ADS-65A-HDBK
29 August 2008

AERONAUTICS DESIGN STANDARD

HANDBOOK

DATA AND TEST GUIDANCE FOR QUALIFICATION OF SENSOR SYSTEMS ON AIRCRAFT

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DATA AND TEST GUIDANCE FOR QUALIFICATION OF SENSOR SYSTEMS

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DATE: 8/29/05

Certification Record

Document Identifier and Title: ADS-65A-HDBK, Aeronautical Design Standard, Data and Test Guidance for Qualification of Sensor Systems

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Rationale for Certification:

Decision:

General Type	Decision (√)	Certification
Specification		Performance
		Detail
Standard		Interface Standard
		Standard Practice
		Design Standard
		Test Method Standard
		Process Standard
Handbook	√	Handbook (non-mandatory use)
Alternative Action		

	Concur	Nonconcur	Date
Division Chief, Mission Equipment Mr. Frederick T. Reed III	✓		8/26/08
AMCOM Standardization Branch Chief Mr. William J. Smith	✓		6/27/2008
Director, Aviation Engineering Dr. William D. Lewis	✓		8/18/2008
AMCOM and PEO, Aviation Standards Executive Ms. Patricia T. Martin	✓		8/29/08

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1.0 SCOPE

This handbook establishes design and documentation guidance for full qualification of vision and targeting sensor systems, which will be completed prior to issue of an Airworthiness Release (**AWR**). It includes statements, analyses and preliminary analyses regarding sensor systems and subsystems. Guidance may be tailored for development of test requirement at the discretion of the Government.

Requirements contained within this document apply only to sensor systems that have the subject equipment or subsystem. Commercial off-the-shelf (**COTS**) systems are not exempt from the requirements herein. **COTS** systems will meet all applicable requirements in order to obtain an airworthiness release. The airworthiness authorities may waive **COTS** requirements. Documentation of the waiver is required. Sensor payloads should be considered as safety critical.

Analysis, inspections, simulations, testing, and demonstration will verify compliance of system, subsystem, or component to the applicable specification.

2.0 APPLICABLE DOCUMENTS

2.1 General

The documents listed below are not necessarily all of the documents referenced herein, but are those needed to understand the information provided by this handbook.

2.2 Government Documents

2.2.1 Specifications, Standards and Handbooks

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

MIL-STD-461	REQUIREMENTS FOR THE CONTROL OF ELECTROMAGNETIC INTERFERENCE CHARACTERISTICS OF SUBSYSTEMS AND EQUIPMENT
MIL-STD-464	ELECTROMAGNETIC ENVIRONMENTAL EFFECTS REQUIREMENTS FOR SYSTEMS
MIL-STD-810	ENVIRONMENTALENGINEERING CONSIDERATIONS AND LABORATORY TESTS

MIL-STD-1425	MILITARY LASERS AND ASSOCIATED SUPPORT EQUIPMENT, SAFETY DESIGN REQUIREMENTS FOR
MIL-STD-1472	HUMAN ENGINEERING
MIL-E-7016	ELECTRICAL LOAD AND POWER SOURCE CAPACITY, AIRCRAFT, ANALYSIS OF
MIL-STD-7080	SELECTION AND INSTALLATION OF AIRCRAFT ELECTRONIC EQUIPMENT
MIL-STD-8591	AIRBORNE STORES, SUSPENSION EQUIPMENT AND AIRCRAFT STORE INTERFACE (CARRIAGE PHASE); GENERAL CRITERIA FOR
MIL-STD- 3009	LIGHTING, AIRCRAFT, NIGHT VISION IMAGING SYSTEM (NVIS) COMPATIBLE
MIL-HDBK-87213	DOD HANDBOOK ELECTRONICALLY/OPTICALLY GENERATED AIRBORNE DISPLAYS
MIL-HDBK-828	MILITARY HANDBOOK LASER RANGE SAFETY
MIL-STD-1787	AIRCRAFT DISPLAY SYMBOLOGY
MIL-STD-7179	FINISHES, COATINGS, AND SEALANTS, FOR THE PROTECTION OF AEROSPACE WEAPONS SYSTEMS

(Copies of these documents are available online at http://assist.daps.dla.mil or from the Standardization Document Order Desk, 700 Robbins Avenue, Building 4D, Philadelphia, PA 19111-5094.)

2.2.2 Other Government Documents, Drawings, and Publications

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

ADS-51-HDBK	AERONAUTICAL DESIGN STANDARD HANDBOOK
ADS-37-PRF	ELECTROMAGNETIC ENVIRONMENTAL EFFECTS (E3) MANAGEMENT, DESIGN, AND TEST REQUIREMENTS

ADS-27-SP	REQUIREMENTS FOR ROTORCRAFT VIBRATION SPECIFICATIONS, MODELING AND TESTING
SAWE RP-7D	MASS PROPERTIES MANAGEMENT AND CONTROL FOR MILITARY AIRCRAFT

(Copies of these documents are available from the United States Army Aviation and Missile Command, Aviation Engineering Directorate, Redstone Arsenal, Alabama.)

2.3 Non-Government Publications

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

SAE-AS-50881	WIRING, AEROSPACE VEHICLE
SAWE-RP7	WEIGHT AND BALANCE CONTROL DATA (FOR AIRPLANES AND HELICOPTERS)
ANSI Z136.1	SAFE USE OF LASERS (AMERICAN STANDARDS INSTITUTE)
SAE ARP 4761	Aerospace Recommended Practice, Guidelines and Methods for Conducting the Safety Assessment Process on Civil Airborne Systems and Equipment

3.0 DEFINITIONS

3.1 Acronyms. Acronyms used in this handbook are defined as follows:

ADS	Aeronautic Design Standard
AMCP	Army Material Command Pamphlet
AWR	Airworthiness Release
CCD Array	Charged Couplet Device Array
cg	Center of Gravity

CFTE	Contractor Furnished Test Equipment
COTS	Commercial Off-the-Shelf
DoDISS	Department of Defense Index of Specifications and Standards
EMC	Electromagnetic Compatibility
EMI	Electromagnetic Interference
EMV	Electromagnetic Vulnerability
EOCCM	Electro-Optical Counter-Counter Measures
fc	Foot Candle
fL	Foot Lambert
FOR	Field of Regard
FOV	Field of View
FLIR	Forward Looking Infrared
GP	Government Property
HFE	Human Factors Engineering
HTS	Head Tracking System
IITV (I2TV)	Image Intensified Television
IR	Infrared
ISO	International Organization for Standardization
LOS	Line of Sight
MRC	Minimum Resolvable Contrast
MRTD	Minimum Resolvable Temperature Differential
MTF	Modulation Transfer Function
NOE	Nap of the Earth

OD	Optical Density
PIDS	Prime Item Development Specification
PNVS	Pilot Night Vision System
SAE	Society of Automotive Engineers
SAWE	Society of Allied Weight Engineers
TAS	Target Acquisition System
TDP	Technical Data Package
TLE	Target Location Error
TPE	Target Pointing Error
UAV	Unmanned Aerial Vehicle
UAS	Unmanned Aerial System

3.2 Reviews. A series of formal and informal reviews should be held during the program to establish a foundation for airworthiness substantiation and assure airworthiness qualification. The AQS should be written to include all reviews that plan the qualification method for the basic aircraft, modification, and alteration to ensure requirement compliance. This specification should be reviewed and approved by the Army. The Qualification Reviews should be held periodically during the program to validate the airworthiness substantiation and assure compliance with all airworthiness qualification requirements. Minor modifications to qualified systems may be made and qualified in compliance with the qualification by similarity process identified in paragraph 4.1 below. Requirements under this section may be tailored with AED approval to reflect constraints of the program.

