NMSU ADS Orbiter UAS
FAA COA Application

Date:
Aug 16, 2007
Rev B

NMSU PSL UAS PROJECT:
Airworthiness Flight Operations
Aeronautics Defense Systems (ADS)
Orbiter Unmanned Aircraft System (UAS)
FAA Certificate of Authorization (COA)

Item: AW-1
Stage: 1
Date: Aug 2007
Issue Status: Open
Action: NMSU PSL
Project Specific: ADS Orbiter UAS
Compliance Target: FAA COA

FAA AVS UAS Program Office:
Aviation Safety, AVS
Aircraft Certification Service, AIR
Aircraft Engineering Division, AIR-100
Unmanned Aircraft System (UAS) Program Office, AIR-160
Attention: Doug Davis, Manager, UAPO

REFERENCE MATERIAL:

FAA Authorization/Certificate:
- FAA Certificate of Authorization, FAA Form 7711-2

FAA Regulation:
- FAR Part 47 – Aircraft Registration
- FAR Part 91 – General Operating and Flight Rules

FAA Order:
- FAA Order 8040.4, dated June 26, 1998, Safety Risk Management
- FAA Order 7610.4K, effective August 2004, Special Military Operations
- FAA Order 4040.26A, dated 3/23/01, Aircraft Certification Service Flight Safety Program
- FAA Order 8130.2, as amended, Airworthiness Certification of Aircraft and Related Products

FAA Advisory Circular:
- FAA AC 91-57, dated 6/9/81, Model Aircraft Operating Standards
- FAA AC 45-2C, dated 8/5/05, Identification and Registration Marking

U. S. Dept of Defense Guidelines:
- MIL-HDBK 516, as amended, Airworthiness Certification Criteria

RTCA SC-203 UAS Guidance Material:
- RTCA DO-304, Guidance Material & Considerations for Unmanned Aircraft Systems, dated March 22, 2007, Appendix I, Best Practices for Small Unmanned Aircraft Systems

International Civil Aviation Task Force Study:
- Joint JAA/Eurocontrol UAV Final Report, dated 11 May 2004, Annex 1, Guidelines for the Regulation of Light UAV Systems

SUBJECT:

Airworthiness Flight Operations Assessment Plan for ADS Model Orbiter UAS

STATEMENT OF ISSUE:

The FAA has no specific requirements for the airworthiness certification and operational approval of a UAS. This NMSU analysis and airworthiness determination is intended to present a method for providing substantiation relative to the airworthiness review and acceptance of the ADS Model Orbiter UAS for issuance of an FAA Certificate of Authorization (COA).

BACKGROUND:

Until UAS issues and concerns can be resolved satisfactorily, NMSU believes: (1) UAS operations are likely to remain segregated from manned aircraft, (2) UAS flights are to be operated with prescribed operating limitations and conditions, and (3) UAS operations will be conducted under specific defined special purpose operations.

Therefore, until UAS airworthiness codes and standards are developed and appropriate airborne equipment available (i.e., sense & avoid), the FAA process for the issuance of a COA or an experimental certificate is an appropriate step toward addressing UAS flight operations in the NAS.

NMSU UAS past initiatives have provided a structured framework of positive control and guidance to personnel essential in the conducting of safe UAS operations, but not limited to: flight testing, training of flight crew and other associated UAS personnel, assessing normal and emergency procedures, preparing standard operations procedures manuals, recommendations for operating limitations & conditions, and responding to matters of airworthiness and continued operational safety.

AIRWORTHINESS PLAN:

NMSU will recommend, based on previous experiences with certificates of authorizations, adequate limitations and conditions necessary to assure safe operations, that will include the estimated time or number of flights required to accomplish the program activity. This NMSU analysis is intended to resolve any concerns the FAA may have as part of the application for FAA COA for the ADS Orbiter UAS.

NMSU will also provide sufficient details to describe the areas over which the flights are to be conducted, including establishing geographical boundaries of the flight test area and any restrictions of flights over densely populated areas, congested airways, and takeoff, departure, and landing approach corridors, to ensure that hazards to other aircraft, persons, and property on the ground are minimized.

ANALYSIS:

Flight Operations of Light UA Systems

The Joint Aviation Authorities (JAA) and Eurocontrol UAS task force has concluded their final report dated May 11, 2004. This report included Annex 1, entitled “Guidelines for the Regulation of Light UAV Systems”. Light UAS covered by these guidelines are those with a maximum take-off mass below 150 kg, and a maximum speed not to exceed 70 kts. These aircraft are intended for operations within 500 meters of the UAS pilot, and not more than 400 ft above ground level.

