

**NEW MEXICO STATE UNIVERSITY (NMSU)
PHYSICAL SCIENCE LABORATORY (PSL)
TECHNICAL ANALYSIS & APPLICATIONS CENTER (TAAC)**

November 16, 2006

SUBJECT:

Airworthiness Operational Assessment

Determination:

New Mexico State University (NMSU), Physical Science Laboratory (PSL), Technical Analysis & Applications Center (TAAC) has determined that the Aeronautics Defense Systems (ADS) Model Aerostar UAS (serial numbers 617 and 618) are airworthy. This determination is based on these systems meeting (1) the guidelines contained in the Department of Defense Handbook entitled "Airworthiness Certification Criteria", MIL-HDBK-516A dated 5 February 2004, (2) Aeronautics Defense Systems (ADS) established manufacturer's type design for the Model Aerostar, and (3) TAAC's subsequent review, analysis, and flight operations/demonstrations of these systems.

NMSU PSL TAAC PROJECT:

Airworthiness Support Data
Aeronautics Defense Systems (ADS)
Model Aerostar Unmanned Aircraft System (UAS)

Action: NMSU PSL TAAC

Project Specific: ADS Model Aerostar UAS, S/N 617 and S/N 618

Compliance Target: FAA Certificate of Authorization (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, AIR-160

FAA Authorization/Certificate Ref:

- FAA Certificate of Authorization, FAA Form 7711-2

FAA Regulation Ref:

- FAR Part 91 – General Operating and Flight Rules
- FAR Part 21 – Certification Procedures for Products and Parts

FAA Order Ref:

- FAA Order 8110.4, as amended, Type Certification
- 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

U. S. Department of Defense Guidelines Ref:

- MIL-HDBK 516, as amended, Airworthiness Certification Criteria
- MIL-STD-882, as amended, Dept of Defense Standard Practice for System Safety
- NAVAIR Instruction 13034.1C, Flight Clearance Policy for Air Vehicles and Aircraft Systems

- Range Commanders Council (Range Safety Group) Supplement to Document 323-99, Range Safety Criteria for Unmanned Air Vehicles, Rationale and Methodology Supplement

STATEMENT OF ISSUE:

The FAA has no specific requirements for the airworthiness certification and operational approval of a UAS. NMSU PSL TAAC intends to present substantiation for the airworthiness review and acceptance of the ADS Model Aerostar UAS for issuance of an FAA Certificate of Authorization (COA), S/N 617 and S/N 618.

BACKGROUND:

Prior to issuance of a COA, the FAA Air Traffic Organization (ATO) will normally request a review by the Flight Standards Service (AFS). Specifically, the Flight Technologies and Procedures Division, AFS-400, evaluates each application to determine if risks associated with the operation have been acceptably mitigated. In some cases, AFS-400 will forward an application to the Aircraft Certification Service (AIR) for an airworthiness determination. Additionally, an application may be referred to the FAA Office of the Chief Counsel (AGC) for determination of the status of the applicant i.e., public or civil.

NMSU PSL TAAC program objective is to conduct flight operations as a public aircraft and employ an airworthiness approach that is based on compensating factors from an operational systems perspective that provides a minimum level of certitude no less than for a manned aircraft operating in the experimental category i.e., with prescribed operating limitations and conditions. Further that NMSU PSL TAAC shall establish an acceptable or minimum level of safety based on a system-wide validation approach, and ensure that flight operations are only performed over sparsely populated surface areas having light air traffic (ref: 14 CFR 91.305)

DISCUSSION:

Until UAS issues and concerns can be resolved satisfactorily, NMSU PSL TAAC believes: (1) these systems will likely be operated in restricted airspace, (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. Until UAS airworthiness codes and standards are developed and appropriate airborne equipment available (i.e., detect, sense & avoid), the FAA process for the issuance of a certificate of authorization (COA) is an appropriate step toward addressing UAS flight operations in the NAS.

