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Section J, Attachment 3, Air Vehicle SS

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PERFORMANCE SPECIFICATION
SYSTEM SPECIFICATION
for the

ADVANCED SMALL UNMANNED AIRCRAFT SYSTEM (ASUAS)

PROGRAM

AIR VEHICLE SYSTEM

Version 1.0

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TABLE OF CONTENTS

1 SCOPE

This System Specification (SS) establishes the performance requirements for the United States Air Force (USAF) Advanced Small Unmanned Aircraft System (ASUAS) Air Vehicle System component of the ASUAS Program. For the purposes of this SS, the “Air Vehicle System” includes the air vehicle, its installed mission payload, and the associated Ground Control Station and support elements.

Identification 1.1

This SS is for the Air Vehicle System, Configuration Item (CI) (TBD).

System Overview 1.2

The ASUAS Program will provide dismounted and base-defense forces with an organic, man-portable, single-operator Group 1 electric vertical-takeoff-and-landing reconnaissance capability, replacing legacy squad-level Group 1 unmanned assets. The system delivers over-the-next-hill electro-optical reconnaissance and target location while remaining man-packable and employable by a minimally-trained operator.

Document Overview 1.3

The performance requirements and verification requirements for the ASUAS Air Vehicle System are documented in sections 3 and 4. This SS captures the minimum requirements for the air vehicle system; requirements designated as “Trade Space” identify Threshold and Objective values to be traded as part of the proposed solution definition (see APPENDIX C). This SS is developed using guidance from DID DI-IPSC-81431A, System/Subsystem Specification Data Item Description, and MIL-STD-961E, DoD Standard Practice for Defense Specifications. In addition to the six (6) major sections of the SS, appendices are included as necessary to define the requirements of the air vehicle system.

2 APPLICABLE DOCUMENTS

General 2.1

The documents listed in this section are specified in sections 3, 4, or 5 of this specification. While every effort has been made to ensure the completeness of the document list, document users are cautioned that they must meet all specified requirements of documents cited in sections 3, 4, and 5, whether or not the documents are listed. When a revision letter or date is not shown, the issue in effect on the release date of this specification applies.

Government Documents 2.2

Specifications, Standards, and Handbooks 2.2.1

The following specifications, standards, and handbooks form a part of this document to the extent specified herein.

Document Number	Document Title	Issue Date
FED-STD-595C	Colors Used in Government Procurement	16 JAN 08
MIL-STD-129R	Military Marking for Shipment and Storage	18 FEB 14
MIL-STD-130N (1)	Identification Marking of U.S. Military Property	16 NOV 12
MIL-STD-461G	Requirements for the Control of Electromagnetic Interference Characteristics of Subsystems and Equipment	11 DEC 15
MIL-STD-464D	Electromagnetic Environmental Effects Requirements for Systems	16 DEC 20
MIL-STD-810H	Environmental Engineering Considerations and Laboratory Tests	31 JAN 19
MIL-STD-882E	System Safety	11 MAY 12
MIL-STD-1472H	Human Engineering	15 SEP 20
MIL-STD-1474E	Noise Limits	15 APR 15
MIL-STD-2525D	Joint Military Symbology	10 JUN 14
MIL-STD-3009	Lighting, Aircraft, Night Vision Imaging System (NVIS) Compatible	02 FEB 01
MIL-STD-3013A	Glossary of Definitions, Ground Rules, and Mission Profiles to Define Air Vehicle Performance Capability	09 SEP 08

MIL-PRF-32565C	Battery, Rechargeable, Sealed, Lithium-Ion, General Specification for	10 AUG 20
MIL-HDBK-516C	Airworthiness Certification Criteria	12 DEC 14
MIL-HDBK-217F (2)	Reliability Prediction of Electronic Equipment	28 FEB 95

Other Government Documents, Drawings, and Publications 2.2.2

The following other Government documents, drawings, and publications form a part of this document to the extent specified herein.

Document Number	Document Title	Issue Date
AFPD 62-6	USAF Airworthiness	18 AUG 20
AFI 62-601	USAF Airworthiness	15 APR 19
AFMAN 91-119	Safety Design and Evaluation Criteria for Nuclear and UAS Weapon Systems	07 JUL 20
DoDI 8500.01	Cybersecurity	07 OCT 19
DoDI 8510.01	Risk Management Framework (RMF) for DoD Systems	19 JUL 22
CNSSI 1253	Security Categorization and Control Selection for National Security Systems	29 JUL 22
NDAA FY2020 Sec. 848	Prohibition on Operation or Procurement of Foreign-Made UAS	20 DEC 19
DIU Blue UAS	Defense Innovation Unit Blue UAS Framework, current baseline	2025

Non-Government Publications 2.3

The following documents form a part of this document to the extent specified herein.

Document Number	Document Title	Issue Date
STANAG 4586 Ed.4	Standard Interfaces of UAS Control System (UCS) for NATO UAS Interoperability	NOV 17
STANAG 4703 Ed.2	Light Unmanned Aircraft Systems Airworthiness Requirements	JUL 19
STANAG 4671 Ed.2	Unmanned Aircraft Systems Airworthiness Requirements (USAR)	SEP 19
ASTM F2910-14	Standard Specification for Design and Construction of a Small Unmanned Aircraft System	2014
ASTM F3002-14a	Standard Specification for Design of the Command and Control System for a Small UAS	2014
ASTM F3005-14a	Standard Specification for Batteries for Use in Small Unmanned Aircraft Systems	2014
RTCA DO-160G	Environmental Conditions and Test Procedures for Airborne Equipment	DEC 10
RTCA DO-178C	Software Considerations in Airborne Systems and Equipment Certification	DEC 11
RTCA DO-254	Design Assurance Guidance for Airborne Electronic Hardware	APR 00

SAE ARP4761A	Guidelines and Methods for Conducting the Safety Assessment Process on Civil Airborne Systems and Equipment	DEC 20
SAE-AS50881F	Wiring, Aerospace Vehicle	29 MAY 15
MISB ST 0601.17	UAS Datalink Local Set (KLV Metadata)	2022
FIPS PUB 140-3	Security Requirements for Cryptographic Modules	22 MAR 19

Order of Precedence 2.4

Unless otherwise noted herein or in the contract, in the event of a conflict between the text of this document and the references cited herein, the text of this document takes precedence. Nothing in this document, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

3 REQUIREMENTS{mk("S3")}

Definitions in section 6.2 help to clarify and form a part of the requirements in sections 3 and 4. Requirements are stated using the verb “shall.”

Performance and Physical Characteristics 3.1

Performance Ground Rules 3.1.1

Ground Rules 3.1.1.1

Unless otherwise specified, the Performance and Physical Characteristics (section 3.1 and subparagraphs) shall be met using the following performance ground rules:

a. Standard Configuration at Gross Takeoff Weight (GTW) with a fully charged energy source and the Standard Payload installed (see 3.2).
b. International Standard Atmosphere (ISA) sea-level conditions as defined by MIL-STD-3013, Appendix A, unless a specific pressure altitude is stated.
c. All air vehicle systems, subsystems, and components operating normally.
d. No wind, unless a specific wind condition is stated.
e. Energy source at Beginning-of-Life (BOL) capacity and 20 °C cell temperature.
f. Single air vehicle operated by a single operator from one Ground Control Station (GCS).

Performance 3.1.2

Hover Endurance 3.1.2.1

The air vehicle shall provide a hover endurance of at least 8 minutes (Threshold) / 20 minutes (Objective) at GTW, out of ground effect (OGE), at ISA sea level, on a single Standard energy source, while retaining the energy reserve of 3.3.4.

Mission Endurance 3.1.2.2

The air vehicle shall have sufficient installed energy to complete the unrefueled reconnaissance sortie illustrated and defined in section A.1 (nominal duration 10.5 minutes), including launch, transit, loiter, and recovery phases, at GTW and ISA sea level.

Operational Radius 3.1.2.3

The air vehicle shall achieve an operational radius of at least 2.0 kilometers (Threshold) / 5.0 kilometers (Objective) from the GCS while maintaining a continuous command-and-control (C2) link (3.4.4) and a payload data link (3.4.5).