3.2.1 Human Factor Reviews. All program reviews should include segments on Manpower and Personnel Integration (MANPRINT) Domains (Manpower, personnel, Training, System Safety, Health Hazards, Soldier Survivability, and Human Factors Engineering (HFE). The HFE domain should include the design progression Warnings/Cautions/Advisory (WCA) system, evaluations, test schedules, plans and results, at a minimum. In all areas that are not compliant with MANPRINT and airworthiness qualification requirements the risk to program and risk mitigation plan should be presented. A preliminary human engineering analysis that should give a prognosis of all the effects occurring that could impair the crew, their sight, or their ability to fly safely, caused by blast overpressure, noise, toxic emissions, and/or expected gas concentration in the cockpit. A preliminary human engineering analysis should be submitted. Consideration should also be given to man-machine-interface and ease of operation for crew and maintenance personnel.

3.2.2 Preliminary Design Review (PDR). A PDR should be conducted as soon as practical after contract award. When the sensor is part of an air vehicle procurement, the air vehicle PDR should include a separate payload PDR, including senor software and sensor integration with the air vehicle. The PDR should be conducted in order to:

1) Identify all Qualification Requirements using a verification matrix.
2) Ensure the design approach complies with performance specification and TRD requirements, design criteria, airworthiness qualification and other contract requirements.
3) Provide an understanding of any design changes.
4) Identify changes impacting airworthiness qualification, compliance with required specifications, or increased risk.
5) Identify changes to the test program resulting from design changes.
6) Assess the technical program and AQS progress.
7) Provide the Government access to the software trouble report database.
8) Status and presentation of resolutions for all SSR action items.
9) Explanation of any open PCRs against software requirements.
10) Software architecture, including top-level CSCI structure and evidence that the following considerations are incorporated in the software design, per the guidance of RTCA-DO-178B: compatibility with the high-level requirements, verifiability, conformance to standards, partitioning integrity, and incorporation of necessary logic affecting system safety.
11) Computer resource allocation, including timing, sequencing requirements, and relevant equipment constraints used in determining allocation.
12) Executive control and start/recovery features of each CSCI.
13) Computer software development facilities, software development tools, test tools.
14) Design features providing for life-cycle software supportability.
15) Review of all software management and quality metrics.
16) Update of software milestone schedule.
17) Update of identified risk areas and risk mitigation measures.
18) Results of software quality and process audits and measurement of software quality metrics as provided for in the Software Quality Assurance Plan.

The following items should be submitted NLT 45 days prior to the PDR:

a. Preliminary layout and preliminary drawings.
b. Preliminary AQS with the verification matrix and its modifications and alterations with Army requirements to include an integrated master schedule.
c. Preliminary Corrosion Prevention and Control Plan.
d. Structural Design Criteria Report using ADS-29, chapter 4 of AMCP 706-201, MIL-S-8698, and section 3.4 of MIL-A-8868B for guidance.
e. Fatigue Methodology Report prepared using section 7-6.3 of ADS-51-HDBK, section 7-4.2.2.2 of AMCP 706-203, section 4-4.2.1.6 of AMCP 706-201, and other appropriate sections of chapter 4 of AMCP 706-201 for guidance.
f. Preliminary E3 Control Plan/Integration Analysis including the following Data Items:
    i) DI-EMCS-80199B

ii) DI-EMCS-81528
iii) DI-EMCS-81542A
iv) DI-EMCS-81295
v) DI-RELI-80669A
vi) DI-RELI-80671A

g. Review of Environmental Qualification Requirements

3.2.3 Critical Design Review (CDR). The requirements specified in this paragraph are applicable to the airworthiness portion of the overall system CDR. The CDR should be conducted prior to release of the payload design for hardware production and/or prior to the initiation of software coding. The CDR should be conducted to determine the characteristics of the design, and to ensure incorporation of requirements prior to commitment to major fabrication. The contractor, in conjunction with the Government, should develop a detailed agenda NLT 30 days prior to the CDR. The following items should be submitted NLT 45 days prior to the CDR:

a. The AQS and verification matrix (Final) – The AQS and verification matrix should show the compliance the aircraft, modifications and alterations with Army requirements to include an integrated master schedule.
b. Production Drawing Package.
c. Safety Assessment Report.
d. Loads and Stress Analysis Damage Tolerance and Fatigue Analyses and Reports.
e. Materials and Processes specifications to be used in the manufacture of the payload related modifications.
f. Preliminary Material Allowable Report.
g. Fatigue Test Plans as Required.
h. Calculated Weight.
i. Electrical Loads Analysis.
j. Final Electromagnetic Environmental Effects Control/Integration Analysis.
k. Draft Human Engineering Design Approach Document.
l. Final Software Design Documents.
m. Final Interface Design Documents.
n. Final Software Test Plan or Software Verification Plan.
o. Explosive Hazard Classification Data Report.
p. Final Functional Hazard Analysis.
q. Final Version of the Software FMECA
r. Status and presentation of resolutions for all PDR action items
s. Explanation of any open PCRs against software requirements.
t. Software architecture, including assignment of CSCI requirements to specific lower-level software components and units
u. Overall information and control flow between software units, and sequencing of software operations.
v. Evidence that the following considerations are incorporated in the software design, per the guidance of RTCA-DO-178B: compatibility with the high-level requirements, consistency, verifiability, conformance to standards, partitioning integrity, and incorporation of necessary logic affecting system safety.

w. Results of activities to determine processor throughput, memory, and bus utilization with respect to Computer resource allocations
x. Computer software development facilities, software development tools, test tools
y. Design features providing for life-cycle software supportability.
z. Review of all software management and quality metrics.
aa. Update of software development schedule.
bb. Update of identified risk areas and risk mitigation measures.
cc. Results of software quality and process audits and measurement of software quality metrics as provided for in the Software Quality Assurance Plan.
dd. Final Software/System/Subsystem Hazard Analysis
ee. Final Software Hazards Analysis Tracking Report.
ff. Final Software Safety Critical Function Analysis.
gg. Preliminary Software Test Description or Software Verification Cases and Procedures.
hh. Communication Design Documents
ii. Results of the Communication BER and frequency management review
jj. Results of any developmental testing performed by the contractor as risk reduction.
kk. Review of Environmental Qualification Test Plans and Results versus Requirements
ll. A thermal loading analysis will be conducted to verify the sensor system's thermal loading does not adversely affect the aircraft.
mm. An aircraft strike analysis should demonstrate that crashworthiness has not been degraded below the requirements or levels appropriate to the particular aircraft as a result of the presence of the sensor system.

3.2.4 Flight Readiness Review (FRR). A FRR should be conducted NLT 45 days prior to the first flight. The FRR should ensure that all airworthiness prerequisites have been addressed and met, hardware and software are sufficiently mature to warrant proceeding with flight testing, and no undue risks are apparent in early flights. The detail of the data should be such that it supports issuance of a Contractor Flight Release (CFR) and/or AWR by the Government (RDECOM AED). Agenda items to be addressed in the FRR may include but are not limited to the following:

a. Presentation of the Army AQS and verification matrix with any revisions that have occurred during the development, design, and modification/alteration process. All revisions should show review and concurrence by Army approval, and the Payload Prime Contractor approval.
b. Updated Loads, Stress, Damage Tolerance and Fatigue Analyses and Reports
c. Evaluation of component and subsystem tests, test failures and corrective actions.
d. Evaluation of management procedures for flight operation.
e. Evaluation of emergency operational procedures.
f. Evaluation of established flight abort criteria.
g. Evaluation and assurance that the prerequisites for first flight have been met.
h. Evaluation of test instrumentation.
i. Evaluation of ground and flight safety practices and procedures.
j. Evaluation of test objectives.
k. Presentation of Flight Test do not exceed Limits and methodology thereof.

l. Static Test Article Report.
m. Evaluation of the software updating process during flight testing.
n. Software Version Description.
o. Software Test Report or Software Verification Results Report.
p. System Integration Test Results.
q. System Safety Hazard Analysis Report.
r. Safety Assessment Report.
s. Software Accomplishment Summary.
t. Review of Environmental SOF Qualification Results versus Requirements
u. Review of E3 Safety of Flight Qualification Results versus Requirements
v. Weight and Balance report

3.2.4.1 Subsequent Flight Readiness Review (SFRR). A SFRR should be conducted prior to any subsequent flights for which the configuration of the air vehicle or software has significantly changed, and prior to conducting flight test activities for purposes that have not been approved in previous flight readiness reviews. The detail of the data should be such that it supports issuance of a CFR and/or AWR by the Government (AMRDEC AED). Information in AQP paragraph 3.3.4 may be required as agenda items.

