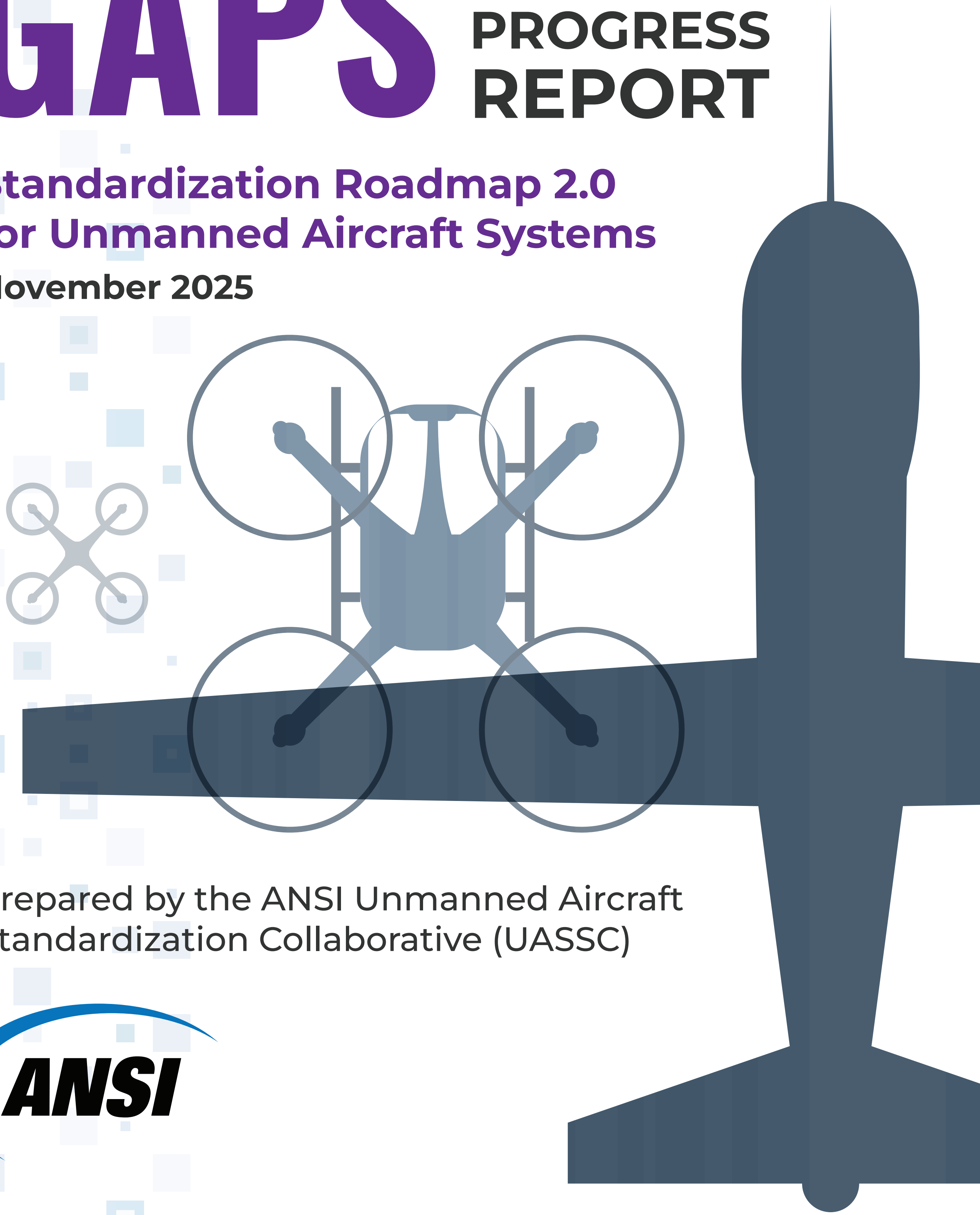
GAPS PROGRESS REPORT

Standardization Roadmap 2.0 for Unmanned Aircraft Systems

November 2025



Prepared by the ANSI Unmanned Aircraft Standardization Collaborative (UASSC)

ANSI

Gaps Progress Reports Version History

S.N.	***Version***	***Publication Date***	***Version Note***
1	June 2021	30 June 2021	
2	December 2021	14 December 2021	
3	June 2022	14 June 2022	
4	December 2022	21 December 2022	
5	May 2023	22 May 2023	
6	March 2024	19 March 2024	
7	November 2024	7 November 2024	
8	May 2025	15 May 2025	
9	November 2025	24 November 2025	Final Version*

*This gaps progress report, and the versions which proceed it, are tied to the UASSC roadmap version 2. The gaps identified in the 2020 roadmap have evolved. Although this is the final version of the gaps progress report against this roadmap, stakeholders are encouraged to contact ANSI if they believe renewed standards coordination activities (workshops, standards landscapes, etc.) or a version 3.0 of a roadmap are needed.

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Gaps Progress Report Overview

The ANSI Unmanned Aircraft Systems Standardization Collaborative (UASSC) is tracking progress by standards developing organizations (SDOs) and others to address the gaps identified in the *UASSC's Standardization Roadmap for Unmanned Aircraft Systems* (Version 2.0, June 2020). The updates provided in this progress report were derived from various sources: direct inputs from SDO staff and subject matter experts (with attribution), SDO alert mechanisms, and independent research by ANSI staff based on publicly available SDO work programmes and other information. As such, this report should not be viewed as a consensus document and it does not necessarily reflect the views of the individuals or organizations named. It is intended to be a "living document" that will be maintained and periodically re-published as standards development work continues or until such time as the UASSC undertakes to develop a next version of its standardization roadmap. Margin comments and suggested edits to the gaps are left in intentionally to be addressed at a later date.

Click on any of the roadmap gap titles below for the most recent updates (highlighted and dated) since the May 2025 progress report. You will see fields for updates since roadmap version 2 was published, new published standards, and new in-development standards. In some cases, staff has determined that a published standard or in-development standard may be responsive to an identified v2 gap(s) or topical area based on the standard's title/abstract. In other cases, staff was unable to make such a determination and, in such cases, the standard is listed at the end of a chapter.

Corrections should be sent to uassc@ansi.org.

Chapter 6. Airworthiness Standards – WG1

High Priority (Tier 1) (Most Critical)

- **Gap A1: UAS Design and Construction (D&C) Standards (05/09/2025)**
- **Gap A2: UAS System Safety (11/17/2025)**
- **Gap A6: Alignment in Standards Between Aviation and Cellular Communities (11/18/2025)**
- **Gap A7: UAS Navigational Systems (11/14/2025)**
- **Gap A8: Protection from Global Navigation Satellite Signals (GNSS) Interference Including Spoofing and Jamming (4/20/2023)**
- **Gap A9: Detect and Avoid (DAA) Capabilities (11/18/2025)**
- **Gap A10: Software Considerations and Approval (04/26/2025)**
- **Gap A12: UAS Cybersecurity (11/18/2025)**
- **New Gap A20: Unlicensed Spectrum Interference Predictability (10/31/2024)**

High Priority (Tier 2) (Critical)

- **Gap A4: Avionics and Subsystems (11/18/2025)**
- **Gap A16: Mitigation Systems for Various Hazards to UAS (11/17/2025)**
- **Gap A18: Maintenance and Inspection (M&I) of UAS (6/10/2021)**
- **Gap A19: Enterprise Operations: Levels of Automation/ Autonomy and Artificial Intelligence (AI) (11/20/2025)**

High Priority (Tier 3) (Least Critical)

- **Gap A13: Electrical Systems (5/15/2025)**
- **Gap A14: Power Sources and Propulsion Systems (11/17/2025)**
- **Gap A15: Noise, Emissions, and Fuel Venting (11/17/2025)**
- **Gap A17: Parachute or Drag Chute as a Hazard Mitigation System in UAS Operations over People (OOP) (04/26/2025)**

Medium Priority

- **Gap A11: Flight Data and Voice Recorders for UAS (5/17/2022)**
- **New Gap A21: Blockchain for UAS (11/17/2025)**

General Airworthiness Standards Feedback

- **Chapter 6 Recommendations/Comments Since v2 was Published**
- **Other Chapter 6 Activity – Relevance to Gaps Not Yet Determined (03/14/2024)**

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Gap A1: UAS Design and Construction (D&C) Standards.

There are numerous standards applicable to the D&C of manned aircraft which are scalable in application to UASCS. However, these standards fail to address the critical and novel aspects essential to the safety of unmanned operations (i.e., DAA, software, BVLOS, C2 link, CS, Highly Integrated System, etc.). Lacking any regulatory certifications/publications/guidance (type certificate (TC)/ supplemental type certificate (STC)/Technical Standard Order (TSO)/AC), manufacturers and/or operators require applicable industry standards capable of establishing an acceptable baseline of D&C for these safety-critical fight operation elements such as CS to support current regulatory flight operations and those authorized by waiver and or grants of exemption. Since the CS is one of the most critical parts and functions of the UAS needed to command and control UA remotely, the standards applicable to traditional manned aviation's airborne electronics (software, hardware, integration, spectrum, etc.) may need to be considered for the UAS as well either in the same manner and level or higher than that of the manned aviation aircraft to provide the acceptable level of safety. Some industry standards such as RTCA DO-278 may be applicable to the software aspects of the CS. However, there are currently no known industry standards that support the D&C of UAS CS, other than ASTM F3002-14a for sUAS under Part 107 and SAE AS6512, which addresses all unmanned systems whose means of conveyance includes air, water, and ground. The AS6512 UxS Control Segment Architecture is concerned with control station software but not the control station software external environment, which including information access, communications, and human-computer interfaces. ASTM F3563-22, *Specification for Design and Construction of Large Fixed Wing Unmanned Aircraft Systems,* addresses requirements for Control Station (CS) of varying size, complexities and functions.

R&D Needed: No

Recommendation:
1) Complete work on in-development standards.
2) Develop D&C standards for UA and CS, and consider operations beyond the scope of regular Part 107 operations such as flight altitudes over 400 feet AGL, and any future technological needs.
3) Develop D&C standards for UA weighing more than 19,000 pounds and develop standards for accompanying CS.

Priority: High (Tier 1)

Organization: ASTM, SAE, ISO, EUROCAE

v2 Status of Progress: Green

v2 Update:
- ASTM F38: F3563-22, WK72958, WK72960
- EUROCAE WG-112 VTOL
- SAE S-18A Autonomy WG/EUROCAE WG-63 SG-1 AIR7121
- SAE S-18/EUROCAE WG-63: AIR7209, ARP4754B, ARP4761A
- SAE A-6A3: ARP94910A
- Numerous standards have been published and are in-development that address the entire spectrum of UAS and its operations.

Updates Since v2 was Published:
- **5/23/2022, Phil Kenul:** ASTM F3563-22, *Specification for Design and Construction of Large Fixed Wing Unmanned Aircraft Systems*
- **11/29/2021, Judith Ritchie, SAE:** New SAE G-35 Modeling, Simulation & Training for Emerging Aviation Technologies and Concepts Committee will develop industry consensus standards that **define the requirements for Modeling and Simulation** (M&S) for aircraft, their technologies and concepts in support of certification regulations

Comments Received on Gap for Future Consideration:
- **11/14/2022, Phil Kenul:** ASTM has released standards (i.e., F2911-14E1, F2930-16E1, F2972-15, F3035-22, F3198-18, F2839-11, F3003-14, F3205-17) in support of manufacturing of light sport aircraft and small UAS (sUAS). These standards include best practices for promoting production compliance, however recently emerging unique aspects of UAS type certification (e.g., Durability and Reliability means of compliance, Associated Elements, Certified Category) require UAS-specific production approval guidance to the UAS community. Part of this task/activity will be to evaluate the other ASTM standards for relevance to production approval for UAS and leverage existing standards insofar as practicable.
- **05/31/2022, Lissa Bern**: Gap Recommendation #2 - Has "regular" been defined or should it be removed? Should a specific CONOPS be used for definition or example explained for regular part 107?
- **11/30/2021, Rhonda Walthall**: Gap Description- Is the intent of integration to include systems as far as referencing SW and HW? SYS is usually considered a different scope level (i.e., DO-178, DO-254, DO-297, etc.) and included.
- **11/30/2021, Rhonda Walthall**: Gap Recommendation #2- Use of "regular" when referencing Part 107 suggests other Part 107 operations are exempt. Recommend definition of regular and its intent to operations.

New Published Standards	New In-Development Standards
05/09/2025, DFranks: SAE G-35 *ARP7094 Recommended Practice for Using Modeling and Simulation for Certification of Aircraft, Products, and Systems* was published. Use of M&S for type certification of the Advanced Air Mobility (AAM) aircraft, product, or system. However, this does not preclude	**04/26/2025, P.Kenul: ASTM F38.01** WK94078 to review *F3298-24 Standard Specification for Design and Construction of Lightweight Unmanned Aircraft Systems (UAS)* to develop expected design requirements in the forthcoming Part 108 NPRM for BVLOS.

this ARP being used for certification of other aircraft types and associated products and systems. **04/26/2025, P.Kenul: ASTM F38.01** *F3298-24 Standard Specification for Design and Construction of Lightweight Unmanned Aircraft Systems (UAS)* was revised. It formerly addressed verification but that has been split out into a new standard in development. **09/02/2024, PK: ASTM F38.01:** F3686-24a Standard Practice for Production Approval of Unmanned Aircraft Systems (UAS) was published (formerly, WK82742). **03/14/2024, M.Carlson: ISO/TC 20/SC16** published: - ISO 5309:2023, *Civil small and light unmanned aircraft systems (UAS), Vibration test methods* specifies the test conditions and methods to be used for the vibration testing of unmanned aircraft system (UAS, including unmanned aircraft and ground station) which applies to level II through V according to ISO 21895. - ISO 5332:2023, *Civil small and light unmanned aircraft systems (UAS) under low-pressure conditions, Test methods* specifies test method to determine the operation ability of unmanned aircraft systems (UAS) at low-air-pressure conditions. This document is applicable to the category of civil small and light UAS, which applies to maximum take-off mass (MTOM) level II through V according to ISO 21895. **03/11/2024, D.Franks: SAE** *ARP4761A Guidelines for Conducting the Safety Assessment Process on Civil Aircraft, Systems, and Equipment* for performing safety assessments of civil aircraft, systems, and equipment. They may be used when addressing compliance with certification requirements (e.g., 14 CFR/CS Parts 23, 25, 27, and 29 and 14 CFR Parts 33, 35, CS-E, and CS-P). **03/11/2024, D.Franks: SAE** *ARP4754B Guidelines for Development of Civil Aircraft and Systems* provides recommendations for the development of aircraft and systems, taking into account aircraft functions and operating environment. It provides practices for ensuring the safety of the overall aircraft design, showing compliance with regulations, and assisting a company in developing and meeting its own internal standards. These practices include validation of requirements and verification of the design implementation for safety, certification, and product assurance. **02/09/2024, P.Kenul:** ASTM F42.07 F3572-22 Standard Practice for Additive Manufacturing – General Principles – Part Classifications for Additive Manufactured Parts Used in Aviation • Intended to be used to assign part classifications across the aviation industries that use AM to produce parts. • Applicable to all AM technologies used in aviation. • Intended to be used to establish a metric for AM parts in downstream documents. • Part classification metric could be utilized by the engineering, procurement, non-destructive inspection, testing, qualification, or certification processes used for AM aviation parts.	**04/26/2025, P.Kenul: ASTM F38.01** WK94232 to review *F3657-23 Standard Specification for Verification of Lightweight Unmanned Aircraft Systems (UAS)* to develop expected verification requirements in the forthcoming Part 108 NPRM for BVLOS. **03/11/2024, D.Franks: SAE** *AIR6110A Contiguous Aircraft/System Development Process Example*, stabilized in March 2024. This technical report is being stabilized following the release of ARP4754B. Appendix E of ARP4754B contains an updated version of the contiguous example which has been coordinated with ARP4761A Appendix Q. AIR6110 is still valid for use with ARP4754A, and it is not expected to be updated in the future. Stabilized status is given to a technical report that has been frozen at the last active revision level. **03/11/2024, D.Franks: SAE** *AIR9953 Applying Development Assurance with Model Based Systems Engineering* will demonstrate how Development Assurance may be applied in an MBSE based development program. This will be performed by utilizing the example in Appendix E of ARP4754B and showing an example of the Development Assurance activities and artifacts in an MBSE context. **02/12/2024, S.Marzac: EUROCAE WG-112 SG-6 Avionics**: - ED-xxx Guidance for the design of electronic checklists for use in VTOL aircraft - Status: Draft - Publication target date: 31/01/2024 - ED-xxx VTOL Minimum Flight Instruments – Display of parameter trends and limitations - Status: Draft - Publication target date: 01/04/2024 **12/5/2022, RFM: RTCA DO-380**. RTCA no longer plans to have a revision of DO-380 as the FAA has declined to use the document and no stakeholder has asked for the update. **12/04/2022, Dave Franks: SAE E-40** AIR7128 - *Integration and Certification Considerations for Electrified Propulsion Aircraft*: this document provides a comprehensive compilation of currently available practices, standards, regulations and guidance material that have been considered relevant for developing an electrified propulsion system (independently or as part of an aircraft) and that may also help the applicants in the process of building their own certification approach with their Authority. It also covers unique considerations for electrified propulsion development and aircraft integration. It focuses on the particularities introduced by the new technology. This document is not intended to represent a proposed Means of Compliance with any particular certification regulation. **05/20/2022, AF: EUROCAE** as launched two new standards: - Minimum Operational Performance Standard for Command Unit Core Layer of UAS to be operated in the EASA certified category of operations - Guidance document to support the development of Means of Compliance (MoC) for EASA Special Condition Light-UAS – Medium Risk

• Classification scheme in this practice establishes a consistent methodology to define and communicate the consequence of failure associated with AM aviation parts. *Without carefully defined part classes, the ability to accurately **gauge the consequence of failure** associated with additively manufactured aviation parts within and across programs, projects, and suppliers becomes exceedingly difficult…* **01/18/2024, P.Kenul: ASTM F3657-23** *Specification for Verification of Lightweight Unmanned Aircraft Systems (UAS) is published by F38.01.* F3657: - separates verification into a new standard from F3298 Design Standard - incorporates D&R methodology into non-FAA operations - updates verification and flight tests to accommodate autonomy **02/12/2024, S.Marzac: EUROCAE WG-112 SG2,** *ED-306 Design Considerations for VTOL Aircraft Protection From Uncontained High-Energy Fragments and Sustained Imbalance* - Published: 21/10/2022 **02/12/2024, S.Marzac: EUROCAE WG-112 SG-1** *ED-296 Guidance on Design Assurance for High Voltage Standards and Power Quality for VTOL Applications* Published: 30/05/2022 **12/05/2022, JR: SAE AIR7209** *Development Assurance Principles for Aerospace Vehicles and Systems:* the purpose of this SAE Aerospace Information Report (AIR) is to provide a high-level set of principles to support aerospace projects required to use a formal development assurance process, such as ARP4754/ED-79 (at latest revision), to show regulatory compliance. Examples of projects where a formal development assurance process is needed are those that have significant functional interactions or whose products cannot be fully analyzed or tested. **12/04/2022, Dave Franks:** SAE AS6512B *Unmanned Systems (UxS) Control Segment (UCS) Architecture*: This document is the Architecture Description (AD) for the SAE Unmanned Systems (UxS) Control Segment (UCS) Architecture Library Revision B or, simply, the UCS Architecture. The architecture is expressed by a library of publications as referenced herein. The other SAE publications in the UCS Architecture Library Revision B are AS6513B and AS6518B. The library also includes the government-owned Autonomous Ground Vehicle Reference Architecture (AGVRA) Data Model Framework Version 3.1A. **12/04/2022 Dave Franks: SAE** AS6849 - *Performance Standards for Passenger and Crew Seats in Advanced Air Mobility (AAM) Aircraft* - This SAE Aerospace Standard (AS) defines qualification requirements, and minimum documentation requirements for forward and aft facing seats in Advanced Air Mobility aircraft. **5/23/2022, Phil Kenul: ASTM** WK62670 now approved as F3563-22, *Specification for Design and Construction of Large Fixed Wing Unmanned Aircraft Systems* developed by committee F38.01.	**5/24/2021, AS: RTCA** expects to have a version A of DO-380 published in the 2025 timeframe.

11/13/2020, JM: ASTM F3478 - *Standard Practice for Development of a Durability and Reliability Flight Demonstration Program for Low-Risk Unmanned Aircraft Systems (UAS) under FAA Oversight* is a new standard, now available. F3478-20 developed by Committee F38.01. **6/11/2020, JM: RTCA** DO-380 - *Environmental Conditions and Test Procedures for Ground Equipment.* This document defines a series of minimum standard environmental test conditions (categories) and applicable test procedures for ground-based equipment. In this document ground-based equipment includes stationary ground, mobile/portable ground, or sea-based equipment.	

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Gap A2: UAS System Safety.	
Numerous UAS airworthiness standards, appropriate regulations, operational risk assessment (ORA) methodologies, and system safety processes already exist. Any gaps that exist in standards applicable to specific vehicle classes and weight are being addressed by SAE S-18A Autonomy WG / EUROCAE WG-63 SG-1 (in collaboration with EUROCAE WG-105).	
R&D Needed: Yes. Further examination is needed to determine if existing safety system processes are indeed adequate and if gaps are being addressed to the extent needed. S-18A Autonomy WG is looking at this.	
Recommendation: Develop an aerospace information report or standard(s) in which the various existing airworthiness and safety analyses methods are mapped to the sizes and types of UAS to which they are most relevant, and the UAS system safety and development assurance are addressed.	
Priority: High (Tier 1)	
Organization: SAE, EUROCAE, RTCA, IEEE, ASTM, DOD, NASA, SAE ITC ARINC IA	
v2 Status of Progress: Green	
v2 Update: • EUROCAE WG-112 VTOL • SAE S-18A Autonomy WG/EUROCAE WG-63 SG-1 AIR7121 (in collaboration with EUROCAE WG-105) • SAE S-18/EUROCAE WG-63 AS7209, ARP4754B, ARP4761A • SAE AS-4 • SAE G-32 (with collaboration with EUROCAE WG-72) • SAE G-34 / EUROCAE WG-114 • Numerous standards have been published and are in-development that address the entire spectrum of UAS and its operations.	
Updates Since v2 was Published: • Joint Authorities for Rulemaking on Unmanned Systems (JARUS) Annex H, UTM **Other Committees with Relevant Work:** • RTCA Internet Protocol Suite Special Committee and AeroMACS • SAE ITC, ARINC IA Internet Protocol Suite subcommittee • SAE ITC, ARINC IA Network Infrastructure and Security subcommittee • SAE ITC, ARINC IA System Architecture and Interfaces subcommittee **Comments Received on Gap for Future Consideration:** • **04/25/23, Rhonda Walthall:** Has there been any consideration in any of these documents about what happens if the UAS has a complete avionics reset mid-flight? • **11/30/21, Rhonda Walthall:** Clarification on gap – as a result of conservative reuse of manned standards updated for UAS applicability? Or as a result new functionality and technology use cases that are now introduced specific for UAS environments.?	
New Published Standards **11/17/2025, CB, ANSI:** F3178-24 Standard Practice for Operational Risk Assessment of Small Unmanned Aircraft Systems (sUAS) **05/09/2025, DFranks: SAE G-35** *AS-6969C Data Dictionary for Quantities Used in Cyber-physical Systems* This data	**New In-Development Standards** **10/21/2025, PK, ASTM:** ASTM F38.02 *WK93681 Standard Guide for In-Time Aviation Safety Management System (IASMS) Functionality* is intended primarily for industry: UAS designers, integrators, and service providers who wish to increase awareness of potential approaches that are suitable for In-Time Aviation Safety Management System (IASMS)

dictionary provides definitions for quantities, measurement units, reference systems, measurands, measurements, and quantity modalities commonly used in the command and control of cyber-physical systems.

03/11/2024, D.Franks: SAE *ARP4761A Guidelines for Conducting the Safety Assessment Process on Civil Aircraft, Systems, and Equipment* for performing safety assessments of civil aircraft, systems, and equipment. They may be used when addressing compliance with certification requirements (e.g., 14 CFR/CS Parts 23, 25, 27, and 29 and 14 CFR Parts 33, 35, CS-E, and CS-P).

03/11/2024, D.Franks: SAE *ARP4754B Guidelines for Development of Civil Aircraft and Systems* provides recommendations for the development of aircraft and systems, taking into account aircraft functions and operating environment. It provides practices for ensuring the safety of the overall aircraft design, showing compliance with regulations, and assisting a company in developing and meeting its own internal standards. These practices include validation of requirements and verification of the design implementation for safety, certification, and product assurance.

03/08/2024, B.Teel: RTCA *Minimum Aviation System Performance Standard (MASPS) on ATN-IPS End-to-End Interoperability and Certification* was published September 2023.

02/12/2024, S.Marzac: EUROCAE WG-112, SG-3 *ED-312 Guidance on Determining Failure Modes in Lithium-Ion Cells for eVTOL Applications* Published: 22/05/2023

02/12/2022, S.Marzac: EUROCAE WG-112, SG-3 *ED-300 Guidance on Conducting an Aircraft Functional Hazard Assessment and Preliminary Aircraft Safety Assessment for a VTOL Using a Generic Example* Published: 07/11/2022

12/05/2022 RFM: RTCA DO-346A *Minimum Operational Performance Standards (MOPS) for the Aeronautical Mobile Airport Communication System* (AeroMACS), the AeroMACS MOPS update, published in June 2022.