The Europeans have detailed an approach to setting UAS safety standards “equivalent “ to manned aircraft using impact kinetic energy as the defining criterion. In developing these guidelines for the regulation of light UA systems, a similar approach is taken, with equivalence being shown against the existing model aircraft fleet.

Two scenarios have been considered (1) a free-fall from 400 ft (the maximum altitude permitted), and (2) maximum impact speed (set at 1.4 x maximum operating speed for fixed wing aircraft), or the terminal velocity, in the case of rotorcraft and lighter than air machines. These two scenarios represent the extremes of the operating envelope.

Compliance with the energy criteria derived from these scenarios will ensure that the ability of the UAS to cause damage or harm is constrained, no matter what the circumstances of the crash or the characteristics of the UAS.

In the maximum impact speed scenario, the factor of 1.4 has been introduced and is based on existing regulatory requirements for manned aircraft flutter prevention. Above this speed, it could be expected that the UA would structurally fail and break-up.

Note: The "free-fall" scenario is intended to address descent of the aircraft in an out of control situation due to failures of primary structure, flight controls, or other critical systems. Examples of such failures foe a rotorcraft would be the unrecoverable loss of the main rotor speed or separation of the main or tail rotor. For a lighter-than-air aircraft such failures could include the rupture or complete separation of the gas envelope.

The European JAA/Eurocontrol task force, with FAA participation, stipulated a single kinetic energy limit which a light UAS must not exceed when assessed against both impact scenarios. This limit has been established following a survey of existing model aircraft. The survey concluded that setting a mass limit of 75 kg or 165 lbs would be comparable with the majority of the existing model fleet.

The UAS survey established a 150 kg limit (twice that of the model aircraft). As the intent is to provide equivalency to with the model aircraft, the 75 kg mass (weight) and the 70 kts speed limitations took precedence in setting the energy level and in no case should the kinetic energy level exceed 95 KJ for higher masses.

Therefore, the regulatory concept for a light UAS uses impact kinetic energy as a basic criterion, where it is linked to the ability of the UA to cause damage and injury on the ground.

Mass of UAS (kg)	**Max Achievable Speed Level Flight (Vmax kts)**	**1.4 Vmax (m/s)**	**Kinetic Energy @1.4 Vmax (KJ)**
60	50	70	76
70	50	70	89
75	50	70	95
80	49	68	95
90	46	64	95
110	42	58	95
130	38	53	95
150	36	49	95

Flight Operations of ADS Orbiter UAS

It is noted that the Aeronautics Defense Systems (ADS) Model Orbiter maximum take-off weight is established at 7.6 kg or 16.76 lbs (far less than the minimum UAS mass shown above). The ADS Orbiter maximum design operating speed is established at 50 kts. Therefore, the 1.4 x Vmax speed computed for structural dynamic considerations, would be established at 70kts.

The impact velocity arising from the "free-fall" scenario will depend upon the aerodynamic drag characteristics of the falling object and so will be specific to the particular design of the UAS. Assuming negligible aerodynamic drag, an object with a mass of 80 kg, dropped from an altitude of 400 ft, will hit the surface at 68 kts, and result in an impact kinetic energy of 95 kilo joules (KJ) [see above].

In the case of the Orbiter, at a gross weight of 7.6 kg or 16.76 lbs , and a computed dive speed of 1.4Vmax speed = 70 kts, NMSU will show that the Orbiter impact kinetic energy level is less than 95 KJ.

Should the object, in fact, exhibit significant aerodynamic drag (without reliance upon any onboard parachute deployment system), impact velocity will be even less and a higher mass may be permissible.

It is noted that the Orbiter is equipped with an automatic parachute recovery system that can be deployed either on command of the operator or automatically at its preprogrammed recovery point.

For illustrative purposes, the table below shows the relationship between the mass and cross-sectional area of a bluff body (with a non-dimensional drag coefficient of about 0.9) arising from the proposed 95 KJ limit.

Mass of Body (kg)	Cross-Sectional Area of Bluff Body (sq meters)	Kinetic Energy at Impact (Kilo Joules) [KJ]
80	0 (negligible drag)	95
115	0.5	95
130	1.0	95
150	1.5	95

From the data presented above, it can be seen that for the Orbiter, and any UAS with a mass of less than 80 kg or 176 lbs, will meet the "free-fall" criterion whatever its drag characteristics and so it need only be considered against the maximum impact speed scenario (first table). If the mass is 80 kg, the maximum achievable level speed must not exceed 49 kts. If the mass is equal to or less than 75 kg, the maximum achievable level speed must not exceed 50 kts. The ADS Orbiter has the same maximum operating level flight speed of 50 kts but its gross take-off weight is significantly less than the 75 kg established for a model aircraft.

