4.5 Fueled aircraft

The fuel tank must be located such that:

- The fuel tank will not touch the ground upon landing the aircraft
- There is adequate clearance between the fuel tank and propeller discs
- In the event of propeller structural failure, the fuel tanks are adequately protected from shrapnel
- All wiring is routed away from the fuel tank to minimize the chances of an ignition of fuel vapors in the event of malfunction of the wiring
- The aircraft's stability augmentation system can handle the differing center of gravity caused by fuel sloshing in the fuel tank
- Reliability and accuracy of fuel gauge

5.4.5 (a). Clearance between fuel tank and ground on smooth, level surface

Clearance	> 15 cm	> 10 cm	> 5 cm	< 5 cm
Risk points	0	10	30	Unairworthy

If the aircraft features sprung landing gear, this standard must be evaluated at the point where the distance is the smallest.

5.4.5 (b). Clearance between fuel tank and propeller discs

Clearance	> 3 cm	> 2 cm	> 1 cm	< 1 cm
Risk points	0	10	30	Unairworthy

Fuel tank protection: OISC requires adequate fuel tank protection in certain circumstances:

- If the aircraft is to be flown strictly VLOS and at a distance from the control station such that, in the event of a fuel tank fire, the fire can be extinguished by the ground crew within 90 seconds of the fire starting. This may be accomplished by any of the following methods: (a) keeping the aircraft close enough to the landed at the location of the ground crew within 90 seconds, (b) flying the aircraft at a distance such that it can be landed at a location away from the control station and reached by the crew within 90 seconds either on foot or using a vehicle.
- If the aircraft is flown BVLOS or the 90-second criterion cannot be realistically met, the following fuel tank protection standards apply: the fuel tank must be positioned and

protected such that, in normal flight, there is negligible risk of the fuel tank becoming punctured. OISC recommends the following fuel tank protections:

- The fuel tank must be located such that shrapnel from the propulsion system is not likely to impact the fuel tank in the event of a structural failure of any component of the propulsion system.
- The fuel tank should feature some protection such as Kevlar, ballistic foam, or some other protection that OISC deems appropriate to prevent rupture of the fuel tank by shrapnel.
- The fuel tank must be oriented such that, if a puncture were to form in any location on the fuel tank, fuel would not leak onto any potential ignition source.
- OISC requires that the fuel tank meet the following crashworthiness requirements, in that the fuel tank does not rupture under the following loads:
    - 4G upward
    - 16G forward
    - 8G sideward
    - 20G downward
    - 1.5G rearward

5.4.5 (c). Fuel tank protection risk points

Fuel tank protection standards	Standards met	Standards not met
Risk points	0	Unairworthy

Wire routing: the following standards apply for wire routing in proximity to the fuel system, which reply regardless of the current carried by the wire or the potential difference the wire is at relative to chassis ground:

- No wires may pass through the fuel tank, including for the purpose of measuring the level of fuel in the tank.
    - Fuel gauges are required in certain circumstances. OISC expects that this will be accomplished by using a float-type device which actuates a sensor located outside of the fuel tank.
- No wires pay pass within 5 cm of any part of the fuel system where fuel vapors could be present, including fuel filling ports and joints between various components in the fuel system

5.4.5 (d). Wire routing risk points:

Wire routing standards	Wire routing standards met	Wire routing standards not met
Risk points	0	Unairworthy

5.4.5 (e). Fuel slosh and aircraft stability/controllability:

- The aircraft stability, including the stability augmentation system if applicable, must be flight-tested at a level of fuel where the fuel sloshing could result in the maximum change in center of gravity
- The aircraft must be free of undesirable flight characteristics due to fuel sloshing, as assessed by the following risk points table:

Flight characteristics	Flight characteristics are comparable to that of a rigid-body aircraft	Some undesirable flight characteristics introduced, such as well-damped oscillation	Substantial undesirable flight characteristics introduced, such as moderately damped oscillation	Significant undesirable flight characteristics introduced, such as lightly damped oscillations
Risk points	0	15	40	Unairworthy

5.4.5 (f). Fuel hose routing: the fuel hoses must be positioned and protected such that friction between the hose and the aircraft structure cannot gradually wear through the tubing. This means that:

- The fuel tubing may not be routed across any sharp corners
- The tubing may not be routed across rough or sharp materials
- The tubing must be bent according to manufacturer specifications

Tubing standards	Tubing standards met	Tubing standards not met
Risk points	0	Unairworthy

5.4.5 (g). Fuel gauge reliability: all aircraft with a maximum takeoff weight over 15 pounds and powered by a fueled propulsion system must have fuel gauges which meet the following specifications:

- The gauges can accurately identify the quantity of usable onboard the aircraft fuel during steady, level, unaccelerated flight.
- The accuracy standards apply to all fuel levels; the fuel gauges must be accurate at all ranges of usable fuel, from empty to full fuel.
- The accuracy of the fuel gauge is assessed as follows:

Accuracy of fuel gauge	$\pm 3\%$ or better	$\pm 5\%$ or better	$\pm 10\%$ or better	Worse than $\pm 10\%$
Risk points	0	10	20	Unairworthy

Except for pressurized fuel systems, the fuel tanks must be vented to allow for air to enter the fuel tanks as fuel is burned. The fuel vent(s) must be positioned such that there is a minimal risk of the vents being clogged by ice or foreign object debris.

5.4.5 (h). Fuel vent risk points

Fuel vent standards	Fuel vent standards met	Fuel vent standards not met
Risk points	0	Unairworthy

The airworthiness status is assessed based on the reduced risk score:

- Between 0 and 5: risk level 1
- Between 5 and 10: risk level 2
- Between 10 and 15: risk level 3
- Over 15: unairworthy

5.4.6 Aircraft to be flown in aerial chase operations

UAS control placement. If the UAS control station is located inside the manned chase aircraft, the UAS control station must be located such that the following requirements are met:

- The UAS control station must not obstruct the flight controls of the chase aircraft
- The UAS control station must not obstruct the manned pilot’s view of the flight instruments, avionics, radio, transponder, trim system, flap actuator, landing gear actuator, or any other aircraft system that the manned PIC deems necessary for safe flight.
- The UAS control station must not restrict the manned pilot’s access to manipulate the flight instruments, avionics, radio, transponder, trim system, flap actuator, landing gear actuator, or any other aircraft system that the manned PIC deems necessary for safe flight.
- The UAS control station, and the location of the seat for the UAS crew must be located and have weights such that the chase aircraft’s maximum takeoff weight and CG limits are not exceeded.

5.4.6 (a). Risk points for UAS control station are assessed as follows:

UAS control location within aircraft	Inapplicable as UAS control station is located on the ground	In-aircraft UAS control station placement meets requirements	In-aircraft UAS control station placement meets
Risk points	0	0	Unairworthy for aerial chase operations

UAS control station power draw. If the UAS control station requires power from the chase aircraft, the following standards must be met:

- The risk points must be assessed based on the power draw per the table below. The power may not exceed 75% of the excess power generated by the airplane's alternator/generator system.
- The PIC of the manned aircraft must have a switch to immediately disconnect the power supply from the manned aircraft.
- The UAS control station must have a backup power source to allow for enough time to land the aircraft in the event of power failure from the manned aircraft.

5.4.6 (b). Power draw as a fraction of excess generated power:

Power draw	Inapplicable as no power from aircraft is required	50% of excess generated power or less	75% of excess generated power or less	Exceeds 75% of excess generated power
Risk points	0	15	30	Unairworthy for aerial chase operations

5.4.6 (c). Power disconnect and backup power standards:

Standards met	Met	Not met
Risk points	0	Unairworthy for aerial chase operations

UAS control station electronic interference with manned aircraft systems. The UAS may not transmit on frequencies which would interfere with any of the following aircraft systems:

- Communication radios
- Navigation radios
- Transponder
- Automatic dependent surveillance broadcast (ADS-B)
- GPS
- WiFi or Bluetooth connections between avionics and electronic flight bag systems
- Any other system the manned aircraft PIC deems essential for safe flight

The applicant must demonstrate that:

- Their radio systems meet all requirements laid out by the FCC or, if flying internationally, the appropriate government authority.
- Their radio systems do not interfere with aircraft systems delineated above.

5.4.6 (d). Radio systems risk points:

Radio interference standards met	Met	Not met
Risk points	0	Unairworthy for aerial chase operations

5.4.6 (e). Manned aircraft collision avoidance: presence of onboard systems to prevent loss of separation between chase aircraft and UAS

Method to maintain separation	UAS automatically makes evasive maneuver if separation with manned aircraft may be lost	Reliant on crew of each aircraft to maintain separation with alert for low separation presented to both crews	Reliant on crew of each aircraft to maintain separation with alert for low separation presented to UAS crew only	Reliant on crew of each aircraft to visually maintain separation
Risk points	0	30	70	95

5.4.6 (f). Crew communications between manned crew and UAS crew

Crew communication system	Crew co-located in cockpit and can speak over aircraft intercom	2-way radio communication which does not require push-to-talk	2-way communication which requires push-to-talk
Risk points	0	20	40

5.4.6 (g). Crew communication: manned sterile cockpit procedures. Any communication between the UAS crew and between the UAS crew and manned aircraft crew must conform to sterile cockpit procedures observed in the manned aircraft. This means that these communication systems must conform to the following standards:

- At any time that the manned aircraft PIC determines that sterile cockpit procedures must be observed, the UAS crew communication system must be configurable such that the manned aircraft crew cannot hear chatter between the UAS crew.
- During times which the manned aircraft crew is observing sterile cockpit procedures, there must be a means for the UAS crew to interject to communicate any flight-critical information to the manned crew. The previous requirement to ensure the manned crew is not exposed to general unmanned crew chatter still applies.

Sterile cockpit standards	Standards met	Standards not met
Risk points	0	Unairworthy

The airworthiness status is found based on the reduced risk score:

- Less than 5: risk level 1
- Between 6 and 15: risk level 2
- Between 16 and 22: risk level 3
- Greater than 26: unairworthy for aerial chase operations

5.4.7 Structural standards for rigid and semi-rigid airships

5.4.7 (a). Minimum safety factor in any member of structure supporting airship bag

Value of FS	$FS > 1.5$	$FS > 1.25$	$FS > 1.15$	$FS < 1.15$
Risk points	0	15	30	Unairworthy

5.4.7 (b). Rigidity: the airship must not deform so much to change the location of the center of mass and center of buoyancy in a manner which adversely effects stability, dynamics, and control.

Rigidity standards	Met	Not met
Risk points	0	Unairworthy

5.4.7 (c). Fin structures: minimum safety factor in spar/rib section

Value of FS	$FS > 1.5$	$FS > 1.25$	$FS > 1.15$	$FS < 1.15$
Risk points	0	15	30	Unairworthy

5.4.7 (d). Fin structures: maximum torsional displacement at outboard end of fin during normal flight loads

Change in angle $\Delta\theta$	$\Delta\theta < 1$	$\Delta\theta < 2^o$	$\Delta\theta < 3^o$	$\Delta\theta > 3^o$
Risk points	0	10	20	Unairworthy

5.4.7 (e). Fin structures: maximum beam-bending deflection angle under normal flight loads

Change in angle $\Delta\theta$	$\Delta\theta < 3$	$\Delta\theta < 5$	$\Delta\theta < 7^o$	$\Delta\theta > 7$
Risk points	0	10	20	Unairworthy

5.4.7 (f). Mounting with bag structure: the rigid part of the airship structure must mount with the bag in a manner which meets the following criteria:

- The possibility of leaks, tears, or punctures must be as low as practicable.
- Stress concentrations must be such that a minimum safety factor of 1.2 is maintained in the area of the bag where it mounts to rigid structures.
- The bag must maintain a tight seal.

Bag mounting criteria	Standards met	Standards not met
Risk points	0	Unairworthy

The airworthiness status is found based on the reduced risk score:

- Between 0 and 5: risk level 1
- Between 6 and 10: risk level 2
- Between 11 and 17: risk level 3
- Greater than 17: unairworthy

5.4.8 Structural standards for non-rigid airships

5.4.8 (a). Rigidity: the airship must feature corrugation or some other feature to maintain adequate rigidity of the bag. This must be such that, during any flight condition expected to be encountered in normal operations, the center of mass and center of buoyancy must not be moved in a manner which adversely effects stability, dynamics, and control.

Rigidity standards	Met	Not met
Risk points	0	Unairworthy

5.4.8 (b). Fin rigidity: maximum change in angle of incidence of fin from design value during normal flight loads.

Change in angle $\Delta\theta$	$\Delta\theta < 1^o$	$\Delta\theta < 2^o$	$\Delta\theta < 3^o$	$\Delta\theta > 3^o$
Risk points	0	10	20	Unairworthy

5.4.8 (c). Structural vibration: in normal flight and with light turbulence, the aircraft must be free of structural oscillations which interfere with controllability or pose a risk of structural damage.

Structural oscillation qualities	No significant structural oscillation is encountered during any flight regime	Some structural oscillation is observed in normal flight with no adverse effect on stability or controllability and no structural damage	Structural oscillations occur at the extremes of the flight envelope with adverse effects on controllability or stability. In this case, the POH must alert the crew as to what regimes these oscillations occur in	Structural oscillations occur during any regime of flight which adversely affect stability or controllability, or oscillations cause structural damage
Risk points	0	40	80	Unairworthy

5.4.8 (d). Minimum factor of safety in bag material considering pressure-vessel loads and loads from fins, gondola, propulsion, etc.

Value of FS	$FS > 1.5$	$FS > 1.25$	$FS > 1.15$	$FS < 1.15$
Risk points	0	15	30	Unairworthy

5.4.8 (e). Gondola mount: the gondola must be mounted such that the following criteria are met:

- Possibilities of leaks, punctures, and tears are minimized.
- There is a smooth transition between the bag material and rigid gondola, such as by incorporating a thicker bag material near the gondola

Gondola mount standards	Standards met	Standards not met
Risk points	0	Unairworthy

The airworthiness status is found based on the reduced risk score:

- Between 0 and 10: risk level 1
- Between 11 and 15: risk level 2
- Between 16 and 26: risk level 3
- Greater than 26: unairworthy

5.4.9 Aircraft to be flown in conditions conducive to lightning

This applies to aircraft operating in conditions which are at an elevated risk of lightning. This includes flights within 10 miles of thunderstorms, flights in precipitation, flights such that the outside air temperature is 0 ± 5 degrees Centigrade, altitudes between 5000 and 15000 feet MSL.

This section contains guidelines for how to make an aircraft safe for operations in this environment. The guidelines are not mandatory to implement.

- Wire shielding: all wire bundles with more than 3 conductors should be shielded with a conductive sleeve.
- Ground straps: the common electrical ground must be connected to the aircraft chassis, which is defined as a any major metallic component of the aircraft structure.
- If the airplane is constructed of nonconductive materials, the exterior of the aircraft should be coated in a conductive material (such as an aluminum foil or mesh) so as to form a Faraday cage around the aircraft.
- Static wicks should be placed long the trailing edges of the aircraft to dissipate any electrical charges that build up during flight. It is recommended that these static wicks have a resistance of 2-600 MΩ.
- For any electronic system which, if failed, would result in immediate flight termination, the following standards should to be met:
    - The power delivery circuitry must ensure that the voltage and current are limited to values such that no damage is done to the electronics.
    - If, even given the precautions in the power delivery circuitry, there is a risk of failure of any critical systems, then two backup systems are required.

These standards are to be interpreted as recommendations and not hard requirements. Ultimately, whether or not the aircraft is airworthy is determined by demonstration. The applicant must fly their aircraft in a location far from people and in weather conditions conducive to lightning.

The aircraft will be rendered airworthy if:

- All of the aircraft’s functionality is maintained during the flight
- No electronic components are damaged after the flight
- No backup systems are needed to safely execute the flight.

5.1.12 (a). Results from flight test

Standards met?	Standards met	Standards not met
Risk points	0	Unairworthy

Part 6: Standards for Payloads

6.1 Applicability

This section does not apply to payloads that meet all the following requirements:

- The payload does not change the external aerodynamic shape of the aircraft in any way.
- The payload does not require the aircraft CG to be located outside of the certificated CG limits, and the payload does not require the aircraft gross weight to exceed the maximum certificated gross weight.
- The payload does not draw power from the aircraft flight battery or any aircraft electrical systems.
- They payload does not interface with any onboard aircraft systems, including GPS, servos, autopilot or stability augmentation system, flight controls, radio systems, or any internal aircraft bus.
- Payloads that are entirely self-contained and not reliant on any aircraft systems.

