U.S. Department
of Transportation

**Federal Aviation
Administration**

800 Independence Ave., S.W.
Washington, D.C. 20591

July 21, 2015

Exemption No. 12102
Regulatory Docket No. FAA–2015–0965

Mr. Keith Cottrill
Innovative Ventures
502 Southwood Drive
Bossier City, LA 71111

Dear Mr. Cottrill:

This letter is to inform you that we have granted your request for exemption. It transmits our decision, explains its basis, and gives you the conditions and limitations of the exemption, including the date it ends.

By letter dated March 31, 2015, you petitioned the Federal Aviation Administration (FAA) on behalf of Innovative Ventures (hereinafter petitioner or operator) for an exemption. The petitioner requested to operate an unmanned aircraft system (UAS) to conduct exploration, usage, and management of land and mineral rights.

See Appendix A for the petition submitted to the FAA describing the proposed operations and the regulations that the petitioner seeks an exemption.

The FAA has determined that good cause exists for not publishing a summary of the petition in the Federal Register because the requested exemption would not set a precedent, and any delay in acting on this petition would be detrimental to the petitioner.

Airworthiness Certification

The UAS proposed by the petitioner are a DJI Phantom 2 and a Turbo Ace Matrix.

The petitioner requested relief from 14 CFR part 21, *Certification procedures for products and parts, Subpart H—Airworthiness Certificates*. In accordance with the statutory criteria provided in Section 333 of Public Law 112−95 in reference to 49 U.S.C. § 44704, and in consideration of the size, weight, speed, and limited operating area associated with the aircraft and its operation, the Secretary of Transportation has determined that this aircraft meets the conditions of Section 333. Therefore, the FAA finds that the requested relief from 14 CFR part 21, *Certification procedures for products and parts, Subpart H—Airworthiness Certificates*, and any associated noise certification and testing requirements of part 36, is not necessary.

The Basis for Our Decision

You have requested to use a UAS for aerial data collection[1]. The FAA has issued grants of exemption in circumstances similar in all material respects to those presented in your petition. In Grants of Exemption Nos. 11062 to Astraeus Aerial (*see* Docket No. FAA−2014−0352), 11109 to Clayco, Inc. (*see* Docket No. FAA−2014−0507), 11112 to VDOS Global, LLC (*see* Docket No. FAA−2014−0382), and 11213 to Aeryon Labs, Inc. (*see* Docket No. FAA−2014−0642), the FAA found that the enhanced safety achieved using an unmanned aircraft (UA) with the specifications described by the petitioner and carrying no passengers or crew, rather than a manned aircraft of significantly greater proportions, carrying crew in addition to flammable fuel, gives the FAA good cause to find that the UAS operation enabled by this exemption is in the public interest.

Having reviewed your reasons for requesting an exemption, I find that—

- They are similar in all material respects to relief previously requested in Grant of Exemption Nos. 11062, 11109, 11112, and 11213;
- The reasons stated by the FAA for granting Exemption Nos. 11062, 11109, 11112, and 11213 also apply to the situation you present; and
- A grant of exemption is in the public interest.

Our Decision

In consideration of the foregoing, I find that a grant of exemption is in the public interest. Therefore, pursuant to the authority contained in 49 U.S.C. 106(f), 40113, and 44701, delegated to me by the Administrator, Innovative Ventures is granted an exemption from 14 CFR §§ 61.23(a) and (c), 61.101(e)(4) and (5), 61.113(a), 61.315(a), 91.7(a), 91.119(c), 91.121, 91.151(a)(1), 91.405(a), 91.407(a)(1), 91.409(a)(1) and (2), and 91.417(a) and (b), to the extent necessary to allow the petitioner to operate a UAS to perform aerial data collection. This exemption is subject to the conditions and limitations listed below.

[1] Aerial data collection includes any remote sensing and measuring by an instrument(s) aboard the UA. Examples include imagery (photography, video, infrared, etc.), electronic measurement (precision surveying, RF analysis, etc.), chemical measurement (particulate measurement, etc.), or any other gathering of data by instruments aboard the UA.

Conditions and Limitations

In this grant of exemption, Innovative Ventures is hereafter referred to as the operator.

Failure to comply with any of the conditions and limitations of this grant of exemption will be grounds for the immediate suspension or rescission of this exemption.

1. Operations authorized by this grant of exemption are limited to the DJI Phantom 2 and Turbo Ace Matrix when weighing less than 55 pounds including payload. Proposed operations of any other aircraft will require a new petition or a petition to amend this exemption.

2. Operations for the purpose of closed-set motion picture and television filming are not permitted.

3. The UA may not be operated at a speed exceeding 87 knots (100 miles per hour). The exemption holder may use either groundspeed or calibrated airspeed to determine compliance with the 87 knot speed restriction. In no case will the UA be operated at airspeeds greater than the maximum UA operating airspeed recommended by the aircraft manufacturer.

4. The UA must be operated at an altitude of no more than 400 feet above ground level (AGL). Altitude must be reported in feet AGL.

5. The UA must be operated within visual line of sight (VLOS) of the PIC at all times. This requires the PIC to be able to use human vision unaided by any device other than corrective lenses, as specified on the PIC's FAA-issued airman medical certificate or U.S. driver's license.

6. All operations must utilize a visual observer (VO). The UA must be operated within the visual line of sight (VLOS) of the PIC and VO at all times. The VO may be used to satisfy the VLOS requirement as long as the PIC always maintains VLOS capability. The VO and PIC must be able to communicate verbally at all times; electronic messaging or texting is not permitted during flight operations. The PIC must be designated before the flight and cannot transfer his or her designation for the duration of the flight. The PIC must ensure that the VO can perform the duties required of the VO.

7. This exemption and all documents needed to operate the UAS and conduct its operations in accordance with the conditions and limitations stated in this grant of exemption, are hereinafter referred to as the operating documents. The operating documents must be accessible during UAS operations and made available to the Administrator upon request. If a discrepancy exists between the conditions and limitations in this exemption and the procedures outlined in the operating documents,

the conditions and limitations herein take precedence and must be followed. Otherwise, the operator must follow the procedures as outlined in its operating documents. The operator may update or revise its operating documents. It is the operator's responsibility to track such revisions and present updated and revised documents to the Administrator or any law enforcement official upon request. The operator must also present updated and revised documents if it petitions for extension or amendment to this grant of exemption. If the operator determines that any update or revision would affect the basis upon which the FAA granted this exemption, then the operator must petition for an amendment to its grant of exemption. The FAA's UAS Integration Office (AFS−80) may be contacted if questions arise regarding updates or revisions to the operating documents.

8. Any UAS that has undergone maintenance or alterations that affect the UAS operation or flight characteristics, e.g., replacement of a flight critical component, must undergo a functional test flight prior to conducting further operations under this exemption. Functional test flights may only be conducted by a PIC with a VO and must remain at least 500 feet from other people. The functional test flight must be conducted in such a manner so as to not pose an undue hazard to persons and property.

9. The operator is responsible for maintaining and inspecting the UAS to ensure that it is in a condition for safe operation.

10. Prior to each flight, the PIC must conduct a pre-flight inspection and determine the UAS is in a condition for safe flight. The pre-flight inspection must account for all potential discrepancies, e.g., inoperable components, items, or equipment. If the inspection reveals a condition that affects the safe operation of the UAS, the aircraft is prohibited from operating until the necessary maintenance has been performed and the UAS is found to be in a condition for safe flight.

11. The operator must follow the UAS manufacturer's maintenance, overhaul, replacement, inspection, and life limit requirements for the aircraft and aircraft components.

12. Each UAS operated under this exemption must comply with all manufacturer safety bulletins.

13. Under this grant of exemption, a PIC must hold either an airline transport, commercial, private, recreational, or sport pilot certificate. The PIC must also hold a current FAA airman medical certificate or a valid U.S. driver's license issued by a state, the District of Columbia, Puerto Rico, a territory, a possession, or the Federal government. The PIC must also meet the flight review requirements specified in 14 CFR § 61.56 in an aircraft in which the PIC is rated on his or her pilot certificate.

14. The operator may not permit any PIC to operate unless the PIC demonstrates the ability to safely operate the UAS in a manner consistent with how the UAS will be operated under this exemption, including evasive and emergency maneuvers and maintaining appropriate distances from persons, vessels, vehicles and structures. PIC qualification flight hours and currency must be logged in a manner consistent with 14 CFR § 61.51(b). Flights for the purposes of training the operator's PICs and VOs (training, proficiency, and experience-building) and determining the PIC's ability to safely operate the UAS in a manner consistent with how the UAS will be operated under this exemption are permitted under the terms of this exemption. However, training operations may only be conducted during dedicated training sessions. During training, proficiency, and experience-building flights, all persons not essential for flight operations are considered nonparticipants, and the PIC must operate the UA with appropriate distance from nonparticipants in accordance with 14 CFR § 91.119.

15. UAS operations may not be conducted during night, as defined in 14 CFR § 1.1. All operations must be conducted under visual meteorological conditions (VMC). Flights under special visual flight rules (SVFR) are not authorized.

16. The UA may not operate within 5 nautical miles of an airport reference point (ARP) as denoted in the current FAA Airport/Facility Directory (AFD) or for airports not denoted with an ARP, the center of the airport symbol as denoted on the current FAA-published aeronautical chart, unless a letter of agreement with that airport's management is obtained or otherwise permitted by a COA issued to the exemption holder. The letter of agreement with the airport management must be made available to the Administrator or any law enforcement official upon request.

17. The UA may not be operated less than 500 feet below or less than 2,000 feet horizontally from a cloud or when visibility is less than 3 statute miles from the PIC.

18. If the UAS loses communications or loses its GPS signal, the UA must return to a pre-determined location within the private or controlled-access property.

19. The PIC must abort the flight in the event of unpredicted obstacles or emergencies.

20. The PIC is prohibited from beginning a flight unless (considering wind and forecast weather conditions) there is enough available power for the UA to conduct the intended operation and to operate after that for at least five minutes or with the reserve power recommended by the manufacturer if greater.

21. Air Traffic Organization (ATO) Certificate of Waiver or Authorization (COA). All operations shall be conducted in accordance with an ATO-issued COA. The exemption holder may apply for a new or amended COA if it intends to conduct operations that cannot be conducted under the terms of the attached COA.

22. All aircraft operated in accordance with this exemption must be identified by serial number, registered in accordance with 14 CFR part 47, and have identification (N−Number) markings in accordance with 14 CFR part 45, Subpart C. Markings must be as large as practicable.

23. Documents used by the operator to ensure the safe operation and flight of the UAS and any documents required under 14 CFR §§ 91.9 and 91.203 must be available to the PIC at the Ground Control Station of the UAS any time the aircraft is operating. These documents must be made available to the Administrator or any law enforcement official upon request.

24. The UA must remain clear and give way to all manned aviation operations and activities at all times.

25. The UAS may not be operated by the PIC from any moving device or vehicle.

26. All Flight operations must be conducted at least 500 feet from all nonparticipating persons, vessels, vehicles, and structures unless:
    a. Barriers or structures are present that sufficiently protect nonparticipating persons from the UA and/or debris in the event of an accident. The operator must ensure that nonparticipating persons remain under such protection. If a situation arises where nonparticipating persons leave such protection and are within 500 feet of the UA, flight operations must cease immediately in a manner ensuring the safety of nonparticipating persons; and
    b. The owner/controller of any vessels, vehicles or structures has granted permission for operating closer to those objects and the PIC has made a safety assessment of the risk of operating closer to those objects and determined that it does not present an undue hazard.

    The PIC, VO, operator trainees or essential persons are not considered nonparticipating persons under this exemption.

27. All operations shall be conducted over private or controlled-access property with permission from the property owner/controller or authorized representative. Permission from property owner/controller or authorized representative will be obtained for each flight to be conducted.

28. Any incident, accident, or flight operation that transgresses the lateral or vertical boundaries of the operational area as defined by the applicable COA must be reported to the FAA's UAS Integration Office (AFS−80) within 24 hours. Accidents must be reported to the National Transportation Safety Board (NTSB) per instructions contained on the NTSB Web site: www.ntsb.gov.

If this exemption permits operations for the purpose of closed-set motion picture and television filming and production, the following additional conditions and limitations apply.

29. The operator must have a motion picture and television operations manual (MPTOM) as documented in this grant of exemption.

30. At least 3 days before aerial filming, the operator of the UAS affected by this exemption must submit a written Plan of Activities to the local Flight Standards District Office (FSDO) with jurisdiction over the area of proposed filming. The 3-day notification may be waived with the concurrence of the FSDO. The plan of activities must include at least the following:
    a. Dates and times for all flights;
    b. Name and phone number of the operator for the UAS aerial filming conducted under this grant of exemption;
    c. Name and phone number of the person responsible for the on-scene operation of the UAS;
    d. Make, model, and serial or N−Number of UAS to be used;
    e. Name and certificate number of UAS PICs involved in the aerial filming;
    f. A statement that the operator has obtained permission from property owners and/or local officials to conduct the filming production event; the list of those who gave permission must be made available to the inspector upon request;
    g. Signature of exemption holder or representative; and
    h. A description of the flight activity, including maps or diagrams of any area, city, town, county, and/or state over which filming will be conducted and the altitudes essential to accomplish the operation.

31. Flight operations may be conducted closer than 500 feet from participating persons consenting to be involved and necessary for the filming production, as specified in the exemption holder’s MPTOM.

Unless otherwise specified in this grant of exemption, the UAS, the UAS PIC, and the UAS operations must comply with all applicable parts of 14 CFR including, but not limited to, parts 45, 47, 61, and 91.

This exemption terminates on July 31, 2017, unless sooner superseded or rescinded.

Sincerely,

John S. Duncan
Director, Flight Standards Service

Enclosures

March 31, 2015

U.S. Department of Transportation, Docket Operations
West Building Ground Floor, Room w12-140
1200 New Jersey Avenue, SE.,
Washington, DC 20590

Petition for Exemption Under Section 333 of the FAA Reform Act and Part 11 of the Federal Aviation Regulations

To Whom It May Concern:

Pursuant to Section 333 of the FAA Modernization and Reform Act of 2012 and 14 C.F.R. Part 11, Innovative Ventures is submitting this petition to U.S. Department of Transportation, Docket Operations. The petitioner is requesting exemption so that they may apply for a Certificate of Authorization (COA). If approved, they will utilize this authorization to operate a UAS (Turbo Ace MATRIX) for the purpose of assisting companies and individuals in the exploration, usage, and management of land and mineral right opportunities they possess. The Petitioner does not intend to use this exemption outside of the United States.

Innovative Ventures requests exemption from the following sections of Title 14:

Part 21 prescribes the procedural requirements for issuing and changing design approvals, productions approvals, airworthiness certificates, and airworthiness approvals.

Section 45.23(b) prescribes that when marks include only the Roman capital letter “N” and the registration number is displayed on limited, restricted or light-sport category aircraft or experimental or provisionally certificated aircraft, the operator must also display on that aircraft near each entrance to the cabin, cockpit, or pilot station, in letters not less than 2 inches nor more than 6 inches high, the words “limited,” “restricted,” “light-sport,” “experimental,” or “provisional,” as applicable.

Section 61.113(a) and (b) prescribes that—

> (a) no person who holds a private pilot certificate may act as a pilot in command of an aircraft that is carrying passengers or property for compensation or hire; nor may that person, for compensation or hire, act as pilot in command of an aircraft.
>
> (b) a private pilot may, for compensation or hire, act as pilot in command of an aircraft in connection with any business or employment if:
>
> > (1) The flight is only incidental to that business or employment; and
> >
> > (2) The aircraft does not carry passengers or property for compensation or hire.

Section 91.7(a) prescribes that no person may operate a civil aircraft unless it is in an airworthy condition.

Section 91.7(b) prescribes that the pilot in command of a civil aircraft is responsible for determining whether that aircraft is in condition for safe flight and that the PIC shall discontinue the flight when unairworthy mechanical, electrical, or structural conditions occur.

Section 91.9(b)(2) prohibits operation of U.S.-registered civil aircraft unless there is available in the aircraft a current approved Airplane or Rotorcraft Flight Manual, approved manual material, markings, and placards, or any combination thereof.

Section 91.103(b) prescribes that a pilot shall for any flight, become familiar with runway lengths at airports of intended use, and takeoff and landing distance information.

Section 91.109(a) prescribes, in pertinent part, that no person may operate a civil aircraft (except a manned free balloon) that is being used for flight instruction unless that aircraft has fully functioning dual controls.

Section 91.119 prescribes that, except when necessary for takeoff or landing, no person may operate an aircraft below the following altitudes:

> (a) *Anywhere*. An altitude allowing, if a power unit fails, an emergency landing without undue hazard to persons or property on the surface.
>
> (b) *Over congested areas*. Over any congested area of a city, town, or settlement, or over any open air assembly of persons, an altitude of 1,000 feet above the highest obstacle within a horizontal radius of 2,000 feet of the aircraft.
>
> (c) *Over other than congested areas*. An altitude of 500 feet above the surface, except over open water or sparsely populated areas. In those cases, the aircraft may not be operated closer than 500 feet to any person, vessel, vehicle, or structure.
>
> (d) *Helicopters, powered parachutes, and weight-shift-control aircraft.* If the operation is conducted without hazard to persons or property on the surface—
>
>> (1) A helicopter may be operated at less than the minimums prescribed in paragraph (b) or (c) of this section, provided each person operating the helicopter complies with any routes or altitudes specifically prescribed for helicopters by the FAA; and
>>
>> (2) A powered parachute or weight-shift-control aircraft may be operated at less than the minimums prescribed in paragraph (c) of this section.

Section 91.121 requires, in pertinent part, each person operating an aircraft to maintain cruising altitude by reference to an altimeter that is set "…to the elevation of the departure airport or an appropriate altimeter setting available before departure."

Section 91.151(a) prescribes that no person may begin a flight in an airplane under VFR conditions unless (considering wind and forecast weather conditions) there is enough fuel to fly to the first point of intended landing and, assuming normal cruising speed, (1) during the day, to fly after that for at least 30 minutes [emphasis added].

Section 91.203(a) prohibits, in pertinent part, any person from operating a civil aircraft unless it has within it (1) an appropriate and current airworthiness certificate; and (2) an effective U.S. registration certificate issued to its owner or, for operation within the United States, the second copy of the Aircraft registration Application as provided for in § 47.31(c).

Section 91.203(b) prescribes, in pertinent part, that no person may operate a civil aircraft unless the airworthiness certificate or a special flight authorization issued under § 91.715 is displayed at the cabin or cockpit entrance so that it is legible to passengers or crew.

Section 91.405(a) requires, in pertinent part, that an aircraft operator or owner shall have that aircraft inspected as prescribed in subpart E of the same part and shall, between required inspections, except as provided in paragraph (c) of the same section, have discrepancies repaired as prescribed in part 43 of the chapter.

Section 91.407(a)(1) prohibits, in pertinent part, any person from operating an aircraft that has undergone maintenance, preventive maintenance, rebuilding, or alteration unless it has been approved for return to service by a person authorized under § 43.7 of the same chapter.

Section 91.409(a)(2) prescribes, in pertinent part, that no person may operate an aircraft unless, within the preceding 12 calendar months, it has had an inspection for the issuance of an airworthiness certificate in accordance with part 21 of this chapter.

Section 91.417(a) and (b) prescribes, in pertinent part, that—

> (a) Each registered owner or operator shall keep the following records for the periods specified in paragraph (b) of this section:
>
> > (1) Records of the maintenance, preventive maintenance, and alteration and records of the 100-hour, annual, progressive, and other required or approved inspections, as appropriate, for each aircraft (including the airframe) and each engine, propeller, rotor, and appliance of an aircraft. The records must include—
> >
> > > (i) A description (or reference to data acceptable to the Administrator) of the work performed; and
> > >
> > > (ii) The date of completion of the work performed; and
> > >
> > > (iii) The signature, and certificate number of the person approving the aircraft for return to service.
> >
> > (2) Records containing the following information:

(i) The total time in service of the airframe, each engine, each propeller, and each rotor.

(ii) The current status of life-limited parts of each airframe, engine, propeller, rotor, and appliance.

(iii) The time since last overhaul of all items installed on the aircraft which are required to be overhauled on a specified time basis.

(iv) The current inspection status of the aircraft, including the time since the last inspection required by the inspection program under which the aircraft and its appliances are maintained.

(v) The current status of applicable airworthiness directives (AD) and safety directives including, for each, the method of compliance, the AD or safety directive number and revision date. If the AD or safety directive involves recurring action, the time and date when the next action is required.

(vi) Copies of the forms prescribed by § 43.9(d) of this chapter for each major alteration to the airframe and currently installed engines, rotors, propellers, and appliances.

(b) The owner or operator shall retain the following records for the periods prescribed:

(1) The records specified in paragraph (a)(1) of this section shall be retained until the work is repeated or superseded by other work or for 1 year after the work is performed.

(2) The records specified in paragraph (a)(2) of this section shall be retained and transferred with the aircraft at the time the aircraft is sold.

(3) A list of defects furnished to a registered owner or operator under

§ 43.11 of this chapter shall be retained until the defects are repaired and the aircraft is approved for return to service.

The petitioner supports his request with the following information:

The petitioner has provided the following information – contained in his petition and supporting documentation including: (1) Phantom 2 user manual v1.4 (2) Phantom 2 Quick start guide (3) Turbo Ace Matrix manual vII (4) ASTM international manual F2500-07 standard practice for Unmanned Aircraft System (UAS) visual range flight operations (5) ASTM international manual F2910-14 Standard Specification for Design and Construction of a Small Unmanned Aircraft System (sUAS) (6) ASTM manual F2911-14 Standard Practice for Production Acceptance of Small Unmanned Aircraft System (sUAS) (7) ASTM manual F3002-14a Standard Specification for Design of the Command and Control System for Small Unmanned Aircraft Systems (sUAS) (8) ASTM manual F3003-14 Standard Specification for Quality

Assurance of a Small Unmanned Aircraft System (sUAS) (9) ASTM manual F3005-14a Standard Specification for Batteries for Use in Small Unmanned Aircraft Systems (sUAS)

Unmanned Aircraft System

The petitioner states he plans to operate two UAS, the PHANTOM 2 and the Turbo Ace Matrix, both are comprised of an unmanned aircraft (UA, PHANTOM, or Turbo Ace Matrix) and a transportable ground station. Both UAS are referred to as a quad-copter with a maximum gross weight of about 3 pounds. They are equipped with four rotors that are driven by electric motors powered by batteries.

The Phantom UAS will be utilized as a training module to provide comparable experience to ensure safety while utilizing the Turbo Ace Matrix UAS. The petitioner plans to attach a small lightweight GoPro 4+ camera to his UA and operate the UA over various areas in the south central United States to enhance academic community awareness and augment land and mineral exploration, use, and management. Petitioner makes the following representations of operational enhancements which he proposes to abide by to ensure this exemption will provide a level of safety at least equal to existing rules:

- He will only operate in reasonably safe environments that are strictly controlled, are away from power lines, elevated lights, airports and actively populated areas;
- He will conduct extensive preflight inspections and protocols, during which safety carries primary importance.

The petitioner states that given the size, weight, speed, and limited operating area associated with the aircraft to be utilized by him, an exemption from 14 CFR part 21, Subpart H (Airworthiness Certificates) and § 91.203 (a) and (b) (Certifications required), subject to certain conditions and limitations, is warranted and meets the requirements for an equivalent level of safety under 14 CFR part 11 and Section 333 of P.L. 112-95 (Section 333).

Petitioner requests an exemption from § 45.23 *Marking of the aircraft* because his UA will not have a cabin, cockpit or pilot station on which to mark certain words or phrases. Further, he states that two-inch lettering is difficult to place on such a small aircraft with dimensions smaller than the minimal lettering requirement. Regardless of this, petitioner states that he will mark his UAS in the largest possible lettering by placing the word “Limited” on its fuselage as required by § 45.29(f) so that he or anyone assisting him as a spotter will see the markings.

The petitioner states that an exemption from §§ 91.405(a), 91.407(a)(1), 91.409(a)(2) and 91.417(a) and (b) *Maintenance inspections* may be required and should be granted since they only apply to aircraft with an airworthiness certificate. However, the petitioner states as a safety precaution he will perform a preflight inspection of his UAS before each flight as outlined in his operating documents.

UAS Pilot in Command (PIC)

The petitioner asserts that under § 61.113 (a) and (b) private pilots are limited to non-commercial operations, however he can achieve an equivalent level of safety as achieved by current regulations because his UAS does not carry any pilots or passengers. Further, he states that, while helpful, a pilot license will not ensure remote control piloting skills. He further indicates that the risks of operating a UAS are far less than the risk levels inherent in the commercial activities outlined in 14 CFR part 61, et seq., thus he requests an exemption from § 61.113 *Private Pilot Privileges and Limitations: Pilot in command.*

Regarding UAS operational training, the petitioner states he has flown numerous practice flights in remote areas as a hobbyist simulating flights for future commercial use to gain familiarization with the characteristics of his UAS' performance under different temperature and weather conditions. He further states that he has over 3,000 hours and has been certified as a multi-engine, instrument qualified pilot. He is a retired USAF bomber pilot and instructor.

UAS Operating Parameters

The petitioner states that he will abide by the following additional operating conditions under this exemption:

- operate his UAS below 1,000 feet and within a radius distance of 1000 feet from the controller to both aid in direct line of sight visual observation;
- operate the UAS for 30 minutes per flight;
- land his UAS prior to the manufacturer's recommended minimum level of battery power;
- operate his UAS only within visual line of sight (VLOS);
- use the UAS' global positioning system (GPS) flight safety feature whereby it hovers and then slowly lands if communication with the remote control pilot is lost;
- conduct all operations under his own personal and flight safety protocols (including posting a warning sign reading: "Attention Aerial Photography in Progress – Remain Back 150 feet") contained in the operating documents and will actively analyze flight data and other sources of information to constantly update and enhance his safety protocols;
- contact respective airports if operations will be within 5 miles to advise them of his estimated flight time, flight duration, elevation of flight and other pertinent information;
- always obtain all necessary permissions prior to operation; and
- have procedures in place to abort flights in the event of safety breaches or potential danger.

Petitioner states that § 91.7(a) prohibits the operation of an aircraft without an airworthiness certificate. The petitioner asserts that since there is currently no certificate applicable to his operation, this regulation is inapplicable.

Petitioner states that § 91.9(b)(2) requires an aircraft flight manual in the aircraft, however since there are no pilots or passengers on board his aircraft and given its size, this regulation is inapplicable. He further indicates an equivalent level of safety will be achieved by maintaining a safety/flight manual with the UAS ground station.

Although petitioner requests an exemption from § 91.103(b) *Preflight action*, he provides no information supporting his request.

Similarly, the petitioner requests an exemption from § 91.109 *Flight instruction; simulated instrument flight and certain flight test,* and provides no information indicating how safety will be maintained if an exemption to this section is granted.

Petitioner states that § 91.119 prescribes safe altitudes for the operation of civil aircraft, but that it allows helicopters to be operated at lower altitudes in certain conditions. Petitioner states he will not operate his UAS above the altitude of 1,000 feet above ground level (AGL) and will also only operate in safe areas away from the public and traffic, thus providing a level of safety at least equivalent to those in relation to minimum safe altitudes. The petitioner asserts that given the size, weight, maneuverability, and speed of his UAS, an equivalent or higher level of safety will be achieved.

Petitioner indicates that § 91.121 *Altimeter settings* is inapplicable since he UAS utilizes electronic GPS with a barometric sensor.

While petitioner requests an exemption from § 91.151(a) *Fuel requirements for flight in VFR conditions*, the UAS specified for this exemption has an auto return function in case of power loss, or loss of communication with PIC.

Public Interest

The petitioner states that aerial videography for geographical awareness and for land and mineral exploration, use, and management has been around for a long time through manned fixed wing aircraft and helicopters. Thus far vast expense of these services has been cost-prohibitive. Granting this exemption to the petitioner would allow him to provide this service at a much lower cost. Further, the petitioner indicates his small UAS will pose no threat to the public given its small size and lack of combustible fuel when compared to larger manned aircraft. The petitioner also states that the operation of his UAS will minimize ecological damage and promote economic growth by providing information to companies and individuals looking to explore the possible uses and management of their land.

PHANTOM 2 User Manual V1.4

For PHANTOM 2 Flight Controller Firmware version V3.10

& PHANTOM 2 Assistant version V3.8

& PHANTOM RC Assistant version V1.1

2015.01

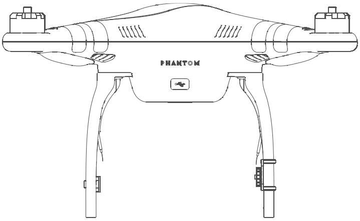
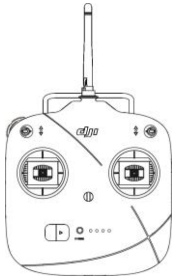
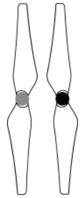
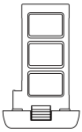
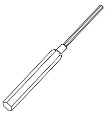
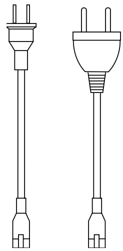
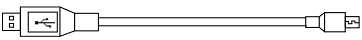
Congratulations on purchasing your new DJI product. Please thoroughly read the entire contents of this manual to fully use and understand the product.

It is advised that you regularly check the PHANTOM 2's product page at www.dji.com which is updated on a regular basis. This will provide services such as product information, technical updates and manual corrections. Due to any unforeseen changes or product upgrades, the information contained within this manual is subject to change without notice.

If you have any questions or concerns regarding your product, please contact your dealer or DJI Customer Service.

Content

In the Box

PHANTOM 2	Remote Controller-2.4GHz	Propeller Pair
		
Intelligent Battery	Charger	Plug Set
		
Screwdriver	Assistant Wrench	Cables
		
Micro-USB Cable	Screws	Accessories Box
		

Legend

Forbidden(Important) Caution Tip Reference

1 PHANTOM 2 Aircraft

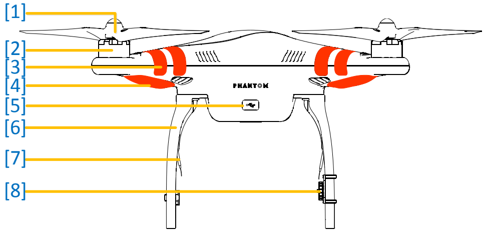


Figure 1-1

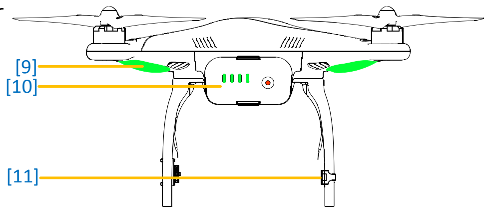


Figure 1-2

[1]Propeller [2]Motor [3]Front Side [4]Front LEDs [5]Micro-USB Port [6]Landing Gear [7]Receiver Antenna [8]CAN-Bus Connector [9]LED Flight Indicators [10]DJI Intelligent Battery [11]Compass

1.1 Built-in Flight Control System Instructions

The built-in flight control system is used to control the entire aircraft's functions in flight such as Pitch (forwards and backwards), Roll (left and right), Elevator (up and down) and Yaw (turn left or right). The flight controller contains the MC (Main Controller), IMU, GPS, compass, receiver.

The IMU (Inertial Measurement Unit) has a built-in inertial sensor and a barometric altimeter that measures both attitude and altitude. The compass reads geomagnetic information which assists the GPS (Global Position System) to accurately calculate the aircrafts position and height in order to lock the aircraft in a stable hover. The receiver is used to communicate with the remote controller and the MC acts as the brains of the complete flight control system connecting and controlling all the modules together.

> The PHANTOM 2 can be configured in the Assistant, by choosing Naza-M mode or Phantom 2 mode. This manual is for Phantom 2 mode. Please refer to the Naza-M V2 Quick Start Manual for more information.

1.2 Connections with Other DJI Products

PHANTOM 2 is compatible with other DJI products, including ZENMUSE H3-2D and H3-3D gimbal , iOSD mini , iOSD Mark II. Below are connections for these products and wireless video transmission module.

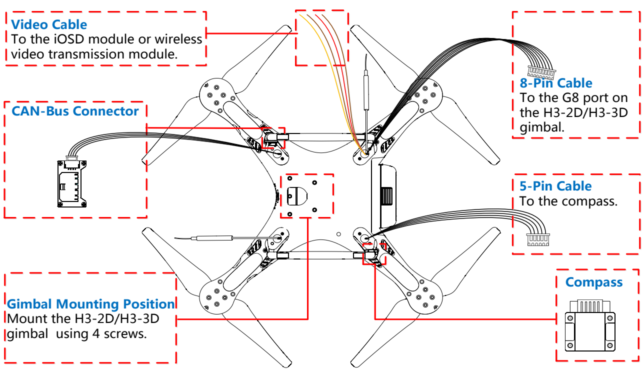


Figure 1-3

Important Notes of Using with Other DJI Products

(1) The video cable can provide power for the wireless video transmission module with a battery voltage (11.1V~12.6V) and a maximum current 2A.

(2) Make sure the working current of the wireless video transmission module you connect can work with an operational voltage between 11.1V~12.6V and the total working current of the iOSD and wireless video transmission module is under 2A, as an overcurrent will damage the central board's components. If the total current exceeds 2A, please be sure to provide power supplied from a separate power source for the wireless video transmission module.

(3) PHANTOM 2 uses a 2.4GHz RC system. To avoid communication interference, it's not recommended to use other 2.4GHz devices (including 2.4G Wi-Fi or 2.4G wireless video transmission module) except the 2.4G Bluetooth and 2.4G Datalink.

(4) Be sure to keep the wireless video transmission module and other communicating devices away from the compass during installation and connection to avoid interference.

(5) To improve the compatibility with ZENMUSE gimbals, the latest factory deliveries of PHANTOM 2 has updated to the Version 2 shown below. H3-2D/H3-3D gimbal can be directly installed for the Version 2 while for Version 1, a H3-3D adapter kit (coming soon) is required to install the H3-3D gimbal.

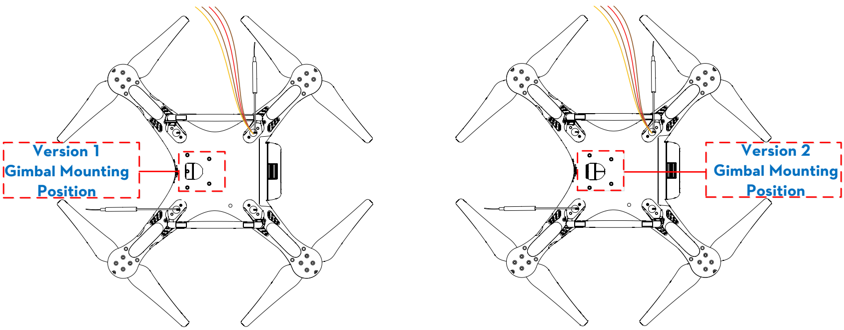


Figure 1-4

(6) When using the H3-3D gimbal, please connect the 8-Pin cable of PHANTOM 2 to the G8 port of H3-3D shown below.

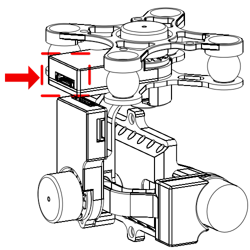


Figure 1-5

Connections with Other DJI Products

(1) Connecting the H3-2D and H3-3D gimbal and wireless video transmission module, the figure below uses H3-2D as an example.

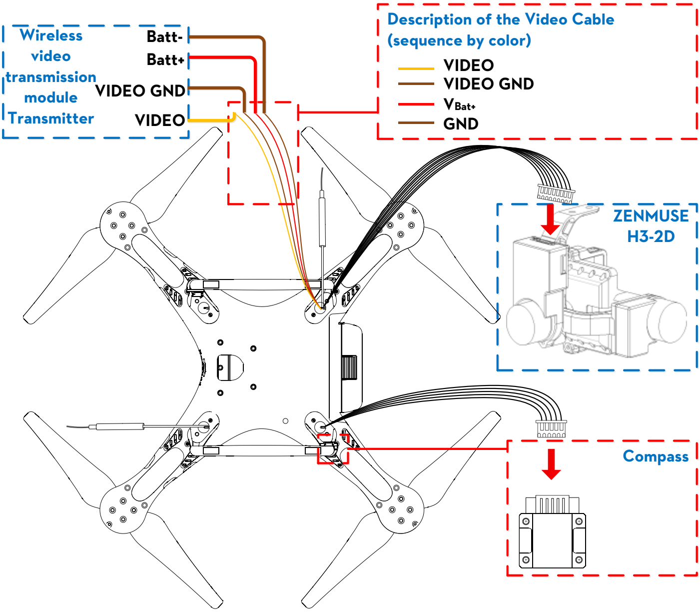


Figure 1-6

(2) Connecting the H3-2D and H3-3D gimbal, iOSD mini and wireless video transmission module, the figure below uses H3-2D as an example.

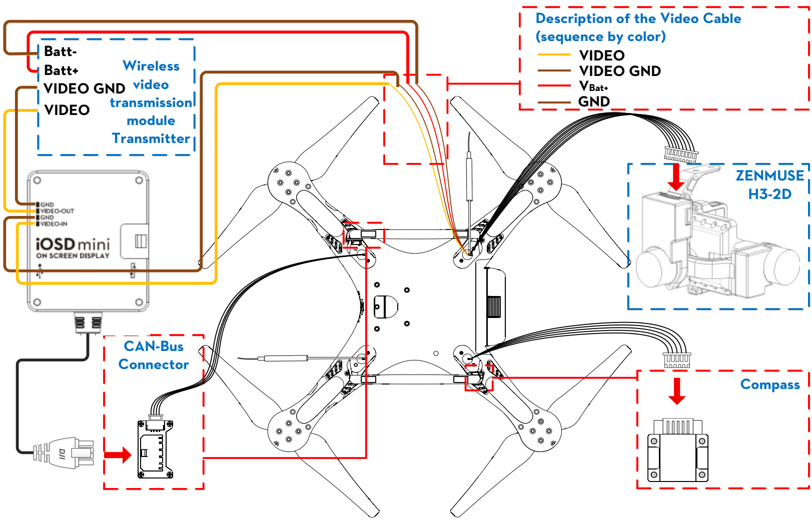


Figure 1-7

(3) Connecting the H3-2D and H3-3D gimbal, iOSD mini and DJI specified wireless video transmission module AVL58, the figure below uses H3-2D as an example.

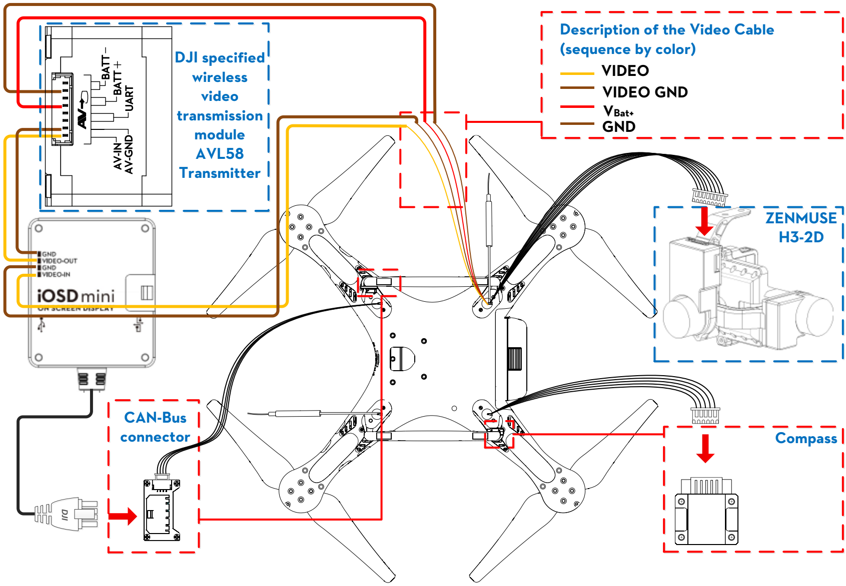


Figure 1-8

We recommend connecting the VBat+ port of the video cable to the two BATT+ ports of the AVL58 simultaneously. The same is true of the GND port of the video cable and two BATT- ports.

(4) Connecting the H3-2D and H3-3D gimbal, iOSD Mark II and wireless video transmission module, the figure below uses H3-2D as an example.

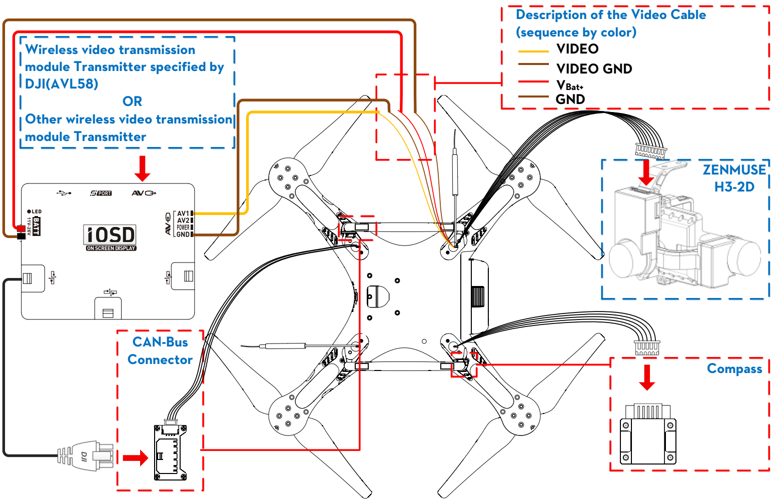
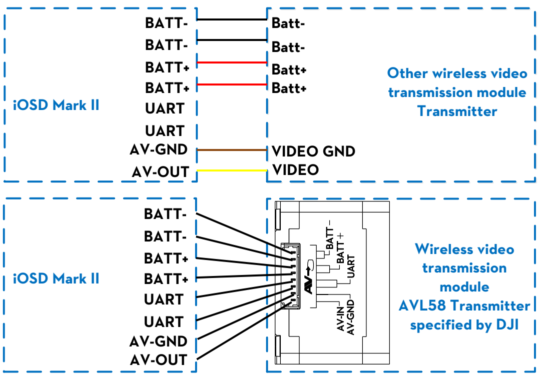


Figure 1-9

The diagram below illustrates the conneciton between the iOSD Mark II and the wireless video transmission module.



Use the 8-Pin cable in the iOSD Mark II package when connecting to the DJI specified wireless video transmission module AVL58.

(5) Using the iPad Ground Station

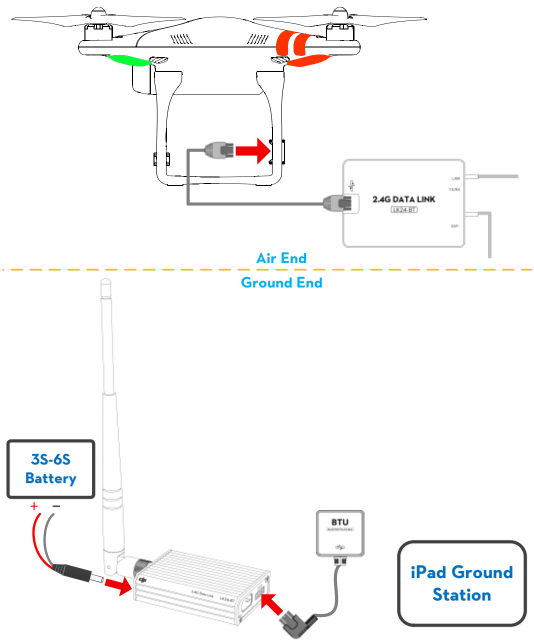


Figure 1-10

> Connect the Air End of 2.4G Bluetooth Datalink to a spared CAN-Bus port of iOSD if an iOSD is used.