NMSU PSL TAAC UAS past initiatives have provided a structured framework of positive control and guidance to personnel essential in the conducting of safe UAS operations i.e., TAAC UAV Systems & Operations Validation Program (USOVP) 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 PSL TAAC is submitting this substantiation document to the FAA for the purposes of (1) providing additional airworthiness support for the certificate of authorization (COA) application for the Aeronautics Defense Systems (ADS) Model Aerostar UAS in accordance with FAA AFS-400 UAS policy material, (2) validating the manufacturer's (Aeronautics Defense Systems (ADS)) established type design for the Model Aerostar UAS, S/N 617 and S/N 618, to include any modifications/changes incorporated on these systems, (3) demonstrating Aerostar UAS compliance in accordance with Department of Defense (DoD) Mil-Hdbk 516 entitled Airworthiness Certification Criteria, and (4) describing a strategic systems approach that focuses on UAS operational objectives at NMSU PSL TAAC.

It is the intent to provide supporting material in enough detail to outline the NMSU PSL TAAC flight operations of the Aerostar configuration, airworthiness, and program objectives. Additionally, NMSU PSL

TAAC recommends, 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 PSL TAAC Document is intended to address airworthiness issues and concerns the FAA may have regarding the application for certificate of authorization (COA) for the ADS Model Aerostar.

NMSU PSL TAAC 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.

ADS Manufacturer Model Aerostar Type Design

The ADS Model Aerostar UAS customers include the Israeli Defense Force (IDF), U.S. Navy, and others around the globe that perform many different types of special purpose operations such as the off-shore oil rig protection mission along the coast of Angola.

NMSU PSL TAAC owns two ADS Model Aerostar UAS (S/N/ 617 and S/N 618). These ADS systems were selected and purchased because of its reputation among international users, demonstrated quality of system design/flexibility and overall system reliability i.e., 8000 flight hours with the DH290 engine version (same as PMA263's Aerostar) and 22,000 flight hours with the Zanzottera 498 engine version (5000 hours with engine version 3) with no critical failures. The system is presently being flown in a number of countries and has accumulated more than 30,000 hours of flight time with three accidents in its history i.e., one electrical failure due to incorrect maintenance (DH290 engine version) and two engine failures during the engine version testing (from DH290 to Zanzottera). Appropriate corrective actions have taken place that includes modified maintenance procedures and changes to the Zanzottera engine version that includes fuel map, crankcase, and pistons.

NMSU PSL TAAC has in its possession descriptive and substantiating data, from Aeronautics Defense Systems (ADS) of Israel for its Model Aerostar UAS, to assist in the airworthiness/safety determination. ADS data is in the process of continuous improvement and generally provided as follows:

- UAS type design checklist.
- UAS minimum operator(s) qualifications.
- UAS reliability numerical and probability data.
- UAS electromagnetic compatibility/electromagnetic interference (EMI).
- UAS flight test reports and other test acceptance documentations
- UAS three-view drawing (air vehicle & ground control station [GCS] configurations).
- UAS software version description documents and a listing of associated computer software configuration items.
- UAS instructions for continued airworthiness of both the air vehicle & GCS, including maintenance manual documentation.
- UAS listing of service life for critical and/or essential systems & equipment (aircraft, engine, propeller, and ground control station).
- UAS safety design and failure analyses (e.g., failure modes & effects analysis (FMEA)), to include air vehicle, GCS, and the command & control features.
- UAS master drawing list (MDL) & appropriate drawings (subsystem/component level only (aircraft, engine, propeller, and GCS)), including any conformity inspection determinations.
- UAS master equipment list (MEL) (include both air vehicle & GCS essential equipment for command & control flight operations), also master minimum equipment list (MMEL).
- UAS aircraft flight manual (AFM) and/or UAV systems operations manual that define, but not limited to, the normal operations and emergency operations e.g., loss-link, engine-out, conflict avoidance deviations from flight plan, etc.

Note: Attached as reference material are ADS provided technical documents (1) Reliability, Availability, Maintenance, Safety (RAMS) Summary Report, (2) Failure Modes, Effects, Critical Analysis (FMECA), and (3) Fault Tree Analysis (FTA) (see Appendix I, J, and K respectively).