6/17/2021, JM: DO-304A *Guidance Material and Considerations for Unmanned Aircraft Systems*. This is an update to the original DO-304 that is a Guidance Document addressing all Unmanned Aircraft Systems (UAS) and UAS operations being considered for realistic implementation in the US National Airspace System (NAS) in the foreseeable future. The Use Cases have been updated in DO-304A to include scenarios for Cargo Missions, Survey Missions, High Altitude Platform Systems, and Urban Air Mobility.

functionality, to aid system design, implementation, evaluation, and operation. IASMS functionality will be referred throughout this standard guide, for convenience, as In-Time Aviation Safety Management ("IASM"). This standard guide serves as a reference to develop a specification for an IASM capability, system, service, or a function. Additionally, this standard guide can be used as a reference for how one or more of these elements could be developed or augmented with IASM. This standard guide is structured such that IASM functions, focusing on the IASMS approach, including monitoring, assessment, and mitigation. Additionally, IASM functions include data exchange as a supporting but essential fourth component of the approach.

03/11/2024, D.Franks: SAE *AIR8622 Applying SOTIF to Aviation Autonomy*. Committee S-18A is looking at the Automotive ISO 21448 Standard for Safety of Intended Functionality, and see how it maps to the System Development and Safety Processes in Aviation as dictated by ARP4754A and ARP476.

03/08/2024, B.Teel: RTCA Certification profiles for TCP / UDP / IP / DHCP / Routing / Mobility / Multilink protocols based on IETF RFCs. Expected Publication September 2024.

03/08/2024, B.Suarez: SAE AIR7121 *Applicability of Existing Development Assurance and System Safety Practices to Unmanned Aircraft Systems* is in ballot. The update should identify that this report calls for updates or complements to 4754 and 4761 to support UAS.

02/12/2024, S.Marzac: EUROCAE WG-112 SG-3: *ED-300A Guidance on conducting an AFHA and PASA for a VTOL using a generic example* - Status: Draft - Publication target date: 28/02/2024

02/12/2024, S.Marzac: EUROCAE WG-112 SG-2 *ED-XXX Guidance for Identification and Mitigation of eMotor Fire Risks* - Status: Draft - Publication target date: 31/01/2025

05/20/2022, AF: EUROCAE WG-105 launched a revision of the published document ED-280. The deliverable, ED-280A, is titled: "*Guidelines for UAS Safety Analysis for the Specific Category (Low and Medium Levels of Robustness)*"

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Gap A4: Avionics and Subsystems.
Existing avionics standards are proven and suitable for UAS. However, they become unacceptable for the following scenarios: 1. As the size of UAS scales down, airborne equipment designed to existing avionics standards are too heavy, large, and/or power hungry. Therefore, new standards may be necessary to achieve an acceptable level of performance for smaller, lighter, more efficient, more economical systems. 2. As the quantity of UAS scales up based on the high demand of UAS operations into the NAS, the new standards are required to handle the traffic congestion. 3. Many UAS introduce new capabilities – new capabilities may not be mature (not statistically proven or widely used) and/or they may be proprietary, therefore industry standards do not exist yet. Avionics are becoming highly integrated with more automation compared to traditional avionics instruments and equipment that were found in manned aviation aircraft a few decades ago. UAS will decreasingly rely on human confirmations, human commands, human monitoring, human control settings, and human control inputs. A time is approaching when the UAS conveys the bare minimum information about its critical systems and mission to the human, that is, a message that conveys, "Everything is OK." Consideration of the interactions that may occur between avionics systems and higher-level mission and decision-making systems is needed. In particular, as the avionics functions become more automated there needs to be clear demarcation of responsibility between lower-level guidance, navigation, and control (GNC) and the higher-level decision-making systems (which may include aspects of AI/ML). Standards to get there are different from those that created the cockpits in use today. Some of the major areas of concern include the reliability and cybersecurity of the command and control (C2) data link, use of DOD spectrum (and non-aviation) on civil aircraft operations, and enterprise architecture to enable UTM, swarm operations, autonomous flights, etc. Cybersecurity, in particular, shall be an important consideration in the development of avionics systems. Cybersecurity is further discussed in section 6.4.6.
R&D Needed: Yes
Recommendation: 1) One approach is to recommend that existing standards be revised to include provisions that address the points listed above. The UAS community should get involved on the committees that write the existing avionics standards. Collaboration around a common technological subject is more beneficial than segregating the workforce by manned vs. unmanned occupancy. The standards should address any differing (manned/unmanned) requirements that may occur. 2) Another approach is to recommend new standards that will enable entirely new capabilities. 3) Complete work on the standards of ICAO, ASTM, SAE, and DOD listed above in the "In-Development Standards" section. 4) Review existing and in-development avionics standards for UAS considerations. 5) Create a framework for UAS avionics spanning both airborne and terrestrial based systems.
Priority: High (Tier 2)
Organization: For Avionics Issues: RTCA, EUROCAE, SAE, SAE ITC ARINC IA, IEEE, AIAA, ASTM, DOD, NASA, ICAO. For Spectrum Issues: FCC, NTIA, International Telecommunication Union (ITU)
v2 Status of Progress: Green
v2 Update: SAE AS-4JAUS published AS8024, *JAUS Autonomous Capabilities Service Set* in June 2019. A new standard in development in SAE G-34 is SAE AS6983, *Process Standard for Qualification of Aeronautical Systems Implementing AI: Development Standard*. ASTM F3298-19, *Standard Specification for Design, Construction, and Verification of Lightweight Unmanned Aircraft Systems (UAS)*, was also published.
Updates Since v2 was Published: • Joint Authorities for Rulemaking on Unmanned Systems (JARUS) Annex H, UTM **Other Committees with Relevant Work:** • SAE ITC, ARINC IA Internet Protocol Suite subcommittee • SAE ITC, ARINC IA Network Infrastructure and Security subcommittee • SAE ITC, ARINC IA Fiber Optics subcommittee • SAE ITC, ARINC IA Data Link Systems subcommittee • SAE ITC, ARINC IA Electronic Flight Bag subcommittee • SAE ITC, ARINC IA System Architecture and Interfaces subcommittee **Comments Received on Gap for Future Consideration:** • **11/22/21, Rhonda Walthall:** A further recommendation is to review if existing standards adequately address very highly integrated avionics, particularly with respect to mixed-criticality computing systems, fault management on same, or integration of different types of applications in the same platform (e.g., flight computers and communications hosted in the same hardware.)

- **11/3/21, Rhonda Walthall:** One aspect of the UAS standardization that appears to be "missing" pertains to pilot training requirements (for the initially manned versions and for remote "piloting" later). A big gap lies in accountability/liability. Pilot in Command means that the pilot has final authority and final responsibility for the operation and safety of the flight. This includes everything from the initial flight planning, to the pre-flight assuring airworthiness of the vehicle, to all aspects of the execution of the flight itself. In the UAS world, a gap exists in determining who has responsibility for the pre-flight, assuring airworthiness, assessing the weather conditions, and calculating weight & balance, or liability in the event of a flight deviation or mishap? RTCA and the other standards organizations don't set responsibility/liability, but many of these concerns will need technical solutions that may need/require standards.
  - **02/12/2024, S.Marzac:** There has been significant industry standards effort for C2, DAA (DO-365, DO-366, DO-398, ED-258, ED-265, ED-271, ED-275).

New Published Standards

10/21/2025, PK, ASTM: *F3442-25 Standard Specification for Detect and Avoid System Performance Requirements*

9/1/2025, CB, ANSI: ISO/IEC JTC1/SC6 standards on Telecommunications and information exchange between systems

1. **ISO/IEC AWI 4005-1**: *Telecommunications and information exchange between systems — Unmanned aircraft area network (UAAN) — Part 1: Communication model and requirements*
2. **ISO/IEC AWI 4005-2**: *Telecommunications and information exchange between systems — Unmanned aircraft area network (UAAN) — Part 2: Physical and data link protocols for shared communication*)
3. **ISO/IEC AWI 4005-3**: *Telecommunications and information exchange between systems — Unmanned aircraft area network (UAAN) — Part 3: Physical and data link protocols for control communication*
4. **ISO/IEC AWI 4005-4**: *Telecommunications and information exchange between systems — Unmanned aircraft area network (UAAN) — Part 4: Physical and data link protocols for video communication*

03/08/2022, B.Suarez, RTCA DO-381A *MOPS for GBSS for Traffic Surveillance* has been published for GBSS to support DAA.

05/20/2022, AF: EUROCAE WG-105 published ED-271: "*Minimum Aviation System Performance Standard for Detect and Avoid (Traffic) in Class A-C airspaces*." This document describes the Detect and Avoid function necessary to support the Remote pilot to operate the RPA in airspace A-C under IFR according to the OSED, ground based DAA not being covered. This standard specifies system characteristics, since it is composed of several individual components

9/20/2021, JM:
RTCA DO-362 *Errata 2 – Command and Control (C2) Data Link Minimum Operational Performance Standards (MOPS), presented by SC-228, Minimum Performance Standards for Unmanned Aircraft System. This Errata restores a table inadvertently excluded from the original document.*

RTCA DO-365B *Errata – Minimum Operational Performance Standards (MOPS) for Detect and Avoid (DAA) Systems, presented by SC-228, Minimum Performance Standards for*

New In-Development Standards

11/18/2025, MBalakrishna, RTCA: DO-362B (Command and Control (C2) Data Link Minimum Operational Performance Standards (MOPS) (Terrestrial)) - Incorporate changes required to harmonize SATCOM compatibility with EUROCAE Standard. Updates required as a result on initial implementation of A revision. Projected Publication Date: March 2028

11/18/2025, MBalakrishna, RTCA: DO-365D (Minimum Operational Performance Standards (MOPS) for Detect and Avoid (DAA) Systems) – Updates are being made to DO-365 to add a class of equipment for ACAS-Xr. Projected Publication Date: December 2026 (schedule slipped to align with ACAS-Xr MOPS)

11/18/2025, MBalakrishna, RTCA: DO-WWW (MASPS: DAA supporting Taxi Operations) - This document will capture guidance and requirements for DAA equipment to facilitate operations of UAS on the surface. Projected Publication Dates: July 2025

11/18/2022, AF: EUROCAE WG-105 launched a revision of the published document ED-271. The deliverable, ED-271A, is titled: '*Minimum Aviation System Performance Specification for Detect & Avoid [Traffic] under IFR*' and will cover all classes of airspaces (A-G).

Unmanned Aircraft System. This Errata corrects a publication error that inadvertently omitted a portion of Appendix H. **6/17/2021, AS: RTCA** DO-387 *Minimum Operational Performance Standards (MOPS) for Electro-Optical/Infrared (EO/IR) Sensors for Traffic Surveillance.* This document contains Minimum Operational Performance Standards (MOPS) for Electro-Optical/Infrared (EO/IR) Sensors for Traffic Surveillance. The EO/IR sensor system is a surveillance source for non-cooperative intruders for a Detect and Avoid (DAA) system used in Unmanned Aircraft Systems (UAS) transiting through Class B, C, D, E and G airspace and performing extended operations higher than 400' Above Ground Level (AGL) in Class D, E (up to Flight Level 180 (FL180)), and G airspace. **3/18/2021, JM:** RTCA DO-365B *Minimum Operational Performance Standards (MOPS) for Detect and Avoid (DAA) Systems, Minimum Performance Standards for Unmanned Aircraft System*. This document contains MOPS for DAA systems used in unmanned aircraft transiting and performing extended operations in Class D, E, and G airspace along with transiting Class B and C airspace. It includes equipment to enable UAS operations near Terminal Areas during approach and departure in Class C, D, E, and G airspace, and off airport locations, but not operating in the visual traffic pattern or on the surface. It does not apply to small UAS (under 55 pounds (lbs)) operating in low level environments (below 400') or other segmented areas. This revision Added Class 3 – ACAS Xu, Non-cooperative DWC applicable to all classes, updated ATAR classes for different performance levels. **12/17/2020, JM:** RTCA DO-362A *Command and Control (C2) Data Link Minimum Operational Performance Standard (Terrestrial)*. This document contains Minimum Operational Performance Standards (MOPS) for the Unmanned Aircraft Systems (UAS) Command and Control (C2) Data Link (Control and Non-Payload Communication (CNPC) terrestrial Link System) used to support the Command and Control functions of a UAS. The CNPC includes the Link System supporting remote pilot-to/from-ATC voice communications, also referred to as ATC relay. **12/17/2020, JM: RTCA** DO-386 Vol I *Minimum Operational Performance Standards for Airborne Collision Avoidance System Xu (ACAS Xu) (Vol I), and DO-386 Vol II Minimum Operational Performance Standards for Airborne Collision Avoidance System Xu (ACAS Xu) (Vol II: Algorithm Design* and *Supplemental Material*. This set of documents document defines the minimum operational performance standards (Vol I) and Algorithm Design Descriptions (Vol II) for the Airborne Collision Avoidance System Xu (ACAS Xu) equipment, designed for platforms with a wide range of surveillance technologies and performance characteristics such as Unmanned Aircraft Systems (UAS). **9/10/2020, JM: RTCA** DO-366A *Minimum Operational Performance Standards (MOPS) for Air-to-Air Radar for Traffic Surveillance*. This document contains the first update to the Minimum Operational Performance Standards (MOPS) for the air-to-air radar for traffic surveillance. The intended application is supporting Detect and Avoid (DAA) operations	

including collision avoidance to detect intruders below 10,000' Mean Sea Level (MSL). These standards specify the radar system characteristics that should be useful for designers, manufacturers, installers and users of the equipment. **9/10/2020, JM: RTCA** DO-382 *Minimum Aviation System Performance Standards CAS Interoperability*. This document presents high level requirements (i.e. Minimum Aviation System Performance Standards (MASPS)) for the interoperability of airborne Collision Avoidance Systems (CAS). Its main objective is to ensure that new CAS do not degrade the operation of existing CAS. It specifies system characteristics that should be useful to designers, manufacturers, installers and users of the equipment. When some requirements cannot be fully defined, explanatory text is included to describe the basis on which requirements are to be developed.	

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Gap A6: Alignment in Standards Between Aviation and Cellular Communities.	
A gap exists in alignment between the aviation and cellular SDO communities, even when sufficient SDO efforts exist within each community. The telecommunications industry has already taken a number of steps to develop standards, particularly in 3GPP, to prepare networks for UAS applications. However, it is expected that fully addressing all KPIs of the C2 link and all the realistic use cases coming from the aviation industry will require further standardization activities.	
R&D Needed: Yes. The FAA also has worked with CTIA to develop testing principles for use of the commercial wireless networks to support UAS and is considering the outcome of those tests in conjunction with the IPPs and other testing.	
Recommendation: Collaboration between the UAS industry and communications industry is required to ensure feasibility of implementation. The aviation and cellular communities should coordinate more closely to achieve greater alignment in architecture and standards between the two communities. Specifically, advance existing work in 3GPP and ensure C2 link requirements are communicated to that group. In addition, architectures and standards could be developed for predicting or guaranteeing C2 link performance for a specific flight that is about to be undertaken.	
Priority: High (Tier 1)	
Organization: 3GPP, GSMA/GUTMA ACJA, ASRI, IEEE, RTCA, EUROCAE, ATIS	
v2 Status of Progress: Green	
v2 Update: Numerous standards are in development.	
Updates Since v2 was Published: • Joint Authorities for Rulemaking on Unmanned Systems (JARUS) Annex H, UTM **Other Committees with Relevant Work:** • GAMA Electric Propulsion and Innovation Committee: *EPIC Concept Paper: Vehicle to Vehicle (V2V) Datalink Communications: Enabling Highly Automated Aircraft and High-Density Operations in the National Airspace (Version 1.0 December 2021)* **Comments Received on Gap for Future Consideration:** • **4/25/2023:** The cellular industry is used to "pushing out" a fix whenever they have a problem. The avionics sector does not work like this; once it is in place changing it should be very hard. From an avionics perspective (going back to Gap A1), the regulations probably need to be set up to allow a certain amount of churn without all of the normal process. Balance is needed between necessary updates and keeping the same spec for 50 years. • **11/22/21, Rhonda Walthall:** There are some communication and networking topics that 3GPP and UAS standard body could collaborate together. For example, they could address technical challenges presented by high altitude UAS interference. The study will characterize different technologies and propose a joint solution that optimizes network performance. In addition, UAS network architecture, including direct communications, network communications and the hybrid model, needs further studies for optimizing network utilization and guaranteeing UAV end-to-end performance. Other R&D topic may include the support of multiple cellular links for UAV reliability and robustness and the inter-network and intra-network handover management.	
New Published Standards **11/17/2025, CB, ANSI:** I*EEE 1937.8-2024: IEEE Recommended Practice for Functional and Interface Specifications for Unmanned Aerial Vehicle (UAV) Cellular*	**New In-Development Standards** **11/18/2025, MBalakrishna, RTCA:** DO-377C (Minimum Aviation System Performance Standards (MASPS) for C2 Link Systems Supporting Operations of Uncrewed Aircraft

Communication Terminals The interface and functional specifications of cellular communication terminals installed on unmanned aerial vehicle (UAV) are presented in this recommended practice. The specifications are described in four categories: the terminals' interface and functional specifications, specifications of data transmission, environmental and reliability specifications, and safety practices. **4/26/2025, PK:** ASTM F3742-24 Standard Guide for Credential-Based A2X Broadcast Security. This standard provides guidance for using cryptographic credentials to secure localized A2X-Direct communications. This guide is intended to assist organizations developing applications built on a wide variety of different communication technologies and is designed to help understand the inter-relationships between a given credential-based security approach and the performance of those underlying communications technologies. **11/06/2024, PM: 3GPP** *TS 23.256, Support of Uncrewed Aerial Systems (UAS) connectivity, identification and tracking; Stage 2 (R19) (latest publication 09/2024)* **11/06/2024, PM: 3GPP** *TS 23.255, Application layer support for Uncrewed Aerial System (UAS); Functional architecture and information flows (R19, Sept.. 2024)* **11/06/2024, PM: 3GPP** *TS 24.501, Non-Access-Stratum (NAS) protocol for 5G System (5GS); Stage 3* (R19, Sept.. 2024). Includes support for authentication and authorization of a UAV, and authorization of C2 communications. **11/06/2014, PM: 3GPP** *TS 24.008, Mobile radio interface Layer 3 specification; Core network protocols; Stage 3* (R19, Sept.. 2024) Includes support for indicating whether UAS services for a given user are allowed. **11/06/2024, PM**: 3GPP *TS 22.125, Uncrewed Aerial System (UAS) support in 3GPP*; Stage 1 (R19, June 2024). Includes requirements for supporting UAS in a cellular system. **11/06/2024, PM: 3GPP** *TS 22.261, Service Requirements for the 5G System*, Stage 1 (R19, Sept.. 2024). Includes service requirements and KPIs related to command and control (C2), payload (e.g., camera) and the operation of radio access nodes on-board of UAVs. **11/06/2024, PM: 3GPP** TR 22.843 *Study on Uncrewed Aerial Vehicle Phase 3, R19* (published December, 2023) **03/08/2024, B.Suarez:** RTCA DO-377B *Minimum Aviation System Performance Standards (MASPS) for C2 Link Systems Supporting Operations of Uncrewed Aircraft Systems in U.S. Airspace* (published December 2023) presents and justifies the Minimum Aviation System Performance Standards (MASPS) for a Command and Control Link System (C2 Link System) used to monitor and control an Uncrewed Aircraft System (UAS). This B version of DO-377 is an expansion of the efforts in DO-377 [1] and DO-377A [2]. It adds an additional CONOPS, Low Altitude	Systems in U.S. Airspace) - Address the concerns about the definition of availability and continuity raised in DO-377B FRAC and describe methods that can be used by UAS OEM, UAS operators and means of compliance for C2 Link systems. Projected Publication Date: December 2027 **11/18/2025, MBalakrishna, RTCA:** DO-410 (C2 Link MOPS for Cellular Networks) - Create a joint standard with EUROCAE WG-105 for use of Cellular commercial networks for C2 Links used for type certificated UAS. Projected Publication Date: March 2026 **11/18/2025, MBalakrishna, RTCA:** DO-XXX (MASPS: Dynamic Frequency Management System) - Standard for Dynamic Frequency Management Services which satisfy 47 C.F.R. Part 88 rules regarding the use & management of the C-band CNPC spectrum between 5030-5091 MHz. – Projected Publication Date: June 2027 **11/06/2024, PM: 3GPP** *23.700-59 Study on architecture enhancements of UAS, UAV and UAM; Phase 3* (work continues in R19). This work includes: 1) Enhancement of Network Exposure Function (NE services to support service exposure and interactions between MNOs and UTM functions for i.e., pre-mission flight planning, in-mission flight monitoring, C2 communication reliability, interfacing with UTM (e.g., supporting the scenario of multiple USS serving the geographical areas corresponding to UAV flight path). 2) Support of network-assisted/ground-based mechanism for DAA (Detect And Avoid), and 3) Support of no-transmit zones for UAVs. **02/12/2024 S.Marzac: EUROCAE WG-105 SG-2 (joint with RTCA SC-228** - *ED-xxx MOPS for UAS Communications by Cellular Networks - Status: Draft - Publication target date: 30/06/2023* - *ER-xxx UAS C2 MASPS European Stakeholders Report - Status: Draft - Publication target date: 30/06/2023*

Delivery Supporting Small Package Delivery, and five new scenarios, two air taxi, two surface taxi and one small package delivery using advanced technologies. **03/01/2024, PM:** *Cellular-enabled Aerial Vehicles: Exploration of the Landscape of the North American Ecosystem*. This paper developed by the GSMA North America describes the 3GPP release capabilities specific to UAVs and provides descriptions of other industry activities beneficial for coordinating the cellular and aviation communities. (published Dec., 2023) **03/01/2024, PM: 3GPP** *5G New Radio (NR)* Enhancements for UAS/UAV. This work ported previous LTE enhancements for UAS/UAV to 5G NR and includes support for PC5 direct cellular communications, broadcast remote ID, and DAA. This work has been completed for 3GPP R18 as of Dec. 2023 and includes a number of published Technical Specifications with UAV-related enhancements: 38.306 (NR), 36.306 (LTE), 38.331 (NR), 36.331 (LTE), 38.300 (NR), 36.300 (LTE), 38.413, 38.423, and 38.101-1 (NR), and 36.101 (LTE). Note that all referenced 3GPP specs are publicly available with no charge and can be found here. **05/09/2023, PM: ACJA** Landscape White Paper on UAS Cellular Ecosystem (published Feb. 14, 2023). This paper describes an exhaustive set of entities involved in cellular communication of uncrewed aviation systems, their interrelationships among each other, related ACJA activities, and external standardization activities. **05/09/2023, PM: ACJA** *Interface for Data Exchange between MNOs and the UAS Ecosystem* (published Dec., 2022). This is the second version of what was previously published as the ACJA Network Coverage Service Definition V1.0. This paper presents the first step in establishing efficient communication between stakeholders in drone air traffic management. The paper models the connectivity and population density data exchange between MNO and UAS as an extension of today's interfaces. **12/5/2022, PM: ACJA** *Reference Method for assessing Cellular C2 Link Performance and RF Environment Characterization for UAS* (published Oct. 2022). The Reference Method includes: 1) the aerial and ground measurement of the cellular RF environment 2) measurement of the C2 link performance between a particular drone type and its control station (CS), and 3) process and procedures for conducting flight measurement operations in a standardized fashion. **12/5/2022, PM**: ATIS-I-0000092 (*3GPP Release 17 - Building Blocks for UAV Applications*). Published July 2022. This report describes how mobile networks supporting the Third Generation Partnership Project (3GPP) Release 17 specifications can enable uncrewed aerial vehicle (UAV) applications. It discusses how 3GPP's work fits with other specifications to address UAV needs and shows how the 3GPP system can be used to enhance the opportunities to safely use UAVs for commercial and leisure applications.	

12/2021, PM: 3GPP TR 33.854, *Study on Security Aspects of UAS (R17)* **9/20/2021, JM: RTCA** DO-262F *Errata – Minimum Operational Performance Standards for Avionics Supporting Next Generation Satellite Systems (NGSS), presented by SC-222, Aeronautical Mobile Satellite (Route) Services (AMS(R)S)*. This Errata added "or DFL" in sections E.2.2.1.1.4 and E.2.2.1.1.6 in DO-262F to correct inconsistencies between the valid equipment combinations listed in Table E-4 and the transceiver descriptions in the aforementioned sections. **9/16/2021, JM:** RTCA DO-377A - *Minimum Aviation System Performance Standards for C2 Link Systems Supporting Operations of Unmanned Aircraft Systems in U.S. Airspace*, was issued 9/16/2021. This document contains the Minimum Aviation System Performance Standards (MASPS) for a C2 Link System connecting a Control Station (CS) and an Unmanned Aircraft (UA). This MASPS contains the standards which specify system characteristics, but it is design and frequency band independent. It is intended to be used by UAS operators, UAS Original Equipment Manufacturers (OEM), C2 Link Service Providers, plus the FAA. Version A updates the original document to provide full analysis for additional use cases not provided in the initial release. This document now provides system performance requirements for Ku and Ka band SATCOM based C2 Link Systems. It contains new material on service level agreements as well as a methodology and an example for how to conduct a link budget analysis. **4/2021, PM**: 3GPP TR 23.755, *Study on application layer support for UAS* (R17) **3/2021, PM**: 3GPP TR 23.754, *Study on supporting UAS connectivity, ID, and tracking* (R17) **2/4/2021, PM**: *ACJA Network Coverage Service Definition V1.0*: This document describes Network Coverage Service, a general architecture comprising stakeholders, services, interfaces and data models for the automated data exchange between MNOs and the UTM ecosystem. **11/3/2020, PM**: *ACJA LTE Aerial Profile V1.00*: This document defines a profile for LTE Aerial Service by listing a number of LTE, Evolved Packet Core, and UE features that are considered essential to launch interoperable services. The defined profile is compliant with 3GPP specifications.	