For a payload to be certified as airworthy, an existing aircraft onto which it will be mounted must be identified. This aircraft must be airworthy as per the relevant section of this manual.

6.2 Requirements

6.2.1 Aerodynamics Changes

This section evaluates any changes to the aircraft's aerodynamics made by the payload.

6.2.1.1 Stability Changes

If the payload changes any of the following, the aircraft stability must be re-evaluated per the relevant part of section 4.2 of this manual:

- Change of moment arm length of any aerodynamic surface.
- Addition of any aerodynamic surface, including contributions from sensors and other apparatuses that are not designed to function as aerodynamic surfaces but have that effect anyway.
- Change in control deflections.
- Substantial changes to the shape of the aircraft which may affect downwash, blanketing of control surfaces, or otherwise influence the stability of the aircraft.

6.2.1.2 Performance Changes

If the payload changes any of the following, the aircraft performance must be evaluated per the relevant part of section 4.2 of this manual:

- Changes to the total wetted area of more than 5%
- Changes to induced drag as effected by a change in aspect ratio or span efficiency factor of lifting surfaces
- Addition of any aerodynamic features that will increase drag

Further, range and endurance of the aircraft must be re-evaluated with the new aerodynamics at various power settings.

6.2.2 Weight and Balance Changes

This section evaluates any changes to the weight and balance of an aircraft, as affected by the payload.

6.2.2.1 Center of Gravity Changes

If the payload moves the center of gravity outside of the design forward and aft limits, or if the CG is moves substantially (more than 5% of the aircraft's maximum vertical dimension) in the vertical direction, the aircraft stability and controllability must be re-evaluated per the relevant part of section 4.2 of this manual. If satisfactory stability and handling characteristics cannot be achieved with the payload, two possibilities exist:

- The payload is unairworthy.
- The aircraft must be modified to provide acceptable stability and controllability, in which case a supplemental type certificate will be issued.

Satisfactory dynamics and handling means that the aircraft meets dynamics and handling airworthiness requirements.

6.2.2.2 Weight Changes

If the weight is increased beyond the maximum certificated gross weight, the aerodynamic performance and structural performance need to be re-evaluated per the relevant part of section 4.2 of this manual.

If the aircraft cannot meet these airworthiness requirements, two possibilities exist:

- The payload is unairworthy.
- The aircraft must be modified to provide acceptable structural and aerodynamic performance, in which case a supplemental type certificate will be issued.
- The range and endurance must be re-evaluated with the new range of maximum takeoff weights.

6.2.3 Power Draw Changes

A payload may draw power from the main flight battery only if the following certification standards are met:

- They payload power draw does not exceed 10% of the power used by the propulsion system at full throttle.
- With full thrust and maximum payload power draw, the battery voltage may not drop more than 5% compared to full thrust and no payload power draw.
- Flight test is conducted to determine new values for range and endurance at various power settings, assuming maximum possible payload power draw.

- The payload power must be able be remotely disconnected by the pilot.
- The payload power draw must be able to be monitored from the ground using telemetry.

A payload may draw power from an alternator or generator driven by the aircraft's fuel-burning engine if the following certification standards are met:

- While operating at no more than 80% of the design limit amperage, the alternator must be able to power the payload at maximum possible power draw and all aircraft systems at maximum possible power draw.
- The payload power must be able to be remotely disconnected by the pilot.
- The payload power draw must be able to be monitored from the ground using telemetry.

If these requirements cannot be met, the payload must be powered with its own independent power system.

6.2.4 Aircraft Systems Interface Changes

If the payload interacts with the flight control surfaces, the following analyses and tests must be completed:

- The payload must not have any adverse effect on aircraft controllability. In turn, the payload must not limit the deflection of control surfaces in any way. Further, if the payload will substantially change the aircraft's inertia tensor, the effectiveness of the flight controls needs to be revaluated.
- Flight test must be conducted in order to verify that any control authority Cooper-Harper score is within 1 point of the original Cooper-Harper score (meaning without a payload).

If the payload interfaces with any aircraft state estimation systems, including (a) GPS, (b) the pitot-static system, or (c) IMU, the following certification standards must be met:

- The payload accessing the state estimation sensors must not interfere with the aircraft autopilot or stability augmentation system's ability to access data from the state estimation sensors.
- The power for the state estimation sensors must be provided by the aircraft and not from the payload.

If the payload interfaces with the aircraft autopilot or stability augmentation system insofar as issuing commands to these systems, the following certification standards apply:

- The payload must be rigorously tested to ensure the commands it sends to the airplane will not cause a loss of control, and that the PIC can always override automated commands.
- The payload must be able to be switched off outright from the ground by the PIC if the payload sends erroneous commands to the airplane.

If the payload relies on using the aircraft radio system, the following certification standards apply:

- The payload’s use of the command and control bandwidth must be such that adequate bandwidth is still available to control the airplane without any loss of performance compared to the configuration without the payload using bandwidth.
- If adequate bandwidth is not available to meet this standard, a separate communications system must be used to communicate with the payload. This secondary communications system must use a different carrier frequency than the aircraft command and control carrier frequency.

They payload may not transmit on the 2.4GHz carrier frequency used by the command and control system.

Part 7: Standards for Modified and Repaired Aircraft

7.1 Applicability

This standard applies to aircraft that are modified in any way from their original state, as well as certain repairs. This includes all modifications, no matter how small.

Routine repairs, maintenance, and replacement of components may be completed by the user without alerting OISC or the Director of Flight Operations. Routine maintenance includes:

- Inspecting, servicing, or replacing components per manufacturer or type certificate guidelines.
- Replacement of common wear items, such as landing gear and propellers.
- Firmware updates.

For a modified aircraft to be certified as airworthy, the unmodified aircraft must meet the applicable airworthiness standards delineated in this manual.

Aircraft modified per a modification specifically mentioned on the aircraft's type certificate need not be subjected to these certification standards.

When a proponent wishes to certify a modified aircraft, they must contact the Director of Flight Operations. The DO must use their best judgement, in conjunction with the guidelines below, to determine which course of certification is most appropriate:

- Extremely minor modifications. For these cases, the DO, or an airworthiness assessor, may certify the modified aircraft as airworthy without inspection, and without issuing an additional certificate of any kind.
    - Addition of aircraft lights with less than 100mA of current draw.
    - Minor change of landing gear, such as change of tire size that does not interfere with any other aircraft components
- Small modifications. In these cases, OISC will issue the proponent OISC Form 337 to certify that the aircraft is repaired properly or of that the modifications are airworthy. This applies to small modifications to the aircraft which do not affect stability, do not add a significant load to the structure, and do not significantly affect the aerodynamics of the aircraft. This includes:
    - Addition of aircraft lights, or any other device which increases power draw from the aircraft by more than 100mA.
    - Major repair after an accident that causes significant structural damage.
    - Major changes to the landing gear, such as the addition of landing gear shrouds. If the structure of the landing gear is affected, supplemental type certification is needed.
    - Changes to aircraft controllability by means of altering deflections of existing control surfaces. Any alteration of aircraft controllability which involves the change of physical dimensions of control surfaces must be certified using a supplemental type certificate.
- Supplemental type certification. This applies to large modifications to the aircraft, but not significant enough changes to warrant applying for a new type certificate. Changes that are appropriate for a supplemental type certificate include:

    - Changes to the powerplant output power or powerplant type, such as using a larger electric motor or replacing an electric motor with a reciprocating motor.
    - Changes to aircraft stability and control characteristics, such as changing the size of aerodynamic surfaces, addition of aerodynamic surfaces, or changes in the size of control surfaces. The overall handling characteristics must comparable or better than the original aircraft.
    - Changes which effect aircraft performance, such as the addition of winglets, wingtip devices on propellers, high-lift devices, or lift-dumping devices, STOL kits, the addition of vortex generators, or increases in fuel/battery capacity.
    - Changes to the aircraft's electronics, avionics, autopilot, or stability augmentation system.
    - Changes to the aircraft maximum takeoff weight, not to exceed 15% of the originally certified maximum takeoff weight, provided the structure can withstand this additional weight and meet minimum safety factor requirements delineated in section 4.2.
- Application for a new type certificate. This applies to modifications which are larger than is appropriate for an STC, including:
    - Changes to the number of powerplants or number of propellers on the aircraft.
    - Substantial changes to the aircraft stability, including changes to the dynamic modes of the aircraft, and worsened dynamic handling characteristics.
    - Substantial changes to aircraft handling characteristics.
    - Changes to the aircraft's maximum takeoff weight by more than 15% compared to the original type certification.
    - Changes which would increase the aircraft's stall speed in a clean configuration (if applicable) by more than 15% compared to the original type certificate.
    - Any changes which would increase the minimum controllable speed of the aircraft.
    - Any changes which would stress the structure beyond its certificated limitations.

Which of these certification routes is appropriate for a given application is ultimately determined by the DO within the framework of these guidelines.

7.2 Standards for Small Modifications

To issue OISC form 337 to certify the airworthiness of a repaired or lightly modified aircraft, the proponent must present the aircraft to OISC for inspection.

Repaired Aircraft

After a major repair, OISC must inspect the repaired aircraft to ensure that the following standards are met:

- The repaired aircraft matches the requirements of the type certificate.
- The aircraft's structure can withstand the same loads as the original structure without yielding or excessive deformation.
- The repair is completed with a high degree of craftsmanship:

  - All parts must fit as designed: flush joints must be flush to one another; orthogonal joints must be orthogonal. Parts must not misfit such that unwanted aerodynamic features are introduced, such as unwanted geometric twist or unwanted dihedral. All tolerances must be within manufacturer-determined acceptable ranges.
  - All adhesive and fasteners must be applied in all areas that require adhesive or fasteners. All adhesive and fasteners used must be appropriate to the application. For example, if CA is used despite a manufacturer's recommendation to use epoxy, the adhesive would not be appropriate.
  - The repair must be completed using manufacturer-recommended parts and procedures where applicable.
  - Any structural repairs must include doubler plates or other additional structural material, if needed to maintain the same structural features as the originally certified design. It is not acceptable for a repaired structure to be weaker than the structure on the original type-certificated aircraft. This additional mass must be accounted for in the permissible aircraft weight and balance.
  - The overall repair job must be of high quality.

Note that it is entirely possible for an aircraft to be unairworthy after having undergone a major accident if the above stipulations cannot be met.

Modified Aircraft

The standard for certifying the airworthiness of modified aircraft are characterized by ensuring not that the modifications are effective, but that they are safe and do not render the aircraft unairworthy.

The standards for each category of modification are delineated below:

Added electronic devices:

- The current drawn by any additional payload must not exceed 10% of the power used by the propulsion system if the aircraft uses an electric propulsion system, or no more than 500mA of current draw without using an additional battery to power the new electronics. If the aircraft does draw power from the main flight battery on an electrically propelled aircraft, flight test must be conducted to determine the new maximum flight time.
- These electronics may not transmit on any carrier frequencies required to control the aircraft unless they are intended to augment or replace the existing radio system.
- All weight-and-balance limitations still apply.
- The electronics must be placed such that the changes to the aircraft do not significantly affect the aerodynamics of the aircraft.
- All additional wires must be carefully managed to avoid interference with any moving parts on the airplane.

Aerodynamic changes:

- All aerodynamic changes must be such that either drag is reduced, or that drag is increased by a negligible amount.

- Flight test must be conducted to find a new value for maximum endurance if aerodynamic changes are made.

Controllability changes

- Any changes must be such that the aircraft controllability is increased. This means that is acceptable, for instance, to increase the maximum pitch and bank angles of a quadcopter or to increase the deflection of an airplane's elevator. It is not acceptable to decrease any of these quantities.
- Exponential and/or dual rates must be added to the controller such that there is not a risk of overcontrolling the aircraft when subtle control inputs are needed, such as during landing.

7.3 Supplemental Type Certification

To issue a supplemental type certificate certifying the airworthiness of a heavily modified aircraft, the proponent must present the aircraft to OISC for inspection.

The standard for supplemental airworthiness certificates is characterized by ensuring that the modifications are effective, not that they are effective.

When a supplemental type certificate is requested, OISC must re-evaluate the aircraft's airworthiness as per the relevant section 4.2 of this manual. Only the relevant parts of section 4.2 need to be evaluated; airworthiness standards unaffected by the design change do not need to be evaluated.

A new set of operating limitations, a new pilot's operating handbook, and a new checklist (if the STC changes the requirements for the checklist) must be published. Similarly to certification of entirely novel aircraft, these documents must be developed bilaterally between the proponent and OISC; OISC must unilaterally approve these documents.

Part 8: Flying Difficulty Evaluation

Flying difficulty evaluation criteria apply independently of aircraft origin or the type of use.

8.1 Airplanes

8.1 (a). Phugoid mode characteristics

Damping ratio	$\zeta \geq 0.04$	$0 \leq \zeta < 0.04$	$T_2 > 25$ seconds	$T_2 \leq 25$ seconds
Risk points	0	10	20	50

In-flight test of mode: introduce a pitch rate disturbance using the elevator or using the combination of control inputs calculated in the experimental certification process. Verify that the resulting motion of the aircraft is commensurate with expectations.

8.1 (b). Short period mode characteristics

Damping ratio	$\zeta > 0.35$	$\zeta > 0.25$	$\zeta > 0.15$	$\zeta < 0.15$
Risk points	0	5	10	30

In-flight test of mode: introduce a disturbance using the combination of control inputs calculated in the experimental certification process. If the short-period mode is expected to be unstable, this should only be done at the PIC's discretion and at a high altitude. Verify that the resulting motion of the aircraft is commensurate with expectations.

8.1 (c). Dutch roll mode characteristics

Damping ratio	$\zeta > 0.4$	$\zeta > 0.19$	$\zeta > 0.08$	$\zeta < 0.08$
Risk points	0	10	20	50

In-flight test of mode: introduce a sideslip disturbance using the rudder or using the combination of control inputs calculated from the airplane analysis application. Verify that the resulting motion of the aircraft is commensurate with expectations.

8.1 (d). Spiral mode characteristics

Doubling time	$T_2 > 12$ seconds	$T_2 > 8$ seconds	$T_2 > 4$ seconds	$T_2 \leq 4$ seconds
Risk points	0	5	10	30

In-flight test of mode: introduce a disturbance according to calculations from the airplane analysis app. Verify that the resulting motion of the aircraft is commensurate with expectations.

8.1 (e). Roll mode characteristics

Time constant	$\tau < 1.4$ seconds	$\tau < 3$ seconds	$\tau < 10$ seconds	$\tau \geq 10$ seconds
Risk points	0	5	10	30

In-flight test of mode: introduce a disturbance according to calculations from the airplane analysis app. Verify that the resulting aircraft motion is commensurate with expectations.

8.1 (f). Static pitch stability/pitch stiffness

Value of $C_{m\alpha}$	$C_{m\alpha} < 2$	$C_{m\alpha} < 1$	$C_{m\alpha} < 0$	$C_{m\alpha} \geq 0$
Risk points	0	5	20	Unairworthy

Introduce an angle of attack disturbance with the elevator and note the initial reaction of the aircraft. Ensure this is commensurate with expectations based on the value of $C_{m\alpha}$.

8.1 (g). Gust sensitivity/static roll stability/roll stiffness

Value of $C_{l\beta}$	$C_{l\beta} < -0.12$	$C_{l\beta} < -0.06$	$C_{l\beta} < 0$	$C_{l\beta} \geq 0$
Risk points	0	5	20	80

Introduce a sideslip disturbance with the rudder and note the initial reaction of the aircraft. Ensure this is commensurate with expectations based on the value of $C_{l\beta}$.

8.1 (h). Static yaw stability/yaw stiffness

Value of $C_{n\beta}$	$C_{n\beta} \geq 0.085$	$C_{n\beta} \geq 0.05$	$C_{n\beta} > 0$	$C_{n\beta} \leq 0$
Risk points	0	5	40	Unairworthy

Introduce a sideslip disturbance with the rudder and note the initial reaction of the aircraft. Ensure this is commensurate with expectations based on the value of $C_{n\beta}$.