Dash Speed 3.1.2.4

The air vehicle shall achieve a dash airspeed of at least 30 knots (Threshold) / 45 knots (Objective) in level flight at ISA sea level and GTW.

Cruise Speed **3.1.2.5**

The air vehicle shall sustain a transit cruise airspeed of at least 15 knots at ISA sea level and GTW while maintaining stabilized flight and payload imaging.

Rate of Climb **3.1.2.6**

The air vehicle shall achieve a vertical rate of climb of at least 3.0 meters per second at GTW and ISA sea level.

Hover Ceiling (OGE) **3.1.2.7**

The air vehicle shall hover OGE at GTW at a density altitude of at least 3,000 feet MSL (Threshold) / 8,000 feet MSL (Objective).

Thrust-to-Weight Ratio **3.1.2.8**

The air vehicle shall provide a static thrust-to-weight ratio of at least 2.0:1 at GTW and maximum continuous power, providing control authority and gust rejection margin.

Wind and Gust Tolerance **3.1.2.9**

The air vehicle shall launch, recover, and maintain a commanded position hold in steady winds of at least 15 knots (Threshold) / 20 knots (Objective) with gusts to 25 knots, holding position within a 3.0-meter radius and 2.0-meter altitude band.

Vertical Launch and Recovery **3.1.2.10**

The air vehicle shall perform an unassisted vertical takeoff and a precision vertical landing from and to an unprepared surface no larger than 3 meters by 3 meters, with no launch or recovery equipment other than the GCS.

Flight Control and Handling Qualities **3.1.2.11**

Stabilized Flight Modes **3.1.2.11.1**

The air vehicle shall provide, as a minimum, an attitude-stabilized (self-leveling) flight mode and a position-hold (GNSS-aided) flight mode, and shall transition between modes without objectionable transients.

GPS-Denied Attitude Hold **3.1.2.11.2**

Upon loss of the GNSS position solution, the air vehicle shall automatically revert to attitude-stabilized flight and maintain controllability, providing clear and unambiguous indication of the reversion to the operator.

Operator Skill Level Handling **3.1.2.11.3**

The air vehicle shall have levels of stability, automation, and normal and emergency procedures commensurate with the skill level of a minimally-trained enlisted operator, and shall be tolerant of common operator errors including delayed and misapplied control inputs.

Loss of Control Resistance 3.1.2.11.4

No single failure of any component, or combination of single independent failures, shall result in an uncommanded loss of control; the air vehicle shall enter the contingency behavior of 3.6.6 in lieu of departing controlled flight.

Acoustic Signature 3.1.2.12

The air vehicle shall produce an A-weighted acoustic signature not exceeding 65 dBA at a slant range of 100 meters during level cruise at GTW, measured in accordance with MIL-STD-1474E.

Physical and Structural Characteristics 3.1.3

Gross Takeoff Weight 3.1.3.1

The air vehicle Gross Takeoff Weight (GTW), including the Standard energy source and the Standard Payload, shall not exceed 0.90 kilograms (Threshold) / 0.70 kilograms (Objective).

Transport Configuration 3.1.3.2

The air vehicle, GCS, and one full set of Standard mission consumables shall stow within a single man-portable case not exceeding 0.010 cubic meters and 3.0 kilograms total, and shall be man-packable by a single person.

Rapid Assembly 3.1.3.3

The air vehicle shall be assembled from its transport configuration to a ready-to-launch state by a single operator, without tools, in no more than 2 minutes.

Configuration 3.1.3.4

The air vehicle shall be a four-rotor electric multirotor in the Quad-X configuration.

Design Service Life 3.1.3.5

The air vehicle airframe design service life shall be at least 500 flight hours and 2,000 launch/recovery cycles for the mission profiles and usage rates contained in APPENDIX A, over a 10-year in-service period.

Structural Load Factors 3.1.3.6

The air vehicle shall perform, without degradation to structure, components, or systems, to a design limit maneuver load factor of -2.0 G to +4.0 G in the body axis throughout the flight envelope. Ultimate loads shall be obtained by multiplying limit loads by a factor of safety of 1.5; the airframe shall not fail catastrophically when subjected to ultimate loads.

Materials, Processes, and Corrosion 3.1.3.7

Airframe primary structure shall use carbon-fiber composite arms not less than 4 mm in thickness. Materials, finishes, and processes shall be selected for corrosion prevention and

control in the operating environment of 3.9, and hazardous materials shall be managed in accordance with the Contractor Hazardous Materials Management Program.

Drop Survivability **3.1.3.8**

The air vehicle, in transport configuration, shall survive a 1.5-meter drop onto a hard surface onto each face without fracture of primary structure and shall remain mission-capable.

Structural Dynamics **3.1.3.9**

The airframe first structural bending mode shall be at least 80 Hz so as not to couple with the flight control bandwidth of 3.4.2.

Propeller Clearance and Frangibility **3.1.3.10**

Propeller tip clearance to any structure shall be at least 5 mm, and propellers shall be of an impact-tolerant, frangible design that minimizes injury and secondary damage on contact.

Mission Payload 3.2

Standard Payload **3.2.1**

The air vehicle shall carry a Standard Payload of at least 100 grams comprising a stabilized electro-optical (EO) sensor, and shall provide the mechanical, electrical, and data interfaces to support the payload without modification to the air vehicle.

Electro-Optical Sensor **3.2.2**

The EO sensor shall provide a continuous-zoom or step-zoom capability sufficient to recognize a man-sized (1.8 m) target at a slant range of at least 300 meters (Threshold) / 500 meters (Objective) under daylight conditions, and shall stream full-motion video at not less than 24 frames per second.

Infrared Sensor (Growth) **3.2.3**

SEE APPENDIX C.

Gimbal Stabilization **3.2.4**

The payload shall be stabilized about at least two axes such that residual line-of-sight jitter does not exceed 150 microradians RMS during cruise in the wind condition of 3.1.2.9.

Target Geo-Location **3.2.5**

The system shall compute and display the geographic coordinates of a sensor-designated ground point with a Target Location Error (TLE) not exceeding 50 meters CE90 at the operational radius of 3.1.2.3.

Imagery Metadata **3.2.6**

The system shall embed KLV metadata in accordance with MISB ST 0601 in the payload video stream, including platform position, sensor pointing, and time.

Propulsion System 3.3

Electric Propulsion 3.3.1

The air vehicle shall use an all-electric distributed propulsion system consisting of four independent brushless motor / electronic-speed-controller (ESC) / propeller channels commanded digitally by the flight control subsystem (3.4.2).

Per-Channel Current Capacity 3.3.2

Each ESC channel shall deliver at least 35 amperes continuous and 45 amperes for a 10-second burst at the propulsion bus voltage of 3.4.1 without exceeding component thermal limits.

Propellers 3.3.3

Each channel shall drive a fixed-pitch propeller; the propeller set shall comprise two clockwise and two counter-clockwise units, and shall be field-replaceable without tools.

Energy Reserve 3.3.4

At completion of the mission profile of section A.1, the air vehicle shall retain an energy reserve of at least 20% of usable energy source capacity to support contingency recovery.

Single-Rotor Failure Response 3.3.5

Because a four-rotor configuration cannot sustain controlled hover following the loss of a single rotor, the propulsion and flight control subsystems shall detect a failed channel and command a controlled descent / flight termination (3.6.6) that minimizes hazard to personnel on the ground. A redundant-rotor growth path is identified in APPENDIX C.

Propulsion Health Monitoring 3.3.6

The system shall monitor per-channel current and, as available, motor vibration signature, and shall record and report degradation trends in accordance with 3.7.3.

Vehicle Subsystems 3.4

Electrical Power and Energy Storage 3.4.1

Energy Source 3.4.1.1

The propulsion bus shall be powered by a rechargeable lithium-based energy source qualified to MIL-PRF-32565, operating over 12.0 to 16.8 volts (4-cell series), providing at least 1500 mAh usable capacity and at least 60 amperes continuous discharge.