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Gap A7: UAS Navigation Systems.
There is a lack of standards specifically for UAS navigation. There is a lack of navigation standards in novel environments where aircraft typically do not operate such as in "urban canyons." Challenging environments may invoke capabilities such as vision-based navigation. Otherwise, UAS could use existing ground infrastructure such as very high frequency (VHF) omni-directional range (VOR), non-directional beacons (NDB) (including ground-based laser tracking and positioning information), instrument landing systems (ILS), and satellite infrastructure (GPS), which has vast coverage, and make use of the new enhanced, long-range navigation (eLORAN) standards in development. UAS navigation can leverage many of the same standards used for manned aircraft, but at a smaller scale and lower altitudes.

UAS stakeholders should evaluate their PNT performance requirements (precision, accuracy, timing, robustness, etc.) for their flight profiles. SAE6857 can be used as a point of reference.
R&D Needed: Yes. A specific R&D effort geared towards applying tracking innovations in satellite navigation for UAS is needed. Additional R&D effort is needed to further mature, test, and validate vision-based navigation systems.
Recommendation: Depending on the operating environments, apply existing navigation standards for manned aviation to UAS navigation and/or develop UAS navigation standards for smaller scale operations and at lower altitudes. Refer to R&D needed. Furthermore, existing navigation practices used by connected/automated vehicle technology should be leveraged to develop integrated feature-based/object-oriented navigation standards to orient the UAS platform in GNSS-deficient areas. Future standards work should be reviewed to allow for the installation of navigation systems on UAS limited by swap capabilities.
Priority: High (Tier 1)
Organization: SAE, NASA, RTCA, EUROCAE, IEEE. SAE ITC ARINC IA
v2 Status of Progress: Green
v2 Update: Existing manned aviation standards still apply to UAS. Standards are in development.

Updates Since v2 was Published:

Other Committees with Relevant Work:
- RTCA SC-228: WG4: Guidance on Navigation for UAS
- SAE ITC, ARINC IA Electronic Flight Bag subcommittee
- SAE ITC, ARINC IA Aeronautical Database subcommittee
- SAE ITC, ARINC IA Global Navigation Satellite System subcommittee
- SAE ITC, ARINC IA System Architecture and Interfaces subcommittee
- SAE ITC, ARINC IA Navigation Data Base subcommittee

Comments Received on Gap for Future Consideration:
- **11/14/2025, EWong, DHS**: Stakeholders should also consider resiliency requirements due to intentional or unintentional interference or degradation of typically used navigation signals. Multi-modal navigation systems capable of cross-checking may be preferred for safety-of-life applications.
- **4/19/23, R Dalhstrom: Gap Description** - (including ground-based laser tracking and positioning information). Track changes reflect suggested change.
- **11/10/21 Alexandra Florin, Wing – RE SC-228 WG4 and ASTM WK75923 -** Regarding these two standards, I would like to suggest to explicitly state that there are no duplication of efforts between RTCA SC-228 and ASTM F38 committees. In particular, the ASTM standard does not apply to operations that are under positive air traffic control (ATC). This, however, does not preclude the use of this standard for UAS-specific traffic management functions. As well, SC-228 does not intend to develop UAS navigation MOPS standards within this WG, instead SC-228 intends to:
  a. Apply existing navigations standards to UAS
  b. Identify navigation gaps when applying existing navigation standards to UAS aircraft
  c. Make recommendations to the RTCA PMC and/or other navigation standards committees to develop modified or new navigation equipment standards that appropriately address the identified navigation gaps

New Published Standards	New In-Development Standards
4/26/2025, PK: ASTM *F3609-25 Specification for Positioning Assurance, Navigation, and Time Synchronization for Unmanned Aircraft Systems (formerly WK75923)* developed by Committee F38.01 was approved. The Standard Specification must define Positioning Assurance and define minimum requirements for the UAS to know where it is positioned (and potentially localized) and the error associated with that position. The Standard Specification must also define Navigation and define minimum requirements for UAS navigation. The Standard Specification must define Time Synchronization and define minimum requirements for the UAS to know that the time value that its systems are using is assured and trusted. 5/24/22, Phil Kenul: NOTE The weight classification is not specified – scope below, the intent is for operations not under ATC but could be under UTM. Weight is generally arbitrary, and we are rather looking at risk. See link in Scope. **2/27/2024**, **Scott Simmons: OGC:** GeoPose 1.0 Data Exchange Standard is an OGC Implementation Standard for exchanging the location and orientation of real or virtual	**11/18/2025, MBalakrishna, RTCA:** DO-VVV (MASPS: Navigation for Automatic Taxi) - Define navigation performance requirements to support automatic taxi operations. Projected Publication Date: December 2026 **11/18/2022, AF: EUROCAE WG-105** launched a revision of the published document ED-301. The deliverable, ED-301A, is titled: '*Guidelines for the use of multi-GNSS solutions for UAS: Medium Risk*'. **6/2/2021, Stu Card**: IEEE Project 802.15 Study Group 4ab: UWB Next Generation is pursuing amendment of 802.15.4z Ultra Wide Band, which offers direct measurement of the range between communicating wireless network nodes, to support additional use cases, among which UAS precision landing, indoor "navigation", etc. are being considered.

geometric objects ("Poses") within reference frames anchored to the earth's surface ("Geo") or within other astronomical coordinate systems. **03/08/2024, B.Teel: RTCA** DO-397, *Guidance Material: Navigation Gaps for Unmanned Aircraft Systems (UAS),* was published in September 2022. The Unmanned Aircraft Systems (UAS) navigation guidance document is intended to educate the community and be used to facilitate future discussions on navigation standards appropriate to support UAS operations. This document is not intended to be the basis for airworthiness certification and operational approval of UAS, a responsibility for civil UAS that lies with the Federal Aviation Administration (FAA) and other Civil Aviation Authorities (CAAs). The UAS manufacturers and operators will be responsible for meeting the airworthiness certification and operational approvals appropriate to the intended use of the UAS. **11/18/2022, AF**: **EUROCAE WG-105** published ED-301: *Guidelines for the Use of Multi-GNSS Solutions for UAS Specific Category – Low Risk Operations SAIL I & II* in August, 2022	

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Gap A8: Protection from Global Navigation Satellite Signals (GNSS) Interference Including Spoofing and Jamming.
There are standards in place for spoofing and jamming mitigation for manned aircraft. However, these standards are currently being updated to reflect increasing demands on GNSS systems, ongoing efforts to improve mitigation measures/operational needs, and heightened awareness of nefarious activities using spoofing and jamming technologies. Given the fact that manned aircraft standards are being updated/improved, there is a significant gap with how these standards may be applied to UAS platforms. See the command and control section for related discussion.
R&D Needed: Yes. An evaluation of the specific characteristics of current aircraft navigation equipment is needed including technical, cost, size, availability, etc. Higher performance spoofing/jamming mitigations should be developed.
Recommendation: There are likely insignificant differences in navigation system protection measures between manned aircraft and UAS, but it is recommended that this be evaluated and documented. Based on this evaluation, standards and/or policy may be needed to enable UAS platforms to be equipped with appropriate anti-spoofing and anti-jamming technologies. Also, operational mitigations are recommended including updating pilot and traffic control training materials to address interference and spoofing.
Priority: High (Tier 1)
Organization: SAE, DOD, NASA, RTCA, EUROCAE, IEEE, SAE ITC ARINC IA
v2 Status of Progress: Green
v2 Update: Existing manned aviation standards still apply to UAS. Standards are in development.
Updates Since v2 was Published: • **8/17/2020, JM**: On 17 August 2020, the Department of Justice (DOJ), the Federal Aviation Administration (FAA), the Department of Homeland Security (DHS), and the Federal Communications Commission (FCC) issued an advisory guidance document to help non-federal public and private entities better understand the federal laws and regulations that may apply to the use of capabilities to detect and mitigate threats posed by Unmanned Aircraft Systems (UAS) operations. See: https://www.fcc.gov/document/federal-agencies-release-advisory-drone-detection-mitigation-tech **Other Committees with Relevant Work:** • SAE ITC, ARINC IA Global Navigation Satellite System subcommittee **Comments Received on Gap for Future Consideration:** • **11/10/21,** SC-228 does not intend to develop UAS navigation MOPS standards within this WG, instead SC-228 intends to: a. Apply existing navigations standards to UAS b. Identify navigation gaps when applying existing navigation standards to UAS aircraft c. Make recommendations to the RTCA PMC and/or other navigation standards committees to develop modified or new navigation equipment standards that appropriately address the identified navigation gaps

New Published Standards	New In-Development Standards
12/5/2022, RFM, RTCA DO-397, *Guidance Material: Navigation Gaps for Unmanned Aircraft Systems (UAS)*, was published in September 2022. This document is laying the initial groundwork to identify gaps in the navigation systems and standards that if filled may better support UAS operations. While all possible future UAS operations is a very broad topic, to limit scope and provide near term focus, this document intentionally is focused on identifying navigation gaps associated with near term IFR and VFR-like planned path UAS operations for higher risk category fixed wing aircraft operating in and out of traditional airports. **5/24/2022:** RTCA SC-159 DO-235C *Interference Report L1 Report* published March 2022	**03/08/2024, BT: RTCA DO-292A** Interference L5 Report, being developed by SC-159, is expected to be published in June 2024. **5/25/2021**, RTCA SC-228 WG4 is developing *Guidance Material for UAS Navigation*

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Gap A9: Detect and Avoid (DAA) Capabilities.
Standards are needed to address systems that provide a DAA capability for UAS that do not have the size, weight, and power (SWAP) required by the current DAA TSOs (TSO-C211, TSO-C212 and TSO-C213). Work already has been done and is ongoing to address this gap as noted in the text above and in the update statement below.
R&D Needed: Yes
Recommendation: 1) Complete the above listed in-development standards. 2) Encourage the development of standards to address and accommodate systems to provide a DAA capability for UAS that cannot accommodate the current SWAP requirements. This is a necessary first step toward approval for smaller or limited performance systems for DAA and full and complete integration of UAS into the NAS. 3) Recommendation that the standards bodies look into the usefulness of Detect and Avoid Track Classification and Filtering for low altitude operations below 1000 feet/400 feet.
Priority: High (Tier 1)
Organization: RTCA, EUROCAE SAE, SAE ITC ARINC IA, AIAA, ASTM, DOD, NASA, 3GPP, IETF
v2 Status of Progress: Green
v2 Update: • RTCA SC-228, WG-1 Phase 2. • RTCA SC-147/EUROCAE WG-75: They continue their work with the addition of Airborne Collision Avoidance System (ACAS) Xa/Xo, ACAS Xu, and ACAS sXu. ACAS Xu will provide DAA minimum performance standards specifically designed for large UAS. ACAS sXu will provide DAA minimum performance standards specifically designed for smaller UAS. • ASTM F38.01 ASTM F3442/F3442M-23 Standard Specification for Detect and Avoid System Performance Requirements for DAA performance requirements standard for low and medium risk UAS operations. • ASTM F38.01 is developing WK62669 on testing and validating low SWAP systems. • IETF DRIP work on trust in Broadcast Remote ID Messages.
Updates Since v2 was Published: **Other Committees with Relevant Work:** • SAE ITC, ARINC IA Aeronautical Databases subcommittee **Comments Received on Gap for Future Consideration:** • **02/9/24, R. Dahlstrom:** Should include drone capabilities to autonomously "Detect and Make Contact with structures". There are drones that make physical contact with structures such as above ground storage tanks, flare stacks, ships hulls and more during flight to collect data, take measurements, etc. • **4/23/23, Rhonda Walthall:** This gap mentions ACAS sXu in a couple of places. ACAS sXu is not very useful without a V2V (or a V2X or an A2X or whatever you want to call it) link. This link is mentioned in part. But this link needs to be specified and standardized; a home-grown proprietary system is not acceptable. This means (among other things) that spectrum has to be allocated for this. This is a big problem as spectrum is not easy to come by. Not mentioning the lack of spectrum is a significant gap in this gap. • **12/3/2021, JM**: DO-381 is mentioned in v2. It was issued 3/30/2020. V2 mentions a DO-381A revision is underway to include a class of reduced performance consistent with en route DWC requirements and that publication was anticipated for April 2021

- **11/22/21, Rhonda Walthall:** Gap Recommendation #2 - The scope of this activity should include both on-board DAA and ground-based DAA as architectural alternatives to address SWAP and cost constraints**.**

New Published Standards	New In-Development Standards
10/21/2025, PK, ASTM: F3742-24 Standard Guide for Credential-Based A2X Broadcast Security (formerly WK84631) provides guidance for using cryptographic credentials to secure localized A2X-Direct communications. Significant attention is directed to DAA types of safety-related applications to delineate the convergence of security controls, communications performance and their impact on safety risk. Most importantly, this guide is intended to assist organizations developing applications built on a wide variety of different communication technologies and is designed to help understand the inter-relationships between a given credential-based security approach and the performance of those underlying communications technologies. 1**10/21/2025, PK, ASTM:** *F3442-25 Standard Specification for Detect and Avoid System Performance Requirements* **11/06/2024, PM: 3GPP** *TS 22.125, Uncrewed Aerial System (UAS) support in 3GPP*; Stage 1 (R19, June. 2024). Includes requirements for supporting UAS in a cellular system. **10/31/2024, SC: IETF** DRIP Entity Tag (DET) for Unmanned Aircraft System Remote ID (UAS RID) was published as RFC 9374. **10/31/2024, SC: IETF** *Drone Remote Identification Protocol (DRIP) Architecture published as RFC 9434* showing how to satisfy RFC 9153 DRIP Requirements and Terminology **10/31/2024, SC: IETF** draft-ietf-drip-auth has been published as RFC 9575 DRIP Entity Tag (DEG) Formats and Protocols for Broadcast Remote Identification (RID). **03/01/2024, PM: 3GPP** *5G New Radio (NR)* Enhancements for UAS/UAV. This work ported previous LTE enhancements for UAS/UAV to 5G NR and includes support for PC5 direct cellular communications, broadcast remote ID, and DAA. This work has been completed for 3GPP R18 as of Dec. 2023 and includes a number of published Technical Specifications with UAV-related enhancements: 38.306 (NR), 36.306 (LTE), 38.331 (NR), 36.331 (LTE), 38.300 (NR), 36.300 (LTE), 38.413, 38.423, and 38.101-1 (NR), and 36.101 (LTE). Note that all referenced 3GPP specs are publicly available with no charge and can be found here. **02/09/2024 P.Kenul: ASTM F38.01** F3623-23 Standard Specification for Surveillance Supplementary Data Service Providers: - Defines minimum performance requirements for Surveillance supplemental data service providers (SDSPs) and associated equipment and services - Surveillance SDSPs may provide aircraft track information to Detect and Avoid (DAA) systems and situational awareness tools to enable beyond visual line of sight (BVLOS) UAS operations and support VLOS operations. **4/20/2023 BT: RTCA** SC-147 published DO-396 ACAS sXU in December 2022. This document sets forth minimum	**11/18/2025, MBalakrishna, RTCA:** DO-362B (Command and Control (C2) Data Link Minimum Operational Performance Standards (MOPS) (Terrestrial)) - Incorporate changes required to harmonize SATCOM compatibility with EUROCAE Standard. Updates required as a result on initial implementation of A revision. Projected Publication Date: March 2028 **11/18/2025, MBalakrishna, RTCA:** DO-365D (Minimum Operational Performance Standards (MOPS) for Detect and Avoid (DAA) Systems) – Updates are being made to DO-365 to add a class of equipment for ACAS-Xr. Projected Publication Date: December 2026 (schedule slipped to align with ACAS-Xr MOPS) **11/18/2025, MBalakrishna, RTCA:** DO-WWW (MASPS: DAA supporting Taxi Operations) - This document will capture guidance and requirements for DAA equipment to facilitate operations of UAS on the surface. Projected Publication Dates: July 2025 **10/21/2025, PK, ASTM**: ASTM F38.01 *WK95242 Standard Specification for Cooperative Detect and Avoid System Requirements* The existing ASTM DAA Standard (F3442/F3442M) addresses broad DAA requirements for operations in low and medium risk airspaces, and encompasses many different use cases, technologies and risk profiles through the application of UAS-specific risk formulas. F3442 also requires detection and avoidance of non-cooperative aircraft. However, to date multiple operators have successfully secured broad-based FAA operational approval for their DAA systems using proven risk assessment and compliance approaches adopted from traditional aviation. These approaches diverge substantially from those used in F3442, and to date they have demonstrated: a. Successful completion of multiple FAA Safety Risk Management Reviews; b. Compliance with the risk criteria of FAA Order 8040.6A Safety Risk Management, Appendix C; c. Continued approval for BVLOS operations without the use of visual observers; and d. Meeting or exceeding all FAA operational safety requirements since their approval. These highly automated approaches in cooperative airspaces take a different approach from F3442 and this standard will address their concept of operations and performance requirements. **10/21/2025, PK, ASTM**: **ASTM F38.02** *WK93896 Standard Practice for Standard Practice for Airborne Risk Analysis of Unmanned Aircraft Systems (UAS)* The standard will be created to support the F3178 ORA standard. The additional detail will provide practical guidance on how to conduct an airborne risk assessment for UAS, including: -Air traffic density and patterns in the operating area -Detect-and-avoid capabilities of UAS and other aircraft -Communication and coordination protocols for deconfliction -Contingency procedures in case of loss of communication or navigation -Methods for quantifying and mitigating the risk of collision -Assumptions on aircraft behavior with respect to avoiding obstacles, including terrain, structures, and other aircraft.

operational performance standards for the Airborne Collision Avoidance System sXu (ACAS sXu) equipment, designed for platforms with a wide range of surveillance technologies and performance characteristics typical of smaller Unmanned Aircraft Systems (sUAS). **12/05/2022, PM:** 3GPP TR 23.700-58 *Study of Further Architecture Enhancement for UAV and UAM* completed Dec. 2022. This work includes broadcast remote ID over cellular, and detect and avoid capability using PC5 direct cellular communications. **11/30/2021, AS: RTCA** DO-381 - *MOPS for Ground-based Surveillance System (GBSS) for Traffic Surveillance*. This document contains MOPS for Ground Based Surveillance Systems (GBSS) used for air traffic surveillance in support of DAA operations for unmanned aircraft. The primary applications will be used in terminal, transit, or extended operational areas in the National Airspace System (NAS) as defined in RTCA Document 365A (DO 365A), Minimum Operational Performance Standards for Detect and Avoid Systems. **9/20/2021, JM: RTCA** DO-362 *Errata 2 – Command and Control (C2) Data Link Minimum Operational Performance Standards (MOPS)*, *presented by SC-228, Minimum Performance Standards for Unmanned Aircraft System*. This Errata restores a table inadvertently excluded from the original document. **9/20/2021, JM: RTCA** DO-365B *Errata – Minimum Operational Performance Standards (MOPS) for Detect and Avoid (DAA) Systems, presented by SC-228, Minimum Performance Standards for Unmanned Aircraft System*. This Errata corrects a publication error that inadvertently omitted a portion of Appendix H. **6/17/2021, JM:** DO-304A *Guidance Material and Considerations for Unmanned Aircraft Systems*. This is an update to the original DO-304 that is a Guidance Document addressing all Unmanned Aircraft Systems (UAS) and UAS operations being considered for realistic implementation in the US National Airspace System (NAS) in the foreseeable future. The Use Cases have been updated in DO-304A to include scenarios for Cargo Missions, Survey Missions, High Altitude Platform Systems, and Urban Air Mobility. **6/17/2021, AS: RTCA** DO-387 *Minimum Operational Performance Standards (MOPS) for Electro-Optical/Infrared (EO/IR) Sensors for Traffic Surveillance*. This document contains Minimum Operational Performance Standards (MOPS) for Electro-Optical/Infrared (EO/IR) Sensors for Traffic Surveillance. The EO/IR sensor system is a surveillance source for non-cooperative intruders for a Detect and Avoid (DAA) system used in Unmanned Aircraft Systems (UAS) transiting through Class B, C, D, E and G airspace and performing extended operations higher than 400' Above Ground Level (AGL) in Class D, E (up to Flight Level 180 (FL180)), and G airspace. **3/18/2021, JM: RTCA:** DO-365B *Minimum Operational Performance Standards (MOPS) for Detect and Avoid (DAA)*	Given the increasing number of UAS operations and the need to ensure safe integration with manned aviation, there is a critical need to have an ASTM Standard Practice for airborne collision risk assessments that enables a clear path towards approval of UAS operations based on standardized risk assessment and mitigation strategies **11/06/2024, PM: 3GPP** *23.700-59 Study on architecture enhancements of UAS, UAV and UAM; Phase 3* (work continues in R19). This work includes: (1) Enhancement of Network Exposure Function (NE services to support service exposure and interactions between MNOs and UTM functions for i.e., pre-mission flight planning, in-mission flight monitoring, C2 communication reliability, interfacing with UTM (e.g., supporting the scenario of multiple USS serving the geographical areas corresponding to UAV flight path). (2) Support of network-assisted/ground-based mechanism for DAA (Detect And Avoid), and (3) Support of no-transmit zones for UAVs. **03/08/2024, B.Suarez: RTCA** *MASPS for Surface Hazard Detection and Avoidance* is underway in SC-228. **03/08/2024, B.Suarez:** Revisions to DO-366 and DO-387 are being worked jointly between RTCA and EUROCAE. - *DO-387 - Minimum Operational Performance Standards (MOPS) for Electro-Optical/Infrared (EO/IR) Sensors System for Traffic Surveillance.* - *DO-366 - Minimum Operational Performance Standards (MOPS) for Air-to-Air Radar for Traffic Surveillance* **11/18/2022 AF:** In 2023, EUROCAE WG-105 will develop a European industry position report on RTCA DO-396 ACAS sXu MOPS to analyze whether the RTCA SC-147 ACAS sXu solution would be implementable in certain airspace or taking into account certain constraints in Europe. **6/1/2022: RTCA SC-147 (joint with EUROCAE WG-75)** has kicked off development of ACAS Xr, which focuses on DAA for rotorcraft and eVTOLs, building on work in ACAS sXU. *02/12/2024 Note: the need for the standard to be finalized is 2025 as full certification is intended for 2028 **5/17/2022, RM:** RFC 9153 *Drone Remote Identification Protocol (DRIP) Requirements and Terminology*, informational but essential. Under review. **11/10/2021:** EUROCAE WG-105 is currently developing ***Minimum Operational Performance Standard (MOPS) for DAA in Very Low-Level operations*** and considering U-Space services laid down by regulation (EU) 2021/664.

Systems, Minimum Performance Standards for Unmanned Aircraft System. This document contains MOPS for DAA systems used in unmanned aircraft transiting and performing extended operations in Class D, E, and G airspace along with transiting Class B and C airspace. It includes equipment to enable UAS operations near Terminal Areas during approach and departure in Class C, D, E, and G airspace, and off airport locations, but not operating in the visual traffic pattern or on the surface. This revision Added Class 3 – ACAS Xu, Non-cooperative DWC applicable to all classes, updated ATAR classes for different performance levels. **12/17/2020, JM: RTCA** DO-386 Vol I *Minimum Operational Performance Standards for Airborne Collision Avoidance System Xu (ACAS Xu) (Vol I), and DO-386 Vol II Minimum Operational Performance Standards for Airborne Collision Avoidance System Xu (ACAS Xu) (Vol II: Algorithm Design* and *Supplemental Material*. This set of documents document defines the minimum operational performance standards (Vol I) and Algorithm Design Descriptions (Vol II) for the Airborne Collision Avoidance System Xu (ACAS Xu) equipment, designed for platforms with a wide range of surveillance technologies and performance characteristics such as Unmanned Aircraft Systems (UAS). **12/17/2020, JM: RTCA** DO-362A *Command and Control (C2) Data Link Minimum Operational Performance Standard (Terrestrial).* This document contains Minimum Operational Performance Standards (MOPS) for the Unmanned Aircraft Systems (UAS) Command and Control (C2) Data Link (Control and Non-Payload Communication (CNPC) terrestrial Link System) used to support the Command and Control functions of a UAS. **9/10/2020, JM: RTCA** DO-382 *Minimum Aviation System Performance Standards CAS Interoperability.* This document presents high level requirements (i.e. Minimum Aviation System Performance Standards (MASPS)) for the interoperability of airborne Collision Avoidance Systems (CAS). Its main objective is to ensure that new CAS do not degrade the operation of existing CAS. It specifies system characteristics that should be useful to designers, manufacturers, installers and users of the equipment. **9/10/2020, JM: RTCA** DO-366A *Minimum Operational Performance Standards (MOPS) for Air-to-Air Radar for Traffic Surveillance*	

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Gap A10: Software Considerations and Approval.
Standards are needed to address software considerations for UAS operations outside of Part 107, control stations, flight control, navigation elements, associated equipment, and support services in the cloud., The majority of the current resources from manned aviation (standards, regulations, ACs, orders, etc.) are targeted at traditional aircraft and do not address the system of systems engineering used in UAS operations comprising man, machine, the NAS, and integration. UAS standards related to software dependability must properly account for all the unknown risks and potential safety issues (e.g., DAA, cybersecurity) during the software design, development, and assurance processes.
R&D Needed: Yes, on assurance methods
Recommendation: 1) Complete in-development standards work of SAE.

2) Develop standards to address software dependability for UAS operating outside of Part 107, control stations, flight control, navigation elements, associated equipment, and support services in the cloud.