4.0 GENERAL GUIDANCE

4.1 Qualification Methods. Qualification should be performed to verify compliance with the Performance Specification of the system on which the payload is intended to be used. Qualification should be by similarity, analysis, test, demonstration, or by inspection in this respective preferred order.

4.2 Qualification by Similarity. Qualification by similarity may be proposed for components or systems that have previously successfully been used in Army aircraft. ADS-51-HDBK or Paragraph 7-3.3 of Army Material Command Pamphlet (AMCP) 706-203 may be used for guidance for qualification by similarity. Items that directly impact system safety should not be qualified by similarity. When qualification by similarity is proposed, formal report should be prepared including all supporting data and qualification reports. Components should be categorized as Category I, II, or III as defined below. All documents related to qualification by similarity for each category are subject to Government approval.

a. Category I. Category I is defined as those components used in the design, which are identical in form and function to those components qualified in previous designs of Army aircraft and have identical operational and environmental requirements. Qualification reports for items in this category should list each part by name, part number, and the other aircraft/systems in which the part was used. A copy of qualification documentation listing appropriate Government, contractor, or military specification, including revisions as pertinent, should be submitted.

b. Category II. Category II is defined as a component with minor modifications that was previously qualified for use in Army aircraft before the component was modified. The modified component must be used in a similar operation and a similar environment as the previously qualified component. Name, part number, and a technical rationale of why the modification to the part is minor enough to waive other qualification methods should list these items.

c. Category III. Category III is defined as those components, which have been used in similar design applications by other contractors/companies and which are proposed to be qualified by similarity. Reports for items in this category should list the component name, part number, and specific identification numbers for the system and aircraft where the component was used, and the report substantiating initial qualification.
Note: For Categories II and III components, the similarity rationale and its supporting documentation should include at least two separate drawings, analyses, reports, and substantiation data that compare the two components, part to part, clearly depicting the similarities and differences between the two components.

4.3 Qualification by Analysis. Qualification by analysis involves proving an item meets specified requirements by a technical evaluation of equations, charts, graphs, circuit diagrams, or representative data. Government review and approval is required.

4.4 Qualification by Formal Testing. Formal qualification testing should be used for component, subassembly and systems that do not meet qualification by similarity or analysis standards. Formal testing should include test plans, test procedures, test reports, Government witnessing (as required) and Government approval.

4.5 Qualification by Demonstration. Qualification by demonstration should be conducted to show the capability of the system or subsystem, to comply with the requirements of the System Performance Specification. A survey should be conducted to show the maximum capability of the system or subsystem.

4.6 Qualification by Inspection. Inspections are performed to determine if the system or subsystem complies with the requirements of the System Performance Specification.

4.7 Qualification through Simulation. The objective of Qualification through Simulation is to show that the simulation adequately represents the system being modeled with respect to critical characteristics under consideration by the simulation. Simulation includes verification through the use of mathematical models which replicates the operation or performance of the equipment being evaluated, the threat and environment in which the equipment should operate; and various combinations of the equipment, threat, and environmental conditions.

4.8 Data Submittal

Electro-optical drawings, optical schematics, and systems performance data should be provided according to the following:

4.8.1 Sensor Package Description and Installation

Verify Design, location, and installation of Sensor System

Standard: Drawings, schematics, and performance data should describe all items of the entire sensor systems/subsystems.

Compliance: Submission of Drawings, schematics, optical prescriptions and performance data describing all items of the entire sensor systems/subsystems. The data should identify by Governmental nomenclature each item of the system/subsystem and should include the functional relationship and purpose of the items. The interconnections to systems, such as structural mounting surface, electrical, and optical requirements should be provided. Structural attachment details of the sensor turret system to the aircraft should also be shown. The structural attachment details should be provided and all loaded joints clearly shown. Mounting details depicting the attachment of the system/subsystem to brackets, pallets, or description/analysis/diagrams should be provided to indicate the performance requirements for safety are met. Electrical schematics and wire diagrams internal to the system/subsystem and wire/diagrams/cable connections should be provided. Electrical schematics/cable connectors, and wire run diagrams should be provided using **MIL-STD-7080** as a guide. An airframe prevention and control procedure containing the following data will be prepared.

a. Materials/finishes to be used during the installation procedure, including but not limited to the mounting hardware, will be compatible with the adjacent airframe structure from a corrosion point of view using **MIL-STD-7179** as a guide.

b. Description of how system corrosion requirements are translated into sub-tier requirements, considering criticality of particular hardware (as determined by the Failure Modes and Effects Criticality Analysis), severity of local environment, and difficulty of maintenance.

c. Bonding materials, procedures and/or modifications for verification of airframe electrical bonding requirements.

Installation instructions should be provided for production. This includes wiring, pinouts, grounding, bonding, and shielding, mounting hardware, connectors, etc. The contractor should provide a document showing what, if any, failures of the environmental and Electromagnetic Interference (EMI) tests would need to be considered by future integrators. The contractor should provide test points on the sensor system to check for bonding of the sensor to the aircraft for maintenance purposes.

Reference: MIL-STD-7080, MIL-STD-7179

4.8.2 Equipment Furnished by Contractor

Verify Design, Performance, and Operation of Contractor Furnished Test Equipment

Standard: Contractor-furnished-test-equipment (**CFTE**) sensor design/analysis/test

Compliance: Contractor-furnished-equipment (**CFTE**) operation and performance characteristics should be submitted when such equipment is furnished as **CFTE,** or if modification of the Government Property (**GP**) is made.

4.8.3 Analysis Requirements

4.8.3.1 Safety Statement and Hazard Analysis

Verify Sensor System Safety and Identify Hazards

Standard: Analysis of the aircraft design should indicate that sensor systems and subsystems are in accordance with the safety criteria.

Compliance: Submission of Safety Statement/Hazard Analysis. Analysis of the aircraft design should indicate that sensor systems and subsystems use the safety guidance of **ADS-51-HDBK**. Hazard analyses should be prepared and submitted. The analysis data should include total system hazard analyses and effects on aircraft safety. Analyses should include, but not be limited to the following analyses:

Reference: MIL-STD-1425, MIL-STD-1472, ANSI Z136.1, ADS-51-HDBK, ADS-51-HDBK, MIL-STD-8591, MIL-E-7016, SAE ARP 4761, and ADS-37-PRF

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4.8.3.2 Pilot Night Vision Systems Analysis

Verify Performance and Design of Pilot Night Vision Systems

Standard: Pilot Night Vision Systems coupled to a helmet-mounted display or helmet-mounted Night Vision Goggle (**NVG**) should be evaluated.

Compliance: Pilot Night Vision Systems coupled to a helmet-mounted display or helmet-mounted Night Vision Goggle (**NVG**) should be evaluated by analysis. The end-to-end analysis should verify that there is sufficient field-of-view and resolution to allow safe flight of the aircraft in marginal light conditions, marginal weather conditions, and Nap-of-Earth (**NOE**) or greater altitudes.

4.8.3.3 Laser Rangefinder Designator Systems Analysis

Verify Design and Performance of Laser Rangefinder Designator Systems

Standard: The Laser Rangefinder Designator Systems in a stabilized turret should meet the U.S. Army Center for Health Promotion and Prevention Medicine (CHPPM) laser safety criteria.

Compliance: The laser designation performance should be by survey and demonstrated using a laser spot scoring system. Laser Rangefinder performance should be evaluated against mission appropriate targets.