Battery Redundancy 3.4.1.2

The air vehicle shall incorporate two independent energy sources arranged such that failure of one source does not cause loss of the air vehicle; this dual-source arrangement satisfies the reliability allocation of 3.8.2. (Derived from the ASUAS reliability analysis, APPENDIX B.)

Regulated Avionics Power 3.4.1.3

A regulated 5.0 V ±5% rail rated at not less than 2 amperes shall power the flight control subsystem, receivers, and peripherals, isolated from propulsion transients.

Reverse-Polarity and Over-Current Protection 3.4.1.4

The main power input shall provide reverse-polarity protection and the propulsion bus shall provide over-current protection.

Battery Management and Thermal Runaway 3.4.1.5

Each energy source shall include a battery management function providing over-charge, over-discharge, and cell-imbalance protection, and the installation shall contain a single-cell thermal runaway without loss of the air vehicle structure.

Flight Control Subsystem 3.4.2

Inertial Sensing 3.4.2.1

The flight control subsystem shall sense three-axis angular rate and three-axis acceleration at a sample rate of at least 2 kHz and barometric altitude, and shall close the attitude/rate stabilization loop at a closed-loop bandwidth of at least 25 Hz.

Flight Control Redundancy 3.4.2.2

The flight control subsystem shall be dual-redundant such that no single flight-control processor or IMU failure results in loss of control; the standby channel shall assume control without operator action. (Derived from the ASUAS reliability analysis, APPENDIX B.)

Arming Interlocks 3.4.2.3

The air vehicle shall arm the propulsion system only when the C2 link is present, the inertial sensors are calibrated, the throttle command is at idle, and the airframe attitude is within 25 degrees of level.

Navigation Subsystem 3.4.3

The air vehicle shall provide a GNSS-aided inertial navigation solution with position accuracy not worse than 3.0 meters CEP under open-sky conditions, and shall support the GPS-denied reversion of 3.1.2.11.2.

Command and Control (C2) Data Link 3.4.4

The air vehicle shall maintain an encrypted, frequency-agile C2 data link with the GCS over the operational radius of 3.1.2.3; link encryption shall meet FIPS PUB 140-3.

Payload Data Link 3.4.5

The air vehicle shall provide a digital payload (video and metadata) downlink to the GCS with end-to-end latency not exceeding 200 milliseconds at the operational radius of 3.1.2.3.

Lost-Link Behavior 3.4.6

On loss of the C2 link for more than 1 second, the air vehicle shall execute the pre-briefed lost-link contingency of 3.6.3 (default: return-to-home), and shall re-establish operator control automatically upon link restoration.

Lighting 3.4.7

The air vehicle shall provide a controllable anti-collision light for visual-line-of-sight operations and a covert/NVIS-compatible mode in accordance with MIL-STD-3009, plus a visible arming-state indicator.

Ground Control Station and Human Systems 3.5

Human Engineering 3.5.1

The GCS and its controls, displays, and procedures shall satisfy the applicable human engineering criteria of MIL-STD-1472 for a dismounted operator.

Control Station Configuration 3.5.2

The GCS shall be a single, handheld or tablet-form man-portable unit not exceeding 1.5 kilograms, operable by one person, and operable while wearing standard-issue gloves.

Displays 3.5.3

The GCS shall present, as a minimum, a moving-map display employing MIL-STD-2525 symbology, live payload video, and air vehicle state and health, and shall be sunlight-readable.

Single-Operator Operation 3.5.4

A single operator shall be able to plan, launch, control, employ the payload, and recover the air vehicle without additional crew.

Setup and Teardown Time 3.5.5

The GCS shall be brought from transport to operational state in no more than 2 minutes by a single operator.

Autonomy and Flight Modes 3.6

Automatic Takeoff and Landing 3.6.1

The air vehicle shall perform automatic takeoff to a commanded altitude and automatic precision landing to the launch point or a commanded recovery point.

Waypoint Navigation 3.6.2

The air vehicle shall autonomously fly an operator-defined route of at least 20 waypoints and execute loiter, orbit, and point-of-interest patterns about a designated location.

Return-to-Home 3.6.3

The air vehicle shall, on operator command or on the contingencies of 3.6.6, autonomously return to and land at a pre-designated home point.

Geofencing 3.6.4

The system shall enforce operator-defined lateral and vertical geofence boundaries and shall prevent commanded flight beyond those boundaries.

Contingency Management 3.6.5

Contingency Behaviors 3.6.6

The system shall define and execute deterministic contingency behaviors for, as a minimum: loss of C2 link (3.4.6), low energy source (3.3.4), loss of GNSS (3.1.2.11.2), and single-rotor failure (3.3.5). Each contingency shall be selectable by the operator during mission planning.

Recorded Information 3.7

Flight Data Recording 3.7.1

The air vehicle shall record flight state (attitude, rate, position, velocity), control commands, energy source state, and link quality at not less than 10 Hz for the full sortie, retrievable post-flight for analysis.

Imagery and Metadata Recording 3.7.2

The system shall record payload imagery with embedded MISB ST 0601 metadata for the full sortie and shall support post-mission export.

Built-In Test and Health Data 3.7.3

The air vehicle shall perform initiated and continuous built-in test (BIT) covering propulsion, power, flight control, navigation, and data links, and shall record health and degradation data supporting the diagnostics of 3.8.6.

Product Support 3.8

Operational Availability (Ao) 3.8.1

The air vehicle system shall achieve an operational availability (Ao) of at least 0.90 over the steady-state operating period.

Mission Reliability (Rm) 3.8.2

The air vehicle shall achieve a mission reliability of at least R = 0.9995 for the 10.5-minute reference sortie of section A.1 (allocation based on the ASUAS reliability analysis, which predicts R = 0.99998 for the redundant configuration; see APPENDIX B).

Loss-of-Thrust Probability 3.8.3

The probability of an uncommanded total loss of thrust shall not exceed 2×10^{-4} per flight hour (allocation traceable to the fault-tree top event of APPENDIX B).

Mean Time Between Failures (MTBF) 3.8.4

The air vehicle shall achieve an operational MTBF of at least 250 flight hours.

Mean Time To Repair (MTTR) 3.8.5

The air vehicle system shall achieve a mean corrective maintenance time (MTTR) at the operator level of not more than 30 minutes.

Diagnostics 3.8.6

System diagnostics shall detect at least 95% of faults and correctly isolate at least 90% of detected faults to a single line-replaceable unit (LRU), with a false-alarm rate not exceeding one per 25 flight hours.

Two-Level Maintenance 3.8.7

The air vehicle shall support a two-level (operator and depot) maintenance concept in which all field-level replacements — arms, motors, propellers, energy sources, and the avionics stack — are removable and replaceable without tools or with a single common tool.

Turn-Around Time 3.8.8

A single operator shall reconfigure the air vehicle for a subsequent sortie, including energy source replacement, in no more than 5 minutes.

Nameplates and Product Marking 3.8.9

The air vehicle and its LRUs shall be marked for identification in accordance with MIL-STD-130.

Climatic and Environmental Conditions 3.9

Natural Climate 3.9.1

The air vehicle system shall operate over an ambient temperature range of -10 °C to +45 °C (Threshold) / -20 °C to +49 °C (Objective), in relative humidity to 95%, and shall withstand storage from -30 °C to +60 °C, in accordance with MIL-STD-810.

Precipitation and Blowing Particulates 3.9.2

The air vehicle shall launch, operate, and recover in light precipitation and in blowing sand and dust, in accordance with the applicable methods of MIL-STD-810.

Induced Environment 3.9.3

The air vehicle and payload shall withstand the vibration and shock of the propulsion-induced and transport environments in accordance with MIL-STD-810, without degradation of the sensing of

3.4.2.1.

Electromagnetic Environmental Effects (E3) 3.9.4

The air vehicle system shall meet the electromagnetic compatibility and self-compatibility requirements of MIL-STD-461 and the system E3 requirements of MIL-STD-464.