8.1 (i). Maximum roll rate

Value of p_{max}	$p_{max} < 20^o$/s	$20 \leq p_{max} \leq 100^o$/s	$100 < p_{max} \leq 300^o$/s	$p_{max} > 300^o$/s
PIC control authority evaluation	Inadequate; Cooper-Harper ≥ 6	Acceptable; Cooper-Harper ≥ 4	Good; Cooper-Harper ≥ 2	Sensitive; Cooper-Harper ≥ 5
Risk points	Unairworthy	20	0	50

Introduce full aileron in either direction and note the resulting motion. Ensure it is commensurate with the value of p_{max} calculated in the aircraft analysis application.

8.1 (j). Initial roll acceleration at reference approach speed with maximum aileron deflection

Value of $\dot{p}_{init}$, degrees/second squared	$\dot{p}_{init} < 3500$	$\dot{p}_{init} < 4500$	$\dot{p}_{init} < 5500$	$\dot{p}_{init} > 5500$
PIC control authority evaluation	Inadequate; Cooper-Harper ≥ 6	Acceptable; Cooper-Harper ≥ 4	Good; Cooper-Harper ≥ 2	Sensitive; Cooper-Harper ≥ 5
Risk points	Unairworthy	20	0	50

Introduce full aileron in either direction and note the resulting notion. Ensure it is commensurate with the calculated value of $\dot{p}_{init}$.

8.1 (k). Pitch control authority, down elevator: value of $\dot{q}_{init}$, initial time rate of change of pitch rate with maximum up-elevator deflection at approach speed.

Value of $\dot{q}_{init}$, degrees/second squared	$\dot{q}_{init} < 3500$	$\dot{q}_{init} < 4500$	$\dot{q}_{init} < 5500$	$\dot{q}_{init} > 5500$
PIC control authority evaluation	Inadequate; Cooper-Harper ≥ 6	Acceptable; Cooper-Harper ≥ 4	Good; Cooper-Harper ≥ 2	Sensitive; Cooper-Harper ≥ 5
Risk points	Unairworthy	20	0	50

Introduce full down elevator and note the resulting motion. Ensure it is commensurate with the calculated value of $\dot{q}_{init}$.

8.1 (l). Pitch control authority, up elevator: value of $\dot{q}_{init}$, initial time rate of change of pitch rate with maximum down-elevator deflection at approach speed.

Value of $\dot{q}_{init}$, degrees/second squared	$\dot{q}_{init} < 300$	$\dot{q}_{init} < 600$	$\dot{q}_{init} < 1000$	$\dot{q}_{init} > 1000$
PIC control authority evaluation	Inadequate; Cooper-Harper ≥ 6	Acceptable; Cooper-Harper ≥ 4	Good; Cooper-Harper ≥ 2	Sensitive; Cooper-Harper ≥ 5
Risk points	Unairworthy	0	20	50

Introduce full up elevator and note the resulting motion. Ensure it is commensurate with the calculated value of $\dot{q}_{init}$.

8.1 (m). Crosswind handling – Cooper-Harper score for crosswind handling

Cooper-Harper score CH	$CH < 3$	$CH \leq 4$	$CH \leq 6$	$CH > 6$
Risk points	0	10	20	Unairworthy

8.1 (n). Crosswind handling – Cooper-Harper score for rudder control authority

Cooper-Harper score CH	$CH < 3$	$CH \leq 4$	$CH \leq 6$	$CH > 6$
Risk points	0	10	20	Unairworthy

8.1 (o). Landing reference speed (evaluate at angle of attack of 6 degrees, maximum landing weight)

Value of V_{ref}	$V_{ref} < 10$ m/s	$10 \leq V_{ref} <$ 14 m/s	$14 \leq V_{ref} < 20$ m/s	$V_{ref} \geq 20$ m/s
Risk points	0	10	20	50

Flight test: conduct a normal approach and landing (3-degree glideslope, roughly 1-degree nose-up pitch) and evaluate the speed.

8.1 (p). Stall handling – wing drop

Stall behavior	Wing stalls at root first; no significant wingtip drop	30-degree or less wingtip drop	60-degree or less wingtip drop	More than 60 degrees of wingtip drop
Risk points	0	5	10	20

Flight test: perform a stall from a level attitude and observe wing drop. Note the stall behavior on the airworthiness certificate. Note the stall handling characteristics on the airworthiness certificate.

8.1 (q). Required landing distance on design landing surface, including flare

Required landing distance d	$d < 35$ m	$d < 70$ m	$d < 100$ m	$d > 100$ m
Risk score	0	20	40	80

This is defined as the distance traveled by the aircraft from reaching an altitude of one wingspan above the ground to coming to rest at the end of the ground roll.

8.1 (r). Required landing distance on design landing surface, rollout only

Required landing distance d	$d < 20$ m	$d < 55$ m	$d < 75$ m	$d > 75$ m
Risk score	0	20	40	80

8.1 (s). Rudder control authority: Cooper-Harper score for rudder ability to counteract engine torque effect. This test should be conducted based on the pilot skill/concentration required to maintain centerline during takeoff at full power.

Cooper-Harper score	$CH < 3$	$CH \leq 4$	$CH \leq 6$	$CH > 6$
Risk points	0	10	20	Unairworthy

8.1 (t). Airplane slipperiness quantification: drag coefficient at 6 degrees angle of attack

Drag coefficient C_D	$C_D \geq 0.6$	$C_D > 0.05$	$C_D > 0.042$	$C_D < 0.035$
Risk points	0	10	25	50

The airport flying difficulty rank R is based on the sum of the risk points S and is computed using the following formula: $R = 0.003S + 1$ and rounding to the nearest integer.

8.2 Multirotors

8.2 (a). Position-hold performance: maximum deviation from target position in any direction in smooth air

Deviation	$< 10\text{cm}$	$< 20\text{cm}$	$< 30\text{cm}$	$> 30\text{cm}$
Risk points	0	5	10	Unairworthy

8.2 (b). Position-hold performance: position hold Cooper-Harper score

Cooper-Harper score	2 or better	4 or better	6 or better	Worse than 6
Risk points	0	15	40	Unairworthy

8.2 (c). Attitude-hold performance: maximum angular deviation from target attitude in either direction (pitch or roll)

Deviation	$< 2^o$	$< 4^o$	$< 6^o$	$> 6^o$
Risk points	0	20	40	Unairworthy

8.2 (d). Attitude-hold performance: attitude-hold Cooper-Harper score

Cooper-Harper score	2 or better	4 or better	6 or better	Worse than 6
Risk points	0	15	40	Unairworthy

8.2 (e). Disturbance rejection: position-hold performance: maximum deviation from target position in any direction in light turbulence

Deviation	$< 15\text{cm}$	$< 30\text{cm}$	$< 45\text{cm}$	$> 45\text{cm}$
Risk points	0	10	20	90

8.2 (f). Disturbance tracking: position-hold performance: Cooper-Harper score in light turbulence

Cooper-Harper score	2 or better	4 or better	6 or better	Worse than 6
Risk points	0	15	40	Unairworthy

8.2 (g). Control tracking: aircraft stability augmentation response to control inputs

Response characteristics	Critically or over-damped	Well-damped	Lightly damped	Extremely lightly damped
Risk points	0	10	40	60

8.2 (h). Control tracking: aircraft stability augmentation response to control inputs Cooper-Harper score

Cooper-Harper score	2 or better	4 or better	6 or better	Worse than 6
Risk points	0	15	40	Unairworthy

8.2 (i). Altitude-hold capabilities during forward/transverse flight: altitude deviation

Altitude hold deviation	< 10cm	< 20cm	< 30cm	> 30cm
Risk points	0	5	10	60

8.2 (j). Altitude-hold capabilities during forward/transverse flight: altitude deviation

Cooper-Harper score	2 or better	4 or better	6 or better	Worse than 6
Risk points	0	15	40	Unairworthy

8.2 (k). Pitch and bank angle limitation

Pitch and bank limits	Limits are below FOM-defined thresholds	Limits meet FOM-defined threshold	No SAS limits: reliant on pilot to maintain FOM pitch and bank limits
Risk points	0	5	30

8.2 (l). Maintaining attitude limits: Cooper-Harper score

Cooper-Harper score	2 or better	4 or better	6 or better	Worse than 6
Risk points	0	15	40	Unairworthy

8.2 (m). Control precision: takeoff/landing precision test

Precision	± 10cm or better	± 20cm or better	± 35cm or better	± 35cm or worse
Risk points	0	15	40	Unairworthy

For this test, the pilot must take the aircraft off from a helipad, fly it to 10 feet in altitude without inputting any other control inputs, and land it again. The difference in the takeoff location of the center of the aircraft and landing location of the center of the aircraft is to be measured.

8.2 (n). Control precision: Cooper-Harper score for landing on precise location

Cooper-Harper score	2 or better	4 or better	6 or better	Worse than 6
Risk points	0	15	40	Unairworthy

This is based on the following test: the aircraft is to be landed on a square pad with a side length not exceeding 1.2 times the maximum diagonal length between propellers. The pilot is to land on the middle of this pad and rate the difficulty of doing so.

8.2 (o). Control precision: azimuth hold ability

Azimuth variation test results	± 2m or better	± 4m or better	± 8m or better	Worse than ± 8m
Risk points	0	15	40	Unairworthy

This is to be assessed by a physical test: from a safe altitude, the aircraft must be aligned to a given azimuth, flown forward 35 meters without any lateral commands. It then must be flown directly backward to the start location. The difference in position measured in the direction perpendicular to the target azimuth must be measured. See the diagram below:

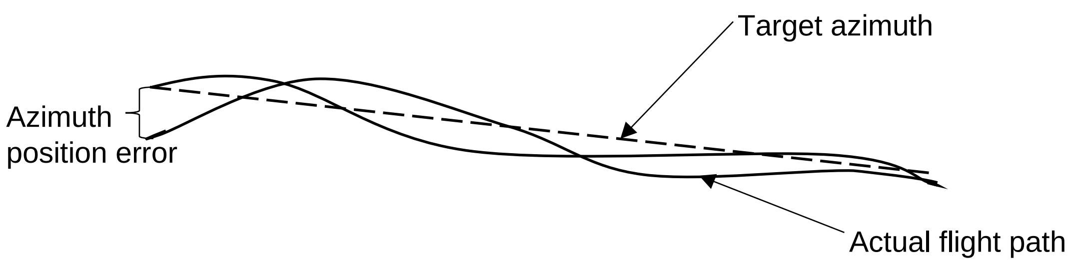

Figure 8-1: Azimuth tracking visualization

8.2 (p). Control precision: azimuth hold ability Cooper-Harper score

Cooper-Harper score	2 or better	4 or better	6 or better	Worse than 6
Risk points	0	15	40	Unairworthy

This is based on the pilot's workload during the test delineated in the previous standard.

The pilot difficulty ranking is computed by summing the risk points and applying the formula: $rank = 0.003 * sum + 1$. Round the rank to the nearest integer on the domain $[1, 3]$.

8.3 Helicopters

8.3 (a). Position-hold performance: position hold Cooper-Harper score

Cooper-Harper score	2 or better	4 or better	6 or better	Worse than 6
Risk points	0	15	40	Unairworthy

8.3 (b). Attitude-hold performance: attitude-hold Cooper-Harper score

Cooper-Harper score	2 or better	4 or better	6 or better	Worse than 6
Risk points	0	15	40	Unairworthy

8.3 (c). Disturbance tracking: position-hold performance: Cooper-Harper score in light turbulence

Cooper-Harper score	2 or better	4 or better	6 or better	Worse than 6
Risk points	0	15	40	Unairworthy

8.3 (d). Maintaining attitude limits: Cooper-Harper score

Cooper-Harper score	2 or better	4 or better	6 or better	Worse than 6
Risk points	0	15	40	Unairworthy

8.3 (e). Control precision: Cooper-Harper score for landing on precise location

Cooper-Harper score	2 or better	4 or better	6 or better	Worse than 6
Risk points	0	15	40	Unairworthy

This is based on the following test: the aircraft is to be landed on a square pad with a side length not exceeding 1.2 times the maximum diagonal length between propellers. The pilot is to land on the middle of this pad and rate the difficulty of doing so.

8.3 (f). Control precision: azimuth hold ability Cooper-Harper score

Cooper-Harper score	2 or better	4 or better	6 or better	Worse than 6
Risk points	0	15	40	Unairworthy

This is based on the pilot’s workload during the test delineated in the previous standard.

8.3 (g). Dynamic rollover: critical rollover angle

Critical angle θ	$\theta > 15^o$	$\theta > 10^o$	$\theta > 5^o$	$\theta < 5^o$
Risk points	0	15	30	Unairworthy

8.3 (h). Static stability: static yaw stability in forward flight

Static stability	Statically stable	Neutrally stable or unstable
Risk points	0	80

8.3 (i). Static stability: static roll stability in forward flight

Static stability	Statically stable	Neutrally stable or unstable
Risk points	0	80

8.3 (j). Static stability: static pitch stability in forward flight

Static stability	Statically stable	Neutrally stable or unstable
Risk points	0	80

8.3 (k). Dynamic stability: growth of oscillations in pitch (hover)

Absolute value of time constant τ	$\tau > 1$ sec	$\tau > 0.6$ sec	$\tau > 0.1$ sec	$\tau < 0.1$ sec
Risk points	0	20	40	Unairworthy

8.3 (l). Dynamic stability: growth of oscillations in roll (hover)

Absolute value of time constant τ	$\tau > 1$ sec	$\tau > 0.6$ sec	$\tau > 0.1$ sec	$\tau < 0.1$ sec
Risk points	0	20	40	Unairworthy

8.3 (m). Dynamic stability: growth of oscillations in yaw (hover)

Absolute value of time constant τ	$\tau > 1$ sec	$\tau > 0.6$ sec	$\tau > 0.1$ sec	$\tau < 0.1$ sec
Risk points	0	20	40	Unairworthy

8.3 (n). Throttle pitch curve: worst-case Cooper-Harper score for maintaining a given altitude or ascent/descent rate

Cooper-Harper score	2 or better	4 or better	6 or better	Worse than 6
Risk points	0	15	40	Unairworthy

The difficulty rank is found based on sum of the risk points according to the following equation:

$$rank = 0.003 * sum + 1.1$$

Round the rank to the nearest integer on the domain $[1, 3]$.

8.4 Airships

8.4 (a). Dynamic yaw stability: during forward flight, no unstable yaw oscillations may develop. The dynamic yaw stability is assessed by the following table:

Dynamic yaw response characteristics	First-order response	Well damped second-order response ($\zeta > 0.5$)	Lightly damped second-order response ($\zeta < 0.5$)	Unstable first or second-order response
Risk points	0	15	50	Unairworthy

8.4 (b). Static pitch stability: critical speed in relation to maximum airspeed that can be developed by propulsion system

Value of $\frac{V_{crit}}{V_H}$	$\frac{V_{crit}}{V_H} > 1.5$	$\frac{V_{crit}}{V_H} > 1.3$	$\frac{V_{crit}}{V_H} > 1.1$	$\frac{V_{crit}}{V_H} < 1.1$
Risk points	0	20	35	Unairworthy

8.4 (c). Yaw control: the airship's yaw must be able to be controlled both at zero airspeed and at nonzero airspeed. At any airspeed from zero to V_H, the airship must be able to generate a yawing moment such that a standard-rate 3-degree turn, at minimum, can be established. This is evaluated by the following table:

Yaw rate*	> 5 deg/s	> 4 deg/s	> 3 deg/s	< 3 deg/s
Risk points	0	5	10	Unairworthy

*Note that, for the purposes of assessing the effectiveness of the yaw controls, the yaw rate at maximum control deflection at airspeeds from 0 to V_H. The minimum value in that set is the yaw rate used for this standard.

8.4 (d). Heading maintenance Cooper-Harper score

Cooper-Harper score	2 or better	4 or better	6 or better	Worse than 6
Risk points	0	15	40	Unairworthy

The pilot must attempt to maintain a constant heading in light turbulence and rate the difficulty of doing so.