4.8.3.4 Laser Safety Analysis

Verify Laser Safety

Standard: Laser systems installed on aircraft should meet the safety requirements as specified within the referenced documents.

Compliance: The analysis should evaluate system design control measures and potential hazards of the laser system.

Reference: MIL-STD-1425, MIL-STD-1472, and ANSI Z136.1.

4.8.3.5 Aircraft Strike Analysis

Verify Effects of an Aircraft Strike

Standard: Analysis should demonstrate that crashworthiness has not been degraded below the requirements or levels appropriate to the particular aircraft as a result of the presence of the sensor system.

Compliance: The analysis should conclude that hazards do not exist because of potential strike areas due to sensor turret structure or any egress blockage by the sensor installation. The hazards are defined within the Airworthiness Qualifications Specifications and Safety Assessment for each aircraft. Perform analysis to verify the structural integrity of the LRU (housing, turret, interface boxes, mounts, etc.). This should be done for crash loads and all flight loads of the aircraft, or as identified in the sensor specification. As an alternative, a Crash Safety acceleration test IAW **MIL-STD-810** may be performed. An emergency egress analysis should be conducted per the following

4.8.3.6 Emergency Egress

Standard: An emergency egress demonstration should verify that changes to aircraft will not impede emergency egress.

Compliance: An emergency egress demonstration should be conducted to verify any change in cockpit configuration do not impede emergency egress from the aircraft.

The crew station should accommodate normal and expedited ingress, as well as normal, emergency, and assisted egress such that the crew station geometry does not hinder access to/from the crew station (canopy doors, locks, handles, etc.); nor does any equipment, control, or crew station geometry impede or cause harm to aircraft or personnel to meet the following timelines:

i. Aircraft with crashworthy fuel cells: all crew and passengers in the most restrictive configuration(s) of personal clothing and equipment (including MOPP IV) must be able to exit the aircraft and clear a distance of at least 10 feet from the nearest exit within 30 seconds. All exit doors must be closed and all personnel must start in a seated position with a locked harness/restraint and hands on controls. All personnel must exit through the same exit (door) location, and at least two-thirds of all possible exits must be tested.

ii. Aircraft not equipped with crashworthy fuel cells must demonstrate emergency egress provisions as stated above, but within 20 seconds.

iii. Assisted Egress must be accomplished within 3 minutes from time of arrival on scene. Assisted egress includes immobilizing the crew members and extracting crew members without adding injury or compounding existing injury.

Evacuation times should be demonstrated by actual tests using personnel approximating 95th-percentile troops with full combat equipment for passengers and 95th-percentile aviators with arctic flight gear and body armor for crew members.

Reference: MIL-STD-810

4.8.3.7 Mechanical Load Analysis

Verify Structural Integrity and Mechanical Load of the Sensor System

Standard: Demonstrate the structural integrity of the sensor turret and the supporting structure of the aircraft.

Compliance: The mechanical load analysis should demonstrate the structural integrity of the sensor turret and the supporting structure of the aircraft. The expected loads should not exceed critical limits and should use the guidance of **ADS-51-HDBK**.

Reference: ADS-51-HDBK

4.8.3.8 Weight and Balance Report

Verify Weight and Balance

Standard: A weight and balance report should show accurate and complete weight and balance calculations of the sensor system.

Compliance: Submission of weight and balance report. This report should show accurate and complete weight and balance calculations of the sensor system. Tables should include the weights, moment of inertia, and center of gravity (**cg**) for the sensor system and subsystems, as well as empty weights, and gross weights, and **cg** for the aircraft. The report should include drawings that show the location of the **cg** for the system and for each subsystem in the system's reference frame. The sensor system reference frame datum should be clearly marked on all drawings.

Reference(s): SAWE RP-7D, Mass Properties Management and Control for Military Aircraft

4.8.3.9 Stress Analysis

Verify Stress on the Aircraft from the Sensor System

Standard: A stress analysis should consider the structural loading effects of the sensor system and mounting bracket on the aircraft.

Compliance: Perform stress analysis of the turret, mount, associated hardware, and aircraft structure to verify that positive margins of safety in all modes of flight. Flight loads should be in accordance with the aircraft specification and structural loads criteria.

4.8.3.10 Preliminary Dynamic Analysis

Verify Dynamic Compatibility

Standard: The equipment as mounted to the aircraft should not have modal frequencies near the four frequencies with the highest amplitude peaks of the specification spectra.

Compliance: A preliminary dynamic analysis should be performed to determine the fundamental dynamic properties of the sensor system/subsystem. These properties should include, but are limited to:

1) Resonant frequencies, damping, and mode shapes of the installed system.
2) The forced response of the installed system with the forcing frequencies of the host equal to the primary forcing frequencies of 1P, 1nP, 2nP, 3nP, and 4nP (where n = number of blades and P = rotor angular velocity).
3) The installed system dynamic effect on the weapon and the host system.

Sensor systems mounted on fixed wing aircraft will be subjected to vibration levels and profiles of the host aircraft.

And, compliance to this requirement should be checked when the equipment is first mounted on the aircraft by means of a rap test (modal testing) or an Aircraft Shake Test.

Reference: ADS-27-SP

4.8.3.11 Electrical Load Analysis

Verify the Electrical Load

Standard: An electrical load analysis should determine for each electrical system that adequate electrical sources are present for all system loading conditions under all operating conditions.

Compliance: An electrical load and power source capacity analysis should be prepared in accordance with **MIL-E-7016**.

Reference: MIL-E-7016.

4.8.3.12 Clearance Analysis

Verify Clearance of the Sensor

Standard: The integration of the sensor package should provide necessary ground, rotor, and weapons trajectory clearance to prevent any collision, or accidents.

Compliance: A clearance analysis should show that there is sufficient clearance between the sensor, ground, rotors, and the weapon's trajectories.

4.8.3.13 Blast Overpressure Analysis

Verify Weapon Effects on the Sensor System

Standard: The launch effects from smoke, flames, and temperature deltas on the visual/infrared optics in the sensor system should also be characterized to determine any operational effects on the mission.

Compliance: The analysis should describe the effects on the sensor systems/subsystems.

4.8.3.14 Electromagnetic Design and Analysis

Verify Electromagnetic Design

Standard: The sensor package should meet the requirements of **ADS-37A-PRF** for electromagnetic environmental effects.

Compliance: An analysis should be performed according to the requirements of **ADS-37A-PRF** for electromagnetic environmental effects to determine compliance.

Reference: ADS-37A-PRF

4.8.3.15 Display, Charge Coupled Devices and Camera Analysis

Verify Design of Displays, Charge Coupled Devices, and Cameras

Standard: Evaluate system performance parameters that are necessary to evaluate image quality.

Compliance: Analysis should be conducted on displays, charge coupled devices, and cameras to evaluate system performance parameters that are necessary to evaluate image quality. Displays, should be evaluated in accordance with section 5.4.1 and charge coupled devices should be evaluated per applicable requirements of section 5.5.3. Cameras should be evaluated per applicable requirements of section 5.5.2 through 5.5.6.

4.8.3.16 Thermal Loading

Verify the Thermal Loading of the Sensor System

Standard: The thermal load of the sensor system should not adversely affect the aircraft.

Compliance: A thermal loading analysis will be conducted to verify the sensor system's thermal loading does not adversely affect the aircraft, equipment, or crew members. Analysis should also cover the aircraft's thermal effects on the sensor and the temperatures found in the avionics bays.

5.0 DETAILED GUIDANCE

5.1 Built in Test (BIT)

Verify functioning of any Built-in Test (BIT)

Standard: BIT will perform failure detection and failure isolation.

Compliance: Verify the BIT will perform failure detection and failure isolation. A BIT may be continuous, automatic, or initiated as required.

5.2 Gimbal Stop Evaluation

Verify the Gimbal Stops Performance

Standard: Mechanical, electrical, and software stops prevent damage to the sensor system and prevent hazards due to lasing of the aircraft and crew.

Compliance: An evaluation of the performance of the gimbal stops should be conducted.