Architecture and Security 3.10

Modular Open Systems Approach 3.10.1

The air vehicle system shall employ a Modular Open Systems Approach and shall implement a STANAG 4586-conformant UAS Control System interface for payload and C2 interoperability.

Cybersecurity 3.10.2

The system shall be designed for and achieve authorization under the Risk Management Framework (DoDI 8510.01), with cryptographic functions meeting FIPS PUB 140-3.

Supply Chain / Blue UAS 3.10.3

The air vehicle system shall comply with the foreign-UAS prohibitions of NDAA FY2020 Section 848 and shall be compliant with the current DIU Blue UAS framework baseline.

Computing Resources and SWaP-C Margin 3.10.4

The air vehicle avionics shall provide not less than 25% spare processing throughput, memory, and electrical power at delivery to support growth.

Utility Attributes 3.11

Transportability 3.11.1

The complete air vehicle system shall be transportable and employable by a single dismounted person carrying it in addition to standard combat load.

System Safety 3.11.2

The air vehicle system shall be designed to eliminate or mitigate hazards in accordance with MIL-STD-882, and all Serious and High residual risks shall be formally accepted by the Government. (The ASUAS system safety assessment is summarized in APPENDIX B.)

Airworthiness Certification 3.11.3

The air vehicle system shall be certified airworthy in accordance with AFPD 62-6 / AFI 62-601 using the criteria of MIL-HDBK-516 as tailored for light UAS, consistent with STANAG 4703.

Spectrum Supportability 3.11.4

All radio-frequency emitters shall have a valid DD Form 1494 spectrum supportability determination for the intended areas of operation.

Frangibility and Ground Safety 3.11.5

The air vehicle shall be designed such that a ground impact at maximum kinetic energy presents a low probability of serious injury to unprotected personnel, consistent with the light-UAS airworthiness intent of STANAG 4703.

4 VERIFICATION{mk("S4")}

General 4.0

Section 4 contains the methodology for verifying the design, operation, and performance of the system to meet all requirements established in Section 3. The prime contractor is responsible for planning, resourcing, performing, and reporting all requirement-compliance verifications; Government formal approval of verification documentation constitutes completion.

Verification Methods 4.0.1

Not Applicable (N) — reserved for section 3 headers that contain no requirement. **Inspection (I)** — non-destructive examination by sensory means, simple manipulation and measurement, and review of documentation. **Analysis (A)** — evaluation by technical calculation or modeling based on physical laws and empirical data. **Demonstration** — non-instrumented operation on a qualitative/pass-fail basis, on the ground (**g**) or in flight (**f**). **Test** — quantitative measurement under controlled conditions: laboratory (**L**), ground (**G**), or flight (**F**).

Performance and Physical Characteristics 4.1

No requirement to verify.

Performance Ground Rules 4.1.1

No requirement to verify.

Ground Rules 4.1.1.1

No requirement to verify.

Performance 4.1.2

No requirement to verify.

Hover Endurance 4.1.2.1

The requirement shall be verified by analysis, ground test, and flight test. Ground test shall include evaluation in a hardware-in-the-loop and/or 6-DOF simulation environment. The requirement shall be successfully verified when the Government confirms the full content of the requirement is met to the extent that the verification method(s) can provide.

Mission Endurance 4.1.2.2

The requirement shall be verified by analysis, ground test, and flight test. Ground test shall include evaluation in a hardware-in-the-loop and/or 6-DOF simulation environment. The requirement shall be successfully verified when the Government confirms the full content of the requirement is met to the extent that the verification method(s) can provide.

Operational Radius **4.1.2.3**

The requirement shall be verified by analysis and flight test. The requirement shall be successfully verified when the Government confirms the full content of the requirement is met to the extent that the verification method(s) can provide.

Dash Speed **4.1.2.4**

The requirement shall be verified by analysis, ground test, and flight test. Ground test shall include evaluation in a hardware-in-the-loop and/or 6-DOF simulation environment. The requirement shall be successfully verified when the Government confirms the full content of the requirement is met to the extent that the verification method(s) can provide.

Cruise Speed **4.1.2.5**

The requirement shall be verified by analysis, ground test, and flight test. Ground test shall include evaluation in a hardware-in-the-loop and/or 6-DOF simulation environment. The requirement shall be successfully verified when the Government confirms the full content of the requirement is met to the extent that the verification method(s) can provide.

Rate of Climb **4.1.2.6**

The requirement shall be verified by analysis and flight test. The requirement shall be successfully verified when the Government confirms the full content of the requirement is met to the extent that the verification method(s) can provide.

Hover Ceiling (OGE) **4.1.2.7**

The requirement shall be verified by analysis and flight test. The requirement shall be successfully verified when the Government confirms the full content of the requirement is met to the extent that the verification method(s) can provide.

Thrust-to-Weight Ratio **4.1.2.8**

The requirement shall be verified by analysis, ground test, and flight test. Ground test shall include evaluation in a hardware-in-the-loop and/or 6-DOF simulation environment. The requirement shall be successfully verified when the Government confirms the full content of the requirement is met to the extent that the verification method(s) can provide.

Wind and Gust Tolerance **4.1.2.9**

The requirement shall be verified by analysis, ground test, and flight test. Ground test shall include evaluation in a hardware-in-the-loop and/or 6-DOF simulation environment. The requirement shall be successfully verified when the Government confirms the full content of the requirement is met to the extent that the verification method(s) can provide.

Vertical Launch and Recovery **4.1.2.10**

The requirement shall be verified by ground demonstration and flight demonstration. The requirement shall be successfully verified when the Government confirms the full content of the

requirement is met to the extent that the verification method(s) can provide.

Flight Control and Handling Qualities 4.1.2.11

No requirement to verify.

Stabilized Flight Modes 4.1.2.11.1

The requirement shall be verified by analysis, ground test, and flight test. Ground test shall include evaluation in a hardware-in-the-loop and/or 6-DOF simulation environment. The requirement shall be successfully verified when the Government confirms the full content of the requirement is met to the extent that the verification method(s) can provide.

GPS-Denied Attitude Hold 4.1.2.11.2

The requirement shall be verified by analysis, ground test, and flight test. Ground test shall include evaluation in a hardware-in-the-loop and/or 6-DOF simulation environment. The requirement shall be successfully verified when the Government confirms the full content of the requirement is met to the extent that the verification method(s) can provide.

Operator Skill Level Handling 4.1.2.11.3

The requirement shall be verified by analysis, ground test, and flight demonstration. Ground test shall include evaluation in a hardware-in-the-loop and/or 6-DOF simulation environment. The requirement shall be successfully verified when the Government confirms the full content of the requirement is met to the extent that the verification method(s) can provide.

Loss of Control Resistance 4.1.2.11.4

The requirement shall be verified by analysis and ground test. Ground test shall include evaluation in a hardware-in-the-loop and/or 6-DOF simulation environment. The requirement shall be successfully verified when the Government confirms the full content of the requirement is met to the extent that the verification method(s) can provide.

Acoustic Signature 4.1.2.12

The requirement shall be verified by analysis and ground test. Ground test shall include evaluation in a hardware-in-the-loop and/or 6-DOF simulation environment. The requirement shall be successfully verified when the Government confirms the full content of the requirement is met to the extent that the verification method(s) can provide.

Physical and Structural Characteristics 4.1.3

No requirement to verify.

Gross Takeoff Weight 4.1.3.1

The requirement shall be verified by inspection. The requirement shall be successfully verified when the Government confirms the full content of the requirement is met to the extent that the verification method(s) can provide.

Transport Configuration **4.1.3.2**

The requirement shall be verified by inspection and ground demonstration. The requirement shall be successfully verified when the Government confirms the full content of the requirement is met to the extent that the verification method(s) can provide.

Rapid Assembly **4.1.3.3**

The requirement shall be verified by ground demonstration. The requirement shall be successfully verified when the Government confirms the full content of the requirement is met to the extent that the verification method(s) can provide.

Configuration **4.1.3.4**

The requirement shall be verified by inspection. The requirement shall be successfully verified when the Government confirms the full content of the requirement is met to the extent that the verification method(s) can provide.