Priority: High (Tier 1)

Organization: ASTM, EUROCAE, RTCA, SAE, SAE ITC ARINC IA

v2 Status of Progress: Green

v2 Update:

- RTCA DO-178, DO-278
- RTCA SC-240/EUROCAE WG-117 for UAS and COTS
- SAE A-6A3
- SAE G-32: JA6678, JA7496
- SAE G-34: AS6983, AIR6987, AIR6988
- SAE S-18A Autonomy WG/EUROCAE WG-63 SG-1
- ASTM F3269-21
- ASTM F3201-~~16~~ 24 *Standard Practice for Ensuring Dependability of Software Used in Unmanned Aircraft Systems (UAS)*
- NIST 800-160 Vol1 Rev1, *System Security Engineering: Trustworthy Secure Systems NIST 800-160 Vol2 Rev1, Developing Cyber-Resilient Systems: SSE Approach*

Updates Since v2 was Published:

Other Committees with Relevant Work:

- RTCA SC-240, Low Risk Software Considerations in Lower Risk Applications, Equipment Certifications and Approvals
- RTCA SC-240, Integration of COTS, Open Source and Service History into Software
- SAE ITC, ARINC IA Software Distribution and Loading subcommittee
- SAE ITC, ARINC IA Electronic Distribution of Software working group
- SAE ITC, ARINC IA Avionics Application/Executive Software subcommittee
- SAE ITC, ARINC IA System Architecture and Interfaces subcommittee

Comments Received on Gap for Future Consideration:

- **02/12/2024, S.Marzac**: Not able to identify any current activity on software or airborne electronic hardware industry standards for DO-178, DO-254, DO-278, DO-380.
  - DO-178C “Software Considerations in Airborne Systems and Equipment Certification” instead of DO-278A for software development of their ground control station due to “familiarity”, but DO-278A was written for and thus includes content specific to ground-based systems.
  - DO-278A “Software Integrity Assurance Considerations for CNS/ATM Systems” and appears to require revision to specifically address emerging UAS/AAM technologies – rather than being specific to “CNS/ATM”.
  - DO-254 “design assurance guidance for airborne electronic hardware” and appears to require revision to specifically address ground-based systems associated with emerging UAS/AAM technologies.
  - DO-380 “Environmental Conditions and Test Procedures for Ground Based Equipment” is not listed. Should not an activity be initiated to address the regulator concerns to support ground based systems development and approval/certification?
- **5/31/2022, Phil Mattson per MITRE HSSEDI** Reference NIST 800-160 Vol1 Rev1 "*System Security Engineering: Trustworthy Secure Systems" & NIST 800-160 Vol2 Rev1 "Developing Cyber-Resilient Systems: SSE Approach*" after "…during the software design, development, and assurance processes [NIST]." Remove Part107, as DHS/DOD may still operate under Part 107 and require cyber secure UAS sub-systems. Reference AIA NAS9948. In Report Body:
  Section 6.4.4 - Add line after Line22 "
  NIST:
  NIST 800-160 Vol1 Rev1, *System Security Engineering: Trustworthy Secure Systems NIST 800-160 Vol2 Rev1, Developing Cyber-Resilient Systems: SSE Approach*
  -

New Published Standards

04/26/2025, PK: *ASTM F3201-24 Standard Practice for Ensuring Dependability of Software Used in Unmanned Aircraft Systems (UAS).* This standard practice intends to ensure the dependability of software that is part of an unmanned aircraft (UA) and its associated elements, which together comprise an unmanned aircraft system (UAS). Dependability includes both the safety and security aspects of the software.

02/28/2024, S.Park, *UL 5500 Remote Software Updates, Edition 1* (last revision 7/7/2023) is applicable to this gap as it

New In-Development Standards

04/26/2025, PK: *ASTM WK94079 to revise F3201-24 Standard Practice for Ensuring Dependability of Software Used in Unmanned Aircraft Systems (UAS)* to support BVLOS operations.

4/14/2023, RFM: RTCA SC-240 is no longer planning to complete the *Lower Risk Software Considerations* document.

12/5/2022, RFM: RTCA SC-240 will update the plan for the *Lower Risk Software Considerations* document. The new plan will be updated at PMC on December 15, 2022.

addresses software dependability and security during and after performing remote software updates. **11/21/2022 AIA:** AIA NAS9948 UAS *Data Protection and Privacy Standard Practice* **5/23/2022 Phil Kenul:** ASTM WK65056/F3269-17 is now F3269-21 *Standard Practice for Methods to Safely Bound Behavior of Aircraft Systems Containing Complex Functions Using Run-Time Assurance*	**11/21/2022, Philip Mattson:** ***AIA NAS9948 Appendices –*** Implementation verification procedures that support *NAS9948 UAS Data Protection and Privacy standard practice*. **5/24/2022, AS:** ***RTCA*** *DO-178C Software Considerations in Airborne Systems and Equipment Certification* and *DO-278A Guidelines For Communication, Navigation, Surveillance, and Air Traffic Management (CNS/ATM) Systems Software Integrity Assurance* which are being examined by RTCA SC-240 and EUROCAE WG 117 for additional material to aid software developers, including UAS SW developers. Documents still in development – Publication Date TBD

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Gap A11: Flight Data and Voice Recorders for UAS.

Standards are needed for crash protected voice and data recorder systems for UAS.

R&D Needed: Yes. Research should be conducted to determine the proper:
1) Size requirements, based on the class of UAS, class of airspace, performance characteristics of the aircraft, and other relevant factors.
2) Test procedures for crash survival based on the class of UAS and performance characteristics, including, but not limited to: impact shock, shear and tensile force, penetration resistance, static crush, high temperature fire, low temperature fire, deep sea pressure and water immersion, and fluid immersion.
3) Method(s) for recording data both on the aircraft and in the CS.
4) Minimum data that must be captured (dependent on UAS size and criticality of operation).

Recommendation: Revise an existing standard and/or draft a new standard, similar to ED-112A, for a voice and data recorder systems for UAS.

Priority: Medium

Organization: SAE, RTCA, ASTM, IEEE, EUROCAE, SAE ITC ARINC IA, IETF DRIP WG

v2 Status of Progress: Green

v2 Update: EUROCAE WG-118: ED-112B

Updates Since v2 was Published:

Other Committees with Relevant Work:
- SAE ITC, ARINC IA Network Infrastructure and Security subcommittee
- ~~SAE ITC, ARINC IA Digital Flight Data Recorder subcommittee~~ **(3/5/2024, CB, no longer active)**
- SAE ITC, ARINC IA System Architecture and Interfaces subcommittee

Comments Received on Gap for Future Consideration:
- **02/12/2024, S.Marzac**: ED-112B published in 2023 does not address AAM flight recording requirements. Instead, WG-118 will be developing a separate AAM flight recording MASPS, in lieu of updating ED-112.

New Published Standards	New In-Development Standards
	5/17/2022, RM: IETF DRIP WG *Secure UAS Network RID and C2 Transport* Draft-moskowitz-secure-nrid-c2 provides for open standards method of sending flight information (i.e., Remote ID messages) to a logging server (Net-RID Service Provider). **6/10/2021,** EUROCAE WG-118 is developing a new lightweight FDR standard that will include UAS

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Gap A12: UAS Cybersecurity.

Cybersecurity needs to be considered in all phases of UAS design, construction, operation, maintenance, training of personnel (pilots, crews, others), including cloud-based functions.

R&D Needed: Yes

<table>
<tr><td colspan="2">Recommendation: Since there exists such a wide spectrum in UAS designs, CONOPS, and operator capabilities, a risk-based process during which appropriate cybersecurity measures are identified is recommended. Explicitly address the need for & efforts directed at assessing/ensuring trustworthiness, esp. of safety critical information & systems that move, store & process it. Explicitly address the need for crypto techniques supporting authenticity, integrity, confidentiality, privacy, etc. & efforts to apply them to UAS.</td></tr>
<tr><td colspan="2">Priority: High (Tier 1)</td></tr>
<tr><td colspan="2">Organization: RTCA, EUROCAE, SAE, ASTM, JARUS, AIA, IETF, ICAO IATF, SAE ITC ARINC IA, 3GPP</td></tr>
<tr><td colspan="2">v2 Status of Progress: Green</td></tr>
<tr><td colspan="2">v2 Update:
RTCA SC-216/EUROCAE WG-72 Aeronautical Systems Security
SAE G-32 (with participation from WG-72, S-18/WG-63, S-18A Autonomy WG/EUROCAE WG-63 SG-1, and G-34): Cyber Physical Systems Security Committee: JA6678, JA7496, JA6801
ASTM F3532-22
IETF DRIP workgroup
AIA NAS9948 UAS Data Protection and Privacy Standard Practice working group
NIST Cybersecurity Framework (CSF)</td></tr>
<tr><td colspan="2">Updates Since v2 was Published:

Other Committees with Relevant Work:
SAE ITC, ARINC IA Network Infrastructure and Security subcommittee
10/31/2024, SC: The International Civil Aviation Organization (ICAO) has established an Ad Hoc Cybersecurity Coordination Committee (AHCCC), Cybersecurity Panel (CYSECP), and a Trust Framework Panel (TFP). The TFP is to develop a digital trust framework for the entire aviation ecosystem, explicitly including but not limited to UAS, and is leveraging inter alia the IETF DRIP work.
Comments Received on Gap for Future Consideration:
5/31/2022, Phil Mattson per MITRE HSSEDI: Section 6.4.6 Cybersecurity - Update Lines 21-26 to following recommended text: "The Aerospace Industries Association (AIA) National Aerospace Standards has published NAS9948 UAS Data Protection and Privacy. The standard practice focuses on data communications protections and privacy for “high” category users such as the federal government. AIA set up a working group within its Emerging Technology Committee which is made up of AIA members, subject matter experts and federal government partners. The standard provided a set of tailored controls ensuring that sensitive location, video and other forms of data are both protected and secure. The standard also provided a set of cyber-attack use cases for manufacturers to consider when designing UAS."</td></tr>
<tr><td>New Published Standards

4/21/2025, DVD: ASTM F3742-24 Standard Guide for Credential-Based A2X Broadcast Security. This standard is designed to help the aviation industry create and fine tune security protections for A2X (aircraft to anything) communication, particularly aircraft-aircraft collision avoidance and DAA communications.

10/31/2024, SC: IETF draft-ietf-drip-auth was published as RFC 9575 DRIP Entity Tag (DET) Authentication Formats and Protocols for Broadcast Remote Identification (RID).

12/05/2022, JR: SAE JA7496 Cyber-Physical Systems Security Engineering Plan (CPSSEP). This SAE Standard establishes practices to:
a. Manage risk and ensure security of a cyber-physical system (CPS) throughout its life cycle by utilizing systems engineering principles;
b. Assess the impact of cyber-physical systems security (CPSS) objectives and requirements;
c. Assess the security risks to CPS technical effectiveness and functions, and address weaknesses and vulnerabilities;
d. Address various domains of consideration (see 3.1) that take into account operating conditions of the system, command and control, configuration management (refer to SAE EIA649), etc., that could negatively impact CPSS or CPS-designed purpose;</td><td>New In-Development Standards

11/18/2025, MBalakrishna, RTCA: DO-362B (Command and Control (C2) Data Link Minimum Operational Performance Standards (MOPS) (Terrestrial)) - Incorporate changes required to harmonize SATCOM compatibility with EUROCAE Standard. Updates required as a result on initial implementation of A revision. Projected Publication Date: March 2028

11/06/2024, PM: 3GPP TR 33.759, Study on Security Enhancements for UAS Phase 3 (in progress for R19)

10/31/2024, SC: IETF DRIP Entity Tags (DET) in the Domain Name System (DNS) is the current name of draft-ietf-drip-registries as it is currently focused on public registries in DNS, although private registries are also needed and standards for them are being developed in closely related IETF DRIP work.

03/11/2024, D.Franks: SAE WIP JA7151 Netlist Analysis Techniques for Hardware Assurance (HwA) is intended to provide guidance, techniques and methods for evaluating hardware assurance of microelectronic parts. The Netlist Analysis Techniques for Hardware Assurance aims to assess an implemented digital design netlist in a microcircuit for undesired device functionality.</td></tr>
</table>

e. Perform design validation and verification to assess security and risk of the CPS.

12/04/2022, RM: IETF *DRIP Entity Tag (DET) for Unmanned Aircraft System Remote ID (UAS RID).* Draft-ietf-drip-rid for trust in Broadcast Remote ID Messages was approved. RFC9374.

6/3/2022, CDB: ASTM WK56374 was approved as F3532-22 *Standard Practice for Protection of Aircraft Systems from Intentional Unauthorized Electronic Interactions* developed by committee F44.50.

6/1/2022, A.Blasgen: CTA published *CTA-2088.1, Baseline Cybersecurity for Small Unmanned Aerial Systems.* This standard builds upon the baseline cybersecurity requirements in CTA-2088 to address the cybersecurity requirements and recommendations relevant to the unique capabilities, uses, and applications of small Unmanned Aerial Systems.

12/2021, PM: 3GPP *TR 33.854, Study on Security Aspects of UAS (R17)*

12/16/2021, CC: ***NAS9948, UAS Data Protection and Privacy***. The scope of this standard is the protection of the Unmanned Aircraft System (UAS) data with respect to data security and privacy throughout the lifecycle of the UAS. This standard is focused on the data security and privacy of operators and operator data. This includes how the data is used, recorded, and protected from origin to destruction internal to the platform and external to the platform (i.e. the cloud). Protections are provided for use by UAS developers, users, and third-party applications. Appendix A describes eight use cases that were identified to describe potential UAS cyber-attacks.

9/20/2021, JM: RTCA DO-362 *Errata 2 – Command and Control (C2) Data Link Minimum Operational Performance Standards (MOPS),* presented by SC-228, Minimum Performance Standards for Unmanned Aircraft System. This Errata restores a table inadvertently excluded from the original document.

12/06/2022 SC: IETF *Drone Remote Identification Protocol Requirements & Terminology "GEN-6 Contact*: DRIP must enable dynamically establishing… strongly mutually authenticated, end-to-end strongly encrypted communications with the UAS RID sender and entities looked up from the UAS ID" to support V2X communications for DAA and other applications. The DRIP working group expects to address this requirement after the current set of basic DRIP drafts are published as RFCs.

12/05/2022, RFM: RTCA expects the publication of DO-362B to be delayed until December 2024. A TOR update will be considered at the PMC on December 15, 2022.

12/05/2022, JR: SAE WIP JA6801 *Cyber Physical Systems Security Hardware Assurance.* This Joint SAE Aerospace and Automotive Standard provides guidance and standardizes practices to:

1. identify and analyze risks associated with hardware components of concern
2. guide the evaluation (including cost and effectiveness) and recommendation of potential countermeasures

12/05/2022, JR: SAE G32 JA6678 Guidelines for Establishing and Maintaining *Cyber Physical Systems Cyber-Resilience*. This SAE Standard standardizes practices to:

a. assess and address vulnerabilities of software for a cyber physical system utilizing systems engineering principles to ensure security and resilience throughout the lifecycle of the system,
b. conduct software assurance and analysis, considering impact on the product's software, hardware, and firmware,
c. address different areas of concern that includes consideration of the interfaces and network of the system and command and control that could be manipulated through a physical process and/or physical input of the data flow and computation,
d. perform design validation and verification to assess security and resiliency of software impacting the cyber physical system safety, security and integrity across the complete lifecycle.

11/21/2022, Philip Mattson: ***AIA NAS9948 Appendices –*** Implementation verification procedures that support NAS9948 *UAS Data Protection and Privacy standard practice*.

5/24/2022, AS - RTCA developing DO-362B Incorporate changes required to harmonize SATCOM compatibility with EUROCAE Standard. Updates required as a result on initial implementation of A revision. Expected publication December 2023

5/17/2022, RGM: IETF **DRIP WG -** *Secure UAS Network RID and C2 Transport* Draft-moskowitz-secure-nrid-c2 provides for secured transmission of Network Remote ID and for Command and Control (C2) messages.

11/10/2021: EUROCAE WG 72 is currently updating **ED-201 "*Aeronautical information system security framework guidance*."**

	5/31/2021, RGM: IETF draft-ietf-drip-auth – *DRIP Entity Tag Authentication Formats and Protocols for Broadcast Remote ID* is a work item to provide authentication for all Remote ID broadcast messages by the DRIP workgroup

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Gap A13: Electrical Systems.

The existing standards from manned aviation need to be scalable to address the entire spectrum of UAS. Unique aspects of UAS electrical systems include: wiring, EWIS, electrical load analysis, aircraft lighting, etc. These areas (electrical systems, wiring, EWIS, etc.) are also not covered for control stations (CSs), auxiliary systems, etc.

UAS such as optionally piloted aircraft carrying cargo and/or passengers need standards for high voltage systems.

R&D Needed: Yes

Recommendation:
1) Complete work on in-development standards.
2) Encourage the development of standards that are scalable to UAS to address electrical systems, wiring, EWIS, electrical load analysis, aircraft lighting, etc., for UA, CS, and auxiliary system(s).
3) Establish maximum voltage limits for propulsion power transmission cables based on UA power needs and maximum operating altitudes.

Priority: High (Tier 3)

Organization: ASTM, SAE, RTCA, AIAA, NASA, ULSE, IEC, IEEE, ISO, SAE ITC ARINC IA, EUROCAE

v2 Status of Progress: Green

v2 Update: Numerous standards have been published and are in-development that address the entire spectrum of UAS and its operations.

Updates Since v2 was Published:

Other Committees with Relevant Work:
- SAE ITC, ARINC IA Fiber Optics subcommittee
- SAE ITC, ARINC IA Cabin Systems subcommittee
- SAE ITC, ARINC IA System Architecture and Interfaces subcommittee
- SAE ITC, ARINC IA Network Infrastructure and Security subcommittee
- SAE AE-10 High Voltage
- SAE AE-11 Aging Models for Electrical Insulation in High-Energy Systems

Comments Received on Gap for Future Consideration:
- 02/28/2024, S.Park, Information as to what types of electrical system standards are needed to determine if any UL Standards are applicable. Electrical Systems encompass a vast variety of product categories and applications and this topic noted numerous standards related to unmanned aircraft (on-board). If the types of electrical systems are related to off-the-aircraft, Control Stations (CS) on the ground, then there could be considerations for specifying, for example, uninterruptible power system and similar requirements applicable for high priority applications (e.g., control towers, industrial control rooms, data centers, etc.).

New Published Standards	New In-Development Standards
5/15/2025, R.Myers, UL: *UL 3030, Unmanned Aircraft Systems* (*Edition 1*) revision was published August 2024. This covers the electrical system of unmanned aircraft systems (UASs), as defined in this Standard, used in flight for commercial applications or flight incidental to business applications. UASs covered by these requirements are intended to be operated by certified UAS pilots as identified in the Federal Regulations, where the unmanned aircraft is less than 25 kg (55 lbs). The UAS is intended to be provided with an internal lithium ion battery that is charged from an external source. UASs are intended to have an operating voltage of not greater than 100 V dc and are intended for outdoor operation. These requirements also cover the electrical shock, fire, and explosion hazards associated with the inherent features of these UASs, as well as the battery	**03/11/2024, D.Franks**: **SAE** WIP AIR8470 *Design considerations for lighting systems to support camera functions* identifies lighting system design factors that impact the performance of cameras systems inside the aircraft. **6/22/2021, MPD: SAE: WIP** ARP8689 *Endurance tests for Aircraft Electric Engine* will provide guidance to test the durability and integrity requirements of Electric Engines to be type certificated for installation in aircraft. This ARP is intended to provide a means to demonstrate compliance to certification requirements of Engines separately of aircraft certification requirements. **11/20/2020, MD: SAE** WIP AIR7357, *Megawatt and Extreme Fast Charging for Aircraft* will detail power levels required for

and charger system combinations provided for recharging the UAS. **03/11/2024, D.Franks**: **SAE** ARP6336 *Lighting Applications for Unmanned Aircraft Systems (UAS)* discusses the unique trade-offs that are necessary to maintain commonality to the U.S. Federal Aviation Regulations (FARs)1 for aerospace lighting. The recommendations set forth in this document are to aid in the design of Unmanned Aircraft (UA) lighting for the size of aircraft and operation for which the aircraft is intended. In addition, certain concepts of operation for which UASs are suited will require unique lighting solutions. **03/11/2024, D.Franks**: **SAE** AE-10 AIR7058 *High-Voltage DC Electromechanical, Solid State, and Hybrid Switching Devices in Aerospace Applications* establishes applicable definitions and terms prior to considering the application domain and use cases in HVDC applications. It will identify commanded switching technologies to be considered for aerospace applications and provide rationale for their selection in the future. **03/11/2024, D.Franks**: **SAE** AE-10 *AIR7502 Aircraft Electrical Voltage Level Definitions* will document the various voltage levels and provide a rational for each level **4/30/2021, MD**: **SAE** AIR6540B *Fundamentals in Wire Selection and Sizing for Aerospace Applications* **1/27/2021, MD: SAE** AIR7502, *Aircraft Electrical Voltage Level Definitions* **6/11/2020, JM: RTCA** DO-380 - *Environmental Conditions and Test Procedures for Ground Equipment*. This document defines a series of minimum standard environmental test conditions (categories) and applicable test procedures for ground-based equipment. In this document ground-based equipment includes stationary ground, mobile/portable ground, or sea-based equipment. The purpose of these tests is to provide a laboratory means of determining the performance characteristics of ground-based equipment in environmental conditions representative of those which may be encountered in ground-based operation of the equipment.	future electric aircraft applications and detail design considerations and use cases for megawatt and extreme fast charging for electric aircraft. The AIR will provide a mapping to other industry standard that may be have relevance as well as detail areas where technology gaps / future design considerations will need to be addressed.

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Gap A14: Power Sources and Propulsion Systems.
Standards are needed for UAS power sources and propulsion systems.
R&D Needed: Yes
Recommendation: 1) Complete work on in-development standards. 2) Encourage the development of standards to address UAS power sources and propulsion systems.
Priority: High (Tier 3)
Organization: ICAO, RTCA, SAE, AIAA, ASTM, DOD, NASA, ULSE, IEC, IEEE, ISO, EUROCAE
v2 Status of Progress: Green
v2 Update: Numerous standards have been published and are in-development that address the entire spectrum of UAS and its operations.
Updates Since v2 was Published:

Other Committees with Relevant Work:
- EUROCAE WG-113 Electric and Hybrid Propulsion Systems
- SAE AE-7F Hydrogen and Fuel Cells
- SAE E-39 Unmanned Aircraft Propulsion Committee
- SAE AE-5CH Hydrogen Airport Taskgroup

Comments Received on Gap for Future Consideration:
- **4/19/23, R Dahlstrom:** May also be too early but this should include ground-based power with electrical tethers to the UAS.

New Published Standards

11/17/2024, CB, ANSI: SAE E-40 *AIR7130 Assessment of Electric Engine Failures Leading to LOPC* (Oct2024) proposes a method to demonstrate compliance to engine certification rules requiring tolerance of the control system to single failures leading to Loss of Power Control (LOPC) or Loss of Thrust Control (LOTC) for electric or hybrid engines. At issue 1, the document was developed to address only fully electric engine configurations targeting single engine CS/part 23 level 1 and 2 aircraft applications.

02/09/2024, P.Kenul: ***ASTM F38.01*** *F3547 Specification for Fuel Cell Power Systems for Use in Small Unmanned Aircraft Systems (sUAS).* This specification:
- defines the requirements for fuel cells and fuel cell-based power systems,
- including hydrogen-based fuel storage and refueling systems used in electric small Unmanned Aircraft Systems (sUAS).

03/11/2024, D.Franks: SAE E-39, *AS8473 Endurance Testing for UAS Engines Having Maximum Power Ratings at or Below 22.4 kW* is applicable to reciprocating engines powering unmanned aerial vehicles (UAV) that have rated power values less than 22.4 kW and are not to be used for human transport. This standard only covers engines designed for 150 hours of operation or higher.

03/11/2024, D.Franks: SAE AE-7M *AIR6326 Aircraft Electrical Power Systems Modeling and Simulation Definitions* defines basic terms and definitions and to provide general guidance for M&S of aircraft EPS.

12/04/2022, DF: SAE E-40 AIR8678 - *Architecture Examples for Electrified Propulsion Aircraft*. This document will describe potential electrified propulsion architectures and provide examples. While providing these example architectures, this document will develop common definitions for the elements of the architectures by defining:
1. The elements of electrified propulsion architectures, including any dedicated power generation and distribution systems as well as energy storage elements.
2. The interfaces to/from the electrified propulsion system.
3. The interfaces within the electrified propulsion system.
4. Electrical energy management and storage architecture of an electrified propulsion system.

12/04/2022, DF: SAE E-40 ARP8676 - *Nomenclature & Definitions for Electrified Propulsion Aircraft*. This document defines the relevant terms and abbreviations related to the design, development, and use of electrified propulsion in aircraft. This definition is provided to enable a consistent use

New In-Development Standards

03/14/2024, M.Carlson: ISO/TC 20/SC16/JWG9 with IEC/TC105 initiated two pending projects for:
- ISO//NP 25009, Unmanned aircraft systems — General requirements and test methods for the hydrogen fuel gas pipes of gaseous hydrogen fuel cell powered UAV
- ISO/NP 25013, Unmanned aircraft systems — General requirements and test methods for the attachable hydrogen cylinders of gaseous hydrogen fuel cell powered UAV

03/11/2024, D.Franks: SAE E-39 *AS7994 Endurance Testing for UAS Engines having Maximum Power Ratings at or Below 22.4 kW* is applicable to reciprocating engines powering unmanned aerial vehicles (UAV) that have rated power values less than 22.4 kW and are not to be used for human transport.

12/04/2022, DF: SAE E-40 AIR7128 - *Integration and Certification Considerations for Electrified Propulsion Aircraft*. This document provides a comprehensive compilation of currently available practices, standards, regulations and guidance material that have been considered relevant for developing an electrified propulsion system (independently or as part of an aircraft) and that may also help the applicants in the process of building their own certification approach with their Authority.

11/28/2021, JM: ***IEEE*** *P1937.9, Requirements for External Power and Power Management Interfaces for Unmanned Aerial Vehicle.* This standard specifies the requirements for external power interfaces of Unmanned Aerial Vehicles (UAV). It defines wireline and wireless Power Management Interfaces for charging and in-flight operations.