(6) Using the PC Ground Station

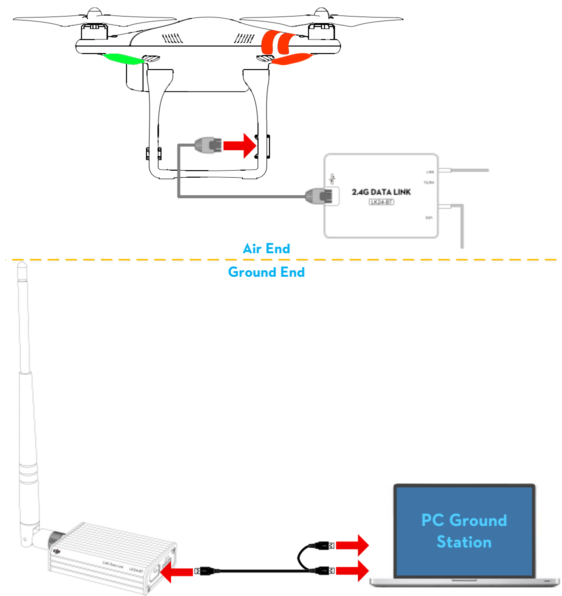
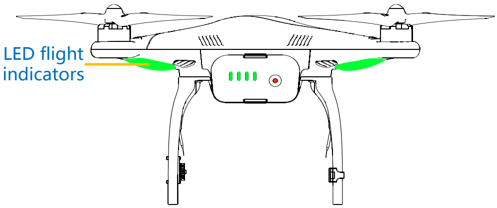


Figure 1-11

1.3 LED Flight Indicators Description

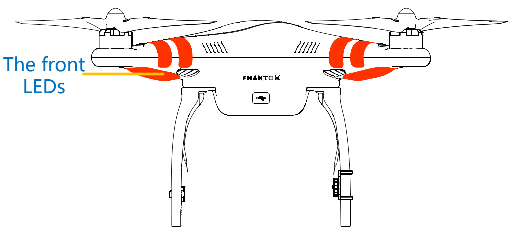
1. **LED flight indicators** are used to show the aircraft's current status. Once powered on, the indicators will light up.



Aircraft in Normal status	Descriptions
	Power On Self-Test
	Warming Up & Aircraft cannot take off during warming up
	Ready to Fly
	Ready to Fly (non-GPS)
Aircraft in abnormal status	**Warnings and errors**
	Remote Controller Signal Lost
	1st Level Low Battery Capacity Warning
	2nd Level Low Battery Capacity Warning
	Not Stationary or Sensor Bias is too big
	Errors & Aircraft cannot fly.
	Compass data abnormal because of ferro-magnetic interference or the compass needs calibration.

> ⚠ (1) The LED indicators diagram above are for Phantom 2 mode. In Naza-M mode, LED indicators will work according to the Naza-M flight control system.
>
> (2) Connect to the PHANTOM 2 Assistant for detailed information about warnings and errors.

2. The front LEDs are for indicating where the nose of the aircraft is. They light up solid red only after the motors have spooled up.



1.4 Notes for PHANTOM 2 using with other DJI products

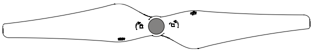
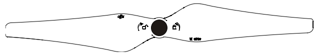
Before using PHANTOM 2 with other DJI products, users should connecting the products correctly and upgrade the firmware as requirements below .

Items to upgrade	Firmware versions required	Assistant for upgrading	Assistant version
P330CB (built-in central board)	V1.0.1.19 or above	PHANTOM 2	V1.08 or above
Zenmuse H3-2D	CMU V1.0，IMU V1.6 or above	PHANTOM 2	V1.08 or above
iOSD Mark II	V3.01 or above	iOSD	V4.0 or above
iOSD mini	V1.06 or above	iOSD	V4.0 or above

*The iOSD Assistant is applied to both iOSD Mark II and iOSD mini.

2 Propellers

PHANTOM 2 uses the original 9-inch propellers which are classified by the color of each central nut. Damaged propellers should be replaced by purchasing new ones if necessary.

Propellers	Grey Nut (9450)	Black Nut (9450 R)
Diagram		
Assembly Location	Attach to the motor thread that **does not have a black dot.**	Attach to the motor thread that **has a black dot.**
Fastening/Un-fastening Instructions	 Lock: Tighten the propeller in this direction.  Unlock: Remove the propeller in this direction.	

2.1 Assembly

1. (Figure 2-1) Remove the four warning cards from the motors after you've read them.
2. (Figure 2-2) Prepare the two grey nut propellers and two black nut propellers. Make sure to match the black nut propellers with the correctly marked black dot motors. Tighten the propellers according to the fastening instructions.

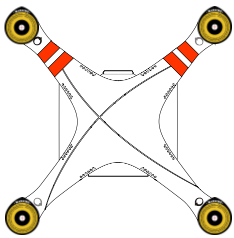


Figure 2-1

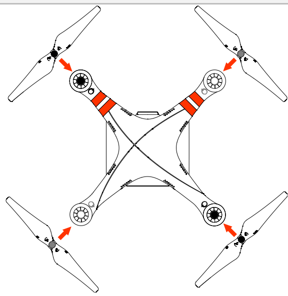


Figure 2-2

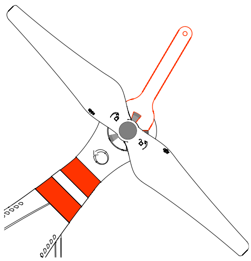


Figure2-3

2.2 Disassembly

(Figure 2-3) Keep the motor deadlocked in place with the assistant wrench (or one hand) and remove the propeller according to the un-fastening instructions.

2.3 Notes

1. Propellers are self tightening during flight. DO NOT use any thread locker on the threads.
2. Make sure to match the propeller nut colors with the corresponding motors.
3. It is advised to wear protective gloves during propeller assembly and removal.
4. Check that the propellers and motors are installed correctly and firmly before every flight.
5. Check that all propellers are in good condition before flight. DO NOT use any ageing, chipped, or broken propellers.
6. To avoid injury, STAND CLEAR of and DO NOT touch the propellers or motors when they are spinning.
7. ONLY use original DJI propellers for a better and safer flight experience.

3 Remote Controller

The PHANTOM 2 remote controller can be configured in the PHANTOM RC Assistant. The sticks mode is Mode 2 on delivery.

⚠	For upgraded remote controller (models: NDJ6 or NRC900), select “Upgrade Version” in Phantom Assistant. For basic remote controller (models: DJ6 or RC900), select “Basic Version” in Phantom Assistant.

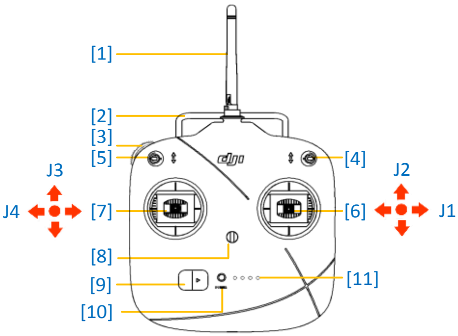


Figure 3-1

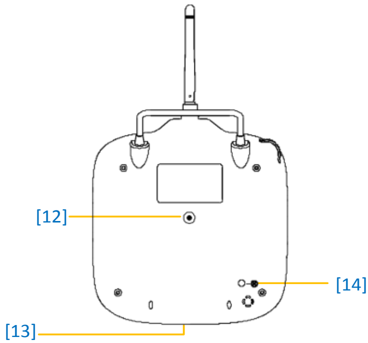


Figure 3-2

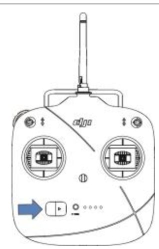
[1]Antenna [2]Carrying Handle [3]Left Dial [4]3-Position Switch S1 [5]3-Position Switch S2 [6]Joystick1(J1;J2) [7]Joystick2(J3;J4) [8]Neck Strap Attachment [9]Power Switch [10]Power Indicator

[11]Battery Level Indicators LED1/LED2/LED3/LED4 (from left to right) [12]Trainer Port

[13]Battery Charge & RC Assistant Port (micro-USB port) [14] Potentiometer

3.1 Power on the Remote Controller

1. Set the S1 and S2 switches to the upper most position and ensure both joysticks are at the mid-point position. Then toggle on the power switch.
2. Push the power switch to the right to power on the remote controller. If the power LED indicator is solid on, the remote controller is functioning normally. The battery level indicators display the current battery level.



⚠	1. Please make sure the battery level of remote controller is enough. If the low voltage warning alert sounds (refer to <Remote Controller Power LED Indicator Status>), please recharge the battery as soon as possible. 2. Charge the remote controller’s battery by using the included micro-USB cable. Using the incorrect type of charging cable may cause damage. 3. Turn off the remote controller before charging. The power LED indicator will display solid red when charging is in progress. The LED indicators will display solid green when the battery is fully charged.

3.2 Remote Controller LED Indicator Status

3.2.1 Remote Controller Power LED Indicator Status

Power LED Indicator	Sound	Remote Controller Status
	None	Functioning normally.
	None	Charging(remote controller is powered off)
	None	Remote controller joysticks calibration error, need to be re-calibrate.
	BB---BB---BB	Low voltage (from 3.5V-3.53V), recharge the remote controller.
	B-B-B......	Critical low voltage (from 3.45V-3.5V). Recharge the remote controller immediately.
	B--B--B......	Alert will sound after 15 minutes of inactivity. It will stop once you start using the remote controller.

The remote controller will power off automatically when battery voltage drops below 3.45V. Land and recharge the battery as soon as possible when the low voltage alert occurs to avoid loss of control during flight.

3.2.2 Remote Controller Battery Level Indicator Status

The battery level indicators will show the current battery level during both the discharging process. The following is a description of the indicators.

: The LED is solid on

: The LED will blink regularly

: The LED is light off

Discharging process				
LED1	LED2	LED3	LED4	Current battery level
				75%~100%
				50%~75%
				25%~50%
				12.5%~25%
				0%~12.5%
				<0%

3.3 Antenna Orientation

The remote controller's antenna should point skywards without obstructions for maximum communication range during flight.

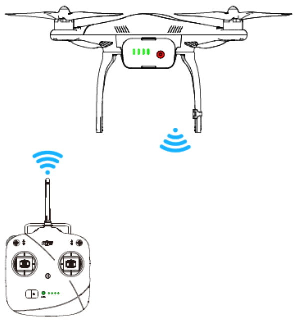


Figure 3-3

3.4 Remote Controller Operation

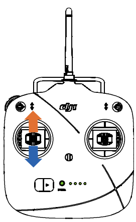
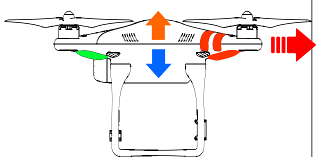
The operations of remote controller are based on mode 2 stick configuration.

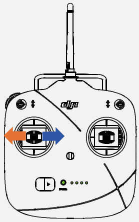
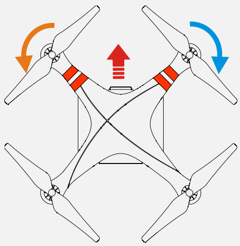
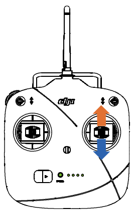
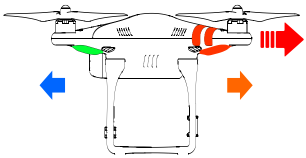
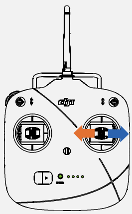
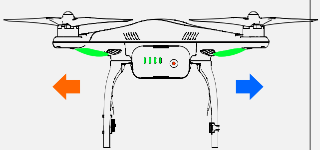
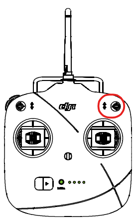
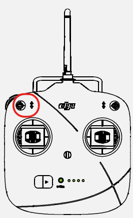
Definitions

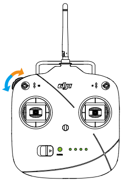
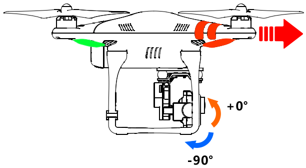
The '**stick neutral**' positions and '**stick released**' mean the control sticks of the remote controller are placed at the central position.

To '**move the stick**' means that the stick of remote controller is pushed away from the central position.

Slide Lever is used for the pitch control of the H3-2D and H3-3D gimbal.

Remote Controller (Mode 2)	Aircraft (nose direction)	Operation details
		The throttle stick controls aircraft altitude/elevation. Push the stick up and the aircraft will rise. Pull the stick down and the aircraft will descend. The aircraft will automatically hover and hold its altitude if the sticks are centered. Push the throttle stick above the centered (mid-point) position to make the aircraft take off. When flying, we suggest that you push the throttle stick slowly to prevent the aircraft from sudden and unexpected elevation changes.

		The yaw stick controls the aircraft rudder. Push the stick left and the aircraft will rotate counter clock-wise. Push the stick right and the aircraft will rotate clock-wise. If the stick is centered, the aircraft will remain facing the same direction. The yaw stick controls the rotating angular velocity of the aircraft. Pushing the stick further away from center results in a faster aircraft rotation velocity.
		The pitch stick controls the aircraft's front & back tilt. Push the stick up and the aircraft will tilt and fly forward. Pull the stick down and the aircraft will tilt and fly backward. The aircraft will keep level and straight if the stick is centered. Pushing or pulling the stick further away from center will result in a larger tilt angle (maximum of is 35°) and faster flight velocity.
		The roll stick controls the aircraft's left & right tilt. Push the stick left and the aircraft will tilt and fly left. Push the stick right and the aircraft will tilt and fly right. The aircraft will keep level and straight if the stick is centered. Pushing the stick further away from center will result in a larger tilt angle (maximum of 35°) and faster flight velocity.
	 Position-1  Position-2  Position-3	S1 is for compass calibration. Toggle the S1 switch from position-1 to position-3 and back to position-1 at least 5 times, which will force the aircraft to enter into compass calibration mode. Users can configure position 3(bottom position) of the S1 switch to trigger the Failsafe in the Assistant.
	 OFF  Course Lock point Lock  Home	S2 is the IOC mode switch. IOC (Intelligent Orientation Control) function can be enabled in the Assistant when in Naza-M mode. Only use the IOC function after you are familiar with flying.

		The left dial controls the pitch of the H3-2D and H3-3D gimbal. The position of left dial determines the pitch angle relative to the horizontal level. Turn the left dial to the right to make the gimbal pitch up. Turn the left dial to the left to make the gimbal pitch down. The gimbal will keep its current position if the dial is static.

(1) For 'Ready to Fly' the aircraft will hover when all sticks are released.

(2) For 'Ready to Fly (non-GPS)' the aircraft will only keep the altitude when all sticks are released.

3.5 Linking the Remote Controller & Built-in Receiver

PHANTOM 2 has a built-in receiver, the link button and indicator located on the bottom of the aircraft as illustrated in the Figure 3-4.

The link between the remote controller and aircraft is already established for you so you can initially skip this procedure. If you ever replace the remote controller, re-establishing the link is required.

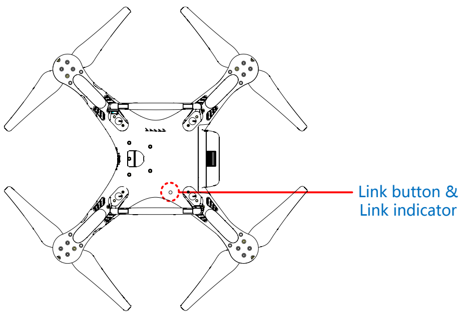


Figure 3-4

Linking procedures

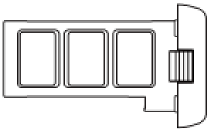
1. Power on the PHANTOM 2.
2. Turn on the remote controller and place it 0.5m~1m away from the aircraft.
3. Push the link button with a thin object and hold it until the Link indicator blinks red, then release it.
4. When the Link indicator turns solid green, the link between the remote controller and the built-in receiver has been successfully established.

Link Indicator	Status
	The remote controller is turned off and there is no 2.4GHz signal around, please turn on the remote controller.
	The receiver is ready for linking.
	There is 2.4GHz signal around but the remote controller is not linked with the receiver,

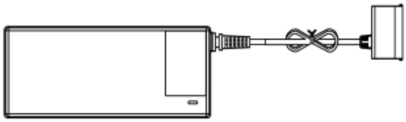
	please carry out the linking procedures.
	The remote controller is linked with the receiver successfully.

4 Intelligent Battery

The intelligent battery is specially designed for the PHANTOM 2, with a battery capacity of 5200mAh, voltage of 11.1V and charge-discharge management functionality. The battery should only be charged with the DJI charger.



Intelligent Battery



Charger

DJI Intelligent Battery Functions	
(1) Balance Charging	Automatically balance the voltage of each battery cell during charging.
(2) Capacity Display	Display the current battery level.
(3) Communicating	The main controller communicates with the battery via communication ports for battery voltage, capacity, current and other information.
(4) Overcharging Protection	Charging stops automatically when the battery voltage reaches 12.8V to prevent overcharging damage.
(5) Over Discharging Protection	Discharging stops automatically when the battery voltage reaches 8.4V to prevent over discharging damage.
(6) Short Circuit Protection	Automatically cuts off the power supply when a short circuit is detected.
(7) Sleep Protection	The battery will enter sleep mode after 10 minutes of inactivity to save power. The static current is 10nA in sleep mode when the battery is powered on without connecting to other devices.
(8) Charging Temperature Detection	The battery will charge only when its temperature is within 0℃~55℃. If the battery temperature is out of this range, the battery will stop charging.

(1) Before use, please read and follow the user manual, disclaimer, and the warnings on the battery. Users take full responsibility for all operations and usage.

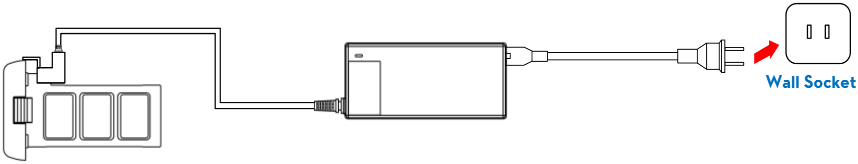
(2) The battery should only be charged with the charger provided by DJI. DJI does not take any responsibility for operation of any charger from a third party.

4.1 Charging Procedures

1. Connect the charger to a wall socket (Use the plug set if necessary).
2. Connect the battery to the charger. If the current capacity of the battery is over 75%, you should power on the battery to begin charging.
3. The Battery Level indicators display current capacity level as the battery charges. Please refer to battery

level indicator description for details.

4. The battery is fully charged when the Battery Level indicator lights are off. Please disconnect the charger and battery when the charging is completed.



4.2 Install the Battery

Push the battery into the battery compartment correctly as the following diagram shows. Make sure to push the battery into the compartment until you hear a 'click' sound.

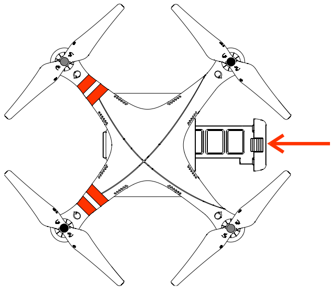


Figure 4-1

> An incorrectly inserted battery may cause one of the following to occur: (1) Bad contact. (2) Unavailable battery information. (3) Unsafe for flight. (4) Unable to take off.

4.3 Battery Usage

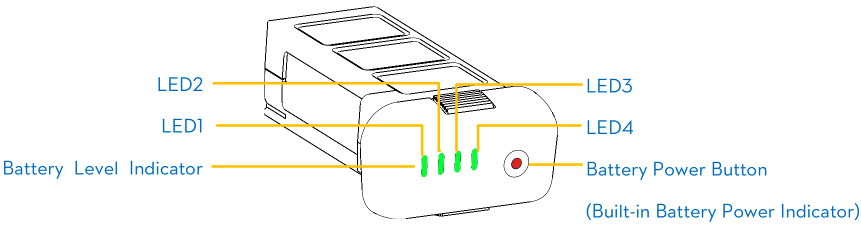


Figure 4-2

(1) Checking the battery level: When the battery is powered off; pressing the battery power button once will indicate the current battery level. Refer to < Battery Level Indicator Description> for details.

(2) Powering on: When the battery is powered off; press the battery power button once and then press and hold for 2 seconds to turn on the intelligent battery.

(3) Powering off: When the battery is powered on; press the battery power button once and then press and hold for 2 seconds to turn off the intelligent battery.

(4) **Checking the battery life:** When the battery is powered off; press and hold the battery power button for 5 seconds to check the battery life. The battery level indicators will show the life and the battery power indicator will blink for 10 seconds, then all LEDs will light out and the intelligent battery will turn off. Refer to < Battery Level Indicator Description> for details.

More battery information is available in the battery tab of the PHANTOM 2 Assistant.

4.4 Description of the Battery Level Indicator

The battery level indicators will show the current battery level during both the charging and discharging process as well as battery life. The following is a description of the indicators.

■ : The LED is solid on   ● : The LED will blink regularly

□ : The LED is light off

Charging process				
LED1	LED2	LED3	LED4	Current battery level
●	□	□	□	0%~25%
●	●	□	□	25%~50%
●	●	●	□	50%~75%
●	●	●	●	75%~100%
□	□	□	□	Full charged

Discharging process				
LED1	LED2	LED3	LED4	Current battery level
■	■	■	■	87.5%~100%
■	■	■	●	75%~87.5%
■	■	■	□	62.5%~75%
■	■	●	□	50%~62.5%
■	■	□	□	37.5%~50%
■	●	□	□	25%~37.5%
■	□	□	□	12.5%~25%
●	□	□	□	0%~12.5%
□	□	□	□	<0%

Battery life				
LED1	LED2	LED3	LED4	Current battery life
■	■	■	■	90%~100%

				80%~90%
				70%~80%
				60%~70%
				50%~60%
				40%~50%
				30%~40%
				20%~30%
				Less than 20%

4.5 Correct Battery Usage Notes

1. Never plug or unplug the battery into the aircraft when it is powered on.
2. The battery should be charged in an environment that is between 0℃ to 40℃, and be discharged in an environment that is between -20℃ to 50℃. Both charging and discharging should be in an environment where the relative humidity is lower than 80%.
3. It's recommended to charge and discharge the battery thoroughly once every 20 charge/discharge cycles. Users should discharge the battery until there is less than 8% power left or until the battery can no longer be turned on. Users should then fully recharge the battery to maximum capacity. This power cycling procedure will ensure the battery is working at its optimal level.
4. For long term storage please place the battery with only a 40~50% capacity in a strong battery box securely. We recommend discharging and charging the battery completely once every 3 months to keep it in good condition. The capacity should be varied in such a cycle (40%~50%)—0%—100%—(40%~50%).
5. It's suggested you purchase a new battery after you have discharged your current battery over 300 times. Please completely discharge a battery prior to disposal.
6. It's suggested that you purchase a new battery if the current battery is swollen or damaged in any way.
7. Never try to recharge or fly with a battery that is swollen or damaged in any way.
8. Never charge the battery unattended. Always charge the battery on a non-flammable surface such as concrete and never near any flammable materials.
9. Safety is extremely important and users can get more information in the DISCLAIMER.

5 Calibrating the Compass

IMPORTANT: Make sure to perform the Compass Calibration procedures prior to the first flight.

The compass is very sensitive to electromagnetic interference which causes abnormal compass data and leads to poor flight performance or even flight failure. Regular calibration of the compass enables the compass to perform at its optimal level.

5.1 Calibration Warnings

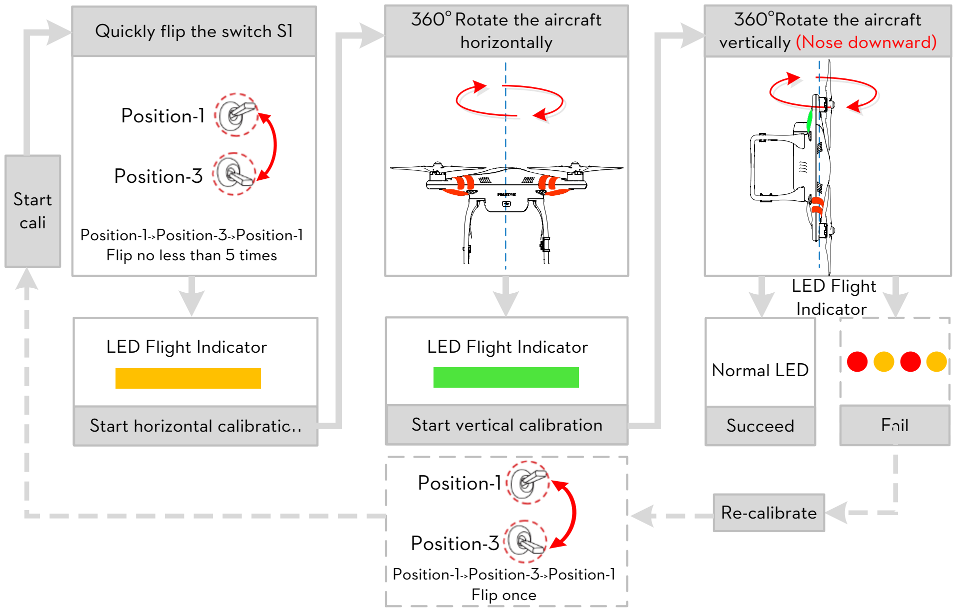
(1) DO NOT calibrate your compass where there is a possibility for the existence of strong magnetic interference such as magnetite, parking structures, and steel reinforcement underground.

(2) DO NOT carry ferromagnetic materials with you during calibration such as keys or cellular phones.

(3) Compass Calibration is very important; otherwise the flight control system will work abnormally.

5.2 Calibration Procedures

Please carry out the calibrating procedures in the flight field before flight. Please watch the quick start video of the PHANTOM 2 for more compass calibration details.



5.3 When Recalibration is required

(1) When Compass Data is abnormal, the LED flight indicator will blink alternating between red and yellow.

(2) Last compass calibration was performed at a completely different flying field/location.

(3) The mechanical structure of the aircraft has changed, i.e. changed mounting position of the compass.

(4) Evident drifting occurs in flight, i.e. the aircraft doesn't fly in straight lines.

6 Flight

6.1 Flying Environment Requirements

(1) Before your first flight, please allow yourself some flight training (Using a flight simulator to practice flying, getting instruction from an experienced person, etc.).

(2) DO NOT fly in bad weather, such as rain or wind (more than moderate breeze) or fog.

(3) The flying field should be open and void of tall buildings or other obstacles; the steel structure within buildings may interfere with the compass.

(4) Keep the aircraft away from obstacles, crowds, power lines, trees, lakes and rivers etc.

(5) Try to avoid interference between the remote controller and other wireless equipment (No base stations or cell towers around).

(6) The flight control system will not work properly at the South Pole or North Pole.

(7) Never use the aircraft in a manner that infringes upon or contravenes international or domestic lays and regulations.

6.2 Starting the Motors

A Combination Stick Command (CSC) is used to start the motors. Push the sticks according to one of the options below to start motors. Once the motors have started, release both sticks simultaneously. The same CSC is used to stop the motors.

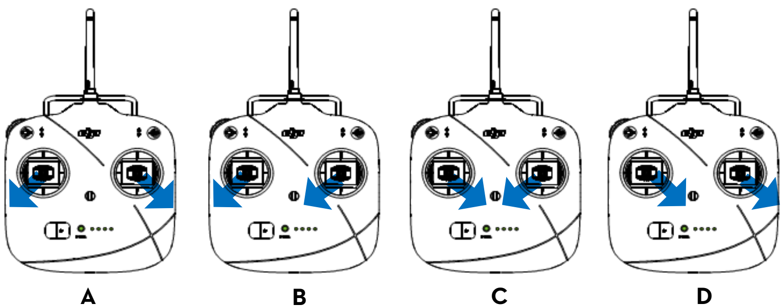


Figure 6-1

6.3 Takeoff/Landing Procedures

1. Start by placing the PHANTOM 2 on the ground with the battery level indicators facing you.
2. Turn on the remote controller.
3. Power on the aircraft by turning on the intelligent battery.
4. When LED flight indicator blinks green/yellow, the PHANTOM 2 is entering Ready to Fly/Ready to Fly (non-GPS) mode. Start the motors with the CSC command.
5. Push the throttle stick up slowly to lift the aircraft off the ground. Refer to <Remote Controller Operation> for more details.
6. Be sure you are hovering over a level surface. Pull down the throttle stick to descend. The stick will lock into

place and the aircraft will descend steadily.

7. After landing, leave the throttle stick down for 3 to 5 seconds to stop the motors. Return throttle stick to middle position after the motors have stopped.

You SHOULD NOT execute the CSC during normal flight! This will stop the motors and cause the aircraft to descend rapidly and drop without any type of control.

(1) When the LED flight indicator blinks yellow rapidly during flight, the aircraft has entered into Failsafe mode, refer to <Failsafe Function> for details.

(2) A low battery capacity warning is indicated by the LED flight indicator blinking red slowly or rapidly during flight. Refer to the <Low Battery Capacity Warning Function> for details.

(3) Watch the quick start video about flight for more flight information.

(4) Aircraft and battery performance is subject to environmental factors such as air density and temperature. Be very careful when flying 3000 meters (9800 feet) or more above sea level, as battery and aircraft performance may be reduced.

(5) When used with a H3-3D gimbal, a GoPro camera, and the iOSD mini, your Phantom 2 will be very close to its maximum takeoff weight. It is not recommended that you attach the Phantom 2 propeller guards at this weight. Otherwise, the aircraft will be unable to fly normally.

6.4 Failsafe Function

The aircraft will enter Failsafe mode when the connection from the remote controller is lost. The flight control system will automatically control the aircraft to return to home and land to reduce injuries or damage. The following situations would make the aircraft fail to receive a signal from the remote controller and enter Failsafe mode:

(1) The remote controller is powered off.

(2) The remote controller is powered on but the S1 is toggled in the position triggering the Failsafe (this must have been configured in the PHANTOM 2 Assistant).

(3) The aircraft has flown out of the effective communication range of the remote controller.

(4) There is an obstacle obstructing the signal between the remote controller and the aircraft, essentially reducing the distance the signal can travel.

(5) There is interference causing a signal problem with the remote controller.

Failsafe works differently depending on the mode the aircraft is in when Failsafe mode is initiated whether it is in the Ready to Fly or Ready to Fly (non-GPS) mode.

Ready to Fly (non-GPS) ---- Automatic landing

The flight control system will try to keep the aircraft level during descent and landing. Note that the aircraft may be drifting during the descent and landing process.

Ready to Fly ---- Automatic go home and land

The flight control system will automatically control the aircraft to fly back to the home point and land.

Home Point

When the aircraft is initializing the Ready to Fly status, the aircraft will record the current GPS coordinates as the home point. It is recommended to lift off only after Ready to Fly status is confirmed for the safety of being able to fly back to home point successfully in case the Failsafe mode is initiated.

Go Home Procedures

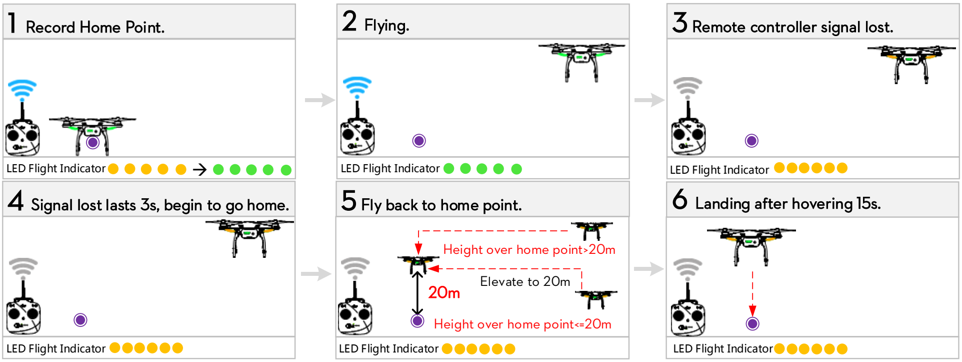


Figure 6-2

(1) In a Failsafe situation, if less than 6 GPS satellites are found for more than 20 seconds, the aircraft will descend automatically.

(2) When the aircraft is landing automatically, users can control the aircraft's position and altitude if the remote controller signal is recovered.

In Phantom 2 mode, users can set a new home point manually when the aircraft is in "Ready to fly" status as long as a home point has been recorded automatically. Quickly flipping the S2 switch of the remote controller from upper most to lower most positions 5 times or more will reset the current aircraft position as a new home point of PHANTOM 2. When successfully reset, you will see a series of rapid green blinks on the LED Flight Indicator. The definition of "home point" is:

(1) The home point is the place PHANTOM 2 returns to when the control signal is lost, which is recorded last time.

(2) The home point is used to calculate the horizontal distance between you and the aircraft, the distance will be displayed as D if using iOSD module.

Regaining Control during Failsafe Procedure

Position of Switch S1	Position-1	Position-2	Position-3 (No triggering the Failsafe)
How to regain control	When the S1 switch is switched to Position-1, toggle the S1 switch to any other position once to regain control. If remote controller's signal is recovered, control is returned back to the pilot.	Regain control as soon as signal is recovered.	

6.5 Low Battery Capacity Warning Function

The low battery capacity warning alerts users when the battery is close to depletion during flight. When it appears, users should promptly fly back and land to avoid accidental damage. The PHANTOM 2 has two levels of low battery capacity warning. The first appears when the battery has less than 30% power and the second appears when it has less than 15% power.

(1) When battery power drops below 30% and LED indicator will blink red slowly.

(2) At lower than 15% the LED indicator will blink red rapidly, the PHANTOM 2 will also begin to descend and land automatically. After it has landed, keep the throttle stick at its lowest point or execute CSC.

(3) There is a hidden third low battery threshold in addition to the 1st and 2nd level warnings. This uses 10.65V as its threshold. Both this voltage threshold and the 2nd Level Low Battery Warning will trigger auto-landing. Altitude can be maintained if necessary by pushing up on the throttle stick.

(1) Remember to fly your PHANTOM 2 back as soon as you see a low battery capacity warning.

(2) Keeping the battery contact needles and pads clean is very important. Any dirt and dust may cause a communication failure.

6.6 Flight Limits Function

All UAV (unmanned aerial vehicle) operators should abide by all regulations from such organizations at ICAO (International Civil Aviation Organization) and per country airspace regulations. For safety reasons, the flight limits function is enabled by default to help users use this product safely and legally. The flight limits function includes height, distance limits.

In Ready to Fly status, height, distance limits works together to restrict the flight. In Ready to Fly (non-GPS) status, only height limit works and the flying height restricted to be not over 120m.

(1) The default parameters in the Assistant is compliant within the definitions of class G ruled by ICAO. (Refer to Airspace Classification to get more details). As each country has its own rules, make sure to configure the parameters to comply with these rules too, before using the PHANTOM 2.

(2) Users in Mainland China can refer to 民用航空空域使用办法.

Max Height & Radius Limits

The Max Height & Radius restricts the flying height and distance. Configuration can be done in the PHANTOM 2 Assistant. Once complete, your aircraft will fly in a restricted cylinder.

Figure 6-3

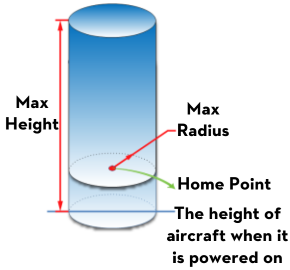


Figure 6-4

Ready to Fly			
	Limits	Ground Station	Rear LED flight indicator
Max Height	The flight height is restricted to fly under the max height.	Warning: Height limit reached.	None.
Max Radius	The flight distance is restricted to fly within the max radius.	Warning: Distance limit reached.	Rapid red flashings when close to the Max radius limit.

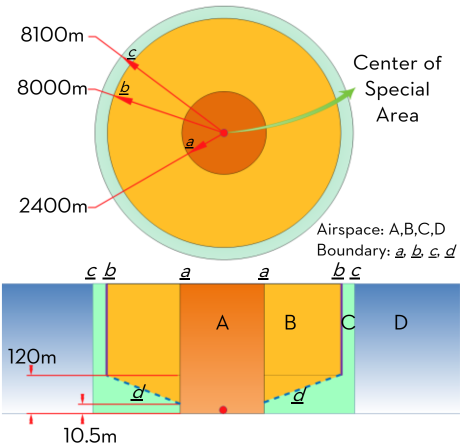
Ready to Fly(non-GPS)			
	Flight Limits	Ground Station	Rear LED flight indicator
Max Height	The flight height is restricted to fly under the minor height between the Max height and 120m.	Warning: Height limit reached.	None.
Max Radius	Not limited, no warnings or LED indicators.		

(1) If the aircraft flies out of the limits, you can still control your aircraft except to fly it further away.

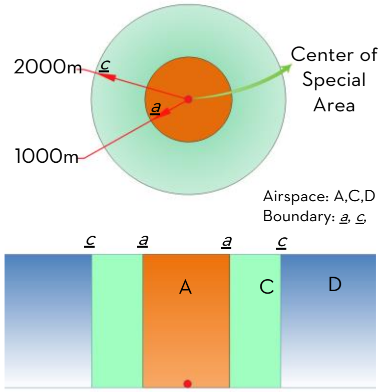
(2) If the aircraft is flying out of the max radius in Ready to Fly (non-GPS) status, it will fly back within the limits range automatically if 6 or more GPS satellites have been found.

6.7 Flight Limits of Special Areas

Special areas include airports worldwide. All special areas are listed on the DJI official website. Please refer to http://www.dji.com/fly-safe/category-mc for details. These areas have been divided into category A and category B.



Category A



Category B

Ready to Fly		
Airspace	**Limits**	**Rear LED Flight Indicator**
A Orange	Motors will not start. If the Phantom flies into a special area in Ready to Fly (non-GPS) mode and Ready to Fly mode activates, it will automatically descend and land then stop its motors.	
B Yellow	If the Phantom flies into a special area in Ready to Fly (non-GPS) mode and Ready to Fly mode activates, it will descend to airspace C and hover 5 meters below edge *d*.	
C Green	No restrictions of flight, but the Phantom will not enter Category A, the aircraft can fly free, but it will not enter Airspace B through Boundary *b & d.* Around Category B sites, the phantom can fly freely, but it will not enter into Airspace A through Boundary *a.*	
D Blue	No restrictions.	None.

Semi-automatic descent: All stick commands are available except the throttle stick command during the descent and landing process. Motors will stop automatically after landing. Users will regain control once the motors have stopped. There is no need to toggle the S1 switch.

(1) When flying in the airspace (A/B/C) of restricted special area, LED flight indicators will blink red ●●●●●● quickly and continue for 3 seconds, then switch to indicate current flying status and continue for 5 seconds at which point it will switch back to red blinking.

(2) For safety reasons, please do not fly close to airports, highways, railway stations, railway lines, city centers and other special areas. Try to ensure the aircraft is visible.

6.8 Conditions of Flight Limits

In different working modes and flight modes, flight limits will differ according to number of GPS satellites found. The following table demonstrates all the cases(√: **available;** ×:unavailable).

All flights are restricted by height, distance and special areas simultaneously.

Phantom mode			
Flight Status	Limits of Special Area	Max Height	Max Radius
Ready to Fly	√	√	√
Ready to Fly (non-GPS)	×	√	×

Naza-M mode				
Control Mode	number of GPS found	Limits of Special Area	Max Height	Max Radius
GPS	≥6	√	√	√
	< 6	×	√	×
ATTI.	≥6	√	√	×
	< 6	×	√	×
Manual	≥6	×	×	×
	< 6	×	×	×

Disclaimer

Please ensure that you are kept up to date with International and Domestic airspace rules and regulations before using this product. By using this product, you hereby agree to this disclaimer and signify that you have read this fully. You agree that you are responsible for your own conduct and content while using this product, and for any direct or indirect consequences caused by not following this manual, violate or disregard any other applicable local laws, administrative rules and social habits thereof.

7 Assistant Installation and Configuration

7.1 Installing Driver and PHANTOM 2 Assistant

Installing and running on Windows

1. Download driver installer and Assistant installer in EXE format from the download page of PHANTOM 2 on the DJI website.
2. Connect the PHANTOM 2 to a PC via a Micro-USB cable.
3. Run the driver installer and follow the prompts to finish installation.
4. Next, run the Assistant installer and follow the prompts to finish installation.
5. Double click the PHANTOM 2 icon on your Windows desktop to launch the software.

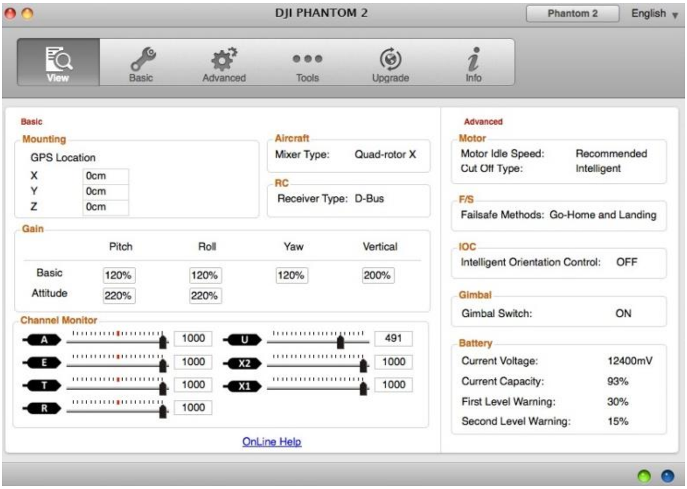
⚠ The installer in EXE format only supports Windows operating systems (Win XP, Win7, Win8 (32 or 64 bit)).

Installing and running on Mac OS X

1. Download the Assistant installer in DMG format from the download page of PHANTOM 2 on the DJI website.
2. Run the installer and follow the prompts to finish installation.

3. When launching for the first time if use Launchpad to run the PHANTOM 2 Assistant, Launchpad won't allow access because the software has not been reviewed by Mac App Store.

4. Locate the PHANTOM 2 icon in the Finder, press the Control key and then click the PHANTOM 2 icon (or right-click the PHANTOM 2 icon using a mouse). Choose Open from the shortcut menu, click open in the prompt dialog box and then software will launch.
5. After the first successful launch, directly launching of the software can be achieved by double-clicking the PHANTOM 2 icon in the Finder or using Launchpad.