Design Service Life **4.1.3.5**

The requirement shall be verified by analysis and laboratory test. The requirement shall be successfully verified when the Government confirms the full content of the requirement is met to the extent that the verification method(s) can provide.

Structural Load Factors **4.1.3.6**

The requirement shall be verified by analysis and laboratory test. The requirement shall be successfully verified when the Government confirms the full content of the requirement is met to the extent that the verification method(s) can provide.

Materials, Processes, and Corrosion **4.1.3.7**

The requirement shall be verified by analysis and inspection. The requirement shall be successfully verified when the Government confirms the full content of the requirement is met to the extent that the verification method(s) can provide.

Drop Survivability **4.1.3.8**

The requirement shall be verified by laboratory test and ground test. Ground test shall include evaluation in a hardware-in-the-loop and/or 6-DOF simulation environment. The requirement shall be successfully verified when the Government confirms the full content of the requirement is met to the extent that the verification method(s) can provide.

Structural Dynamics **4.1.3.9**

The requirement shall be verified by analysis and laboratory test. The requirement shall be successfully verified when the Government confirms the full content of the requirement is met to the extent that the verification method(s) can provide.

Propeller Clearance and Frangibility 4.1.3.10

The requirement shall be verified by inspection and laboratory test. The requirement shall be successfully verified when the Government confirms the full content of the requirement is met to the extent that the verification method(s) can provide.

Mission Payload 4.2

No requirement to verify.

Standard Payload 4.2.1

The requirement shall be verified by inspection and ground test. Ground test shall include evaluation in a hardware-in-the-loop and/or 6-DOF simulation environment. The requirement shall be successfully verified when the Government confirms the full content of the requirement is met to the extent that the verification method(s) can provide.

Electro-Optical Sensor 4.2.2

The requirement shall be verified by analysis, ground test, and flight test. Ground test shall include evaluation in a hardware-in-the-loop and/or 6-DOF simulation environment. The requirement shall be successfully verified when the Government confirms the full content of the requirement is met to the extent that the verification method(s) can provide.

Infrared Sensor (Growth) 4.2.3

The requirement shall be verified by analysis. The requirement shall be successfully verified when the Government confirms the full content of the requirement is met to the extent that the verification method(s) can provide.

Gimbal Stabilization 4.2.4

The requirement shall be verified by analysis, ground test, and flight test. Ground test shall include evaluation in a hardware-in-the-loop and/or 6-DOF simulation environment. The requirement shall be successfully verified when the Government confirms the full content of the requirement is met to the extent that the verification method(s) can provide.

Target Geo-Location 4.2.5

The requirement shall be verified by analysis and flight test. The requirement shall be successfully verified when the Government confirms the full content of the requirement is met to the extent that the verification method(s) can provide.

Imagery Metadata 4.2.6

The requirement shall be verified by inspection and ground test. Ground test shall include evaluation in a hardware-in-the-loop and/or 6-DOF simulation environment. The requirement shall be successfully verified when the Government confirms the full content of the requirement is met to the extent that the verification method(s) can provide.

Propulsion System 4.3

No requirement to verify.

Electric Propulsion 4.3.1

The requirement shall be verified by inspection and ground test. Ground test shall include evaluation in a hardware-in-the-loop and/or 6-DOF simulation environment. The requirement shall be successfully verified when the Government confirms the full content of the requirement is met to the extent that the verification method(s) can provide.

Per-Channel Current Capacity 4.3.2

The requirement shall be verified by laboratory test and ground test. Ground test shall include evaluation in a hardware-in-the-loop and/or 6-DOF simulation environment. The requirement shall be successfully verified when the Government confirms the full content of the requirement is met to the extent that the verification method(s) can provide.

Propellers 4.3.3

The requirement shall be verified by inspection. The requirement shall be successfully verified when the Government confirms the full content of the requirement is met to the extent that the verification method(s) can provide.

Energy Reserve 4.3.4

The requirement shall be verified by analysis and flight test. The requirement shall be successfully verified when the Government confirms the full content of the requirement is met to the extent that the verification method(s) can provide.

Single-Rotor Failure Response 4.3.5

The requirement shall be verified by analysis and ground test. Ground test shall include evaluation in a hardware-in-the-loop and/or 6-DOF simulation environment. The requirement shall be successfully verified when the Government confirms the full content of the requirement is met to the extent that the verification method(s) can provide.

Propulsion Health Monitoring 4.3.6

The requirement shall be verified by analysis and ground test. Ground test shall include evaluation in a hardware-in-the-loop and/or 6-DOF simulation environment. The requirement shall be successfully verified when the Government confirms the full content of the requirement is met to the extent that the verification method(s) can provide.

Vehicle Subsystems 4.4

No requirement to verify.

Electrical Power and Energy Storage 4.4.1

No requirement to verify.

Energy Source 4.4.1.1

The requirement shall be verified by inspection and laboratory test. The requirement shall be successfully verified when the Government confirms the full content of the requirement is met to the extent that the verification method(s) can provide.

Battery Redundancy 4.4.1.2

The requirement shall be verified by analysis and laboratory test. The requirement shall be successfully verified when the Government confirms the full content of the requirement is met to the extent that the verification method(s) can provide.

Regulated Avionics Power 4.4.1.3

The requirement shall be verified by laboratory test. The requirement shall be successfully verified when the Government confirms the full content of the requirement is met to the extent that the verification method(s) can provide.

Reverse-Polarity and Over-Current Protection 4.4.1.4

The requirement shall be verified by inspection and laboratory test. The requirement shall be successfully verified when the Government confirms the full content of the requirement is met to the extent that the verification method(s) can provide.

Battery Management and Thermal Runaway 4.4.1.5

The requirement shall be verified by analysis and laboratory test. The requirement shall be successfully verified when the Government confirms the full content of the requirement is met to the extent that the verification method(s) can provide.

Flight Control Subsystem 4.4.2

No requirement to verify.

Inertial Sensing 4.4.2.1

The requirement shall be verified by analysis and laboratory test. The requirement shall be successfully verified when the Government confirms the full content of the requirement is met to the extent that the verification method(s) can provide.

Flight Control Redundancy 4.4.2.2

The requirement shall be verified by analysis, laboratory test, and ground test. Ground test shall include evaluation in a hardware-in-the-loop and/or 6-DOF simulation environment. The requirement shall be successfully verified when the Government confirms the full content of the requirement is met to the extent that the verification method(s) can provide.

Arming Interlocks 4.4.2.3

The requirement shall be verified by laboratory test and ground demonstration. The requirement shall be successfully verified when the Government confirms the full content of the requirement

is met to the extent that the verification method(s) can provide.

Navigation Subsystem 4.4.3

The requirement shall be verified by analysis and flight test. The requirement shall be successfully verified when the Government confirms the full content of the requirement is met to the extent that the verification method(s) can provide.

Command and Control (C2) Data Link 4.4.4

The requirement shall be verified by analysis, ground test, and flight test. Ground test shall include evaluation in a hardware-in-the-loop and/or 6-DOF simulation environment. The requirement shall be successfully verified when the Government confirms the full content of the requirement is met to the extent that the verification method(s) can provide.

Payload Data Link 4.4.5

The requirement shall be verified by analysis and flight test. The requirement shall be successfully verified when the Government confirms the full content of the requirement is met to the extent that the verification method(s) can provide.

Lost-Link Behavior 4.4.6

The requirement shall be verified by ground test and flight test. Ground test shall include evaluation in a hardware-in-the-loop and/or 6-DOF simulation environment. The requirement shall be successfully verified when the Government confirms the full content of the requirement is met to the extent that the verification method(s) can provide.

Lighting 4.4.7

The requirement shall be verified by inspection and ground demonstration. The requirement shall be successfully verified when the Government confirms the full content of the requirement is met to the extent that the verification method(s) can provide.

Ground Control Station and Human Systems 4.5

No requirement to verify.