6/22/2021, MPD: SAE
- WIP ARP8689 *Endurance tests for Aircraft Electric Engine* will provide guidance to test the durability and integrity requirements of Electric Engines to be type certificated for installation in aircraft. This ARP is intended to provide a means to demonstrate compliance to certification requirements of Engines separately of aircraft certification requirements.
- WIP AS6679 Functional and Installation Recommendations for Aircraft Liquid Hydrogen Storage and Distribution Systems provides functional and installation recommendations for aircraft liquid hydrogen storage and distribution systems. It also proposes a reference description of the functions implemented by these systems.

of technical language throughout the standards developed by the E-40 committee. **4/7/2021, MPD: SAE** E-39 Unmanned Aircraft Propulsion Committee published ARP6971, *Power and Torque Determination for UAS Engines Having Maximum Power Ratings at or Below 22.4 kW*	• WIP AS6968 *Connection Set of Conductive Charging for Light Electric Aircraft*. Technical requirements related to the design and minimum performance requirements of connection set of conductive charging systems used for charging electrically powered aircraft. **11/20/2020, MD: SAE** AIR7357, Megawatt and Extreme Fast Charging for Aircraft

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Gap A15: Noise, Emissions, and Fuel Venting.	
No published standards have been identified that address UAS-specific noise, emissions, and fuel venting standards and requirements.	
R&D Needed: Yes. Data would be helpful.	
Recommendation: 1) Complete in-development standards. 2) Encourage the development of standards to address noise, emissions, and fuel venting issues for UAS. This is a necessary first step toward UAS rulemaking relating to these topics.	
Priority: High (Tier 3)	
Organization: ICAO, EPA, RTCA, SAE, AIAA, ASTM, DOD, NASA, ISO	
v2 Status of Progress: Not Started	
v2 Update: • SAE A-21 Project Working Team for UAM Noise • Numerous standards have been published and are in-development that address the entire spectrum of UAS and its operations. • FAA published final rule on Mattenet M2 noise measurements, EASA publishes guidelines on drones. • ICAO CAEP WG1 Task N.06 Hub – Noise from emerging technology aircraft.	
Updates Since v2 was Published: **Comments Received on Gap for Future Consideration:** • **04/14/2023, Jose Alonso:** ICAO CAEP WG1 (Task N.06) continues, this update includes published standards by FAA and EASA. https://www.icao.int/meetings/DRONEENABLE2022/pages/default.aspx • **11/30/22, Jose Alonso:** Though no final standards or regulations have been published, this subject is being actively supported by ICAO CAEP WG1 (Task N.06), FAA, Volpe Center and NASA. FAA has recently issued NPRM for Noise Certification Standards: Matternet Model M2 Aircraft. (Docket 2021-0710 Notice 21-01).	
New Published Standards	**New In-Development Standards**
11/17/2025, CB, SAE: A-21: *ARP6973A - Aircraft Noise Level Reduction Measurement of Building Façades (May 2025)* provides two methods for measuring the aircraft noise level reduction of building façades. Airports and their consultants can use either of the methods presented in this ARP to determine the eligibility of structures exposed to aircraft noise to participate in an FAA-funded Airport Noise Mitigation Project, to determine the treatments required to meet project objectives, and to verify that such objectives are satisfied. **03/14/2024, M.Carlson: ISO/TC 20/SC16,** *ISO 5305:2024, Noise measurements for UAS (unmanned aircraft systems)* specifies methods for recording the time history of instantaneous sound pressure in several positions around rotor powered unmanned aircraft systems (UAS) with a maximum take-off mass (MTOM) of less than 150 kg in accordance with ISO 21895[9]. The UAS can be either electrically powered or fuel-powered. It is not applicable to the tilt-rotor or tilt-wing UAS. **02/12/2024, S.Marzac, Boeing**: EASA Consultation Paper: Environmental protection technical specifications (noise)	**11/29/2021: JR: SAE** WIP ARP4721/1A *Monitoring Aircraft Noise and Operations: System Description, Acquisition, and Operation* **11/29/2021: JR: SAE** WIP ARP4721/2A *Monitoring Aircraft Noise and Operations: System Validation*

applicable to VTOL-capable aircraft powered by non-tilting rotors, issued 12/12/2023. **4/14/2023, Jose Alonso, Collins:** *Noise Certification Standards: Matternet Model M2 Aircraft* **4/14/2023, Jose Alonso, Collins:** *EASA guidelines on noise level measurements for drones below 600kgs*	

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Gap A16: Mitigation Systems for Varous Hazards to UAS

There are no UAS-specific standards in the areas of hazard mitigation systems for bird strikes on UAS, engine ingestion, hail damage, water ingestion, lightning, electrical wiring, support towers, etc.

R&D Needed: Yes

Recommendation:
1) Complete in-development standards.
2) Create new standards to include hazard mitigation systems for bird strikes on UAS, engine ingestion, icing, and lightning.

Priority: High (Tier 2)

Organization: Various SAE Committees, SAE ITC ARINC IA

v2 Status of Progress: Green

v2 Update: SAE has a number of standards in development as noted in the text.

Updates Since v2 was Published:

Other Committees with Relevant Work:
- SAE ITC, ARINC IA System Architecture and Interfaces subcommittee
- SAE E-41 Engine Corrosion – Runway Deicing Products
- SAE G-28 Simulants for Impact and Ingestion Testing

Comments Received on Gap for Future Consideration:
- **11/30/21, Rhonda Walthall,** A16: Recommendation from a colleague: UAV engines and structures will be certified with respect to different hazards, A starting point may be "*EASA - European Aviation Safety Agency Certification Specifications for Engines"* - CS-E for examples regarding CS-790 Ingestion of Rain and Hail and CS-E-800 Bird Strike and Ingestion.

New Published Standards	New In-Development Standards
11/17/2025, CB, ANSI: SAE G-28 AS6999 - Standard Test Method for Measuring Impact Forces and Pressures of a Soft Projectile on an Inclined Rigid Flat Surface (Jan 2024) describes methods for measuring dynamic forces, pressures, and projectile fragment distribution patterns during an impact between a soft or frangible projectile and a rigid flat inclined surface. It also describes the hardware, setup, and instrumentation required.	**12/04/2022, DF: SAE** G-28 WIP AS7371 *Standard Test Method for Normal Impact of a Soft Projectile on a Hemispherical Leading Edge*. This document describes a method for measuring deformations, and fragment distribution patterns during an impact between a soft or frangible projectile and a regular helispherical leading edge. The document describes the hardware, setup, and instrumentation required. **12/04/2022, DF: SAE** G-28 WIP AS7372 *Standard Test Method for Normal Impact of a Soft Projectile on a Clamped Plate.* This document describes a method for measuring deformations from a normal impact between a soft or frangible projectile and clamped plate. The document describes the hardware, setup, and instrumentation required. In this test method a soft body projectile impacts a square ductile plate clamped on all four sides

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Gap A17: Parachute or Drag Chute as a Hazard Mitigation System in UAS Operations over People (OOP).

Standards are needed to address parachutes or drag chutes as a hazard mitigation system in UAS operations, particularly OOP, from the perspectives of FAA Type Certification (TC), Production Certificates (PC) and Airworthiness Certificates (AC).	
R&D Needed: No	
Recommendation: Complete work on ASTM WK65042, *New Specification for Operation Over People*.	
Priority: High (Tier 3)	
Organization: ASTM, AIAA, SAE, PIA, DOD, NASA	
v2 Status of Progress: Green	
v2 Update: ASTM F38: F3322	
Updates Since v2 was Published: • EASA NPA 2022-06 "Introduction of a regulatory framework for the operation of drones" **Comments Received on Gap for Future Consideration:**	
New Published Standards	**New In-Development Standards**
04/26/2025 PK: ASTM *F3322-24a Standard Specification for Small Unmanned Aircraft System (sUAS) Parachutes* revision was published (former WK87943). This specification covers the design and manufacture requirements for deployable parachutes of small Unmanned Aircraft (sUA)/small Unmanned Aircraft Systems (sUAS). This specification defines the design, fabrication, and test requirements of installable, deployable Parachute Recovery Systems (PRS) that are designed to be integrated into an sUA to lessen the impact energy of the system should the sUA fail to sustain normal, stable safe flight. **5/3/2023, PK: ASTM** F38.01, F3389/F3389M-21, *Standard Test Method for Assessing the Safety of Small Unmanned Aircraft Impacts* revision now available. Approval of WK76302. **11/14/2022, PK:** ASTM F3322-22 *Standard Specification for Small Unmanned Aircraft System (sUAS) Parachutes* developed by Committee F38.01.	

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Gap A18: Maintenance and Inspection (M&I) of UAS.	
M&I standards for UAS are needed.	
R&D Needed: No	
Recommendation: Complete work on standards in development to address M&I for all UAS.	
Priority: High (Tier 2)	
Organization: ASTM, ISO, SAE, SAE ITC ARINC IA	
v2 Status of Progress: Green	
v2 Update: Numerous standards have been published and are in-development that address the entire spectrum of UAS and its operations.	
Updates Since v2 was Published: **Other Committees with Relevant Work:** • SAE ITC, ARINC IA System Architecture and Interfaces subcommittee **Comments Received on Gap for Future Consideration:**	
New Published Standards	**New In-Development Standards**

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Gap A19: Enterprise Operations: Level of Automation/Autonomy and Artificial Intelligence (AI).
Neither the current regulatory framework nor existing standards support fully autonomous flights at this time.
R&D Needed: Yes

Recommendation:

1) Develop standards and guidelines for the safety, performance, and interoperability of fully autonomous flights, taking into account all relevant factors needed to support the seamless integration of UAS into the NAS. These include: type of aircraft/UA, operators/pilots/crew, air traffic controllers, airspace service suppliers/providers, lost link procedures, human factors/human-machine interactions as well as levels of human intervention, etc.
2) Encourage the development of standards to address fully autonomous flights, per the FAA Reauthorization Act of 2018 and the needs of the UAS industry and end users.
3) Encourage the development of consistent, uniform, harmonized, standardized, and aviation field- acceptable definitions of terms like autonomy, automation, autonomous, AI, machine learning, deep learning, etc. This will lay a foundation for identification of correct and incorrect definitions/ terminologies.

Priority: High (Tier 2)

Organization: SAE, SAE ITC ARINC IA, RTCA, AIAA, ASTM, DOD, NASA, FCC, Aerospace Vehicle Systems Institute (AVSI), ULSE, ISO/IEC JTC1/SC42

v2 Status of Progress: Green

v2 Update:

- SAE S-18A Autonomy WG/EUROCAE WG-63 SG-1: AIR7121
- SAE G-34/EUROCAE WG-114: AS6983, AIR6987, AIR6988
- SAE AS-4JAUS: AS8024
- SAE S-18/EUROCAE WG-63: various standards
- UL Standards & Engagement: UL 4600

Updates Since v2 was Published:

- EASA NPA 2022-06 "*Introduction of a regulatory framework for the operation of drones*"
- Joint Authorities for Rulemaking on Unmanned Systems (JARUS) Annex H, UTM
- AI Risk Management Framework | NIST
- AI Risk Management Framework: Second Draft - August 18, 2022 (nist.gov)
- AI RMF Playbook (nist.gov)

Other Committees with Relevant Work:

- SAE ITC, ARINC IA System Architecture and Interfaces subcommittee
- Flight Safety Foundation: Autonomous and Remotely Piloted Aviation Capabilities (ARPAC) advisory committee (AC) or "ARPAC AC"

Comments Received on Gap for Future Consideration:

- **6/1/22, Deborah Kirkman, Flight Safety Foundation:** The Autonomous and Remotely Piloted Aviation Capabilities (ARPAC) advisory committee (AC) was chartered by the Flight Safety Foundation to develop safety-focused recommendations to venues addressing uncrewed aircraft systems (UAS) and BVLOS (non-recreational) operations. The ARPAC is also chartered to develop guidance on best practices and policies for safety for emerging operations and missions of varying size. Membership includes regulators, operators, manufacturers, service providers, and non-governmental organizations (NGOs). The ARPAC AC currently has three active working groups: the Humanitarian WG – providing input on unique needs and considerations for humanitarian uncrewed missions; the Airspace and Safety Risk Methodology WG, addressing safety methodologies to support key humanitarian and commercial use cases; and the Advanced Air Mobility WG, which is focused on developing safety guidance related to highly automated and autonomous operations.

New Published Standards	New In-Development Standards
11/17/2025, CB, ANSI: AIR6987, *Artificial Intelligence in Aeronautical Systems: Taxonomy* (Nov 2024) provide a classification of AI techniques that may be used in AI-based systems for aeronautical products. Aeronautical products include products in Airborne and Air Traffic Management (ATM) and Air Navigation Systems (ANS) domains for crewed and uncrewed aircraft. **02/12/2024, S.Marzac: JARUS** *Methodology for Evaluation of Automation on UAS Operations* (April, 2023) **02/12/2024, S.Marzac: JARUS** *White Paper Whitepaper on Considerations for Automation of the Airspace Environment* (January, 2024)	**11/20/2025, GF, UL:** The Technical Committee (TC) to support UL 4601 is in the process of being formed. Standards development will start in January 2026. Updates for UL 4601, *Evaluation of Autonomous Unmanned Aerial Systems* will be available in 2026. **11/17/2025, CB, ANSI: ISO TC20/SC16/WG6,** *ISO/ CD 25132: Classification of civil unmanned aircraft system (UAS) autonomous flight control levels* defines the classification of civil unmanned aircraft system (UAS) autonomous flight control levels. Based on the human machine role allocation, this document defines 6 UAS autonomous levels, from no autonomy (level 0) to full autonomy (level 5). **6/1/2022, DK, ARPAC AC:** Upcoming products of the ARPAC AC, targeted for CY22 are:

5/23/2022, Phil Kenul: ASTM WK65056 approved as F3269-21 *Standard Practice for Methods to Safely Bound Behavior of Aircraft Systems Containing Complex Functions Using Run-Time Assurance*. This includes revisions from the F3269-17 version. **5/23/2022, Phil Kenul: ASTM WK63418** approved as F3548-21 *Standard Specification for UAS Traffic Management (UTM) UAS Service Supplier (USS) Interoperability* developed by Committee F38.02. It was revised to include UAM Traffic management with work being conducted by the UAM Task Group. **4/30/2021, RG: SAE** AIR6988 / EUROCAE ER-022, *Artificial Intelligence in Aeronautical Systems: Statement of Concerns*. This document reviews current aerospace software, hardware, and system development standards used in the certification/approval process of safety-critical airborne and ground-based systems, and assesses whether these standards are compatible with a typical Artificial Intelligence (AI) and Machine Learning (ML) development approach. The document then outlines what is required to produce a standard that provides the necessary accommodation to support integration of ML-enabled sub-systems into safety-critical airborne and ground-based systems, and details next steps in the production of such a standard. **4/22/2021, JM:** According to the ISO/IEC JTC1 AG2 Technology Trend Report on Drone, a published standard is ISO/IEC TR 29119-11:2020, *Software and systems engineering – Software testing – Part 11: Guidelines on the testing of AI-based systems*	- A Toolkit supporting humanitarian and other BVLOS operations in low resource and remote locations, utilizing highly automated or autonomous UAS - A gated process for evaluating highly automated uncrewed systems, including a capability maturity model for assessing the readiness of aviation systems employing highly automated or autonomous components - Inputs to FSF for submission to ICAO regarding operator needs for working with regulators to get timely safety approvals for BVLOS Operations and on the need for broader inputs, incorporating human factors, in a gated evaluation framework for highly automated aviation systems. **SA**E AS6983, *Process Standard for Development and Certification/Approval of Aeronautical Safety-Related Products Implementing AI* **02/01/2021, RG: SAE WIP** AIR6994 / EUROCAE ER-xxx, *Artificial Intelligence in Aeronautical Systems: Use Cases Considerations*. The purpose of this AIR/ER is to capture suggested use cases derived from the potential incorporation of machine learning technologies in certifiable/approved aeronautical systems in order to illustrate the concerns outlined by AIR6988/ER-022 (Statement of Concerns). **6/1/2020, JM:** UL 4601, *Evaluation of Autonomous Unmanned Aerial Systems*. This Standard will build upon ANSI/UL 4600 while addressing needs unique to the unmanned aerial systems industry. This Standard will cover the safety principles and processes for evaluation of autonomous unmanned aerial systems, specifically their ability to perform their intended function either without human intervention or via teleoperation. The Standard also covers the reliability of hardware and software necessary for machine learning, sensing of the operating environment, and other safety aspects of autonomy.

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New Gap A20: Unlicensed Spectrum Interference Predictability.
Performance in the unlicensed spectrum bands is inherently unpredictable to some extent. There are approaches to enhance modeling and prediction, but there has been little work towards doing so. Identification of Key Performance Indicators needs to be demonstrated/analyzed.
R&D Needed: Yes. ASTM's Remote ID workgroup is performing studies to determine likely performance under various RF conditions.
Recommendation: Additional R&D could include statistical characterization of congestion in various environments (urban, rural, etc.), and study of interference caused by aerial radios.
Priority: High (Tier 1), especially in evaluating Remote ID broadcast range
Organization: See list of organizations listed in the text.
v2 Status of Progress: New
v2 Update: None provided
Updates Since v2 was Published: **12/28/2020, JM:** On December 28, 2020 the Federal Aviation Administration (FAA) announced final rules for unmanned aircraft systems (UAS) or drones that will require Remote Identification (Remote ID) of drones and allow operators of small drones to fly over people and at night under certain conditions. • Remote ID information • Remote ID rule (PDF) • Operations Over People and at Night Information • Operations Over People and at Night rule (PDF)

Comments Received on Gap for Future Consideration: • **12/12/22, Comment:** Revisit this gaps description and intent with regards to unlicensed spectrum with any future update to the roadmap • **11/22/21, Rhonda Walthall:** The scope of this activity should include both on-board DAA and ground-based DAA as architectural alternatives to address SWAP and cost constraints.	
New Published Standards **5/23/2022 Phil Kenul: ASTM** WK76077 now published as F3411-22 *Standard Specification for Remote ID and Tracking* developed by Committee F38.02. This is an updated version from the F3411-19 version.	**New In-Development Standards** **10/31/2024, SC: ASTM** *WK91742 Revision of F3411-22a Standard Specification for Remote ID and Tracking* based primarily on deployment experience.

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New Gap A21: Blockchain for UAS.	
There are no published industry standards for blockchain in the aviation ecosystem (including but not limited to UAS).	
R&D Needed: Yes	
Recommendation: Complete in-development standards and write new standards to address blockchain for UAS.	
Priority: Medium	
Organization: SAE International, SAE-ITC, ISO, IEEE, IETF DRIP WG	
v2 Status of Progress: New	
v2 Update: None provided	
Updates Since v2 was Published: • **6/2/2021, Stu Card:** IETF DRIP WG members are investigating the use of blockchains, distributed ledger technologies and smart contracts to support registries (esp. but not exclusively for Remote ID) with desirable properties such as non-repudiation and tunable tradeoffs between operator privacy and public transparency. Blockchain also has potential to supplement flight data recording (Gap A11, Stu Card comment). **Comments Received on Gap for Future Consideration:**	
New Published Standards **11/17/2025, CB, SAE:** AIR7123 - Overview of Blockchain-Based Digital Authorized Release Certificate (Jan 2025) provides an overview, process, and implementation guidance on use of blockchain technology for a secure, immutable, and traceable digital authorized release certificate. This document does not standardize the process nor is it meant for authorities to recognize the standard as an acceptable means of recording data collected through the required authorized release certificate (ARC) tags. **11/17/2025, CB, SAE:** AIR7161 - Guidance for Digital Thread Data Standards Enablement, Monitoring, and Quantification with the Digital Thread Framework and Digital Thread Index (Jan 2025) provides an overview and guidance to enable and monitor the use of Digital Thread data standards and the quantification of digital tread efficacy with the Digital Thread Qualitative Index. This document does not standardize the process. However, it does provide a methodology to determine efficiencies and inefficiencies of Digital Thread utilization across various phases of the product lifecycle. **11/17/2025, CB, SAE:** AIR7367 - Considerations for Requirements, Specifications, and Framework of a Digital Thread in Aircraft Data Life Cycle Management (Dec 2023) describes the considerations for requirements, specifications, and framework of digital thread in the aircraft product life cycle management. This document is not intended to define an overarching rendition of implementation-dependent features around software or architecture.	**New In-Development Standards** **09/02/2024 PK: ASTM** *WK91742 Revision of F3411-22a Standard Specification for Remote ID and Tracking.* After 2 years of publication, FAA implementation, International adoption, manufacturer implementations, and receiver implementations, a lot of "field data" has been gathered that inform revisions to this standard. **5/17/2022 RM: IETF DRIP WG:** draft-ietf-drip-registries proposes methodologies for blockchain ledgers for UAS registration actions.

03/11/2024 D.Franks, SAE: *AIR7356 Blockchain for Unmanned Aircraft Systems and Advanced Air Mobility* focuses on opportunities, challenges, and requirements in use of blockchain for Unmanned Aircraft Systems (UAS) operating at and below 400 feet above ground level (AGL) for commercial use. **11/22/2021, JR: SAE** ARP6984 *Determination of Cost Benefits from Implementing a Blockchain Solution* published 8/19/2021 **3/1/2021, MPD: SAE** ARP6823 *Electronic Transactions for Aerospace Systems; An Overview* **9/18/2020, MPD: SAE** AIR7501 *Aircraft Asset Lifecycle and Digital Data Standards Overview* **4/21/2020, MPD: SAE** AIR6904 *Rationale, Considerations, and Framework for Data Interoperability for Health Management within the Aerospace Ecosystem*. Mentioned in roadmap v2 as published.	

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Chapter 6 Recommendations/Comments Since v2 was Published:

- **6/1/2022 Brandon Suarez:** Suggest that ANSI add a new GAP on V2X Surveillance and Communication. DO-304A articulates a technical gap opened by the FAA Remote ID rulemaking that amended 91.215/225 to not allow UAS to equip with Transponder or ADS-B. GAMA White Paper from 2021 provides some basis. RTCA SC-228 has formed an Ad Hoc WG to develop White Paper in collaboration with SC-186 and SC-147.

Other Chapter 6 Activity – Relevance to Gaps Not Yet Determined

New In-Development Standards

- **03/14/2024, M.Carlson: ISO TC20/SC16/WG6,** *ISO/NP 25132: Classification of civil unmanned aircraft system (UAS) autonomous flight control levels* defines the classification of civil unmanned aircraft system (UAS) autonomous flight control levels. Based on the human machine role allocation, this document defines 6 UAS autonomous levels, from no autonomy (level 0) to full autonomy (level 5).

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Chapter 7. Flight Operations Standards: General Concerns – WG2

High Priority (Tier 1) (Most Critical)

High Priority (Tier 2) (Critical)

Medium Priority

General Flight Operations Standards Feedback

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Gap O1: Privacy.	
UAS-specific privacy regulations are needed as well as standards to enable the privacy framework. Privacy law and rulemaking related to UAS, including topics such as remote ID and tracking, are yet to be clearly defined.	
R&D Needed: Yes	
Recommendation: Develop UAS-specific privacy standards as needed and appropriate in response to the evolving policy landscape. Monitor the ongoing policy discussion.	
Priority: Medium	
Organization: ISO/IEC JTC1/SC 27, ISO/TC 20/SC 16, APSAC, IACP, IETF	
v2 Status of Progress: Yellow	
v2 Update: ISO/IEC JTC1/SC 27, ISO/TC 20/SC 16, APSAC, IACP, IETF	

Updates Since v2 was Published:
• **12/28/2020, JM:** On December 28, 2020 the Federal Aviation Administration (FAA) announced final rules for unmanned aircraft systems (UAS) or drones that will require Remote Identification (Remote ID) of drones and allow operators of small drones to fly over people and at night under certain conditions.
  ○ Remote ID information
  ○ Remote ID rule (PDF)
  ○ Operations Over People and at Night Information
  ○ Operations Over People and at Night rule (PDF)
 	
Comments Received on Gap for Future Consideration:	

New Published Standards	**New In-Development Standards**
12/1/2021, Phil Mattson: The ***UAS Data Protection and Privacy Standard Practice, NAS9948***, developed through the Aerospace Industries Association (AIA) was just approved for publication. Chris Carnahan can provide further details. This standard was developed based on concerns raised by the interagency Aviation Cyber Initiative Community of Interest, facilitated by the DHS S&T Standards in collaboration with the MITRE Homeland Security Systems Engineering and Design Institute and the National Cybersecurity Center of Excellence.	**5/17/2022 RM: IETF DRIP WG**: draft-moskowitz-drip-secure-nrid-c2 provides for full encryption (CIA) for Command and Control (C2). **05/31/2021 RGM:** IETF DRIP WG *UAS Operator Privacy for Remote ID Messages* (draft-moskowitz-drip-operator-privacy) for Operator PII in Remote ID messages.