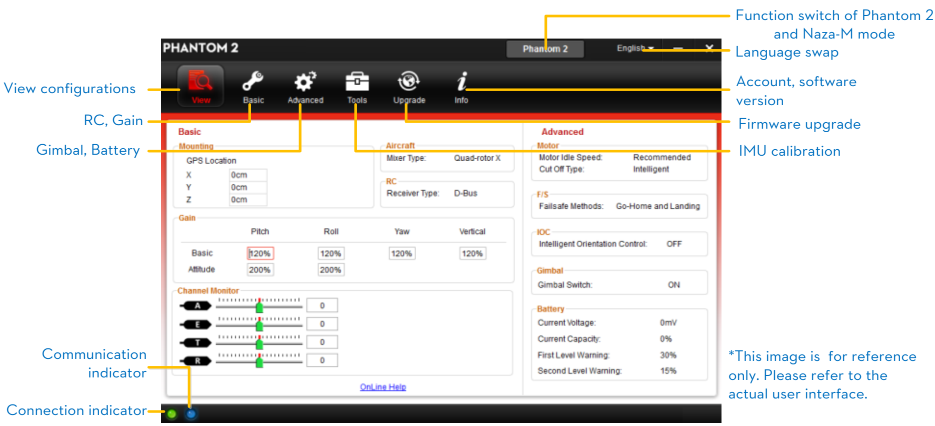


Installer in DMG format supports only Mac OS X 10.6 or above.

Usage of PHANTOM 2 Assistant on Mac OS X and Windows are exactly the same. The Assistant pages appear in other places of this manual are on the Windows for example.

7.2 Using the PHANTOM 2 Assistant on a PC

1. Start up the PC, power on the PHANTOM 2, then connect the PHANTOM 2 to the PC with a Micro-USB cable. DO NOT disconnect until configuration is finished.
2. Run the PHANTOM 2 Assistant and wait for the PHANTOM 2 to connect to the Assistant. Observe the indicators on the bottom of the screen. When connected successfully, the connection indicator is and communication indicator is blinking .
3. Choose [Basic] or [Advanced] configuration pages.
4. View and check the current configuration in the [View] page.



*This image is for reference only. Please refer to the actual user interface.

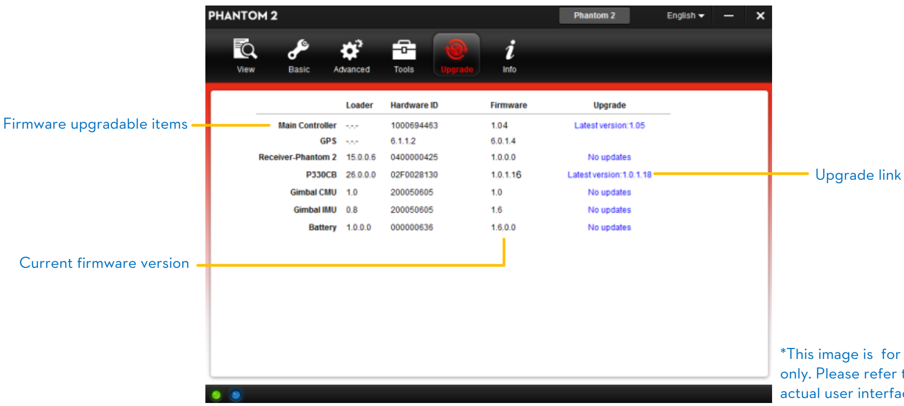
⚠ (1) Users should not enable the Naza-M function before finishing Advanced Flight Maneuvers procedure in the " PHANTOM Pilot Training Guide”. If the Naza-M mode is enabled, users can switch the control mode between ATTI. Mode, GPS Mode or Manual Mode, and access the advanced settings (e.g. IOC). In addition, the LED located on the rear frame arms will display Naza-M flight status indications instead of the PHANTOM 2’s indicators. Do not enable the Naza-M mode unless you are an experienced user or guided by a professional.

(2) You can change to the Phantom 2 mode by clicking the same button used to turn on the Naza-M mode. This operation will disable the Naza-M mode and enable Phantom 2 mode. All parameters will be returned to factory settings.

7.3 Firmware upgrade of PHANTOM 2

Please refer to the PHANTOM 2 Assistant to install driver and PHANTOM RC Assistant, and then follow the procedures below to upgrade the software and firmware; otherwise the PHANTOM 2 might not work properly.

1. An internet connection is required to upgrade PHANTOM 2´s firmware.
2. Click the [Upgrade] icon to check the current firmware version and whether the installed firmware is the latest version. If not, click the relative links to upgrade.
3. Be sure to wait until the Assistant shows “finished”. Click OK and power cycle the PHANTOM 2 after 5 seconds. Once completed, the firmware is up to date.



*This image is for reference only. Please refer to the actual user interface.

⚠ （1） DO NOT power off until the upgrade is finished.

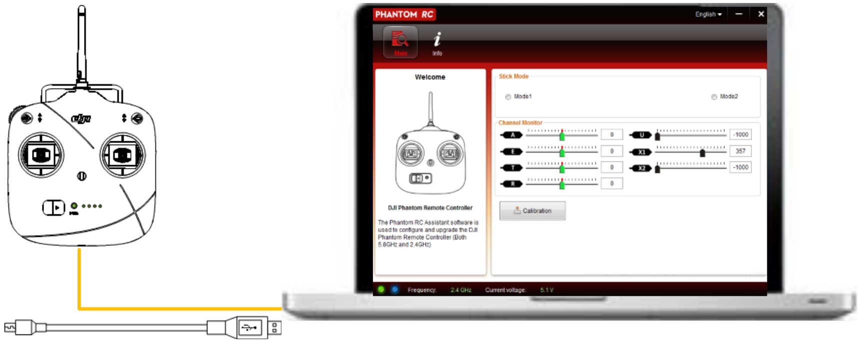
（2） If the firmware upgrade failed, the main controller will enter a waiting for firmware upgrade status automatically. If this happens, repeat the above procedures.

Firmware upgradable items: （1） Main Controller （2） P330CB(Main Board) （3） Receiver （4） Gimbal CMU （5） Gimbal IMU （6） Battery

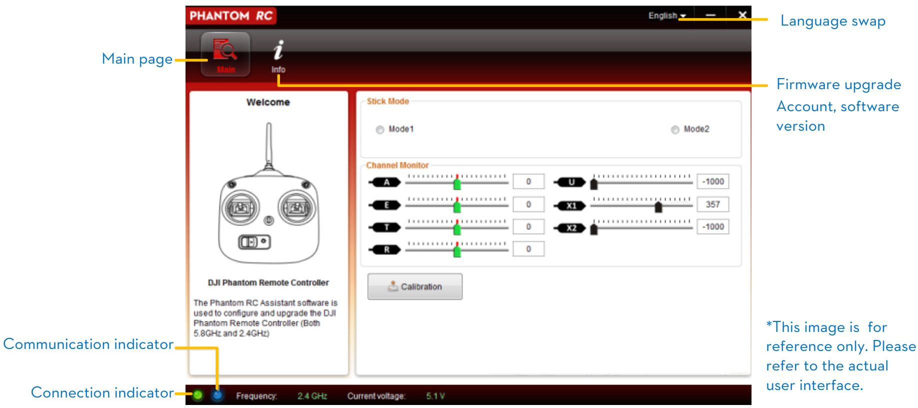
7.4 PHANTOM RC Assistant Description

Please follow the procedures to finish the configuration of the remote controller.

1. Turn off the remote controller and find the Micro-USB port on the bottom of it.
2. Start up the PC, power on the remote controller, and then connect the remote controller to the PC with a Micro-USB cable. DO NOT disconnect until the configuration is finished.
3. Run the PHANTOM RC Assistant and wait for the remote controller to connect to the Assistant. Observe the indicators on the bottom left of the screen. When connected successfully, the connection indicator is and communication indicator is blinking.
4. Finish configuration in the [Main] page.
5. Finish upgrade in the [Info] page if necessary.



Main Page of the 2.4GHz Remote Controller



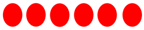
8 Appendix

8.1 Specifications

Aircraft	
Operating environment temperature	-10℃ to 50℃
Power consumption	5.6W
Supported Battery	DJI Intelligent battery
Weight (including the battery)	1000g
Take-off Weight	≤1300g
Hovering Accuracy (Ready to Fly)	Vertical: 0.8m; Horizontal: 2.5m
Max Yaw Angular Velocity	200°/s
Max Tilt Angle	35°
Max Ascent / Descent Speed	Ascent: 6m/s; Descent: 2m/s
Max Flight Speed	15m/s (Not Recommended)
Wheelbase	350mm
2.4GHz Remote Controller	
Operating Frequency	2.4GHz ISM
Communication Distance (open area)	1000m
Receiver Sensitivity (1%PER)	-97dBm
Working Current/Voltage	120 mA@3.7V
Built-in LiPo Battery Working Current/Capacity	3.7V, 2000mAh
DJI Intelligent Battery	
Type	3S LiPo Battery
Capacity	5200mAh, 11.1V
Charging Environment Range	0℃ to 40℃
Discharging Environment Range	-20℃ to 50℃

8.2 LED Flight Indicators Description

Aircraft in Normal status	Descriptions
	Power On Self-Test
	Warming Up & Aircraft cannot take off during warming up
	Ready to Fly
	Ready to Fly (non-GPS)
Aircraft in abnormal status	**Warnings and errors**
	Remote Controller Signal Lost
	1st Level Low Battery Capacity Warning

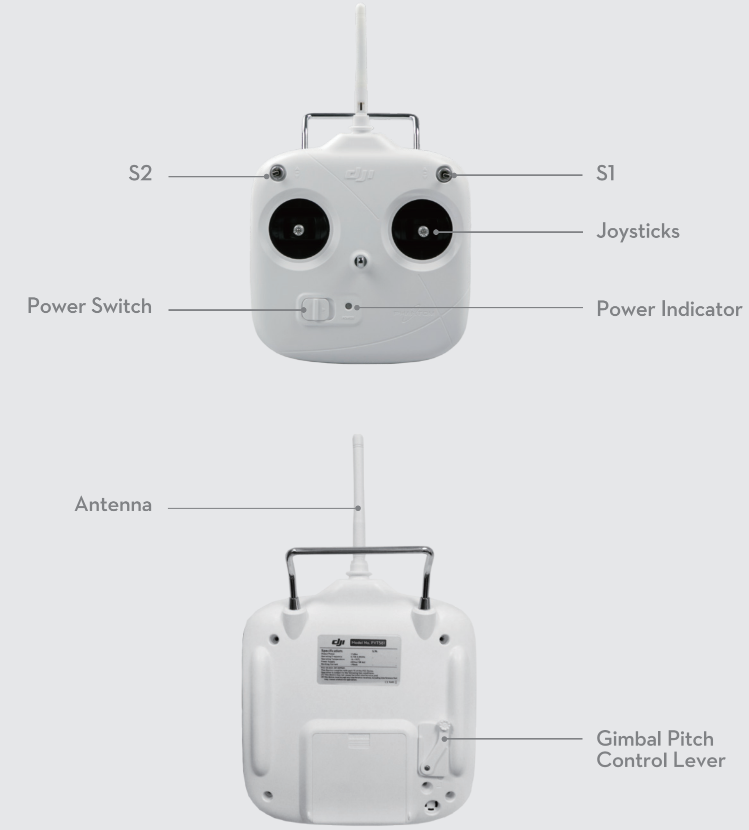
	2nd Level Low Battery Capacity Warning
	Not Stationary or Sensor Bias is too big
	Errors & Aircraft cannot fly.*
	Compass data abnormal because of ferro-magnetic interference or the compass needs calibration.

* Users can connect to the PHANTOM 2 Assistant to get detailed information about warnings and errors.

PHANTOM 2

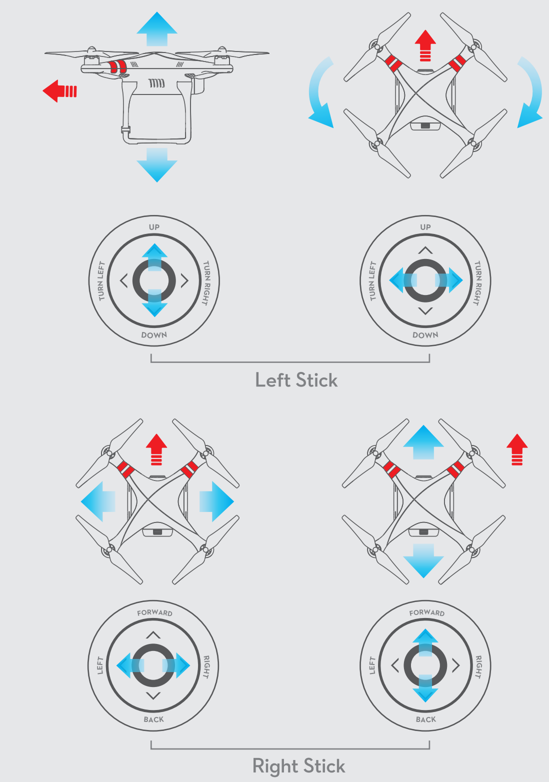
QUICK START GUIDE

Learn More : www.dji.com



Basic Flight Operations

Forward Direction (Indicates Front Side)



PHANTOM 2

QUICK START GUIDE

0

Scan QR Code to Watch the Quick Start Video or browse direct to www.dji.com/tutorial/phantom-2-tutorial/

① Product Introduction

② Quick Start Guide

③ H3-2D Gimbal Assembly

⚠ ATTENTION: For SAFETY reasons and for further flight instruction, it is advised that you watch the videos above in full before attempting to use the Phantom 2.

1 ATTACHING THE PROPELLERS

- Remove the four warning cards from the motors.
- Screw the propellers, clockwise for grey nuts and anti-clockwise for black nuts, onto the four motors. Be sure to match the black propeller nuts with the black dot motors.

⚠ ATTENTION: DO NOT use thread lock on the propeller shafts.

2 SETUP OF THE ZENMUSE H3-2D GIMBAL (OPTIONAL)

- The ZENMUSE H3-2D gimbal is recommended for a better aerial photography experience. The installation is quick and convenient, as the GCU and other control interfaces have been built into the Phantom 2.
Please refer to the "H3-2D Gimbal Quick Start Guide" for more details.

3 PREPARING THE REMOTE CONTROLLER

- Be sure S1 and S2 are switched to the upper most position.
- Install 4 x AA batteries into the back of the Remote Controller.

⚠ ATTENTION: A continuous beeping sound emitted from the Remote Controller indicates LOW BATTERY VOLTAGE.

4 TURNING THE FLIGHT BATTERY ON/OFF

- Press the circular button once, then press and hold for 2 seconds to turn on the flight battery.
- Press the circular button once, then press and hold for 2 seconds to turn off the flight battery.

⚠ ATTENTION: Pressing the circular button once with no further action will indicate current BATTERY LEVEL.

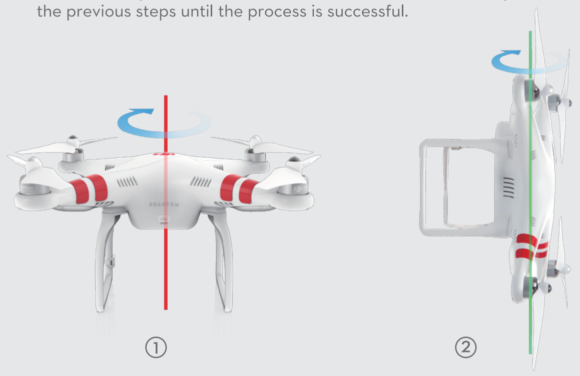
5 LED FLIGHT INDICATORS

- Slow green flashing indicates ready to fly with GPS.
- Slow yellow flashing indicates ready to fly without GPS.
- Fast yellow flashing indicates your Remote Controller is switched off.
- Fast red flashing indicates low flight battery level.
- Please refer to the card attached to the Remote Controller for more details.

6 CALIBRATING THE COMPASS

- Rapidly flip the S1 switch from the 'fully up' to the 'fully down' positions for at least 6 times.
- Once the LED Flight Indicators change to display solid yellow, the compass calibration mode has been initiated.
- Holding the Phantom 2 horizontally, rotate it 360° on its center axis until the LED Flight Indicators switch to solid green.
- Then while holding the Phantom 2 vertically, rotate 360° on its center axis until the LED Flight Indicators light disappears.

⚠ ATTENTION: If the LED Flight Indicators flash between yellow and red, then the process has FAILED. You must start over and repeat the previous steps until the process is successful.



7 BEGINNING YOUR FIRST FLIGHT

- Start by placing the Phantom 2 on the ground with the Battery Level Indicator lights facing yourself.
- Switch on the Remote Controller.
- Turn on the flight battery.
- Pull both sticks on the remote controller to bottom corners as shown to start/stop the motors.
- Start flying.

⚠ ATTENTION: ONLY stop the motors after the Phantom 2 has landed, DO NOT stop the motors during flight!

Turbo Ace MATRIX

Quadcopter User Manual

V11

Table of Contents

INTRODUCTION

1.1 Welcome to the World of Quadcopters

The MATRIX is spawning a new era in super quadcopter design. Its larger & powerful motors, propellers and batteries offer up to three times the flight time and payload of a traditional quad. The extra payload and flight time allow you to carry a variety of cameras to produce unmatched cinematic quality video. Sporty low-profile architecture, its triple carbon fiber deck supports an extra wide 1000mm wingspan that folds down to fit inside an optional aluminum carrying case (no dismounting and remounting of propellers, landing skids or gimbal required). The MATRIX's ideally positioned camera mount on the nose offers wide angle views unobstructed by propeller shadows, reflections and landing skids. Its well-balanced center of gravity, with battery and gimbal position flexibility, greatly reduces swinging and improves the video quality of the traditional under-mounted battery/gimbal design.

Quadcopters are loosely classified into several categories - from toys for amusement to complex units for professional video, science & research. Now, a new class of quadcopter is emerging for commercial applications. The Turbo Ace MATRIX is the clear leader in this group with a list of outstanding features: advanced PC interface (so you can update or customize the flight controller), cutting edge auto-stabilizing mode for videographers, anti-vibration mounts, dynamically balanced motors for high definition video production, and a host of other upgrades to improve reliability. Unlike most quadcopters, the MATRIX is fully assembled and tested in the USA for outdoor flight and it is ready to produce high quality video right out of the box. If you are starting from scratch, the MATRIX RTF package even includes a paired transmitter that is fully programmed and calibrated. If you already have a transmitter, all you need is an ARF package. For additional cross-training, you can choose from our optional professional Phoenix flight simulator, an easy-to-fly helicopter, and/or a mini Walkera QR X350 quad. As with all Wow Hobbies' featured RC helicopters, MATRIX parts, upgrades and accessories are fully supported online and locally in the USA.

1.2 Important Instructions

* **Read the entire Matrix Instruction Manual** on your included USB flash drive before you operate the Matrix.

* Follow the instruction manual for a **tied down flight test on a bench**. This is the safest way to make sure the Matrix quadcopter has not been damaged during shipping.
* Foldable Matrix aluminum arms operate on guiding carbon tracks with keyed circular locks on each end. To release the arm from the folded or operating ends of the track**, please unscrew the arm bolt counter-clockwise for a height of 1/8" before the lock will release**. If the bolt is not unscrewed to a sufficient height, you may risk scratching the carbon track.
* Prior to each takeoff, make sure the GPS antenna/compass is erected from the folded position and screwed down.
* When mounting a propeller, use loctite and make sure the propeller clamp sits flat against the top of the propeller. Even new propellers may need to be balanced if vibration shows on video. Use a blade balancer with heavy gauge tape adhered to the underside of the blade for balance. In bright sunlight, the GoPro 3 may show rolling shutter jello. Use ND8 filter if necessary to slow down its shutter speed.
* Battery must be positioned by moving it backward and forward until the front and back weights are balanced from the center point of the Naza flight controller. You can lift the matrix up with a finger on each side of the matrix to check the balance (see manual for details). The battery can be placed either on top or bottom of the Matrix.
* Camera must be balanced like a seesaw on a brushless gimbal, otherwise the gimbal motors will be stressed and vibrate.

Maintaining the Matrix's LiPo Batteries

* Matrix batteries are made up of 6 cells and each cell must be maintained between 3.7V to 4.2V. The total voltage for Matrix batteries should be maintained between 22.2V (3.7Vx6) and 25.2V (4.2Vx6) without load. It's very important to **keep each cell above 3.7V**. A cell is at risk of being damaged or life shortened at 3.67V per cell without load.
* Each Matrix battery includes a yellow charging/discharging plug and a white balancing plug. Both plugs must be plugged in to charge the battery. The yellow plug with thicker gauge wires enables a faster charge rate, while the white plug with 1 small red wire and 6 small black wires enables the charger to balance charge 6 individual cells. When all 6 cells reach approximately 4.2V each for a total of 25.2V, the charger will automatically stop.
*** A battery meter is one of the easiest way to monitor voltage for any LiPo battery.** There are seven pins on the battery meter. One of the pins is marked with a "-" symbol, which should

line up with the black wire of the battery's white balancing plug. The first number displayed is the total voltage of the battery, followed by each individual cell.

Before & After Each Flight

* Attitude mode is the most reliable way to fly for experienced pilots, as it is not susceptible to GPS interference. GPS mode is commonly used by beginners, but once more experience is acquired, attitude mode is highly recommended (you can still use GPS mode as a backup). When orientation is lost, do not panic. Just flip to GPS mode and let go of the cyclic stick, and GPS will take over. Do not to attempt to recover the craft with the cyclic stick. There is a certain time of the year in which solar flare may interfere with GPS. To recover the craft in such a case, switch to manual (not attitude) mode. Please be aware that if the Matrix has passed through airport X-ray screening, near a magnet or has been relocated more than 30 miles from where it was originally calibrated, the GPS may need to be recalibrated depending on the geographic latitude at which you are located (see manual).
* Before each flight, always turn on the transmitter first, then plug in the Matrix battery. Then, you need to allow enough time for the flight controller and GPS to warm up and initialize. The Naza Lite takes approximately 2 minutes to warm up. The yellow LED light will turn off when the Naza Lite is ready for use.
*** After each flight, always unplug the Matrix battery** first, then turn off the transmitter. If you forget, the quadcopter and/or transmitter will continue to drain power and the battery will be damaged.

Dos

* Do initialize the Matrix & takeoff from a large, leveled surface.
* Do implement a pre-flight checklist & use it consistently before takeoff.
* Do unplug the Matrix battery when maintaining or upgrading the quadcopter.
* Do dismount propellers if battery is plugged in while updating the flight controller.

Don'ts

* Don't operate near people or pets & do not allow people to approach an operating quadcopter.

* Don't use magnets (e.g. magnetized screwdrivers & tools) in close proximity to the GPS antenna/compass.

* Don't attempt to catch a quadcopter.

1.3 Quick Start

The MATRIX has a convenient foldable arm / landing skid design. When you first remove it from the box, please make sure that the GPS antenna (See diagram 2.5) is erected and properly tightened by turning the top locking cylinder in a clock-wise direction. Next, loosen the arm screws located on top of the folding track. These screws are keyed so they must be loosened and raised by about 1/8 of an inch in order for the arms to fold, unfold the arms, and tighten them back in a clock-wise manner. Make sure the round key located on the bottom of the screw is securely locked into the circular key on the track. When it is properly locked in, it will prevent the arms from accidentally folding during flight. Next, if you wish to fold the landing skid, you may loosen the 2 side screws on each of the 4 legs. Pull the leg down to lengthen it. Tighten the 2 screws back on each of the landing skid legs. Refer to section 5 TESTING & OPERATIONS (Please DO NOT install the propellers during the testing procedure). Attach the battery to either on top or bottom of the Matrix. Lift the Matrix up with one finger on each side from the center of Naza flight controller. Move the battery until the Matrix is leveled like a see-saw with equal weight on both sides. See Figure 3.4.4. It is important to note that the Matrix will not fly properly and may lose control and crash if the center of gravity is not balanced at the middle of the Naza flight control. Turn on the transmitter and within 2 seconds plug in the MATRIX battery to bind. If your unit comes with DJI NAZA, please observe the blinking yellow LED light located behind the quad, which indicates the controller is in warm up stage. Wait for about 2 minutes until the yellow light stops flashing. Please check the LED light description at section 5.3 and 5.4. Attitude mode is the most reliable way to fly for intermediate to advance level pilots as all GPS is susceptible to interference and sun spots activities. However, GPS remains to be the easiest and the safest way to fly for beginners. Select the attitude mode from your transmitter, if you are a trained pilot and use the GPS mode as a backup. Move both sticks of the transmitter together in one action down to the lower right or left corner to start the motors. Release right stick and immediately give the left stick about 10% throttles so the motors will not cease. It will not lift off until the throttle stick passes 50%. Have an experienced pilot test fly it on a bench while tied down. No defective claim is allowed if the unit is crashed, so please be very careful.

1.4 Features

- Extra wide 15-inch propellers for optimum flight time
- High payload
- High efficiency voltage with 6 cells Li-Po battery
- Unobstructed front positioned camera mount
- Center of gravity rolling camera compensation
- Quick foldable design for easy portability
- Advanced Multi-Counter-Rotating Rotor System designed for outstanding stability & performance
- Intelligent Programmable Flight Controller
- Built-in Altitude Hold when throttle stick is released at 50% Throttle
- Flight Controller with PC software interface
- Dual Flight Mode: Sport Flying Mode & Auto Leveling Aerial Video Mode
- Advanced Gyro with 6-DOF Motion & MEMS Sensor Technology
- Full Compatibility with Standard 2.4GHz Systems
- 4 Dynamically Balanced C4234 Brushless Motors with outstanding power and minimal vibration
- 4 Independent 40A ESCs for Outstanding Performance, Reliability & Ease of Maintenance
- Square Anti-Twist Mount Impact-Resistant Propellers with low noise operation
- High Payload suited for professional camera & video equipment
- Optional Single Axis Quadruple Anti-Shock Camera Mount (available)
- Optional High Capacity 8000mAh Batteries for extended flight (available)
- Optional FPV Integration (available)
- Optional Sports Mode for faster flight capability

1.5 Specifications

Three models: MATRIX Lite, MATRIX Silver, and MATRIX Black

- Dimensions including propellers: 1000 mm × 392 mm × 135 mm
- Motor: 4 x 42mm Outrunner Brushless Motors
- ESC: 4 x 40A Electronic Speed Controllers
- Propellers: 2 x CW and 2 x CCW, 15 inches carbon
- Receiver & Transmitter Requirements: 2.4GHz 6 to 14 Channel RX/TX Pair
- Standard Battery: LiPo 6S (22.2v) 5300mAh 20C 1P. Flight time 15 min

- Optional Battery: LiPo 6S (22.2v) 8000mAh 20C 1P. Flight time 25 min
- Weight Without Battery & Camera mount:3.5 lbs
- Maximum Payload: 3.5 lbs. For proper operation and stability please limit the payload to 2.5 lbs.
- Wind Tolerance: Class 5

1.6 Flight Controller Specifications

Supported Multi-rotor	Quad-rotor I4, X4 / Hex-rotor I6, X6, IY6, Y6
Supported ESC output	400Hz refresh frequency
Recommended Transmitter	PCM or 2.4GHz with a minimum of 4 channels
Working Voltage Range	MC:4.8V~5.5V VU: 7.2V ~ 26.0 V (recommend 2S ~ 6S LiPo)
Power Consumption	MAX1. 5W (0.3A@5V) Normal:0.6W (0.12A@5V)
Operating Temperature	-10°C ~ 50°C
Assistant Software System Requirement	Windows XP sp3 / Windows 7
Max Yaw Angular Velocity	200°/s
Max Tilt Angle	45°
Ascent / Descent	±6m/s
Weight	MC:25g VU:20g GPS:21.3g
Dimensions	MC: 45.5mm x 31.5mm x 18.5mm VU: 32.2mm x 21.1mm x 7.7mm GPS & Compass 46mm(diameter)x9mm
Built-In Functions	Three Modes Autopilot Enhanced Fail-safe Low Voltage Protection S-Bus Receiver Support 2-axle Gimbal Support

1.7 Packing List

- USB 8GB Flash Drive with test flight video, application software and the MATRIX User Manual

- 1 x Turbo Ace MATRIX Quad Flyer (3 x Body Plates – Top Cover, Middle, Bottom, 4 x Motors, 4 x ESC, Flight Controller)
- 2 x CCW Propellers (1555 Type) & 2 x CW Propellers (1555R Type)
- Programming USB-to-Micro USB Cable to link to your PC
- 2 x Velcro Battery Strap (on Matrix) 1 x Velcro Battery Strap
- Batteries: Included with RTF Package but not included with ARF Package
- Receiver: Included with RTF Package but optional on ARF Package

1.8 Caution & Safety

- As the operator of the Turbo Ace MATRIX, it is your responsibility to follow all proper procedures, protocols and precautions to ensure the safe operation of the MATRIX. **The operator must wear safety glasses and any bystanders must be protected in a safe area. Do not operate the MATRIX in the proximity of children, pets, cars and other vulnerable property.** The owner and the operator of the MATRIX assumes all liability for any damages caused in the operation of the MATRIX, including but not limited to personal injury, equipment and property damage.
- If your package includes a transmitter radio, **do not pull on the transmitter's antenna when removing it from the foam packaging tray.** Remove the transmitter by pulling on the neck strap holder.
- Since the MATRIX propellers are dismounted for shipping purposes, you must first follow the setup instructions in this user manual to mount the propellers. Any attempt to skip procedures will end in a bad crash.
- **Do not be tempted to fly a new and large RC aircraft, such as the MATRIX, out of the box, especially after shipping. Prior to its maiden flight, please tie the MATRIX down to a stationary workbench for 3 battery test flights.** Any crashed aircraft is not eligible for dead-on-arrival or any other defective equipment claims. If you are new to RC equipment, please seek the help of an experienced RC equipment operator to prevent damage and injury.
- **If you have purchased a MATRIX ARF package, you must first program the end points of each ESC then calibrate your transmitter to the MATRIX (See Section 4.2). If you are using your own transmitter you must reprogram each ESC independently. (See Section 4.1).** Any attempt to fly without proper transmitter calibration and ESC programming will result in a crash and it will invalidate any

DOA claim. If you have purchased an RTF (ready-to-fly) unit with transmitter, please ignore these steps.

- Additional Velcro should be added on the flight battery to prevent the battery sliding from side to side.
- **Operator must tie down MATRIX and remove all propellers when it is hooked up to a computer.** Any incorrect settings or values may trigger an accidental motor startup. Turbo Ace, its distributors and dealers are not liable for any damages caused by mishandling of the MATRIX and its associated equipment.
- **Operator should use Loctite to secure all necessary screws on the MATRIX, excluding propeller locking screws.** Blue Loctite can be applied directly to the screw and should not come in contact with any plastic propellers or parts which will crack during flight. Please do not use red Loctite, as it can only be removed with extreme heat.

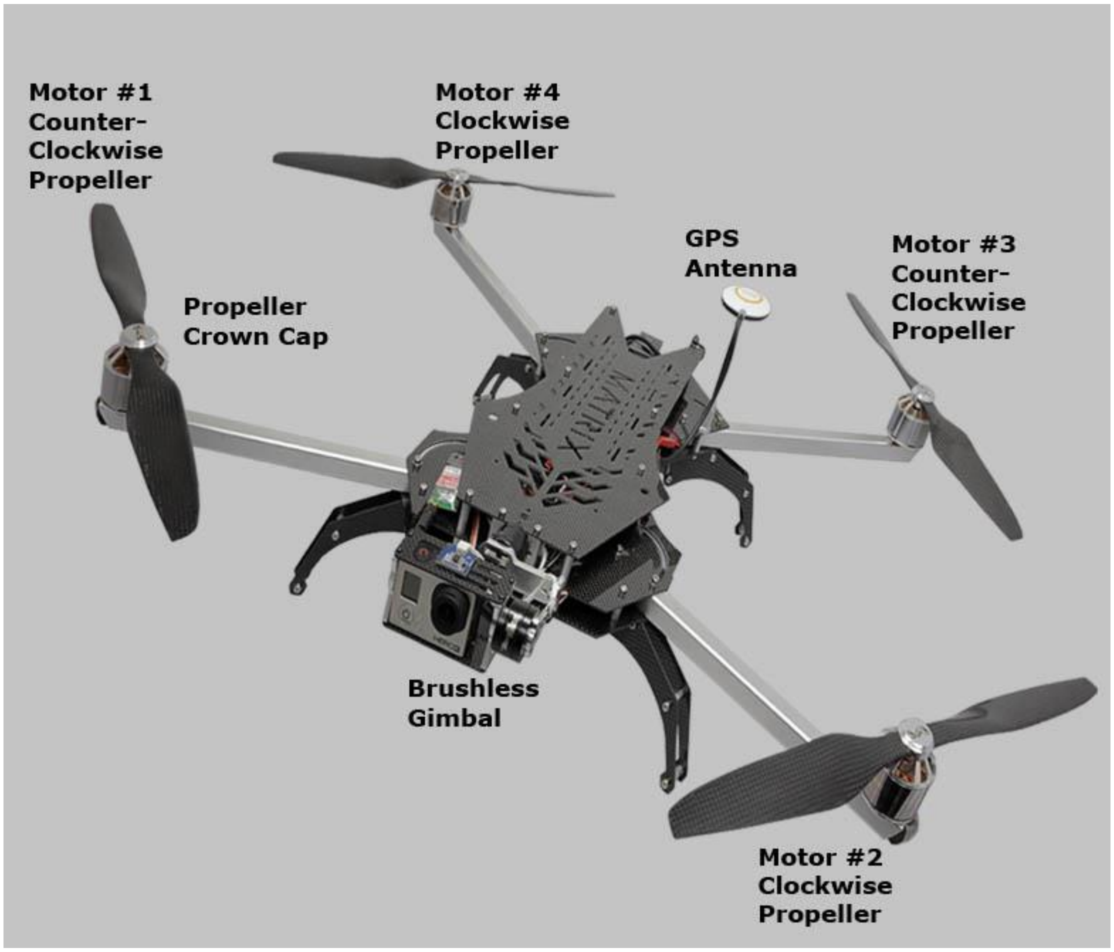
1.9 DOA Claim

Even though the main assembly with attached electronics has been assembled and tested in the USA before it is shipped to you. If your package includes a receiver or transmitter, the whole package will be tested as a complete set. If your order does not include a transmitter, you will be required to program the end points of each ESC and calibrate your transmitter.

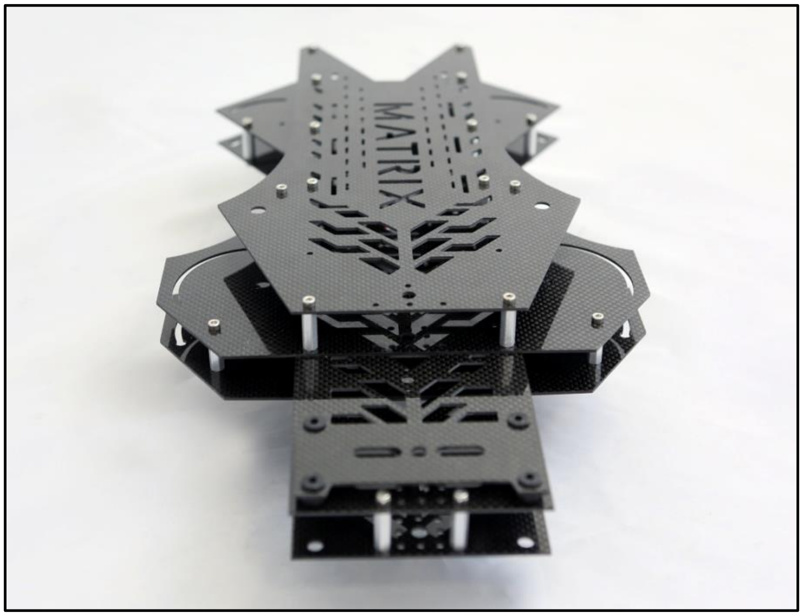
- DOA (Dead-On-Arrival) must be claimed within 24 hours of receipt.
- Do not return any products without authorization. If you need to return a product for service, you will need to acquire a Return Merchandise Authorization (RMA Number) through e-mail (support@wowhobbies.com) or our website. If we don't have a record of your request, your returned product will be rejected.
- No DOA claims can be made when you pick up your MATRIX from our store because it will be test flown live before you take it home.
- No DOA claims can be made once the device has been crashed, including, but not limited to, blades tipping on the ground or any equipment failure after shipping that was not uncovered by skipping the 3 battery test flights with the tie-down bench test.
- There is no warranty, return or exchange on all RC products.

DIAGRAMS AND PARTS

2.1 Top View



2.2 Profile View



2.3 Part Specifications

No.	Part	Specifications	QTY	Units	Remarks
1	Chassis	Carbon Fiber	1	SET	
2	Arm	High Strength Aluminum Tubing	4	PCS	
3	Skid Landing	Carbon Fiber	4	SET	
4	Motor	C4234 400KV Brushless Motor	4	PCS	
5	Propeller	1555 (Normal),1555R (Reverse) 15-inch Carbon Fiber with high fiber & low resin content	4	PCS	
6	Head Hangers	Elastic Damping, Shock Absorber Suspension	1	SET	
7	ESC	6S 40A high-Speed Electronic Controller	4	PCS	

8	Flight Control System	DJI NAZA- LITE / DJI NAZA V2	1	PCS	

2.4 Technical Parameters

Width	Diameter From Outer Edges of Motors	765 mm	±3mm
Extended Width	Diameter From Extended Propellers	1111 mm	
Motors Center to Center	Diameter From Center of Motor to Center of Motor on Opposite Side	724 mm	±3mm
Height	Bottom of Skid Landing to Top of Motor Cover (including GPS Compass)	132 mm (200 mm)	
Propeller	2 x CW & 2 x CCW	381 mm	
Battery	LiPo 6S	22.2V	
Single Weight	No battery, receiver, load	3.3 lbs	±10g
Flight Distance	Limited by Sight & the Receiver/Transmitter		
Flight Time	6S 5300mAh, 1P Battery, receiver	20 minutes	No wind hover
Wind strength	≤5	Class	

2.5 Parts List

MATRIX SETUP

3.1 Unpacking the MATRIX

Remove all MATRIX contents from the box. To avoid damaging the transmitter antenna, do not pull on it to remove the transmitter out of the box. Instead, pull on the neck strap to safely remove the transmitter from the box.

3.2 Skid Landing Leg Assembly

Figure 3.2-1 ***Four sets of Skid Landings disassembled***

(1) Please skip this section if your unit comes fully assembled. Take two 15mm 3.0mm posts (Female/Female) and screw on both sides of the skid landing plates on the bottom two holes (as indicated in Figure 3.2-2).

(2) Take one inner skid bracket and screw on both sides of the skid landing plates on the top hole (as indicated in Figure 3.2-2).

(3) Repeat steps 1 – 2 for the remaining three Skid Landings.

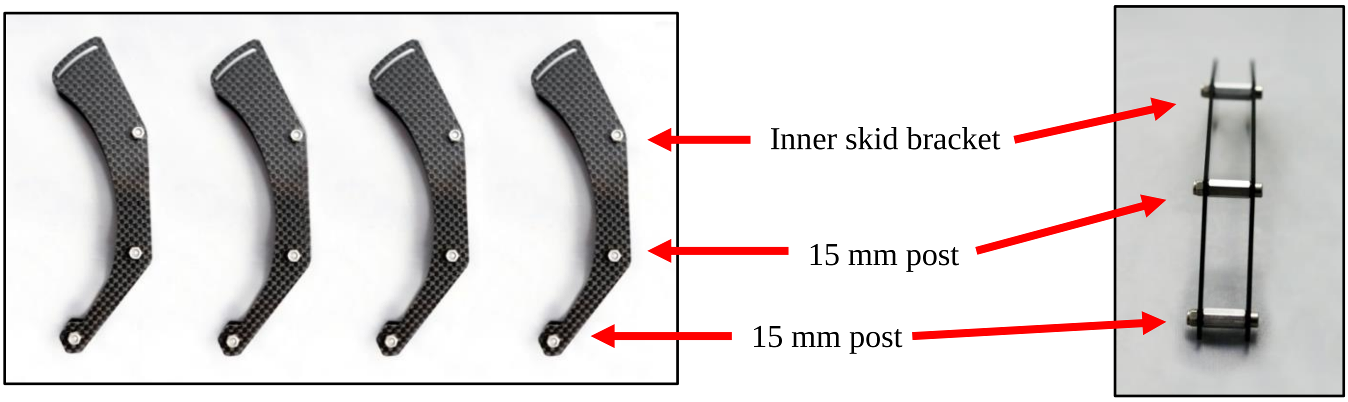


Figure 3.2-2 ***Four sets of Skid Landings assembled***

Figure 3.2-3 ***One Skid Landing Leg***

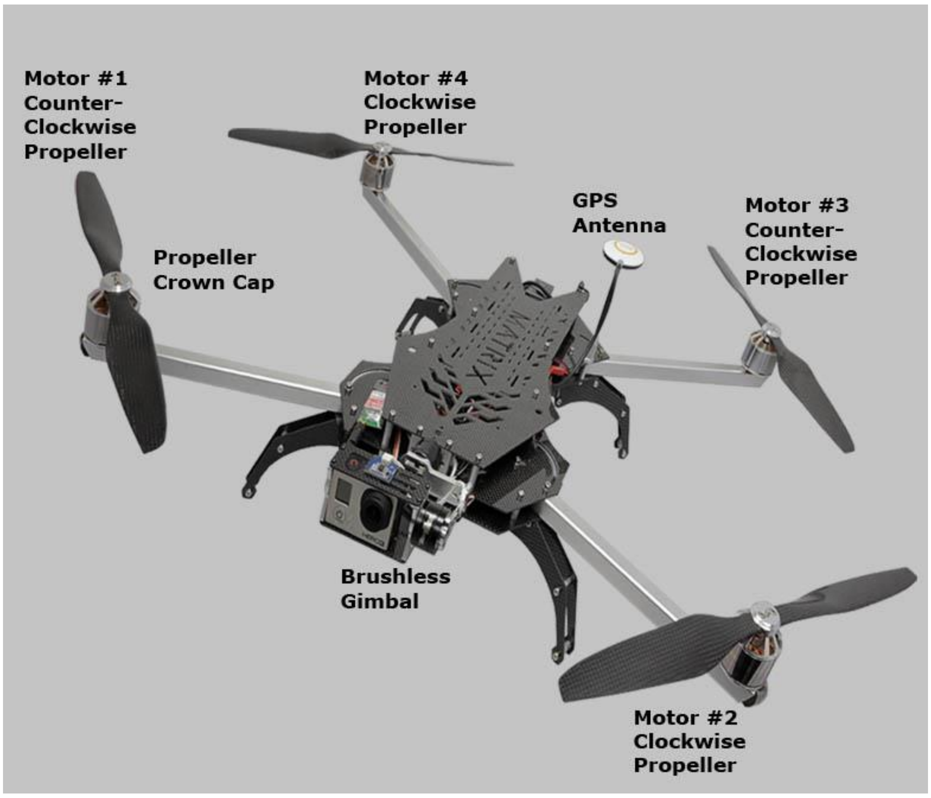
3.3 Mounting Propellers

There are a total of 4 propellers in your package.

(1) Unscrew and remove the propeller screws from the motor and remove the motor cover.

(2) Due to the precision needed to reduce vibration, the propellers are design to fit tightly on the motors. Using the figure below, insert labeled propeller to corresponding motor. Motors #1 & #3 use Counter Clockwise propellers and motors #2 and #4 use Clockwise propellers. Failure to mount the correct propeller(s) on the designated motor will result in a crash.