Human Engineering 4.5.1

The requirement shall be verified by analysis and inspection. The requirement shall be successfully verified when the Government confirms the full content of the requirement is met to the extent that the verification method(s) can provide.

Control Station Configuration 4.5.2

The requirement shall be verified by inspection and ground demonstration. The requirement shall be successfully verified when the Government confirms the full content of the requirement is met to the extent that the verification method(s) can provide.

Displays 4.5.3

The requirement shall be verified by inspection and ground demonstration. The requirement shall be successfully verified when the Government confirms the full content of the requirement is met to the extent that the verification method(s) can provide.

Single-Operator Operation 4.5.4

The requirement shall be verified by ground demonstration and flight demonstration. The requirement shall be successfully verified when the Government confirms the full content of the requirement is met to the extent that the verification method(s) can provide.

Setup and Teardown Time 4.5.5

The requirement shall be verified by ground demonstration. The requirement shall be successfully verified when the Government confirms the full content of the requirement is met to the extent that the verification method(s) can provide.

Autonomy and Flight Modes 4.6

No requirement to verify.

Automatic Takeoff and Landing 4.6.1

The requirement shall be verified by ground demonstration and flight demonstration. The requirement shall be successfully verified when the Government confirms the full content of the requirement is met to the extent that the verification method(s) can provide.

Waypoint Navigation 4.6.2

The requirement shall be verified by ground test and flight test. Ground test shall include evaluation in a hardware-in-the-loop and/or 6-DOF simulation environment. The requirement shall be successfully verified when the Government confirms the full content of the requirement is met to the extent that the verification method(s) can provide.

Return-to-Home 4.6.3

The requirement shall be verified by ground test and flight test. Ground test shall include evaluation in a hardware-in-the-loop and/or 6-DOF simulation environment. The requirement shall be successfully verified when the Government confirms the full content of the requirement is met to the extent that the verification method(s) can provide.

Geofencing 4.6.4

The requirement shall be verified by ground test and flight test. Ground test shall include evaluation in a hardware-in-the-loop and/or 6-DOF simulation environment. The requirement shall be successfully verified when the Government confirms the full content of the requirement is met to the extent that the verification method(s) can provide.

Contingency Management 4.6.5

No requirement to verify.

Contingency Behaviors 4.6.6

The requirement shall be verified by analysis, ground test, and flight test. Ground test shall include evaluation in a hardware-in-the-loop and/or 6-DOF simulation environment. The requirement shall be successfully verified when the Government confirms the full content of the requirement is met to the extent that the verification method(s) can provide.

Recorded Information 4.7

No requirement to verify.

Flight Data Recording 4.7.1

The requirement shall be verified by inspection and ground test. Ground test shall include evaluation in a hardware-in-the-loop and/or 6-DOF simulation environment. The requirement shall be successfully verified when the Government confirms the full content of the requirement is met to the extent that the verification method(s) can provide.

Imagery and Metadata Recording 4.7.2

The requirement shall be verified by inspection and ground test. Ground test shall include evaluation in a hardware-in-the-loop and/or 6-DOF simulation environment. The requirement shall be successfully verified when the Government confirms the full content of the requirement is met to the extent that the verification method(s) can provide.

Built-In Test and Health Data 4.7.3

The requirement shall be verified by ground test and flight demonstration. Ground test shall include evaluation in a hardware-in-the-loop and/or 6-DOF simulation environment. The requirement shall be successfully verified when the Government confirms the full content of the requirement is met to the extent that the verification method(s) can provide.

Product Support 4.8

No requirement to verify.

Operational Availability (Ao) 4.8.1

The requirement shall be verified by analysis. The requirement shall be successfully verified when the Government confirms the full content of the requirement is met to the extent that the verification method(s) can provide.

Mission Reliability (Rm) 4.8.2

The requirement shall be verified by analysis. The requirement shall be successfully verified when the Government confirms the full content of the requirement is met to the extent that the verification method(s) can provide.

Loss-of-Thrust Probability 4.8.3

The requirement shall be verified by analysis. The requirement shall be successfully verified when the Government confirms the full content of the requirement is met to the extent that the verification method(s) can provide.

Mean Time Between Failures (MTBF) 4.8.4

The requirement shall be verified by analysis. The requirement shall be successfully verified when the Government confirms the full content of the requirement is met to the extent that the verification method(s) can provide.

Mean Time To Repair (MTTR) 4.8.5

The requirement shall be verified by analysis and ground demonstration. The requirement shall be successfully verified when the Government confirms the full content of the requirement is met to the extent that the verification method(s) can provide.

Diagnostics 4.8.6

The requirement shall be verified by analysis and ground test. Ground test shall include evaluation in a hardware-in-the-loop and/or 6-DOF simulation environment. The requirement shall be successfully verified when the Government confirms the full content of the requirement is met to the extent that the verification method(s) can provide.

Two-Level Maintenance 4.8.7

The requirement shall be verified by inspection and ground demonstration. The requirement shall be successfully verified when the Government confirms the full content of the requirement is met to the extent that the verification method(s) can provide.

Turn-Around Time 4.8.8

The requirement shall be verified by ground demonstration. The requirement shall be successfully verified when the Government confirms the full content of the requirement is met to the extent that the verification method(s) can provide.

Nameplates and Product Marking 4.8.9

The requirement shall be verified by inspection. The requirement shall be successfully verified when the Government confirms the full content of the requirement is met to the extent that the verification method(s) can provide.

Climatic and Environmental Conditions 4.9

No requirement to verify.

Natural Climate 4.9.1

The requirement shall be verified by analysis and laboratory test. The requirement shall be successfully verified when the Government confirms the full content of the requirement is met to

the extent that the verification method(s) can provide.

Precipitation and Blowing Particulates 4.9.2

The requirement shall be verified by laboratory test and ground demonstration. The requirement shall be successfully verified when the Government confirms the full content of the requirement is met to the extent that the verification method(s) can provide.

Induced Environment 4.9.3

The requirement shall be verified by laboratory test. The requirement shall be successfully verified when the Government confirms the full content of the requirement is met to the extent that the verification method(s) can provide.

Electromagnetic Environmental Effects (E3) 4.9.4

The requirement shall be verified by analysis and laboratory test. The requirement shall be successfully verified when the Government confirms the full content of the requirement is met to the extent that the verification method(s) can provide.

Architecture and Security 4.10

No requirement to verify.

Modular Open Systems Approach 4.10.1

The requirement shall be verified by analysis and inspection. The requirement shall be successfully verified when the Government confirms the full content of the requirement is met to the extent that the verification method(s) can provide.

Cybersecurity 4.10.2

The requirement shall be verified by analysis and inspection. The requirement shall be successfully verified when the Government confirms the full content of the requirement is met to the extent that the verification method(s) can provide.

Supply Chain / Blue UAS 4.10.3

The requirement shall be verified by inspection and analysis. The requirement shall be successfully verified when the Government confirms the full content of the requirement is met to the extent that the verification method(s) can provide.

Computing Resources and SWaP-C Margin 4.10.4

The requirement shall be verified by analysis and inspection. The requirement shall be successfully verified when the Government confirms the full content of the requirement is met to the extent that the verification method(s) can provide.

Utility Attributes 4.11

No requirement to verify.

Transportability 4.11.1

The requirement shall be verified by inspection and ground demonstration. The requirement shall be successfully verified when the Government confirms the full content of the requirement is met to the extent that the verification method(s) can provide.

System Safety 4.11.2

The requirement shall be verified by analysis. The requirement shall be successfully verified when the Government confirms the full content of the requirement is met to the extent that the verification method(s) can provide.

Airworthiness Certification 4.11.3

The requirement shall be verified by analysis and inspection. The requirement shall be successfully verified when the Government confirms the full content of the requirement is met to the extent that the verification method(s) can provide.

Spectrum Supportability 4.11.4

The requirement shall be verified by inspection. The requirement shall be successfully verified when the Government confirms the full content of the requirement is met to the extent that the verification method(s) can provide.