5.3 Bonding and Grounding

Verify Bonding and Grounding

Standard: Electrical and electronic bonds should meet the requirements of **ADS-37A-PRF**, paragraph 3.10 and **MIL-STD-464**, paragraph 5.10.3.

Compliance: Perform applicable requirements in accordance with **ADS-37A-PRF**, paragraph 3.10.

Reference: MIL-STD-464, ADS-37A-PRF

5.4 Displays

5.4.1 Displays

Verify Display Performance

Standard: Displays should be evaluated for relevant performance parameters.

Compliance: Display tests should include, but will not be limited to: modulation transfer function (**MTF**), minimum resolvable temperature differential (**MRTD**), and minimum resolvable contrast (**MRC**). Display luminance, uniformity (shades of gray), and resolution should be sufficient to allow for the maximum image detail at an optimal viewing distance. Display flicker should be evaluated and minimized to determine the effects on visibility and readability. Additional tests should be conducted to determine the effects of direct and indirect light on the visibility of displays and monitors. Displays should use the guidance of **MIL-HDBK-87213** unless otherwise stated in applicable specifications.

Reference: MIL-HDBK-87213

5.4.1.1 Sensor Symbology

Verify Symbology Compliance and Readability

Standard: Symbology should be readable when displayed against an image or field and will have limited obscuration. Symbology and imagery will be discernable.

Compliance: Test and evaluation of symbology, compatibility, and readability should be conducted. NVG compatible displays will meet the requirements of **MIL-STD-3009** for Type I, Class A, night vision goggles, the requirements of **MIL-STD-1472** for display of information, and **MIL-STD-1787** for flight display information requirements. Also, refer to **MIL-STD-1295** for symbology guidance.

Reference: MIL-STD-3009, MIL-STD-1472, MIL-STD-1295

5.4.1.2 Display Lighting

Verify Display Lighting Performance

Standard: Applicable test parameters should include: luminance, chromaticity, and spectral radiance of the display. The display should be readable in a combined environment consisting of 10,000 fc diffuse illuminance and a specular reflection of a 200 fL glare source.

Compliance: Tests and analysis will be used to verify that applicable lighting requirements of the above and **MIL-STD-3009** are met. NVG compatible displays will meet the requirements of **MIL-STD-3009** for Type I, Class A, night vision goggles.

Reference: MIL-STD-3009

5.4.2 Image Registration

Verify Image Registration

Standard: Night/Day/Image intensified systems will be registered to other vision systems as required by the design specification. If not specified within the development specification, the registration requirements will be of a level that allows for safe conduct of mission when switching to different sensors.

Compliance: If not specified within the development specification, the registration requirements will be of a level that allows for safe conduct of mission when switching to different sensors. Images will be registered throughout the display from the center to the edges. Image registration is verified by correlation of features in the image. Ghosting and double images should not be present in a properly registered image.

5.4.3 Image Fusion Performance

Verify Image Fusion Performance

Standard: Image fusion or blending of sensor images will be performed in a way as to aid in mission conduct.

Compliance: Verify fused or blended images have adequate methodology for adjusting the ratios of the combined images. Resolution of blended images will not fall below the requirements of the least sensitive sensor in the blended image.

5.4.4 Non-uniformity Correction Algorithms

Verify Non-uniformity Correction Algorithms

Standard: Performance of non-uniformity correction (NUC) algorithms should be evaluated.

Compliance: The analysis of NUC algorithms should be performed to include the following image artifacts: ghosting, distortion, and uniformity. If not otherwise specified, ghosting will be evaluated by visual and, or measurement. Distortion and uniformity will not exceed plus, or minus 5% across the entire display.

5.5 Vision Systems

5.5.1 Direct View Optical Systems

Verify the Performance of Direct View Optical Systems (DVO)

Standard: Direct view optical systems will perform as stated within the applicable specifications. If not stated within the specification, DVO will be evaluated for mission requirements. Tests should include resolution and FOV as applicable.

Compliance: Direct View Optical Systems will be evaluated for optical resolution and field of view.

5.5.2 Image Intensified Systems

Verify the Performance of Image Intensified Systems

Standard: Image intensified systems will meet performance requirements under varying low light level conditions. Image intensified systems should be evaluated for resolution, FOV, image uniformity, distortion, and blooming.

Compliance: Performance and resolution of image intensified systems should be tested over the full range from starlight to full moon conditions, with varying target frequency and contrast levels. The system should be tested in the presence of point sources to evaluate the effects of blooming. Image intensified systems should not be damaged from optical radiation outside the 600 to 900 nanometer waveband and should operate in urban environments without saturation (blooming) due to cultural lighting.

5.5.3 Imaging Arrays

Verify the Performance of Imaging Arrays

Standard: CCD array performance parameters should include: color characterization, opto-electronic conversion, resolution, speed, dynamic range, **MTF**, read noise, dark current, quantum yield, full well, linearity, pixel non-uniformity, sensitivity, signal to noise, offset, camera gain constant, blemishes, and 3D noise. The imaging arrays should by tested to ensure adequate resolution, dynamic range, signal to noise ratio, and MTF. Infrared Arrays should also evaluate the **MRTD** and **NEDT.**

Compliance: Characterization of **Imaging Arrays** should be conducted in accordance with International Organization for Standardization (**ISO**) requirements or Government standards when available.

5.5.4 Vision System Performance

Verify the Performance of Vision Systems

Standard: Vision systems should meet all top-level performance requirements.

Compliance: Verify Vision Systems meet all top-level performance requirements, regardless of component, or subsystem performance.

5.5.5 Pilot Night Vision System (PNVS)

Verify the Performance of Pilot Night Vision Systems (PNVS)

Standard: Performance of PNVS should be verified.

Compliance: Compliance: Pilot Night Vision Systems such as Forward Looking Infra-Red (**FLIR**) and **I2TV** with a helmet-mounted display system, or a helmet or body-mounted night vision goggle, or helmet mounted display alone should be laboratory and flight tested to ensure sufficient field of view (**FOV**), field of regard (FOR), head tracking rate, head tracking acceleration, and resolution to allow safe flying of the aircraft in marginal light and weather conditions, and at NOE or above altitudes. The imaging arrays should by tested to ensure adequate resolution, dynamic range, signal to noise ratio, and **MTF**. Infrared Arrays should also evaluate the **MRTD** and **NEDT**. Critical sensor performance critical parameters should be evaluated using a thermal system performance model such as Night Vision Thermal Imaging System Performance Model (**NVTHERM**). The model should include, but is not limited to the evaluation of the image quality and the minimum resolvable temperature differential of the primary and backup pilotage systems. PNVS systems testing should be conducted in the presence of natural and artificial obscurants.

5.5.6 Vision Systems: Day and Night

Verify the Performance of Vision Systems: Day and Night

Standard: Infrared, **I2TV**, day cameras and lowlight camera systems should be determined by modeling/analysis, laboratory, and flight testing to ensure all critical performance parameters are met.

Compliance: Image quality at varying light levels, as required for conduct of mission, when integrated into the aircraft should be evaluated. Day/Night Vision Systems should require end-to-end performance evaluation by modeling, test, and demonstration. Performance should be evaluated in all fields of view and zoom settings, with polarity reversal over the sensor's Field of Regard (**FOR).** Demonstration should be conducted in the presence of natural and artificial obscurants. The sensor should be capable of moving the **LOS** in accordance with the system specification with regard to slew rate and acceleration. Slew rate and acceleration should be optimized to minimize overshoot or undershoot, and not adversely affect stability. All applicable features of the sensor system found within the following section should be evaluated, per applicable requirements.

5.5.7 Vision Systems: Day and Night with Target Acquisition

Verify the Performance of Vision Systems: Day and Night with Target Acquisition Systems

Standard: Vision Systems with target acquisition should be evaluated to ensure their ability to properly identify targets and guide weapons.