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Gap O2: Continued Operational Safety (COS).	
The existing industry standards and regulatory framework related to COS from manned aviation still apply to UAS. However, there exist some gaps unique to UAS certification and its operations.	
R&D Needed: Yes	
Recommendation: Complete in-development standards.	
Priority: High (Tier 1)	
Organization: SAE, EUROCAE, SAE-ITC, RTCA, JARUS, ASTM, IEEE	
v2 Status of Progress: Green	
v2 Update: SAE S-18A Autonomy WG/EUROCAE WG-63 SG-1 (in collaboration with WG-105), SAE S-18/EUROCAE WG-63, SAE G-34/EUROCAE WG-114, SAE G-32, SAE AS-4, RTCA SC-240/EUROCAE WG-117, RTCA SC-228, etc. are addressing this standards gap.	
Updates Since v2 was Published: **Comments Received on Gap for Future Consideration:**	
New Published Standards	**New In-Development Standards**

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Gap O3: Beyond Visual Line of Sight (BVLOS).
Although there is an existing BVLOS standard with supplemental revisions in the works and a best practices document, robust BVLOS operations will require a comprehensive DAA solution, Remote ID, and UTM infrastructure to be completely effective. Additional safety measures must be considered such as reduced limits on energy transfer; weight; speed; altitude; stand-off and redundant systems for power; collision avoidance; positioning; loss-of-control automatic soft landing; and

methods for two-way communications between the competent operator and worker supervisor(s) or workers to ensure safety of BVLOS operations. These standards should be addressed in a collaborative fashion. In addition, pilot competency and training is especially critical for BVLOS operations. It is anticipated that appendices for BVLOS will be added to ASTM F3266-18, *Standard Guide for Training Remote Pilots in Command of Unmanned Aircraft Systems (UAS) Endorsement*
R&D Needed: Yes
Recommendation: Complete work on aforementioned BVLOS standards and related documents in development and address for future consideration UAS including payloads larger than 55 pounds as defined in Part 107. Research is also required but more to the point connectivity is needed to ensure interoperability or compatibility between standards for BVLOS/DAA/Remote ID/UTM/C2.
Priority: High (Tier 1)
Organization: ASTM, IETF, SAE ITC ARINC IA, IETF DRIP WG, RTCA
v2 Status of Progress: Green
v2 Update: Published and in-development standards are noted in the text.

Updates Since v2 was Published:
• Joint Authorities for Rulemaking on Unmanned Systems (JARUS) Annex H, UTM
• **12/28/2020, JM:** On December 28, 2020 the Federal Aviation Administration (FAA) announced final rules for unmanned aircraft systems (UAS) or drones that will require Remote Identification (Remote ID) of drones and allow operators of small drones to fly over people and at night under certain conditions.
  - Remote ID information
  - Remote ID rule (PDF)
  - Operations Over People and at Night Information
  - Operations Over People and at Night rule (PDF)
• **03/11/2024, RG:** DOT/FAA RIN: 2120-AL82, Unmanned Aircraft Systems Operations Using Special Airworthiness (OMB website publication in fall 2022). This rulemaking would enable certain low altitude unmanned aircraft systems (UAS) operations, while ensuring the safety and efficiency of the United States airspace. It is the next step in incrementally integrating UAS into the national airspace system (NAS), providing for expanded safety, societal, and economic advantages and benefits. Using consensus-based standards, this rulemaking would establish a new section under title 14 of the Code of Federal Regulations part 21 (14 CFR part 21) describing the regulatory process for issuing special airworthiness certificates for unmanned aircraft (weighing up to 1,320 pounds) as well as the acceptance of their associated elements.
 	
Other Committees with Relevant Work:
• SAE ITC, ARINC IA Ku/Ka Band Satellite subcommittee
• SAE ITC, ARINC IA Air-Ground Communications System subcommittee
• SAE ITC, ARINC IA Global Navigation Satellite System subcommittee
• SAE ITC, ARINC IA System Architecture and Interfaces subcommittee
• SAE ITC, ARINC IA Aeronautical Operational Control subcommittee
 	
Comments Received on Gap for Future Consideration:
• **02/12/2024, S,Marzac, Boeing:** In the Gap O3 description, consider mentioning the FAA BVLOS rulemaking efforts in the gap description.

New Published Standards	**New In-Development Standards**
11/17/2025, CB, ANSI: ASTM F3609-25 Standard Specification for Positioning Assurance, Navigation, and Time Synchronization (PNT) for Unmanned Aircraft Systems (UAS) (April 2025) 1.1 This specification covers requirements and classifications for positioning assurance, navigation, and time synchronization for unmanned aircraft systems. 1.2 This specification may support UAS-specific traffic management functions. This specification does not apply to operations that are under positive air traffic control (ATC). 1.3 The requirements and framework defined in this specification are not application- or solution-specific and may be applied to unmanned aircraft system traffic management (UTM), remote identification, other third-party services, vehicle-to-vehicle communications, vendor-operator contracts, or other use cases.	**4/26/2025, PK:** ASTM WK93843 revision of F3178 to address air risk in support of BVLOS. **10/31/2024, SC: ASTM** *WK91742 Revision of F3411-22a Standard Specification for Remote ID and Tracking* based primarily on deployment experience. **5/31/2021, RGM:** IETF DRIP WG draft-moskowitz-drip-secure-nrid-c2 - *Secure UAS Network RID and C2 Transport* secure data transmission for Network Remote ID messages and C2.

1.4 This specification applies to both airworthiness and operational domains. Meeting the performance and other requirements may be by design, operational, or other means. **4/26/2025, PK:** *ASTM F3178-24 Standard Practice for Operational Risk Assessment of Unmanned Aircraft Systems (UAS)* focuses on preparing operational risk assessments (ORAs) to be used for supporting unmanned aircraft systems (UAS) design, airworthiness, and subsequent applications to the CAA for approval of low altitude operations (for example, below 400 ft AGL). **5/23/2022, Phil Kenul: ASTM** WK63418 now published as F3548-21 *Standard Specification for UAS Traffic Management (UTM) UAS Service Supplier (USS) Interoperability* developed by Committee F38.02. It was revised to include UAM Traffic management with work being conducted by the UAM Task Group. **5/23/2022, Phil Kenul:** ASTM WK76077 now published as F3411-22 *Standard Specification for Remote ID and Tracking* developed by Committee F38.02. Revisions published since the 2019 version.	

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Gap O4: UAS Operations Over People (OOP).

Standards are needed for UAS OOP.

R&D Needed: No

Recommendation: Complete work on ASTM WK85104~~WK65042, New Specification~~ for Operation Over People.

Priority: High (Tier 1)

Organization: ASTM

v2 Status of Progress: Green

v2 Update: ASTM F3389-20, ASTM F38 WK65042

Updates Since v2 was Published:

12/28/2020, JM: On December 28, 2020 the Federal Aviation Administration (FAA) announced final rules for unmanned aircraft systems (UAS) or drones that will require Remote Identification (Remote ID) of drones and allow operators of small drones to fly over people and at night under certain conditions.

- Remote ID information
- Remote ID rule (PDF)
- Operations Over People and at Night Information
- Operations Over People and at Night rule (PDF)

Comments Received on Gap for Future Consideration:

- **5/3/23, Phil Kenul:** Delete WK65042, now being covered under WK85104 see below new work item. Since the original WK has been replaced with the evolution of the discussion on the ASTM OOP project, track changes show this proposed it. The intent of the recommendation has not changed, just the project identification.

New Published Standards	New In-Development Standards
4/26/2025, PK: ASTM F3322-24a *Standard Specification for Small Unmanned Aircraft System (sUAS) Parachutes* developed by Committee F38.01. **5/3/2023, PK:** ASTM F38.01, *F3389/F3389M-21, Standard Test Method for Assessing the Safety of Small Unmanned Aircraft Impacts* revision now available. Approval of WK76302.	**10/21/2025, PK, ASTM**: ASTM F38.02 WK93993 Standard Practice for Standard Practice for Ground Risk Analysis of Unmanned Aircraft Systems (UAS) will support the Operational Risk Assessment (ORA) standard (F3178 with additional ground risk assessment for UAS, including: What to consider when choosing a population density map resolution. ? What types of population density maps are there and pro's/con's, including guidance on what map types to use. ? How to use maps that may have deficiencies and make proper adjustments. ? How to account for flight over non uniform population density areas and transient flight

	over higher population density areas. ? How to account for sheltering in different scenarios. ? The updated Operational Risk Assessment (ORA) standard (F3178) needs a supporting standard for completing the ground risk analysis and to define industry best practices around the equations and values for using quantitative methods in a practical and user-friendly way. This standard is also expected to be necessary for applying the proposed FAA Part 108 BVLOS rules. **10/21/2025, PK, ASTM**: ASTM F38.02 WK95240 Standard Practice for Drone Show Operations for Multi-aircraft Drone Show Operations including: - Requirements to support manufacturers and operators of outdoor drone shows deployed to provide visual entertainment to an audience. - Necessary baseline requirements of utilized UAS technology including navigation, geofence, and communications. - Operational procedures to maximize safety **5/3/2023, PK:** ASTM F38.02, WK85104 *Standard Practice for Supporting Compliance with Requirements for sUAS Operations Over People*. *New standard for d*etermination of aircraft: – injury potential, demonstrating that aircraft do not contain exposed rotating parts that can lacerate skin on contact with a human being, – evaluation of aircraft designs for safety defects. – determine if a baseline set of methods to reduce the pilot workload and skill requirements – Working Group shall include CAAs in the review and revision process of the Standard Practice to ensure international harmonization. – review other ASTM standards for relevance to production approval for UAS and leverage existing standards insofar as practicable.

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Gap O5: UAS Operations and Weather.
Standards are needed for flight planning, forecasting, and operating UAS (including data link and cockpit/flight deck displays), particularly in low altitude and/or boundary layer airspace. Gaps have been identified related to two different facets of weather, and the related acquisition and dissemination of weather-related data, especially as it relates to BVLOS operations: 1) Weather requirements for flight operations of UAS. For example, to operate in airspace BVLOS, the aircraft must meet certain standards for weather robustness and resiliency, e.g., wind, icing, instrument meteorological conditions (IMC), etc. 2) Weather data standards themselves. Currently, published weather data standards by National Oceanic and Atmospheric Administration (NOAA), World Meteorological Organization (WMO), ICAO, and others do not have sufficient resolution (spatial and/or temporal) for certain types of UAS operations and have gaps in low altitude and boundary layer airspaces. Other standardized delivery mechanisms for weather data exist, but the considerations must be made with respect to the computational processing power required on the aircraft or controller to use such data. Additionally, standards for cockpit displays, data link, avionics, and voice protocols that involve, transmit, or display weather will need to be amended to apply to UAS (e.g., the "cockpit display" in a UAS CS).
R&D Needed: Yes. Research should be conducted to determine the following: 1) For a given UAS CONOPS, what spatial and temporal resolution is required to adequately detect weather hazards to UAS in real-time and to forecast and flight plan the operation? 2) What are the applicable ways to replicate the capability of a "flight deck display" in UAS C2 systems for the purpose of displaying meteorological information (and related data link communications with ATC)?

<table>
<tr><td colspan="2">3) To what extent can boundary layer conditions be represented in existing binary data formats?
4) To what extent can current meteorological data acquisition infrastructure (e.g., ground-based weather radar) capture data relevant to UAS operations, particularly in low altitude airspace?
5) What weather data and data link connectivity would be required to support fully autonomous UAS operations with no human operator in the loop?
6) What is the highest temporal resolution currently possible with existing or proposed meteorological measurement infrastructure?
7) To what extent do operators need to consider that weather systems have different natural scales in both space and time, depending on whether the weather systems occur in polar, mid-latitude, or tropical conditions?</td></tr>
<tr><td colspan="2">Recommendation: Encourage relevant research, amending of existing standards, and drafting of new standards (where applicable).</td></tr>
<tr><td colspan="2">Priority: High (Tier 2)</td></tr>
<tr><td colspan="2">Organization: RTCA, SAE, NOAA, WMO, NASA, universities, National Science Foundation (NSF) National Center for Atmospheric Research (NCAR), ASTM, SAE ITC ARINC IA</td></tr>
<tr><td colspan="2">v2 Status of Progress: Yellow</td></tr>
<tr><td colspan="2">v2 Update: NASA, ASTM F38 Weather Supplemental Data Service Provider Sub-Group</td></tr>
<tr><td colspan="2">Updates Since v2 was Published:

Other Committees With Relevant Work:
• SAE ITC, ARINC IA Airborne Weather Radar working group
• SAE E-41 Engine Corrosion – Runway Deicing Products

Comments Received on Gap for Future Consideration:</td></tr>
<tr><td>New Published Standards

02/09/2024, P.Kenul: ASTM F3673-23 Standard Specification for Performance for Weather Information Reports, Data Interfaces, and Weather Information Providers (WIPs)
- Defines the standard of performance for weather information reports, analyses, and services performed by a weather information provider (WIP)
- Supports extensible traffic management (xTM) systems, unmanned aircraft systems (UAS) and vertical takeoff and landing (VTOL) systems operating from the surface to 5000 ft (1524 m) above ground level (AGL) are addressed.
- One objective of this specification is to harmonize the standard across CAAs internationally to enable subject matter compatibility across standards developed by other standards development organizations (SDOs).

5/1/2023, Scott Simmons: OGC 19-086r4: OGC API – Environmental Data Retrieval Standard was revised 8/5/2022 (originally published 8/13/2021). Standard permits extraction of multidimensional data (focus on weather) along a flight corridor or operational volume. In use by NOAA, UK Met Office.</td>
<td>New In-Development Standards

03/11/2024 D.Franks, SAE: WIP AIR6962 Ice Protection for Unmanned Aerial Vehicles. Ac-9c is conducting a review of icing materials that would be educational to a designer of a UAV ice protection system is provided. Additionally, the differences between unmanned and manned ice protection systems are explored along with a discussion on how these differences can be addressed.</td></tr>
</table>

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Gap O6: UAS Data Handling and Processing.
Given the myriad of UAS "observation" missions in support of public safety, law enforcement, urban planning, construction, and a range of other applications, and given the diversity of standards applicable to the UAS lifecycle, a compilation of best practices is needed to identify standards-based "architectural guidance" for different UAS operations.
R&D Needed: No R&D should be required, as community examples already exist. However, interoperability piloting of recommended architectures with the user community based on priority use cases/scenarios is recommended.
Recommendation: Develop an informative technical report to provide architectural guidance for data handling and processing to assist with different UAS operations.
Priority: Medium
Organization: OGC, ISO TC/211, SAE ITC ARINC IA, AIA
v2 Status of Progress: Green

v2 Update: As noted in the text, the OGC GeoTIFF standard was adopted as an OGC standard in 2019, and best practices are in development in OGC UxS DWG.

Updates Since v2 was Published:
• Joint Authorities for Rulemaking on Unmanned Systems (JARUS) Annex H, UTM
• **11/8/2021, SS:** OGC Command and Control data exchange format Interoperability Experiment. New activity to assess a data model for command and control data exchange with focus on mission planning for data acquisition. This effort likely has impacts elsewhere in the roadmap. Project started November 2021; see Call for Participation.
 	
Other Committees With Relevant Work:
• SAE ITC, ARINC IA Systems Architecture and Interfaces subcommittee
• AIA NAS9948 UAS Data Protection and Privacy Standard Practice working group
 	
Comments Received on Gap for Future Consideration:
• **5/31/2022, Phil Mattson per MITRE HSSEDI:** Add reference to AIA NAS9948 "UAS Data Protection and Privacy Standard Practice" as it uses the CSF in the standard practice. Explains tailored controls for sUAS. While this standard practice is a start, it does not consider all gaps in UAS Data Protection in the systems associated with UAS (e.g., payload connections, third-party connections to/from UTM USS's). NAS9948 is agnostic to architectures and UAS operational types. In Report Body:
  ◦ Section 7.6 Data Handling and Processing - Recommend change title to "Data Handling, Processing & Protection"
  ◦ Add paragraph on data protections: "As part of a continuing effort to increase cybersecurity on all UAS sub-systems that process, store, or transmit data that is used by government, commercial and private citizens, standards have been developed to aid in providing users of these systems the ability to assess security posture of the products and services they are using. These standards derive their authority from national policy for cybersecurity and privacy protection. AIA NAS9948 outlines a standard practice for protecting data at rest and in motion. These protections are a key component in validating and ensuring the data provided is from a secure, trusted source."

New Published Standards	New In-Development Standards
2/27/2024 OGC *Cloud Optimized GeoTIFF (COG) Standard* approved. Published July 2023 **5/31/2022 PM, AIA:** NAS9948 UAS Data Protection and Privacy Standard Practice **11/8/2021, SS:** *OGC Sensor Things API Part 2 – Tasking Core [OGC 17-079r1]*. IoT tasking of onboard sensors for data acquisition. Published 8 Jan 2019. Inadvertently left out of roadmap v2	**5/14/2025 SS: OGC: The** OGC Connected Systems Standard Working Group which aims to advance an API for sensor management, including ordering, tasking, collecting, command and control. The WG is nearly completion of the *OGC UAS Command and Control Interoperability Experiment*. **5/1/2023 SS: OGC** API – Connected Systems in development to update the OGC Sensor Web Enablement Standards used in space and aviation with modern RESTful APIs. Connected Systems will be interoperable with OGC SensorThings API. **11/21/2022, Philip Mattson:** ***AIA NAS9948 Appendices –*** Implementation verification procedures that support NAS9948 UAS Data Protection and Privacy standard practice

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Gap O7: UTM Services Performance Standards.
UTM service performance standards are needed.
R&D Needed: Yes. Considerable work remains to develop the various USS services listed as well as testing to quantify the level of mitigation they provide. Only after some level of flight testing to define the “realm of the possible” can the community of interest write performance-based standards that are both achievable and effective in mitigating operational risk.
Recommendation: There is quite a lot of work for any one SDO. A significant challenge is finding individuals with the technical competence and flight experience needed to fully address the subject. What is needed is direction to adopt the performance standards and associated interoperability standards evolving from the research/flight demonstrations being performed by the research community (e.g., NASA/FAA RTT, FAA UTM Pilot Project, UAS Test Sites, GUTMA, etc.). Given a draft standard developed by the experts in the field (i.e., the ones actively engaged in doing the research), SDOs can apply their expertise in defining testable and relevant interoperability and performance-based requirements and thus quickly converge to published standards. **Gap 07a?**
Priority: High (Tier 2)

Organization: NASA, ASTM, ISO, IEEE, EUROCAE, JARUS

v2 Status of Progress: Green

v2 Update: New activity is underway in ASTM, IEEE, ISO, EUROCAE, and JARUS.

Updates Since v2 was Published:

- Joint Authorities for Rulemaking on Unmanned Systems (JARUS) Annex H, UTM

Comments Received on Gap for Future Consideration:

- **11/1/21, Brent Klavon:** Suggest "Only after some level of flight test to establish a statistically significant amount of operational data, can the community of interest update the performance-based standards to both be achievable and provide quantifiable mitigations to operational risk." Wanted to give a little more credit to the current draft of the ASTM F38 standard and better represent the path forward.
- **11/22/22, Greg Orrell:** MITRE HSSEDI: Recommend a rewrite of this recommendation. The enormity of the undertaking is understood. However, this does not get to what would be needed to move forward on standards. Suggest: There is quite a lot of work for any one SDO. With the multiple systems needing to perform and interconnect to support uncrewed services, several performance standards will be required to support the performance needs. These would include standards for the service, the supporting infrastructure, and the interconnection between stakeholders. With inputs from stakeholders, SDOs can apply their expertise in defining testable performance-based requirements and quickly converge to publish standards. Stakeholders will support the definition of the needs, priority of the needs, and the interoperability to support success.
- **11/22/22, Greg Orrell:** Not sure if cybersecurity standards for UTM would fall under UTM Service Performance Standards. MITRE HSSEDI suggested a new gap that covers cybersecurity for UTM specifically. Interconnections between private & commercial USS's and private & commercial connecting with government systems are facing challenges around cybersecure connections.
- **5/31/2022, Phil Mattson per MITRE HSSEDI:** Cybersecurity impacts across UTM are not tracked in the ANSI Roadmap. Suggest adding a Gap and a section/paragraph here or in Section 7.6 that discusses the cybersecurity gap of interconnecting private and government systems interchangeably in a safe manner for UTM. Reference ASTM F3548-21 "Standard Specification for UAS Traffic Management (UTM) UAS Service Supplier (USS) Interoperability" for some additional guidance. F38.02 WK63418 is the contact working group in ASTM. Consider a Gap (O7a) that outlines authentication from third-party service data. Security critical injections could increase operational safety risks. In Report Body:
  - Section 7.7 UAS Traffic Management - Several updates needed by industry and SDO's to update this section. Recommend group coordination on section updates. Future versions of the ConOps (v3) and the UTM Flight Test activities could help better define and fill cybersecurity gaps in UTM.
- **02/12/2024, S,Marzac, Boeing:** FAA rulemaking in this domain will highlight the gaps and the IFR/VFR will determine the type and performance of services. Current development does not cover remotely supervised operations, but assumes on-board pilot in VMC.

New Published Standards	New In-Development Standards
5/23/2022, Phil Kenul: ASTM WK63418 was approved as F3548-21 *Standard Specification for UAS Traffic Management (UTM) UAS Service Supplier (USS) Interoperability* developed by Committee F38.02. It was revised to include UAM Traffic management with work being conducted by the UAM Task Group.	**5/3/2023, PK: ASTM** F38.02, new WK85414 *Revision of F3548-21 Standard Specification for UAS Traffic Management (UTM) UAS Service Supplier (USS) Interoperability*. F3548-21 on UTM USS Interoperability has been tested and demonstrated globally and has been identified in the U-space guidance material as a possible means of compliance. This revision of the standard will update the standard to address gaps identified through demonstrations and mapping to the U-space regulation and to meet other anticipated needs. Key topics for the revision will include: – Increased flexibility in allowing conflicts between operational intents when permitted by regulations – Priority and preemption – Negotiation – Related fairness concepts **5/3/2023, PK: ASTM** F38.02, new WK85415 *Standard Specification for UAM PSU Interoperability*. Revision to build upon the digital traffic management infrastructure established in the UTM F3548 and adapt to unique characteristics of the AAM domain including:

	– Define interoperability protocols, APIs, and functional requirements for digital traffic management systems for Advanced Air Mobility (AAM) – Focus on Provider of Services for UAM (PSU) and its necessary functions and interfaces – AAM-specific entities (e.g., constrained waypoints, volumes) – Address unique interfaces and integrations (e.g., Vertiports, Legacy ATM, UTM) – Flight planning, coordination, and execution as per prevailing AAM CONOPS – UAM Interoperability Performance Requirements Focus Areas – CONOPS and description of target operating environment – Prioritization Framework, Resource Definition, Status, and Information Sharing, Conformance Monitoring

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Gap O8: Remote ID: Direct Broadcast.

Standards are needed for transmitting UAS ID and tracking data with no specific destination or recipient, and not dependent on a communications network to carry the data. Current direct broadcast standards for aviation and telecommunications applications do not specifically address UAS operations, including secure UAS ID, authentication, and tracking capabilities, and specifically when UAS operations are conducted outside ATC.

R&D Needed: Yes, to enhance observer trust in UAS ID in an unconnected environment.

Recommendation:
1) Revise published ASTM F3411 Remote ID standard once UAS Remote ID Rule is finalized.
2) Continue development of the Open Source implementations and enablement.
3) Continue development of 3GPP specs and ATIS standards to support direct communication broadcast of UAS ID and tracking data with or without the presence of a 4G or 5G cellular network.

Priority: High (Tier 1)

Organization: ASTM, 3GPP, ATIS, IETF

v2 Status of Progress: Green

v2 Update:
- ASTM F3411-22
- 3GPP WI810049 Release 16
- EUROCAE WG-105
- ASD-STAN
- IEEE P1920.2
- IETF DRIP workgroup

Updates Since v2 was Published:
12/28/2020, JM: On December 28, 2020 the Federal Aviation Administration (FAA) announced final rules for unmanned aircraft systems (UAS) or drones that will require Remote Identification (Remote ID) of drones and allow operators of small drones to fly over people and at night under certain conditions.
- Remote ID information
- Remote ID rule (PDF)
- Operations Over People and at Night Information
- Operations Over People and at Night rule (PDF)

10/31/2023, SC: FAA Accepted Means of Compliance; Remote Identification of Unmanned Aircraft; Correction (published 11/14/2023), references ASTM F3586-22 Standard Practice for Remote ID Means of Compliance to Federal Aviation Administration Regulation 14 CFR Part 89

Comments Received on Gap for Future Consideration:

New Published Standards	New In-Development Standards
4/26/2025, Phil Kenul: ASTM F3411-22a *Standard Specification for Remote ID and Tracking* revision was approved. F3411 was developed by Committee F38.02.	**11/06/2024, PM: 3GPP: Technical Report** *23.700-59, Study of further architecture enhancements for UAS, UAV, and UAM* (work continues for R19). This work includes broadcast

11/06/2024, PM: 3GPP *TS 23.256, Support of Uncrewed Aerial Systems (UAS) connectivity, identification and tracking; Stage 2 (R19) (latest publication 9/2024)* **10/31/2024, SC: IETF** draft-ietf-drip-auth was published as RFC 9575 DRIP Entity Tag (DET) Authentication Formats and Protocols for Broadcast Remote Identification (RID). **10/31/2024, SC: IETF** *Drone Remote Identification Protocol (DRIP) Architecture published as RFC 9434* showing how to satisfy RFC 9153 DRIP Requirements and Terminology **03/01/2024, PM: 3GPP** *5G New Radio (NR)* Enhancements for UAS/UAV. This work ported previous LTE enhancements for UAS/UAV to 5G NR and includes support for PC5 direct cellular communications, broadcast remote ID, and DAA. This work has been completed for 3GPP R18 as of Dec. 2023 and includes a number of published Technical Specifications with UAV-related enhancements: 38.306 (NR), 36.306 (LTE), 38.331 (NR), 36.331 (LTE), 38.300 (NR), 36.300 (LTE), 38.413, 38.423, and 38.101-1 (NR), and 36.101 (LTE). Note that all referenced 3GPP specs are publicly available with no charge and can be found here. **5/18/2023, KM:** IEEE 1920.1-2022, *Trial-Use Standard for Aerial Network Communication* defines air-to-air communications for self-organized ad hoc aerial networks. It outlines the network service architecture, security framework, and data model. IEEE Std 1920.1 is agnostic to the type of network (Wireless or Cellular or other) and it is applicable to manned and unmanned, small and large, and civil and commercial aircraft systems. **12/04/2022, RM: IETF** *DRIP Entity Tag (DET) for Unmanned Aircraft System Remote ID (UAS RID).* Draft-ietf-drip-rid for trust in Broadcast Remote ID Messages was approved. RFC9374. **11/14/2022, PK:** ASTM F3586-22 *Practice for Standard Practice for Remote ID Means of Compliance to Federal Aviation Administration Regulation Part 89* developed by Committee F38.02. Recently published and adopted by FAA as an Acceptable MOC.	remote ID over cellular, and detect and avoid capability using PC5 direct cellular communications. **10/31/2024, SC: ASTM** *WK91742 Revision of F3411-22a Standard Specification for Remote ID and Tracking* based primarily on deployment experience.