(3) Over tightening the motor cover screw may damage the motor aluminum threads. Repeat this for all 4 propellers.



3.4 Battery Requirements & Installation

(1) Standard Battery: 6-S LiPo, 22.2V, 5300mAh, 35C, 1P

(2) Optional Extended Flight Battery: 6-S LiPo 22.2V, 8000mAh, 25/50C, 1P

(3) Release the two wide Velcro battery straps on the tail of the MATRIX bottom plate. Make sure a Velcro strip is added to the battery and the body of the Matrix to prevent it from sliding. Secure it with the two wide Velcro battery straps.

(4) Move battery forward/backward until weight is equal from center of the Naza flight controller. You can balancing the Matrix like a see-saw by lifting it up with fingers on each side of the Naza Flight controller until it is leveled. Your camera, propellers and all devices must be installed before balancing. See diagram 3.4-1

(5) Do not plug in the battery at this time.

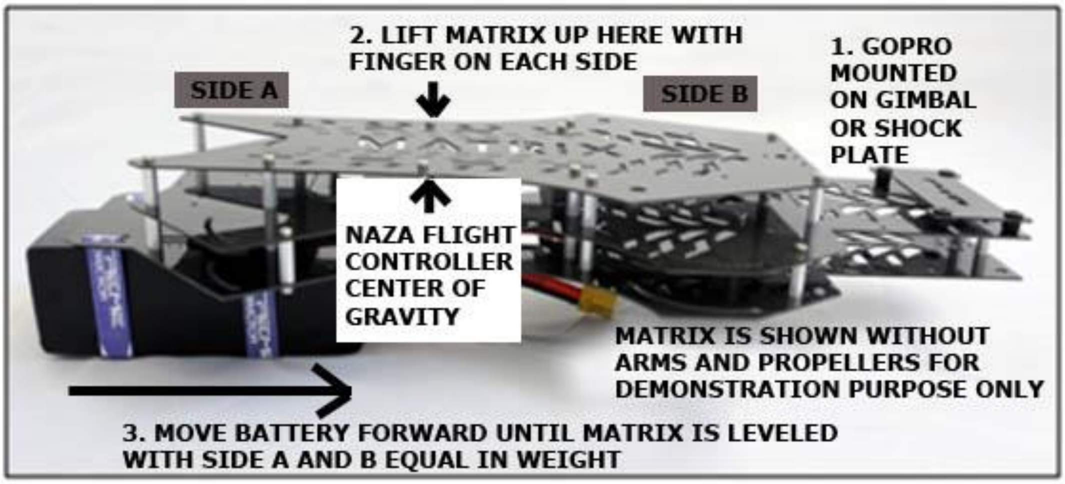


Figure 3.4-1 *Balance at center of gravity*

ELECTRONICS SETUP & ADJUSTMENT for Walkera Devo 10 Transmitter

If you have purchased an RTF package, please skip Section 4.1 through 4.5 because all settings are already complete and your MATRIX and transmitter have been paired and test flown as a set. Unless you are familiar with the settings, any changes might override the factory's setting and disable the aircraft, affecting its performance and flight reliability.

If you have purchased an ARF package, you must complete Section 4.1 ESC Programming and Section 4.2 Transmitter Calibration. MATRIX ESCs needs to reprogram independently. Also, in order for a flight controller to work properly, your specific transmitter has to be calibrated to work with each new MATRIX. Crashes will be imminent if you skip these one-time procedures to match a MATRIX with a transmitter.

4.1 ESC Programming for Transmitter (A Must Setup For ARF)

Video Instruction:
How to calibrate the ESC for MATRIX:
https://www.dropbox.com/s/zcf72jgoeng92c9/How%20to%20calibrate%20the%20ESC.MP4

Please skip this ESC programming step if you have purchased RTF unit, since all ESC have been re-programmed. Please follow the steps below very carefully, as they will only take a few minutes.

(1) Very important: Remove all 4 propellers from the motors for safety.
(2) Double check to make sure all ESC connectors are marked/labeled (#1 through #4 matching the connectors on the flight controller #1 through #4) so that you will be able to keep track of the corresponding connectors when you need to put them back later.
(3) Disconnect all 4 ESC connectors from the NAZA flight controller so they may not interfere with each other's programming.
(4) Move the throttle stick all the way down. Now turn on the transmitter.

(5) Disconnect X3 on NAZA flight controller and plug into AUX1 on the receiver.

(6) Insert one of the labeled ESC connectors into the receiver's throttle channel port while watching for the correct polarity. Black/dark brown wires are usually on the edge of the receiver. Please verify polarity in your receiver manual if you are not using the stock Walkera receiver.

(7) Move the throttle stick all the way up.

(8) Within 3 seconds, connect the battery to the MATRIX's battery plug (The MATRIX battery plug is still connected to all 4 ESCs but only one ESC should be connected to the receiver at a time.)

(9) When the ESC makes 1 beeping sounds, immediately move the throttle stick all the way down. The ESC will then make 2 beeping. (If you did not hear the 1 beeping sounds when entering programming mode or you did not hear 2 beeping after the ESC have completed its programming then you need to move throttle all the way down and disconnect the battery from the MATRIX battery plug and repeat from step #6 to #9 for the ESC.) If you did not experience any problems, then you have completed programming on this ESC which now retains the high and low end point data in its memory. Disconnect the battery from the MATRIX's battery connector then disconnect the ESC connector from the receiver.

(10) Repeat this process for each ESC from Step#6 through Step#9. Please make sure you have programmed all 4 ESCs by starting from the #1 labeled ESC and finishing with #4 labeled ESC. Your transmitter power should remain in the power on position throughout the entire process of programming all 4 ESCs.

(11) After you have successfully re-programmed all 4 ESCs, unplug the battery from the MATRIX battery plug then turn off the transmitter.

(12) Insert the 4 ESC connectors, labeled #1 through #4 back to corresponding M1 through M4 ports on your NAZA flight controller. The black/dark brown wire (-) for each of the ESC connectors are closest to the red NAZA label of the flight controller.

4.2 Transmitter Calibration for Transmitter (Required Setup For ARF)

Video Instruction:
How to set up your transmitter calibration for MATRIX:
https://www.dropbox.com/s/s4vhtkqq1v3r0px/How%20to%20set%20up%20your%20transmitter%20calibration%20for%20X830.MP4
How to set up your autopilot and voltage setting for MATRIX:
https://www.dropbox.com/s/vfaa6tcf8v4qdc2/How%20to%20set%20up%20your%20autopilot%20and%20voltage%20setting%20for%20X830.MP4

If you have purchased your MATRIX with a transmitter (RTF package) please skip this section because we have already completed the calibration. If you are using a transmitter that has never been paired with your new MATRIX, you will need to calibrate your transmitter to the MATRIX flight controller using the following procedure. Any change to the quadcopter or setting change to the transmitter might require transmitter calibration.

(1) **Very important!! Remove all 4 propellers from the motors for safety.**
(2) Tie down your MATRIX
(3) Turn on your transmitter radio.
(4) Connect battery to the MATRIX battery connector.
(5) Connect the provided Programming USB Cable from your PC computer's USB port (XP or WIN7 or WIN8) to the Micro USB port on the MATRIX communication port (on the LED side panel of the MATRIX). (If the computer does not recognize the USB, the USB driver is located in the provided 8GB USB flash drive)
(6) Double click on the NAZAInstaller.exe located in the provided 8GB USB flash drive and install the NAZA ASSISTANT SOFTWARE.
(7) Double click on the application file named NAZA ASSISTANT SOFTWARE. Wait for the program to start up.
(8) Click **MOUNTING** Use to input the distance between GPS and Main Flight Controller.
(9) Click **MOTOR MIXER**
MIXER TYPE: Please select **Quad-rotor X** and remember to click WRITE after you update any settings (WRITE is #7 on top of FIGURE 4.2)
(10) Click **TX CALI**

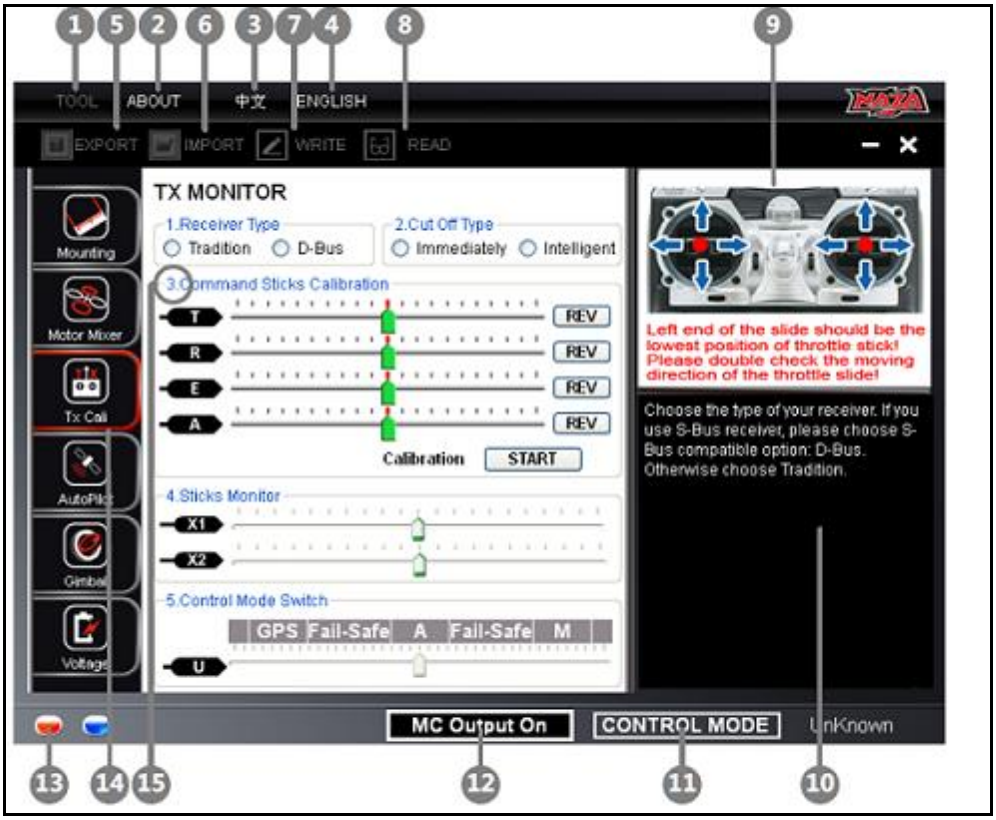


Figure 4.2-1 *NAZA Assistant Software Program Screenshot*

(1) RECEIVER TYPE: Please choose "**TRADITION**" for Walkera or Spektrum or Futaba receiver.

(2) CUT OFF TYPES: Default setting from WOW is "IMMEDIATELY".

(3) COMMAND STICKS CALIBRATION: Click **START** to begin the calibration process. Please make sure to move both sticks to their end points. This means you are moving both sticks all the way up, down, left and right. (Note: If a transmitter stick is moved left or down, one of the on-screen sliders will move to the left. If a transmitter stick is moved right or up, one of the on-screen sliders will move to the right. If slider is moved at the opposite direction, click the NORM or REV to reverse the direction of the slider movement)

- Throttle/Yaw Stick controls "T" (Throttle): Stick down and "T" slides left (reduce Power) & stick up and "T" slides right (increase Power).

- Throttle/Yaw Stick controls "R" (Rudder): Stick left and "R" slides left (nose to the left) & stick right and "R" slides right (nose to the right).

- Directional Stick controls “E” (Elevator): Stick down and “E” slides left (tilts back) & stick up and “E” slides right (tilts forward)

- Directional Stick controls A (Aileron): Stick left and “A” slides left (leans left) & stick right and “A” slides right (leans right).

After Calibration, place all sticks at the center which will turn all sliders green. At this point click **FINISH** to end.

(4) STICKS MONITOR is not used at this time.
(5) CONTROL MODE SWITCH: (Please see Section 4.7 MATRIX Wiring Connection Chart)
   Setting the GPS Attitude and Attitude and Manual Mode on the Mix on Walkera Devention Transmitter:

Setting the GPS, Attitude and Manual Mode on the Mix Switch on MATRIX:

(1) The NAZA Assistant screen should show a Control Mode Switch with GPS | Fail Safe | A | Fail Safe | M. (The “GPS” represent the GPS Mode, the “A” represent “Attitude Mode” and the “M” represent “Manual Mode”.) You need a 3 position switch for the Control Mode Switch. For example: When using Devention 10 and RX 1002, the Control Mode Switch is assigned to the MIX SWITCH on the transmitter. This is done by connecting the Receiver’s Gear channel to the Flight Controller’s “U” channel (See FIGURE 4.2). Then press ENT on the Devo 10→Model Menu→Device Output→Gear and select MIX SW by press L or R and make sure Function shows ACTIVE.
(2) Now you need to make sure when the MIX SWITCH is flipped forward (away from you) the switch will change the flight controller to “GPS Mode”. If the Control Mode Switch (See FIGURE 4.2 bottom) slider is closer to “M” or “A”, then the Control Mode Switch slider is in the wrong position. To bring the slider closer to “GPS”, press ENT button on your transmitter→Function Menu→Reverse Switch→Gear and reverse your GEAR SWITCH setting (which is now set to your MIX SWITCH setting) by pressing L or R. This change will bring the Control Mode Switch slider closer to “GPS”.
(3) Move your MIX SWITCH to the middle position to set the midpoints for the middle position first. If the “A” segment turns blue please skip to Step #5.
(4) If the “A” segment does not turn blue, press ENT on your transmitter→Function Menu→Sub Trim→Gear and adjust your GEAR

SWITCH's midpoint by pressing the L or R button until "A" segment turns blue.

(5) Flip the MIX SWITCH forward (away from you). If the "GPS" segment turns blue then skip to Step #7.

(6) If the "GPS" segment does not turn blue, press ENT on your transmitter→Function Menu→ Travel Adjust→Gear. Use the UP/DN button to select -100.0% and adjust your GEAR SWITCH's endpoint by pressing the L or R button until "GPS" segment turns blue.

(7) Flip the MIX SWITCH backward (towards you). If the "M" segment turns blue then skip to Section 4.2.11.

(8) If the "M" segment does not turn blue, press ENT on your transmitter→Function Menu→ Travel Adjust→Gear. Use the UP/DN button to select +100.0% and adjust your GEAR SWITCH's endpoint by pressing the L or R button until "M" segment turns blue.

(9) If FIXED ID BIND is used, transmitter can be turn on and off to bind and re-bind, which will make fail safe testing easier (see Section Fixed ID Bind). To test Fail-Safe, press ENT on your transmitter→Function Menu→ Fail Safe→Gear. Use the UP/DN to adjust the Fail-Safe setting for Gear to around -44% and turn off transmitter to check/test if fail safe turn blue on screen (if fail safe does not turn blue, re-bind the transmitter and adjust Fail-Safe setting for Gear until fail safe turn blue while transmitter is off.) This procedure will make sure fail-safe is active while transmitter is off or circumstances signal lost during flight.

AUTO PILOT

(1) BASIC PARAMETERS: Recommend setting for Pitch set to 130%, Roll set to 120%, Yaw set to 90% and Vertical set to 120% and ATTITUDE GAIN is Pitch set to 100% and Roll set to 100%. REMOTE ADJUST is set to INH. Basic Gain and Attitude Gain should never set to lower than 90%, otherwise crash might result.

(2) ENHANCED FAILED-SAFE METHODS (GPS module is required). The recommended settings for enhanced failed-safe methods are GO-HOME and LANDING. (Please refer to DJI NAZA User Manual's page 21 for enhanced failed-safe methods).

(3) INTELLIGENT ORIENTATION CONTROL (IOC): (GPS module is required). Check the box next to "3. Intelligent Orientation Control". If GPS is installed, the settings for Devention 10 and RX 1002 are as follows. Assign

the intelligent orientation control to the Flight Mode Switch on the transmitter, by pressing ENT on the Devention10→Model Menu→Device Output→Flap (AUX 1) and selecting FMOD SW by pressing L or R (Make sure Type Select is Airplane mode, pressing ENT on the Devention10→model menu→type select→airplane) and making sure that Function shows as ACTIVE.

(1) The NAZA Assistant screen should show INTELLIGENT ORIENTATION CONTROL with Home Lock | Course Lock | Off. You need a 3 position switch for the Intelligent Orientation Control Switch. For example: When using Devention 10 and RX 1002, the Intelligent Orientation Control Switch is assigned to the Flight Mode Switch on the transmitter. This is done by connecting the Receiver's Flap (AUX 1) channel to the Flight Controller's "X2" channel. Then press ENT on the Devo 10→Model Menu→Device Output→Flap (AUX 1) and select FMOD SW by pressing L or R and making sure the Function shows as ACTIVE.
(2) Now you need to make sure when the FMOD SW is flipped forward (toward the ground) the switch will change the Intelligent Orientation Control to "Off". If the slider is closer to "Course Lock" or "Home Lock", then the Intelligent Orientation Control Switch slider is in the wrong position. To bring the slider closer to "Off", press ENT button on your transmitter→Function Menu→Reverse Switch→Flap (AUX 1) and reverse your Flap (AUX 1) SWITCH setting (which is now set to your FMOD SW setting) by pressing L or R. This change will bring the Intelligent Orientation Control Switch slider closer to "Off".
(3) Move your FMOD SWITCH to the middle position to set the midpoints for the middle position first. If the "Course Lock" segment turns blue, please skip to Step #5.
(4) If the "Course Lock" segment does not turn blue, press ENT on your transmitter→Function Menu→Sub Trim→Flap (AUX 1) and adjust your Flap's (AUX 1) midpoint by pressing the L or R button until "Course Lock" segment turns blue.
(5) Flip the FMOD SWITCH forward (toward the ground). If the "Off" segment turns blue then skip to Step #7.
(6) If the "Off" segment does not turn blue, press ENT on your transmitter→Function Menu→ Travel Adjust→Flap (AUX 1). Use the UP/DN button to select +100.0% and adjust your Flap (AUX 1)'s endpoint by pressing the L or R button until "Off" segment turns blue.

(7) Flip the FMOD SWITCH backward (towards the sky). If the "Home Lock" segment turns blue, then skip Step #8.

(8) If the "Home Lock" segment does not turn blue, press ENT on your transmitter→Function Menu→ Travel Adjust→Flap (AUX 1). Use the UP/DN button to select -100.0% and adjust your GEAR SWITCH's endpoint by pressing the L or R button until "Home Lock" segment turns blue.

Home Lock only activates while MATRIX is about 30 feet (10 meters) away from the home position (Takeoff Position). To change the Home Lock position during flight, please refer to the DJI User Manual for detailed instructions and functions of HOME LOCK and COURSE LOCK.

4.3 Transmitter & Receiver Compatibility Table (For ARF Only)

The MATRIX prefers a 2.4GHz system, but also supports 35MHz, 40MHz, and 72MHz.

No.	Brand	Transmitter	Receiver
1	Walkera	DEVENTION 10	RX1002
2	Spektrum	DX8	AR8000
3	JR	DSX7	RD721
4	JR	9XII	
5	WFLY	FT06-C	FRP06
6	Futaba	14SG	R7008SB
7	Futaba	6EX	R146iP
8	Futaba	10C	
9	Sanwa	RD8000	92777
10	Hi-TEC	Eclipse7	FRP06

4.4 Receiver, Flight Controller & Auto-stabilization Setup

FIGURE 4.4

(1) Connect Channel #T wire from the flight controller to the THROTTLE channel of the receiver. Watch for polarity.

(2) Connect Channel #E wire from the flight controller to the ELEV channel of the receiver.

(3) Connect Channel #A wire from the flight controller to the AILE channel of the receiver.

(4) Connect Channel #R wire from the flight controller to the RUDDER channel of the receiver.

(5) Connect Channel #U wire from the flight controller to the GEAR channel of the receiver.

(6) Connect Gyrox brushless gimbal tilt control cable to the AUX 4 channel of the receiver.

(7) Connect Channel #X2 wire from the flight controller to the AUX 1 channel of the receiver.

(8) Connect Channel #X3 wire from the flight controller to the LED Versatile Unit (PMU).

Setting up MATRIX to ensure a smooth flight with GPS or Attitude mode

To ensure the smooth flight of your Turbo Ace MATRIX, please make sure that you setup and fly the MATRIX in GPS or Attitude mode. In order for GPS or Attitude mode to function, first it is important to make sure the mix switch on your radio is all the way forward. Please refer to Section 4.2 Transmitter Calibration. If you own a Walkera radio such as the Devo 10, you will need to reverse the gear channel in your radio so that when you flip the gear switch forward, it enables GPS or Attitude Mode.

If you are experiencing difficulties in handling the aircraft, it may be because it is not in GPS or Attitude Mode.

You may skip the following setup instructions if you have purchased the Turbo Ace MATRIX with a transmitter radio, as we have already completed all the setup for you. If you have purchased a MATRIX without a radio, please see the following to make sure your radio is setup correctly.

Setting up and checking Turbo Ace MATRIX flight mode for GPS or Attitude Mode.

Plug in a 3 pin cable connector to the "INPUT" channel U of the NAZA flight controller. Connect the other end of the cable to the GEAR output on your receiver with the brown wire closest to the edge of the receiver casing (If you have a receiver other than a Walkera WK2801-PRO, Devention or Spektrum, please check your receiver manual for polarity).

MATRIX with GPS module (Assign GEAR to 3 position toggle switch, WOW default MIX switch for Devention 10):

Go to your radio setup, press ENT→Model Menu→Device Output→assign GEAR to MIX SW (MATRIX without GPS). This means that every time the **MIX** switch is flipped forward on your radio, it will toggle the GEAR output of the receiver and tell the controller to perform GPS Mode. If you own a Walkera radio, the gear channel in the radio should be changed from normal to REVERSE (Please refer to section 4.2 Transmitter Calibration, for detail adjustment for GPS/Attitude/Manual mode) You can use the NAZA Assistant Software to double check the MIX switch operation after you have completed the above setup.

Turn on your transmitter radio (Warning: Always tie down the MATRIX and remove all propellers when you perform any setting changes to the transmitter or NAZA Assistant Software. Failure to do so may cause serious issues, as the MATRIX motor may start up if an incorrect value is entered). Connect the provided Programming USB-to-Micro USB cable from your PC computer’s USB port (XP or WIN7) to Micro USB port on the MATRIX communication port (on the LED side panel of the MATRIX). Please connect this cable after the transmitter is bound to the receiver.

Double click on the NaZaInstaller.exe located in the provided 8GB USB flash drive to install the NAZA ASSISTANT SOFTWARE

After completion of the installation of the NAZA ASSISTANT SOFTWARE, double click on the application file named NAZA ASSISTANT SOFTWARE. Wait for the program to start up.

Select the TX Calibration tab at the left column of the screen.

MATRIX with GPS
You will see the 5 mode tabs: GPS, Fail Safe, A, Fail Safe, M. When you flip the MIX switch on your radio, you will see the selection flipping between GPS and A and M. When the MIX switch is flipped forward, you will see GPS is selected which enables GPS Mode. The GPS Mode is the mode you should be using to fly your MATRIX. M mode has no stabilization and will make it very difficult to operate the aircraft.
IMPORTANT: Make sure that the MIX switch on your radio is in the forward/middle position before taking off and during the entire flight. (Please refer to section 4.2 Transmitter Calibration if GPS and A and M mode do not turn blue on the screen when you flip the MIX switch).

4.5 Transmitter Settings (For ARF Only)

(1) Aircraft Mode: Fixed-wing airplane mode. **Do not use helicopter mode**
(2) Rudder: 0% to 100% with No Mixing
(3) Curve: Channel 1, 2, 3 & 4 all set to zero
(4) Gyro: Fine tune to maximize stability
(5) Move both throttle stick and throttle trim by looking at the LCD screen to the middle position- Very important, otherwise motors will not start
(6) Use transmitter rudder trim to adjust heading (yaw) (if changes are made to trim settings recalibration is required)
(7) For added stability on the MATRIX, you may choose to set the dual rate to 55%

Please double check all settings, tie down the MATRIX to a bench, and test fly it to check the settings. Some transmitters use random bind, which means you have to plug in the battery to the MATRIX within 2-3 seconds after the radio is turned on. Please observe the LED light located at the back of the MATRIX cover (Please refer to Section 5.3 LED light description). Most receivers flash before binding and remain solid after binding, so please make sure your receiver has been properly bound to your transmitter. Do not launch the MATRIX on its maiden flight until all operations are confirmed as normal, especially after shipping. Tie it down to a bench for a preflight check. Failure to do so may cause serious damage to the MATRIX and/or people around it. Factories and dealers will not be liable for any damages from the operation of this aircraft.

4.6 Transmitter Flight Control & Gain Adjustments (For ARF Only)

We do not recommend any inexperienced users to adjust the flight control or Gain values using the DJI NAZA Assistant software. It is a steep learning curve for these adjustments, which we have already fine-tuned and completed for you. Improper settings may cause the MATRIX to lose control and may result in serious damage. If the original factory settings are altered in any way, with the exception of transmitter calibration adjustments for ARF packages, it will automatically void the 24-hour “No Dead on Arrival” guarantee. Dead on arrival returns are strictly checked for setting changes and tampering. Although it can be mastered over time, the MATRIX flight controller adjustments are quite sophisticated and complicated. Do not attempt to change these settings until you are familiar with the setup. Please go to online forums to learn about the flight control settings, as we do not provide any technical support for these settings.

When you have purchased the ready to fly unit, there are 3 control modes which we have setup on your flight controller and transmitter, GPS and ATTITUDE and MANUAL. GPS Mode has the best auto stabilization and ability to perform GPS Lock, making the aircraft very easy to fly, which is more appropriate for videographic and photographic applications. Attitude Mode has some auto stabilization and ability to perform altitude hold and makes the aircraft easier to fly, which is also suitable for videography and photography applications. Manual Mode is suited for experienced pilots to gain more manual control in adverse. Do not switch to the MANUAL mode if you are a beginner.

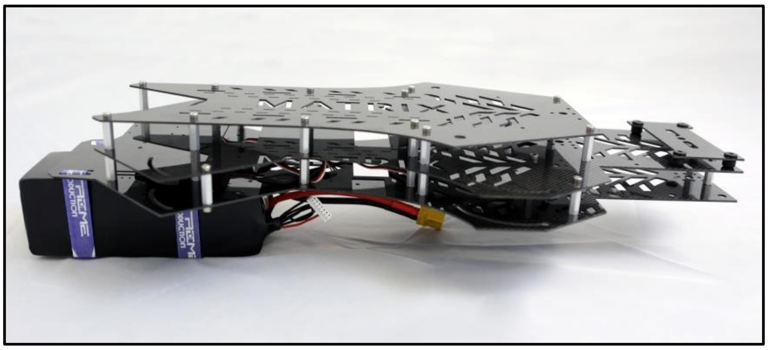
MATRIX with GPS: The three modes can be switched during flight by toggling the MIX switch on top of your radio. In the ready to fly MATRIX, we have set this switch on your radio to GPS MODE when it is toggle forward and ATTITUDE MODE when it is toggled middle and MANUAL MODE when it is toggled backward. Before takeoff, please make sure all the front panel switches on your transmitter are flipped forward and all switches such as the flight mode/hold switches on the side panel are pushed down.

The basic gain and attitude gain values of the MATRIX can be adjusted in the AUTOPILOT section when you run the DJI NAZA ASSISTANT SOFTWARE. The default setting for BASIC GAIN is Pitch set to 130%, Roll set to 120%, Yaw set to 90% and Vertical set to 120% and ATTITUDE GAIN is Pitch set to 100% and Roll set to 100% (**Warning**: BASIC GAIN should never be set lower than 90%). Again, it is very important to remember to tie down the aircraft and remove all the propellers when you are programming the fight controller with the supplied Programming USB-MicroUSB cable. Failure to do so may cause accidental motor start up with incorrect values entered and may result in serious injury. Always remember to tie down the MATRIX to a bench for test flights after you have changed any settings. (If the motor does not spin after perform the CSC, please re-calibrate/perform the Command Sticks Calibration).

4.7 MATRIX Wiring Connection Chart for Devo 10 & RX1002

MATRIX with GPS module		Devo 10 & RX1002						INDICATES ONLY ONE CAN BE ACTIVATED
RX1002		NAZA FC		TX Setting Output		Gimbal Servo		MATRIX
ELEV		E						
AILE		A						
THRO		T						
RUDD		R						
GEAR		U		GEAR→MIX SW				GPS - ATTITUDE MODE - MANUAL
AUX1		X2		AUX1(FLAP)—> F. MOD				OFF - COURSE LOCK - HOME LOCK
AUX2								
AUX4				AUX4				TILT CONTROL FOR GIMBAL
BATT								TELEMETRY (OPTIONAL)

ELECTRONICS SETUP & ADJUSTMENT for Spektrum DX 8 Transmitter



If you have purchased an RTF package, please skip Section 4.1 through 4.5 because all settings are already complete and your MATRIX and transmitter have been paired and test flown as a set. Unless you are familiar with the settings, any changes might override the factory's setting and disable the aircraft, affecting its performance and flight reliability.

If you have purchased an ARF package, you must complete Section 4.1 ESC Programming and Section 4.2 Transmitter Calibration. MATRIX ESCs needs to reprogram independently. Also, in order for a flight controller to work properly, your specific transmitter has to be calibrated to work with each new MATRIX. Crashes will be imminent if you skip these one-time procedures to match a MATRIX with a transmitter.

4.1 ESC Programming for Spektrum DX 8 Transmitter (A Must Setup For ARF)

Video Instruction:
How to calibrate the ESC for MATRIX:
https://www.dropbox.com/s/qwvt489g9j6zs7x/Calibration%20for%20Spektrum%20ESCs.MP4

Please skip this ESC programming step if you have purchased RTF unit, since all ESC have been re-programmed. Please follow the steps below very carefully, as they will only take a few minutes.

(1) IMPORTANT: Remove all 4 propellers from the motors for safety.
(2) Double check to make sure all ESC connectors are marked/labeled (#1 through #4 matching the connectors on the flight controller #1 through #4) so that you will be able to keep track of the corresponding connectors when you need to put them back later.
(3) Disconnect all 4 ESC connectors from the NAZA flight controller so they may not interfere with each other's programming.
(4) Move the throttle stick all the way down. Now turn on the transmitter.
(5) Disconnect X3 on NAZA flight controller and plug into AUX 1 on the receiver.
(6) Insert one of the labeled ESC connectors into the receiver's throttle channel port while watching for the correct polarity. Black/dark brown wires are usually on the edge of the receiver. Please verify polarity in your receiver manual if you are not using the stock receiver. (Make sure the Receiver and Transmitter radio are bound)
(7) Move the throttle stick all the way up.
(8) Within 3 seconds, connect the battery to the MATRIX's battery plug (The MATRIX battery plug is still connected to all 4 ESCs but only one ESC should be connected to the receiver at a time.)
(9) When the ESC makes 1 beeping sounds, immediately move the throttle stick all the way down. The ESC will then make 2 beeping. (If you did not hear the 1 beeping sounds when entering programming mode or you did not hear 2 beeping after the ESC have completed its programming then you need to move throttle all the way down and disconnect the battery from the MATRIX battery plug and repeat from step #6 to #9 for the ESC.) If you did not experience any problems, then you have completed programming on this ESC which now retains the high and low end point data in its memory. Disconnect the battery from the MATRIX's battery connector then disconnect the ESC connector from the receiver.
(10) Repeat this process for each ESC from Step#6 through Step#9. Please make sure you have programmed all 4 ESCs by starting from the #1 labeled ESC and finishing with #4 labeled ESC. Your transmitter power should remain in the power on position throughout the entire process of programming all 4 ESCs.
(11) After you have successfully re-programmed all 4 ESCs, unplug the battery from the MATRIX battery plug. Insert the 4 ESC connectors, labeled #1 through #4 back to corresponding M1 through M4 ports on your NAZA

flight controller. The black/dark brown wire (-) for each of the ESC connectors are closest to the red NAZA label of the flight controller.

4.2 Transmitter Calibration for Spektrum DX 8 Transmitter (A Must Setup For ARF)

Video Instruction:

1. How to set up fail safe for Spektrum transmitter for X830:
   https://www.dropbox.com/s/pw2nogpjubwaubj/3.%20Failsafe%20SPK.MP4
2. How to set up Spektrum transmitter calibration for X830:
   https://www.dropbox.com/s/z64exwcmna634j6/4.%20TX%20Calibration%20Settings%20SPK.MP4
3. How to fine tune Spektrum for X830:
   https://www.dropbox.com/s/8ybfe61e6o8bxae/5.%20Fine%20Tune%20SPK.MP4
4. How to set up the gain setting for X830:
   (Default setting is not recommended for carry heavy equipment)
   https://www.dropbox.com/s/2pkkn3ipc73tbwy/7.%20Gain%20Setup.MP4
5. How to set up the voltage setting for X830:
   https://www.dropbox.com/s/clsrg9ixxp8b2xn/9.%20Voltage%20Setup.MP4

If you have purchased your MATRIX with a transmitter (RTF package) please skip this section because we have already completed calibration. If you are using a transmitter that has never been paired with your new MATRIX, you will need to calibrate your transmitter to the MATRIX flight controller using the following procedure. Any change to the quadcopter or setting change to the transmitter might require transmitter calibration.

(1) **Important!! Remove all 4 propellers from the motors for safety.**

(2) Tie down your MATRIX

(3) Turn on your transmitter radio.

(4) Connect battery to the MATRIX battery connector.

(5) Connect the provided Programming USB Cable from your PC computer's USB port (XP or WIN7 or WIN8) to the Micro USB port on the MATRIX communication port (on the LED side panel of the MATRIX). (If the computer does not recognize the USB, the USB driver is located in the provided 8GB USB flash drive)

(6) Double click on the NAZAInstaller.exe located in the provided 8GB USB flash drive and install the NAZA ASSISTANT SOFTWARE.

(7) Double click on the application file named NAZA ASSISTANT SOFTWARE. Wait for the program to start up.

(8) Click **MOUNTING** Use to input the distance between GPS and Main Flight Controller.

(9) Click **MOTOR MIXER**
MIXER TYPE: Please select **Quad-rotor X** and remember to click WRITE after you update any settings (WRITE is #7 on top of FIGURE 4.2)

(10) Click **TX CALI**

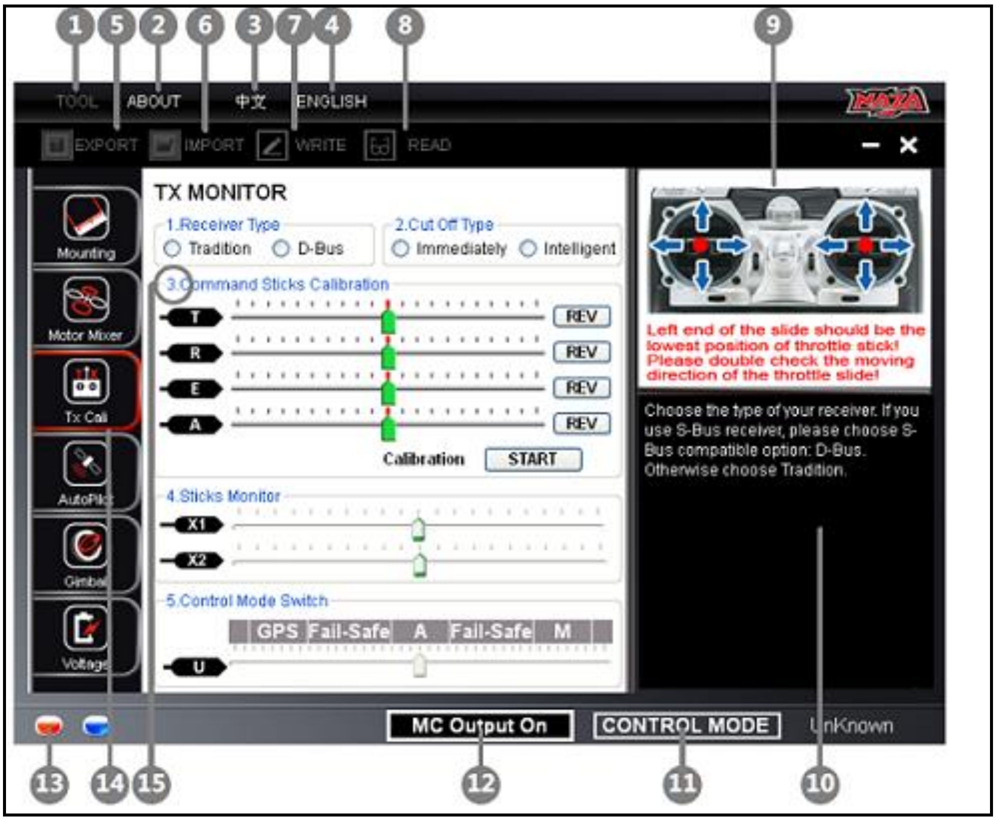


Figure 4.2-1 *NAZA Assistant Software Program Screenshot*

(11) RECEIVER TYPE: Please choose “**TRADITION**” for Walkera or Spektrum or Futaba receiver.

(12) CUT OFF TYPES: Default setting from WOW is “IMMEDIATELY”.

(13) COMMAND STICKS CALIBRATION: Click **START** to begin the calibration process. Please make sure to move both sticks to their end points. This means you are moving both sticks all the way up, down, left and right. (Note: If a transmitter stick is moved left or down, one of the on-screen sliders will move to the left. If a transmitter stick is moved right or up, one of the on-screen sliders will move to the right. If slider is moved at the opposite direction, click the NORM or REV to reverse the direction of the slider movement)

- Throttle/Yaw Stick controls "T" (Throttle): Stick down and "T" slides left (reduce elevation) & stick up and "T" slides right (increase elevation).

- Throttle/Yaw Stick controls "R" (Rudder): Stick left and "R" slides left (nose to the left) & stick right and "R" slides right (nose to the right).

- Directional Stick controls "E" (Elevator): Stick down and "E" slides left (tilts back) & stick up and "E" slides right (tilts forward)

- Directional Stick controls A (Aileron): Stick left and "A" slides left (roll left) & stick right and "A" slides right (roll right).

After Calibration, place all sticks at the center which will turn all sliders green. At this point click **FINISH** to end.

(14) STICKS MONITOR is not used at this time.

(15) CONTROL MODE SWITCH: (Please see Section 4.7 MATRIX Wiring Connection Chart)

Setting the GPS Attitude and Attitude and Manual Mode on the Flap Switch on Spektrum DX8 Transmitter

Setting the GPS, Attitude and Manual Mode on the Flap Switch on MATRIX:

(1) The NAZA Assistant screen should show a Control Mode Switch with GPS | Fail Safe | A | Fail Safe | M. (The "GPS" represent the GPS Mode, the "A" represent "Attitude Mode" and the "M" represent "Manual Mode".) You need a 3 position switch for the Control Mode Switch. For example: When using Spektrum DX8 and AR8000, the Control Mode Switch is assigned to the Flap switch on the transmitter. This is done by connecting the Receiver's AUX1 channel to the Flight Controller's "U" channel (See FIGURE 4.2). Hold down roller while turning on the Spektrum DX8→scroll down to "Switch Select"→scroll down to "Flap" press roller→change to "AUX 1" (If you cannot find Flap in the list, you will need to change the model type to "Airplane", in order for "Flap" to show up in the selection.

(2) Now you need to make sure when the Flap Switch is flipped forward (away from you) the switch will change the flight controller to "GPS Mode". If the Control Mode Switch (See FIGURE 4.2 bottom) slider is closer to "M" or "A",

then the Control Mode Switch slider is in the wrong position. To bring the slider closer to “GPS”. Turn on transmitter→Click on roller→scroll down to “Servo Setup”→scroll to “travel” and click on roller, which will have a flashing box→scroll to “Reverse”, click the roller to make the flashing box become solid →scroll down to “Throttle” and change to “AUX 1”→scroll down to the NOR and REV box→ click the roller to reverse the AUX 1 channel (which is now set to your Flap Switch setting). This change will bring the Control Mode Switch slider closer to “GPS”.

(3) How to set up fail safe for Spektrum transmitter, please following the instruction in the video link below https://www.dropbox.com/s/pw2nogpjubwaubj/3.%20Failsafe%20SPK.MP4

(4) Move your Flap Switch to the middle position to set the sub trim for the middle position first. If the “A” segment turns blue please skip to Step #6.

(5) If the “A” segment does not turn blue, Click on roller→scroll down to “Servo Setup”→scroll to “travel” and click on roller, which will have a flashing box→scroll to “subtrim”, click the roller to make the flashing box become solid →scroll down to “Throttle” and change to “AUX 1”→scroll down to the 0 and adjust the until “A” segment turns blue.

(6) Flip the Flap Switch forward (away from you). If the “GPS” segment turns blue then skip to Step #8.

(7) If the “GPS” segment does not turn blue, Click on roller→scroll down to “Servo Setup”→scroll to “travel” and click on roller, which will have a flashing box→ scroll down to “Throttle” and change to “AUX 1”→scroll down to the 100% and adjust the value until “GPS” segment turns blue.

(8) Flip the Flap Switch backward (towards you). If the “M” segment turns blue then skip to Section 4.2.11.

(9) If the “M” segment does not turn blue, Click on roller→scroll down to “Servo Setup”→scroll to “travel” and click on roller, which will have a flashing box→ scroll down to “Throttle” and change to “AUX 1”→scroll down to the 100% and adjust the value until “M” segment turns blue. Make sure to test the failsafe by turn off your transmitter and the slider should move to failsafe and turn blue and the throttle will go to midpoint on the screen.

AUTO PILOT

(1) BASIC PARAMETERS: Recommend setting for Pitch set to 130%, Roll set to 120%, Yaw set to 90% and Vertical set to 120% and ATTITUDE GAIN is Pitch set to 100% and Roll set to 100%. REMOTE ADJUST is set to INH.

Basic Gain and Attitude Gain should never set to lower than 100%, otherwise crash might result.

(2) ENHANCED FAILED-SAFE METHODS. (GPS module is required.) Recommended setting for enhanced failed-safe methods is to set it to GO-HOME and LANDING. (Please refer to DJI NAZA User Manual’s page 21 for enhanced failsafe methods.)

(3) INTELLIGENT ORIENTATION CONTROL (IOC): (GPS module is required.) Check the box next to “3. Intelligent Orientation Control”. If GPS is installed, the settings for Spektrum DX 8 and AR8000 as follows. Assign the intelligent orientation control to the F MODE Switch on the transmitter, connecting the Receiver’s Gear channel to the Flight Controller’s “X2” channel (See FIGURE 4.2). Hold the roller while turning on the Spektrum DX8→scroll down to “Switch Select”→scroll to “Gear” change to “Inh”→scroll to “F MODE” change to “Gear”.

(4) Now you need to make sure when the F MODE Switch is flipped forward (toward the ground) the switch will change the Intelligent Orientation Control to “Off”. If the slider is closer to “Course Lock” or “Home Lock”, then the Intelligent Orientation Control Switch slider is in the wrong position. To bring the slider closer to “Off”. Turn on transmitter→click on roller→scroll to “Servo Setup”→scroll to “Travel”, click on roller, which will have a flashing box→ scroll down to “Reverse”→scroll down to “Throttle” and change to “Gear”→scroll down to NOR & REV to reverse your Channel Gear setting to “REV” (which is now set to your F MODE Switch setting). This change will bring the Intelligent Orientation Control Switch slider closer to “Off”.