8.4 (e). Altitude maintenance Cooper-Harper score

Cooper-Harper score	2 or better	4 or better	6 or better	Worse than 6
Risk points	0	15	40	Unairworthy

The pilot must attempt to maintain a constant altitude in light turbulence and rate the difficulty of doing so.

8.4 (f). Landing Cooper-Harper score

Cooper-Harper score	2 or better	4 or better	6 or better	Worse than 6
Risk points	0	15	40	Unairworthy

The pilot must attempt to land the airship in light turbulence and rate the difficulty of doing so.

8.4 (g). Control complexity Cooper-Harper score

Cooper-Harper score	2 or better	4 or better	6 or better	Worse than 6
Risk points	0	15	40	Unairworthy

The pilot must rate the overall complexity and intuitiveness of the controls, and how easy it is for a single pilot to manage the controls to effect all state variables of the aircraft.

The difficulty rank is found based on the sum of the risk points and the following equation:

$$rank = 0.008 * sum + 1.1$$

The rank is rounded to the nearest integer on the domain $[1, 3]$.

Part 9: Schedule II Airworthiness Standards

This set of standards applies according to 1.7.5.

The control station must include the following functionality:

- Battery monitoring, to include: voltage, current draw, cumulative charge burned. Depending on the proponent's desires, this can be expressed as a percentage of a fully charged battery. If the aircraft is instead fueled, the control station must display the amount of fuel remaining and the fuel flow rate.
- Signal/link status: based on information such as signal-to-noise ratio, the link strength must be displayed. This must include a threshold for when the signal is too weak to effectively control the aircraft or receive telemetry.
- Propulsion system performance, to include: RPM, exhaust gas temperature, cylinder head temperature, oil temperature (as applicable depending on the propulsion system type)
- Security concerns: the applicant must identify security vulnerabilities in their system and mitigations.
- POH content: the POH must include detail about lost link procedures and must have a detailed lost link checklist.
- Critical parts list: the applicant must identify a comprehensive list of critical parts. Critical parts are defined as parts which, if they fail, will immediately result in the catastrophic ending of the flight.
- Tests with probable failures, including one engine inoperative, GPS failure, etc.
- Control station capabilities: discontinue the flight, dynamically re-route the aircraft, abort takeoff/landing.

9.1 Control Station Standards

9.1 (a). Battery/energy monitoring standards

Standards met?	Met	Not met
Risk points	0	Unairworthy

9.1 (b). Propulsion system monitoring standards

Standards met?	Met	Not met
Risk points	0	Unairworthy

9.1 (c). Control station capabilities standards

Standards met?	Met	Not met
Risk points	0	Unairworthy

9.2 Security Concerns

9.2 (a). Security concerns and mitigations identified

Standards met?	Met	Not met
Risk points	0	Unairworthy

These standards are still in development.

9.3 POH Content and Documentation

9.3 (a). Lost link procedures/checklist included

Standards met?	Met	Not met
Risk points	0	Unairworthy

9.3 (b). Critical parts identified

Standards met?	Met	Not met
Risk points	0	Unairworthy

Note that, depending on the critical parts list, OISC may require additional testing and analysis of the critical parts.

9.4 Tests with Probable Failures

The aircraft must be tested and demonstrated to be controllable with the following failures:

- One engine inoperative – this is applicable only to aircraft designs which have redundancy as a consequence of having multiple engines. For example, a multiengine airplane must be tested with one engine inoperative
- No GPS/GNSS link
- No magnetic compass
- For aircraft with multiple redundant AHRS systems, testing with one system INOP

9.4 (a). Aircraft controllable with probable failures

Standards met?	Met	Not met
Risk points	0	Unairworthy

9.5 Schedule II Structures Standards

For aircraft with a maximum takeoff weight of greater than 55 lbs, the following enhanced structural standards apply.

The aircraft's structure must be assessed by either one of the two following methods:

- Destructive testing until material failure
- Testing to validate results from a structural model

In either case, physical experimentation is required.

9.5.1 Destructive testing standards

These standards require that the proponent construct an entire aircraft with identical material composition, geometry, and mass properties as the aircraft design. Expensive components, such as motors, may be replaced with cheaper analogs: for example, an electric motor could be replaced with a metal cylinder of similar mass.

This experiment must begin by loading the aircraft at 90% of the ultimate load. Note that the ultimate load must be based on the load factor requirements in section 1.9.1.

The proponent must determine the appropriate load distribution for this test. OISC offers the following guidance:

- For assessing the load on the wing spar and horizontal stabilizer spar, the load should be based on flying the airplane at maximum weight, a maximally forward CG, and the tail surfaces trimmed to maintain level flight. Apply the load factors in 1.9.1.
- Landing gear should be tested at maximum landing weight and a load factor of 3Gs. Consider how the aircraft is landed: for example, on an airplane, a slip to landing in a crosswind would result in one of the main gears being loaded before the other main gear. Again looking at the example of airplanes, the gear might be subjected to side loads during a crosswind landing.
- Rotor loads should be computed based on the aircraft flying at its maximum takeoff weight and the rotor producing as much thrust as possible. Consider the load factors in 1.9.1.

The airworthiness of the aircraft is assessed based on the tested safety factor against failure:

9.5.1 (a) Minimum safety factor against material failure

Value of FS	$FS > 1.8$	$FS > 1.6$	$FS > 1.4$	$FS < 1.4$
Risk points	0	20	40	Unairworthy

9.5.2 Structural model validation standards

Under this scheme of certification, the aircraft need not undergo destructive testing. This scheme requires a comprehensive structural model to be developed which can predict:

- Normal and shear stress
- Strain, to include linear displacements and displacement angles for beam-type elements and twist rate and twist angle for elements under torsional loads.
- Buckling

In order to be certified as airworthy, the proponent must:

- Create a CAD model of the aircraft in question with all structural elements modeled with accurate geometry and material composition.
- Assess the loads acting on the aircraft based on the guidance in section 9.5.1.

- Run a FEA structural model with mesh adaptation until a mesh-independent solution is found. The model should be run at 1.1 times the maximum load that the aircraft will be subjected to. The proponent must verify that there is a safety factor of at least 1.15 against yielding anywhere in the structure.
- Assess the effect of manufacturing tolerances and other sources of uncertainty. OISC does not require that multiple FEA models be run, but the proponent must come up with an estimation for the uncertainty of the FEA model. This uncertainty must be expressed in terms of easily measurable variables, such as displacement.

Based on these results, the airworthiness is assessed:

Uncertainty: if the displacement/displacement angle exceeds the range of predicted values, the aircraft is unairworthy until this discrepancy is rectified.

Actual minimum safety factor and maximum error of FEA model. The following matrix shows the risk points allocated based on both (a) the minimum safety factor from the FEA model, and (b) the maximum error in displacement between the FEA model and physical test.

9.5.2 (a) Structural model error and minimum safety factor against yielding

	Error better than 1%	Error better than 3%	Error better than 5%	Error worse than 5%
$FS > 1.5$	0	10	40	Unairworthy
$FS > 1.3$	10	20	80	Unairworthy
$FS > 1.1$	20	40	Unairworthy	Unairworthy
$FS < 1.1$	30	60	Unairworthy	Unairworthy

9.6 Critical Parts

For aircraft subject to Schedule II airworthiness standards, all critical parts must be identified. Critical parts are defined as parts which will cause a complete loss of the aircraft if the parts fail.

These critical parts are subject to the following standards:

- For all of these critical parts, the aircraft must be flown only with parts identical to the parts on the aircraft used to assess airworthiness.
- Alternative critical parts may be used upon OISC certification.
- The proponent must delineate an inspection and maintenance schedule for these critical parts.

Part 10: Enhanced Security Standards

This section of the manual applies to operations conducted within 100nm of any airspace controlled by a hostile foreign government or within 100nm of any area of sociopolitical turmoil.

OISC requires that professional penetration testing be conducted for aircraft being operated in these environments. The goals of this penetration test are:

- Determine the vulnerability of the aircraft to be controlled by anyone other than the control station operator/pilot.
- Determine the vulnerability of the aircraft's commands and state to be read by a third party.
- Determine mitigations against the vulnerabilities found

These standards are still in development.

Appendix A: Useful Equations for Aircraft Analysis

A.1 Aerodynamics

A.1.1 Thin Airfoil Theory

$a_0 = 2\pi$ per radian

For cambered airfoils:

$\frac{dz}{dx}(\xi)$ camber slope transformed according to $\xi = \frac{c}{2}(1 - \cos\theta)\,, d\xi = \frac{c}{2}\sin\theta\, d\theta$

Find Fourier coefficients according to:

$A_0 = \alpha - \frac{1}{\pi}\int_0^\pi \frac{dz}{dx}(\theta) d\theta$

$A_1 = \frac{2}{\pi}\int_0^\pi \frac{dz}{dx}(\theta)\cos\theta\, d\theta$

$A_2 = \frac{2}{\pi}\int_0^\pi \frac{dz}{dx}(\theta)\cos 2\theta\, d\theta$

Find desired parameters based on Fourier coefficients:

$\alpha_{L=0} = \alpha - \left(A_0 + \frac{A_1}{2}\right)$ (Note that the α terms in the expressions for A_0 and $\alpha_{L=0}$ cancel)

$C_l = a_0(\alpha - \alpha_{L=0})$

$C_{mc/4} = \frac{\pi}{4}(A_2 - A_1)$

$x_{cp} = \frac{c}{4}(1 + \frac{\pi}{C_l}(A_1 - A_2))$

Drag estimation for flat plates (roughly applicable to thin airfoils)

$\delta(x) = \frac{5x}{\sqrt{Re_x}}$ Laminar flow boundary layer height

$\delta(x) = \frac{0.37x}{Re_x^{0.2}}$ Turbulent flow boundary layer height

$Re_{cr} = 5 \times 10^5$ Reynolds number to transition from laminar to turbulent flow

$C_f = \frac{1.328}{\sqrt{Re_L}}$ Laminar flow skin friction coefficient

$C_f = \frac{0.074}{Re_L^{0.2}}$ Turbulent flow skin friction coefficient

A.1.2 Prandtl Lifting Line Theory

Fundamental equation of Prandtl Lifting Theory:

$$\alpha(y_0) = \frac{\Gamma(y_0)}{\pi V_\infty c(y_0)} + \alpha_{L=0}(y_0) + \frac{1}{4\pi V_\infty}\int_{-\frac{b}{2}}^{\frac{b}{2}} \frac{\left(\frac{d\Gamma}{dy}\right) dy}{y_0 - y}$$

Variable transformation for analysis:

$y = -\frac{b}{2}\cos\theta$

Transformed fundamental equation of Prandtl Lifting Line Theory:

$$\alpha(\theta_0) = \frac{2b}{\pi c(\theta_0)}\sum_{n=1}^{\infty} A_n \sin n\theta_0 + \alpha_{L=0}(\theta_0) + \sum_{n=1}^{\infty} nA_n \frac{\sin n\theta_0}{\sin\theta_0}$$

Expand over ~20 odd terms to get reasonably accurate results. Note that the even terms can be ignored for symmetrical wings.

A.2 Aircraft Dynamics (Airplanes)

A.2.1 Stability Derivative Estimation

Longitudinal set

$C_{w0} = \frac{mg}{\frac{1}{2}\rho u_0^2 S}$	From ASEN3128 coursework.
$C_{xu} = -2C_{D0} - 2C_{L0}\tan\theta_0$	From Cornell.edu publication.
$C_{x\alpha} = C_{l0} - C_{D\alpha}$	From Etkin and Reid textbook.
$C_{x\dot{\alpha}} \approx 0$	From Etkin and Reid textbook.
$C_{xq} \approx 0$	From Etkin and Reid textbook.
$C_{zu} \approx 0$	From Cornell.edu publication. For incompressible flow only.
$C_{z\alpha} = -(a_w + C_{D0})$	From Etkin and Reid textbook.
$C_{z\dot{\alpha}} = -2a_t V_H \frac{\partial\epsilon}{\partial\alpha}$	From Etkin and Reid textbook.
$C_{zq} = -2a_t V_H$	From Etkin and Reid textbook.
$C_{mu} \approx 0$	From Cornell.edu publication. For incompressible flow only.
$C_{m\alpha} = -a_w(h_n - h)$	From Etkin and Reid textbook.

$C_{m\dot{\alpha}} = -2a_t V_H \frac{l_t}{\bar{c}} \frac{\partial \epsilon}{\partial \alpha}$ From Etkin and Reid textbook.

$C_{mq} = -2a_t V_H \frac{l_t}{\bar{c}}$ From Etkin and Reid textbook. Contribution from horizontal tail.

$C_{mq} = -0.7C_{l\alpha} \cos\Lambda_{c/4} \left(\frac{AR(\frac{1}{2}(h_{nw}-h)+2(h_{nw}-h)^2)}{AR+2\cos\Lambda_{c/4}} + \frac{1}{24}\frac{AR^3 \tan^2\Lambda_{c/4}}{AR+6\cos\Lambda_{c/4}} + \frac{1}{8}\right)$ From USAF DATCOM. Contribution from wing. Applies to low-speed (incompressible) flow only.

$\frac{\partial \epsilon}{\partial \alpha} = 4.44\left(K_A K_\lambda K_H \cos^{0.5}\Lambda_{\frac{c}{4}}\right)^{1.19}$ From USAF DATCOM. In which:

$K_A = \frac{1}{AR} - \frac{1}{1+AR^{1.7}}$

$K_\lambda = \frac{10-3\lambda}{7}$

$K_H = \frac{1-\left|\frac{h_H}{b}\right|}{\sqrt[3]{\frac{2l_H}{b}}}$ Note that h_H is the horizontal stabilizer MAC height above wing MAC.

Lateral set

$C_{y\beta} = -a_f \frac{S_f}{S}\left(1 - \frac{\partial \sigma}{\partial \beta}\right)$ Vertical tail contribution to $C_{y\beta}$. From Etkin and Reid textbook.

$C_{yp} = -a_f \frac{S_f}{S}\left(\frac{2z_f}{b} - \frac{\partial \sigma}{\partial p}\right)$ Vertical tail contribution to C_{yp}. From Etkin and Reid textbook.

$C_{yr} = a_f \frac{S_f}{S}\left(\frac{2l_f}{b} - \frac{\partial \sigma}{\partial r}\right)$ Vertical tail contribution to C_{yr}. From Etkin and Reid textbook.

$C_{l\beta} = \frac{-z_f S_f}{Sb} a_f\left(1 - \frac{\partial \sigma}{\partial \beta}\right)$ Vertical tail contribution to $C_{l\beta}$. From ASEN3128 coursework.

$C_{l\beta} = -a_w \sin\Gamma \frac{y_w}{b}$ Wing dihedral contribution to $C_{l\beta}$, also applies to horizontal stabilizer. From ASEN3128 coursework.

$C_{l\beta} = -C_L \frac{y_w}{b} \sin 2\Lambda$ Wing sweep contribution to $C_{l\beta}$. From Cornell.edu publication.

$C_{l\beta} = 1.2\sqrt{AR}\,\frac{z_{wing}(h+w)}{b^2}$ Wing mounting position contribution to $C_{l\beta}$. From Stengel textbook. $z_{wing}$is location of wing MAC below CG of aircraft. h is height of fuselage; w is width.

$C_{lp} = \frac{-2a}{Sb^2}\int_0^{b/2} c(y)y^2 dy$ Wing/horizontal tail contribution to C_{lp}. From ASEN3128 coursework.

$C_{lr} = a_f \frac{S_f}{S}\frac{z_f}{b}(\frac{2l_f}{b} + \frac{\partial\sigma}{\partial r})$ Vertical tail contribution to C_{lr}. From Etkin and Reid textbook.

$C_{n\beta} = a_f V_V (1 - \frac{\partial\sigma}{\partial\beta})$ Vertical tail contribution to $C_{n\beta}$. From Etkin and Reid textbook.

$C_{np} = a_f V_V (\frac{2z_f}{b} - \frac{\partial\sigma}{\partial p})$ Vertical tail contribution to C_{np}. From Etkin and Reid textbook.