Orbiter Kinetic Energy Computation

Kinetic Energy:
W = ½ x M (lbs gravity) x (square of the speed (ft/sec)) = ft-lbs

Conversion Factors:
Pounds (lbs) = kilograms (kg) x 2.205
Joules (J) = foot-pounds (ft-lbs) x 1.356
Knots (kts) = feet/sec x 1.689
Ft/Sec = 0.5921 x kts

Given:
M = Orbiter Gross Weight = 7.6 kg
M = 7.6 kg x 2.205 = 16.76 lbs
V = Orbiter Maximum Operating Level Flight Speed = 50 kts

1.4Vmax = 1.4 x Orbiter Maximum Operating Level Flight Speed
1.4Vmax = 1.4 x 50 kts = 70 kts
1.4Vmax = 70 kts x 0.5921 = 41.45 ft/sec

Note: 1.4 speed factor addresses existing regulatory requirements for structural dynamic considerations and is established for manned aircraft flutter prevention

Calculation:
W = ½ x 16.76 lbs x (square of 1.4Vmax in ft/sec)
W = ½ x 16.76 lbs x (square of 41.45 ft/sec)
W = ½ x 16.76 lbs x 1718 ft/sec = 14397 ft-lbs
W = 14397 ft-lbs x 1.356 = 19522 joules
W = 19.522 Kilo Joules (KJ)

The Orbiter computed kinetic energy is approximately 20 KJ which is significantly less than the allowable maximum limit of 75 KJ for a model aircraft and the maximum established 95 KJ for a UAS.

Orbiter Minimum Safe Operating Altitude

It is noted that the manufacturer has established a minimum operational safe altitude for the Orbiter as follows: (1) 500 ft AGL and (2) 1000 ft above data-link LOS (reference Limitations and Data, pg L-1) (see Appendix C). Accordingly, NMSU will request as part of the COA application, a minimum safe operational altitude not to exceed 1200 ft.

Orbiter is equipped with an automatic parachute recovery system that can be deployed either on command of the operator or automatically at its preprogrammed recovery point. The parachute recovery system is a required system for the Orbiter and will be used on each and every flight. Therefore, although the altitude is increased by three fold, the air vehicle should exhibit significant aerodynamic drag and the impact velocity should not exceed the energy limits established for the Orbiter.

NMSU Recommended Operating Limitations & Conditions:

1. Air Vehicle Configuration

- Orbiter may be operated at its maximum take-off weight of 7.6 kg.
- Orbiter may be operated at the maximum operating flight level speed of 50 kts (CAS).
- Orbiter has a computed impact kinetic energy of no more than 20 KJ < 95 KJ maximum allowable when assessed against both a high speed and free-fall impact scenarios.

2. Inspection Requirements

- Orbiter UAS will be inspected by NMSU to ascertain the applicability of these guidelines.
- Orbiter UAS is supported by test and analysis that demonstrates satisfactory evidence that the system is subject only to the provisions of these guidelines.

3. Certification and Registration

- Orbiter will not have a certificate of airworthiness.
- Orbiter will not be registered or bear markings of any type.
- Orbiter will be operated in accordance with the FAA COA and its restrictions.

4. Hazardous Operations

- Orbiter will not be operated in a manner that creates a hazard to other persons or property.
- Orbiter will not be allowed to perform acrobatic maneuvers.

5. Daylight Operations

- Orbiter will not be operated except between the hours of sunrise and sunset.
- Orbiter will not be operated when environmental conditions are such that the UAS pilot cannot adequately perform his/her function of preventing aerial collisions.

6. Operation near Aircraft: Right-of-Way Rules

- Orbiter to see and avoid other aircraft and shall yield the right-of-way to all aircraft.
- Orbiter shall not create a collision hazard with respect to any other aircraft.
- Orbiter shall not fly at a height exceeding 1200 ft AGL minimum safe operating altitude.

7. Operations near People or Property

- Orbiter will not be operated within 3 nautical miles of any congested area of a city, town, or settlement.
- Orbiter will not be operated within 500 ft of any person, vehicle, or structure not part of the operation.
- Orbiter will not be operated within 300 ft of any person other than the UAS pilot during take-off and landing.

8. Operations in Certain Airspace

- Orbiter shall not be operated within controlled airspace.
- Orbiter shall not be operated within any Special Use Airspace.
- Orbiter shall not be operated in airspace designated in a NOTAM relating to temporary restricted airspace established for reasons of aviation safety or national security.