(5) Move your F MODE Switch to the middle position to set the midpoints for the middle position first. If the “Course Lock” segment turns blue please skip to Step #4.

(6) If the “Course Lock” segment does not turn blue, click on roller→scroll to “Servo Setup”→scroll to “Travel” and change to “subtrim”→scroll down to “Throttle” and change it to “Gear”→scroll down to “0”→adjust the value until “Course Lock” segment turns blue.

(7) Flip the F MODE Switch forward (toward the ground). If the “Off” segment turns blue then skip to Step #6.

(8) If the “Off” segment does not turn blue, click on roller→scroll to “Servo Setup”→scroll to “Travel”→scroll down to “Throttle” and change it to “Gear”→scroll down and adjust the value until “Off” segment turns blue.

(9) Flip the F MODE Switch backward (towards the sky). If the “Home Lock” segment turns blue.

(10) If the "Home Lock" segment does not turn blue, click on roller→scroll to "Servo Setup"→scroll to "Travel"→scroll down to "Throttle" and change it to "Gear"→scroll down and adjust the value until "Home Lock" segment turns blue.

Home Lock only activates while MATRIX is about 30 feet (10 meters) away from the home position (Takeoff Position). To change the Home Lock position during flight, please refer to the DJI User Manual for detailed descriptions and functions of HOME LOCK and COURSE LOCK.

4.3 Transmitter & Receiver Compatibility Table (For ARF Only)

The MATRIX prefers a 2.4GHz system, but also supports 35MHz, 40MHz, and 72MHz.

No.	Brand	Transmitter	Receiver
1	Walkera	DEVENTION 10	RX1002
2	Spektrum	DX8	AR8000
3	JR	DSX7	RD721
4	JR	9XII	
5	WFLY	FT06-C	FRP06
6	Futaba	14SG	R7008SB
7	Futaba	6EX	R146iP
8	Futaba	10C	
9	Sanwa	RD8000	92777
10	Hi-TEC	Eclipse7	FRP06

4.4 Receiver, Flight Controller & Auto-stabilization Setup

FIGURE 4.4

(1) Connect Channel #T wire from the flight controller to the THROTTLE channel of the receiver. Watch for polarity.

(2) Connect Channel #E wire from the flight controller to the ELEV channel of the receiver.

(3) Connect Channel #A wire from the flight controller to the AILE channel of the receiver.

(4) Connect Channel #R wire from the flight controller to the RUDDER channel of the receiver.

(5) Connect Channel #U wire from the flight controller to the AUX 1 channel of the receiver.

(6) Connect Gyrox Brushless gimbal tilt control cable to the AUX 3 channel of the receiver.

(7) Connect Channel #X2 wire from the flight controller to the GEAR channel of the receiver.

(8) Connect Channel #X3 wire from the flight controller to the LED Versatile Unit (PMU).

Setting up MATRIX to ensure a smooth flight with GPS or Attitude mode

To ensure the smooth flight of your Turbo Ace MATRIX, please make sure that you setup and fly the MATRIX in GPS or Attitude mode. In order for GPS or Attitude mode to function, first it is important to make sure the flap switch on your radio is all the way forward. Please refer to Section 4.2 Transmitter Calibration. If you own a Spektrum radio such as the DX8, you will need to reverse the gear channel in your radio so that when you flip the gear switch forward, it enables GPS or Attitude Mode. If you are experiencing difficulties in handling the aircraft, it may be because it is not in GPS or Attitude Mode.

You may skip the following setup instructions if you have purchased the Turbo Ace MATRIX with a transmitter radio, as we have already completed all the setup for you. If you have purchased a MATRIX without a radio, please see the following to make sure your radio is setup correctly.

Setting up and checking Turbo Ace MATRIX flight mode for GPS or Attitude Mode.

Plug in a 3 pin cable connector to the "INPUT" channel U of the NAZA flight controller. Connect the other end of the cable to the AUX 1 output on your receiver with the brown wire closest to the edge of the receiver casing (If you have a receiver other than a Walkera, Devention or Spektrum, please check your receiver manual for polarity).

MATRIX with GPS module (Assign AUX 1 to 3 position toggle switch, WOW default Flap switch for Spektrum DX 8):
Hold down roller while turning on the Spektrum DX8→scroll down to “Switch Select”→scroll down to “Flap” press roller→change to “AUX 1” (If you cannot find Flap in the list, you will need to change the model type to “Airplane”, in order for “Flap” to show up in the selection. This means that every time the **Flap** switch is flipped forward on your radio, it will toggle the AUX 1 output of the receiver and tell the controller to perform GPS Mode. For Spektrum radio, you will need to change from normal to reverse on the AUX 1 channel in your radio so that when you flip the Flap switch forward on the radio, you are activating the GPS mode. The reason to setup the radio this way is to ensure everything is in the correct default mode when all the switches on your radio are all the way forward (away from you). You can use the

NAZA Assistant Software to double check the Flap switch operation after you have completed the above setup.

Turn on your transmitter radio (Warning: Always tie down the MATRIX and remove all propellers when you perform any setting changes to the transmitter or NAZA Assistant Software. Failure to do so may cause serious issues, as the MATRIX motor may start up if an incorrect value is entered). Connect the provided Programming USB-to-Micro USB cable from your PC computer's USB port (XP or WIN7) to Micro USB port on the MATRIX communication port (on the LED side panel of the MATRIX). Please connect this cable after the transmitter is bound to the receiver.

Double click on the NaZaInstaller.exe located in the provided 8GB USB flash drive to install the NAZA ASSISTANT SOFTWARE

After completion of the installation of the NAZA ASSISTANT SOFTWARE, double click on the application file named NAZA ASSISTANT SOFTWARE. Wait for the program to start up.

Select the TX Calibration tab at the left column of the screen.

MATRIX with GPS
You will see the 5 mode tabs: GPS, Fail Safe, A, Fail Safe, M. When you flip the Flap switch on your radio, you will see the selection flipping between GPS and A and M. When the Flap switch is flipped forward, you will see GPS is selected which enables GPS Mode. The GPS Mode is the mode you should be using to fly your MATRIX. M mode has no stabilization and will make it very difficult to operate the aircraft.
IMPORTANT: Make sure that the Flap switch on your radio is in the forward/middle position before taking off and during the entire flight. (Please refer to section 4.2 Transmitter Calibration if GPS and A and M mode do not turn blue on the screen when you flip the Flap switch).

4.5 Transmitter Settings (For ARF Only)

(1) Aircraft Mode: Fixed-wing airplane mode. **Do not use helicopter mode**
(2) Rudder: 0% to 100% with No Mixing
(3) Curve: Channel 1, 2, 3 & 4 all set to zero
(4) Gyro: Fine tune to maximize stability

(5) Move both throttle stick and throttle trim by looking at the LCD screen to the middle position- Very important, otherwise motors will not start

(6) Use transmitter rudder trim to adjust heading (yaw) (will require recalibration if rudder is adjusted via trim and or subtrim is used)

(7) For added stability on the MATRIX, you may choose to set the dual rate to 55%

Please double check all settings, tie down the MATRIX to a bench, and test fly it to check the settings. Some transmitters use random bind, which means you have to plug in the battery to the MATRIX within 2-3 seconds after the radio is turned on. Please observe the LED light located at the back of the MATRIX cover (Please refer to Section 5.3 LED light description). Most receivers flash before binding and remain solid after binding, so please make sure your receiver has been properly bound to your transmitter. Do not launch the MATRIX on its maiden flight until all operations are confirmed as normal, especially after shipping. Tie it down to a bench for a preflight check. Failure to do so may cause serious damage to the MATRIX and/or people around it. Factories and dealers will not be liable for any damages from the operation of this aircraft.

4.6 Transmitter Flight Control & Gain Adjustments (For ARF Only)

We do not recommend any inexperienced users to adjust the flight control or Gain values using the DJI NAZA Assistant software. It is a steep learning curve for these adjustments, which we have already fine-tuned and completed for you. Improper settings may cause the MATRIX to lose control and may result in serious damage. If the original factory settings are altered in any way, with the exception of transmitter calibration adjustments for ARF packages, it will automatically void the 24-hour “No Dead on Arrival” guarantee. Dead on arrival returns are strictly checked for setting changes and tampering. Although it can be mastered over time, the MATRIX flight controller adjustments are quite sophisticated and complicated. Do not attempt to change these settings until you are familiar with the setup. Please go to online forums to learn about the flight control settings, as we do not provide any technical support for these settings.

When you have purchased the ready to fly unit, there are 3 control modes which we have setup on your flight controller and transmitter, GPS and ATTITUDE and MANUAL. GPS Mode has the best auto stabilization and ability to perform GPS Lock, making the aircraft very easy to fly, which is more appropriate for videographic and photographic applications. Attitude Mode has some auto stabilization and ability to perform attitude hold and makes the aircraft easier to fly, which is also suitable for videographic and photographic applications. Manual Mode is suited for experienced pilots to gain more manual control in adverse. Do not switch to the MANUAL mode if you are a beginner.

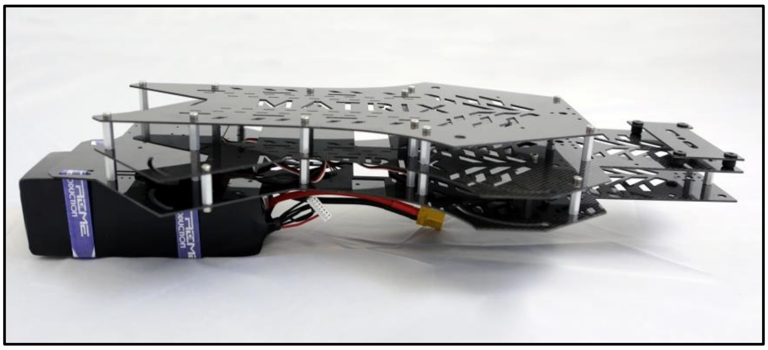
MATRIX with GPS: The three modes can be switched during flight by toggling the Flap switch on top of your radio. In the ready to fly MATRIX, we have set this switch on your radio to GPS MODE when it is toggle forward and ATTITUDE MODE when it is toggled middle and MANUAL MODE when it is toggled backward. Before takeoff, please make sure all the front panel switches on your transmitter are flipped forward and all switches such as the flight mode/hold switches on the side panel are pushed down.

The basic gain and attitude gain values of the MATRIX can be adjusted in the AUTOPILOT section when you run the DJI NAZA ASSISTANT SOFTWARE. The default setting for BASIC GAIN is Pitch set to 130%, Roll set to 120%, Yaw set to 90% and Vertical set to 120% and ATTITUDE GAIN is Pitch set to 100% and Roll set to 100% (**Warning**: BASIC GAIN should never be set lower than 90%). Again, it is very important to remember to tie down the aircraft and remove all the propellers when you are programming the fight controller with the supplied Programming USB-MicroUSB cable. Failure to do so may cause accidental motor start up with incorrect values entered and may result in serious injury. Always remember to tie down the MATRIX to a bench for test flights after you have changed any settings. (If the motor does not spin while perform the CSC, please re-calibrate/perform the Command Sticks Calibration).

4.7 MATRIX Wiring Connection Chart for Spektrum DX 8 & AR8000

MATRIX with GPS module		DX 8 & AR8000						INDICATES ONLY ONE CAN BE ACTIVATED
AR8000		NAZA FC		TX Setting Output		Gimbal Servo		MATRIX
ELEV		E						
AILE		A						
THRO		T						
RUDD		R						
AUX1		U		AUX 1→Flap SW				GPS - ATTITUDE MODE - MANUAL
AUX3				AUX3				TILT CONTROL FOR GIMBAL
Gear		X2		Gear→F. Mod				OFF - COURSE LOCK - HOME LOCK
BATT								TELEMETRY (OPTIONAL)

ELECTRONICS SETUP & ADJUSTMENT for Futaba 14SG Transmitter



If you have purchased an RTF package, please skip Section 4.1 through 4.5 because all settings are already complete and your MATRIX and transmitter have been paired and test flown as a set. Unless you are familiar with the settings, any changes might override the factory's setting and disable the aircraft, affecting its performance and flight reliability.

If you have purchased an ARF package, you must complete Section 4.1 ESC Programming and Section 4.2 Transmitter Calibration. MATRIX ESCs needs to reprogram independently. Also, in order for a flight controller to work properly, your specific transmitter has to be calibrated to work with each new MATRIX. Crashes will be imminent if you skip these one-time procedures to match a MATRIX with a transmitter.

4.1 ESC Programming for Futaba 14SG Transmitter (A Must Setup For ARF)

Video Instruction:
How to calibrate the ESC for MATRIX:
https://www.dropbox.com/s/z09ojui7ptd4rxr/1.%20Futaba%20Esc%20Programing.MP4

Please skip this ESC programming step if you have purchased RTF unit, since all the ESCs have been re-programmed. Please follow the steps below very carefully, as they will only take a few minutes.

(1) Very important: Remove all 4 propellers from the motors for safety.
(2) Double check to make sure all ESC connectors are marked/labeled (#1 through #4 matching the connectors on the flight controller #1 through #4) so that you will be able to keep track of the corresponding connectors when you need to put them back later.
(3) Disconnect all 4 ESC connectors from the NAZA flight controller so they may not interfere with each other's programming.
(4) Move the throttle stick all the way down. Now turn on the transmitter.
(5) Disconnect X3 on NAZA flight controller and plug into port 8 on the receiver.
(6) Turn on Futaba radio→double tap "LNK"→go to "Reverse"→go to THR and set it to "REV"
(7) Insert one of the labeled ESC connectors into the receiver's throttle channel (wow default port 3) port while watching for the correct polarity. Black/dark brown wires are usually on the edge of the receiver. Please verify polarity in your receiver manual if you are not using the stock receiver.
(8) Move the throttle stick all the way up.
(9) Within 3 seconds, connect the battery to the MATRIX's battery plug (The MATRIX battery plug is still connected to all 4 ESCs but only one ESC should be connected to the receiver at a time.)
(10) When the ESC makes 1 beeping sounds, immediately move the throttle stick all the way down. The ESC will then make 2 beeping. (If you did not hear the 1 beeping sounds when entering programming mode or you did not hear 2 beeping after the ESC have completed its programming then you need to move throttle all the way down and disconnect the battery from the MATRIX battery plug and repeat from step #7 to #10 for the ESC.) If you did not experience any problems, then you have completed programming on this ESC which now retains the high and low end point data in its memory. Disconnect the battery from the MATRIX's battery connector then disconnect the ESC connector from the receiver.
(11) Repeat this process for each ESC from Step#7 through Step#10. Please make sure you have programmed all 4 ESCs by starting from the #1 labeled ESC and finishing with #4 labeled ESC. Your transmitter power should remain in the power on position throughout the entire process of programming all 4 ESCs.
(12) After you have successfully re-programmed all 4 ESCs, unplug the battery from the MATRIX battery plug

(13) Now reverse the throttle back to normal on Futaba radio→double tap "LNK"→go to "Reverse"→go to THR and set it to "NORM"

(14) Insert the 4 ESC connectors, labeled #1 through #4 back to corresponding M1 through M4 ports on your NAZA flight controller. The black/dark brown wire (-) for each of the ESC connectors are closest to the red NAZA label of the flight controller.

4.2 Transmitter Calibration for Futaba 14SG Transmitter (A Must Setup For ARF)

Video Instruction:

1. How to connect Futaba RX and setup Futaba TX for Matrix:
   https://www.dropbox.com/s/vztqrvhplxq3h80/2.%20Futaba%20RX%20Setup.MP4
2. How to set up fail safe for Futaba transmitter for Matrix:
   https://www.dropbox.com/s/63n1ylwy4lnvl7y/6.%20Futaba%20Control%20Mode%20Failsafe.MP4
3. How to set up Futaba transmitter calibration for Matrix:
   https://www.dropbox.com/s/wws2w6pyba91ra9/5.%20Futaba%20TX%20Callibration.MP4
4. How to set up the gain setting for Matrix:
   (Default setting is not recommended for carry heavy equipment)
   https://www.dropbox.com/s/2pkkn3ipc73tbwy/7.%20Gain%20Setup.MP4
5. How to set up advanced setting for Matrix:
   https://www.dropbox.com/s/76vv670q6jb99lu/8.%20Advanced%20Setup.MP4
6. How to set up the voltage setting for Matrix:
   https://www.dropbox.com/s/clsrg9ixxp8b2xn/9.%20Voltage%20Setup.MP4

If you have purchased your MATRIX with a transmitter (RTF package) please skip this section because we have already completed calibration. If you are using a transmitter that has never been paired with your new MATRIX, you will need to calibrate your transmitter to the MATRIX flight controller using the following procedure. Any change to the quadcopter or setting change to the transmitter might require transmitter calibration.

(1) **Very important!! Remove all 4 propellers from the motors for safety.**

(2) Tie down your MATRIX

(3) Turn on your transmitter radio.

(4) Connect battery to the MATRIX battery connector.

(5) Connect the provided Programming USB Cable from your PC computer's USB port (XP or WIN7 or WIN8) to the Micro USB port on the MATRIX communication port (on the LED side panel of the MATRIX). (If the computer does not recognize the USB, the USB driver is located in the provided 8GB USB flash drive)

(6) Double click on the NAZAInstaller.exe located in the provided 8GB USB flash drive and install the NAZA ASSISTANT SOFTWARE.

(7) Double click on the application file named NAZA ASSISTANT SOFTWARE. Wait for the program to start up.

(8) Click **MOUNTING** Use to input the distance between GPS and Main Flight Controller.

(9) Click **MOTOR MIXER**
MIXER TYPE: Please select **Quad-rotor X** and remember to click WRITE after you update any settings (WRITE is #7 on top of FIGURE 4.2)

(10) Click **TX CALI**

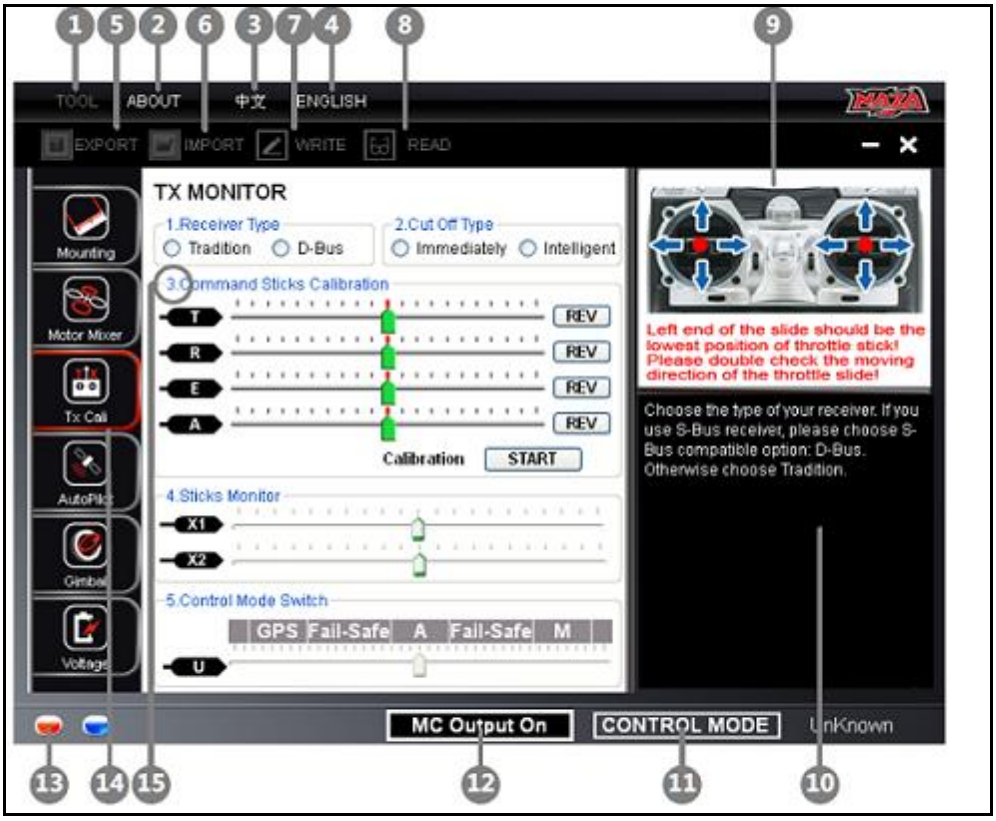


Figure 4.2-1 *NAZA Assistant Software Program Screenshot*

(11) RECEIVER TYPE: Please choose "**TRADITION**" for Walkera or Spektrum or Futaba receiver.

(12) CUT OFF TYPES: Default setting from WOW is "IMMEDIATELY".

(13) COMMAND STICKS CALIBRATION: Click **START** to begin the calibration process. Please make sure to move both sticks to their end points. This means you are moving both sticks all the way up, down, left and right. (Note: If a transmitter stick is moved left or down, one of the on-screen sliders will move to the left. If a transmitter stick is moved right or up, one of the on-screen sliders will move to the right. If slider is moved at the opposite direction, click the NORM or REV to reverse the direction of the slider movement)

- Throttle/Yaw Stick controls "T" (Throttle): Stick down and "T" slides left (reduce power) & stick up and "T" slides right (increase power).

- Throttle/Yaw Stick controls "R" (Rudder): Stick left and "R" slides left (nose to the left) & stick right and "R" slides right (nose to the right).

- Directional Stick controls "E" (Elevator): Stick down and "E" slides left (tilts leans back) & stick up and "E" slides right (tilts forward)

- Directional Stick controls A (Aileron): Stick left and "A" slides left (leans left) & stick right and "A" slides right (leans right).

After Calibration, place all sticks at the center which will turn all sliders green. At this point click **FINISH** to end.

(14) STICKS MONITOR is not used at this time.

(15) CONTROL MODE SWITCH: (Please see Section 4.7 MATRIX Wiring Connection Chart)
Setting the GPS Attitude and Attitude and Manual Mode on the SB Switch on Futaba 14SG Transmitter:

Setting the GPS, Attitude and Manual Mode on the Mix Switch on MATRIX:

(1) The NAZA Assistant screen should show a Control Mode Switch with GPS | Fail Safe | A | Fail Safe | M. (The "GPS" represent the GPS Mode, the "A" represent "Attitude Mode" and the "M" represent "Manual Mode".) You need a 3 position switch for the Control Mode Switch. For example: When using Futaba 14SG and R7008SB, the Control Mode Switch is assigned to the SB switch on the transmitter. This is done by connecting the Receiver's 5 channel to the Flight Controller's "U" channel (See FIGURE 4.2). Turn on the Futaba

14SG, double tap “LNK”→scroll down to “Function” press “RTN”→scroll down to channel 5→Change CTRL to “SB”.

(2) Now you need to make sure when the SB Switch is flipped forward (away from you) the switch will change the flight controller to “GPS Mode”. If the Control Mode Switch (See FIGURE 4.2 bottom) slider is closer to “M” or “A”, then the Control Mode Switch slider is in the wrong position. To bring the slider closer to “GPS”, double tap “LNK”→scroll down to “REVERSE” →scroll down to Channel 5→tap “RTN” and reverse your Channel 5 setting to “REV” (which is now set to your SB Switch setting). This change will bring the Control Mode Switch slider closer to “GPS”.

(3) Transmitter can be turn on and off to bind and re-bind, which will make fail safe testing easier. To setup Fail-Safe, double tap “LNK”→scroll down to “END POINT”→scroll down to Channel 5→adjust travel value until the failsafe turn blue→double tap “LNK”→scroll down to “FAIL SAFE”→scroll down to Channel 5→scroll to F/S and change to “F/S”→scroll to “POS” and hold “RTN” for 1 sec, it will set the value for failsafe itself.

(4) Move your SB Switch to the middle position to set the sub trim for the middle position first. If the “A” segment turns blue please skip to Step #6.

(5) If the “A” segment does not turn blue, double tap “LNK”→scroll down to “SUB-TRIM”→scroll down to Channel 5→change the value until “A” segment turns blue.

(6) Flip the SB Switch forward (away from you). If the “GPS” segment turns blue then skip to Step #8.

(7) If the “GPS” segment does not turn blue, double tap “LNK”→scroll down to “ENDPOINT”→scroll down to Channel 5→find the travel value and tap “RTN”→value will flash and you can change the value until “GPS” segment turns blue.

(8) Flip the SB Switch backward (towards you). If the “M” segment turns blue then skip to Section 4.2.11.

(9) If the “M” segment does not turn blue, double tap “LNK”→scroll down to “ENDPOINT”→scroll down to Channel 5→ find the travel value and tap “RTN”→value will flash and you can change the value until “M” segment turns blue. Make sure to test the failsafe by turn off your transmitter and the slider should move to failsafe and turn blue.

AUTO PILOT

(1) BASIC PARAMETERS: Recommend setting for Pitch set to 130%, Roll set to 120%, Yaw set to 90% and Vertical set to 120% and ATTITUDE GAIN is Pitch set to 100% and Roll set to 100%. REMOTE ADJUST is set to INH. Basic Gain and Attitude Gain should never set to lower than 100%, otherwise crash might result.

(2) ENHANCED FAILED-SAFE METHODS. (GPS module is required.) Recommended setting for enhanced failed-safe methods is to set it to GO-HOME and LANDING. (Please refer to DJI NAZA User Manual's page 21 for enhanced failed-safe methods.)

(3) INTELLIGENT ORIENTATION CONTROL (IOC): (GPS module is required.) Check the box next to "3. Intelligent Orientation Control". If GPS is installed, the settings for Futaba 14SG and R7008SB are as follows. Assign the intelligent orientation control to the SE Switch on the transmitter, connecting the Receiver's 6 channel to the Flight Controller's "X2" channel (See FIGURE 4.2). Turn on the Futaba 14SG, double tap "LNK"→scroll down to "Function" press "RTN"→scroll down to channel 6→Change CTRL to "SE".

(4) Now you need to make sure when the SE Switch is flipped forward (toward the ground) the switch will change the Intelligent Orientation Control to "Off". If the slider is closer to "Course Lock" or "Home Lock", then the Intelligent Orientation Control Switch slider is in the wrong position. To bring the slider closer to "Off",
double tap "LNK"→scroll down to "REVERSE" →scroll down to Channel 6→tap "RTN" and reverse your Channel 6 setting to "REV" (which is now set to your SE Switch setting). This change will bring the Intelligent Orientation Control Switch slider closer to "Off".

(5) Move your SE Switch to the middle position to set the midpoints for the middle position first. If the "Course Lock" segment turns blue please skip to Step #4.

(6) If the "Course Lock" segment does not turn blue, double tap "LNK"→scroll down to "SUB TRIM"→scroll down to Channel 6→adjust the value until "Course Lock" segment turns blue.

(7) Flip the SE Switch forward (toward the ground). If the "Off" segment turns blue then skip to Step #6.

(8) If the "Off" segment does not turn blue, double tap "LNK"→scroll down to "END Point"→scroll down to Channel 6→find the travel value and tap "RTN"→adjust the value until "Off" segment turns blue.

(9) Flip the SE Switch backward (towards the sky). If the "Home Lock" segment turns blue.

(10) If the "Home Lock" segment does not turn blue, double tap "LNK"→scroll down to "END Point"→scroll down to Channel 6→find the travel value and tap "RTN"→adjust the value until "Home Lock" segment turns blue.

Home Lock only activates while MATRIX is about 30 feet (10 meters) away from the home position (Takeoff Position). To change the Home Lock position during flight, please refer to the DJI User Manual for detailed descriptions and functions of HOME LOCK and COURSE LOCK.

4.3 Transmitter & Receiver Compatibility Table (For ARF Only)

The MATRIX prefers a 2.4GHz system, but also supports 35MHz, 40MHz, and 72MHz.

No.	Brand	Transmitter	Receiver
1	Walkera	DEVENTION 10	RX1002
2	Spektrum	DX8	AR8000
3	JR	DSX7	RD721
4	JR	9XII	
5	WFLY	FT06-C	FRP06
6	Futaba	14SG	R7008SB
7	Futaba	6EX	R146iP
8	Futaba	10C	
9	Sanwa	RD8000	92777
10	Hi-TEC	Eclipse7	FRP06

4.4 Receiver, Flight Controller & Auto-stabilization Setup

FIGURE 4.4

(1) Connect Channel #A wire from the flight controller to the channel 1 of the receiver.

(2) Connect Channel #E wire from the flight controller to the channel 2 of the receiver.

(3) Connect Channel #T wire from the flight controller to the channel 3 of the receiver. Watch for polarity.

(4) Connect Channel #R wire from the flight controller to the channel 4 of the receiver.

(5) Connect Channel #U wire from the flight controller to the channel 5 of the receiver.

(6) Connect Channel #X2 wire from the flight controller to the channel 6 of the receiver.

(7) Connect Gyrox Brushless gimbal tilt control cable to the channel 7 of the receiver.

(8) Connect Channel #X3 wire from the flight controller to the LED Versatile Unit (PMU).

Setting up MATRIX to ensure a smooth flight with GPS or Attitude mode

To ensure the smooth flight of your Turbo Ace MATRIX, please make sure that you setup and fly the MATRIX in GPS or Attitude mode. In order for GPS or Attitude mode to function, first it is important to make sure the mix switch on your radio is all the way forward. Please refer to Section 4.2 Transmitter Calibration. If you are experiencing difficulties in handling the aircraft, it may be because it is not in GPS or Attitude Mode.

You may skip the following setup instructions if you have purchased the Turbo Ace MATRIX with a transmitter radio, as we have already completed all the setup for you. If you have purchased a MATRIX without a radio, please see the following to make sure your radio is setup correctly.

Setting up and checking Turbo Ace MATRIX flight mode for GPS or Attitude Mode.

Plug in a 3 pin cable connector to the "INPUT" channel U of the NAZA flight controller. Connect the other end of the cable to the Channel 5 output on your receiver with the brown wire closest to the edge of the receiver casing (If you have a receiver other than a Walkera, Devention or Spektrum, please check your receiver manual for polarity).

MATRIX with GPS module (Assign Channel 5 to 3 position toggle switch, WOW default SB switch for Futaba 14SG):
Turn on the Futaba 14SG, double tap “LNK”→scroll down to “Function” press “RTN”→scroll down to channel 5→Change CTRL to “SB”. This means that every time the **SB** switch is flipped forward on your radio, it will toggle the Channel 5 output of the receiver and tell the controller to perform GPS Mode. For Futaba radio, you might need to change from normal to reverse on the AUX 1 channel in your radio so that when you flip the SB switch forward on the radio, you are activating the GPS mode. The reason to setup the radio this way is to ensure everything is in the correct default mode when all the switches on your radio are all the way forward (away from you). You can use the NAZA Assistant Software to double check the SB switch operation after you have completed the above setup.

Turn on your transmitter radio (Warning: Always tie down the MATRIX and remove all propellers when you perform any setting changes to the transmitter or NAZA Assistant Software. Failure to do so may cause serious issues, as the MATRIX motor may start up if an incorrect value is entered). Connect the provided Programming USB-to-Micro USB cable from your PC computer’s USB port (XP or WIN7) to Micro USB port on the MATRIX communication port (on the LED side panel of the MATRIX). Please connect this cable after the transmitter is bound to the receiver.

Double click on the NaZaInstaller.exe located in the provided 8GB USB flash drive to install the NAZA ASSISTANT SOFTWARE

After completion of the installation of the NAZA ASSISTANT SOFTWARE, double click on the application file named NAZA ASSISTANT SOFTWARE. Wait for the program to start up.

Select the TX Calibration tab at the left column of the screen.

MATRIX with GPS
You will see the 5 mode tabs: GPS, Fail Safe, A, Fail Safe, M. When you flip the SB switch on your radio, you will see the selection flipping between GPS and A and M. When the SB switch is flipped forward, you will see GPS is selected which enables GPS Mode. The GPS Mode is the mode you should be using to fly your MATRIX. M mode has no stabilization and will make it very difficult to operate the aircraft.
IMPORTANT: Make sure that the SB switch on your radio is in the forward/middle position before taking off and during the entire flight. (Please refer to section 4.2 Transmitter Calibration if GPS and A and M mode do not turn blue on the screen when you flip the Flap switch).

4.5 Transmitter Settings (For ARF Only)

(1) Aircraft Mode: Fixed-wing airplane mode. **Do not use helicopter mode**
(2) Rudder: 0% to 100% with No Mixing
(3) Curve: Channel 1, 2, 3 & 4 all set to zero
(4) Gyro: Fine tune to maximize stability
(5) Move both throttle stick and throttle trim by looking at the LCD screen to the middle position- Very important, otherwise motors will not start
(6) Use transmitter rudder trim to adjust heading (yaw)
(7) For added stability on the MATRIX, you may choose to set the dual rate to 55%

Please double check all settings, tie down the MATRIX to a bench, and test fly it to check the settings. Some transmitters use random bind, which means you have to plug in the battery to the MATRIX within 2-3 seconds after the radio is turned on. Please observe the LED light located at the back of the MATRIX cover (Please refer to Section 5.3 LED light description). Most receivers flash before binding and remain solid after binding, so please make sure your receiver has been properly bound to your transmitter. Do not launch the MATRIX on its maiden flight until all operations are confirmed as normal, especially after shipping. Tie it down to a bench for a preflight check. Failure to do so may cause serious damage to the MATRIX and/or people around it. Factories and dealers will not be liable for any damages from the operation of this aircraft.

4.6 Transmitter Flight Control & Gain Adjustments (For ARF Only)

We do not recommend any inexperienced users to adjust the flight control or Gain values using the DJI NAZA Assistant software. It is a steep learning curve for these adjustments, which we have already fine-tuned and completed for you. Improper settings may cause the MATRIX to lose control and may result in serious damage. If the original factory settings are altered in any way, with the exception of transmitter calibration adjustments for ARF packages, it will automatically void the 24-hour "No Dead on Arrival" guarantee. Dead on arrival returns are strictly checked for setting changes and tampering. Although it can be mastered over time, the MATRIX flight controller adjustments are quite sophisticated and complicated. Do not attempt to change these settings until you are familiar with the setup. Please go to online forums to learn about the flight control settings, as we do not provide any technical support for these settings.

When you have purchased the ready to fly unit, there are 3 control modes which we have setup on your flight controller and transmitter, GPS and ATTITUDE and MANUAL. GPS Mode has the best auto stabilization and ability to perform GPS Lock, making the aircraft very easy to fly, which is more appropriate for videographic and photographic applications. Attitude Mode has some auto stabilization and ability to perform attitude hold and makes the aircraft easier to fly, which is also suitable for videographic and photographic applications. Manual Mode is suited for experienced pilots to gain more manual control in adverse. Do not switch to the MANUAL mode if you are a beginner.

MATRIX with GPS: The three modes can be switched during flight by toggling the SB switch on top of your radio. In the ready to fly MATRIX, we have set this switch on your radio to GPS MODE when it is toggle forward and ATTITUDE MODE when it is toggled middle and MANUAL MODE when it is toggled backward. Before takeoff, please make sure all the front panel switches on your transmitter are flipped forward and all switches such as the flight mode/hold switches on the side panel are pushed down.

The basic gain and attitude gain values of the MATRIX can be adjusted in the AUTOPILOT section when you run the DJI NAZA ASSISTANT SOFTWARE. The default setting for BASIC GAIN is Pitch set to 130%, Roll set to 120%, Yaw set to 90% and Vertical set to 120% and ATTITUDE GAIN is Pitch set to 100% and Roll set to 100% (**Warning**: BASIC GAIN should never be set lower than 90%). Again, it is very important to remember to tie down the aircraft and remove all the propellers when you are programming the fight controller with the supplied Programming USB-MicroUSB cable. Failure to do so may cause accidental motor start up with incorrect values entered and may result in serious injury. Always remember to tie down the MATRIX to a bench for test flights after you have changed any settings. (If the motor does not spin while perform the CSC, please re-calibrate/perform the Command Sticks Calibration).

4.7 MATRIX Wiring Connection Chart for Futaba 14SG & R7008SB

MATRIX with GPS module	14SG & R7008SB			INDICATES ONLY ONE CAN BE ACTIVATED
R7008SB	NAZA FC	TX Setting Output	Gimbal Servo	MATRIX
1	A			
2	E			
3	T			
4	R			
5	U	SB		GPS - ATTITUDE MODE - MANUAL
6	X2	SE		OFF - COURSE LOCK - HOME LOCK
7		RD		TILT CONTROL FOR GIMBAL
BATT				TELEMETRY (OPTIONAL)

TESTING & OPERATIONS

5.1 Tie-Down Flight Test

(1) Tie down all four arms (not the skids) of the MATRIX to a heavy fixture such as a table or a work bench. Make sure there is plenty of space around the aircraft. If you have the random binding transmitter such as the Devention 10, please make sure there are no other similar radios in the vicinity during the binding process.

(2) Prior to initiating your MATRIX, make sure it is on a water level surface and do not move the MATRIX before takeoff or during the binding process. Failure to do so will result in miscalculating of the 3-Axis gyro compensation and the MATRIX will not be able to operate properly.

(3) Make sure your battery is fully charged using a battery meter (about 4.1V to 4.2V per cell on all 6 cells) Plug in the battery connector to the power input connector from the chassis. Do not run any LiPo battery to below 3.5V per cell or a total of 21.0V for the MATRIX 6 cells battery, otherwise the battery will be permanently damaged.

(4) After 2 seconds of initialization, the MATRIX will issue 5 consecutive “beep” tones.

(5) Place your transmitter flat on a table in front of you with the joystick facing up. Make sure all switches above the two control sticks on the transmitter are pushed forward and away from you and the two switches at the very top of the transmitter side panel is pushed down towards the table. Move the throttle stick (left stick) to the lowest position towards you. At this time, you do not need to move the directional stick (right stick), which is spring loaded and will always return to the middle position when released). Now you can turn your transmitter “ON”.

(6) Wait another six seconds for 5 consecutive “beep” tones from the MATRIX, which indicate that binding between the receiver and the transmitter is complete. Before moving any controls on the transmitter, it’s always good practice to find the solid LED light on the receiver & telemetry module to confirm that binding has been completed.

(7) Stay at a safe distance and execute the combination stick command (CSC) to start motors.

(8) Make sure Motor #1 and Motor #3 propellers are rotating in a CCW (counter clock wise) direction and Motor #2 and Motor #4 propellers are rotating in a CW (clockwise direction). As you increase the throttle, the propellers should speed up and vice versa.

(9) Moving the rudder stick (which also controls the throttle) to the right should decelerate CCW propellers (Motor #1 & Motor #3), thereby decreasing CW torque so the aircraft turns CCW. Moving the rudder to the left should decelerate CW propellers (Motor #2 & Motor #4), thereby decreasing CCW torque so the aircraft turns CW.

(10) Moving the directional stick to the top should decelerate the two front propellers (Motor #1 & Motor #2) and moving the directional stick to the bottom should decelerate the back propellers (Motor #3 & Motor #4). Moving the directional stick to the left should decelerate the left propellers (Motor #2 & Motor #3), and moving the directional stick to the right should decelerate the right propellers (Motor #1 & Motor #4).

(11) Move the throttle stick to lowest position and the propeller should come to a stop. Unplug the battery from the copter then turn the transmitter off.

(12) Repeat above Steps #2-11 twice more so that you complete 3 rounds of 8 to 10 minutes of tie-down flight.

5.2 Actual Flight Test & Training

(1) Pick a calm day or find a large empty indoor space. Keep all people and pets away from the flight test area and place the MATRIX on a level surface.

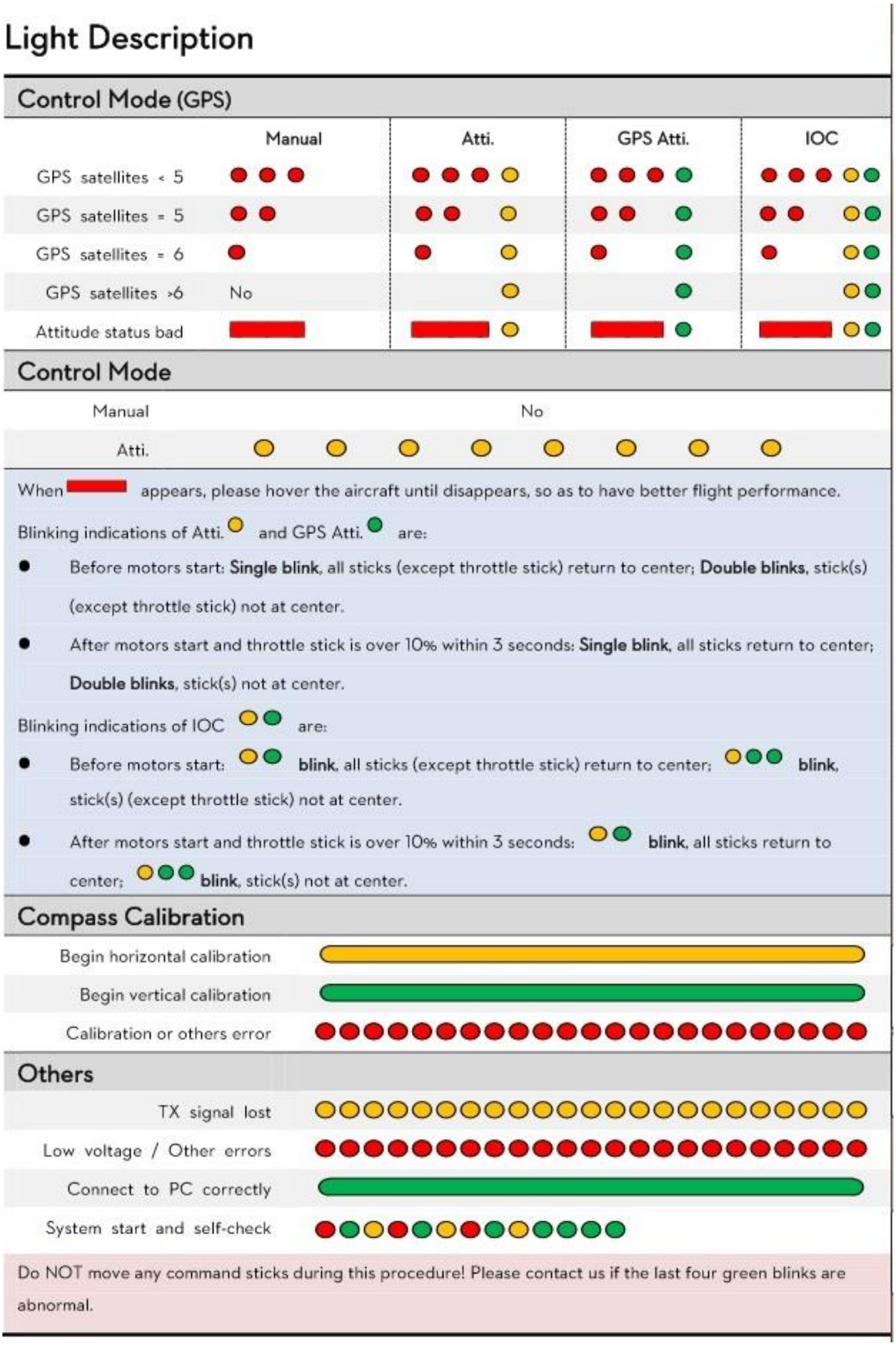
(2) Repeat Steps #2-11 under 5.1

(3) If you fly the MATRIX too close to the ground, the wash (deflected air) coming back up from the ground may cause significant flight instability. As with all propeller driven systems, you should try to keep larger aircraft at least 3 to 4 feet from the ground and avoid flying in a small room, which deflects air current. Before takeoff, you may also notice some vibration of the aircraft caused by auto stabilization from the deflected air. Once the aircraft lifts away from the ground, it will stabilize.