$C_{nr} = -a_f V_V (\frac{2l_f}{b} + \frac{\partial\sigma}{\partial r})$ Vertical tail contribution to C_{nr}. From Etkin and Reid textbook.

A.2.2 Stability Derivative Dimensionalization

All this information is taken from tables 4.4 and 4.5 in Etkin and Reid.

Longitudinal

$X_u = \rho u_0 S C_{w0} \sin\theta_0 + \frac{1}{2}\rho u_0 S C_{xu}$

$Z_u = -\rho u_0 C_{w0} \cos\theta_0 + \frac{1}{2}\rho u_0 S C_{zu}$

$M_u = \frac{1}{2}\rho u_0 \bar{c} S C_{mu}$

$X_w = \frac{1}{2}\rho u_0 S C_{x\alpha}$

$Z_w = \frac{1}{2}\rho u_0 S C_{z\alpha}$

$M_w = \frac{1}{2}\rho u_0 \bar{c} S C_{m\alpha}$

$X_q = \frac{1}{4}\rho u_0 \bar{c} S C_{xq}$

$Z_q = \frac{1}{4}\rho u_0 \bar{c} S C_{zq}$

$M_q = \frac{1}{4}\rho u_0 \bar{c}^2 S C_{mq}$

$X_{\dot{w}} = \frac{1}{4}\rho \bar{c} S C_{x\dot{\alpha}}$

$Z_{\dot{w}} = \frac{1}{4}\rho \bar{c} S C_{z\dot{\alpha}}$

$M_{\dot{w}} = \frac{1}{4}\rho \bar{c}^2 S C_{m\dot{\alpha}}$

Lateral

$Y_v = \frac{1}{2}\rho u_0 S C_{y\beta}$

$L_v = \frac{1}{2}\rho u_0 b S C_{l\beta}$

$N_v = \frac{1}{2}\rho u_0 b S C_{n\beta}$

$Y_p = \frac{1}{4}\rho u_0 b S C_{yp}$

$L_p = \frac{1}{4}\rho u_0 b^2 S C_{lp}$

$N_p = \frac{1}{4}\rho u_0 b^2 S C_{np}$

$Y_r = \frac{1}{4}\rho u_0 b S C_{yr}$

$L_r = \frac{1}{4}\rho u_0 b^2 S C_{lr}$

$N_r = \frac{1}{4}\rho u_0 b^2 S C_{nr}$

Control derivatives

$X_{\delta e} = \frac{1}{2}\rho u_0^2 S C_{x\delta e}$

$Z_{\delta e} = \frac{1}{2}\rho u_0^2 S C_{z\delta e}$

$M_{\delta e} = \frac{1}{2}\rho u_0^2 S\bar{c} C_{m\delta e}$

$X_{\delta p} = \frac{1}{2}\rho u_0^2 S C_{x\delta p}$

$Z_{\delta p} = \frac{1}{2}\rho u_0^2 S C_{z\delta p}$

$M_{\delta p} = \frac{1}{2}\ \rho u_0^2\ S\bar{c} C_{m\delta p}$

$Y_{\delta a} = \frac{1}{2}\rho u_0^2 S C_{y\delta a}$

$L_{\delta a} = \frac{1}{2}\rho u_0^2 S b C_{l\delta a}$

$N_{\delta a} = \frac{1}{2}\rho u_0^2 S b C_{n\delta a}$

$Y_{\delta r} = \frac{1}{2}\rho u_0^2 S C_{y\delta r}$

$L_{\delta r} = \frac{1}{2}\rho u_0^2 S b C_{l\delta r}$

$N_{\delta r} = \frac{1}{2}\rho u_0^2 S b C_{n\delta r}$

A.2.3 Airplane Dynamics Matricies

All this information is from (4.9,18) and (4.9,19) in Etkin and Reid.

Longitudinal set

$$\begin{bmatrix}\Delta\dot{u}\\ \dot{w}\\ \dot{q}\\ \Delta\dot{\theta}\end{bmatrix} = \begin{bmatrix} \frac{X_u}{m} & \frac{X_w}{m} & 0 & -g\cos\theta_0 \\ \frac{Z_u}{m - Z_{\dot{w}}} & \frac{Z_w}{m - Z_{\dot{w}}} & \frac{Z_q + mu_0}{m - Z_{\dot{w}}} & \frac{-mg\sin\theta_0}{m - Z_{\dot{w}}} \\ \frac{1}{I_y}\left(M_u + \frac{M_{\dot{w}} Z_u}{m - Z_{\dot{w}}}\right) & \frac{1}{I_y}\left(M_w + \frac{M_{\dot{w}} Z_u}{m - Z_{\dot{w}}}\right) & \frac{1}{I_y}\left(M_q + \frac{M_{\dot{w}}\left(Z_q + mu_0\right)}{m - Z_{\dot{w}}}\right) & -\frac{M_{\dot{w}} mg\sin\theta_0}{I_y(m - Z_{\dot{w}})} \\ 0 & 0 & 1 & 0 \end{bmatrix} \begin{bmatrix}\Delta u\\ w\\ q\\ \Delta\theta\end{bmatrix}$$

$$\Delta\dot{x}_E = \Delta u\cos\theta_0 + w\sin\theta_0 - u_0\Delta\theta\sin\theta_0$$

$$\Delta\dot{z}_E = -\Delta u\sin\theta_0 + w\cos\theta_0 - u_0\Delta\theta\cos\theta_0$$

Lateral set

$$\begin{bmatrix}\dot{v}\\ \dot{p}\\ \dot{r}\\ \dot{\phi}\end{bmatrix} = \begin{bmatrix} \frac{Y_v}{m} & \frac{Y_p}{m} & \frac{Y_r}{m} - u_0 & g\cos\theta_0 \\ \frac{L_v}{I'_x} + I'_{zx}N_v & \frac{L_p}{I'_x} + I'_{zx}N_p & \frac{L_r}{I'_x} + I'_{zx}N_r & 0 \\ I'_{zx}L_v + \frac{N_v}{I'_z} & I_{zx}L_p + \frac{N_p}{I'_z} & I'_{zx}L_r + \frac{N_r}{I'_z} & 0 \\ 0 & 1 & \tan\theta_0 & 0 \end{bmatrix} \begin{bmatrix}v\\ p\\ r\\ \phi\end{bmatrix}$$

$$\dot{\psi} = r\sec\theta_0$$

$$\Delta\dot{y}_E = u_0\psi\cos\theta_0 + v$$

$$I'_x = (I_x I_z - I_{zx}^2)/I_z$$

$$I'_z = (I_x I_z - I_{zx}^2)/I_x$$

$$I'_{zx} = I_{zx}/(I_x I_z - I_{zx}^2)$$

A.2.4 Stability Derivative Transformation

Longitudinal set

$$(X_u)' = X_u \cos^2 \xi - (X_w + Z_u) \sin \xi \cos \xi + Z_w \sin^2 \xi$$

$$(X_w)' = X_w \cos^2 \xi + (X_u - Z_w) \sin \xi \cos \xi - Z_u \sin^2 \xi$$

$$\left(X_q\right)' = X_q \cos \xi - Z_q \sin \xi$$

$$(X_{\dot{u}})' = Z_{\dot{w}} \sin^2 \xi$$

$$(Z_u)' = Z_u \cos^2 \xi - (Z_w - X_u) \sin \xi \cos \xi - X_w \sin^2 \xi$$

$$(Z_w)' = Z_w \cos^2 \xi + (Z_u + X_w) \sin \xi \cos \xi + X_u \sin^2 \xi$$

$$\left(Z_q\right)' = Z_q \cos \xi + X_q \sin \xi$$

$$(Z_{\dot{u}})' = -Z_{\dot{w}} \sin \xi \cos \xi$$

$$(Z_{\dot{w}})' = Z_{\dot{w}} \cos^2 \xi$$

$$(M_u)' = M_u \cos \xi - M_w \sin \xi$$

$$(M_w)' = M_w \cos \xi + M_u \sin \xi$$

$$\left(M_q\right)' = M_q$$

$$(M_{\dot{u}})' = -M_{\dot{w}} \sin \xi$$

$$(M_{\dot{w}})' = M_{\dot{w}} \cos \xi$$

Lateral set

$$(Y_v)' = Y_v$$

$$\left(Y_p\right)' = Y_p \cos \xi - Y_r \sin \xi$$

$$(Y_r)' = Y_r \cos \xi + Y_p \sin \xi$$

$$(L_v)' = L_v \cos \xi - N_v \sin \xi$$

$$\left(L_p\right)' = L_p \cos^2 \xi - \left(L_r + N_p\right) \sin \xi \cos \xi + N_r \sin^2 \xi$$

$$(L_r)' = L_r \cos^2 \xi - \left(N_r - L_p\right) \sin \xi \cos \xi - N_p \sin^2 \xi$$

$$(N_v)' = N_v \cos \xi + L_v \sin \xi$$

$$\left(N_p\right)' = N_p \cos^2 \xi - \left(N_r - L_p\right) \sin \xi \cos \xi - L_r \sin^2 \xi$$

$$(N_r)' = N_r \cos^2 \xi + \left(L_r + N_p\right) \sin \xi \cos \xi + L_p \sin^2 \xi$$

A.2.5 Inertia Transformation

The inertia terms marked with an asterisk are the transformed inertia values.

$$I_x^* = I_x \cos^2 \xi + I_z \sin^2 \xi + I_{zx} \sin 2\xi$$

$$I_z^* = I_x \sin^2 \xi + I_z \cos^2 \xi - I_{zx} \sin 2\xi$$

$$-I_{zx}^* = \frac{1}{2}(I_x - I_z) \sin 2\xi + I_{zx}(\sin^2 \xi - \cos^2 \xi)$$

A.3 Structures

A.3.1 Basic Stress and Strain Relations

Basic stress equations

$\sigma = \frac{F_N}{A}$	Normal stress
$\tau = \frac{T}{A}$	Shear stress
$F_s = \frac{\sigma_{fail}}{\sigma_{applied}}$	Safety factor
$\sigma > 0$	Tensile stress

Pressure vessel stress

$\sigma_{xx} = \frac{PR}{2t}$, $\sigma_{\theta\theta} = \frac{PR}{t}$	Cylindrical pressure vessel
$\sigma = \frac{PR}{2t}$	Spherical pressure vessel

Strain

$\epsilon = \frac{\delta}{L_0}$	Strain, with L_0 as original length
$\sigma = \epsilon E$	Hooke's law for normal stress
$\tau = G\gamma$	Hooke's law for shear stress
$\epsilon_{yy} = -\nu\epsilon_{xx}$	Poisson's ratio relation
$\epsilon_{zz} = -\nu\epsilon_{xx}$	Poisson's ratio relation
$G = \frac{E}{2(1+\nu)}$	Relation between G, E, ν

Stress-strain matrix relations

$$\begin{bmatrix}\epsilon_{xx}\\ \epsilon_{yy}\\ \epsilon_{zz}\\ \gamma_{xy}\\ \gamma_{yz}\\ \gamma_{zx}\end{bmatrix}=\begin{bmatrix}\frac{1}{E} & -\frac{\nu}{E} & -\frac{\nu}{E} & 0 & 0 & 0\\ -\frac{\nu}{E} & \frac{1}{E} & -\frac{\nu}{E} & 0 & 0 & 0\\ -\frac{\nu}{E} & -\frac{\nu}{E} & \frac{1}{E} & 0 & 0 & 0\\ 0 & 0 & 0 & \frac{1}{G} & 0 & 0\\ 0 & 0 & 0 & 0 & \frac{1}{G} & 0\\ 0 & 0 & 0 & 0 & 0 & \frac{1}{G}\end{bmatrix}\begin{bmatrix}\sigma_{xx}\\ \sigma_{yy}\\ \sigma_{zz}\\ \tau_{xy}\\ \tau_{yz}\\ \tau_{zx}\end{bmatrix}$$

$$\begin{bmatrix}\sigma_{xx}\\ \sigma_{yy}\\ \sigma_{zz}\\ \tau_{xy}\\ \tau_{yz}\\ \tau_{zx}\end{bmatrix}=\begin{bmatrix}\hat{E}(1-\nu) & \hat{E}\nu & \hat{E}\nu & 0 & 0 & 0\\ \hat{E}\nu & \hat{E}(1-\nu) & \hat{E}\nu & 0 & 0 & 0\\ \hat{E}\nu & \hat{E}\nu & \hat{E}(1-\nu) & 0 & 0 & 0\\ 0 & 0 & 0 & G & 0 & 0\\ 0 & 0 & 0 & 0 & G & 0\\ 0 & 0 & 0 & 0 & 0 & G\end{bmatrix}\begin{bmatrix}\epsilon_{xx}\\ \epsilon_{yy}\\ \epsilon_{zz}\\ \gamma_{xy}\\ \gamma_{yz}\\ \gamma_{zx}\end{bmatrix},\ \hat{E}=\frac{E}{(1-2\nu)(1+\nu)}$$

Thermal effects on stress and strain

$\epsilon=\frac{\sigma}{E}+\alpha\Delta T$

$\sigma=E(\epsilon-\alpha\Delta T)$

$\delta=\frac{\sigma L}{E}+\alpha\Delta TL$

Stress transformation

θ is counterclockwise rotation from x axis to x' axis

$\sigma_x'=\frac{\sigma_x+\sigma_y}{2}+\frac{\sigma_x-\sigma_y}{2}\cos 2\theta+\tau_{xy}\sin 2\theta$ Transformed normal stress

$\sigma_y'=\frac{\sigma_x+\sigma_y}{2}-\frac{\sigma_x-\sigma_y}{2}\cos 2\theta-\tau_{xy}\sin 2\theta$ Transformed normal stress

$\tau_{xy}'=-\frac{\sigma_x-\sigma_y}{2}\sin 2\theta+\tau_{xy}\cos 2\theta$ Transformed shear stress

$\sigma_{1,2}=\frac{\sigma_x+\sigma_y}{2}\pm\sqrt{\left(\frac{\sigma_x-\sigma_y}{2}\right)^2+\tau_{xy}^2}$ Principal stresses

$\tau_{mzx}=\sqrt{\left(\frac{\sigma_x+\sigma_y}{2}\right)^2+\tau_{xy}^2}$ In plane maximum shear stress

$\tau_{max}=\frac{\sigma_1-\sigma_3}{2}$ Maximum shear stress, any plane

$\tan 2\theta_p=\frac{2\tau_{xy}}{\sigma_x-\sigma_y}$ Angle of frame for principal stresses

$\tan 2\theta_s = \frac{-\sigma_x - \sigma_y}{2\tau_{xy}}$ Angle of frame for maximum in-plane shear stress

A.3.2 Beam Theory

Sign conventions

Figure A-1: Beam theory sign conventions

Differential equations

$p(x)$ External load

$V(x)$ Shear force

$M(x)$ Bending moment

$\theta(x)$ Bending angle

$v(x)$ Displacement

$-p(x) = V'(x)$

$-V(x) = M'(x)$

$M(x) = EI\theta'(x)$

$\theta(x) = v'(x)$

$M(x) = EIv''(x)$

$V(x) = -EIv'''(x)$

$p(x) = EIv^{(4)}(x)$

Stress and curvature

$\sigma_x = -\frac{M_z y}{I_z}$ Normal stress

$\kappa = -\frac{\sigma_x}{Ey} = v''(x)$ Curvature

$M_z = EI_z\kappa$ Bending moment

Boundary conditions

Physical support condition	v	v'	V	M
Pinned/roller joint	0	Unknown	Unknown	0
Clamp	0	0	Unknown	Unknown
Free end with applied efforts F_0, M_0	Unknown	Unknown	F_0	M_0
Vertical roller joint	Unknown	0	0	Unknown

Figure A-1: Beam theory boundary conditions

Matching conditions about a point q where there is either (a) a point load, or (b) a discontinuity in the distributed load.

Find force and moment matching conditions by computing $\Sigma M = 0$ and $\Sigma F = 0$ at the point q under the following assumptions:

- Distributed load does not act
- Forces do not cause moments

Regardless of loads, the displacement and deflection angle matching conditions are:

$$v_1(q) = v_2(q)$$

$$\theta_1(q) = \theta_2(q)$$

A.3.3 Torsion

Additional nomenclature

ρ Radius from center

R Outer radius

T Applied torque

t Thickness

b Rectangular lengthwise dimension

A_E Area enclosed by the midline of a closed thin-walled specimen.