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Gap O9: Remote ID: Network Publishing.
Standards are needed for secure UAS ID, authentication, and tracking data transmitted over a secure communications network (e.g., cellular, satellite, other) to a specific destination or recipient. Current manned aviation standards do not extend to the notion of transmitting UAS ID and tracking data over an established secure communications network to an internet service or group of services, specifically the cellular and satellite networks and cloud-based services. Nor do they describe how that data is received by and/or accessed from an FAA-approved internet-based database.
R&D Needed: Yes
Recommendation: 1) Revise the published ASTM F3411 Remote ID standard and other applicable standards once UAS Remote ID Rule is finalized. 2) Continue development of 3GPP specs and ATIS standards related to remote ID of UAS and UTM support over cellular or satellite networks.
Priority: High (Tier 1)
Organization: ASTM, 3GPP, ATIS, IETF
v2 Status of Progress: Green

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v2 Update:
- ASTM F3411-22
- 3GPP WI810049 Release 16
- EUROCAE WG-105
- ASD-STAN
- IEEE P1920.2
- IETF DRIP workgroup

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Updates Since v2 was Published:
- Joint Authorities for Rulemaking on Unmanned Systems (JARUS) Annex H, UTM
- **12/28/2020, JM:** On December 28, 2020 the Federal Aviation Administration (FAA) announced final rules for unmanned aircraft systems (UAS) or drones that will require Remote Identification (Remote ID) of drones and allow operators of small drones to fly over people and at night under certain conditions.
- Remote ID information
- Remote ID rule (PDF)
- Operations Over People and at Night Information
- Operations Over People and at Night rule (PDF)

10/31/2023, SC: FAA Accepted Means of Compliance; Remote Identification of Unmanned Aircraft; Correction (published 11/14/2023), references ASTM F3586-22 Standard Practice for Remote ID Means of Compliance to Federal Aviation Administration Regulation 14 CFR Part 89

Comments Received on Gap for Future Consideration:

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New Published Standards

4/26/2025, Phil Kenul: ASTM F3411-22a *Standard Specification for Remote ID and Tracking* revision was approved. F3411 was developed by Committee F38.02.

11/06/2024, PM: 3GPP *TS 23.256, Support of Uncrewed Aerial Systems (UAS) connectivity, identification and tracking; Stage 2 (R19) (latest publication 09/2024)*

11/06/2024, PM: 3GPP *TS 23.255, Application layer support for Uncrewed Aerial System (UAS); Functional architecture and information flows (R19, Sept. 2024)*

11/06/2024, PM: 3GPP *TS 24.501, Non-Access-Stratum (NAS) protocol for 5G System (5GS); Stage 3* (R19, Sept. 2024). Includes support for authentication and authorization of a UAV, and authorization of C2 communications.

11/06/2014, PM: 3GPP *TS 24.008, Mobile radio interface Layer 3 specification; Core network protocols; Stage 3* (R19, Sept.. 2024) Includes support for indicating whether UAS services for a given user are allowed.

11/06/2024, PM: 3GPP *TS 22.125, Uncrewed Aerial System (UAS) support in 3GPP*; Stage 1 (R19, June 2024). Includes requirements for supporting UAS in a cellular system.

11/06/2024, PM: 3GPP TS 23.256, Support of Uncrewed Aerial Systems (UAS) connectivity, identification and tracking; Stage 2 (R19, Sept. 2024)

10/31/2024, SC: IETF *Drone Remote Identification Protocol (DRIP) Architecture published as RFC 9434* showing how to satisfy RFC 9153 DRIP Requirements and Terminology

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New In-Development Standards

11/06/2024, PM: 3GPP *23.700-59, Study of further architecture enhancements for UAS, UAV, and UAM* (work continues for R19). This work includes broadcast remote ID over cellular, and detect and avoid capability using PC5 direct cellular communications.

10/31/2024, SC: ASTM *WK91742 Revision of F3411-22a Standard Specification for Remote ID and Tracking* based primarily on deployment experience.

5/17/2022, RGM: IETF Draft-moskowitz-crowd-sourced-rid provides for Broadcast Remote ID harvesting for uploading by 3rd party collectors into UTM.

5/31/2021, RGM: IETF draft-moskowitz-drip-secure-nrid-c2 - Secure UAS Network RID and C2 Transport secure data transmission for Network Remote ID messages and C2 by the DRIP workgroup.

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03/01/2024, PM: 3GPP *23.700-58, Study of further architecture enhancements for uncrewed aerial systems and urban air mobility* *(R18, March 2023)* **5/18/2023, KM:** IEEE 1920.1-2022, *Trial-Use Standard for Aerial Network Communication* defines air-to-air communications for self-organized ad hoc aerial networks. It outlines the network service architecture, security framework, and data model. IEEE Std 1920.1 is agnostic to the type of network (Wireless or Cellular or other) and it is applicable to manned and unmanned, small and large, and civil and commercial aircraft systems. **12/05/2022, PM**: ATIS-I-0000092 *3GPP Release 17 - Building Blocks for UAV Applications*. Published July 2022. This report describes how mobile networks supporting the Third Generation Partnership Project (3GPP) Release 17 specifications can enable uncrewed aerial vehicle (UAV) applications. It discusses how 3GPP's work fits with other specifications to address UAV needs and shows how the 3GPP system can be used to enhance the opportunities to safely use UAVs for commercial and leisure applications. **12/04/2022, RM: IETF** DRIP Entity Tag (DET) for Unmanned Aircraft System Remote ID (UAS RID). Draft-ietf-drip-rid for trust in Broadcast Remote ID Messages was approved. RFC9374. **3/31/2021, PM: 3GPP** TR 23.754, Study on supporting UAS connectivity, ID, and tracking (R17). Subsequent normative work in 3GPP on network publishing remote ID. Estimated completion 1Q2022	

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Gap O10: Geo-fence Exchange.
Standards have been developed (or are in development) to provide a consistent description of the limits of a geo-fence. Standards also exist to define and encode the geometry for a geo-fence. However, a new standard or a profile of an existing standard is needed to exchange geo-fence data. This standard must encode the attributes of a geo-fence necessary for UAS operators or autonomous systems to respond to the proximity of a geo-fence.
R&D Needed: Yes. The encoding mechanism should reply upon existing standards. Investigation is needed to identify which attributes should be included to handle geo-fence interaction. R&D is needed to trigger unmanned aircraft landing or evasion when approaching/entering/leaving a geo-fenced location (including when it comes into close proximity of manned aircraft).
Recommendation: A draft conceptual model should be developed that identifies allowed geometries in 2D, 3D, as well as temporal considerations and which articulates the necessary attributes. Critical to this model is a definition of terminology that is consistent with or maps to other UAS operational standards. The model should consider "active" vs. "passive" geo-fences, the former being geo-fences where a third party intervenes in the aircraft operation, and the latter being geo-fences where the UAS or operator is expected to respond to proximity/intersection. The model should also define geo-fences with respect to the aircraft operational limits, either: 1) the aircraft operates inside a geo-fence and an action occurs when the aircraft leaves that geo-fence, or 2) the aircraft operates outside a geo-fence and an action occurs when the aircraft intersects the geo-fence boundary. The conceptual model can be used to develop one or more standard encodings so that equipment manufacturers can select the ideal format for their hardware (e.g., XML, JSON, binary). Industry has taken the lead on proposing geo-fencing solutions improving safety on current UAS operations but guidelines from the UAS community (industry + regulator) are needed to harmonize this functionality. The geo-fence exchange standard must be machine-readable to take advantage of existing geospatial processing code and ensure consistent application of rules against the geo-fence as well as be a format suitable to allow manufacturers to integrate (and update) hard geo-fence limitations into UAS firmware.
Priority: High (Tier 2)

Organization: OGC, ISO/TC 20/SC 16, EUROCAE, ICANN, IETF, AIA

v2 Status of Progress: Green

v2 Update:
- EUROCAE WG-105 SG-33 / UTM Geo-fencing
- Standards are in development

Updates Since v2 was Published:
- Joint Authorities for Rulemaking on Unmanned Systems (JARUS) Annex H, UTM
- **11/8/2021:** OGC and W3C are revising the Spatial Data on the Web Best Practices document (https://www.w3.org/TR/sdw-bp/). Revision will include a chapter on general geofence practices and use.
- **6/10/2021,** Joint OGC-W3C effort on developing Standards to (1) exchange geofence content and (2) define behavior of entity encountering a geofence. Work just under way, planned to be applicable for UAS, autonomous ground vehicles, and others.

Comments Received on Gap for Future Consideration:
- **5/31/2022, Phil Mattson per MITRE HSSEDI:** Gap O10: Geo-fence Exchange. Standards have been developed (or are in development) to provide a consistent description of the limits of a geo-fence. Standards also exist to define and encode the geometry for a geo-fence. However, a new standard or a profile of an existing standard is needed to exchange geo-fence data. This standard must encode the attributes of a geo-fence necessary for UAS operators or autonomous systems to respond to the proximity of a geo-fence.
- **5/14/2025: S.Simmons:** OGC geofence standardization is currently inactive but could initiate an activity if needed to meet requirements.

New Published Standards	New In-Development Standards
5/31/2022 PM, AIA: NAS9948 *UAS Data Protection and Privacy Standard Practice*	**11/21/2022, Philip Mattson: AIA NAS9948 Appendices –** Implementation verification procedures that support NAS9948 UAS Data Protection and Privacy standard practice. OGC Features and Geometries JSON: https://www.ogc.org/projects/groups/featgeojsonswg. New Standard in work that provides additional capabilities not in GeoJSON including other Coordinate Reference Systems and complex geometries and geometry collections.

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Gap O11: Geo-fence Provisioning and Handling.

There is a need for standards and a guiding best practices document to inform manufacturers of the purpose, handling, and provisioning requirements of geo-fences.

R&D Needed: Yes. The proposed geo-fence exchange standard discussed earlier will suffice for the geo-fence content. Standards will be required to translate regulatory guidance into provisioning/unprovisioning rules as well as interpretation of aircraft behavior when encountering a geo-fence. There are many existing methods to deploy such data to hardware.

Recommendation: Create a best practices document on geo-fence provisioning and handling and standards describing circumstances under which geo-fence provisioning must occur as well as for autonomous and remote pilot behavior. These documents should include specific guidance on when geo-fences must be provisioned to an aircraft, conditions under which geo-fences may be unprovisioned, and how an aircraft must behave when approaching or crossing a geo-fence. For a passive geo-fence boundary, behavior is governed based on the attributes contained in the geo-fence data, such as: not entering restricted airspace, notifying the operator to turn off a camera, changing flight altitude, etc. For active geo-fences, the documents should detail the types of third-party interventions. These best practices may not need to be expressed in a separate document, but rather could be provided as content for other documents for control of aircraft operations, such as UTM. Ideally, the geo-fence provisioning standards will integrate with regulatory systems such as the FAA-USS to support the safe, seamless, and timely management of the overall system.

Priority: Medium

Organization: OGC, RTCA, EUROCAE

v2 Status of Progress: Not Started

v2 Update:
- EUROCAE WG-105 SG-33 / UTM Geo-fencing
- Standards are in development

Updates Since v2 was Published:
- Joint Authorities for Rulemaking on Unmanned Systems (JARUS) Annex H, UTM
- **6/10/2021,** OGC Command and Control data exchange format Interoperability Experiment. Will include geofence data exchange and provisioning

Comments Received on Gap for Future Consideration:	
New Published Standards	**New In-Development Standards**

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New Gap O12: Design and Operation of Aerodrome Facilities for UAS.	
Standards do not exist for special cases of UAS-only infrastructure. Existing standards should be evaluated for addressing special considerations for UAS. Numerous standards apply to mixed use infrastructure (manned and UAS).	
R&D Needed: Yes	
Recommendation: Complete work on standards in development. Look at how existing standards for dual-use (manned and unmanned) ground infrastructure (airports, heliports) can be applied in the UAS context for unmanned-only locations.	
Priority: High (Tier 2)	
Organization: ASTM, ISO, SAE, NFPA, AASHTO	
v2 Status of Progress: New	
v2 Update: None provided	
Updates Since v2 was Published: **Comments Received on Gap for Future Consideration:** • **11/22/21, Comment from Ken Holland, NFPA**: I am not aware of any work or consideration being done with this, but honestly, I do not think this is within the scope of the document and possibly outside the committee scope.	
New Published Standards **11/17/2025, CB, ANSI:** ISO 5491:2023 Vertiports — Infrastructure and equipment for vertical take-off and landing (VTOL) of electrically powered cargo unmanned aircraft systems (UAS) defines the requirements for constructing a vertiport. This document applies to vertiports of type A (micro) as defined in ISO 5015-2. **11/14/2022, PK:** ASTM F3423/F3423M-22 *Standard Specification for Vertiport Design* was approved.	**New In-Development Standards**

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New Gap O13: UAS Service Suppliers (USS) Process and Quality.
The airborne standards discussed in Chapter 6 don't address the process and quality requirements needed for the 24/7 cloud-based operations associated with UAS Service Suppliers (e.g., security, privacy, health monitoring, etc.). Non-aviation cloud-based standards and initial UTM standards (e.g., RID and UTM) don't address the safety and consistency requirements needed for the NAS. Standards are needed to ensure adequate process assurance and quality for the cloud-based USS that are providing functions with safety and security considerations. The standards need to define multiple levels of assurance given the varying function, end user vehicle, and operational environment. However, for a given USS function, end user vehicle, and operational environment, the assurance level should be consistent across all USS providers of that function. See also sections 7.7 on UTM and 7.8 on Remote ID.
R&D Needed: No
Recommendation: • Develop a USS quality standard, with multiple classification levels, that includes tailoring of existing software, security, and quality standards related to a USS and any cloud-specific process aspects (e.g., external verification, audits, version compatibility checks) • Develop a standard that maps the appropriate classification level for each planned UTM/USS service coupled with the end user vehicle and operational environment. This may be included in the USS quality standard.
Priority: High (Tier 2)
Organization: ASTM, EUROCAE, ISO, RTCA, SAE
v2 Status of Progress: New
v2 Update: None provided
Updates Since v2 was Published: • Joint Authorities for Rulemaking on Unmanned Systems (JARUS) Annex H, UTM

Comments Received on Gap for Future Consideration:	
New Published Standards	**New In-Development Standards** **11/17/2024, CB, ANSI:** SAE WIP JA7215A - A7214 Special Considerations for the Application of IVHM to Autonomous Aircraft and Vehicles provides for recommendations for the application of IVHM specifically to vehicles that utilize computation – driven systems to perform the piloting (dynamic driving) task for a portion or the complete trip. The “driver” support system (DSS), greatly reduces or eliminates the need for an onboard human to be in command of the vehicle’s operation. The vehicle’s longitudinal, lateral, and in aerospace, the vertical direction of the vehicle is controlled by software for part or all of the trip. **12/04/2022, DF:** SAE WIP ARP6803A *IVHM Concepts, Technology and Implementation Overview*. This SAE Aerospace Recommended Practice (ARP) examines a comprehensive construct of an Integrated Vehicle Health Management (IVHM) capability. This document provides a top-level view of the concepts, technology, and implementation practices associated with IVHM. The document is up for a 5-year review and we will be working on updating the document with the help of the core team and committee members.

Chapter 7 Recommendations/Comments Since v2 was Published:

- No recommendations received relation of publication of this report.

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Chapter 8. Flight Operations Standards: Infrastructure Inspections, Environmental Applications, Commercial Services, Workplace Safety – WG3

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Gap I1: UAS Inspections of Power Plant and Industrial Process Plant Assets.	
No published standards have been identified for inspections of power plant and industrial process plant assets using UAS.	
R&D Needed: No	
Recommendation: Develop standards for power plant inspections using UAS	
Priority: High (Tier 3)	
Organization: ASME BPV Committee on Nondestructive Examination (V) and ASME Mobile Unmanned Systems (MUS) Standards Committee, AMPP (formerly NACE)	
v2 Status of Progress: Green	
v2 Update: As noted in the text, ASME is developing a standard on the use of UAS to perform inspections of power plant and industrial process plant assets.	
Updates Since v2 was Published: **Comments Received on Gap for Future Consideration:** **4/19/23, R Dahlstrom:** All Power Plant and Industrial Process Plant assets can benefit from the role of UAS in assisting with critical visual and contact-based inspections. Certain conditions require an inspector to be able to touch a probe tip, such as one that measures metal thickness, to a surface. Facility owners and operators should use sUAS that make physical contact for touch-based measurements and other touch-based inspections, when possible, to mitigate the risk of workers at elevation.	
New Published Standards	**New In-Development Standards**
11/17/2025, CB, ANSI: ASME MUS-1 – 2024 Use of Unmanned Aircraft Systems (UAS) for Inspections provides the requirements for the use of UAS to safely and reliably perform inspections to obtain quality data and repeatable results. It is the responsibility of the user of this Standard to determine whether using UAS to perform the inspection is the proper method for the desired outcome.	**5/8/2023, LF: AMPP** is developing SP21467 Annotation Methodology for Imagery of Corrosion This standard aims to establish a methodology and classification taxonomy for computer vision assessment of corrosion imagery. Computer vision is a technology whereby an algorithm assesses the degree of corrosion of an image of a surface, in place of or in augmentation to a human operator. To properly calibrate this technology, visual imagery needs to be collected and annotated with human experts as to the degree of corrosion. This data synthesis process will follow a fixed taxonomic structure, documented in this standard. This document contains a standard for the manual process for categorizing and annotating (labeling) visual imagery of corrosion, where the images are full color, at least 30 dots per inch or pixels per inch (DPI/PPI) and taken in generic or single surface settings. **11/18/2021, LF**: AMPP SC 02, *TR 21515 Exterior Coating Inspections via Remotely Operated Aerial Systems* has a new title and scope. To provide state-of-the-art information on the use of remotely operated aerial systems (drones) for inspecting coatings, either through direct contact or from a distance. This report is intended for use by asset integrity engineers, facility managers, coating inspectors, health and safety engineers, corrosion technicians, ships surveyors, drone operators, and others. This report discusses external aerial inspections only. AMPP SC 11 also initiated a new standard practice SP21533 *Remote Inspections for Nuclear Spent Fuel Integrity* to communicate the benefits, approaches, and recommended actions for remote inspections of nuclear spent fuel storage casks as an asset integrity management activity undertaken by the power industry.

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Gap I2: Crane Inspections.
Standards are needed to establish requirements for the use of UAS in the inspection, testing, maintenance, and operation of cranes and other material handling equipment covered within the scope of ASME's B30 volumes.
R&D Needed: No

Recommendation: Complete work on draft B30.32-20XX, Unmanned Aircraft Systems (UAS) used in Inspection, Testing, Maintenance, and Lifting Operations to address crane inspections using UAS.	
Priority: Medium	
Organization: ASME	
v2 Status of Progress: Green	
v2 Update: Work continues on development of the draft B30.32 standard.	
Updates Since v2 was Published: **Comments Received on Gap for Future Consideration:**	
New Published Standards **6/14/2022, PR:** ASME B30.32-2021, Unmanned Aircraft Systems (UAS) Used in Inspection, Testing, Maintenance and Load-Handling Operation, was recently published on May 6, 2022.	**New In-Development Standards**

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Gap I3: Inspection of Building Facades using Drones.	
There are no known published standards for vertical inspections of building facades and their associated envelopes using a drone. A standard is needed to provide building professionals and remote pilots with a methodology for documenting facade conditions utilizing a sensor mounted to a drone. This should include best practices for the operation of the drone and establish an approach to sensing a building facade, preserving the data, and utilizing data recorded for reporting purposes. The standard should consider the safe operating distance from a building, which may vary depending on the construction material of the facade, and the size and height of the building. It should also take into account FAA requirements that apply to operational navigation (visual and beyond line of sight) and OOP. In addition, the standard should consider the relationship between the licensed design professional and the remote pilot if they are not one-in-the-same. For example, the local jurisdiction authority may stipulate that only a licensed design professional may qualify the inspection results. The remote pilot may help document the inspection findings, but might not be qualified to provide analysis.	
R&D Needed: Yes, for navigation systems to mitigate potential GPS reception loss while operating in close proximity of structures that might obstruct GPS transmission signals.	
Recommendation: Expand work on ASTM WK58243, *Visual Inspection of Building Facade using Drone* to include non-visual sensors, such as radar and thermal.	
Priority: Medium	
Organization: ASTM	
v2 Status of Progress: Green	
v2 Update: As noted, standards are in development.	
Updates Since v2 was Published: **Comments Received on Gap for Future Consideration:** • **02/09/2024** R&D Also needed to ensue sensors used can dependably and reliability detect glass. Sensors may sometimes see through the glass and think it is not there. Other times sensors may be fooled by reflecting sunlight into not seeing the structure.	
New Published Standards	**New In-Development Standards**

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Gap I4: Low-Rise Residential and Commercial Building Inspections Using UAS.
There is a need for a set of best practices or a standard operating procedure (SOP) to inform industry practitioners how to conduct low-rise residential and commercial inspections using UAS.
R&D Needed: No
Recommendation: Develop a guide or SOP for low-rise residential and commercial inspections using UAS. The document should consider safe operating distance from the building, which may vary depending on the construction material of the facade, and the size and height of the building. It should also take into account FAA requirements that apply to operational navigation (visual and beyond line of sight whether day or night), and OOP.
Priority: Medium

Organization: ASHI, ASTM	
v2 Status of Progress: Unknown	
v2 Update: No update provided at this time.	
Updates Since v2 was Published: **Comments Received on Gap for Future Consideration:**	
New Published Standards	**New In-Development Standards**

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Gap I5: Bridge Inspections.	
Standards are needed for conducting bridge inspections using a UAS to provide state Department of Transportation agencies and bridge owners with a methodology for documenting bridge conditions utilizing sensors mounted to a UAS. This should include best practices for the operation of the UAS and establish an approach to sensing a bridge structure, preserving the data, and utilizing data recorded for reporting and modeling purposes. All bridge types should be considered, including rail, road, and pedestrian. The role of UAS in assisting with fracture critical inspections, which usually require an inspector to be able to touch the fracture critical element, should be considered. Bridge owners and operators should use sUAS that make physical contact for touch-based fracture and other touch-based inspections, when possible, to mitigate the risk of workers at elevation. The standards should address safety and operator training. They should also take into account FAA requirements that apply to operational navigation (visual and beyond line of sight) and OOP (to include vehicular traffic), including short-term travel over people and traffic. In addition, the standards should consider the relationship between the qualified bridge inspector and the remote pilot if they are not one-and-the-same. The remote pilot may help document the inspection findings, but might not be qualified to provide an analysis. Recommendations on how to coordinate their work to maximize the value of UAS-enabled inspections should be part of new standards.	
R&D Needed: Yes, for navigation systems to mitigate potential GPS reception loss, magnetic compass biases, imprecise barometric pressure and other data points critical for safe flight of a UAS while in close proximity to structures. R&D is also needed on the role of collision avoidance systems.	
Recommendation: Develop standards for bridge inspections using a UAS	
Priority: Medium	
Organization: AASHTO, ASTM, state DOTs, AMPP (formerly NACE)	
v2 Status of Progress: Yellow	
v2 Update: ASTM WK58243	
Updates Since v2 was Published: **Comments Received on Gap for Future Consideration:**	
New Published Standards	**New In-Development Standards** **11/18/2021, LF:** AMPP SC 02, [*TR 21515 Exterior Coating Inspections via Remotely Operated Aerial Systems*](#) has a new title and scope. To provide state-of-the-art information on the use of remotely operated aerial systems (drones) for inspecting coatings, either through direct contact or from a distance. This report is intended for use by asset integrity engineers, facility managers, coating inspectors, health and safety engineers, corrosion technicians, ships surveyors, drone operators, and others. This report discussed external aerial inspections only.