(4) If you are a beginner pilot, we highly recommend that you purchase a simulator training package or a trainer unit to practice. Though the MATRIX is equipped with easy to fly auto stabilization for safety, do not attempt to operate the aircraft without any flight experience. Always try to maintain the tail-in position (tail towards you) because that is the easiest orientation to keep your aircraft in control.

(5) As your skills improve, additional training includes flying in circles, figure 8s, backwards, sideways and other exercises to improve coordination.

5.3 LED Light Description for NAZA-Lite



5.4 LED Light Description for NAZA-V2

LED Description

System Status	LED Flashing
System start and self-check	
IMU abnormal data or need advanced calibration*	
Warm up after power on	
The aircraft is moved or bias of sensors too big	
Compass error too big, need recalibration.	
Transmitter (TX) signal lost, enter the FailSafe.	
TX stick(s) mid point error too big	
Low voltage alert or other abnormal alert* (e.g. Configuration error, TX data error, Enable low voltage protection without PMU, SN error or Compass abnormal work.)	
Record forward direction or home point	
Control Mode Indictor	Manual Mode: None ATTI. Mode: (stick(s) not at center) GPS Mode: (stick(s) not at center) IOC Mode: (stick(s) not at center)
GPS Signal State Indicator (GPS/Compass Module is necessary)	GPS Signal is Best(GPS Satellite number > 6): None GPS Signal is Well(GPS Satellite number = 6): GPS Signal is Bad (GPS Satellite number = 5) : GPS Signal is Worst (GPS Satellite number < 5):

Compass Calibration	LED Flashing
Begin horizontal calibration	
Begin vertical calibration	
Calibration or others error	

5.5 Battery Tips

(1) Set the alarm on your transmitter radio to a safe range. Trying to extend the flight time when the battery is low will only put your aircraft at risk. Always check your battery before each flight.

(2) Unlike other rechargeable batteries, LiPo batteries can easily be damaged if you drain them below 3.5V per cell (6 Cells x 3.5V = 21.0V). Do not force your battery to continue running when it’s low. Doing so will only permanently damage your battery.

(3) Disconnect the battery plug from the MATRIX when you are done flying. Do not leave your battery plugged into the MATRIX after a flight.

(4) An inexpensive battery meter with an alarm would be a smart tool to have. Always check each battery's charge before each flight. A fully charged battery should be around 4.1V to 4.2V per cell (Multiply that by 6 for a 6 cells battery).

(5) A transmitter battery is a lot more reliable and convenient than 8 "AA" batteries for your transmitter. With a larger capacity, longer lifespan and the desired voltage, the transmitter battery is also rechargeable using the same battery charger as the helicopter battery.

5.6 Flight Time

Voltage warning settings for your MATRIX have been programmed conservatively to protect your batteries. To obtain longer flight times, on-board voltage must be observed during flight by using the telemetry function in your radio. Monitoring your batteries for maximum drain will greatly improve flight time but it requires knowledge of Li-Po battery power management. The rule of thumb is that the total operating voltage on the MATRIX cannot be drained to less than 21.0v total (3.5V per cell) during flight. After you have landed the MATRIX, the voltage reading will increase since no load is applied. The total no load voltage shall not be drained to less than 22.02v total (3.67V per cell) otherwise the battery may get damaged. Over drained batteries are not returnable, so caution must be used while operating Li-Po powered aircraft. Default setting for the NAZA Voltage Monitor:

1. Protection Switch→ON

2. Battery→ Battery Type: 6S LiPo

3. First Level Protection→ No Load is set to 22.8V, Loss is set to 0.6V and Loaded is set to 22.2V

4. Second Level Protection→ No Load is set to 19.2V, Loss is set to 0.6V and Loaded is set to 18.6V

CAMERA MOUNT SETUP

6.1 Gyrox Brushless Gimbal Setup

First, balance the gimbal and battery on the quad by adjusting the battery position. Battery should rest on the same plate as the gimbal mount (shock plate/battery mounting plate). Equilibrium can be tested by holding the quad on both sides with two fingers underneath the chassis hub cover.

Unlike servo driven gimbals, brushless gimbals require precision in order to properly balance your camera on the mounting plate. It is important to read and follow these installation instructions:

(1) Cameras heavier than a GoPro (0.5lb) will overload the brushless motors and caused them to fail. Use a camera that is equal to or lighter than a GoPro.

(2) (Skip this step if your brushless gimbal already has the GoPro fixed mount) Strap the camera down to the base plate of the mount. Allow the camera to move side to side for center of gravity adjustment. Shift the camera left or right until the center of gravity is obtained, then tighten the strap if needed. Do not power up the gimbal in the process. When the center of gravity is correct, the camera will stay level and will not tip easily to either side on the rolling axis of the mount.

(3) During initialization, remember that the camera must be leveled and the gimbal and multi-rotor cannot be handheld. Keep both perfectly still on a flat, stable surface. Apply power to the gimbal with a 3-cell Lipo 11.1v-12.6v(3S MAX, The gimbal board will short out if connected to the main power distribution cable.) and wait 5-10 seconds. You will notice the gimbal motors initialize and start leveling. The gimbal will then be ready for operation.

(4) If the center of gravity is off, the gimbal will buzz or shake. Shift the camera until the shaking stops.

(5) Brushless gimbals have a much quicker compensation than traditional servo-driven gimbal. Rough handling will cause your gimbal to malfunction. If this occurs, unplug the power and go through the initialization by setting it on the ground.

6.2 MATRIX CAMERA MOUNT SERVO CONTROL SETUP

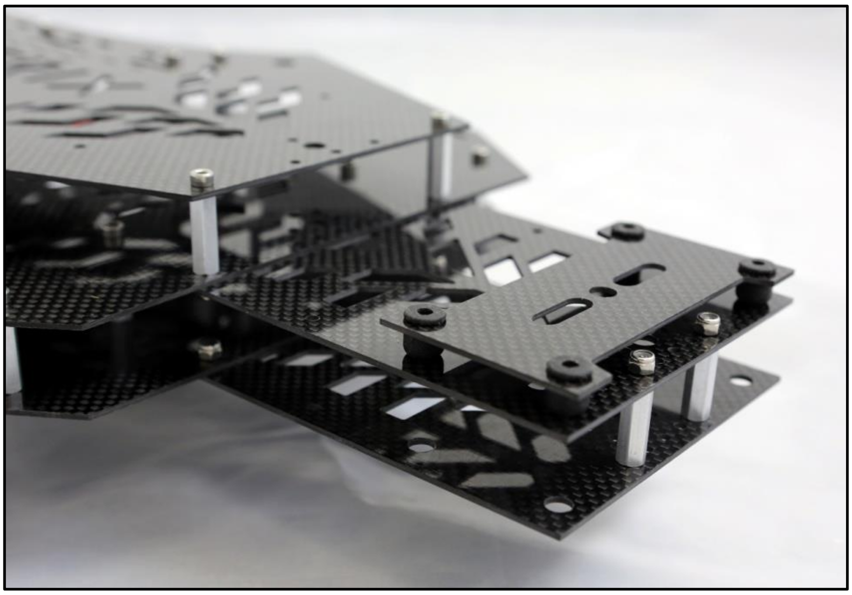


Figure 6.1-1 ***MATRIX Camera Mount Plate and Shock Plate***

IMPORTANT: Only digital servos are compatible with the Naza flight controller. Using an analog servo will cause malfunctioning, produce loud buzzing noises and burn up the servo. A light buzzing sound from a digital servo is, however, normal. The MATRIX features built-in gyros for camera mount auto compensation so there is no need to purchase separate gyros for your camera mount.

6.2.1 How to set your camera TILT (PITCH) auto compensation control for the MATRIX-S flight controller, receiver and transmitter

Connect flight controller F2 to tilt (pitch) servo.
Connect receiver's (For Walkera Devo 10 is Aux 4, For Spektrum DX8 is Aux 3, or Futaba 14SG is channel 7) Channel (assuming the AUX4 channel has not been already used for flight mode control or other functions) to flight controller's X1 using a 3 wire cable with the black ground wire closest to the edge of the flight controller (some receivers' polarity for ground may be different, so see your receiver manual for more details). Go to AUTOPILOT tab in DJI NAZA Assistant Software to set all remote adjustments to INH, and go to the GIMBAL tab to click ON to enable the gimbal manual control. Additionally, when you tilt the MATRIX forwards or backwards, the MATRIX gyro will sense the tilt so the camera mount servo will also automatically compensate for that by pitching the camera in the opposite direction to

compensate. Go to the GIMBAL tab in DJI NAZA Assistant Software, and go to the 3. With Automatic Control Gain, you can increase the gain to make camera mount auto compensation movement faster or decrease the gain to make auto compensation movement slower. Moreover, if the camera mount is moving in the wrong direction, you can click the button under DIRECTION, to change between “NORM” and “REV”.

For Walkera Devention 10, the AUX 4 knob can be turned to adjust the camera mount’s tilt action.

6.2.2 How to set your camera auto compensation ROLL control for the MATRIX flight controller, receiver and transmitter

Connect flight controller F1 to roll servo. Now the servo will automatically compensate when the MATRIX rolls. First, tie down your MATRIX before you turn on your transmitter radio, then connect the battery to the MATRIX. Connect the provided Programming USB cable from your PC computer’s USB port (XP or WIN7) to Micro USB port on the MATRIX communication port (on the LED side panel of the MATRIX). Please connect this cable after the transmitter has been bound to the receiver. Go to the GIMBAL tab to click ON to enable the gimbal manual control. Additionally, when you roll the MATRIX left or right, the MATRIX gyro will sense the roll so the camera mount servo will also automatically compensate for that by rolling the camera mount in the opposite direction to compensate. Go to the GIMBAL tab in DJI NAZA Assistant Software, and go to the 3. With Automatic Control Gain, you can increase the gain to make camera mount auto compensation movement faster or decrease the gain to make auto compensation movement slower. Moreover, if the camera mount is moving in the wrong direction, you can click the button under DIRECTION, to change between “NORM” and “REV”.

6.2.3 How to adjust the compensation gain and servo direction reversal in the DJI NAZA Assistant Software

Remove all 4 propellers for safety- please do not skip this or serious accidents may occur. Turn on your radio and connect the battery (plugging in the main battery to the MATRIX is required to provide power to the gimbal servos) to the MATRIX. Make sure your transmitter throttle stick is all the way down before binding. For safety, please be very cautious to avoid moving the throttle stick of your transmitter during the entire process. Connect the USB cable from your PC to the micro USB port of the MATRIX communication port (on the LED side panel of the MATRIX). Double click on the application DJI NAZA Assistant Software. At first launch of the application, the language may appear in Chinese- click on this Chinese tab anyway and change the language to English by clicking on the tab on the top of the screen. Sometimes when you launch an application and you don't see anything, it may be because the screen is hidden behind the previous application such as Windows Explorer, which you may have launched previously. Click on the "Gimbal" tab on the left panel of the screen. Now test the gimbal on the MATRIX by tilting it firmly on your hands. When the MATRIX tilts up the gimbal should travel and compensate in the opposite direction by tilting down. The camera should continue to lock on the subject you are shooting. If, however, the gimbal compensates in the same direction, go to 3. Automatic Control Gain under direction and click the box "NORM" or “REV” on the screen to reverse the servo travel. Test the gimbal compensation for roll action, and if compensation is in the same direction, simply click the box below direction for roll “NORM” or “REV”. Now test the gimbal for the amount of compensation. Note that the factory default compensation for tilt is set at 0.00. Each gimbal servo travels differently so adjustments may be required. If the gimbal compensation is too much or too little, you may adjust both the gimbal tilt and gimbal roll value by entering the number on the gain. When you have completed the settings, click on "Write" at the top of the program. You must click on “Write,” otherwise the data might not be loaded onto the MATRIX controller.

6.3 Flight Control Adjustment for Auto-Stabilization

Over attitude gain control may affect the vibration on the MATRIX. This type of vibration is particularly noticeable during climb out when there is a violent shake during acceleration. Also, any drastic weight change, such as loading on a DSLR camera, may require the attitude control gain adjustment. To access the adjustment, open the DJI NAZA Assistant Software, which is contained in the included flash drive. Connect the MATRIX to a Windows based PC with Windows 8 or Windows 7 or XP (For Windows to run this application, a current DirectX driver may be required). Upon initial application launch, you may see unreadable Chinese language. Just click on the top tab, and change language to English. Select the "AUTOPILOT" tab on the left column of the screen. Adjust the Basic Gain and Attitude Control Gain for Pitch, Roll, Yaw and Vertical by increments of 10. It is important that you click the "WRITE" tab, otherwise the new settings will not be stored in the flight controller.

6.4 Basic Gain and Attitude Gain Adjustment for Stabilization

Recommended settings for BASIC GAIN is Pitch set to 130%, Roll set to 120%, Yaw set to 90% and Vertical set to 120%, and for ATTITUDE GAIN is Pitch set to 100% and Roll set to 100%. **Warning**: BASIC GAIN needs to be set at a minimum of 90%. If your MATRIX is not as stable after a heavy camera or camera mount is installed, you should increase the BASIC GAIN and ATTITUDE GAIN by 15%-25% each time and re-test the performance of your MATRIX. Please refer to 4.6.3 to adjust your BASIC GAIN and ATTITUDE GAIN.

Assumptions on DJI NAZA FC design:

Assume aircraft flies stable as a general rule, which means FC outputs control signal to motor when it finds frame tilts for a stabilization recovery. We consider this non-RC tilt as an error.

According to the previous flight states, on the condition that vibration occurs during tilt, this can still be regarded as the stable state.

When the aircraft tilts to a certain direction, it will engender a tendency which could be reinforced.

Notice: Assumption 2 is not contradictory to Assumption 3.

We haven't built MATRIX mathematical modeling, which needs adjustments in Gain Tuning through personal sense. It is suggested that users grab the aircraft on the ground when tuning, which takes patience and skill. You will only get a comparatively ideal value after hours of tuning. **When setting Basic Gain and Attitude Gain Parameters, please exercise caution and always have the MATRIX tied down to a bench.**

MAINTENANCE & REPAIR

7.1 Replacing Motors (For Repairs Only)

To simplify motor replacement, the MATRIX motors can be disconnected once you remove the bottom frame, and motor wire is connected to ESC. **Please remember to reapply Loctite when putting bolts and screws back.**

(1) Make sure your battery is disconnected from the MATRIX.

(2) Identify the motor that needs to be replaced and put a marking sticker on the corresponding extension arm so you can identify which motor you are working on.

(3) Remove the bolts that secure the motor mount.

(4) Unscrew all the bottom bolts to dismount the bottom.

(5) Disconnect the three connectors for the old motor from the ESC and remove the old motor from the extension arm. All brushless motor wires have 3 wires. Prior to disconnection, please mark down the color of motor wire and the motor you're replacing.

(6) Feed the three motor connectors through the extension arm and connect three motor connectors to the ESC.

(7) Remount the new motor on the end of the extension arm using the bolts with Loctite.

(8) Please verify that the three motor wires are installed in the right positions by doing a tie-down flight test described in Section 5.1 and pay special attention to the motor that was replaced (look for the marking sticker on the extension arm). Always make sure to motor direction is correct, Motor #1 and #3 are counter clockwise, and motor #2 and #4 are clockwise.

(9) If the motor direction is correct, go to the next step. If the motor direction is incorrect, you may have made a mistake. Check your connections and make necessary corrections. Two wires connected incorrectly will cause the motor to spin in the wrong direction. Now tidy up the wires by pushing them back into the extension arm. For reverse the motor direction, just swap 2 motor wires on the ESC.

(10) If you make any changes, always repeat the tie-down flight tests in Section 5.1 until you are satisfied that everything is operating properly.

7.2 Replacing ESC (For Repairs Only)

When replacing the MATRIX ESC, you must follow a specific procedure, otherwise you may risk damage to the ESC wires, which may in turn short circuit the ESC and Flight Controller. **Please remember to reapply Loctite when putting bolts and screws back.**

(1) Make sure your battery is disconnected from the MATRIX.
(2) Remove the screw that lock the MATRIX folding arm
(3) Unscrew all the bolts from the top and bottom carbon.
(4) Disconnect the three motor connectors between the motor and ESC. Prior to disconnection, please mark down the color of motor wire and the motor you're replacing.
(5) Remove the corresponding ESC signal connector from the flight controller. Prior to disconnection and dismount the defective ESC.
(6) Trace the ESC's power supply wires back to the battery connector and disconnect the corresponding ESC's red and black bullet connectors.
(7) Carefully remove the ESC from the bottom frame. Mark the old ESC for future reference.
(8) Replace the new ESC and connect the ESC signal connector to the flight controller (for motor #1 ESC signal connector, it's connected to M1 on the flight controller. Motor #4 connector is connected to M4, etc…)
(9) Reconnect the ESC's power supply wire, the red and black bullet connectors back to the battery connector.
(10) Connect the motor connector back to the ESC.
(11) Remount the bottom frame and mount the extension arm.
(12) Please verify that the three motor wires are installed in the right positions by doing a tie-down flight test described in Section 5.1 and pay special attention to the motor that was replaced (look for the marking sticker on the extension arm). Always make sure to motor direction is correct, Motor #1 and #3 are counter clockwise, and motor #2 and #4 are clockwise.
(13) If the motor direction is correct, go to the next step. If the motor direction is incorrect, you may have made a mistake. Check your connections and make necessary corrections. Two wires connected incorrectly will cause the motor to spin in the wrong direction. Now tidy up the wires by pushing them back into the extension arm. For reverse the motor direction, just swap 2 motor wires on the ESC.

(14) If you make any changes, always repeat the tie-down flight tests in Section 5.1 until you are satisfied that everything is operating properly.

7.3 Replacing Extension Arms (For Repairs Only)

When replacing the MATRIX extension arm, you must follow a specific procedure, otherwise you may risk damage to the motor wires, which may in turn short circuit the entire flight controller and the ESC assembly. **Please remember to reapply Loctite when putting bolts and screws back.**

(1) Make sure your battery is disconnected from the MATRIX.
(2) Remove the screw that lock the MATRIX folding arm
(3) Unscrew all the bolts from the bottom frame. Put markers on the motor wires (1, 2 & 3) and the corresponding ESC wires (1, 2 & 3) coming out of the extension arm that needs to be replaced.
(4) Identify the extension arm that needs to be replaced and put a marking sticker on the corresponding motor and ESC so you can identify which arm, motor and ESC you are working on.
(5) Remove the bolts that secure the motor.
(6) Unscrew all the bolts from the bottom frame to dismount the bottom frame.
(7) Remove the two carbon skid plates.
(8) Remove the two screws that lock the extension arm.
(9) Disconnect the three connectors for the motor from the ESC and remove the motor from the extension arm. All brushless motor wires have 3 wires. Prior to disconnection, please mark down the color of motor wire and the motor you're replacing. Yellow wires are toward the inside of the Matrix, black wires are connected to the middle of the ESC pin and red wires are toward the outside edge of the Matrix.
(10) Feed the three motor connectors through the new extension arm and connect three motor connectors to the ESC.
(11) Remount the bottom frame by put back all the bolts from the bottom frame.
(12) Attach the new extension arm back to the frame and lock the extension arm onto the frame
(13) Please remember to use Loctite for all
(14) Please verify that the three motor wires are installed in the right positions by doing a tie-down flight test with the propellers removed. Always make sure to motor direction is correct, Motor #1 and #3 are counter clockwise, and motor #2 and #4 are clockwise.

(15) If the motor direction is correct, go to the next step. If the motor direction is incorrect, you may have made a mistake. Check your connections and make necessary corrections. Two wires connected incorrectly will cause the motor to spin in the wrong direction. Now tidy up the wires by pushing them back into the extension arm. For reverse the motor direction, just swap 2 motor wires on the ESC.

(16) If you make any changes, always repeat the tie-down flight tests in Section 5.1 until you are satisfied that everything is operating properly.

(17) Very important! Before attaching the carbon landing skid plates to the CNC brackets, please first make sure the inner CNC bracket is secured to the anchor shoulder bolt. If the carbon landing skids plates are installed first, it will cause the anchor bolt to misalign and possibly strip the CNC bracket screw hole.

(18) Attach the carbon skid plates on both sides of the inner and the outer CNC brackets with the 6mm screws.

FIXED ID BIND for Walkera Devo 10 transmitter

Setting up a Fixed ID bind between your MATRIX and Devo 10

IMPORTANT: When adjusting the settings of the MATRIX (while it is turned on), make sure that the propellers are removed and that the unit is securely tied down before proceeding in order to avoid any accidental flight.

Please ignore this step if you have a Futaba or Spektrum transmitter/receiver

Start by plugging in the Walkera bind plug (comes with receiver, if purchased) to the "batt." port on the receiver, followed by plugging in the battery for the MATRIX. The red light on the receiver should blink rapidly. Wait for the MATRIX's connection tune to finish playing, then proceed by unplugging the bind plug (the red light should now blink at a slower pace); followed by the battery.
NOTE: The transmitter does not need to be on for this step.

Setting up the Fixed ID on your transmitter

First go through the steps to bind the MATRIX to your transmitter (1. Turn on the transmitter 2. Plug the battery into the MATRIX 3. The MATRIX is bound when the red light on the receiver turns solid). From the home screen of the transmitter, go into the Main Menu screen and select: Model Menu → Fixed ID → turn Status to "On"→ set the ID code to your desired value and hit enter. You will see a little menu saying "ID Match." After the menu disappears, unplug the MATRIX battery, followed by the transmitter and you're done!
IMPORTANT: ALWAYS turn off the transmitter AFTER unplugging the MATRIX). Now your MATRIX will only bind with only the transmitter that you have set up the fixed ID bind with.

Designation: F2500 – 07

Standard Practice for Unmanned Aircraft System (UAS) Visual Range Flight Operations[1]

This standard is issued under the fixed designation F2500; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This practice prescribes guidelines that govern the visual flight operation of unmanned aircraft systems in civil airspace in order to provide for the safe integration of unmanned aircraft flight operations with manned aircraft flight operations.

1.2 This practice applies to those operations conducted for civil purposes other than sport or recreation that remain within the visual range of the pilot in command (see Terminology F2395 for a definition of "visual range").

1.3 This practice complies with the known rules, regulations, and public law available at the time of its publication. Should any conflict with a rule, regulation, or public law arise, the user must comply with rule and should notify ASTM of the conflict.

1.4 *This practice only prescribes accepted methods for visual range flight operation of unmanned aircraft systems.*

1.5 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

F2395 Terminology for Unmanned Aircraft Systems

2.2 *Federal Regulations:*[3]

14 CFR Part 43
14 CFR Part 71
14 CFR Part 73
14 CFR Part 91
14 CFR Part 93
14 CFR Part 99
AFS800HB, 8700.1, FSGA 94-12 Procedures Drug/Alcohol Testing, Joint Flight Standards Information Bulletin for Air Transportation (FSAT), General Aviation (FSGA), and Airworthiness (FSAW), FSAT 94-18, FSGA 94-12, and FSAW 94-50, Procedures for Reporting of Alcohol or Drug Test Results and Refusals to Submit to Testing by Flight Crewmembers to CAMI, November 18, 1994

3. Terminology

3.1 *Definitions of Terms Specific to This Standard:*

3.1.1 *mile(s)—in this document*, "mile" refers to nautical miles.

4. Summary of Practice

4.1 This practice prescribes additional methods for safe, visual range flight operations of unmanned aircraft systems, including flight procedures, aircraft system requirements, pilot license or certificate requirements, maintenance requirements, and special flight operations.

5. Significance and Use

5.1 Safe operation of the unmanned aircraft is of the primary importance to the unmanned aircraft industry and for successful integration of unmanned aircraft with manned aircraft in civil airspace. Operators and pilots-in-command of unmanned aircraft systems shall comply with applicable Federal Aviation Regulations (14 CFR Part 43, 14 CFR Part 71, 14 CFR Part 73, 14 CFR Part 91, 14 CFR Part 93, and 14 CFR Part 99). This standard includes the minimum additional methods that should be followed by unmanned aircraft system operators, including pilots-in-command, on every visual range flight to ensure the safe operation of the aircraft and safety of people and property in the air and on the ground. This visual range flight operation standard shall be used in conjunction with appropriate unmanned aircraft system airworthiness and pilot qualification standards.

6. General Methods

6.1 *Applicability:*

[1] This practice is under the jurisdiction of ASTM Committee F38 on Unmanned Aircraft Systems and is the direct responsibility of Subcommittee F38.02 on Flight Operations.

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[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

[3] Available from Federal Aviation Administration (FAA), 800 Independence Ave., SW, Washington, DC 20591, http://www.faa.gov.

6.1.1 This standard prescribes methods governing the operation of unmanned aircraft systems operating within visual range of the pilot-in-command.

6.1.2 This standard is intended for visual range flight operations of unmanned aircraft systems for other than sport or recreation.

6.2 *Pilot Qualifications:*

6.2.1 The pilot in command of a UAS operating under this standard shall have an approved[4] license or certificate with the appropriate ratings and limitations for that UAS.

6.3 *Responsibility and Authority of the Pilot in Command:*

6.3.1 The pilot-in-command of an UAS is directly responsible for, and is the final authority as to, the safe operation of that aircraft.

6.3.2 In an in-flight emergency requiring immediate action, the pilot-in-command may deviate from any guideline of this standard, or applicable Civil Aviation Authority (CAA) regulations, to the extent required in order to meet the conditions of that emergency and shall, when applicable, advise the appropriate airspace controlling agency of his/her intentions or actions as soon as possible once the conditions of the emergency are satisfied and further deviation is no longer necessary.

6.3.3 Each pilot-in-command that deviates from a regulation under 6.3.2 shall, upon request of the Administrator or representative, send a written report of the deviation to the Administrator.

6.3.4 Deviations under 6.3.2 shall always minimize the risk to people or property, even if the choice increases the risk to the UAS.[5]

6.4 *UAS Airworthiness:*

6.4.1 The pilot-in-command of the UAS is responsible for determining whether that aircraft and associated systems are in condition for safe flight. The pilot-in-command shall discontinue the flight when unairworthy conditions occur.

6.4.2 The operator will ensure the UAS conforms to an approved airworthiness standard, or an airworthiness certificate, and is appropriately registered for use.

6.5 *Careless or Reckless Operation:*

6.5.1 No person may operate an aircraft in a careless or reckless manner so as to endanger life or property of another.

6.6 *Dropping Objects:*

6.6.1 No pilot-in-command of a UAS may allow any object to be dropped from that aircraft in flight that creates a hazard to persons or property. However, this section does not prohibit the dropping of any object if reasonable precautions are taken to avoid injury or damage to persons or property. The pilot-in-command shall ensure the drop area remains clear throughout the operation.

6.6.2 The operator of a UAS must take all reasonable precautions to prevent the inadvertent release of the objects.

6.7 *Alcohol and Drugs*—No person may act or attempt to act as pilot-in-command of a UAS:

6.7.1 Within 8 h after the consumption of any alcoholic beverage,

6.7.2 While under the influence of alcohol,

6.7.3 While using any drug or medication that affects the person's faculties in any way contrary to safety, or

6.7.4 While having 0.04 % by weight or more alcohol in the blood. (See AFS800HB, 8700.1, FSGA 94-12.)

7. Flight Guidelines

7.1 *Preflight Action*—Each pilot in command shall, before beginning a flight, become familiar with all available information concerning that flight. This information shall include (at a minimum):

7.1.1 Appropriate weather observations, reports, or forecasts, or a combination thereof, for the operating area and expected duration of the flight,

7.1.2 Proximity to airports and airspace defined in 7.7-7.12 of this standard,

7.1.3 Location of emergency landing areas,

7.1.4 Maintenance and inspection records,

7.1.5 Pilot Operating Handbooks,

7.1.6 All applicable notices to airmen (NOTAMs) as published by the CAA for the duration of the flight operations,

7.1.7 Conduct the UAS pre-flight inspection IAW the pilot's operating handbook, and

7.1.8 Verify the absence of electromagnetic interference in the operating area in the planned frequency range.

7.2 *Night Operation*—Night operations require that:

7.2.1 The pilot-in-command of the UAS is rated for night operations, and

7.2.2 The UAS is configured and properly lighted for night operation.

7.3 *Operating Near Other Aircraft*—No UAS may operate so close to another aircraft, manned or unmanned, so as to create a collision hazard. No UAS may operate in formation flight except by arrangement with the pilot-in-command of each aircraft in the formation.

7.4 *Right-of-Way*—The pilot-in-command shall follow the right of way rules given in 14 CFR Part 91.113. When there is doubt, always maneuver to avoid a collision.

7.5 *Minimum Safe Altitudes:*

7.5.1 Except when necessary for takeoff and landing, UAS operations are to be conducted at altitudes that permit the pilot-in-command to conduct an emergency landing without undue hazard to persons or property.

7.5.2 When determining safe separation from obstacles during the operation, the pilot shall consider his vehicle size, weight, and speed when determining the safe distance from people and property that are not associated with the operation.

7.6 *Maximum Altitudes*—Visual range flight operations normally remain within Class G airspace. Pilots shall not operate the aircraft at an altitude where they can no longer provide visual collision avoidance.

[4] In this standard, "approved" means approved by the administrator CAA, his designated representative, or by an organization recognized by the CAA to do so.

[5] For example, in the event of an engine failure, the UAS pilot may choose to perform the emergency landing in a rough field or trees rather than land on a highway with traffic present.

7.7 *Operating On or In the Vicinity of an Airport in Class G Airspace:*

7.7.1 Operations on an airport in Class G airspace are prohibited without approval of that airport's authority/management.

7.7.2 Operations within 3 miles from center of a public airport in Class G airspace are prohibited without notification and approval of that airport's authority/management.

7.7.3 Operations within 1 mile from center of a charted, private airport in Class G airspace shall make a reasonable effort to notify the owner prior to the operation.

7.7.4 The operator shall publish a NOTAM or post a notice at the airfield concerning the operation.

7.8 *Controlled Airspace*—Operations, under this standard, within Class A, B, C, D, and E airspace are prohibited without prior approval of the controlling authority.

7.9 *Special Use Airspace:*

7.9.1 Operations within prohibited areas, restricted areas, national security areas, and warning areas are prohibited without prior approval of the using or controlling authority as appropriate.

7.9.2 Operations within active military operating areas, military training routes, alert areas, or controlled firing areas are allowed, but the pilot should exercise extreme caution. When possible, schedule UAS operations to coincide with minimal levels of activity, or contact the controlling agency for traffic advisories.

7.10 *Temporary Flight Restrictions*—UAS operations shall observe all temporary flight restrictions designated in CAA NOTAMs. Operations are prohibited without prior approval of the controlling authority.

7.11 *Special Flight Rules Areas*—Operations within airspace designated as special flight rules areas are prohibited without prior approval of the controlling authority.

7.12 *Air Defense Identification Zones*—Operations into, within or out of air defense identification zones are prohibited without prior approval of the controlling authority.

7.13 *Fuel/Energy Requirements*—UAS operators shall not plan to fly with less than 15 % of total endurance for either propulsion or control systems.

7.14 *Visibility Minimums*—Obstructions to visibility include but are not limited to weather, buildings, and ground environment such as trees and hills. These variables can affect the operation in several unanticipated ways and precludes establishing a numerical requirement. This requires the pilot to evaluate each flight independently. Visual range flight operations require sufficient visibility for the pilot-in-command to maintain control of the UAS at all times, establish required minimum safe altitude of the UAS, maintain required clearance with all aircraft and obstacles, and remain clear of clouds.

7.15 *Flight Logs*—The operator shall maintain the flight logs for the UAS. These may include aircraft, control system, pilot, or operator logbooks, or a combination thereof. At a minimum, the operator shall record date, aircraft identification, total flight time, number of landings, flight description, incidents or mishaps, maintenance discrepancies, and pilot's name. See Appendix X1 for an example logbook format. The logbook may be in electronic format and must be available to inspect upon request of an inspector or representative of the governing body.

7.16 *Pilot Operating Handbook*—Operators under this standard shall have, and reference, a Pilot Operating Handbook for the UAS system. Operators are responsible for the quality of materials and construction under this standard. Operators who construct more than 51 % of their UAS may provide their own Pilot Operating Handbook.

8. Equipment and Documentation Requirements

8.1 *Equipment Requirements*—The following equipment requirements are based on an operational necessity and may or may not be part of the UA or addressed in the UAS airworthiness documentation. They are included here for operational safety.

8.1.1 A UAS operating under this standard must have an instrument(s) which will provide the pilot in command with an indication(s) of remaining UAS endurance.

8.1.2 Operations above 400 ft above ground level (AGL) require an altitude measuring device and an automatic altitude hold function.

8.2 *Documentation Required*—Anyone operating a UAS under this standard shall maintain documentation that the UAS meets approved airworthiness standards and that the pilot is appropriately trained and qualified.

9. Special Flight Operations

9.1 *Training*—UAS flight training performed under this standard shall be conducted at an approved flying facility or over an appropriate, sparsely populated area.

9.2 *Flight Test*—UAS airworthiness flight testing, including maintenance check flights, performed under this standard shall be conducted over sparsely populated areas.

10. Maintenance

10.1 *Operation After Maintenance, Preventive Maintenance, Rebuilding or Alterations:*

10.1.1 The operator will assure that work is performed by people authorized to do the work and documented in the appropriate logs.

10.1.2 Any action affecting airworthiness shall require a maintenance check flight prior to resuming for-hire operations.

10.2 *Inspections*—The operator must comply with the periodic inspection requirements listed in the appropriate maintenance manuals. The inspection may be conducted by the builder or a maintenance technician qualified on that type of UAS. The inspector shall use the inspection checklist approved in the UAS' airworthiness records. An inspection log shall be maintained and kept with the UAS.

10.3 *Maintenance Records*—Maintenance records shall be maintained and kept with the UAS. The records shall at least contain the name of the mechanic, the certificate or other authorization of the mechanic, the maintenance action or the discrepancy and corrective action, and the date of completion.

The mechanic shall sign the log to indicate completion in accordance with the aircraft manuals.

10.4 *Transfer of Records*—Maintenance and inspection records must be transferred to any new operator of the UAS, if that UAS is to be used in for-hire applications. Flight log information must also be passed such that the new operator knows the total flight time accrued and any incidents that might affect airworthiness. Any aircraft deemed un-repairable must have logs so noted before transfer or discarding.

11. Keywords

11.1 flight; operation; UAS; visual range

ANNEX

(Mandatory Information)

A1. SAMPLE OPERATIONS CHECKLISTS

A1.1 *Flight Operation Checklists* —Flight operations checklists are typically separated into six phases of flight checks which are Pre-Flight, Control Systems Check, Before Take Off, In-Flight Operations, Landing, and Post-Flight Operations. Any checklist will vary based on the complexity of the specific UAS. This sample is provided for guidance only.

A1.1.1 *Pre-Flight:*

A1.1.1.1 Before the first flight of the day, all transmitter, on-board aircraft, and camera batteries are fully charged. Review appropriate maintenance logs.

A1.1.1.2 Check all control surfaces, that is, rudder, elevator and ailerons for signs of damage, loose hinges, and overall condition.

A1.1.1.3 Check the control linkages are secure and the condition of the control horns and brackets.

A1.1.1.4 Check the wing to make sure it is in good structural condition and properly secured and aligned to the airframe.

(1) Check the motor/engine and mounting system to make sure it is firmly attached to the airframe.

A1.1.1.5 Check the propeller for chips, cracks, looseness and any deformation.

A1.1.1.6 Check the landing gear for strut damage, secure attachment to the airframe, and the wheels are in good shape and rotate freely.

A1.1.1.7 Check that the servos are firmly attached to the airframe and all receiver connections are secure.

A1.1.1.8 Check all electrical connections making sure they are plugged in and secured to the airframe.

A1.1.1.9 Check that the payload equipment and mounting system are secure and operational.

A1.1.1.10 Perform an overall visual check of the aircraft prior to arming any power systems.

A1.1.1.11 Repair or replace any part found to be unairworthy in the pre-flight prior to take-off.

A1.1.2 *Control Systems Check:*

A1.1.2.1 Make every effort to assure that no one is using your radio's frequency in the vicinity before turning on your transmitter.

A1.1.2.2 Make sure that all of your body parts, clothing, other obstructions, and bystanders are well away from any propeller and its arc before turning power on to any systems. Make sure the aircraft is secure and will not move if the motor was suddenly powered up.

A1.1.2.3 Outloud—"CLEAR PROP."

A1.1.2.4 Turn on the transmitter. If it displays information such as aircraft memory and battery voltage, be sure these numbers are correct.

A1.1.2.5 Make sure that the throttle stick on the transmitter is in the power off position.

A1.1.2.6 Connect the battery or turn on the power switch to the aircraft, or both.

A1.1.2.7 Turn the transmitter off. If the control surfaces are moving about, someone else is on your frequency or there is another interference source close enough to abort the flight.

A1.1.2.8 Turn the transmitter back on if the control surfaces were normal.

A1.1.2.9 Check for proper operation of control surfaces.

A1.1.2.10 Elevator stick back—elevator up, stick forward—elevator down.

A1.1.2.11 Looking from behind the aircraft: Rudder stick left—rudder left, stick right—rudder right.

A1.1.2.12 Looking from behind the aircraft: Aileron stick left—left aileron up, right aileron down. Aileron stick right—right aileron up and left aileron down.

A1.1.2.13 Make sure that all servos are steady and not chattering or making any other abnormal noise when in operation or idle.

A1.1.2.14 Check the motor/engine for proper operation. Firmly secure the aircraft and gradually increase the throttle to full power and back down to idle—checking for lack of thrust, vibration or other possible anomalies. Check that the motor stops completely when the throttle stick is at the power off position, and the prop brake (if activated) is working properly.

A1.1.2.15 Payload equipment power is on. Check to make sure the triggering device is working correctly.

A1.1.2.16 Follow the recommended procedures as outlined in your radio transmitter/receiver owners manual for the proper field range test.

A1.1.3 *Before Take Off:*

A1.1.3.1 Transmitter antenna is fully extended.

A1.1.3.2 Transmitter trim settings in proper position.

A1.1.3.3 Receiver antenna is fully extended.

A1.1.3.4 Check that the take off area is clear of obstructions and people.

A1.1.3.5 Double check wind direction and review potential emergency landing areas.

A1.1.3.6 Set flight timer alarm.

A1.1.3.7 Outloud—“TAKE OFF.”

A1.1.3.8 Launch aircraft.

A1.1.4 *In-Flight:*

A1.1.4.1 Climb to a safe altitude and check control systems away from potential hazards. Reset trims if necessary.

A1.1.4.2 Keep aircraft at a safe operating distance from people and buildings.

A1.1.4.3 If aircraft must be flown over buildings or people, make every effort to minimize that time.

A1.1.4.4 Continually scan the flight and ground areas for potential hazards.

A1.1.5 *Landing:*

A1.1.5.1 Check the control systems and make sure the trims are set that if necessary, an emergency abort of the landing can be made.

A1.1.5.2 Scan landing area for potential obstruction hazards and recheck wind conditions.

A1.1.5.3 Outloud—“LANDING.”

A1.1.5.4 Always be prepared to go around.

A1.1.5.5 Carefully land the aircraft away from obstructions and people.

A1.1.6 *Post-Flight:*

A1.1.6.1 Turn the power off to the aircraft or disconnect the batteries, or both.

A1.1.6.2 Turn off the transmitter.

A1.1.6.3 Turn the power off to the payload equipment.

A1.1.6.4 Visually check aircraft for signs of damage or excessive wear, or both.

A1.1.6.5 Remove the batteries.

A1.1.6.6 Secure the aircraft.

APPENDIX

(Nonmandatory Information)

X1. SAMPLE FLIGHT AND MAINTENANCE LOGS

X1.1 Fig. X1.1 shows an example of a flight log. This particular log also requires the use of an aircraft Maintenance Log (see Fig. X1.2).

X1.2 Fig. X1.2 shows an example of a maintenance log. This particular log also requires the use of a Pilot’s Log (see Fig. X1.1).

Crew Member	Date	Aircraft	Function	Type	Start Time	End Time	Total Time	Launch Quantity	Landing Quantity	Comments (Location, other crew, weather, etc.)

Experience Summary	Brought Fwd		
Type	Hours	Launch	Landing
Autonomous (A)			
Ground (G)			
Launch System (L)			
Manual (M)			
Simulator (S)			

	Hours This Page	Quantity This Page		Total Experience		
		Launch	Landing	Hours	Launch	Landing
Autonomous (A)						
Ground (G)						
Launch System (L)						
Manual (M)						
Simulator (S)						

UAV System Experience Logbook

Chief Controller Signature on page completion

FIG. X1.1 Sample Pilot Flight Log

Date	Aircraft	Avionics	Airframe	Engine	Archive	Wing Mount	xTE->CM	zTE->CM
Descriptions						Checklists		
Aircraft Modifications since last flight:						Checks	Initials	Date
						Before Flight		
						Engine		
					Initials:	Avionics		
Flight Objectives:						Mid Bay		
						Assembly		
						Met Ground Check		
						Runway		
					Initials:	Start		
Flight Notes:						After Flight		
						Gndbase		
						Aircraft		
						Meteorological Ground Check		
						Reference	Left Wing	Right Wing
						P	P	P
						T	T	T
						U	U	U
					Initials:		#	#
Maintenance Comments:					Oil	Fuel	Gross	Flight
					Start	S	S	S
					End	E	E	E
					Change	C	C	C
					Hours	Avionics	Airframe	Engine
					This flight			
					TTIS			
					TSO			
				Initials:	Total Cycles			

FIG. X1.2 Sample Maintenance Log

Designation: F2910 – 14

Standard Specification for Design and Construction of a Small Unmanned Aircraft System (sUAS)[1]

This standard is issued under the fixed designation F2910; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This specification defines the design, construction, and test requirements for a small unmanned aircraft system (sUAS).

1.2 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

F2908 Specification for Aircraft Flight Manual (AFM) for a Small Unmanned Aircraft System (sUAS)

F2909 Practice for Maintenance and Continued Airworthiness of Small Unmanned Aircraft Systems (sUAS)

F2911 Practice for Production Acceptance of a Small Unmanned Aircraft System (sUAS)

F3002 Specification for Design of the Command and Control System for Small Unmanned Aircraft Systems (sUAS)

F3003 Specification for Quality Assurance of a Small Unmanned Aircraft System (sUAS)

F3005 Specification for Batteries for Use in Small Unmanned Aircraft Systems (sUAS)

3. Terminology

3.1 *Definitions of Terms Specific to This Standard:*

3.1.1 *continued safe flight, n*—a condition whereby a UA is capable of continued safe flight, possibly using emergency procedures, without requiring exceptional pilot skill. Upon landing some UA damage may occur as a result of a failure condition.