Compliance: Vision Systems: Day and Night with Target Acquisition Systems should be evaluated per Section 5.5.6 with the addition of targeting requirements. Target Acquisition includes, but is not limited to the following: operating modes; automatic features including prepoint, boresighting, stabilization, image quality, and uniformity; manual and auto target tracking; laser range finding; laser designation; target location; accuracy and handover; sensor **FOV** switching and focus, and target acquisition. Other requirements include: exposure time and acquisition timeline assessment for target tracking, engagement or handover, point mode, flight path vector mode, elevation mode, and scan mode. If not specified, systems will have a target location error of 25meters, or less.

5.6 Laser and Laser Systems

5.6.1 Laser and Laser System Safety

Verify Laser and Laser Systems Safety

Standard: Laser and Laser Systems will be evaluated on the aircraft to ensure safety interlock functionality and laser performance.

Compliance: Laser and Laser Systems should be evaluated and tested by the U.S. Army Center for Health Promotion and Prevention Medicine (CHPPM). Laser and Laser Systems will be evaluated on the aircraft to ensure safety interlock functionality and laser performance. This should include all lasers mounted or carried onto the aircraft. Lasers should meet safety requirements prescribed in the Laser Safety Analysis Section. Laser Systems should be tested and data presented to the U.S. Army Laser Safety Office. Non eye-safe laser will be considered as direct fire weapons with regard to qualification requirements. The following items should be considered as a part of this test:

a. Applicable tests, as deemed appropriate by CHPPM, may include laser beam divergence, power, Nominal Ocular Hazard Distance (NOHD) and other parameters. Eye safe modes must pass safety testing and analysis. Lasers that are determined to be Eye safe by CHPPM are not required to be wired through the master arm switch.

b. Safety interlocks on the high voltage laser electronics unit box (usually mounted off gimbal). The laser should be prohibited from firing while the aircraft is on the ground without having to initiate a positive override. The override switch should allow ground testing of laser functions. All personnel must have adequate laser goggle protection during the testing. The required optical density (OD) of protective goggles should be calculated for all lasers. Calculations should determine if laser goggles are required.

c. A fail-safe switch should be provided for selection of either the tactical or the eye-safe beam. A feedback sensor should be used to determine if the correct selection switch has been activated.

d. A software inhibitor (laser masking) should control the laser field of regard so that the beam will not strike any part of the aircraft or any peripherals. Laser energy should not be reflected back into the eyes of the pilot, crew, or personnel.

e. The laser should not randomly fire due to electromagnetic interference (EMI).

f. A laser firing indictor light or other display symbology should be provided to indicate when the laser is firing. Indicator lighting, and/or symbology should meet all applicable requirements.

g. Continuous operator interaction should be required to fire the laser.

h. A laser status switch should be provided to inform the pilot or ground personnel that the laser is in active mode. An indictor light or other display symbology should be provided to indicate when the laser is armed. Indicator lighting, and/or symbology should be Type I, Class A, NVG compatible.

5.6.2 Laser and Laser System Performance

Verify Laser and Laser Systems Performance

Standard: Laser and Laser System Performance when mounted on the aircraft, gun, or as a part of a stabilized turret should be characterized for beam pointing and stability and tracking.

Compliance: Laser and Laser System Performance when mounted on the aircraft, gun, or as a part of a stabilized turret should be characterized using a laser evaluation system. Accuracy measurements should be conducted for stationary and moving targets. Arming to lasing time will be evaluated. If not specified, this time interval will be less than 20 seconds to avoid an adverse impact upon the mission.

5.6.2.1 Pulsed Laser (Q-switched) Verification

Verify Pulsed Laser (Q-Switched) Performance

Standard: Pulsed laser characteristics should be verified to ensure performance.

Compliance: Pulsed Laser Characterization requires measurement of the following parameters: pulse energy (1^{st} pulse and steady state), beam divergence, bore sight error, pulse width, pulse repetition frequency (**PRF**), pulse-to-pulse time stability, power consumption, pulse duration, missing pulses, mode stability, double pulsing, radiation outside lasing wavelength, radiation outside the main beam (**ROMB**), M-square factor, repetition rate, duty cycle, and wavelength accuracy.

5.6.2.2 Continuous Wave (CW) Lasers

Verify Performance of Continuous Wave (CW) Lasers

Standard: CW laser characteristics should be verified to ensure performance.

Compliance: Continuous wave (**CW**) lasers characterization requires measurement output power for each mode of operation, wavelength accuracy, wavelength stability, power stability, power consumption, radiation outside the main lasing wavelength, beam divergence, **ROMB**, and mode stability. **CW** lasers that re modulated (chopped) or have a blink mode will be evaluated per this section.

5.6.2.3 Multiple Wavelength Lasers

Verify Characteristics of Multiple Wavelength Lasers

Standard: Multiple wavelength laser characteristics should be verified to ensure performance.

Compliance: All wavelengths in a Multi-Wavelength Laser system will be evaluated as per above applicable requirements.

5.6.2.4 Laser Rangefinders

Verify the Performance of Laser Rangefinders

Standard: Laser Rangefinders will report ranges to accuracy allowable for safe firing of any weapon system that employs the Rangefinder. Target location calculations involving laser ranging will at worst case contribute less than 10 percent of the total target location error if not specified within system specifications.

Compliance: Rangefinders used for target location or any other types of location should be evaluated to determine if they meet the minimum mission requirements. Eye-safe and non-eye safe lasers will meet the applicable requirements of this section.

5.6.2.5 Boresight Retention

Verify Boresight Retention

Standard: Boresight Retention and accuracy should be verified to determine coincidence with the airframe line of sight. Boresight should be maintained throughout the mission to meet targeting requirements for the weapons system.

Compliance: Boresight Retention and accuracy should be measured and the boresight should be verified to be coincident with the airframe line of sight.

5.6.2.6 Laser Illuminators

Verify Performance of Laser Illuminators

Standard: Performance of laser illuminators should be verified.

Compliance: Laser Illuminators should meet all applicable requirements for the type of laser employed. Laser illuminators should be operated in such a way as to avoid lasing of the crew and any sensors sensitive to laser radiation. An arming switch and a switch that requires continuous pressure should also be required to fire any non-eye safe laser illuminator. The term laser pointer should not be used to describe laser illuminators in excess of 5 mW of power. A survey will be conducted to determine the effects of the laser illuminator on the aircraft and any equipment carried in, or on the aircraft, including (**NVGs**).

5.6.2.7 Designator Systems

Verify Performance of Designator Systems

Standard: Laser designator performance should be surveyed and demonstrated. The Laser designator will be evaluated to determine the system's total pointing error, dictated by the weapon system requirement if not specified within the system specification.

Compliance: The laser designation performance should be surveyed and demonstrated using a laser spot scoring system. Data should be processed through the Laser Designation Weapon System Simulation (**LDWSS)** Model to establish probability of hit (ph) and probability of kill (pk). Pulse repetition frequency (**PRF**) and Pulse Interval Modulation (**PIM**) coding will be evaluated when required by specification.

5.6.2.8 Laser Test Ranges

Verify Laser Test Range Suitability

Standard: Laser Test Range Suitability should be verified.

Compliance: Laser tests should be conducted on a certified and approved laser range. Non-specular targets should be used to prevent intrabeam viewing by unprotected personnel. Specular surfaces should be removed from laser line of sight. Optical densities for the protective eyewear should be calculated for personnel within the laser firing range for the specific wavelength being used. Multiple wavelength lasers should require protective eyewear to protect against each laser wavelength.

5.7 Tracking Performance

Verify Tracking Performance

Standard: Integrity and accuracy of EO and IR sensor target spot tracking systems should be verified.

Compliance: Manual and automatic tracker control of the sensor line of sight should function to ensure safe and accurate weapons delivery. Break locks will not result in uncommanded run-off in the line of sight and will result in laser termination. Multi-track systems will be evaluated by the same criteria while tracking multiple targets.

5.8 Target Location Accuracy

Verify Target Location Accuracy

Standard: Verify resolution of sensor input.