Based on Aeronautics Defense Systems (ADS) descriptive and substantiating data, the TAAC believes the ADS Model Aerostar UAS meets a level of certitude equivalent to other similar systems (e.g., Shadow, Hunter, Pioneer, etc). The Aerostar has accumulated in excess of 30,000 hours of operational flight worldwide during the last two years, and is able to demonstrate similar reliability and credibility with manned aircraft when operated in a controlled environment with appropriate prescribed operating limitations and conditions.

Department of Defense (DOD) Airworthiness Determination

The U.S. Department of the Navy, Naval Air Systems Command (NAVAIR), has issued a flight clearance for the Aeronautics Defense Systems (ADS) Model Aerostar UAS (S/N 602), in accordance with its policy and procedures for air vehicles and aircraft systems, and in accordance with the guidelines contained in U.S. Department of Defense Handbook 516, entitled “Airworthiness Certification Criteria”. The UAS flight clearance included the ground control station (GCS), data links, flight control system, communication systems and links, etc., as well as the air vehicle.

NMSU PSL TAAC has established a relationship with the U.S. Navy (PMA-263) flight team at Patuxent River Naval Air Station, MD. PMA -263 is the U.S. Navy’s unmanned aircraft system (UAS) test and evaluation branch and has extensive experience with the operations of the Aerostar since 1999. An open dialog exists between TAAC and PMA-263, and system changes, operating procedures, and configurations are discussed with the UAS manufacturer. TAAC’s UAS (S/N 617 and S/N 618) are similar to PMA-263 (S/N 602) and training for maintenance, operators, and system configuration control is coordinated as a common system by the UAS manufacturer (ADS). NMSU PSL TAAC reviewed modifications and other improvements on S/N 617 and S/N 618 and has determined that these changes will introduce no adverse effect on system airworthiness.

The NAVAIR flight clearance process involves an independent engineering assessment of airworthiness, safety of flight, and unusual risk. The airworthiness determination addresses the air system configuration to safely attain, sustain, and terminate flight in accordance with approved usage limitations. The safety of flight determination includes prescribed and accepted limits for injury/death to personnel and damage to equipment, property, and/or environment. Sufficient performance data information has been generated and provided to certify the air vehicle for flight operations within restricted military use airspace and also outside confined/protected areas, provided FAA authorization is obtained.

Civil & Public Certification Compatibility

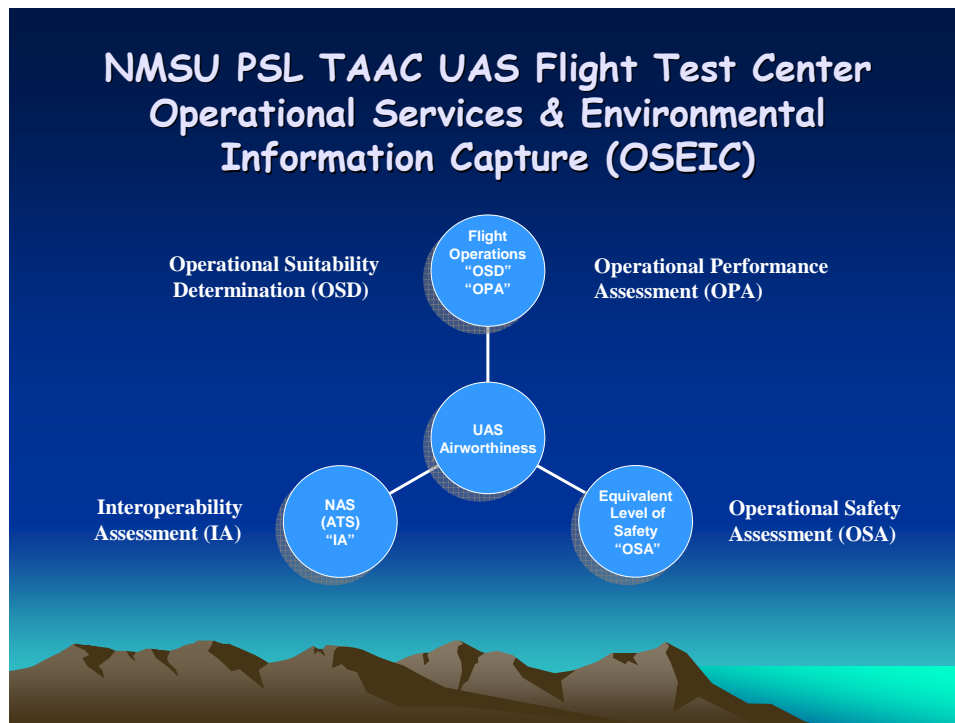
	Civil (14 CFR) Process	Public (OSS&E) Process
Customer	Airline	Major Command (MAJCOM)
Certification Authority	FAA	Single Manager
Compliance Agent	FAA or designee	Chief Engineer/DCMA
Maintenance/ Operational Criteria	14 CFR Parts 43, 91, 121, 135, 145	AFPD/AFI 11-2 & 21 series
Certification Criteria	14 CFR Parts 23, 25, 33	Airworthiness Certification Criteria (MIL-HDBK-516A)