Frangibility and Ground Safety 4.11.5

The requirement shall be verified by analysis and laboratory test. The requirement shall be successfully verified when the Government confirms the full content of the requirement is met to the extent that the verification method(s) can provide.

Table 4-1. Verification Cross Reference Matrix (VCRM)

Legend: N – Not applicable I – Inspection A – Analysis g – Ground demonstration f – Flight demonstration L – Laboratory test G – Ground test F – Flight test

Section 3	Section 4	SS Title	N	I	A	g	f	L	G	F
3.1	4.1	Performance and Physical Characteristics	X							
3.1.1	4.1.1	Performance Ground Rules	X							
3.1.1.1	4.1.1.1	Ground Rules	X							
3.1.2	4.1.2	Performance	X							
3.1.2.1	4.1.2.1	Hover Endurance			X				X	X
3.1.2.2	4.1.2.2	Mission Endurance			X				X	X
3.1.2.3	4.1.2.3	Operational Radius			X					X
3.1.2.4	4.1.2.4	Dash Speed			X				X	X
3.1.2.5	4.1.2.5	Cruise Speed			X				X	X
3.1.2.6	4.1.2.6	Rate of Climb			X					X

3.1.2.7	4.1.2.7	Hover Ceiling (OGE)			X					X
3.1.2.8	4.1.2.8	Thrust-to-Weight Ratio			X				X	X
3.1.2.9	4.1.2.9	Wind and Gust Tolerance			X				X	X
3.1.2.10	4.1.2.10	Vertical Launch and Recovery				X	X			
3.1.2.11	4.1.2.11	Flight Control and Handling Qualities	X							
3.1.2.11.1	4.1.2.11.1	Stabilized Flight Modes			X				X	X
3.1.2.11.2	4.1.2.11.2	GPS-Denied Attitude Hold			X				X	X
3.1.2.11.3	4.1.2.11.3	Operator Skill Level Handling			X		X		X	
3.1.2.11.4	4.1.2.11.4	Loss of Control Resistance			X				X	
3.1.2.12	4.1.2.12	Acoustic Signature			X				X	
3.1.3	4.1.3	Physical and Structural Characteristics	X							
3.1.3.1	4.1.3.1	Gross Takeoff Weight		X						
3.1.3.2	4.1.3.2	Transport Configuration		X		X				
3.1.3.3	4.1.3.3	Rapid Assembly				X				
3.1.3.4	4.1.3.4	Configuration		X						
3.1.3.5	4.1.3.5	Design Service Life			X			X		
3.1.3.6	4.1.3.6	Structural Load Factors			X			X		
3.1.3.7	4.1.3.7	Materials, Processes, and Corrosion		X	X					
3.1.3.8	4.1.3.8	Drop Survivability						X	X	
3.1.3.9	4.1.3.9	Structural Dynamics			X			X		
3.1.3.10	4.1.3.10	Propeller Clearance and Frangibility		X				X		
3.2	4.2	Mission Payload	X							
3.2.1	4.2.1	Standard Payload		X					X	
3.2.2	4.2.2	Electro-Optical Sensor			X				X	X
3.2.3	4.2.3	Infrared Sensor (Growth)			X					
3.2.4	4.2.4	Gimbal Stabilization			X				X	X
3.2.5	4.2.5	Target Geo-Location			X					X
3.2.6	4.2.6	Imagery Metadata		X					X	
3.3	4.3	Propulsion System	X							
3.3.1	4.3.1	Electric Propulsion		X					X	
3.3.2	4.3.2	Per-Channel Current Capacity						X	X	
3.3.3	4.3.3	Propellers		X						
3.3.4	4.3.4	Energy Reserve			X					X

3.3.5	4.3.5	Single-Rotor Failure Response			X				X	
3.3.6	4.3.6	Propulsion Health Monitoring			X				X	
3.4	4.4	Vehicle Subsystems	X							
3.4.1	4.4.1	Electrical Power and Energy Storage	X							
3.4.1.1	4.4.1.1	Energy Source		X				X		
3.4.1.2	4.4.1.2	Battery Redundancy			X			X		
3.4.1.3	4.4.1.3	Regulated Avionics Power						X		
3.4.1.4	4.4.1.4	Reverse-Polarity and Over-Current Protection		X				X		
3.4.1.5	4.4.1.5	Battery Management and Thermal Runaway			X			X		
3.4.2	4.4.2	Flight Control Subsystem	X							
3.4.2.1	4.4.2.1	Inertial Sensing			X			X		
3.4.2.2	4.4.2.2	Flight Control Redundancy			X			X	X	
3.4.2.3	4.4.2.3	Arming Interlocks				X		X		
3.4.3	4.4.3	Navigation Subsystem			X					X
3.4.4	4.4.4	Command and Control (C2) Data Link			X				X	X
3.4.5	4.4.5	Payload Data Link			X					X
3.4.6	4.4.6	Lost-Link Behavior							X	X
3.4.7	4.4.7	Lighting		X		X				
3.5	4.5	Ground Control Station and Human Systems	X							
3.5.1	4.5.1	Human Engineering		X	X					
3.5.2	4.5.2	Control Station Configuration		X		X				
3.5.3	4.5.3	Displays		X		X				
3.5.4	4.5.4	Single-Operator Operation				X	X			
3.5.5	4.5.5	Setup and Teardown Time				X				
3.6	4.6	Autonomy and Flight Modes	X							
3.6.1	4.6.1	Automatic Takeoff and Landing				X	X			
3.6.2	4.6.2	Waypoint Navigation							X	X
3.6.3	4.6.3	Return-to-Home							X	X
3.6.4	4.6.4	Geofencing							X	X
3.6.5	4.6.5	Contingency Management	X							
3.6.6	4.6.6	Contingency Behaviors			X				X	X
3.7	4.7	Recorded Information	X							
3.7.1	4.7.1	Flight Data Recording		X					X	

3.7.2	4.7.2	Imagery and Metadata Recording		X					X	
3.7.3	4.7.3	Built-In Test and Health Data					X		X	
3.8	4.8	Product Support	X							
3.8.1	4.8.1	Operational Availability (Ao)			X					
3.8.2	4.8.2	Mission Reliability (Rm)			X					
3.8.3	4.8.3	Loss-of-Thrust Probability			X					
3.8.4	4.8.4	Mean Time Between Failures (MTBF)			X					
3.8.5	4.8.5	Mean Time To Repair (MTTR)			X	X				
3.8.6	4.8.6	Diagnostics			X				X	
3.8.7	4.8.7	Two-Level Maintenance		X		X				
3.8.8	4.8.8	Turn-Around Time				X				
3.8.9	4.8.9	Nameplates and Product Marking		X						
3.9	4.9	Climatic and Environmental Conditions	X							
3.9.1	4.9.1	Natural Climate			X			X		
3.9.2	4.9.2	Precipitation and Blowing Particulates				X		X		
3.9.3	4.9.3	Induced Environment						X		
3.9.4	4.9.4	Electromagnetic Environmental Effects (E3)			X			X		
3.10	4.10	Architecture and Security	X							
3.10.1	4.10.1	Modular Open Systems Approach		X	X					
3.10.2	4.10.2	Cybersecurity		X	X					
3.10.3	4.10.3	Supply Chain / Blue UAS		X	X					
3.10.4	4.10.4	Computing Resources and SWaP-C Margin		X	X					
3.11	4.11	Utility Attributes	X							
3.11.1	4.11.1	Transportability		X		X				
3.11.2	4.11.2	System Safety			X					
3.11.3	4.11.3	Airworthiness Certification		X	X					
3.11.4	4.11.4	Spectrum Supportability		X						
3.11.5	4.11.5	Frangibility and Ground Safety			X			X		

5 PACKAGING

For acquisition purposes, the packaging requirements shall be as specified in the contract or order. When packaging of materiel is to be performed by DoD or in-house contractor personnel, these personnel need to contact the responsible packaging activity to ascertain packaging requirements. Preservation, packing, and marking shall be in accordance with MIL-STD-2073-1 and MIL-STD-129, and identification marking in accordance with MIL-STD-130. Lithium energy sources shall be packaged, marked, and shipped in accordance with applicable hazardous-materials regulations.