9. Visual Reference

- The Orbiter will only be operated by visual reference of the pilot, unless, visual observer(s) are situated throughout the flight operations area to ensure that visual contact of the Orbiter is maintained at all times.

10. Flight Termination System (FTS)

- Orbiter will not be operated unless it is equipped with a functioning FTS that will immediately terminate its flight in the event of a failure of its control system, including the flight control data link.

Note: Orbiter is equipped with an automatic parachute recovery system that can be deployed either on command of the operator or automatically at its preprogrammed recovery point. A reusable airbag is incorporated in the design to inflate and protect the payload.

NMSU Preliminary Safety Risk Hazard Assessment:

ADS Model Orbiter UAS

The preliminary Hazard Analysis/Safety Assessment has taken into consideration the airworthiness of the Orbiter UAS, the pre-flight reviews (Independent Safety Review and Flight Readiness Review) that are a part of each mission, pre-flight briefing and post-flight critique, operating procedures, see and avoid procedures, volume of air traffic operations at the Las Cruces Airport and in the UA operating airspace, general weather conditions, density of population on the surface underlying the UA flight areas, and ATC and public awareness. The following are salient facts that provide details of the Hazard Analysis/Safety Assessment.

1. Airworthiness

The Orbiter UAS is considered airworthy and capable of operating safely and in conformance to the criteria as set forth in the foregoing airworthiness analysis and for its intended operation within the confines and provisions of the FAA COA. Condition type inspections will be conducted prior to each flight to validate airworthiness. The following Aeronautics Defense Systems (ADS) manuals (see list of appendices) and the CAA of Israel Special Permit for the Orbiter, contain important information that affects airworthiness and therefore is considered an integral part of the NMSU Orbiter airworthiness and operational suitability determination:

- ADS Orbiter Mini UAV System (see last pg for quick overview of UA specifications).
- ADS Orbiter PGCS Check List [white] (preflight check, normal procedures before launch, launch, and after launch, routine flight indicator monitoring, control handover, recovery, teardown, return home (RH) reset).
- ADS Orbiter Limitations and Data (L1 thru L4) [green] (UMAS limitations, UA airspeed limits, data-link, weather, battery power, parachute).
- ADS Orbiter Emergency Procedures (E1 thru E11) [yellow] (quick reference table that includes malfunctions, severity, and operator's actions, listing of malfunctions i.e., payload, battery power, flight controls, GPS/INS, engine power, PGCS software, data-link).
- ADS Orbiter Maintenance Manual, dated March 2007, P/N 990018, (contains but not limited to: maintenance concept and safety instructions, test equipment, preventive maintenance, levels O, I, and D maintenance schedules, packing, handling, storage, and transportation (PHST)).
- ADS Orbiter Description & Operation Manual, dated March 2007, P/N 990039, (contains but not limited to: system description i.e., mission capabilities, system characteristics, aerial platform, vehicle subsystems, propulsion system, power supply, aerial data-link, landing system, payloads, personal ground control station (GCS), ground support equipment (GSE), system operation i.e., personal control unit (PCU), performance data, deployment & teardown procedures).
- Civil Aviation Authority (CAA) of Israel Special Permit for ADS Orbiter UAS.

2. Pre-Flight Briefing and Post-Flight Critique

Before each flight, all NMSU personnel involved in the flight operation of the UA will meet together for a briefing on the mission plan, operating procedures, contingency procedures, and to ensure all personnel are knowledgeable of the intended flight operation procedures and understand their respective responsibilities. At the conclusion of each flight, a post-flight critique will be performed to evaluate the total operation with emphasis on identifying any deficiencies or problems. Any identified deficiency or problem will be corrected prior to the next flight.

3. Operating Procedures
Operating procedures are designed to achieve the safest operation possible. All launches and landing will be performed in a remote location. A NOTAM defining the flight operations airspace will be issued in advance of any flight operations. All flight operations will be consistent with 14 CFR 91 criteria.

4. See-and-Avoid Criteria
Direct visual observation of the UA will be maintained at all times, either through the use of visual observer(s) on the surface. The visual observer will operate within the stated FAA permissible distance parameters. Since the visual observer can see above and below as well as behind the UA, the actual safety factor is greater than that capable of a pilot in a manned aircraft.

5. Volume of Air Traffic
The planned Orbiter flights operations airspace is situated in a remote area and is adjacent to a portion of the White Sands Missile Range Restricted Area (R-5107B). The volume of air traffic within the proposed Orbiter flights operations airspace is extremely light, if any at all, due to the location and the very low altitude to be used.

6. Weather Conditions
Inherently, the weather conditions in the UA flight airspace consist of clear skies with unlimited visibility. No UA flights will be performed in marginal weather conditions.