Compliance: Input from the sensor payload, i.e., resolvers and laser rangefinders should be of sufficient resolution and accuracy to safely support target location systems for weapons engagement and other mission requirements. If not specified, target location error (**TLE**) should not exceed 25 meters.

5.9 Electro-Optical Counter Counter Measures (EOCCM)

Verify Performance of EOCCM

Standard: EOCCM will demonstrate the ability of the sensor system in hostile environments. **Compliance:** Sensor systems on aircraft operating in hostile areas should be hardened against known threats. Sensor performance should be evaluated with any fixed position filters installed. Sensor systems should have the maximum survivability and stealth without severely degrading sensor performance. Requirements for stealth and survivability should be defined by applicable documents, such as the **TDP**, **PIDS**, the **ORD**, or other documentation. Aircraft slated to operate in hostile areas not meeting these requirements require documentation of the shortcoming in the airworthiness release.

5.10 Electro-Magnetic Vulnerability (EMV) Requirements

Verify the Sensor System's Electro-Magnetic Vulnerability Requirements

Standard: The sensor system should perform its mission during exposure to friendly and hostile electromagnetic emitters

Compliance: The sensor should meet **EMV** requirements, **IAW ADS-37A-PRF**. The sensor system should perform its mission during exposure to friendly and hostile electromagnetic emitters as defined in **ADS-37A-PRF**, paragraph 3.4

Reference: ADS-37A-PRF

5.11 Armament Effects

Verify Armament Effects on the Sensor System

Standard: Armament impacts on sensor performance should be evaluated

Compliance: Armament impacts on sensor performance should be evaluated during flight-testing. Target acquisition and designation response to blast effects, debris, and weapons' rate of fire should have little or no impact on sensor performance.

5.12 Full Qualification Environmental Test Requirements per Applicable Specification

Standard: Sensor system performance will not be degraded when subject to the following environmental testing.

Compliance: Conduct the following for full qualification of the sensor system.

a. Explosive Atmosphere **MIL-STD-810**
b. Vibration **MIL-STD-810**
c. Temperature/Altitude/Humidity **MIL-STD-810**
d. Acceleration **MIL-STD-810**

e. Humidity **MIL-STD-810**
f. Fungus **MIL-STD-810**
g. Sand and Dust **MIL-STD-810**
h. Rain **MIL-STD-810**
i. Icing/Freezing Rain **MIL-STD-810**
j. High and Low Temperature Storage per **MIL-STD-810** Operational and Non-operating
k. Salt (Atmosphere) Fog **MIL-STD-810**
l. Shock EO sensor system should meet the requirements of **MIL-STD-810**, to include Functional Shock, Crash Hazard Shock, and Bench Handling test
m. Solar Radiation (Displays) **MIL-STD-810**
n. Lightning Strike **ADS-37-PRF**

Environmental testing in accordance with **MIL-STD-810** will employ the current version of the standard. The proper method and procedure for conduct of the test will be determined by choosing the procedure that most accurately reflects conditions the sensor system will be subjected to in the field.

Reference: MIL-STD-810 and ADS-37-PRF

5.13 Optical Components

Verify the performance of optical components

Standard: Optical components should not be degraded by exposure to the applicable environmental tests.

Compliance: Visual and functional testing will be conducted to verify that the performance of optical components has not been degraded by environmental testing.

5.14 Environmental Stress Screening (ESS)

Verify the effect of ESS on the sensor system.

Standard: Each EO/IR/LD payload should be subjected to **ESS**.

Compliance: Test, demonstration, and analysis.

5.15 Software

The software for Electro-optical and Sensor systems should be developed in accordance with DO-178B. Only software that has been modified at the source code level, compiled, and linked without errors will be considered for airworthiness. “Patched code” will not be considered for airworthiness. All warnings, whether compiler or linker generated, must be addressed in writing (preferably in the Software Version Description Document) in order for the resulting operational flight program (executable) to be considered for airworthiness. Documentation must be submitted for all software for review and approval by the Software Engineering Directorate

(SED). Software used for pilotage should be designed as flight critical (software level A). Software for targeting should be designed as safety critical (software level B). Software for reconnaissance and surveillance should be designed as mission essential (software level C).

5.15.1 Software Documentation: The following development artifacts should be required for analysis:

5.15.1.1 Plan for Software Aspects of Certification (PSAC): The PSAC should be developed, maintained and delivered IAW DI-MISC-80508 and per the guidance of RTCA-DO-178B paragraph 11.1.

5.15.1.2 Software Verification Plan (SVP): The SVP should be developed, maintained and delivered IAW DI-MISC-80508 and per the guidance of RTCA DO 178B, paragraph 11.3.

5.15.1.3 Software Configuration Management Plan (SCMP): The SCMP should be developed, maintained and delivered IAW DI-MISC-80508 and per the guidance of RTCA-DO-178B, paragraph 11.4.

5.15.1.4 Software Development Plan (SDP): The SDP should be developed, maintained and delivered IAW DI-IPSC-81427A and per the guidance of RTCA-DO-178B, paragraph 11.2. The SDP should describe how the Developer will develop, conduct, manage, and monitor all software related activities. The SDP should address the handling of any safety critical software to include the documentation, the flow down of all identified hazards mitigated by software to software safety requirements, safety requirements to the source code, and unit testing up through system level testing. The SDP should include the Developer software safety program. The safety program described in the SDP should address the software hazards analysis and tracking system to be used on the program.

5.15.1.5 Software Test Plan (STP): The STP should be developed, maintained and delivered IAW DI-IPSC-81438A. The STP should describe plans for qualification testing of the software. It should also describe the software test environment to be used for the testing; it identifies the test to be performed and provides schedules for test activities. The STP should address the method(s) that will be used to perform software regression testing, if required, for the safety requirements identified in the SRS.

5.15.1.6 System/Subsystem Specification (SSS): The SSS should be developed, maintained and delivered IAW DI-IPSC-81431A and per the guidance of DO-178B, paragraph 11.9. The SSS should specify the requirements and the methods used to assure that each requirement has been met.

5.15.1.7 System/Subsystem Design Document (SSDD): The SSDD should be developed, maintained and delivered IAW DI-IPSC-81432A. The SSDD should describe the design and the operational and support environments. It should describe the organization of the system as composed of Hardware Configuration Items (HWCIs), CSCIs, and manual operations. The SSDD should allocate the system requirements to the hardware, software, and operations elements that comprise the system. When one system requirement is allocated to more than one of the system elements, the specific function must be specified that each of the system elements is required to perform (if applicable).

5.15.1.8 Interface Requirements Specification (IRS): The IRS should be developed, maintained and delivered IAW DI-IPSC-81434A and per the guidance of DO-178B, paragraph 11.9. The IRS should distinguish (e.g., flag) all software safety requirements from the other software requirements. The Software IRS should specify the requirements imposed on the Hardware/Software Interface, and the interfaces between software. An IRS is required for each CSCI to be integrated into the platform and each platform CSCI that was modified for the integration.

5.15.1.9 Interface Control Document (ICD): The ICD should be developed, maintained and delivered IAW DI-CMAN-81248A. The ICD should define the electrical signal types, interface circuitry for each type, and the mechanical interface requirements.

5.15.1.10 Interface Design Description (IDD): The IDD should be developed, maintained and delivered IAW DI-IPSC-81436A. The IDD should trace to the SRS/IRS with special flags for the implementation of any safety software requirements. The IDD should incorporate as applicable any information that would be located in a data base design description using DI-IPSC-81437 as guidance. The IDD should specify the detailed design for one or more interfaces between one or more CSCIs and other configuration items or critical items. If it is not included in the SDD, an IDD is required for each CSCI to be integrated into the platform, and each platform CSCI that was modified for the integration.