Note: Mil-Hdbk-516, as amended, establishes the minimum set of airworthiness certification criteria that is used by the U.S. Navy, U.S. Air Force, and U.S. Army in the issuance of airworthiness approvals. Mil-Hdbk-516 is an integral part of the NAVAIR flight clearance process. The National Airworthiness Team (NAT), who is responsible for processing, tracking, and issuance of NAVAIR flight clearances, uses Mil-Hdbk-516 as a guide in determining the applicability and tailoring the data requirements for each specific application e.g., information required for determination of flight operating limitations for a UAS.

NMSU PSL TAAC UAS Operational Services & Environmental Information Capture (OSEIC)

NMSU PSL TAAC has in place a “systems approach” that is based on the development of an Operational Services & Environmental Information Capture (OSEIC) similar to what was collectively accomplished by the TAAC in the development of its UAS concept of operations document and the UAS regulatory and certification roadmap with recommended issue papers. The OSEIC concept allows the TAAC team to identify a system level operational approach that can assist in establishing an airworthiness criteria that provides an equivalent (minimum) level of safety, and also create a review process that could address FAA policy and guidance for operating public UAS in the NAS.

Process:



Briefly, the NMSU PSL TAAC UAS proposed systems approach (using the ADS Aerostar for modeling) is to address the following components for the OSEIC:

I. Operational Suitability Determination (OSD)/Operational Performance Assessment (OPA):

NMSU PSL TAAC operational suitability determination (OSD) or operational performance assessment (OPA) is being developed, using an appropriate UAS operations procedures manual (e.g., an enhanced USOPV procedures document), for operations along the lines of an air operating certificate with detailed operating specifications. A three-phase OSD operations inspection authorization (OIA) will be proposed during the assessment to cover the pre-flight phase (planning, briefing, checklists, etc) , in-flight phase (engine start, taxi, take-off, climb, en-route/cruise, performance of special purpose operations, descent, approach to landing, landing, taxi, engine shutdown), and post-flight phase (de-brief, safety improvement, etc). UAS flight operations are unique in the NAS and should cover communications between air vehicle, GCS, and ATM (NAS) and with other aircraft. Demonstrations during this OSD/OPA phase will attempt to address all phases of flight (normal and emergency operations).

The general factors affecting the NMSU PSL TAAC operational suitability determination process have been grouped into six fundamental areas: (1) UAS Resources, (2) UAS Description & Capabilities, (3)

UAS Flight Testing, (4) UAS Flight Planning, (5) UAS Flight Procedures, and (6) Flight Operations (Execution). See Appendix F for details on NMSU PSL TAAC OSD/OPA.

II. Operations Safety Assessment (OSA):

NMSU PSL TAAC operational safety assessment (OSA), is based on but not limited to, Department of Defense published Supplement to Document 323-99, Range Safety Criteria for Unmanned Air Vehicles, Rationale and Methodology Supplement, and FAA Order 4040.26, Aircraft Certification Service Flight Safety Program (i.e., principles and fundamentals of defining a flight safety program using a type inspection authorization (TIA) and the low/medium/high risk assessment concept). A three-phase OSA operations inspection authorization (OIA) will be proposed during the assessment to cover the platform segment, GCS segment, and communications segment for all phases of flight.