7. Population Density
The UA flight operations airspace is located in the Southwest section of New Mexico. This is a very sparsely populated area, one of the least populated in the entire United States. The flight operations airspace is in a remote area without any populated areas beneath or in close proximity to the flight activity.

8. ATC/Public Awareness
An Orbiter project plan will be provided to the Albuquerque Air Route Traffic Control Center (ARTCC) at least seven days in advance of any flights. In addition, the appropriate Area Operations Supervisor in the Albuquerque ARTCC, will be notified of each intended flight a minimum of 1 hour in advance. Also, because of the close proximity to White Sands Missile Range (WSMR), advance coordination will be effected with appropriate organizations at WSMR. In addition, all pilots will have an opportunity to know about the UA flight activity by receiving information that is contained in the Notice to Airmen (NOTAM) that will be issued for each UA flight.

CONCLUSION:

ADS is a well established developer in Israel of various models of UAS such as the Aerostar and Aerolight which have collectively accumulated in excess of 20,000 flight hours. The Orbiter, a field level mini UA system for close surveillance and reconnaissance missions, has accumulated more than 500 flight hours. These systems have been used successfully in a number of countries throughout the world.

NMSU will ensure, in conjunction with the above approach, that the airworthiness determination is controlled by inspections of the design and construction, plus function and reliability (F&R) flights, flight testing of significant duration to ensure adequate stability, control, and performance characteristics, as may be deemed necessary. Oversight of these functions may be conducted by NMSU personnel on behalf of the FAA under the provisions of the COA and reported on a quarterly basis.

Along with the above supporting material, NMSU can make the Orbiter UAS available for FAA inspection, as required. NMSU will fly the system with its own pilots, within the restrictions imposed by the FAA COA.

NMSU AIRWORTHINESS FINDINGS:

The Orbiter, a mini unmanned aircraft system (UAS), (1) has its type design developed, manufactured, and tested by Aeronautics Defense Systems (ADS) of Israel, (2) is supported by descriptive and substantiating data that includes systems manuals (description & operation, maintenance, system checklist, limitations and data, and emergency procedures) [see appendices], (3) meets or exceeds the European "Guidelines for the Regulation of Light UAV Systems", (4) is recognized by the CAA of Israel by issuance of a special permit (experimental certificate), (5) has operating safety guidelines established by NMSU, and (6) is supported by a preliminary NMSU safety risk hazard assessment.

Note: Israel is a country with which the U.S. FAA has established formal relationships with the Israeli Civil Aviation Authority (CAA). A Bilateral Airworthiness Agreement (BAA) is in existence for the reciprocal acceptance of civil aeronautical articles and it is considered a full scope agreement that applies to all aeronautical products (aircraft, engines, and propellers), appliances, and components. Although the BAA and its airworthiness implementation procedures are not applicable to unmanned aircraft systems at this time, the FAA recognizes the technical competency of the CAA of Israel. Appendix G shows an English version of the Israeli CAA issued Special Permit (Experimental Certificate) for the ADS Orbiter UAS. It is currently in the renewal process by the CAA of Israel and will be made available to the FAA upon request.

Subsequent flight tests and operations demonstrations of the UAS will be conducted by NMSU personnel and in accordance with (1) special provisions in the FAA COA, and (2) NMSU PSL unmanned systems operations and validations program (USOVP) requirements that include standard operating procedures (SOP) and platform/mission specific operating limitations and conditions.

NMSU AIRWORTHINESS DETERMINATION:

Consistent with NMSU knowledge of what is required to achieve safe UAS flight operations, a commitment to ensure safety is maintained, and coupled with the analysis/assessment defined in the above factors for the ADS Orbiter UAS, NMSU has determined that (1) ADS Orbiter UAS is airworthy i.e., conforms to the manufacturer's established type design and is in condition for safe operations, and (2) injury to persons or property along the UA flight path is considered "extremely improbable" when operated in accordance with the provisions of the FAA COA.

Enclosures:
Appendix A – ADS Orbiter Mini UAV System
Appendix B – ADS Orbiter PGCS Check List [white]
Appendix C – ADS Orbiter Limitations and Data (L1 thru L4) [green]
Appendix D – ADS Orbiter Emergency Procedures (E1 thru E11) [yellow]
Appendix E – ADS Orbiter Maintenance Manual, dated March 2007, P/N 990018
Appendix F – ADS Orbiter Description & Operation Manual, dated March 2007, P/N 990039
Appendix G – Civil Aviation Authority (CAA) of Israel Special Permit for ADS Orbiter UAS