3.1.2 *launch and recovery load, n*—those loads experienced during normal launch and recovery of the UA.

3.1.3 *limit load, n*—those loads experienced in the normal operation and maintenance of the UA.

3.1.4 *manufacturer, n*—entity responsible for assembly and integration of components and subsystems to create a safe operating sUAS.

3.1.5 *permanent deformation, n*—a condition whereby a UA structure is altered such that it does not return to the shape required for normal flight.

3.1.6 *propulsion system, n*—consists of one or more power plants (for example, a combustion engine or an electric motor and, if used, a propeller or rotor) together with the associated installation of fuel system, control and electrical power supply (for example, batteries, electronic speed controls, fuel cells, or other energy supply).

3.1.7 *small unmanned aircraft system, sUAS, n*—composed of the small unmanned aircraft (sUA) and all required on-board subsystems, payload, control station, other required off-board subsystems, any required launch and recovery equipment, and command and control (C2) links between the sUA and the control station. For purposes of this standard sUAS is synonymous with a small Remotely Piloted Aircraft System (sRPAS) and sUA is synonymous with a small Remotely Piloted Aircraft (sRPA).

3.1.8 *structural failure, n*—a condition whereby the structure is not able to carry normal operating loads.

3.1.9 *supplier, n*—any entity engaged in the design and production of components (other than a payload which is not required for safe operation of the sUAS) used on a sUAS.

3.1.9.1 *Discussion*—Where the supplier is not the manufacturer, the supplier can only ensure that the components comply with accepted consensus standards.

3.2 *Shall versus Should versus May*—Use of the word "shall" implies that a procedure or statement is mandatory and must be followed to comply with this standard, "should" implies recommended, and "may" implies optional at the discretion of the supplier, manufacturer, or operator. Since "shall" statements are requirements, they include sufficient detail needed to define compliance (for example, threshold

[1] This specification is under the jurisdiction of ASTM Committee F38 on Unmanned Aircraft Systems and is the direct responsibility of Subcommittee F38.01 on Airworthiness.

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[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

values, test methods, oversight, reference to other standards). “Should” statements are provided as guidance towards the overall goal of improving safety, and could include only subjective statements. “Should” statements also represent parameters that could be used in safety evaluations, and could lead to development of future requirements. “May” statements are provided to clarify acceptability of a specific item or practice, and offer options for satisfying requirements.

4. Applicability

4.1 This standard is written for all sUAS that are permitted to operate over a defined area and in airspace authorized by a nation’s governing aviation authority (GAA). It is assumed that a visual observer(s) will provide for the sense-and-avoid requirement to prevent collisions with other aircraft and that the maximum range and altitude at which the sUAS can be flown at will be specified by the nation’s GAA. Unless otherwise specified by a nation’s GAA this standard applies only to UA that have a maximum takeoff gross weight of 55 lb/25 kg or less.

5. Requirements

5.1 *General:*

5.1.1 The sUAS shall be designed and constructed to meet sUAS limitations and performance capabilities required by the nation’s GAA.

5.1.2 The sUA shall be designed and constructed so that the maximum level flight speed cannot exceed the maximum airspeed authorized by the nation’s GAA. In addition, the maximum level flight airspeed should not exceed an airspeed that would prevent the sUA from remaining within the confines of the defined operational area without excessive maneuvering or exceptional pilot skill.

5.1.3 The sUAS shall be designed using appropriate and reasonable engineering design and verification techniques. Test shall be conducted in accordance with section 5.11 to verify that the design requirements have been satisfied and the results of the tests recorded and available for future reference.

5.1.4 The sUAS shall be designed and constructed to initialize in a known, safe state when power is applied.

5.1.5 The sUA should be designed and constructed to minimize the likelihood of fire, explosion, or the release of hazardous chemicals, materials, and flammable liquids or gasses, or a combination thereof, in flight or in the event of a crash, hard landing, or ground handling mishap. This includes, but is not limited to: containing the fire if the sUA crashes; protecting first responders from hazards at the crash site; use of flame resistant materials; suppression of in-flight fires; and protection against battery-induced fires.

5.1.6 During the design process, the manufacturer shall determine the permissible range of weight and positions of the center of gravity of the sUA. The sUA shall then be designed and constructed to ensure that the center of gravity remains within this permissible weight and range for all intended payloads, fuel, batteries, and other onboard items. If removing/adding ballast is permitted, the sUAS aircraft flight manual shall include instructions with respect to loading, marking, and securing of removable ballast and ensuring the center of gravity remains within limits that can be controlled by the control system and ensures adequate aerodynamic stability. The aircraft flight manual shall have a method to verify or calculate CG location.

5.1.7 During the design process, the manufacturer shall determine the maximum takeoff gross weight and minimum operational empty weight for the sUA.

5.1.8 The sUAS should be designed and constructed to minimize injury to persons or damage to property during operation.

5.1.8.1 Designs that use exposed, rigid sharp structural objects should be minimized. For those systems that might have components capable of causing injury due to misuse or mishandling, a warning/caution statement should be added to the aircraft flight manual alerting the crew to the risk.

5.1.8.2 The sUA shall be designed so that the sUA will remain controllable and predictable or capable of performing a safe recovery maneuver in the event of asymmetric deployment of any single, normal control surface as well as high-lift/drag devices (trailing edge flaps, leading edge flaps or slats, spoilers, flaperons, and the like).

5.1.9 The sUA shall be designed and constructed so that all fasteners will remain secure over the operational and environmental range of flight conditions.

5.1.10 The sUA should be designed and constructed so that it is possible to determine quickly that all doors, panels, and hatches that can be opened are secured before takeoff.

5.1.11 *Construction*—In addition to construction requirements specified above:

5.1.11.1 The sUAS should incorporate materials that have the strength, corrosion resistance, and durability characteristics appropriate to the application in the design.

5.1.11.2 Energy absorbing structure should be used wherever possible.

5.1.11.3 Material strength design properties should be based on analysis or testing, or both, determined by the manufacturer/supplier that confirms these material strength design properties have been achieved. Documentation of this analysis or testing, or both, should be recorded and available at either the manufacturer’s or supplier’s location (as appropriate) for future reference.

5.2 *Structure:*

5.2.1 The sUA structure shall be designed and constructed so that:

5.2.1.1 The structure will not fail at 1.5 times the limit loads. This shall be verified either through analysis or testing as determined by the manufacturer/supplier.

5.2.1.2 Binding, chafing, or jamming of controls do not occur at 1.5 times the limit load threshhold. This shall be verified by test.

5.2.1.3 The structure can withstand limit loads and launch and recovery loads without permanent deformation.

5.2.2 The sUA and systems required for continued safe flight shall be designed and constructed to be capable of supporting flight loads predicted by analysis or flight test to be encountered throughout the proposed flight envelope to include atmospheric gusts or evasive maneuvering loads, or both.

5.2.3 The sUA and systems required for continued safe flight shall be designed and constructed to withstand normal landing impact loads without damage that would affect safety of flight of subsequent flights unless it can be maintained, repaired, and inspected as per procedures that will ensure continued safe operation.

5.2.4 The manufacturer shall develop and provide instructions to ensure any damage caused by shipping or handling are identified prior to flight. These instructions should normally be part of the pre-flight inspection procedures in the aircraft flight manual but may be included in other instructions as deemed necessary by the manufacturer.

5.3 *Propulsion:*

5.3.1 The propulsion system (including batteries for electric power plants) shall be designed and constructed to:

5.3.1.1 Operate throughout the flight envelope,

5.3.1.2 Conform to the installation instructions provided by the propulsion system supplier, and

5.3.1.3 Have a positive means to cut off ignition or fuel flow both in-flight and on the ground.

5.3.2 Propulsion system controls and displays at the control station shall be designed and constructed to be adequate to control the propulsion system safely under all operating conditions as determined by the manufacturer or the engine supplier, or both. Examples include:

5.3.2.1 Ability to be able to observe whether engine is on or off (corroborated by multiple sensors).

5.3.2.2 Ability to command the engine off quickly.

5.3.2.3 Ability to have a multi-step safeguard in turning the engine on or off.

5.3.2.4 Vital engine instruments as determined by the manufacturer or engine supplier/manufacturer, or both, as necessary to properly control the engine such as: fuel flow and pressure, RPM, manifold pressure, carburetor icing detector, exhaust temperature, and cylinder head temperature for combustion engines and current, temperature, etc for electric propulsion (or other parameters applicable to the propulsion system design).

NOTE 1—May not be applicable for rotorcraft or manually controlled sUAS using simple model aircraft radio control equipment.

5.3.3 *Propellers:*

5.3.3.1 All propellers should be non-metallic.

5.3.3.2 Propellers (both fixed and variable pitch) should be designed to have adequate structural strength.

5.3.3.3 Provisions shall be made to ensure that the propulsion system shaft and propeller rotational speed do not exceed the value specified by the supplier.

5.3.4 The propulsion system should be designed to minimize failure for reasons other than insufficient fuel or electrical power and to support normal operations throughout the anticipated lifecycle of the system or until reaching the manufacturer/supplier-determined inspection or replacement interval.

5.3.5 *Fuel and Oil Systems*—For sUA using a combustion propulsion system:

5.3.5.1 The fuel and oil systems shall be designed and constructed to be capable of supplying fuel and oil to the power plant throughout the entire flight envelope at the required rate and pressure specified by the propulsion system supplier;

5.3.5.2 The fuel and oil systems shall be designed so that there is a means of determining the amount of fuel and oil on board when the UA is on the ground, whether via internal sUA systems or external means;

5.3.5.3 Piping, fittings, valves, O-rings, and gaskets used shall be resistant to deterioration caused by fuel, oil, and lubricating grease;

5.3.5.4 Each fuel system and oil system shall be designed to be able to withstand 1.5 limit loads; and

5.3.5.5 Each fuel system (excluding bladder type systems) shall be designed so that it is vented to the atmosphere and can be drained when the aircraft is on the ground.

5.3.6 *Cooling*—Not all sUA require a cooling system. However, if one is necessary the following requirements apply:

5.3.6.1 The cooling system shall be designed and constructed to ensure adequate cooling of the power plant at the highest ambient temperatures expected during maximum climb rate and cruise operations of the sUA.

5.3.6.2 The cooling system should be designed and constructed so that any air induction system filters can be inspected, serviced, or replaced, or a combination thereof, as part of routine maintenance as specified by the manufacturer.

5.3.6.3 Where necessary to maintain a safe operating temperature, naturally aspirated cooling shall be supplemented by an appropriate cooling method.

5.3.7 The exhaust system shall be designed and constructed to ensure that hot exhaust gases do not impinge directly on nearby unprotected surfaces.

5.3.8 For combustion engine power plants, the system shall include:

5.3.8.1 An ignition switch incorporated into the controls available at the control station, and

5.3.8.2 A means of interrupting engine ignition on the aircraft to permit external operation to shut down the engine when the aircraft is on the ground.

5.3.9 For aircraft using electric power plants, the system shall include:

5.3.9.1 A master switch or other means (for example, removing battery) mounted on the aircraft to permit external operation to shut down the power plant when the aircraft is on the ground and

5.3.9.2 A means to permit the operator to determine the capacity remaining in the batteries.

5.3.10 *Batteries*—Refer to Specification F3005 for design requirements.

5.4 *Command and Control (C2) Link*—Refer to Specification F3002 for design requirements.

5.5 *Data Link*—Reserved.

5.6 *Systems and Equipment:*

5.6.1 All system components shall be designed and constructed to:

5.6.1.1 Be appropriate to their intended function and

5.6.1.2 Function properly when installed.

5.6.2 The sUAS design may include an air data system based upon a pitot-static system installed on the aircraft. If a pitot-static system is installed it should be calibrated at an interval defined by the manufacturer.

NOTE 2—May not be applicable for rotorcraft or manually controlled sUAS using simple model aircraft radio control equipment.

5.6.3 *Flight, Navigation, and Power Plant Displays*—The sUAS should be capable of down linking data concerning flight, power plant, and navigation parameters as identified in 5.6.4.

NOTE 3—May not be applicable for manually controlled sUAS using simple model aircraft radio control equipment.

5.6.4 The control station shall provide the pilot with all information required for accurate control of the sUAS. Refer to Specification F3002 for design requirements.

NOTE 4—May not be applicable for manually controlled sUAS using simple model aircraft radio control equipment.

5.6.5 *Equipment, Systems, and Installation*—Each item of equipment, each system, and each installation shall be designed and constructed so that when performing its intended function, it does not adversely affect the response, operation, or accuracy (as specified by the manufacturer) of any equipment required for the safe operation of the sUAS.

5.6.6 The system should be designed and constructed so that the aircraft remains controllable or automatically initiates a predictable and safe maneuver in the event of the failure of any flight critical component or system.

5.6.7 *Automatic Pilot*—Any automatic pilot shall be designed and constructed so that it is possible for the operator to assume manual control of the trajectory of the aircraft at any time during the flight or ground handling.

NOTE 5—This is not to be interpreted as mandating that the pilot shall be able to engage true stick to surface control at any time.

5.6.8 *Electrical System:*

5.6.8.1 An electrical load analysis shall be performed to ensure that electrical bus loads and capacity are adequate to power all aircraft systems and installed payloads.

5.6.8.2 The electrical system shall be designed and constructed so that:

(1) There is a means to enable the operator to determine the correct operation of the electrical system, including correct operation of any generator;

(2) Circuit protective devices are incorporated where necessary to ensure that wiring is not overloaded;

(3) Electrical wiring and cables have adequate capacity;

(4) Loosening of connections over the range of vibrations expected is prevented; and

(5) If there is provision for applying external electrical power to the aircraft when on the ground, connection points are adequately labeled with respect to current and voltage and polarity limitations.

5.6.9 *Anti-Collision Lights*—Anti-collision lights shall be installed and functional for night operations.

5.6.10 *Landing Gear:*

5.6.10.1 For sUA that use conventional landing, the landing gear shall be designed and constructed to accommodate normal landing impact loads without damage to the structure.

5.6.10.2 If the landing gear is retractable and its status cannot be confirmed visually, there shall be an indicator or display at the control station to advise the operator that the landing gear is:

(1) Securely locked down before landing and

(2) Stowed securely in the correct position for flight when landing gear is selected up.

5.7 *Payloads*—All payloads shall be designed and constructed so that the safe operation of the sUAS is not prevented by electronic emissions, weight/location, or other characteristics of the payload. This is the responsibility of the manufacturer if the payload is provided as part of the delivered system. If the manufacturer allows additional supplier provided payloads to be installed in the field by the operator then the manufacturer shall provide guidance to the operator as to how to verify that this requirement has been met.

5.8 *Control Station*—Refer to Specification F3002 for design requirements.

5.9 *Launch and Recovery System*—Any required launch and recovery system shall be designed, constructed, and tested in accordance with an appropriate consensus standard.

5.10 *System Level:*

5.10.1 *Stalls (aerodynamic departure from controlled flight):*

NOTE 6—Not applicable for rotorcraft or sUAS manually controlled using simple model aircraft radio control equipment.

5.10.1.1 For sUA that are not equipped with automatic stall protection, a means shall be provided to warn the pilot when the aircraft is approaching the stall. The warning shall be available to the pilot and be an audible or distinctive tone or a flashing visual indicator, or a combination thereof, and shall be initiated when the aircraft is no less than 10 % above the stall speed/angle of attack.

5.10.1.2 The manufacturer shall design the sUAS so that recovery from any departure from safe flight can be accomplished with a single specific action that positively returns the aircraft to controlled flight.

5.10.2 If the sUAS is equipped with an automatic departure prevention capability, that subsystem shall be shown to have appropriate reliability even to the extent of having battery power independent of the primary power system or to the extent of protecting the power to the departure-prevention subsystem such that failures in other subsystems do not cut power to the departure-prevention subsystem. The minimum selectable speed on the control station shall be limited to an airspeed equivalent to 1.1 times the stall speed in level flight at maximum gross take off weight.

5.10.3 *Performance with One Power Plant Inoperative:*

5.10.3.1 For sUA with more than one power plant, the sUA shall be designed and constructed so that in the event of power plant failure:

(1) The aircraft remains controllable when one power plant fails if flight cannot be sustained with the remaining power plant(s), and

(2) The descent flight path can be controlled from the control station, or

(3) The system defaults to a safe automated recovery procedure.

NOTE 7—A power shutdown command to the remaining power plant(s) is an acceptable automated recovery procedure.

5.10.3.2 For single power plant aircraft, the system shall be designed and constructed so that in the event of power plant failure:

(1) The descent flight path can be controlled from the control station or

(2) The system defaults to a safe automated recovery procedure.

5.10.4 *Stability*—Except for rotorcraft and those sUA that depend upon a stability augmentation system, the aircraft shall be designed to be longitudinally, directionally, and laterally positively statically stable for all weight and CG positions in the operational flight envelope.

5.10.5 Departure from controlled flight (stall, spin, uncommanded control inputs, etc) shall be known to the operator at all times during flight.

5.11 *Test:*

5.11.1 Tests shall be conducted to verify that appropriate sUAS design and construction requirements above have been satisfied.

5.11.2 *Operating Limitations*—During the test program the manufacturer shall determine and document in the aircraft flight manual appropriate operating limitations and other information necessary for safe operation of the system. This shall include any wind limitations as well as features of the control station and the C2 link functions of the system.

5.11.3 The manufacturer shall verify the proper completion of each ready-to -sUAS by conducting a final system test in accordance with the requirements below. The following ground check and flight test procedures shall be conducted and documented for each ready-to-fly sUAS.

5.11.3.1 *Ground check*—Before flight-testing, the manufacturer shall conduct a thorough ground inspection of each sUAS produced to verify at least the following:

5.11.3.2 *Weight and balance*—Empty weight and proper center of gravity location has been calculated or measured and verified to be within limits, or can be verified based on quality control procedures where aircraft of like type design and configuration are being manufactured.

5.11.3.3 *Systems check*—The proper function of all switches and circuits, instrumentation, brakes, and any other appropriate systems shall be verified.

5.11.3.4 *Flight controls check*—All flight controls shall be checked for smooth and proper function and proper maximum deflections. The safe operating range of C2 link(s) shall be verified in accordance with Specification F3002.

5.11.3.5 *Propulsion system check*—Propulsion system checks and procedures shall be performed, as applicable to the design, to verify:

(1) Proper propulsion system installation, (for example, spark ignition, turbine, electric);

(2) Proper servicing of any propulsion system fluids;

(3) No apparent fuel, oil, or coolant leaks;

(4) Propeller installation and pitch adjustment;

(5) Performance of a propulsion system "run-in" with adjustments;

(6) Tachometer indicates propulsion system idle revolutions per minute and maximum static revolutions per minute are within supplier/manufacturer published limits;

(7) Proper function of propulsion system instrumentation or speed control, or both;

(8) Proper function of ignition system(s); and

(9) Proper function of all battery system(s).

5.11.3.6 *Placards Check*—The sUAS shall be checked to verify that all placards and switch markings are in place, as applicable.

5.11.3.7 *Preflight Inspection*—The following shall be verified:

(1) All required documentation shall be available at the control station.

(2) All visible surfaces are free of deformation, distortion, or other evidence of failure or damage.

(3) Inspection of all visible fittings and connections for defective or unsecure attachment.

(4) Complete walk-around/pre-flight inspection in accordance with the aircraft flight manual.

(5) All doors and panels are closed and locked.

5.11.3.8 *Taxi Test*—After completion of the ground check, a taxi test, if appropriate, shall be conducted to verify as applicable:

(1) Brake function,

(2) Landing gear tracking and steering, and

(3) Proper compass readings, to be verified by a reference, and corrected.

5.11.3.9 *Flight Test*—Safe flight operation of each completed sUAS shall be verified, as applicable, to include acceptable handling and control characteristics, stall characteristics, propulsion system operation, airspeed indications, and overall suitability for normal flight in accordance with the aircraft flight manual. The flight test procedure, at a minimum, shall include recorded verification of the following:

(1) Takeoff runway wind, outside air temperature, and pressure altitude;

(2) Demonstration of safe takeoff for the operating conditions specified for the sUAS;

(3) Demonstration of safe climb out;

(4) Appropriate response to flight controls in all configurations;

(5) Demonstration of safe recovery from stall, including verification of appropriate stall warning and stall recovery characteristics.

NOTE 8—Not applicable for rotorcraft or sUAS manually controlled using simple model aircraft radio control equipment.

(6) Demonstration that there are not any unexpected or abnormal performance or handling characteristics; and

(7) Proper propulsion system operating temperatures.

5.12 *Quality Assurance*—Requirements in Specification F3003 shall be adhered to for sUAS that are designed and constructed per this standard.

5.13 *Documentation:*

5.13.1 *Design:*

5.13.1.1 The manufacturer shall retain documentation of appropriate engineering design data and verification results including data showing compliance with this standard.

5.13.1.2 All design documentation may be developed in the manufacturer's format or using best available documentation practices (for example, engineering notebook format).

5.13.1.3 For multiple systems that are designed and constructed per this standard, the manufacturer should comply with documentation requirements contained in Practice F2911.

5.13.1.4 *sUAS Manual(s):*

(1) An aircraft flight manual shall be developed in accordance with Specification F2908.

(2) If not included in the aircraft flight manual, a maintenance manual shall be developed in accordance with Practice F2909 as required to assure continued airworthiness.

(3) Other maintenance manuals—Other maintenance manuals may be prepared if desired or required by the manufacturer or the nation's governing aviation authority or both. If such documents are required or desired they may be prepared in manufacturer's normal accepted format.

5.13.2 *Construction*—The supplier/manufacturer shall retain appropriate drawings and schematics used to build the sUAS and shall retain the results of appropriate acceptance testing until the sUAS is no longer in production or until support is no longer being provided.

5.13.3 *Test*—The manufacturer shall retain documentation of appropriate verification results including data showing compliance with this standard and shall retain the results of appropriate acceptance testing until the sUAS is no longer in production or until support is no longer being provided.

5.13.4 *Quality Assurance*—Adhere to documentation requirements in Specification F3003.

6. Keywords

6.1 small unmanned aircraft; sUA; small unmanned aircraft system; sUAS

Designation: F2911 – 14^ε1

Standard Practice for Production Acceptance of Small Unmanned Aircraft System (sUAS)[1]

This standard is issued under the fixed designation F2911; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

ε¹ NOTE—Corrected title editorially in March 2014.

1. Scope

1.1 This standard defines the production acceptance requirements for a small unmanned aircraft system (sUAS).

1.2 This standard is applicable to sUAS that comply with design, construction, and test requirements identified in Specification F2910. No sUAS may enter production until such compliance is demonstrated.

1.3 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

F2585 Specification for Design and Performance of Pneumatic-Hydraulic Unmanned Aircraft System (UAS) Launch System

F2908 Specification for Aircraft Flight Manual (AFM) for a Small Unmanned Aircraft System (sUAS)

F2909 Practice for Maintenance and Continued Airworthiness of Small Unmanned Aircraft Systems (sUAS)

F2910 Specification for Design, Construction, and Test of a Small Unmanned Aircraft System (sUAS)

F3003 Specification for Quality Assurance of a Small Unmanned Aircraft System (sUAS)

F3005 Specification for Batteries for Use in Small Unmanned Aircraft Systems (sUAS)

3. Terminology

3.1 *Definitions of Terms Specific to This Standard:*

3.1.1 *manufacturer, n*—entity responsible for assembly and integration of components and subsystems to create a safe operating sUAS. The builder of kit built systems provided by a manufacturer must conform to the manufacturer's assembly and test instructions without deviation in order for that kit-built system to meet this standard.

3.1.2 *propulsion system, n*—consists of one or more power plants (for example, a combustion engine or an electric motor and, if used, a propeller or rotor) together with the associated installation of fuel system, control and electrical power supply (for example, batteries, electronic speed controls, fuel cells, or other energy supply).

3.1.3 *small unmanned aircraft system, sUAS, n*—composed of the small unmanned aircraft (sUA) and all required on-board subsystems, payload, control station, other required off-board subsystems, any required launch and recovery equipment, and command and control (C2) links between the UA and the control station. For purposes of this standard sUAS is synonymous with a small Remotely Piloted Aircraft System (sRPAS) and sUA is synonymous with a small Remotely Piloted Aircraft (sRPA).

3.1.4 *supplier, n*—any entity engaged in the design and production of components (other than a payload which is not required for safe operation of the sUAS) used on a sUAS.

3.1.4.1 *Discussion*—Where the supplier is not the manufacturer, the supplier can only ensure that the components comply with accepted consensus standards.

3.2 *Shall versus Should versus May*—Use of the word "shall" implies that a procedure or statement is mandatory and must be followed to comply with this standard, "should" implies recommended, and "may" implies optional at the discretion of the supplier, manufacturer, or operator. Since "shall" statements are requirements, they include sufficient detail needed to define compliance (for example, threshold values, test methods, oversight, reference to other standards). "Should" statements are provided as guidance towards the overall goal of improving safety, and could include only subjective statements. "Should" statements also represent parameters that could be used in safety evaluations, and could lead to development of future requirements. "May" statements

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are provided to clarify acceptability of a specific item or practice, and offer options for satisfying requirements.

4. Applicability

4.1 This standard is written for all sUAS that are permitted to operate over a defined area and in airspace defined by a nation's governing aviation authority (GAA). It is assumed that a visual observer(s) will provide for the sense-and-avoid requirement to prevent collisions with other aircraft and that the maximum range and altitude at which a sUAS can be flown will be specified by the nation's GAA. Unless otherwise specified by a nation's GAA this standard applies only to UA that have a maximum take off gross weight of 55 lb/25 kg or less.

5. Requirements

5.1 *Production:*

5.1.1 *General:*

5.1.1.1 The manufacturer is responsible for a product that complies with accepted consensus standards at the time of delivery and is demonstrated as fit and safe for flight. For sUAS assembled from components provided by a supplier, the supplier shall provide detailed instructions to the manufacturer concerning the assembly and test of those components. The components supplied by a supplier shall include a declaration that the components have been designed and manufactured in accordance with an accepted consensus standard and that the components, when assembled, tested, and maintained in accordance with the supplier's instructions, meet the safety standards implied by the applicable consensus standards. If required by a nation's GAA, the manufacturer/supplier shall also comply with any requirements for compliance with any applicable technical standard orders for specific components or systems, or both.

5.1.1.2 The manufacturer is responsible for ensuring that the sUAS has been assembled in accordance with the component supplier's instructions and complies with Specification F2910.

5.1.1.3 *Compliance with Quality Assurance Standard*—Quality assurance shall be exercised across production in accordance with Specification F3003.

5.1.2 *Structure*—sUAS airframe structures shall meet the requirements specified in Specification F2910. sUAS structures using materials that have no applicable certified material characteristics shall be demonstrated to be suitable for the mission involved.

5.1.2.1 *Material procurement*—Components used shall be consistent and uncontrolled variation or substitution shall be avoided.

5.1.2.2 *Assembly practices*—Consistent, accepted practices and assembly using materials such as epoxy, CA cements, shall be applied in accordance with product supplier's data sheets for safety and acceptable results.

5.1.2.3 *Tooling*—Molds, tooling, and jigs shall be used that produce an airframe which conforms to the engineering design in terms of part fit, assembly tolerances, defect size, and other requirements documented in the design.

5.1.2.4 *Fastening and joining*—Mechanical components such as fittings, pushrods, rotor structures and fittings shall be properly secured using safety wire, thread locking adhesives, crimping, welding or other effective means of restraining mechanical components.

5.1.2.5 *Lubrication*—Where lubrication of fittings is used, the manufacturer shall ensure that the lubricant used is appropriate to the application, thermal range and predicted load.

5.1.3 *Propulsion:*

5.1.3.1 *Motor/engine mounting*—Consistent, accepted practices and assembly using materials such as epoxy, CA cements, and the like shall be applied in accordance with product supplier's data sheets for safety and acceptable results.

5.1.3.2 *Security*—Motor/engine/propeller mounting shall be verified to meet manufacturer/supplier specified torque levels and security.

5.1.3.3 *Dynamic balancing*—Prior to installation, propellers or rotors or rotor blades shall be statically and dynamically balanced per design specification.

5.1.3.4 *Propulsion batteries*—For electric propulsion systems, provisions in Specification F3005 shall apply.

5.1.4 *Systems*—Systems that can be shown not to be impacted by, or to impact on, other subsystems may be demonstrated independent of all-up functional verification of systems. For example, a launch sub system that has no interface with the flight control system may be demonstrated to meet functionality with an airframe or a dummy airframe.

5.1.5 *Payload:*

5.1.5.1 *Physical*—Payload(s) shall be mounted in the manner specified by the sUAS design or manufacturer's instructions (or both) with attention given to proper shock and vibration attenuations. Current draw from primary power systems (batteries, generators, and so forth) shall be verified during production and functionality of circuit protection and fusing shall also be verified. If the manufacturer allows payloads to be installed post-production, then specific requirements for the design installation, and test of these type payloads shall be specified in the aircraft flight manual developed in accordance with Specification F2908 or the maintenance and continued airworthiness documentation developed in accordance with Practice F2909. Maximum safe gross weight of the system shall be determined and payload weight shall not result in a gross weight that exceeds maximum determined safe gross weight.

5.1.5.2 *Effect on CG location*—Payloads shall be located as specified by the sUAS designer and center of gravity for each aircraft shall be verified with payload installed. This shall include center of gravity changes due to fuel consumption or in-flight offloaded payloads, or both.

5.1.5.3 *Accountability for system design changes*—No change in physical location of components may be made without engineering definition of the impact of such change on flight performance or electronic or electrical compatibility of command and control systems that are impacted by such change. Where a change in systems performance is predicted for such physical change, the change shall be validated to ascertain that system functionality will remain within specification limits. When such changes are made to accommodate issues such as unavailability of parts or material, those changes shall be documented in an engineering change order (ECO) using manufacturer's normally accepted format and processing/storage procedures.

5.1.6 *Ground Support Equipment:*

5.1.6.1 *Control station*—The control station may be as simple as a commercial off the shelf transmitter or as complex as a mobile shelter complete with control displays, C2 link receivers, warning devices, recording equipment, battery charging, independent electrical power and so forth. Whatever the production system, it shall be demonstrated as part of production acceptance to comply with the specifications of the system design and integration and supplier's specifications for the equipment used. The requirement is to ensure a consistent, known configuration that does not introduce errors in operation of the sUAS that can lead to degradation of the system or sUAS flight safety. Production verification shall include verification of the product for each control station produced to ensure that the sUAS will be controlled as required to comply with sUAS operational standards consistently.

5.1.6.2 *Launch and recovery systems (if required)*—The launch and recovery system may be as simple as hand launch or as complex as a bungee, pneumatic or hydraulic launcher. Whatever the production system, it shall be demonstrated to comply with the specifications of the system design and integration and suppliers specifications for the equipment used. The requirement is to ensure a consistent, known configuration that does not introduce errors in operation of the sUAS that can lead to system degradation, crew safety or sUAS flight safety. Production verification shall include verification of the product for each launch and recovery system produced to ensure that the sUAS will be launched safely within the launch envelope specified by manufacturer If applicable the launch system shall meet the requirements of F2585.

5.1.7 *System Level:*

5.1.7.1 *Configuration management plan*—The sUAS manufacturer shall develop a configuration management plan to ensure that a standard configuration for each sUAS is established and maintained and to provide objective evidence of production conformance to specifications and continued effectiveness of the quality management system.

5.1.7.2 *Product specification*—The sUAS characteristics shall be documented in a product specification in the manufacturer's normal accepted format. In this specification, the sUAS standard configuration shall be defined to provide a basis for product verification testing.

5.1.7.3 *Product verification plan*—A product verification plan shall be developed to ensure the following activities are included in the formal verification testing of the sUAS required in 5.1.7.4.

(1) Engineering design—The production of the sUAS shall be based on the standard configuration report and released engineering data (that is, drawings, processes, specifications, and so forth) in the manufacturer's normal accepted format that are specifically associated with that configuration. Design modifications required to meet production contingencies shall be documented in an ECO for that change and the change shall be identified by serial number block.

(2) Assembly instructions—Appropriate assembly instructions in the manufacturer's normal accepted format shall be used to assure the uniformity and repeatability of production processes.

(3) Tooling—Tooling appropriate to the sUAS design shall be used to assure control of critical dimensions and the repeatability of production from unit to unit.

(4) Material inspection—Manufacturers shall ensure that suppliers of material items (raw material, components, and assemblies) are in compliance with consensus standards for those material items. Incoming materials and equipment to be installed in the sUAS shall be inspected for proper configuration and quality of workmanship before their use. Inspections may be performed at the supplier's location or the manufacturer's location or both.

(5) In-process inspection—When appropriate, subassemblies of the sUAS shall be inspected (for proper configuration and quality of workmanship) before installation into the next higher assembly. Production plans shall delineate product flow with appropriate in-process inspection points identified.

5.1.7.4 *Design validation*—A formal validation of the sUAS component or system design shall be performed by the sUAS supplier or manufacturer in accordance with requirements in Specification F2910.

5.2 *System Level Production Acceptance:*

5.2.1 *Production In-Process Tests*—Major subassemblies of each sUAS shall be tested (as appropriate) to verify proper operation before their installation into the next higher assembly. These subassemblies can include, but are not necessarily limited to, the following:

5.2.1.1 *Structure*—Structures validated during engineering development and prototyping need be revalidated only if design changes or material and process changes are introduced that have not been validated during development and flight test of the design. In those instances, the segment of test for the structure that is affected by the design or material change shall be revalidated using the same procedure used during development.

5.2.1.2 *Propulsion*—The manufacturer shall subject a statistical sample of each serial block or model line of propulsion components to performance testing that validates that the propulsion system meets the supplier's stated performance.

5.2.1.3 *C2 links*—A production plan shall be generated and enforced by the manufacturer that ensures that all links involved are determined by production acceptance to meet the manufacturer's specification and the design requirements for the specific mission involved.

5.2.1.4 *Data link*—When a downlink is used to transmit information that is not necessary for command and control, that the link shall be tested to prove that it does not degrade primary flight control.

5.2.1.5 *Payload*—When a payload is used to generate the information or action needed for commercial function, any electric, thermal, or active payload shall be tested in the simulated operational environment to prove that the payload does not degrade primary flight control.

5.2.2 *Production Final Acceptance Test:*

5.2.2.1 The manufacturer shall test at least the first article sUAS in accordance with Specification F2910 to confirm that the design requirements and design operational capabilities are achieved in the final production systems. In this process, each design requirement shall be verified and the verification documented in the manufacturer's normal accepted format. This product verification shall be repeated for any major modification to the sUAS. If allowed or required by the nation's GAA, these product verification tests can also be performed by an independent entity.

5.2.2.2 All major components (air vehicle, control stations, launch and recovery equipment [if applicable], and the like) of the sUAS shall be tested by the manufacturer to ensure proper operation before shipment and operational use. Where major components are tested separately procedures shall be developed and implemented to ensure compatibility and proper function after shipment but before operational use. Testing of every production unit for range is not necessary since this is verified in the design, construct, and test phase.

5.3 *Quality Assurance*—Quality assurance shall be exercised across production in accordance with Specification F3003.

5.4 *Documentation:*

5.4.1 *General:*

5.4.1.1 *Configuration management plan*—A configuration management plan for use during production shall be prepared in the manufacturer's normal accepted format. The purpose of this plan is to ensure that consistency of the configuration of the sUAS in production is maintained.

5.4.1.2 *Aircraft flight manual*—An aircraft flight manual shall be prepared for each type sUAS. This document shall be prepared in accordance with Specification F2908.

5.4.1.3 *Maintenance and continued airworthiness documentation*—If not included in the aircraft flight manual, documentation that addresses maintenance and continued airworthiness shall be prepared in accordance with Practice F2909.

5.4.1.4 *Other maintenance manuals*—Other manuals may be prepared if desired or required by the manufacturer or nation's GAA or both. If such documents are required or desired they may be prepared in the manufacturer's normal accepted format.

5.4.2 *Production:*

5.4.2.1 *Standard configuration report*—A standard configuration report shall be prepared in the manufacturer's normal accepted format for each sUAS in accordance with section 5.1.7.1.

5.4.2.2 *Product specification*—A product specification shall be prepared in the manufacturer's normal accepted format in accordance with 5.1.7.2.

5.4.2.3 *Product verification plan*—A product verification plan shall be prepared in the manufacturer's normal accepted format for each sUAS in accordance with 5.1.7.3.

5.4.2.4 *Product verification report*—A product verification report that shows the results of product verification shall be prepared in the manufacturer's normal accepted format for each sUAS.

5.4.2.5 *As-built logs*—An "as-built log" shall be prepared in the manufacturer's normal accepted format for each delivered sUAS. In the log, the part number, name and serial number of each system configuration item shall be recorded. These records shall be retained by the supplier or manufacturer as long as the sUAS is in operational service. When a block of serial numbered sUAS are produced to the same specifications against the four documents listed immediately above, one as-built log will suffice for the block.

5.4.3 *Test:*

5.4.3.1 *Production in-process test report*—A production in-process test report for each delivered sUAS shall be prepared in the manufacturer's normal accepted format.

5.4.3.2 *Production final acceptance test report*—A production acceptance test report shall be prepared in the manufacturer's normal accepted format for each delivered sUAS in accordance with 5.2.2. These records shall be retained by the manufacturer as long as the sUAS is in operational service.

5.4.4 *Quality Assurance:*

5.4.4.1 *QA plan*—A QA plan for use during production shall be prepared in accordance with Specification F3003.

6. Keywords

6.1 production; small unmanned aircraft system; sUAS

Designation: F3002 – 14a

Standard Specification for Design of the Command and Control System for Small Unmanned Aircraft Systems (sUAS)[1]

This standard is issued under the fixed designation F3002; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This specification is provided as a consensus standard in support of an application to a nation's governing aviation authority (GAA) for a permit to operate a small unmanned aircraft system (sUAS) for commercial or public use purposes.

1.2 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

F2910 Specification for Design, Construction, and Test of a Small Unmanned Aircraft System (sUAS)

F2911 Practice for Production Acceptance of a Small Unmanned Aircraft System (sUAS)

F3003 Specification for Quality Assurance of a Small Unmanned Aircraft System (sUAS)

2.2 *EN Standard:*[3]

EN 62262 Degrees of protection provided by enclosures for electrical equipment against external mechanical impacts (IK code)

2.3 *IEC Standard:*[3]

IEC 60529 Degrees of protection provided by enclosures (IP Code)

3. Terminology

3.1 *Definitions:*

3.1.1 *bit error rate detection, BER, n*—rate at which errors occur in a transmission system; applicable to any system that transmits data over a network of some form in which noise, interference, and phase jitter may cause degradation of the digital signal.

3.1.2 *command and control (C2) link(s), n*—safety-critical radio-frequency (RF) link(s) between the ground control station (GCS) and the unmanned aircraft (UA).

3.1.3 *C2 range, n*—distance between GCS and UA at which positive control of the UA can be maintained.

3.1.4 *downlink, n*—any RF link from UA to GCS.

3.1.5 *flight control system, FCS, n*—composed of system components intended to take GCS commands via a C2 link and control flight control surfaces and propulsion systems.

3.1.5.1 *Discussion*—The FCS may include autopilot functions, lost-link functions, fly-away protection functions, payload functions, and navigation functions. The FCS may be contained in one discrete component or multiple discrete components.

3.1.6 *fly away, n*—unintended flight outside of operational boundaries (altitude/airspeed/lateral) as the result of a failure of the control element or onboard systems, or both.

3.1.7 *fly-away protection system, n*—a system that will return the UA safely to the surface, or keep the UA within the intended operational area, when the C2 link between the pilot and the UA is lost.

3.1.8 *ground control station, GCS, n*—a land- or sea-based control center that provides the facilities for human control of UA.

3.1.9 *licensed band, n*—any frequency or range of frequencies in which transmission requires permission from a governing body (for example, the Federal Communications Commission [FCC]).

3.1.10 *link error, n*—degradation of the digital signal between the GCS and the UA that can be monitored by techniques including BER detection.

3.1.11 *link integrity, n*—acceptable rate of transactions completed with undetected error.

[1] This specification is under the jurisdiction of ASTM Committee F38 on Unmanned Aircraft Systems and is the direct responsibility of Subcommittee F38.01 on Airworthiness.

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[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

[3] Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036, http://www.ansi.org.

3.1.12 *link timeout, n*—time between the actual lost-link event being validated and the system initiating the lost-link procedure.

3.1.13 *lost link, n*—occurrence in which the pilot in command (PIC) has lost the ability to control positively the sUAS because of degradation, loss or interruption of the necessary control or monitoring link(s), or both.

3.1.14 *manufacturer, n*—entity responsible for assembly and integration of components and subsystems to create a safe operating sUAS.

3.1.15 *pilot in command, PIC, n*—the pilot responsible for the operation and safety of the UA during flight time.

3.1.16 *positive control, n*—a condition in which commanded changes in the UA flight path result in the expected maneuver(s) within an expected period of time.

3.1.17 *small unmanned aircraft system, sUAS, n*—composed of the small unmanned aircraft (sUA) and all required on-board subsystems, payload, control station, other required off-board subsystems, any required launch and recovery equipment, and C2 links between the sUA and the control station.

3.1.18 *unmanned aircraft, UA, n*—airborne portion of the sUAS.

3.1.19 *uplink, n*—any RF link from GCS to UA.

3.2 *Acronyms:*

3.2.1 *BER*—Bit Error Rate

3.2.2 *C2*—Command and Control

3.2.3 *FCC*—Federal Communications Commission

3.2.4 *FCS*—Flight Control Station

3.2.5 *GAA*—Governing Aviation Authority

3.2.6 *GCS*—Ground Control Station

3.2.7 *GPS*—Global Positioning System

3.2.8 *HMI*—Human/Machine Interface

3.2.9 *PIC*—Pilot in Command

3.2.10 *RF*—Radio Frequency

3.2.11 *RFI*—Radio Frequency Interference

3.2.12 *RX*—Receiver

3.2.13 *sUA*—Small Unmanned Aircraft

3.2.14 *sUAS*—Small Unmanned Aircraft System

3.2.15 *TX*—Transmitter

3.2.16 *UA*—Unmanned Aircraft

4. Applicability

4.1 This standard is written for all sUAS that are permitted to operate over a defined area and in airspace authorized by a nation's GAA. It is assumed that one or more visual observers will provide for the sense and avoid requirement to avoid collisions with other aircraft and that the maximum range and altitude at which the sUAS can be flown will be specified by the nation's GAA. Unless otherwise specified by a nation's GAA, this standard applies only to UA that have a maximum gross takeoff weight of 25 kg (55 lb) or less.

5. Functional Architecture

5.1 A high-level functional block diagram of the C2 system is presented in Fig. 1.

6. General Requirements

6.1 The following are general C2 requirements involving the system components listed below:

6.1.1 All C2 system and UA components shall minimize RFI so as not to degrade C2 link performance below acceptable levels.

6.1.2 All C2 system and UA components shall minimize RFI so as not to corrupt data transmitted or received over the C2 link.

6.1.3 All C2 system electronic components shall be protected from impacts that may occur during normal operation (an impact rating of EN 62262 IK06 is recommended).

6.1.4 All C2 system electronic components shall be protected from environmental conditions that may occur during normal operation.