The purpose of the operational safety assessment (OSA) is to evaluate the risks associated with the conducting of a UAS flight operation in the NAS and will be based primarily on, but not limited to,: (1) the operational environment (prescribed operating limitations & conditions) and the intended functions (i.e., special purpose operations), and (2) the operational hazard assessment (OHA) that identifies and classifies potential hazards for the key functions of the UAS during all phases of flight.

The OHA will include the hazard at the functional level as a failure or malfunction e.g., loss of command & control during the take-off phase, etc. The effect of each hazard described in enough detail to classify the severity of the hazard. Based on the severity classification (e.g., catastrophic, hazardous, major, minor, no safety effect), there is a need to assign a qualitative and quantitative probability. It would be reasonable to assign, for example, catastrophic as a hazard that would result in multiple fatalities to persons in the air and/or ground due to collisions with other manned aircraft in flight or structures and/or persons on the ground. This event should be so unlikely that it is not anticipated to occur during the entire operational life of an entire system or fleet. See Appendix G for details on NMSU PSL TAAC OSA.

Additionally, prior to the beginning of any mission (series of flights to achieve the planned objective), there are two separate reviews to ensure that safety is maintained. The first is an Independent Safety Review (ISR), which includes individuals who are not involved directly in the NMSU PSL TAAC UAS programs. Individuals participating in the ISR are primarily from White Sands Missile Range, Holloman AFB, and other military installations and civil organizations that are knowledgeable of aviation criteria and safety standards. No UAS flight operations are performed until identified safety issues are resolved to the ISR group's satisfaction. The second review is the Flight Readiness Review (FRR), which is conducted shortly before the beginning of flight operations. The FRR is conducted primarily by NMSU PSL TAAC safety personnel who are involved in the UAS operations; however, the process always involves others that are not directly involved in the UAS operation. Similar to the ISR, no UAS flights will occur until deficiencies identified during the FRR are corrected.

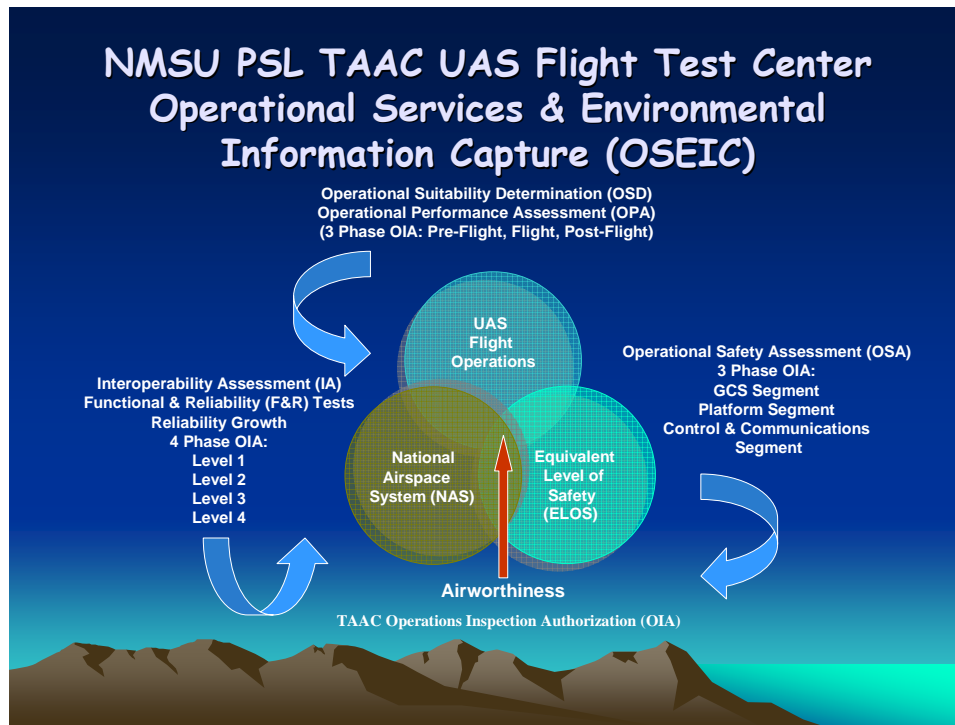
III. Functional & Reliability (F&R) Tests/Interoperability Assessment (IA):