There are three types of theory for which torsion equations are provided:

1. Exact theory. This applies to torsional specimens with either solid or hollow circular cross sections.

2. Open thin walled. This applies to torsional specimens with a cross-section which can either be decomposed or rectified into rectangles.
3. Closed thin walled. This applies to torsional specimens with a cross-section that has a single shear flow circuit.

Strain

Exact	$\gamma = \rho \frac{d\phi}{dx}$
Open thin walled	$\gamma = \rho \frac{d\phi}{dx}$
Closed thin walled	$\gamma = \rho \frac{d\phi}{dx}$

Stress

Exact	$\tau_{max} = \frac{TR}{J}, \tau = \frac{T\rho}{J}$
Open thin walled	$\tau_{max} = \frac{Tt}{J_\alpha}$
Closed thin walled	$\tau_{max} = \frac{T}{2t_{min}A_E}$

Torsional stiffness area parameter

Exact	$J_{solid} = \frac{\pi}{2}R^4, J_{hollow} = \frac{\pi}{2}(R_o^4 - R_i^4)$
Open thin walled	$J_\alpha = \alpha b t^3, J_\beta = \beta b t^3$
Closed thin walled	$J_{CTW} = \frac{4A_E^2}{\oint \frac{ds}{t}}$

Torque as a function of other parameters

Exact	$T = JG\frac{d\phi}{dx}$
Open thin walled	$T = J_\beta G\frac{d\phi}{dx}$
Closed thin walled	$T = J_{CTW}G\frac{d\phi}{dx}$

Twist angle

Exact $\phi_{AB} = \frac{TL}{GJ}$

Open thin walled $\phi_{AB} = \frac{TL}{GJ_{\beta}}$

Closed thin walled $\phi_{AB} = \frac{TL}{GJ_{CTW}}$

Note that for $\frac{b}{t} \geq 10$, the approximation can be made that $\alpha \approx \beta \approx \frac{1}{3}$. Sum J terms as scalars.

Appendix B: Flight Test Cards for Operational Certification

B.1 Airplanes

Note: these testcards require some computations to be completed ahead of time.

The test campaign is structured such that a basic checkout flight is completed first. After the first checkout flight, there are several test cards to address various airworthiness standards. There is no need for these cards to be completed in any particular order, except that the basic checkout flight to be completed first.

Test cards begin on the next page.

Flight 1: Basic Checkout Flight

Pilot in command:

Date: Time:

Objectives:

- Explore basic aircraft handling characteristics
- Validate basic aircraft reliability

Departure

Check	Action
	Set flaps to predetermined setting. Flap setting:
	Rotate at predetermined speed. Rotation speed:
	Climb at predetermined pitch and power settings. Pitch: Power:
	Cooper-Harper rating for takeoff, rotation, and climb:
	Maintain power and pitch attitude until predefined altitude is reached: Altitude:
	Remain above takeoff location for 5 minutes, fly at a 1-degree pitch attitude in a clean configuration
	Cooper-Harper rating for SLUF flight

Cruise

Check	Action
	Reduce power to predetermined throttle setting:
	Trim to hands-off level flight
	Execute turns at 15 degrees bank
	Execute turns at 30 degrees bank
	Continue for 10 minutes
	Cooper-Harper rating for turns at various bank angles

Slow flight

Check	Action
	Gradually reduce speed and set flaps to:
	Maintain airspeed of:
	Perform turns at 30 degrees of bank.
	Cooper-Harper rating for slow flight:
	Gradually remove flaps and increase speed such that the airplane is in a 1-degree pitch up attitude and in SLUF flight.

Landing

Check	Action
	Fly pattern at airspeed:
	Fly final at airspeed:
	Cooper-Harper rating for approach, landing, and rollout

Post flight

Check	Action
	Record battery drain
	Inspect airplane carefully
	Prepare corrective action list

Dynamics and Handling Requirements – standard airplane dynamic modes

Note that all dynamics and handling requirements must be evaluated at every extreme of the weight/balance envelope, including:

- Maximum takeoff weight
- CG forward limit
- CG aft limit
- Minimum possible operational weight

Static stability

Check	Action
	Record aircraft center of gravity location in the chordwise direction as well as in the vertical direction. $x_{CG} =$ $z_{CG} =$
	Record aircraft gross weight. $m =$
	Establish the airplane at the desired trim speed and at an altitude of at least 300 feet AGL.
	Introduce an angle of attack disturbance using the elevator and note the initial response from the airplane.
	Classify the airplane as statically stable or statically unstable in pitch
	Introduce a sideslip disturbance using the rudder and note the initial reaction in both roll and yaw from the airplane.
	Classify the airplane as statically stable or statically unstable in roll
	Classify the airplane as statically stable or statically unstable in roll

Dynamic stability

Check	Action
	Record aircraft center of gravity location in the chordwise direction as well as in the vertical direction. $x_{CG} =$ $z_{CG} =$
	Record aircraft gross weight. $m =$
	Establish the airplane at the desired trim speed and at an altitude of at least 300 feet AGL.
	Activate the phugoid mode.
	Based on the phugoid modal response, determine if the calculated damping ratio is reasonable.
	Activate the short period mode.
	Based on the short period modal response, determine if the calculated damping ratio is reasonable.
	Activate the Dutch roll mode.
	Based on the Dutch roll modal response, determine if the calculated damping ratio is reasonable.

	Activate the spiral mode.
	Based on the spiral modal response, determine if the calculated doubling time is reasonable.
	Activate the roll mode..
	Based on the roll modal response, determine if the calculated time constant is reasonable.

Control authority

Check	Action
	Record aircraft center of gravity location in the chordwise direction as well as in the vertical direction. $x_{CG} =$ $z_{CG} =$
	Record aircraft gross weight. $m =$
	Establish the airplane at the desired trim speed and at an altitude of at lest 300 feet AGL.
	Introduce full aileron input in either direction.
	Check that the maximum roll rate and time rate of change of roll rate are commensurate with the calculated values.
	Cooper-Harper rating for roll control authority.
	Introduce full up-elevator control.
	Check that the calculated value for initial time rate of change of pitch rate is commensurate with the aircraft's performance.
	Cooper-Harper rating for up-elevator control authority.
	Introduce full down-elevator control.
	Check that the calculated value for initial time rate of change of pitch rate is commensurate with the calculated value.
	Cooper-Harper rating for down-elevator control authority.

CG Range

Check	Action
	Calculate CG position for a trim speed of $1.5V_s$ with a 1-degree up-elevator deflection.
	Fly the aircraft at the trim speed calculated above and determine the following:

	• Cooper-Harper rating for elevator control authority at the given CG location. • Cooper-Harper rating for longitudinal static stability (pitch stiffness) at the given CG location. • Find minimum speed which the airplane can reach and maintain level flight. Depending on the CG location, this can be above the speed at which the wing will stall. • Record this information, along with the aircraft weight and CG location.
	Move the CG forward by 0.03, in units of $\frac{x}{c}$ and perform the following: • Determine the minimum speed in the same manner as before. • Cooper-Harper rating for elevator control authority at given CG location. • Record this information, along with the aircraft weight and CG location.
	Continue moving the CG forward until any of the following conditions are met: • The Cooper-Harper elevator control authority rating worsens by 3 points. • The Cooper-Harper elevator control authority rating reaches a value of 5. • The minimum speed is such that the wing cannot stall. The CG location at which one of these conditions are met is the forward CG limit.
	Reset the CG back to the original position determined in the first step of this card.
	Move the CG aft by 0.03, in units of $\frac{x}{c}$ and perform the following: • Cooper-Harper rating for longitudinal static stability (pitch stiffness) at the given CG location. • Record this information, along with the aircraft weight and CG location.
	Continue moving the CG aft until any of the following conditions are met: • Cooper-Harper static longitudinal stability rating worsens by 3 points • Cooper-Harper static longitudinal stability rating reaches a value of 5.

Crosswind handling

Repeat for multiple flap settings and crosswind component values.

Check	Action
	Record aircraft center of gravity location in the chordwise direction as well as in the vertical direction. $x_{CG} =$ $z_{CG} =$
	Record aircraft gross weight. $m =$
	Establish aircraft on 3-degree glideslope approach

	Record approach airspeed, crosswind component, flap settings
	Cooper-Harper rating for crosswind handling capability.
	Cooper-Harper rating for rudder control authority.

Dynamics and Handling Requirements – unconventional airplane dynamic modes or stability-augmented airplanes

Static stability

Check	Action
	Record aircraft center of gravity location in the chordwise direction as well as in the vertical direction. $x_{CG} =$ $z_{CG} =$
	Record aircraft gross weight. $m =$
	Establish the airplane at the desired trim speed and at an altitude of at least 300 feet AGL.
	Introduce an angle of attack disturbance using the elevator and note the initial response from the airplane.
	Classify the airplane as statically stable or statically unstable in pitch
	Introduce a sideslip disturbance using the rudder and note the initial reaction in both roll and yaw from the airplane.
	Classify the airplane as statically stable or statically unstable in roll
	Classify the airplane as statically stable or statically unstable in roll

Dynamic stability – easy-to-activate second-order modes

Check	Action
	Record aircraft center of gravity location in the chordwise direction as well as in the vertical direction. $x_{CG} =$ $z_{CG} =$
	Record aircraft gross weight. $m =$
	Establish the airplane at the desired trim speed and at an altitude of at least 300 feet AGL.
	For all dynamic modes that fit into this category, provide an estimate of damping ratio and the conditions required to activate it.

Dynamic stability – easy-to-activate first-order modes

Check	Action
	Record aircraft center of gravity location in the chordwise direction as well as in the vertical direction. $x_{CG} =$ $z_{CG} =$
	Record aircraft gross weight. $m =$
	Establish the airplane at the desired trim speed and at an altitude of at least 300 feet AGL.
	For all dynamic modes that fit into this category, provide an estimate of time constant and the conditions required to activate it.

Dynamic stability – difficult-to-activate second-order modes

Check	Action
	Record aircraft center of gravity location in the chordwise direction as well as in the vertical direction. $x_{CG} =$ $z_{CG} =$
	Record aircraft gross weight. $m =$
	Establish the airplane at the desired trim speed and at an altitude of at least 300 feet AGL.
	For all dynamic modes that fit into this category, provide an estimate of damping ratio and the conditions required to activate it.

Dynamic stability – difficult-to-activate first-order modes

Check	Action
	Record aircraft center of gravity location in the chordwise direction as well as in the vertical direction. $x_{CG} =$ $z_{CG} =$
	Record aircraft gross weight. $m =$
	Establish the airplane at the desired trim speed and at an altitude of at least 300 feet AGL.
	For all dynamic modes that fit into this category, provide an estimate of time constant and the conditions required to activate it.

Roll control authority

Check	Action
	Record aircraft center of gravity location in the chordwise direction as well as in the vertical direction. $x_{CG} =$ $z_{CG} =$
	Record aircraft gross weight. $m =$
	Establish the airplane at the desired trim speed and at an altitude of at least 300 feet AGL.
	Introduce full aileron control in either direction.
	Note the initial roll acceleration and ensure it is commensurate with the calculated value.
	Note the maximum roll rate and ensure it is commensurate with the calculated value.
	Cooper-Harper rating for roll control authority.

Pitch control authority

Check	Action
	Record aircraft center of gravity location in the chordwise direction as well as in the vertical direction. $x_{CG} =$ $z_{CG} =$
	Record aircraft gross weight. $m =$
	Establish the airplane at the desired trim speed and at an altitude of at least 300 feet AGL.
	Introduce full down elevator and ensure the time rate of change of pitch rate is commensurate with the calculated value.
	Cooper-Harper rating for down elevator control authority.
	Introduce full up elevator and ensure the time rate of change of pitch rate is commensurate with the calculated value.
	Cooper-Harper rating for up elevator control authority.

Crosswind handling / rudder control authority

Repeat for multiple flap settings and crosswind component values.

Check	Action
	Record aircraft center of gravity location in the chordwise direction as well as in the vertical direction. $x_{CG} =$ $z_{CG} =$
	Record aircraft gross weight. $m =$
	Establish aircraft on 3-degree glideslope approach
	Record approach airspeed, crosswind component, flap settings
	Cooper-Harper rating for crosswind handling capability.
	Cooper-Harper rating for rudder control authority

CG Range

Check	Action
	Calculate CG position for a trim speed of $1.5V_s$ with a 1-degree up-elevator deflection.
	Fly the aircraft at the trim speed calculated above and determine the following: • Cooper-Harper rating for elevator control authority at the given CG location. • Cooper-Harper rating for longitudinal static stability (pitch stiffness) at the given CG location. • Find minimum speed which the airplane can reach and maintain level flight. Depending on the CG location, this can be above the speed at which the wing will stall. • Record this information, along with the aircraft weight and CG location.
	Move the CG forward by 0.03, in units of $\frac{x}{c}$ and perform the following: • Determine the minimum speed in the same manner as before. • Cooper-Harper rating for elevator control authority at given CG location. • Record this information, along with the aircraft weight and CG location.
	Continue moving the CG forward until any of the following conditions are met: • The Cooper-Harper elevator control authority rating worsens by 3 points. • The Cooper-Harper elevator control authority rating reaches a value of 5. • The minimum speed is such that the wing cannot stall. The CG location at which one of these conditions are met is the forward CG limit.
	Reset the CG back to the original position determined in the first step of this card.

	Move the CG aft by 0.03, in units of $\frac{x}{c}$ and perform the following: • Cooper-Harper rating for longitudinal static stability (pitch stiffness) at the given CG location. • Record this information, along with the aircraft weight and CG location.
	Continue moving the CG aft until any of the following conditions are met: • Cooper-Harper static longitudinal stability rating worsens by 3 points • Cooper-Harper static longitudinal stability rating reaches a value of 5.

Aerodynamic Performance Requirements

Landing Performance

All landing performance data must be evaluated at maximum landing weight. Further, the landing distance needs to be evaluated with varying headwind/tailwind components.

Check	Action
	Record headwind/tailwind component.
	Record aircraft weight.
	Establish aircraft on 3-degree glideslope approach
	Measure landing reference speed V_{REF}
	Make a normal landing; do not let the airplane float excessively to touch down smoothly. Prioritize landing on a specific point while ensuring the touchdown descent rate is low enough to comfortably avoid any damage to the airplane.
	Measure the ground roll distance in addition to the distance between the aircraft first becoming within one wingspan of the ground and the aircraft coming to rest at the end of the ground roll.

Climb Performance

Check	Action
	Record aircraft weight.
	Record density altitude.
	Measure climb rate and groundspeed at varying airspeeds to find V_X and V_Y. The aircraft must be in a clean configuration.

	Measure climb rate at V_Y. The aircraft must be in a clean configuration.
	Measure climb angle at V_X. The aircraft must be in a clean configuration.
	Measure maximum climb angle in landing configuration.

Stall Handling

Check	Action
	Record aircraft center of gravity location in the chordwise direction as well as in the vertical direction. $x_{CG} =$ $z_{CG} =$
	Record aircraft gross weight. $m =$
	Perform a stall from SLUF flight in clean configuration.
	Note the stall speed.
	Note any wingtip drop that occurs during stall.
	Cooper-Harper rating for stall in clean configuration.
	Perform a stall from SLUF flight with half flaps applied.
	Note the stall speed.
	Note any wingtip drop that occurs during stall.
	Cooper-Harper rating for stall in half-flaps configuration.
	Perform a stall from SLUF flight in landing configuration.
	Note the stall speed.
	Note any wingtip that occurs during stall.
	Cooper-Harper rating for stall in landing configuration.

Maximum Dive Speed

This test must be completed at maximum takeoff weight.

Check	Action
	Establish the aircraft at an altitude of 400 feet AGL.
	At full power, apply down elevator to dive the airplane.
	When the speed stabilizes, record the maximum attained airspeed.

	Note any signs of control reversal encountered in flight.

Minimum Turn Radius

Check	Action
	Establish the aircraft at an airspeed equal to 1.3 times the stall speed in a clean configuration at a load factor of 2. This is equivalent to approximately $1.85V_S$.
	Enter a 60-degree banked turn while maintaining level altitude.
	Estimate the turning radius.