6.1.5 All C2 electronic devices shall be labeled with power requirements.

6.1.6 The C2 system's antenna, associated RF connections and System Acceptance Test Report shall be furnished as part of the C2 system.

6.1.7 Signal and power connectors for C2 electronic devices shall provide self-locking or positive locking connectors to ensure continuity of power and signal transmission during normal operation.

6.1.8 The C2 system shall provide for mounting to a fixed surface using rigid or semi-rigid fasteners. (Non-rigid fasteners, such as strings, rubber bands, and glue, are not permitted for this purpose.)

7. C2 System Spectrum Requirements

7.1 Small UAS operations using unlicensed bands shall be conducted in accordance with applicable regulations.

7.2 Small UAS operations using a licensed band shall obtain approval to use that band from the appropriate governing agency.

8. C2 Link

8.1 *Functional Requirements*—The C2 link shall provide C2 link status to the UA FCS to allow the UA FCS to initiate lost-link logic when C2 link connectivity is lost.

8.2 *Performance Requirements:*

8.2.1 The rate of C2 link transactions completed with undetected error shall not exceed 0.001 %.

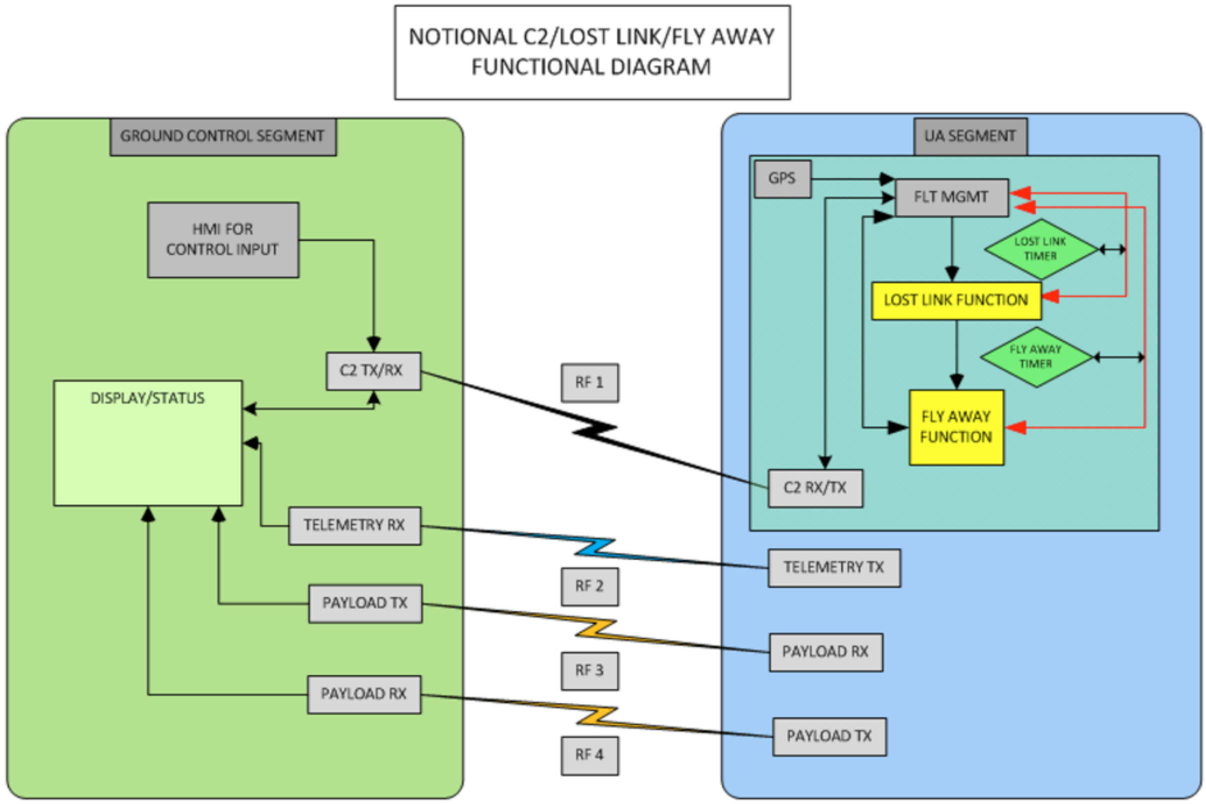
8.2.2 The C2 link shall be capable of transmitting the minimum set of data required by the GAA.

8.2.3 The C2 link shall be capable of receiving the minimum set of data required by the GAA.

8.2.4 The C2 link shall transmit all data that are safety critical as established by the manufacturer.

8.2.5 A loss of connectivity for longer than a maximum duration to be established by the country's GAA shall trigger a lost-link condition.

8.2.6 The C2 link shall prevent unauthorized ground control stations from pairing with or controlling the UA.



DESCRIPTION
On the Ground Station side, the Display function may be separate from the HMI control input function or contained within the HMI control input function
On the UA side, the light green box represents where the flight management, lost link function and timer, fly away protection function, potential navigation input (GPS) and the C2 RX and TX may reside. All of these functions could reside in one physical device or multiple devices.

RF links are depicted as individual link pairs-they may be in one radio or multiple radios, depending on regulatory requirements

The lost link function is depicted to be triggered prior to a fly away function

FIG. 1 High-Level Functional Block Diagram of the C2 System

8.2.7 The C2 link shall be rated by the manufacturer with maximum range.

8.2.8 C2 radios shall be labeled with operating frequency and channel information.

8.3 *Testing Requirements*—If a C2 downlink is required by the manufacturer for safety-of-flight or operational requirements, or both, the C2 link data integrity shall be monitored while C2 system elements are emitting RF and the GCS transmitter is operating at maximum transmission power.

9. GCS

9.1 *Operational Requirements:*

9.1.1 There shall be a means for verifying before flight that the fly-away protection system is capable of functioning properly during flight.

9.2 *Functional Requirements:*

9.2.1 If a C2 downlink is required by the manufacturer for safety-of-flight or operational requirements, or both, the GCS shall be capable of providing position and altitude data to the PIC.

9.2.2 If a C2 downlink is required by the manufacturer for safety-of-flight or operational requirements, or both, the GCS shall provide the capability to monitor the C2 uplink bit error rate.

9.2.3 If a C2 downlink is required by the manufacturer for safety-of-flight or operational requirements, or both, the GCS shall provide the capability to monitor the C2 downlink bit error rate.

9.2.4 If a C2 downlink is required by the manufacturer for safety-of-flight or operational requirements, or both, the GCS shall provide the capability to monitor link status.

9.2.5 If a C2 downlink is required by the manufacturer for safety-of-flight or operational requirements, or both, the GCS shall provide an alert to the PIC when a lost-link condition is entered.

9.2.6 If a C2 downlink is required by the manufacturer for safety-of-flight or operational requirements, or both, the GCS shall provide an alert to the PIC if the uplink or downlink message error rate exceeds 0.001.

9.2.7 If a C2 downlink is required by the manufacturer for safety-of-flight or operational requirements, or both, the GCS shall provide an alert to the PIC when an incompatibility is detected between the GCS and the systems with which it communicates.

9.2.8 If a C2 downlink is required by the manufacturer for safety-of-flight or operational requirements, or both, the GCS shall provide a lost-link condition status to the PIC.

9.2.9 A backup power supply capable of lasting long enough for a safe UA recovery shall be provided.

9.2.10 If warning lights are used, red shall signify a warning, yellow shall signify caution, and green shall signify satisfactory status.

9.2.11 If warning lights are used, a unique audible alarm tone consistent with the warning lights shall sound for a maximum of two seconds.

9.2.12 If a C2 downlink is required by the manufacturer for safety-of-flight or operational requirements, or both, displays of flight-critical information, including fuel level, battery status, and conformance with restrictions on airspeed, altitude, and lateral distance from the GCS, shall be made readily available to the PIC.

9.2.13 The GCS shall provide the capability of performing a reduced-range test to test link capability in situ.

9.3 *Interoperability Requirements:*

9.3.1 The GCS shall verify that it is configured to control the intended UA before flight.

9.4 *Design Requirements:*

9.4.1 If a C2 downlink is required by the manufacturer for safety-of-flight or operational requirements, or both, the GCS shall provide a visible indication of link status.

9.4.2 The GCS shall provide a manual or automatic means of interfacing a C2 link reduced-range attenuator between the C2 RF source and the link antenna.

9.4.3 The GCS shall provide a capability to test and measure the maximum RF output of the C2 link to and from the UA at a specified line-of-sight distance.

9.4.4 The GCS shall provide the operator an interface for interpreting the results of the C2 link reduced-range test.

9.4.5 The GCS shall prevent the PIC from launching the UA while the C2 link reduced-range attenuator is in use.

9.5 *Testing:*

9.5.1 The GCS transmitter maximum range value shall be tested.

9.5.2 The GCS receiver maximum range value shall be tested.

10. Unmanned Aircraft

10.1 *Operational Requirements:*

10.1.1 The responses to a lost-link condition shall include a combination of one or more of the following actions:

10.1.1.1 Landing the UA after the expiration of the C2 link timeout counter,

10.1.1.2 Returning the UA to the UA launch/takeoff location or some other previously designated location within the operation area,

10.1.1.3 Termination of the flight in a predictable manner after confirmation of lost link and the expiration of the C2 link timeout counter, or

10.1.1.4 Loitering within the operational area for a specified period of time before initiating one of the above three techniques.

10.2 *Functional Requirements:*

10.2.1 If a C2 downlink is required by the manufacturer for safety-of-flight or operational requirements, or both, the UA shall transmit position and altitude data to the PIC.

10.2.2 The UA shall record any occurrence of a lost-link condition.

10.2.3 The UA shall execute lost-link logic upon occurrence of a lost-link condition.

10.3 *Performance Requirements:*

10.3.1 The UA shall be capable of remaining in a contained area if one has been specified by the PIC.

10.4 *Interoperability Requirements:*

10.4.1 A C2 lost link shall not cause UA system failures.

10.4.2 The lost-link function shall be capable of executing after the C2 uplink capability fails.

10.4.3 The lost-link function shall be capable of executing after the C2 downlink capability (if one is required by the manufacturer for safety-of-flight or operational requirements, or both) fails.

10.5 *Design Requirements:*

10.5.1 The UA transmitter shall be labeled with operating frequency and channel information.

10.5.2 The UA receiver shall be labeled with operating frequency and channel information.

10.5.3 The UA antenna(s) shall be mounted such that the performance and functionality of the antenna are met regardless of UA attitude or orientation relative to the GCS.

10.6 *Testing:*

10.6.1 The UA transmitter maximum range value shall be tested.

10.6.2 The UA receiver maximum range value shall be tested.

11. Fly-Away Functionality

11.1 *Functional Requirements*—Any failure of fly-away functionality shall be recorded.

11.2 *Performance Requirements:*

11.2.1 The fly-away function shall be capable of executing after the C2 uplink capability fails.

11.2.2 The fly-away function shall be capable of executing after the C2 downlink capability (if one is required by the manufacturer for safety-of-flight or operational requirements, or both) fails.

12. Design Documentation and Change Requirements

12.1 Refer to Specification F2910, Practice F2911, and Specification F3003 for specific requirements on the following topics:

12.1.1 Quality assurance procedures,

12.1.2 Configuration control and documentation of changes, and

12.1.3 Verification and validation.

13. Keywords

13.1 permit; small unmanned aircraft system; sUAS

Designation: F3003 – 14

Standard Specification for Quality Assurance of a Small Unmanned Aircraft System (sUAS)[1]

This standard is issued under the fixed designation F3003; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This standard defines the quality assurance requirements for the design, manufacture, and production of a small unmanned aircraft system (sUAS).

1.2 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

F2910 Specification for Design, Construction, and Test of a Small Unmanned Aircraft System (sUAS)

3. Terminology

3.1 *Definitions of Terms Specific to This Standard:*

3.1.1 *manufacturer, n*—entity responsible for assembly and integration of components and subsystems to create a safe operating sUAS. The builder of kit built systems provided by a manufacturer must conform to the manufacturer's assembly and test instructions without deviation in order for that kit built system to meet this standard.

3.1.2 *permanent record, n*—records that shall be kept for each sUAS produced.

3.1.3 *propulsion system, n*—consists of one or more power plants (for example, a combustion engine or an electric motor and, if used, a propeller or rotor) together with the associated installation of fuel system, control and electrical power supply (for example, batteries, electronic speed controls, fuel cells, or other energy supply).

3.1.4 *quality assurance manual, QAM, n*—documentation of the quality assurance program.

3.1.5 *quality assurance program, QAP, n*—method of inspections used by the manufacturer to validate and ensure the proper production thereof.

3.1.6 *quality assurance record, QAR, n*—record of quality assurance associated with each sUAS produced.

3.1.7 *small unmanned aircraft system, sUAS, n*—composed of the small unmanned aircraft (sUA) and all required on-board subsystems, payload, control station, other required off-board subsystems, any required launch and recovery equipment, and command and control (C2) links between the UA and the control station. For purposes of this standard, sUAS is synonymous with a small Remotely Piloted Aircraft System (sRPAS) and sUA is synonymous with a small Remotely Piloted Aircraft (sRPA).

3.1.8 *supplier, n*—any entity engaged in the design and production of components (other than a payload which is not required for safe operation of the sUAS) used on a sUAS.

3.1.8.1 *Discussion*—Where the supplier is not the manufacturer, the supplier can only ensure that the components comply with accepted consensus standards.

3.2 *Shall versus Should versus May*—Use of the word "shall" implies that a procedure or statement is mandatory and must be followed to comply with this standard, "should" implies recommended, and "may" implies optional at the discretion of the supplier, manufacturer, or operator. Since "shall" statements are requirements, they include sufficient detail needed to define compliance (for example, threshold values, test methods, oversight, reference to other standards). "Should" statement are provided as guidance towards the overall goal of improving safety, and could include only subjective statements. "Should" statements also represent parameters that could be used in safety evaluations, and could lead to development of future requirements. "May" statements are provided to clarify acceptability of a specific item or practice, and offer options for satisfying requirements.

4. Applicability

4.1 This standard is written for all sUAS that are permitted to operate over a defined area and in airspace defined by a nation's governing aviation authority (GAA). It is assumed that a visual observer(s) will provide for the sense-and-avoid

[1] This test method is under the jurisdiction of ASTM Committee F38 on Unmanned Aircraft Systems and is the direct responsibility of Subcommittee F38.01 on Airworthiness.

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[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

requirement to prevent collisions with other aircraft and that the maximum range and altitude at which a sUAS can be flown will be specified by the nation's GAA. Unless otherwise specified by a nation's GAA this standard applies only to UA that have a maximum take off gross weight of 55 lb/25 kg or less.

4.2 If a QA manager of a manufacturer that meets a recognized QA standard (ISO, etc) develops and retains evidence that the provisions of that recognized QA standard meets the spirit and intent of this standard then that QA manager can state that the manufacturer's QA process meets the provisions of this standard. The manufacturer's QA manager shall ensure that supplier's QA processes meet applicable portions of this standard.

5. Quality Assurance Program (QAP)

5.1 Manufacturers of sUAS shall develop a QAP in accordance with the criteria established within this standard.

5.2 *Quality Assurance Manual (QAM)*—Manufacturers shall document their QAP in the form of a QAM.

5.3 *Quality Assurance Administration*—The manufacturer's administration charged with the implementation of the QAP may consist of one or more company employees, company officials, or manufacturer's agents or assigns. The individuals or entities that make up the quality assurance administration shall be identified within the QAM. The QAP methodology and any quality requirements flowing down to suppliers shall be documented in the QAM.

5.4 *Quality Assurance Record (QAR)*—A record shall be maintained of the date of acceptance and the origin of materials used in the production of system components considered by the manufacturer to be required for the safe operation of their sUAS (see Note 1 and 5.4.1).

NOTE 1—The intent of this record is to provide a means for the manufacturer to identify and reduce the number of sUAS within a fleet that may be affected by a materials anomaly that would require corrective action, thereby reducing the economic impact of such corrective action.

5.4.1 The manufacturer shall maintain a QAR for each sUAS produced. Each QAR shall consist of the following:

5.4.1.1 Applicable final inspection records, check, and test documentation from the production acceptance procedures (see Section 8).

5.4.1.2 A copy of the manufacturer's Record of Compliance.

5.4.1.3 The configuration of each sUAS at its point of delivery (for continued operational safety monitoring purposes), including associated parts lists, installed equipment lists, software version/versions, and a listing of all engineering changes and any deviations from the initial as designed/as tested configuration.

NOTE 2—Each item listed in 5.4.1 shall include the sUAS serial number and date of manufacture.

5.5 *Quality Assurance Revisions*—A system shall be implemented to ensure that only the latest revisions to the QAM are in use.

5.6 *Quality Assurance Audits*—The manufacturer shall conduct a biennial (every two years) audit of their QAP and maintain a record of all such audits. Any determination of noncompliance shall be resolved and a revision to the QAM shall be made if necessary to address any anomalies found.

6. Engineering and Manufacture

6.1 *Record of Compliance*—The manufacturer shall keep a permanent record of the design documentation used to show compliance for a particular configuration.

6.2 *Configuration Control*—All sUAS configurations in production shall have Records of Compliance to the latest released revision.

6.3 *Production Documentation*—The manufacturer shall maintain a record of all production documentation, including revisions to both manufacturing material, or assembly processes, or both. Production documentation shall include, but is not limited to, the following:

6.3.1 Parts lists,
6.3.2 Process sheets/routings,
6.3.3 Component and assembly drawings,
6.3.4 Manufacturing instructions and specifications,
6.3.5 Tooling and gauge drawings,
6.3.6 Software,
6.3.7 Tooling and test equipment calibration documentation, and
6.3.8 Manufacturing material tests.

6.4 *Special Processes*—A system shall be implemented to control all special processes and services related to the production of airframe components considered by the manufacturer to be critical to the structural integrity of the sUAS, such as welding, brazing, heat treatment, plating, structural composites, adhesive bonding, and others appropriate to the sUAS design, that ensures that each process and service is performed in accordance with approved specifications containing definitive standards of quality. Required periodic inspection or calibration, or both, of tooling, gauges, solutions, or any critical equipment used in special processes related to the production of sUAS shall be documented.

7. QA Inspections

7.1 Manufacturers shall implement and document in the QAP a system of inspections to validate conformity of product to all applicable engineering requirements and production specifications.

7.1.1 Conforming, nonconforming, and items awaiting inspection shall be segregated or clearly distinguishable. Items found to be nonconforming shall either be evaluated by a Materials Review Board (MRB) per 7.3 or rejected per 7.4.

7.2 *Receiving Inspection*—The manufacturer shall implement a purchasing procedure that shall ensure all items ordered are clearly specified. Incoming items provided by outside vendors shall be inspected for conformity to applicable specifications or production documentation or both. A record of such acceptance, to include the person accepting the material, shall be included in the permanent record.

7.3 *Evaluation of Nonconforming Items by a Materials Review Board*—A Materials Review Board (MRB) shall be established to determine the disposition of items that do not conform to all applicable engineering requirements and production specifications (nonconforming items) and shall consist of one or more manufacturer's designated technical representatives. MRB representatives shall be identified within the QAM. If analysis, additional inspection, functional checks, repair, rework, or a use "as is" determination assures that an item meets all of the relevant design requirements, the MRB may authorize its use in the production of a sUAS. Otherwise, the item shall be rejected.

7.4 The manufacturer shall keep a permanent record showing the disposition of nonconforming items that have been evaluated and accepted by the MRB. The QAR shall document the use of any nonconforming material.

7.5 *Rejection of Nonconforming Items*—A process for disposing of items found to be unusable due to damage, shelf life limits, or other variations shall be defined and implemented. A rejected item shall be mutilated, disposed of, or sufficiently marked as rejected to ensure that it is not used in the production of a sUAS. A rejected item may be secured in a reserved holding area for future disposition or disposal.

8. Production Acceptance

8.1 *Final Inspections*—The manufacturer shall verify and record that the QAR up to the point of acceptance testing is current for each sUAS produced prior to conducting the following production acceptance procedures.

8.2 *Final Testing*—The manufacturer shall validate the proper completion of any ready to fly sUAS by conducting a final system test in accordance with the requirements of Specification F2910.

8.3 *Instrument Calibration*—Any sUAS instrument requiring periodic calibrations shall have a calibration with traceability to a documented requirement (including currency) or tolerance. Tools or test equipment (pitot/static tester, compass, and so forth) used to calibrate a sUAS instrument, as well as all test equipment, should be documented and calibrated with traceability to a recognized standard.

8.4 *Resolution of Discrepancies*—The manufacturer shall develop and implement a system to correct any anomalies found during ground checks or flight testing and be documented in the QAP.

8.4.1 *Noncompliance*—Any sUAS that fails any production acceptance test required by this practice shall be physically tagged as noncompliant. Anomalies shall be reworked per manufacturer's instructions and each reworked anomaly shall be reevaluated.

8.4.2 *Noncompliance Tag*—A noncompliance notice shall be attached to the aircraft in such a manner that it is in clear view of a potential operator of the sUAS.

8.5 *Production Acceptance Documentation*—A written checklist may be used as an acceptable method of documenting production acceptance inspections, checks, and tests and shall be included in the QAR for each sUAS if one is used.

9. Assignment of QA Duties and Responsibilities

9.1 Duties for all QA representatives shall be documented and specify responsibilities and levels of authority.

9.2 sUAS manufacturers may assign QA duties and responsibilities to outside parties for the purpose of establishing satellite manufacturing, assembly, or distribution facilities, or a combination thereof. Any such assignment shall be documented in the QAP.

9.3 sUAS manufacturers shall establish training and evaluation programs for all personnel assigned QA duties and responsibilities.

9.4 The manufacturer shall take appropriate steps to ensure that persons performing the QA representative role can provide independent input on product conformity to the manufacturer's senior management.

10. Keywords

10.1 production acceptance; quality assurance; QA; small unmanned aircraft system; sUAS

Standard Specification for Batteries for Use in Small Unmanned Aircraft Systems (sUAS)[1]

This standard is issued under the fixed designation F3005; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This standard defines the requirements for batteries used in small Unmanned Aircraft Systems (sUAS).

1.2 This standard does not define requirements for the systems in which sUAS battery packs may be utilized.

1.3 This standard is subordinate to Specification F2910.

1.4 If allowed by a nation's GAA, certain sUAS may be exempt from this standard and may use commercial off-the-shelf (COTS) batteries in non-safety-critical payloads (lithium chemistries may not be exempted). Air transport regulations still shall be adhered to when air transport is used for COTS cells or batteries in bulk.

1.5 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

F2910 Specification for Design, Construction, and Test of a Small Unmanned Aircraft System (sUAS)

2.2 *Other Standards:*

ANSI/ASQ Z1.4-2008 Sampling Procedures and Tables for Inspection by Attributes[3]

UL 1642 Standard for Lithium Batteries[4]

3. Terminology

3.1 *Definitions and Acronyms*—The standard terminology for sUAS as defined in higher level standards applies in general to this standard except as noted below.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *C-rating, n*—maximum steady-state current (amps) at which the battery cell or pack may be discharged without having pack temperature exceed the CTT of its constituent cell(s) or result in a reduction in cell life. C-rating is expressed as a multiple of the capacity. For example, a battery with a nominal capacity of 4 Ah may have a C-rating of 5C, meaning that 20 A would be considered its maximum safe current.

3.2.2 *characteristic thermal threshold, CTT, n*—the temperature beyond which a rechargeable battery cell of particular chemistry and structure will exhibit permanent deterioration of its critical performance parameters as evident upon subsequent charge/discharge cycles. Cell capacity and internal resistance are critical performance parameters. CTT is rated at both upper and lower thresholds.

3.2.3 *depth of discharge, DOD, n*—ratio of cell or pack capacity expended relative to its nominal capacity.

3.2.4 *pack, n*—a single cell or composition of battery cells connected in series or in parallel or both plus monitoring electronics, structure, and connector(s).

3.2.5 *pack assembler, n*—that supplier which performs the manufacturing processes that integrate the essential components into a functional pack. In the event that multiple suppliers are involved in the assembly process, the pack assembler is the supplier that performs the final electrical connection(s). One supplier may weld solderable tabs to a batch of cells, a second supplier may connect circuitry, wiring and a connector, and yet a third may install the assembly in a plastic housing. In this example, the second supplier would be the pack assembler.

3.2.6 *shall versus should versus may, v*—use of the word "shall" implies that a procedure or statement is mandatory and must be followed to comply with this standard, "should" implies recommended, and "may" implies optional at the discretion of the supplier, manufacturer, or operator. Since "shall" statements are requirements, they include sufficient detail needed to define compliance (for example, threshold

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[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

[3] Available from American Society for Quality (ASQ), 600 N. Plankinton Ave., Milwaukee, WI 53203, http://www.asq.org.

[4] Applicable only to 5.1 on cell suppliers.

Available from Underwriters Laboratories (UL), 2600 N.W. Lake Rd., Camas, WA 98607-8542, http://www.ul.com.

values, test methods, oversight, reference to other standards). "Should" statement are provided as guidance toward the overall goal of improving safety and could include only subjective statements. "Should" statements also represent parameters that could be used in safety evaluations and could lead to development of future requirements. "May" statements are provided to clarify acceptability of a specific item or practice and offer options for satisfying requirements.

3.2.7 *small unmanned aircraft system, sUAS, n*—composed of the small unmanned aircraft (sUA) and all required on-board subsystems, payload, control station, other required off-board subsystems, any required launch and recovery equipment, and command and control (C2) links between the sUA and the control station. Since any one of the preceding subsystems may affect reliability and thus safety of the sUAS, batteries used in those subsystems shall comply with this standard unless failure of the battery will not compromise safety. For purposes of this standard sUAS is synonymous with small Remotely Piloted Aircraft System (sRPAS), and SUA is synonymous with a small Remotely Piloted Aircraft (sRPA).

3.2.8 *supplier, n*—any entity engaged in the design or production of a battery pack or any component of a pack intended for use in a sUAS. The *cell supplier* is the manufacturer of the fundamental cell(s) constituent in a battery core. Various suppliers contribute to the production of a pack, and any differences between them are described both explicitly and by context throughout the document.

3.3 *Acronyms:*

3.3.1 *COTS*—Commercial off the Shelf

3.3.2 *CTT*—Characteristic Thermal Threshold

3.3.3 *DOD*—Depth of Discharge

3.3.4 *IC*—Internal Combustion

3.3.5 *Li*—Lithium

3.3.6 *LiFe*—Lithium Ferrite (commonly used, abbreviated reference to $LiFePO_4$)

3.3.7 *$LiFePO_4$*—Lithium Iron Phosphate

3.3.8 *LiIon*—Lithium Ion

3.3.9 *LiPo*—Lithium Polymer (commonly used term for a package-specific variation of the Lithium Ion chemistry)

3.3.10 *MSDS*—Material Safety Data Sheet

3.3.11 *NiCd*—Nickel Cadmium

3.3.12 *NiMH*—Nickel Metal Hydride

3.3.13 *PCM*—Protective Circuit Module

3.3.14 *PVC*—Polyvinyl Chloride

3.3.15 *SDS*—Safety Data Sheet

3.3.16 *SLA*—Sealed Lead Acid

3.3.17 *sUAS*—Small Unmanned Aircraft System

3.3.18 *UAS*—Unmanned Aircraft System

3.3.19 *UN-GHS*—United Nations Global Harmonization System

4. Applicability

4.1 This standard relates to and is referenced by other sUAS standards at the sUAS system level as listed in Section 2. This standard is mandatory at any point in the sUAS system in which batteries are used, except for payload downlinks that have no effect on flight safety.

4.2 This standard is written for all sUAS that are permitted to operate over a defined area and in airspace defined by a nation's GAA. Unless otherwise specified by a nation's GAA, this standard applies only to UA that have a maximum takeoff gross weight of 55 lb/25 kg.

4.3 Criticality of this standard is derived from safety risk analysis. The following failures are critical and are listed hierarchically, the first being the most critical:

4.3.1 Loss of independent power for flight termination by any means requiring battery power, resulting in inability to terminate the flight safely;

4.3.2 Failure of primary power for the FCS resulting in loss of control to permit safe flight or recovery;

4.3.3 Failure of ignition power (if a battery is utilized instead of a magneto, alternator, generator or the like for internal combustion) or primary power for electric propulsion, creating the inability to return the sUAS to base and creating a ground impact hazard.

5. Cells

5.1 *Responsibility of Cell Suppliers*—As a minimum, the cell supplier shall possess and provide the following:

5.1.1 *Process Control Plan* for the specific cell being provided, including *Quality Control Procedures* and *Recording Methods*.

5.1.2 A *Quality Assurance Plan* for the specific cell being provided, including compliance with UL 1642 requirements for cells.

5.1.3 *MSDS*, also known as SDS per the UN-GHS for chemicals classification.

5.1.4 *Technical Data Sheet* shall be a formal document, not preliminary or informal. The manufacturer's datasheet shall include specification of the upper CTT.

5.1.5 Every cell shall be marked with its *Lot Number* and *Supplier's Name* to aid failure analysis, facilitate traceability, and minimize the extent of a recall should such action become necessary.

5.2 *Responsibility of Pack Assembler:*

5.2.1 *Lot Testing*—A sample from each lot of cells shall be subjected to capacity testing and physical inspections. The capacity test and physical inspections may, but are not required to be performed on the same cells. Sampling shall be in accordance with ANSI/ASQ Z1.4-2008. Any alternate plan must be approved by the GAA. The sampling plan shall accept on zero defects.

5.2.1.1 *Capacity Test*—The sample shall undergo one complete charge-discharge cycle to verify the integrity of the lot. A charge-discharge cycle is defined as a full charge followed by a full discharge to the depth specified by the cell manufacturer or as typical for the subject chemistry.

5.2.1.2 *Physical Inspection*—Physical inspections shall be performed on the sample. A subject cell is to be rejected for any of the following conditions:

(1) Swelling;

(2) Electrolyte leakage;

(3) Out-gassing;

(4) Odor, even in the absence of visible electrolyte leakage, an obvious odor shall be considered evidence of a deteriorated cell;

(5) Deformed or damaged casing;

(6) Punctures;

(7) Tab condition—Seals are to be undamaged, and welds are to be unbroken and of satisfactory quality. If a cell is supplied with a PCM connected, accessible solder connections to the tabs shall also be inspected. If a solder connection is unacceptable, it may be reworked by the pack assembler.

5.2.2 *Received-Voltage Test*—The pack assembler shall measure this voltage on every cell in the lot. The measurement shall be made before any load or charge has been applied to the cell. The measurement is taken directly at the cell tab, bypassing any protection circuitry that may be connected. In the event that a cell's received voltage is outside limits that are normal or recoverable for the particular chemistry, the cell shall be rejected. The received voltage shall not vary significantly from what is considered the typical chemistry-specific storage/shipping voltage or the mean measurement for the bulk of the lot. The received voltage for a lot will typically vary little from cell to cell and certainly should remain within a 10 % window. (For example, a LiPo will normally be shipped in a half-charge state, holding at about 3.8 V). If the cell is outside the storage/shipping voltage, the cell shall undergo the capacity test and physical inspections of 5.2.1 to ensure its integrity. The received-voltage test may be performed as part of the assembly process rather than as an incoming test if the lot will be utilized for production before significant self-discharge occurs.

5.2.3 *Records and Certifications*—The pack assembler shall obtain and make available to the GAA and the procuring entity pertinent information regarding the pack assembly. These data shall be available so long as that pack model is marketed or sold and for a minimum of three years thereafter. These data shall either be shipped with the pack(s), provided upon request or be accessible by other means such as the pack assembler's website:

5.2.3.1 *The technical data sheet from the cell supplier for cells used in the pack*;

5.2.3.2 *The MSDS (also known as SDS per the UN-GHS for chemicals classification) for the cell type used in the pack*;

5.2.3.3 *The data items, by lot*, listed under 5.1.3 – 5.1.5 (that is, the pack assembler is to carry forward the data provided by the cell supplier);

5.2.3.4 *Pack assembler's specified shipping/storage voltage*—These data are not intended to be a record of measured voltage for each pack but to stipulate the voltage range that the procuring entity can expect to measure upon receipt of a pack for the particular chemistry;

5.2.3.5 *The lot number of constituent cells used in a pack traceable to the pack serial number*;

5.2.3.6 *Date of manufacture of the pack*—As defined in Section 6, the date may be codified in the serial number.

5.2.4 *Pack Assembly Requirements*—A multi-cell pack shall not contain cells from more than one lot. An exception may be made if three conditions are met: *(1)* the date of manufacture of the cells are within a six-month span; *(2)* all cells to be used in the pack are tested for capacity and found to be within 5 % of each other; and *(3)* all of the cells were manufactured recently enough to be considered acceptable for use in new construction for the particular chemistry.

5.2.5 *Final Test*—As a minimum, each completed pack shall be subjected to two charge-discharge cycles, following which the pack shall be charged to its appropriate, chemistry-specific shipping/storage voltage. A charge-discharge cycle is defined as a full charge followed by a full discharge to the depth specified by the cell manufacturer or as typical for the subject chemistry. The pack shall demonstrate its rated capacity by means of this testing to be acceptable for delivery to the procuring entity.

6. Mechanical Design and Assembly

6.1 *In-Process Quality*—The assembly process shall be devised such that it is conducive to observation of the physical conditions listed in 5.2.1.2. This requirement does not stipulate inspection of cells beyond lot testing but rather is intended to maximize exposure of the cells to visual scrutiny during assembly.

6.2 *Cell Connections*—Cells shall be interconnected using techniques that minimize failure caused by vibration and impact. If tab-to-tab connection of individual cells is used to form a pack, the connection shall be resistance-welded to the individual cell terminal. If cells are interconnected using double-sided printed circuit connecting boards, these boards shall have plated-through tab slots or holes.

6.3 *Wiring*—All power and cell-sensing wiring shall be strain relieved at the junction with the cell or interconnect tabs and secured at a point before exiting the pack.

6.4 *Vibration*—The pack assembly may be surrounded with impact and vibration-absorbent material such that the assembled pack meets governing-body requirements for shipment by air.

6.5 *Puncture Resistance*—An assembled pack having one or more non-rigid cells shall be housed in a protective material that provides resistance to mechanical penetration beyond that of the bare, unprotected cell. LiPo cells are one such example of a non-rigid cell and shall as a minimum be sheathed in a conforming PVC wrap or other similar material. Other means of housing non-rigid cells, such as a plastic or metal casing may be employed. If the pack is being designed for a specific system, the required protection shall be defined at the system level, taking into consideration the form of propulsion (IC or electric) and whether the sUAS will be carried on another aircraft for launch.

6.6 *Identification*—Pack identification is required as follows:

6.6.1 *Supplier*—The pack assembler defined in 3.2.5 shall be identified by name on the pack (a company logo is not sufficient labeling);

6.6.2 *Capacity*—The pack capacity, rendered in Amp-hours (Ah) or milli-Amp-hours (mAh) shall be stated on the pack.

6.6.3 *Serialization*—The pack assembler shall serialize the final pack assembly and maintain records that correlate cell lot number with battery pack serial number (see 5.2.3.5). Records shall also identify the date of manufacture of the pack assembly. A serial number that contains a date code is an acceptable means of documenting the date (for example, YYMMXXXX, YYWWXXXX).

6.6.4 *Safety Warnings*—Appropriate safety warnings particular to the battery chemistry shall be affixed to the pack. In the case of packs too small or otherwise unable to accommodate all such warnings, the information may appear on the smallest quantity container in which the pack(s) are shipped. The following shows an example of a typical warning label for a lithium battery:

CAUTION:
DO NOT DISPOSE OF IN FIRE
DO NOT HEAT ABOVE 60C (140F)
DO NOT DISASSEMBLE
DO NOT PUNCTURE OR CRUSH
DO NOT ALLOW TERMINALS TO SHORT
SEE OWNER'S MANUAL FOR ADDITIONAL DETAILS

6.6.5 *Recovery Identification*—The outer pack enclosure or larger portion thereof shall by some means be yellow in color to provide easy identification at a crash site. Some portion of the yellow coloring shall be discernible when viewed from any angle.

7. Electrical Design

7.1 Cells used for sUAS are anticipated to be NiCd, NiMH, LiIon, LiFe, $LiFePO_4$, LiPo, or SLA. The use of any of these chemistries is anticipated in applications in which primary power is an IC engine. Electric propulsion systems are likely to use LiIon, LiFe, or LiPo cells because of the demand for superior power density. Vented lead acid cells shall not be used in sUAS. The electrical design and performance criteria are as follows:

7.1.1 *Capacity*—The capacity stated on the pack label is to be based either on the typical capacity of a newly manufactured pack or that of a "broken-in" pack, *whichever is less*. The "broken-in" capacity is defined as the typical capacity observed at the flattest portion of the life-cycle curve for the pack. Data on the broken-in capacity of constituent cells may be used to aid in determining the broken-in capacity of a new pack design if these data exist. The pack designer shall perform the testing and research on the pack design necessary to ascertain capacity before stating it on pack marking or by other means of advertising. The capacity test should be done under lab conditions of 25C, ambient humidity and no forced cooling. The capacity of any pack that carries a nominal claimed capacity should be within 1 Sigma of the nominal capacity so stated in which the statistical sample is 100%.

7.1.2 *Charge*—Before storage or shipping from the pack assembler, the pack shall be charged/discharged to a level that is optimal for transport and long-term storage for the particular chemistry.

7.1.3 *Wiring*—Wiring used shall be of sufficient gauge and capacity that the wire temperature does not exceed the thermal rating of the insulation type during highest normal expected load.

7.1.4 *Connectors*—Any connector that is part of the pack assembly shall conform to the following criteria:

7.1.4.1 *Contacts*—Connector contacts shall be gold-plated or otherwise treated to optimize conductivity and to aid in the prevention of oxidation or corrosion. Contact resistance shall be low enough that the connector body temperature does not exceed temperatures that would cause failure of the connector materials or pose other hazards to the pack under the highest normal expected load during discharge.

7.1.4.2 *Configuration*—The connector may include heavy-duty pins for power and smaller pins for the cell-balance nodes in packs with series-connected cells. If single pins are used for main power and return lines, the pin itself shall have multiple points of contact (at least two) to preclude power failure as a result of loss of a single point of contact. Alternatively, the use of multiple single-point pins may be employed to satisfy the need for redundancy.

7.1.4.3 *Non-Electrical Materials*—Connectors shall be selected having housing material that is rated to withstand temperatures at which the particular cell chemistry can operate safely.

7.1.5 *Node Access*—The design shall provide connector access to the nodes between individual serial sub-packs or cells. Charge of pack end-to-end voltage alone is not satisfactory; the intra-cell nodes in any pack with series-connected cells shall be accessible to facilitate monitoring of overcharge conditions. Even if a pack design includes integrated cell-balancing, a node access connector shall still be included to facilitate a sUAS which might monitor node voltages for safety purposes. Alternatively, a pack with integrated cell-balancing or other self-monitoring circuitry may provide the node voltage or other sufficient health information through a data bus rather than a node access connector.

7.1.6 *Thermal Performance*—Life cycle and cell capacity deteriorate when a cell reaches temperatures beyond the characteristic thermal threshold (CTT) specific to the particular chemistry. In the case of lithium chemistries, as an example, the upper CTT has been found to be 140°F (60°C). The battery pack shall therefore be designed to minimize internal heat generation during operational discharge. Effects of cell internal resistance, tab resistance and pack capacity should be considered in combination when evaluating their effect on self-heating. If a continuous discharge current is to be specified or advertised for the pack, that rating is to be for operation at no greater than the CTT of its constituent cells. Performance to this criteria shall be validated and recorded by the pack designer or other supplier's operational testing.

8. Maintenance

8.1 Maintenance of the pack and the recording of maintenance data is the responsibility of the user. The pack chemistry and demands of the application determine the frequency of periodic testing required to evaluate the performance of the pack throughout its life cycle. The designer of the sUAS system shall perform a reasonable amount of testing to determine this frequency and the minimum capacity that is required for the pack to be deemed flight-worthy.

8.1.1 *Charging*—Charging systems designed for the specific battery chemistry shall be used. Multi-chemistry chargers are acceptable but shall be programmed such that the specific pack chemistry is charged accordingly.

8.1.1.1 *Series-Cell Balancing (Lithium Chemistries)*—All Li batteries shall be charged using equipment that provides precise balance charging. Alternatively, a conventional bipolar charger may be used if the pack has integrated cell-balancing circuitry. For added safety, charging may be done in a flame- and explosion-resistant enclosure.

8.1.1.2 *Temperature Change (Lithium Chemistries)*—A decrease in capacity of a lithium cell can result from receiving a charge at low temperatures or from temperature decrease following a full charge cycle. A lithium pack should therefore be subjected to a load or protected from significant temperature decrease after receiving a full charge. To further aid in mitigation of this risk, the charging system should test the battery condition before charge, adjust for ambient temperature and provide recording and diagnostics for all charges.

8.1.1.3 *Physical Inspection*—Prior to charging, every pack shall be inspected per the criteria established by 8.1.4. If no defects are found the pack may be charged.

8.1.2 *Routine Evaluation*—Pack capacity should be measured and recorded once each 100 cycles during normal operations. The following provide guidance for the service-life of a pack:

8.1.2.1 *Test Marking*—As a minimum, the recording of data obtained by periodic testing should be implemented by labeling the individual pack with its capacity and the date on which it was tested.

8.1.2.2 *High Utilization*—In an environment in which operations regularly require DOD exceeding 80 %, additional emphasis should be placed on periodic maintenance to ensure that adequate capacity is retained.

8.1.2.3 *Low Utilization*—Pack capacity should be validated and the data recorded in a battery log at any time a pack is utilized after storage for a period of three months or more.

8.1.2.4 *Service Limit*—Packs that have lost 20% of their rated capacity should be removed from service.

8.1.3 *Storage*—The pack shall be charged/discharged to a level that is optimal for storage based on the particular chemistry. All Li packs should be stored at approximately one-half capacity or at the supplier-specified charge level for long term storage any time a pack is out of service for more than one month.

NOTE 1—Most Li chemistries have very low self-discharge rates (depending on the current draw of any integral circuitry), but are susceptible to degradation if subjected to temperature decrease when left fully charged. Other chemistries have self-discharge rates that require that the pack be either float-charged periodically or charged cyclically once each month of storage. Recommendations provided by the supplier should be followed.

8.1.4 *Damage Evaluation*—A pack that has been involved in a crash or any event that has resulted in physical damage shall be evaluated to determine if it must be disposed of or if it is repairable and fit to return to service.

8.1.4.1 *Disposal*—The pack shall be disposed of if any of the following conditions are observed:

(1) Electrolyte leakage;

(2) Odor (even in the absence of visible damage, an obvious odor shall be considered evidence of a deteriorated pack);

(3) Punctured or crushed casing;

(4) Severe swelling (moderate swelling in LiPo packs is typical and not cause for disposal);

(5) Mechanically stressed electrical connector.

8.1.4.2 *Return to Service*—To be deemed fit for service; the pack shall be subjected to a complete charge/discharge cycle to verify its capacity is within the service limit per 8.1.2.4. A permanent record of the pack, identified by serial number shall be created describing the damage, the date of the incident and any repairs made.

9. Keywords

9.1 small unmanned aircraft system battery; sUAS system battery