NMSU PSL TAAC functional & reliability (F&R) testing program that includes an interoperability assessment (IA) is a key component in determining safe operations in the NAS. A three-phase F&R operations inspection authorization (OIA) will be proposed during the assessment to cover the reliability growth i.e., level 1 (flight within the immediate test area), level 2 (flight within the immediate test area and buffer zone), level 3 (flight not to exceed the established COA restrictions). Level 4 is anticipated to be sufficient additional tests to be able to make recommendations to the FAA regarding special purpose operations (ref: FAR 21.25) outside of the COA restrictions.

One of the key areas that NMSU PSL TAAC will be involved with is the conducting of an operational safety assessment for onboard unmanned aircraft systems, as well as ground control station (GCS) essential systems and equipment. Also, the performing of functional & reliability (F&R) tests from an overall interoperability standpoint for flight operations in the NAS i.e., to ensure that (1) the aircraft system will operate with the ground systems and other airborne systems, and (2) the air traffic management information applications, the interfacing systems, and the ground applications are compatible.

The FAA AFS-400 UAS Policy 05-01 supports UAS flight activities that can demonstrate that the proposed operations can be conducted at an acceptable level of safety. FAA intends to approve COA applications supported by a system safety study (and more than likely for airworthiness applications in the experimental category) if the conclusion of the study indicates that a collision with another aircraft, parachutist or other civil airspace user is extremely improbable. See Appendix H for details on NMSU PSL TAAC F&R Tests and IA.

SUMMARY:



The process identified above will assist NMSU PSL TAAC in defining/capturing an operational services and environmental information (OSEIC) that is project specific (e.g., ADS Aerostar) and at a much lower and detail level to say this is “how” we determined an appropriate level of airworthiness (ref: FAA AFS-400 UAS policy memo 05-01, section 6.3, Airworthiness Certification - General).

NMSU PSL TAAC Mission Specific Objectives:

The special purpose operations (reference FAR 21.25(b)) have been highlighted as examples (see below). PSL TAAC past programs and activities have demonstrated that the organization is able to address these special purpose operations based on: (1) establishing a UAS airworthiness criteria that can provide an equivalent (minimum) level of certitude and safety, and (2) ensuring basically there are no features and/or characteristics of the UAS to make it unsafe when operated under the limitations prescribed for its intended use. The intended use, in these instances, is to be addressed initially by the issuance of an appropriate experimental certificate with purposes for research & development (FAR 21.191(a)), showing compliance with regulations (FAR 21.191(b)), and crew training (FAR 21.191(c)).

**UAS Special Purpose Operations
(Mission Specific Examples)**

PSL TAAC Activities	(1)	(2)	(3)	(4)	(5)	(6)	(7)
A. Research & Development		x	x	x			x
B. Flight Testing & Validation		x	x	x			x
C. Flight Crew & Ground Training		x	x	x			x
D. Flight Planning & Procedures		x	x	x			x
E. Flight Operations & Execution		x	x	x			x
F. Safety Recommendations & Documentation		x	x	x			x
G. Resources (personnel, facilities, operations area)	x	x	x	x	x	x	x

Reference (FAR 21.25(b))

- (1) Agricultural (spraying, dusting, and seeding, and livestock /predatory animal control)
- (2) Forest & Wildlife Conservation
- (3) Aerial Surveying (photography, mapping, and oil & mineral exploration)
- (4) Patrolling (pipelines, power-lines, and canals)
- (5) Weather Control (cloud seeding)
- (6) Aerial Advertising (skywriting, banner towing, airborne signs, and public address systems)
- (7) Any Other Operation specified by the Administrator

NMSU PSL TAAC is currently conducting of flight tests using the Aeronautics Defense Systems (ADS) Aerostar UAS in accordance with a comprehensive TAAC developed standard operating procedures (SOP) manual and other documentation.