Structural Requirements

Aeroelasticity Effects – clean configuration

Check	Action
	Establish airplane at minimum control speed
	Maintain the airspeed for a minimum of two minutes
	Note any structural oscillations or control reversal effects
	Increase the airspeed by 2 m/s and repeat until V_{DF} is reached
	After having tested 5 airspeeds, land the airplane and inspect the structure for signs of plastic deformation or excessive wear.

Aeroelasticity Effects – half-flaps configuration

Check	Action
	Establish airplane at minimum control speed
	Maintain the airspeed for a minimum of two minutes
	Note any structural oscillations or control reversal effects
	Increase the airspeed by 2 m/s and repeat until V_{DF} is reached
	After having tested 5 airspeeds, land the airplane and inspect the structure for signs of plastic deformation or excessive wear.

Aeroelasticity Effects –landing configuration

Check	Action
	Establish airplane at minimum control speed
	Maintain the airspeed for a minimum of two minutes
	Note any structural oscillations or control reversal effects
	Increase the airspeed by 2 m/s and repeat until V_{DF} is reached
	After having tested 5 airspeeds, land the airplane and inspect the structure for signs of plastic deformation or excessive wear.

Post-Flight Actions

These procedures must be executed at the end of every flight.

Post flight

Check	Action
	Record battery drain
	Inspect airplane carefully
	Prepare corrective action list

B.2 Multirotors

Note: these testcards require some computations to be completed ahead of time.

The test campaign is structured such that a basic checkout flight is completed first. After the first checkout flight, there are several test cards to address various airworthiness standards. There is no need for these cards to be completed in any particular order, except that the basic checkout flight to be completed first.

Test cards begin on the next page.

Flight 1: Basic Checkout Flight

Pilot in command:

Date: Time:

Objectives:

- Explore basic aircraft handling characteristics
- Validate basic aircraft reliability

Departure

Check	Action
	Climb at predetermined power settings. Power:
	Cooper-Harper rating for takeoff and climb:
	Maintain power until predefined altitude is reached: Altitude:
	Remain above takeoff location for 5 minutes.
	Cooper-Harper rating for position-hold performance:

Cruise

Check	Action
	Reduce power to predetermined throttle setting:
	Trim aircraft.
	Fly the aircraft in the vicinity of the takeoff location to ascertain basic handling qualities.
	Identify any handling characteristics that need to be corrected.

Landing

Check	Action
	Fly at predetermined descent rate.
	Land at predetermined location.
	Cooper-Harper rating for approach and landing.

Post flight

Check	Action
	Record battery drain / fuel burn.
	Inspect airplane carefully
	Prepare corrective action list

Flight 2: Handing quality determination

Position hold

Check	Action
	Establish aircraft in steady position in clean air.
	Measure position-hold performance and Cooper-Harper rating:
	Establish aircraft in steady position in turbulent air.
	Measure position-hold performance and Cooper-Harper rating:
	Prepare corrective action list

Attitude hold

Check	Action
	Establish aircraft in steady attitude in clean air.
	Measure attitude-hold performance and Cooper-Harper rating:
	Prepare corrective action list

Control tracking

Check	Action
	Make control inputs for all 4 aircraft controls.
	Determine control response characteristics and get Cooper-Harper rating:
	Prepare corrective action list

Altitude hold

Check	Action
	Establish aircraft in steady altitude in clean air.
	Measure altitude-hold performance and Cooper-Harper rating:
	Prepare corrective action list

Pitch/bank limits

Check	Action
	Maintain maximum allowable roll and pitch per FOM requirements
	Cooper-Harper rating for maintaining attitude limits:
	Prepare corrective action list

Takeoff and landing precision

Check	Action
	Determine target for aircraft to land on. Make landing on this target.
	Measure deviation from target location and Cooper-Harper score:
	Prepare corrective action list

Azimuth hold

Check	Action
	Establish aircraft in steady azimuth in clean air. Fly forward 100 meters and back along the same track.
	Measure azimuth-hold performance and Cooper-Harper rating:
	Prepare corrective action list

Flight 3: Structures and performance

Rate of climb and endurance

Check	Action
	Record density altitude.
	Take off and climb as quickly as possible. Record climb rate.
	Fly aircraft until fuel/battery levels require landing. Measure endurance.
	Prepare corrective action list

Structural oscillations

Check	Action
	Fly the aircraft at extremes of the flight envelope and attempt to produce structural oscillations.
	Record any oscillations that occur.
	Prepare corrective action list

B.3 Helicopters

Note: these testcards require some computations to be completed ahead of time.

The test campaign is structured such that a basic checkout flight is completed first. After the first checkout flight, there are several test cards to address various airworthiness standards. There is no need for these cards to be completed in any particular order, except that the basic checkout flight to be completed first.

Test cards begin on the next page.

Flight 1: Basic Checkout Flight

Pilot in command:

Date: Time:

Objectives:

- Explore basic aircraft handling characteristics
- Validate basic aircraft reliability

Departure

Check	Action
	Climb at predetermined power settings. Power:
	Cooper-Harper rating for takeoff and climb:
	Maintain power until predefined altitude is reached: Altitude:
	Remain above takeoff location for 5 minutes.
	Cooper-Harper rating for position-hold performance:

Cruise

Check	Action
	Reduce power to predetermined throttle setting:
	Trim aircraft.
	Fly the aircraft in the vicinity of the takeoff location to ascertain basic handling qualities.
	Identify any handling characteristics that need to be corrected.

Landing

Check	Action
	Fly at predetermined descent rate.
	Land at predetermined location.
	Cooper-Harper rating for approach and landing.

Post flight

Check	Action
	Record battery drain / fuel burn.
	Inspect airplane carefully
	Prepare corrective action list

Flight 2: Handing quality determination

Position hold

Check	Action
	Establish aircraft in steady position in clean air.
	Measure position-hold performance and Cooper-Harper rating:
	Establish aircraft in steady position in turbulent air.
	Measure position-hold performance and Cooper-Harper rating:
	Prepare corrective action list

Attitude hold

Check	Action
	Establish aircraft in steady attitude in clean air.
	Measure attitude-hold performance and Cooper-Harper rating:
	Prepare corrective action list

Pitch/bank limits

Check	Action
	Maintain maximum allowable roll and pitch per FOM requirements
	Cooper-Harper rating for maintaining attitude limits:
	Prepare corrective action list

Takeoff and landing precision

Check	Action
	Determine target for aircraft to land on. Make landing on this target.
	Measure deviation from target location and Cooper-Harper score:
	Prepare corrective action list

Azimuth hold

Check	Action
	Establish aircraft in steady azimuth in clean air. Fly forward 100 meters and back along the same track.
	Measure azimuth-hold performance and Cooper-Harper rating:
	Prepare corrective action list

Dynamic rollover angle

Check	Action
	Establish aircraft in condition where dynamic rollover is likely. Allow the aircraft to roll to an angle less than the calculated dynamic rollover angle and attempt to recover.
	Assess whether calculated dynamic rollover angle is reasonable and general handling traits for dynamic rollover.
	Prepare corrective action list

Stability

Check	Action
	Establish the helicopter in steady forward flight.
	Introduce a pitch disturbance. Observe the initial reaction and dynamic reaction.
	Repeat for roll and yaw.
	Prepare corrective action list

Flight 3: Structures and performance

Rate of climb and endurance

Check	Action
	Record density altitude.
	Take off and climb as quickly as possible. Record climb gradient.
	Fly aircraft until fuel/battery levels require landing. Measure endurance.
	Prepare corrective action list

Structural oscillations

Check	Action
	Fly the aircraft at extremes of the flight envelope and attempt to produce structural oscillations.
	Record any oscillations that occur.
	Prepare corrective action list

B.4 Airships

Note: these testcards require some computations to be completed ahead of time.

The test campaign is structured such that a basic checkout flight is completed first. After the first checkout flight, there are several test cards to address various airworthiness standards. There is no need for these cards to be completed in any particular order, except that the basic checkout flight to be completed first.

Test cards begin on the next page.

Flight 1: Basic Checkout Flight

Pilot in command:

Date: Time:

Objectives:

- Explore basic aircraft handling characteristics
- Validate basic aircraft reliability

Departure

Check	Action
	Remove mooring mast and climb at predetermined power settings. Power:
	Cooper-Harper rating for takeoff and climb:
	Maintain power until predefined altitude is reached: Altitude:
	Remain above takeoff location for 5 minutes.
	Cooper-Harper rating for position-hold performance:

Cruise

Check	Action
	Reduce power to predetermined throttle setting:
	Trim aircraft.
	Fly the aircraft in the vicinity of the takeoff location to ascertain basic handling qualities.
	Identify any handling characteristics that need to be corrected.

Landing

Check	Action
	Fly at predetermined descent rate.
	Land at predetermined location.
	Cooper-Harper rating for approach and landing.

Post flight

Check	Action
	Record battery drain / fuel burn.
	Inspect airplane carefully
	Prepare corrective action list

Flight 2: Dynamics and handling qualities

Static stability and dynamic yaw stability

Check	Action
	Establish aircraft in steady level unaccelerated flight.
	Introduce a pitch disturbance and note static stability characteristics.
	Repeat for roll and yaw.
	Establish aircraft in steady level unaccelerated flight.
	Introduce yaw disturbance and note dynamic response characteristics.
	Enter SLUF at maximum possible airspeed. Record this airspeed
	Introduce a pitch disturbance and verify that the aircraft possesses static pitch stability.
	Prepare corrective action list.

Control

Check	Action
	Establish aircraft in SLUF.
	Adjust the pitch of the aircraft. Note handling qualities or any idiosyncrasies.
	Yaw the aircraft and measure the yaw rate. Note handling qualities or any idiosyncrasies.
	Control the altitude on a large-scale by changing the trim altitude of the aircraft. Note handling qualities or any idiosyncrasies.
	Control the altitude of the aircraft on a small scale, such as what is required for takeoff and landing. Note handling qualities or any idiosyncrasies.
	Cooper-Harper rating for approach and landing.

Rate of climb and endurance

Check	Action
	Record density altitude.
	Take off and climb as quickly as possible. Record climb rate.
	Descend as quickly as possible. Record descent rate.
	Fly aircraft until fuel/battery levels require landing. Measure endurance.
	Prepare corrective action list

Structural oscillations

Check	Action
	Fly the aircraft at extremes of the flight envelope and attempt to produce structural oscillations.
	Record any oscillations that occur.
	Prepare corrective action list

Appendix C: Certificate Templates

C.1 Airworthiness Certificate

The airworthiness certificate template begins on the next page.

Note that the airworthiness and type certificates also include information regarding whether the aircraft is compliant with various government contract requirements. Even though this is not an airworthiness issue, it is included for reference.

STANDARD AIRWORTHINESS CERTIFICATE

(1) Registration marks	(2) Type-certificated make and model	(3) Serial number, if applicable	(4) Category of operation, operational/experimental

(5) Authority and basis for issuance

This airworthiness certificate is issued by the Office of Integrity Safety, and Compliance, and certifies that, as of the date of issuance, the aircraft to which issued has been inspected and found to conform to the type certificate therefor, to be in condition for safe operation, and has been shown to meet the requirements of the applicable comprehensive and detailed airworthiness code.

(6) Terms and conditions

Unless sooner surrendered, suspended, revoked, or a termination date is otherwise established by the Director of Flight Operations, this airworthiness certificate is effective if the maintenance, preventative maintenance, and alterations are performed in accordance with OISC-recommended procedures.

(7) Restrictions

Aircraft certified for experimental flight only must adhere to the following limitations on operation:

1. The aircraft may only be flown in a remote location, far from any infrastructure or people who could be adversely affected by an aircraft malfunction,
2. Regardless of the applicable flight rules, the aircraft may only be flown in daytime VFR conditions, and
3. The aircraft must be flown by an experienced pilot, and
4. The aircraft may only be flown for engineering and testing purposes.

Aircraft certified for operational flight have no restrictions other than those imposed by FAA flight rules and the UCB UAS FOM.

Date of issuance	OISC representative name	OISC representative signature

Any alteration, reproduction, or misuse of this certificate may be punishable by suspension of UCB UAS credentials.

This aircraft is certified for the following special applications:

Application or system - airplane	**Mark if certified**
Autopilot/stability augmentation system	YES/NO
Flight during nighttime hours	YES/NO
Flight in precipitation	YES/NO
Flight in cold weather	YES/NO
Flight in conditions with a risk of incidental icing	YES/NO
Flight in extended icing conditions	YES/NO
Multiengine	YES/NO
Fueled propulsion system	YES/NO
Flight BVLOS/in IMC	YES/NO
Aerial chase operations	YES/NO
Lightning	YES/NO

Application or system - multirotor	**Mark if certified**
Flight during nighttime hours	YES/NO
Flight in precipitation	YES/NO
Flight in cold weather	YES/NO
Flight in conditions with a risk of incidental icing	YES/NO
Variable-pitch rotors	YES/NO
Fueled propulsion system	YES/NO
Clutch systems	YES/NO
Flight BVLOS/in IMC	YES/NO
Aerial chase operations	YES/NO
Stability augmentation system	YES/NO
Lightning	YES/NO

Application or system - helicopter	**Mark if certified**
Flight during nighttime hours	YES/NO
Flight in precipitation	YES/NO
Flight in cold weather	YES/NO
Flight in conditions with a risk of incidental icing	YES/NO
Fueled propulsion system	YES/NO
Clutch systems	YES/NO
Flight BVLOS/in IMC	YES/NO
Aerial chase operations	YES/NO
Automation reliability	YES/NO
Stability augmentation system	YES/NO
Lightning	YES/NO

Application or system - airship	**Mark if certified**
Flight during nighttime hours	YES/NO
Flight in precipitation	YES/NO
Flight in cold weather	YES/NO
Flight in conditions with a risk of incidental icing	YES/NO
Fueled propulsion system	YES/NO
Aerial chase operations	YES/NO
Rigid and semi-rigid	YES/NO
Non-rigid	YES/NO
Lightning	YES/NO

The aircraft is certified for the following use:

Normal:	High load factor:

An aircraft certified for normal operation must avoid turbulent flight and may not intentionally execute any maneuver which results in a high load factor.

(8) United States Government contract eligibility

FEDERAL	**STATE**	**LOCAL**
YES/NO	YES/NO	YES/NO

C.2 Type Certificate

The type certificate template begins on the next page.

TYPE CERTIFICATE

This type certificate is issued by the Office of Integrity, Safety, and Compliance to the following proponent:

ORIGINAL MANUFACTURER NAME

MANUFACTURER LOCATION, TO INCLUDE ADDRESS, BUILDING, ROOM NUMBER AS APPLICABLE

This type certificate affirms that the product type design listed below complies with the applicable type certification airworthiness standards.