5.15.1.11 Software Requirements Specification (SRS): The SRS should be developed, maintained and delivered IAW DI-IPSC-81433A and per the guidance of DO-178B, paragraph 5.5 and paragraph 11.9. The SRS should distinguish (e.g., flag) all software safety requirements from the other software requirements. The SRS should specify the requirements the software performs and the methods to be used to ensure that each requirement has been met. Each safety related requirement should be individually flagged. The SRS should include a matrix that shows requirements traceability between the SRS and the higher level specification (e.g., System/Subsystem Specification (SSS)). An SRS is required for each CSCI to be integrated into the platform and each platform CSCI that was modified for the integration.

5.15.1.12 Software Design Description (SDD): The SDD should be developed, maintained and delivered IAW DI-IPSC-81435A and per the guidance of DO-178B, paragraph 11.10. The SDD should trace to the SRS with special flags for the implementation of any safety software requirements. The SDDs should describe the design of the software. The SDD should also describe software design decisions, the architectural design and detailed design (defined as the lowest software components that make up the CSCIs (e.g., Computer Software Units (CSUs), Packages)) needed to implement the software. The SDD should include a matrix that shows where requirements from the corresponding SRS are designed into the software code. An SDD is required for each CSCI to be integrated into the platform and each platform CSCI that was modified for the integration.

5.15.1.13 Software Test Description (STD): The STD should be developed, maintained and delivered IAW DI-IPSC-81439A and per the guidance of DO-178B, paragraph 5.5 and paragraph 11.13. The STD should include the test preparations, test cases, and test procedures to be used to perform qualification testing of the software. The STD should include a matrix that shows requirements traceability between the SRS, SSS and the STD. An STD is required for each CSCI to be integrated into the platform, and each platform CSCI that was modified for the integration.

5.15.1.14 Software Test Report (STR): The STR should be developed, maintained and delivered IAW DI-IPSC-81440A and per the guidance of DO-178B, paragraph 11.14. The STR should be the record of the software qualification testing performed. The STR should include the result of each test, the procedures used for the test, and the personnel that witnessed the test. An STR is required for each CSCI to be integrated into the platform, and each platform CSCI.

5.15.1.15 Software Version Description (SVD): The SVD should be developed, maintained and delivered IAW DI-IPSC-81442A. An SVD should be developed and delivered for any version of the system released for formal testing/production/fielding. The SVD should identify and describe a software version. It is used to release, track, and control software. The SVD should contain a list of all changes incorporated into the software version since the previous version. The SVD identifies the problem reports, change proposals, and change notices associated with each change, and the effects of each change on the system operation and on interfaces with other hardware and software. An SVD is required for each CSCI to be integrated into the platform, and each platform CSCI.

5.15.1.16 System Integration Test (SIT) Description: The SIT description should be developed, maintained and delivered IAW DI-IPSC-81439A and per the guidance of DO-178B, paragraph 5.5 and paragraph 11.13. The SIT description should include the test preparations, test cases, and test procedures to be used to perform integration testing of the software. Tests should be included in the SIT description to ensure that the software and hardware function together to meet the requirements in the SSS and SRS. The SIT description should include a matrix that shows requirements traceability between the SSS, SRS and the SIT description.

5.15.1.17 System Integration Test (SIT) Report: The SIT report should be developed, maintained and delivered IAW DI-IPSC-81440A and per the guidance of DO-178B, paragraph 11.14. The SIT report should be the record of the software qualification testing performed. The SIT report should include the result of each test, the procedures used for the test, and the personnel that witnessed the test.

5.15.1.18 Problem Reports: All Software Problems should be tracked from identification to correction per the guidance of DO-178B, paragraph 11.17. Reports should be delivered at lease monthly.

5.15.1.19 Software Problems/Change Reports: The Developer should develop a software defect management approach, which is documented in the Software Development Plan (SDP). The defect history of any software product delivered at any time should be provided with that product. The Developer should maintain a software problem/change tracking database that addresses software safety issues and is electronically available for Government review/access in plant and remotely.

5.15.1.20 Software Product Specification (SPS): The SPS should include the source and executables. The Developer should develop a final Software Product Specification (SPS) in contractor format IAW DI-IPSC-81441A.

5.15.1.21 Software Failure Modes and Effects Criticality Analysis (FMECA): A FMECA should be conducted and delivered IAW DI-ILSS-81495. A FMECA is performed to determine the operational impacts hardware and hardware/software interface failures will have on the system.

5.15.1.22 Safety Assessment Report (SAR): The Developer should perform a software safety assessment and prepare a Safety Assessment Report IAW DI-SAFT-80102B.

5.15.2 Software Testing

5.15.2.1 Formal Qualification Test (FQT)

5.15.2.1.1 All Electro-optical and sensor system integration and operation should be verified on a Software Integration Lab (SIL) or Avionics Integration Lab (AIL) bench prior to being installed on the flight test aircraft.

5.15.2.1.2 Draft CSCI test reports and a draft SIT report should be submitted for review prior to AWR approval to install the software in the initial test aircraft.

5.15.2.1.3 A FQT for the software should be performed by the contractor and witnessed by appropriate Government representatives. The FQT will use the test procedures specified in the STD and SIT documents to demonstrate / verify that each software requirement specified in the SSS and SRS are met and passed.

5.15.2.1.4 The final CSCI test reports and SIT report should be submitted for review prior to production AWR approval.

5.15.2.2 Structural Coverage Analysis / Testing

The contractor should perform One Hundred percent structural coverage (analysis/testing) for any source code that functions in a critical capacity or is designated to have a software hazard risk index of 1,2,3, or 4 or a designated DO-178B (or equivalent) Level A, B or C criticality. The structural coverage (analysis/testing) should show compliance to the expected value or be within a range of expected values for the respective module. Any software tool utilized to support structural coverage (analysis/testing) should be listed and should have been certified per DO-178B or equivalent. Modified Conditional Decision Coverage is required for flight critical (DO-178B Level A or equivalent) software. The contractor should document the selected method for demonstrating the structural coverage (analysis/testing) of the software in the SDP.

5.16.0 Maintainability

Verify maintainability

Standard: The system should be designed in such a way as to promote ease of maintenance. Modular construction should be used to perform repair by replacement. The unit should be serviceable with the minimum number of common tools as practical.

Compliance: Demonstrate maintainability and ease of maintenance.

5.16.1 Maintenance Concept

a. Identify the level of maintenance. Descriptions such as filed repair\ replacement, or depot repair need to be identified.
b. Develop maintenance procedures and operations during the development activities. Testing should confirm compliance to requirements using JSSG-2000B as a guide.
c. Description of operation and maintenance instructions must be compatible with interfacing systems and support equipment as well as the integrated digital environment (IDE) using JSSG-2000B as a guide. System compatibility and procedure information development should include:
    (1) Definition of the level at which they will be used (field, intermediate, or depot).
    (2) Interfaces with other systems and equipment at each defined level.
    (3) Maintenance data collection system interface for each defined level.

5.17.0 Safety of Flight Test Requirements

Safety of Flight (SOF) test requirements are listed in ADS-62-SP

5.18.0 Unmanned Aerial Vehicle/Unmanned Aerial Systems Analysis

5.18.1 Analysis of Unmanned Aerial Systems/Vehicles (UAS/UAV)

Verify performance of UAS

Standard: UAS analysis includes all applicable analysis, tests and demonstration of included subsystems and components.

Compliance: UAVs when under control of a control station, (ground or aerial), will be evaluated as a unit consisting of the control station and the air vehicle. End to end performance evaluation should be conducted on the combined **UAV** and control station combination. Factors affecting the capabilities of the **UAV/UAS** will be included in the evaluation. These factors include, but are not limited to factors such as data latency, compression ratios, work load, etc. Effects of data compression will be assessed to determine how system resolution is affected.

5.18.2 Lasers

Verify Laser Performance

Standard: **UAV**s will be designed in such a way to prevent locking of laser firing mechanisms, or inadvertent firing due to loss of data links. **UAV** laser systems must meet the same requirements as those for manned aircraft.

Compliance: Perform test, evaluation and analysis per applicable laser sections.

6.0 NOTES