**NMSU PSL TAAC AIRWORTHINESS STATEMENT:
Aerostar Unmanned Aircraft System (UAS) (S/N 617 and S/N 618)**

NMSU PSL TAAC airworthiness process and supporting documentation for the Aerostar are submitted as part of the application package for a certificate of authorization (COA). The substantiation for the Aerostar is based on TAAC's subsequent review, analysis, tests, and validation of the (1) U.S. Navy NAVAIR flight clearance and (2) manufacturer (ADS) type design data, consistent with the guidelines contained in the Department of Defense Mil-Hdbk-516, Airworthiness Certification Criteria.

NMSU PSL TAAC assessment of the Aerostar airworthiness is based on the U.S. Navy's, NAVAIR, issuance of a flight clearance for the Aerostar UAS (serial #602) UAS, in accordance with Mil-Hdbk-516 airworthiness certification criteria and guidelines. Additional support for the airworthiness certification includes (1) Aeronautics Defense Systems' (ADS) type design for the Aerostar UAS, and (2) NMSU PSL TAAC documentation and substantiation, either previously submitted and/or on file, that aircraft S/N 617 and S/N 618 have been checked for conformity to ADS type design requirements. Any changes and/or improvements that have been incorporated on these aircraft have been reviewed by NMSU PSL TAAC personnel, and determined they will introduce no adverse effect on the continued airworthiness of these systems.

Ongoing flight tests, operations, and demonstrations of the Aerostar have been conducted in accordance with (1) special provisions in the existing FAA COA, and (2) NMSU PSL TAAC unmanned systems operations and validations program (USOVP) requirements, which include standard operating procedures (SOP) and platform/mission specific operating limitations and conditions. Unless the FAA COA special provisions have been determined to be more restrictive, the UAS limits, special warnings, cautions, notes, and other remarks of the NAVAIR flight clearance (highlighted in blue print), are considered applicable to the NMSU PSL TAAC Aerostar systems. UAS flights may be conducted with accelerometer reinstalled

(per manufacturer's specifications) to warn of aerodynamic loads in excess of aircraft limit load design capability, and potential hazard to structural airframe/control integrity. This matter will be reviewed further by the safety committee.

Issuance of an appropriate FAA Certificate of Authorization (COA) with adequate operating restrictions is essential to conducting flight test demonstrations and evaluations. Further supporting data is contained in the appendices to this briefing document.

Enclosures: Appendices

Appendix A – ADS Model Aerostar UAS Type Design
Appendix B – NAVAIR Flight Clearance for ADS Model Aerostar UAS
Appendix C – NMSU PSL TAAC Aerostar S/N617 and S/N 618
Appendix D – NMSU PSL TAAC Internal Guidance UAS Airworthiness
Appendix E – NMSU PSL TAAC Operations Inspection Authorization (OIA)
Appendix F – NMSU PSL TAAC Operational Suitability Determination (OSA)
Appendix G – NMSU PSL TAAC Operational Safety Assessment (OSA)
Appendix H – NMSU PSL TAAC Interoperability Assessment (IA)
Appendix I – ADS Aerostar UAS Reliability, Availability, Maintenance, Safety (RAMS) Report 1477
Appendix J – ADS Aerostar UAS Failure Modes and End Effect Criticality (FMECA) Report 1475
Appendix K – ADS Aerostar UAS Fault Tree Analysis (FTA) Report 1476

Referenced TAAC UAS Forms & Checklists:

- TAAC Facility Inspection Checklist
- TAAC Preflight Inspection Checklist
- TAAC En-route Inspection Checklist
- TAAC Post-flight Inspection Checklist
- TAAC Operations Procedures Manual
- TAAC Proficiency/Qualification Checklist
- TAAC Operations Inspection Authorization
- Statement of Conformity, FAA Form 8130-9
- Service Difficulty Report, FAA Form 8070-1
- Safety Improvement Report, FAA Form 8740-5
- AFS Application for Certificate of Waiver or Authorization, FAA Form 7711-2
- Type Inspection Authorization (TIA), FAA Form 8110.1 (*modified for internal TAAC use only*)
- FAA Order 8130.2D, dated 2/15/00, Airworthiness Certification of Aircraft & Related Products