TYPE MODEL NAME	DATE OF ISSUANCE	OISC-RECCOMMENDED PILOT SKILL LEVEL

TYPE CERTIFICATE DATA SHEET

Propulsion system

1. Motor make(s) and model(s)
2. Fuel or battery type
3. Engine RPM limits and maximum continuous power
4. Acceptable propellers and spinners, including diameter tolerances and RPM tolerances at full throttle

Airspeed limitations

1. V speeds, to include V_A, V_{no}, V_{NE}, V_{FE}.

Weight and balance limits

1. CG forward and aft limits at varying gross weights
2. Maximum weight
3. Fuel capacity/battery capacity
4. Maximum payload

Control surface specifications

1. Dimensions and maximum deflections of each control surface

Overall properties, to include:

1. Basic dimensioned drawing of the aircraft
2. Key characteristic dimensions, such as wing planform area, propeller diameters, tail moment arms, etc.
3. Location of datum for weight-and-balance purposes

Reference to OISC-approved pilot's operating handbook

Application or system - airplane	**Mark if certified**
Autopilot/stability augmentation system	YES/NO
Flight during nighttime hours	YES/NO
Flight in precipitation	YES/NO
Flight in cold weather	YES/NO
Flight in conditions with a risk of incidental icing	YES/NO
Flight in extended icing conditions	YES/NO
Multiengine	YES/NO
Fueled propulsion system	YES/NO
Flight BVLOS/in IMC	YES/NO
Aerial chase operations	YES/NO
Lightning	YES/NO

Application or system - multirotor	**Mark if certified**
Flight during nighttime hours	YES/NO
Flight in precipitation	YES/NO
Flight in cold weather	YES/NO
Flight in conditions with a risk of incidental icing	YES/NO
Variable-pitch rotors	YES/NO
Fueled propulsion system	YES/NO
Clutch systems	YES/NO
Flight BVLOS/in IMC	YES/NO
Aerial chase operations	YES/NO
Stability augmentation system	YES/NO
Lightning	YES/NO

Application or system - helicopter	**Mark if certified**
Flight during nighttime hours	YES/NO
Flight in precipitation	YES/NO
Flight in cold weather	YES/NO
Flight in conditions with a risk of incidental icing	YES/NO
Fueled propulsion system	YES/NO
Clutch systems	YES/NO
Flight BVLOS/in IMC	YES/NO
Aerial chase operations	YES/NO
Automation reliability	YES/NO
Stability augmentation system	YES/NO
Lightning	YES/NO

Application or system - airship	**Mark if certified**
Flight during nighttime hours	YES/NO
Flight in precipitation	YES/NO
Flight in cold weather	YES/NO
Flight in conditions with a risk of incidental icing	YES/NO
Fueled propulsion system	YES/NO
Aerial chase operations	YES/NO
Rigid and semi-rigid	YES/NO
Non-rigid	YES/NO
Lightning	YES/NO

The aircraft is certified for the following use:

Normal:	High load factor:

An aircraft certified for normal operation must avoid turbulent flight and may not intentionally execute any maneuver which results in a high load factor.

(8) United States Government contract eligibility

FEDERAL	**STATE**	**LOCAL**
YES/NO	YES/NO	YES/NO

C.3 OISC Form 337

The Form 337 template begins on the next page:

University of Colorado at Boulder
Office of Integrity, Safety, and Compliance
Flight Operations Department

OISC FORM 337: MAJOR REPAIR OR ALTERATION

1. AIRCRAFT:

Registration mark		CU serial number (if applicable)	
Make		Model	

2. OWNER:

Name	
Address	

3. UNITS WORKED ON

Unit	Repair	Modification	Make	Model	Serial number
Airframe					
Powerplant					
Propeller					
Appliance					

APPROVAL FOR RETURN TO SERVICE

The aircraft is approved / rejected for return to service.

Name of OISC airworthiness inspector: Date:

I certify that the repair and/or alterations made to the aircraft identified in items 1 and 3 above have been made in accordance with the requirements of the Airworthiness Certification Manual and that the information furnished herein is true and correct to the best of my knowledge.

Signature of OISC airworthiness inspector: ___________________________________

DESCRIPTION OF WORK ACCOMPLISHED

Aircraft registration mark	
Date	

Attach description of work completed to this form.

C.4 Supplemental Type Certificate

The Supplemental Type Certificate template begins on the next page:

SUPPLEMENTAL TYPE CERTIFICATE

This supplemental type certificate is issued by the Office of Integrity, Safety, and Compliance to the following proponent:

STC MANUFACTURER NAME

MANUFACTURER LOCATION, TO INCLUDE ADDRESS, BUILDING, ROOM NUMBER AS APPLICABLE

This type certificate affirms that the product type design listed below complies with the applicable supplemental type certification airworthiness standards.

STC NAME	DATE OF ISSUANCE	OISC-RECCOMMENDED PILOT SKILL LEVEL

This supplemental type certificate is issued by the Office of Integrity, Safety, and Compliance as an approved modification for the following aircraft:

ORIGINAL AIRCRAFT NAME

MANUFACTURER LOATION, TO INCLUDE ADDRESS, BUILDING, ROOM NUMBER AS APPLICABLE

DATE IF ISSUANCE OF ORIGINAL TYPE CERTIFICATE

This supplemental type certificate is valid strictly for the aircraft type mentioned above.

TYPE CERTIFICATE DATA SHEET

Summary of changes to aircraft

Unit	Modification(s) made
Airframe	
Powerplant	
Propeller	
Performance	

Summary of effects of changes to aircraft

Category	Change(s) resulting from
Aerodynamic performance	
Stability and control	
Structural performance	

Electronics performance Additional category	

Dimensioned drawing of modified aircraft relative to original aircraft, including materials used to construct the modified parts

Reference to OISC-approved amended pilot's operating handbook

Appendix D: Comprehensive Acronym, Symbol, and Term List

D.1 Mathematical Symbols

Aerodynamic forces

X	Aerodynamic force in $\hat{x}$ direction
Y	Aerodynamic force in $\hat{y}$ direction
Z	Aerodynamic force in $\hat{z}$ direction

Aerodynamic moments

L	Aerodynamic moment about $\hat{x}$ axis
M	Aerodynamic moment about $\hat{y}$ axis
N	Aerodynamic moment about $\hat{z}$ axis

Angular rates

p	Angular rate about $\hat{x}$ axis
q	Angular rate about $\hat{y}$ axis
r	Angular rate about $\hat{z}$ axis

Translational velocities

u	Relative wind velocity along $\hat{x}$ axis
v	Relative wind velocity along $\hat{y}$ axis
w	Relative wind velocity along $\hat{z}$ axis
$\vec{V} = [u, v, w]^T$	Relative wind velocity vector
$V = \lvert\vec{V}\rvert$	Relative wind velocity vector magnitude (airspeed)

Attitude specification Euler angles

ψ	Azimuth angle
θ	Elevation angle

ϕ Bank angle

Displacement

x_E Coordinate of aircraft center of mass location relative to NED frame along $\hat{N}$ axis.

y_E Coordinate of aircraft center of mass location relative to NED frame along $\hat{E}$ axis.

z_E Coordinate of aircraft center of mass location relative to NED frame along $\hat{D}$ axis.

Miscellaneous angles

$\alpha = \tan^{-1}\frac{w}{u}$ Angle of attack, angle of oncoming airflow relative to body $\hat{x}$ axis, measured in xz plane.

$\beta = \tan^{-1}\frac{v}{V}$ Sideslip angle, angle of oncoming airflow relative to body $\hat{x}$ axis, measured in xy plane

ϵ Downwash angle, characterizes disturbance in airflow about horizontal stabilizer

σ Sidewash angle, characterizes disturbance in airflow about vertical stabilizer

Groupings of aircraft degrees of freedoms

Longitudinal: $u, w, q, \theta, x_E,\ z_E$

Lateral: v, p, r, ϕ, ψ, y_E

V speeds – important reference speeds for identifying aircraft performance and limitations

V_s Stall speed in clean configuration.

V_{s0} Stall speed in landing configuration.

V_x Speed for best angle of climb. Corresponding angle of climb θ.

V_y Speed for best rate of climb. Corresponding rate of climb V_h.

V_{ref} Landing reference speed.

V_A Design maneuvering speed.

V_O Maximum operating maneuvering speed.

V_{NE} Never-exceed speed.

V_{DF} Demonstrated maximum diving speed.

V_H Maximum airspeed in level flight at maximum continuous power.

Airfoil parameters

α Angle of attack; typically measured as the angle between the chord line of the root of the wing and the oncoming airflow. Absolute angle of attack standard also exists; α defined such that $\alpha = 0$ when lift is zero. Usually designated as α_{abs}.

a_0 Lift curve slope of airfoil. Takes a value of 2π per radian for thin airfoils.

C_l Lift coefficient (2D).

q Dynamic pressure. Can be calculated as $q = \frac{1}{2}\rho u^2$

ρ Air density. Can be found based on standard atmosphere data.

u_∞ Free-stream flow speed. Also referred to as true airspeed.

C_d Drag coefficient (2D).

C_m Airfoil pitching moment coefficient. Note 3D effects are typically ignored. Positive pitching moment acts to pitch the airplane up, which is consistent with the definition of M given previously.

c Chord length.

c_f Skin friction coefficient, a component of 2D drag coefficient.

L' Lift per unit span.

D' Drag per unit span.

M' Pitching moment per unit span.

Full wing/aircraft parameters

a Lift curve slope of full finite wing.

b Wingspan.

S Wing planform area.

AR Wing aspect ratio.

λ Taper ratio. Calculated as $\lambda = C_t/C_r$.

c_t Chord length at wingtip.

c Chord length at wing root.

$\bar{c}$ Mean chord length.

Λ Sweepback angle of quarter chord line.

Γ Dihedral angle. Dihedral (as opposed to anhedral) corresponds to positive Γ.

C_D Drag coefficient (3D).

D Drag force.

M Pitching moment.

L Total aircraft lift.

e Span efficiency factor, which takes a value less than or equal to unity, depending on wing planform geometry. Describes efficiency of wing planform geometry; quantifies how elliptical the lift distribution is.

e_0 Oswald efficiency factor which takes a value less than or equal to unity, and less than the value of e. Dependent on whole aircraft geometry. Describes efficiency of aircraft geometry.

C_L Lift coefficient (3D).

n Load factor.

Basic structures notation

σ Normal stress.

τ Shear stress.

ϵ Normal strain.

γ Shear strain.

E Modulus of elasticity (Young's modulus).

G Shear modulus.

I Second moment of area.

J Torsional stiffness parameter.

FS Factor of safety, defined as $\sigma_{max}/\sigma_{applied}$ (or similar for shear stress).

ν Poisson's ratio.

Beams

y Distance above neutral axis of beam.

M Bending moment.

V Shear force.

θ, v' Deflection angle. Notation used interchangeably.

v Deflection.

Torsion

$\frac{\partial \phi}{\partial x}$ Twist rate.

ϕ Twist angle.

L Length of torsional specimen.

Stresses

σ_{xx} Normal stress along $\hat{x}$ axis. Similar notation applies to normal strain.

τ_{xy} Shear stress with cut plane normal vector parallel to $\hat{x}$, force parallel to $\hat{y}$. Similar notation applies to shear strain.

σ'_{xx} Transformed normal stress value σ_{xx}. Similar notation for other transformed stresses.

θ Stress transformation angle

θ_p Stress transformation angle corresponding to principal stress.

τ_{max} Maximum in-plane shear stress.

σ_1 First principal stress.

σ_2 Second principal stress. $\sigma_2 < \sigma_1$.

D.2 Specialized Engineering and Aviation Terminology

AHRS Attitude and heading reference system

Control derivative Describes how particular forces and moments acting on an aircraft change with control deflections.

Critically damped In reference to dynamic stability: aircraft's response returns to equilibrium as quickly as possible without oscillating. Corresponds to $\zeta = 1$.

Damped frequency Oscillation frequency of system without control, but with damping.

Dynamic mode A specific way in which the aircraft oscillates. A mode is defined by its natural frequency, damping ratio, stability, and the degrees of freedom along which the aircraft oscillates.

Dynamic Stability Characterizes aircraft's response to a disturbance over time; is dynamically stable if it returns to and stays at equilibrium condition.

Elastic deformation	Describes situation in which material is stressed, but is below yield stress so that the material returns exactly to its undeformed configuration when the stress is removed.
Envelope	In reference to dynamic stability: exponential curve that either defines or bounds system response.
Equilibrium	State in which forces and moments acting on the aircraft sum to zero, and in turn the aircraft does not experience any linear or angular acceleration.
First-order response	System response to a disturbance is constructed only from exponential functions: no oscillations occur.
GNSS	Global Navigation Satellite System, which is a more general term than GPS and includes all major navigation satellite systems, such as GPS (United States), GLONASS (Russia), BeiDou (China), Galileo (European Union)
INOP	Inoperative
Jesus bolt/nut	Colloquial name for a bolt or nut which would cause catastrophic loss of the aircraft if it were to fail. Also referred to as a critical part.
Natural frequency	Oscillation frequency of system without control or damping.
Oscillatory	In reference to dynamic stability: aircraft's response involves oscillations. Also referred to as having a second-order response.
Overdamped	In reference to dynamic stability: aircraft's response returns to equilibrium without oscillating, but not as quickly as possible. Corresponds to $\zeta > 1$.
Pitch damping	Describes moment produced which opposes the pitch rate, and in turn limits the maximum pitch rate of the aircraft.
Pitch stiffness	Describes static stability about y axis.
Plastic deformation	Describes situation in which material is stressed, but above yield stress so that the material retains permanent deformation even when the stress is removed.
Roll damping	Describes moment produced which opposes the roll rate, and in turn limits the maximum roll rate of the aircraft.
Roll stiffness	Describes static stability about x axis.
SLUF	Acronym for steady, level, unaccelerated flight. Describes a condition in which the aircraft's altitude and airspeed are constant and the load factor is 1G.
Stability derivative	Describes how particular forces and moments acting on an aircraft change as other parameters, such as airspeed, angle of attack, etc. change.

Static Stability	Characterizes aircraft's initial response to a disturbance; is statically stable if initial response is toward equilibrium condition.
Undamped	In reference to dynamic stability: aircraft's response involves oscillations that are constant in magnitude. Corresponds to $\zeta = 0$.
Underdamped	In reference to dynamic stability: aircraft's response involves oscillations that decay in magnitude over time. Corresponds to $0 < \zeta < 1$.
Yaw damping	Describes moment produced which opposes the yaw rate, and in turn limits the maximum yaw rate of the aircraft.
Yaw stiffness	Describes static stability about z axis.

Airplane dynamic modes

Note: unconventional airplanes or airplanes with artificial stabilization will likely have different modes.

Longitudinal modes

- Phugoid mode – a second-order mode which contains primarily changes in u and w and results in oscillation at a low frequency. This mode is generally stable and is lightly damped. This mode is generally easy to activate in flight.
- Short period mode – a second-order mode which contains primarily changes in q and θ and results in oscillation at a high frequency. This mode is generally stable and is well-damped. This mode is generally difficult to activate in flight.

Lateral modes

- Dutch roll mode – a second-order mode with changes in all lateral degrees of freedom; the oscillation is at a low frequency. This mode is generally easy to activate in flight.
- Roll mode – a first-order mode that has a fast response; contains almost pure rolling motion. This mode is generally stable.
- Spiral mode – a first-order mode that has a slow response. This mode entails slowly growing or slowly decaying values in all lateral degrees of freedom. This mode may be unstable or stable depending on flight conditions and aircraft design.

D.3 CU-Specific Terminology

Associate Vice Chancellor	Individual with final responsibility and authority regarding
Authorizing Document	Document that delineates the rules which an operator must adhere to, i.e. COA

AVC	Associate Vice Chancellor of Integrity, Safety, and Compliance
Certificate of Authorization	Document issued to public entity by the FAA authorizing UAS
CFI	CU Flight Instructor
Checkride	Event where an examiner administers a practical test to evaluate
COA	Certificate of Authorization
Crewmember	A CU-certified individual serving an FAA-required position on the flight crew
	crewmembers per FOM; final authority regarding
CU Flight Instructor	Individual authorized to give flight instruction; certified per FOM
CU	University of Colorado
Director of Flight Operations	Individual delegated by AVC as responsible for running the Flight Operations Department
DO	Director of Flight Operations
Examiner	Individual authorized to teach ground school and certify
FAA	Federal Aviation Administration
FAR	Federal Aviation Regulation; references title 14 of code of federal regulations
Flight Operations Manual	CU-owned manual governing UAS flights
FOM	Flight Operations Manual
NAS	National Airspace System
OISC	Office of Integrity, Safety, and Compliance
	Operation
Operation	Sequence of flights and surrounding planning that the PIC
Organization	An institution within CU that conducts UAS operations, i.e. CU Police
PI	Principal Investigator
PIC	Pilot in Command certified per FOM
Pilot in Command	Individual certified per FOM who holds legal authority and
Principal Investigator	Highest ranking academic team member involved in a UAS

Proponent	Individual/entity seeking a type certificate or an airworthiness certificate
UAS	Unmanned Aircraft System
UCB	University of Colorado at Boulder
Visual Line of Sight	Criteria for UAS operations set out in FAR107.31 which requires crew members to be able to see the attitude, altitude, orientation, etc. of the UAS
VLOS	Visual Line of Sight, as defined in FAR107.31

Appendix E: Version Change Summaries

Version	Date	Changes
1.1	14 May 2021	Minor changes to airplane dynamic mode airworthiness standards

Appendix F: References

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