6 NOTES

(This section contains information of a general or explanatory nature that may be helpful, but is not mandatory.)

Acronyms and Abbreviations 6.1

Acronym	Meaning
Ao	Operational Availability
AFLCMC	Air Force Life Cycle Management Center
AGL	Above Ground Level
ASUAS	Advanced Small Unmanned Aircraft System
BIT	Built-In Test
BOL	Beginning of Life
C2	Command and Control
CE90	Circular Error 90%
CEP	Circular Error Probable
CDRL	Contract Data Requirements List
dBA	A-weighted Decibel
DID	Data Item Description
DIU	Defense Innovation Unit
EO	Electro-Optical
ESC	Electronic Speed Controller
E3	Electromagnetic Environmental Effects
FIPS	Federal Information Processing Standard
FMECA	Failure Modes, Effects and Criticality Analysis
FTA	Fault Tree Analysis
GCS	Ground Control Station
GNSS	Global Navigation Satellite System
GTW	Gross Takeoff Weight
IMU	Inertial Measurement Unit
IR	Infrared
ISA	International Standard Atmosphere
ISR	Intelligence, Surveillance and Reconnaissance
KLV	Key-Length-Value

LRU	Line Replaceable Unit
MISB	Motion Imagery Standards Board
MOSA	Modular Open Systems Approach
MSL	Mean Sea Level
MTBF	Mean Time Between Failures
MTTR	Mean Time To Repair
NVIS	Night Vision Imaging System
OGE	Out of Ground Effect
RMF	Risk Management Framework
Rm	Materiel / Mission Reliability
RMS	Root Mean Square
SS	System Specification
SUAS	Small Unmanned Aircraft System
SWaP-C	Space, Weight, Power and Cooling
TBD	To Be Determined
TLE	Target Location Error
T/W	Thrust-to-Weight
UAS	Unmanned Aircraft System
VCRM	Verification Cross Reference Matrix

Definitions 6.2

Term	Definition
Air Vehicle	The unmanned aircraft, including its airframe, propulsion, avionics, and installed payload, exclusive of the Ground Control Station.
Contingency Behavior	A deterministic, pre-briefed automatic response executed by the air vehicle upon a defined off-nominal condition (e.g., lost link, low energy).
Gross Takeoff Weight (GTW)	The ready-to-fly mass of the air vehicle including energy source(s) and the Standard Payload.
Ground Control Station (GCS)	The man-portable unit from which an operator plans, commands, and monitors the air vehicle and payload.
Objective	The desired operationally meaningful, time-critical, and affordable capability beyond the Threshold; the Government's stated goal.
Standard Configuration	The air vehicle configured with the Standard Payload and the Standard energy source, meeting the SWaP-C margins of 3.10.4.
Standard Payload	The reference mission payload defined in 3.2.1 used to establish performance requirements.

Threshold	The minimum acceptable value of a performance parameter below which the capability is of no operational value.
Trade Space	Requirements for which the offeror proposes a value between a stated Threshold and Objective as part of the proposed solution; see APPENDIX C.

APPENDIX A — MISSION PROFILE AND USAGE

This appendix defines the reference reconnaissance sortie used to establish the endurance and energy requirements of section 3.1.2. The profile corresponds to the ASUAS Nominal Sortie (nominal duration 10.5 minutes) and is the basis for the mission reliability allocation of 3.8.2.

Table A-1. ASUAS Nominal Reconnaissance Sortie (A.1)

Phase	Description	Duration (min)	Altitude AGL (m)	Notes
1	Pre-flight / BIT	0.0	0	Power-up, initiated BIT, GNSS acquisition, arming interlocks satisfied.
2	Vertical Launch & Climb	0.5	60	Automatic vertical takeoff to 60 m AGL; climb at ≥ 3 m/s.
3	Transit Outbound	2.0	60	Cruise at ≥ 15 kt to the reconnaissance area (nominal 1.5 km).
4	Loiter / Reconnaissance	5.0	80	Orbit / point-of-interest imaging at 80 m AGL; payload employment.
5	Transit Inbound	2.0	60	Cruise return to recovery point.
6	Recovery / Precision Land	0.5	0	Automatic precision vertical landing at home point.
7	Post-flight / Reserve	0.5	0	Shutdown with ≥ 20% energy reserve retained (3.3.4).
Σ	**Total sortie**	**10.5**	—	Unrefueled; energy reserve ≥ 20% retained at shutdown.

Usage: a maximum utilization rate of 30 sorties per aircraft per month is assumed for the design-service-life spectrum of 3.1.3.5.

APPENDIX B — RELIABILITY AND SYSTEM SAFETY BASIS

This appendix summarizes the reliability, availability, maintainability, and system-safety basis underlying the allocations of sections 3.8, 3.4.1.2, 3.4.2.2, and 3.11.2. Values derive from the ASUAS reliability model: a Reliability, Availability & Maintainability (RAM) prediction, a Fault-Tree Analysis (FTA) of the "Loss of Thrust" top event, and a Failure Modes, Effects & Criticality Analysis performed to MIL-STD-1629A and MIL-STD-882E.

Table B-1. ASUAS Reliability and Safety Allocations

Parameter	Allocation / Prediction	Basis / Trace
Single propulsion channel λ	≤ 185 failures / 10^6 h	MADe RAM prediction (single Battery→FC/ESC→Motor→Prop channel).
Single-channel R(1 h)	≥ 0.9998	MADe RAM; maps to 3.8.4 MTBF allocation.
Loss-of-Thrust top event	≤ 2×10^{-4} / flight hour	MADe Fault Tree top event predicted at 1.85×10^{-4} (3.8.3).
Single-points-of-failure (baseline quad)	24, all order-1	MADe FTA cut sets — a quad cannot fly on three rotors; drives 3.3.5 and APPENDIX C.
Highest-importance item	Energy source (FV ≈ 7.7%)	MADe FTA importance ranking; drives the dual-source requirement 3.4.1.2.
Redundant-configuration R(10.5 min)	≥ 0.9995 required; 0.99998 predicted	Dual energy source + dual flight controller (3.4.1.2, 3.4.2.2); maps to 3.8.2.
Redundant-configuration MTTF	≈ 4,673 h predicted	MADe RBD with two 1-of-2 parallel groups (battery, flight control).
System-safety risk (loss of thrust)	Catastrophic; residual mitigated	MIL-STD-882E FMECA; baseline Frequent×Catastrophic (RAC 1A) reduced by redundancy & inspection (3.11.2).

Key finding carried into requirements: the baseline four-rotor configuration has 24 order-1 single-points-of-failure (a quad cannot sustain controlled hover on three rotors). This drives the controlled-descent requirement 3.3.5, the dual-energy-source requirement 3.4.1.2, the redundant flight-control requirement 3.4.2.2, and the six-rotor growth trade in APPENDIX C.

APPENDIX C — TRADE SPACE

The following requirements are designated Trade Space. For each, the offeror shall propose a value between the Threshold and Objective as part of its solution definition; proposed values are evaluated in accordance with Section M of the solicitation.

Table C-1. ASUAS Trade Space Requirements

Paragraph	Attribute	Threshold	Objective	Trade Notes
3.1.2.1 / 3.1.2.2	Endurance	8 min hover / 10.5 min sortie	≥ 20 min hover	Offeror proposes energy source sizing and airframe efficiency to extend endurance; scored per Section M.
3.1.2.3	Operational Radius	2.0 km	5.0 km	Data-link power/antenna trade against SWaP and spectrum supportability.
3.2.3	Infrared Sensor	Not required (EO only)	Integrated cooled/uncooled IR channel	Growth payload for night reconnaissance; offeror proposes SWaP-C provisioning per 3.10.4.
3.3.5	Rotor Redundancy	Quad-X (controlled descent on rotor loss)	Hexa-X (continued flight on single-rotor loss)	Reliability trade identified by the ASUAS FTA: a six-rotor growth path removes the 24 order-1 cut sets at a SWaP and cost penalty.