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Gap I6: Railroad Inspections: Rolling Stock Inspection for Transport of Hazardous Materials (HAZMAT).
Standards are needed to address rolling stock inspections for regulatory compliance of transporting HAZMAT. Considerations for BVLOS and nighttime operations are critical. OSHA standards (29 C.F.R. 1910) related to personal protective equipment (PPE) need to be factored in. SDOs should consult/engage with the rail industry in the development of such standards.
R&D Needed: Yes. Current inspection procedures are likely more hands-on when in close proximity of HAZMAT containers, so using UAS to reduce the inspector's exposure is similar to other inspection use cases. There are many on-going R&D activities for UAS inspection applications.
Recommendation: It is recommended that guidance be developed for performing inspections of HAZMAT rolling stock that incorporates OSHA and FRA requirements.
Priority: Low

Organization: SAE, OSHA, ASME	
v2 Status of Progress: Unknown	
v2 Update: No update provided at this time.	
Updates Since v2 was Published: **Comments Received on Gap for Future Consideration:**	
New Published Standards	**New In-Development Standards**

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Gap I7: Railroad Inspections: BVLOS Operations.	
Standards are needed to address BVLOS operations for railroad inspection. See section 7.3 on BVLOS.	
R&D Needed: Yes. Research to develop underlying technologies for BVLOS at low altitudes.	
Recommendation: It is recommended that standards be developed that define a framework for operating UAS BVLOS for rail system infrastructure inspection. This may include the need to identify spectrum used for BVLOS railroad inspections.	
Priority: High (Tier 3)	
Organization: SAE, ASTM AC-478 BLOS, American Public Transportation Association (APTA), American Railroad Engineering and Maintenance-of-Way Association (AREMA), ASME	
v2 Status of Progress: Green	
v2 Update: As noted above and in the text.	
Updates Since v2 was Published: **Comments Received on Gap for Future Consideration:**	
New Published Standards	**New In-Development Standards**

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Gap I8: Railroad Inspections: Nighttime Operations.	
Standards are needed to address nighttime operations for railroad inspections. Railroads operate 24/7, which poses significant hurdles for leveraging UAS technology for rail system infrastructure inspections. The majority of inspections occur during daytime, but incident inspections can occur at any time of day or under poor visibility conditions and, hence, may have OSH considerations.	
R&D Needed: Yes. Current R&D activities for operating UAS at night are unknown. Exposing UAS technology and operators to nighttime operations is necessary to encourage the maturation of the technology and processes.	
Recommendation: It is recommended that standards be developed that define a framework for operating UAS at night.	
Priority: Low	
Organization: SAE, ASTM AC-478 BLOS, APTA, AREMA	
v2 Status of Progress: Unknown	
v2 Update: No update provided at this time.	
Updates Since v2 was Published: **12/28/2020, JM:** On December 28, 2020 the Federal Aviation Administration (FAA) announced final rules for unmanned aircraft systems (UAS) or drones that will require Remote Identification (Remote ID) of drones and allow operators of small drones to fly over people and at night under certain conditions. • Remote ID information • Remote ID rule (PDF) • Operations Over People and at Night Information • Operations Over People and at Night rule (PDF) **Comments Received on Gap for Future Consideration:**	
New Published Standards	**New In-Development Standards**

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Gap I9: Inspection of Power Transmission Lines, Structures, and Environs Using UAS.
No standards have been identified that specifically address the qualifications of UAS pilots or specifications of a UAS to operate near energized equipment to meet Federal Energy Regulatory Commission (FERC) physical and cyber security requirements. (See also section 6.4.6 on cybersecurity.) Nor have any standards been identified that specifically address the qualifications of UAS pilots to operate around transmission and distribution equipment. This equipment may include telephone, fiber, and cable assets, as well as natural gas and pipeline assets. A standard is needed to address these issues

as well as operational best practices and training in how to conduct a safe inspection of power transmission lines, structures, and environs using drones. See also section 10.3 on UAS flight crew.
R&D Needed: Yes. There is a need to study acceptable methods of airspace deconfliction around electrical equipment and infrastructure. Identifying appropriate data to collect and study relevant airspace activity around electrical equipment is recommended. Understanding the impact of electromagnetic interference around different types of high voltage lines can help identify what mitigation techniques are needed. Further study should be undertaken regarding the effects of magnetic field interference on UAS C2 signals and communications when in the proximity of energized high voltage electrical transmission, distribution, or substation equipment. Acceptable C2 link methods for BVLOS operation exist, but establishing the equipment and techniques for managing autonomous operations during disruptions in connectivity can help spur further acceptable BVLOS practices. Different DAA techniques exist internationally and in the U.S. Studying their effectiveness in the U.S. NAS is needed.
Recommendation: Develop standards related to inspections of power transmission lines, structures, and environs using UAS. Review and consider relevant standards from other organizations to determine manufacturer requirements. As part of the standard, include guidelines on aircraft performance requirements and safe pilot and autonomous flight operations in proximity to energized equipment, for example, to avoid a scenario where arcing occurs.
Priority: High (Tier 3)
Organization: SAE, IEEE, Department of Energy (DOE), North American Electric Reliability Corporation (NERC), FERC, ORNL, ASTM, ASME
v2 Status of Progress: Green
v2 Update: As noted, ASME has some relevant work and SAE is contemplating future work. The ASTM F38 Executive Committee gap analysis viewed this as a low priority for F38, with no action at this time.
Updates Since v2 was Published: **Comments Received on Gap for Future Consideration:** • **4/19/23, R Dalstrom:** This should include sUAS that make physical contact for touch-based measurements such as those that measure the thickness of steel or the thickness of the protective coatings and other touch-based inspections when possible.

New Published Standards	New In-Development Standards
11/21/2025, CB, ANSI: IEEE P1936.2-2023, *Photogrammetric Technical Standard of Civil Light and Small Unmanned Aircraft Systems for Overhead Transmission Line Engineering*. The standard specifies the operational methods, accuracy indicators and technical requirements for the photogrammetry for light-small civil drone applications in power grid engineering surveys and design. The light and small civil drones in this standard refers to: （1）Fixed-wing UAV or multi-rotor UAV is applied as the flying platform. （2）Powered by battery or fuel. （3）The weight is between 0.25kg and 25kg without payload. （4）The maximum active radius is 15km and the maximum operational altitude is 1km. **11/25/2020, SK,** IEEE P2821, *Guide for Unmanned Aerial Vehicle-based Patrol Inspection System for Transmission Lines*, was published.	

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Gap I10: Pesticide Application Using UAS.
Standards are needed to address pesticide application using UAS. Issues to be addressed include communication and automated ID, treatment efficacy (treatment effectiveness), operational safety, environmental protection, equipment reliability, and integration into the national air space, as further described below. • **Communication.** As pesticide application occurs in near-ground air space, it is also the domain of manned aerial application aircraft. Automated ID and location communication is critical in this increasingly crowded, near surface airspace. • **Treatment Efficacy and Drift Mitigation.** Assumptions that spraying patterns and efficacy are similar to heavier, existing manned aircraft are incorrect for lighter, multi-rotor UAS. Equipment standards for differing size and rotor configurations may be needed.

• **Operational Safety and Environmental Protection.** Safety to operators, the general public, and the environment are critical. Transporting hazardous substances raises further safety and environmental concerns. As noted, UAS operate in low altitude air space with various surface hazards including humans and livestock. Standards for safety need to be developed based on the FAA's models of risk as a function of kinetic energy. See also section 9.2 on HAZMAT. • **Equipment Reliability.** Aviation depends on reliability of the equipment involved. Failure at height often results in catastrophic damage and represents a serious safety hazard. Reliability of equipment and specific parts may also follow the FAA's risk curve, though catastrophic failure and damage of expensive equipment that is not high kinetic energy (precision sprayers, cameras, etc.) may require higher standards of reliability due to the potential for large economic loss due to failure. • **Airspace Integration.** This is tied to automated ID and location communication so that other aircraft can sense the spraying UAS and avoid collisions. Detailed flight plans are probably not necessary and controlled airspace restrictions are already in place.
R&D Needed: Yes. Mostly engineering development, demonstration, and performance including factors unique to UAS which could impact off-target drift. There is some indication that treatment efficacy and drift mitigation does not meet expectations in some scenarios.
Recommendation: Develop standards for pesticide application using UAS. Organizations such as NAAA, USDA Aerial Application Technology Research Unit (AATRU), ASABE, and ASSURE should be consulted in conjunction with such standards development activities.
Priority: High (Tier 3)
Organization: ISO/TC 23/SC 6, CEN/TC 144, ASABE
v2 Status of Progress: Green
v2 Update: As noted in the text, standards development is underway by ISO and CEN with respect to aerial application by manned aircraft that has potential relevance to UAS.
Updates Since v2 was Published: **Comments Received on Gap for Future Consideration:** • **4/19/23, R Dalstrom:** Should this be chemical application instead of pesticide? Agricultural drones spray fertilizer, herbicide. mildewcide, etc. not just pesticide. Further, tethered drones are being used to wash elevated water towers and other building and structures using various chemicals, soaps, etc. There are regulation for operating drones to dispense or spray substances (including disinfectants) such as14 CFR Part 137, **Agricultural Aircraft Operations**. Not all substances fall under this regulation but "economic poison" such as pesticides do.

New Published Standards	**New In-Development Standards**

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Gap I11: Commercial Package Delivery via UAS.
Standards are needed to enable UAS commercial package delivery operations.
R&D Needed: Yes
Recommendation: 1) Complete work on ASTM WK62344 and SAE AIR7121. Review small UAS oriented standards for scaling into larger UAVs (those that exceed Part 107 and have Part 135 applicability). 2) Write new standards to address commercial package delivery UAS and its operations.
Priority: High (Tier 3)
Organization: ASTM, SAE, RTCA, EUROCAE, SAE ARINC
v2 Status of Progress: Green
v2 Update: Relevant standards in development are noted above.
Updates Since v2 was Published: **Comments Received on Gap for Future Consideration:**

New Published Standards	**New In-Development Standards**
03/08/2024, B.Teel: *DO-398A Operational Services and Environment Definition (OSED) for Uncrewed Aircraft Systems Detect and Avoid Systems (DAA)* was published in December 2023. **12/05/2022: RFM**: RTCA DO-398, the OSED that was contained in DO-365() has been published in September 2022	**11/18/2025, MBalakrishna, RTCA:** DO-365D (Minimum Operational Performance Standards (MOPS) for Detect and Avoid (DAA) Systems) – Updates are being made to DO-365 to add a class of equipment for ACAS-Xr. Projected Publication Date: December 2026 (schedule slipped to align with ACAS-Xr MOPS) RTCA SC-228 WG-1 OSED for Surface Ops, Small Package Delivery, Air Taxi

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Gap I12: Occupational Safety Requirements for UAS Operated in Workplaces.	
There is a need for occupational safety standards for operating UAS in workplaces. In addition to collision avoidance and awareness systems that are required to be installed on critical infrastructure, at construction sites, and on buildings, such standards should address: 1) Hazard identification, risk characterization, and mitigation to ensure the safe operation of UAS in workplaces. This includes incorporating hazard prevention through safety design features/concepts such as frangible UAS, lightweight manipulators, passive compliant systems, safe actuators, passive robotic systems, operating warning devices (audio/visual), two-way communications between the operator and worker supervisor(s) or workers, etc. It also includes the deployment of Personal Protective Equipment (PPE) such as helmets and other equipment and gears. 2) Training, especially in relation to: a) the competency, experience and qualification of UAS operators; b) operator, bystander, and worker safety; c) identification of potential hazards to equipment such as cranes, elevators, fork lifts, etc.; and, d) corrective actions, procedures, and protocols that are needed to mitigate safety hazards. (See also section 10.3 on UAS Flight Crew.)	
R&D Needed: Yes. Collecting and analyzing objective data about negative safety outcomes is a key to identifying causes of injuries. This includes investigating: 1) navigation and collision avoidance systems in the design of commercial UAS so as to proactively address workplace safety. 2) the effects of stiffness and pliability in structural designs of UAS in relation to UAS collisions with critical infrastructure. 3) the severity of UAS collisions with workers wearing and not wearing helmets and other protective devices. 4) potential safety risks of drones in the workplace such as anti-collision lights distracting workers, increasing noise levels, psychological effects. 5) potential mitigation methods that follow the hierarchy of controls to reduce risks of drones to workers. See also section 7.4 on Operations Over People and section 9.2 on HAZMAT (e.g., operations at a chemical manufacturing plant).	
Recommendation: 1) Develop proactive approach-based occupational safety standards/recommended best practices for UAS operations in workplace environments. Such work should be done in collaboration and consultation with diverse groups (governmental and non-governmental), to help integrate UAS operations in construction and other industries while ensuring the safety and health of workers and others in close proximity to the UAS. 2) Develop educational outreach materials for non-participating people in workplaces, including construction sites where UAS operations are taking place. Occupational safety and health professional organizations should invite speakers on UAS workplace applications to further increase awareness among their members. 3) Encourage the voluntary reporting of events, incidents, and accidents involving UAS in workplace environments. 4) Encourage BLS to modify the SOII and CFOI databases to facilitate search capability that would identify injuries caused by UAS.	
Priority: High (Tier 2)	
Organization: SAE, ASTM, ASSP, BLS, OSHA, NIOSH, CPWR, ISO/TC 20/SC 16, FAA, NTSB, etc.	
v2 Status of Progress: Yellow	
v2 Update: These recommendations require community efforts. It is believed that work is underway by NIOSH in regard to recommendations 1 and 2.	
Updates Since v2 was Published: **Comments Received on Gap for Future Consideration:**	
New Published Standards	**New In-Development Standards**

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New Gap I13: Inspection of Pipelines and Operating Facilities - BVLOS Operations.
Standards are needed to address BVLOS operations for pipeline inspection.
R&D Needed: No.
Recommendation: Develop standards that define a framework for operating UAS BVLOS for pipeline inspection as well as standards that describe best practices and use cases for the pipeline industry. Request API to review their portfolio of pipeline inspection standards to determine if revisions to enable inspections performed by UAS could be incorporated. Complete AMPP (formerly NACE) SP21435 on monitoring of pipeline integrity threats.
Priority: Medium
Organization: API, AMPP (formerly NACE), Pipeline Research Council International (PRCI) (R&D), California Energy Commission (R&D), ASME, ASTM F38
v2 Status of Progress: New
v2 Update: None provided

Updates Since v2 was Published:
Comments Received on Gap for Future Consideration:

New Published Standards	**New In-Development Standards**

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New Gap I14: Inspection of Pipelines and Operating Facilities – Sensor Validation & Use.

Standards are needed for minimum testing to validate sensors on UAS platforms at varying flight altitudes utilized for pipeline inspections. Standards are needed to provide agencies and operators with a methodology for documenting pipeline conditions utilizing sensors mounted to a UAS. This should include best practices for the operation of the UAS and establish an approach to sense and avoid surrounding infrastructure within facilities, safeguarding the data, and utilizing data recorded for reporting and modeling purposes. The standards should address safety and operator training. They should also consider FAA requirements that apply to operational navigation (visual and beyond line of sight).

R&D Needed: Yes, for validation of sensor quality and accuracy on varying platforms (long-range and short-range UAVs) for risks associated with:

- Environmental changes (i.e., ground movement, water saturation, slip / subsidence / sinkhole / erosion)
- Third-party threats
- Active loading on pipelines (i.e., equipment crossing right of way (ROW), equipment on ROW, material on ROW)
- Waterways (i.e., boat anchorage, dredging, levee construction / maintenance)
- Structures (i.e., building construction, fence installation, non-permanent structure on ROW)
- Pipeline monitoring (i.e., exposure (pipe), pipeline construction / maintenance, possible leak / lost gas, slip / subsidence / sinkhole / erosion / metal loss / corrosion)
- Earthwork (i.e., clearing, drainage, excavation, mining activity)
- Forestry (i.e., logging activity, portable sawmill operations)

Recommendation: Develop standards for validating sensor quality and accuracy on UAS platforms utilized for pipeline inspections. Request API to review their portfolio of pipeline inspection standards to determine if revisions to enable inspections performed by UAS could be incorporated. Complete the following AMPP (formerly NACE) documents under development: SP21435, ~~and SP~~TM21436, and TR21572 ~~standard practices~~.

Priority: Medium

Organization: API, AMPP (formerly NACE), PRCI (R&D), California Energy Commission (R&D), ASME

v2 Status of Progress: New

v2 Update: None provided

Updates Since v2 was Published:

Comments Received on Gap for Future Consideration:

- **5/5/2023, Laura Feix, AMPP:** Follow up: Brad Wilder, Director of Standards, AMPP- AMPP's SC 10 Asset Integrity Committee recently decided to split the former SP21436 Large Standoff Magnetometry (LSM) Inspection of Pipelines into two documents, a test method and technical report: TM21436 *Test Method for Large Standoff Magnetometry Inspection of Pipelines* and TR21572 *Application of Large Standoff Magnetometry for the Inspection of Pipelines* which is reflected via track changes. As noted in the UASSC V2 text under 4.11 NACE International (NACE) on page 106, large scale magnetometry is a sensor/inspection technique that is platform agnostic; the sensor may be mounted on wheels for a human to walk the pipeline, on a robotic crawler, or on a drone (which is the reason for mentioning in the roadmap). Is the current update to the UASSC strictly related to gaps or is the text also being revised? There are references to SP21436 in the text of 8.2.4 and 8.4.5 so didn't know if it is necessary to revise the text to reflect the fact that there are now two consensus documents under development. Since the SP21436 designation will be replaced by TM21436 and TR21572, am unsure how to have future traceability. Along the same line, if it becomes necessary to update the UASSC V2 Section 4.11 to reflect the new organization of AMPP as the successor to NACE, please let us know.

New Published Standards	**New In-Development Standards**
	5/5/2023 LF, AMPP: AMPP's SC 10 Asset Integrity Committee recently decided to split the former SP21436 Large Standoff Magnetometry (LSM) Inspection of Pipelines into two documents, a test method and technical report: TM21436 Test Method for Large Standoff Magnetometry Inspection of Pipelines and TR21572 Application of Large Standoff Magnetometry for the Inspection of Pipelines

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New Gap I15: UAS in Airport Operations.

Standards are needed for UAS usage in airport operations.

R&D Needed: Yes
Recommendation: Develop standards for the application of UAS in airport operations
Priority: Medium
Organization: Standards bodies publishing UAS standards and/or regulators
v2 Status of Progress: New
v2 Update: None provided
Updates Since v2 was Published: • **6/1/2022, PK**: ICAO has started a Joint Task Force (JTF) between the RPAS Panel and the Aerodrome Design and Operations Panel (ADOP), which is tasked with updating ICAO SARPs, PANS, and guidance material to integrate RPAS into commercial airports and heliports. Separately, the ADOP has begun work on Vertiports.

New Published Standards	New In-Development Standards
12/05/2022 RFM: RTCA DO-398, the OSED that was contained in DO-365() has been published in September 2022	**12/05/2022 RFM**: RTCA DO-398 Revision A is planned for Publication in February 2024 to include ACAS sXr. RTCA SC-228 WG-1 OSED for Surface Operations, Small Package Delivery, Air Taxi Operations

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New Gap I16: Commercial Cargo Transport via UAS.
Additional standards may be needed to enable UAS commercial cargo transport and operations.
R&D Needed: Yes. Review existing standards used for traditional commercial cargo transport and determine gaps that are unique to UAS.
Recommendation: Complete work on in-development standards. Engage with industry to determine intent for future services (e.g., replace short haul rail and road freight with small general aviation aircraft cargo operations).
Priority: Medium
Organization: SAE, RTCA, EUROCAE, SAE, ARINC, ASME, ASTM
v2 Status of Progress: New
v2 Update: None provided
Updates Since v2 was Published: **Comments Received on Gap for Future Consideration:**

New Published Standards	New In-Development Standards
12/05/2022 RFM: RTCA DO-398, the OSED that was contained in DO-365 has been published in September 2022 **6/17/2021, JM:** DO-304A *Guidance Material and Considerations for Unmanned Aircraft Systems*. This is an update to the original DO-304 that is a Guidance Document addressing all Unmanned Aircraft Systems (UAS) and UAS operations being considered for realistic implementation in the US National Airspace System (NAS) in the foreseeable future. The Use Cases have been updated in DO-304A to include scenarios for Cargo Missions, Survey Missions, High Altitude Platform Systems, and Urban Air Mobility. The document is intended to educate the community and be used to facilitate future discussions on UAS standards. It provides the aviation community a definition of UAS, a description of the operational environment, and a top-level functional break down. It is NOT intended to be the basis for airworthiness certification and operational approval of UAS.	**11/18/2025, MBalakrishna, RTCA:** DO-365D (Minimum Operational Performance Standards (MOPS) for Detect and Avoid (DAA) Systems) – Updates are being made to DO-365 to add a class of equipment for ACAS-Xr. Projected Publication Date: December 2026 (schedule slipped to align with ACAS-Xr MOPS) **12/05/2022 RFM**: RTCA DO-398 Revision A is planned for Publication in February 2024 to include ACAS sXr. RTCA SC-228 WG-1 *OSED for Surface Operations, Small Package Delivery, Air Taxi Operations*

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New Gap I17: Commercial Passenger Air Taxi Transport via UAS (short-haul flights carrying few passengers and/or cargo).

Standards are needed to support commercial short haul transport via UAS covering areas such as aircraft automation, passenger cabin interiors and furnishings, safety equipment and survival, etc.

R&D Needed: Yes

Recommendation:

1) Complete work on in-development standards. Complete work on use of AI and non-deterministic techniques on autonomous, non-piloted UAS. Develop safety and operations standards applicable to non-piloted UAS carrying passengers.
2) Consult the NASA AAM ConOps and write standards to address commercial passenger air taxi transport via UAS.

Priority: High (Tier 1)

Organization: ASTM, RTCA, SAE, EUROCAE, SAE ITC ARINC IA

v2 Status of Progress: New

v2 Update: None provided

Updates Since v2 was Published:

Comments Received on Gap for Future Consideration:

New Published Standards	New In-Development Standards
12/05/2022 RFM: RTCA DO-398, the OSED that was contained in DO-365() has been published in September 2022 **12/05/2022 JR, SAE** AS6849 *Performance Standards for Passenger and Crew Seats in Advanced Air Mobility (AAM) Aircraft*. This SAE Aerospace Standard (AS) defines qualification requirements, and minimum documentation requirements for forward and aft facing seats in Advanced Air Mobility aircraft. The goal is to achieve occupant protection under normal operational loads and to define test and evaluation criteria to demonstrate occupant protection when the seat is subjected to statically applied ultimate loads and to dynamic test conditions. While this document addresses system performance, responsibility for the seating system is divided between the seat manufacturer and the installation applicant. The seat manufacturer's responsibility consists of meeting all the seat system performance requirements. The installation applicant has the ultimate system responsibility in assuring that all requirements for safe seat installation have been met. **6/17/2021, JM:** DO-304A *Guidance Material and Considerations for Unmanned Aircraft Systems.* This is an update to the original DO-304 that is a Guidance Document addressing all Unmanned Aircraft Systems (UAS) and UAS operations being considered for realistic implementation in the US National Airspace System (NAS) in the foreseeable future. The Use Cases have been updated in DO-304A to include scenarios for Cargo Missions, Survey Missions, High Altitude Platform Systems, and Urban Air Mobility. The document is intended to educate the community and be used to facilitate future discussions on UAS standards. It provides the aviation community a definition of UAS, a description of the operational environment, and a top-level functional break down. It is NOT intended to be the basis for airworthiness certification and operational approval of UAS.	**12/05/2022 RFM**: RTCA DO-398 **Revision** A is planned for Publication in February 2024 to include ACAS sXr. RTCA SC-228 WG-1 *OSED for Surface Operations, Small Package Delivery, Air Taxi Operations*

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New Gap I18: Commercial Passenger Transport via UAS (long-haul flights carrying many passengers).

Standards are needed to support commercial passenger transport via UAS and its operations.

R&D Needed: Yes	
Recommendation: Complete work on in-development standards to support commercial passenger transport via UAS and its operations. Industry and SDOs should work together to develop standards to enable this type of operation.	
Priority: Medium	
Organization: RTCA, SAE, EUROCAE, SAE ARINC IA	
v2 Status of Progress: New	
v2 Update: None provided	
Updates Since v2 was Published: **Comments Received on Gap for Future Consideration:**	
New Published Standards	**New In-Development Standards**

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New Gap I19: Commercial Sensing Services.	
Standards are needed to enable the provision of commercial sensing services by UAS operators. Such standards should address the integrity and security of the information collected, transmitted, and stored by the service provider on behalf of the client.	
R&D Needed: Yes	
Recommendation: Develop standards to enable commercial sensing services. Industry groups should be consulted to determine if additional and/or higher-level standards are required for UAS sensor operations conducted by outsourced service providers.	
Priority: High (Tier 1)	
Organization: ASME, AMPP (formerly NACE), ASTM	
v2 Status of Progress: New	
v2 Update: None provided	
Updates Since v2 was Published: **Comments Received on Gap for Future Consideration:** • **11/8/2021, SS**: If the gap is with respect to the sensors, then there is a whole suite of Standards from OGC used in satellite and aerial remote sensing, including Sensor Observation Service: https://www.ogc.org/standards/sos	
New Published Standards **11/17/2025, CB, ANSI:** IEEE P1937.7-2024, *Standard for the Unmanned Aerial Vehicle (UAV) Polarimetric Remote Sensing Method for Earth Observation Applications.* The standard specifies an Unmanned Aerial Vehicle polarimetric remote sensing method for Earth objects observation applications.	**New In-Development Standards** **11/28/2021, JM:** IEEE P1937.6, *Standard for Unmanned Aerial Vehicle (UAV) Light Detection and Ranging (LiDAR) Remote Sensing Operation.* This standard specifies the operational methods and data management for Unmanned Aerial Vehicle Light Detection and Ranging (LiDAR) remote sensing applications.

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New Gap I20: Use of sUAS for Newsgathering.	
Standards or best practices are needed on the use of drones by newsgathering organizations whether the drone controllers are stationary or mobile. sUAS use for newsgathering operations should also include safety and health considerations for participating crew and the public from the NIOSH and OSHA aspects.	
R&D Needed: No	
Recommendation: Develop operational best practices or standards on the use of UAS by newsgathering organizations	
Priority: High (Tier 1)	
Organization: companies, industry trade associations	
v2 Status of Progress: New	
v2 Update: None provided	
Updates Since v2 was Published: **Comments Received on Gap for Future Consideration:**	
New Published Standards	**New In-Development Standards**

Chapter 8 Recommendations/Comments Since v2 was Published:

- **02/12/2024 S.Marzac, Boeing:** Suggested new gap Small UAS for Aircraft Inspection

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Chapter 9. Flight Operations Standards: Public Safety – WG4

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Gap S1: Use of sUAS for Public Safety Operations.	
The roadmap version 1.0 gap stated that "Standards are needed on the use of drones by the public safety community."	
R&D Needed: No	
Recommendation: The roadmap version 1.0 recommendation stated "With the publication of NFPA® 2400, *Standard for Small Unmanned Aircraft Systems (sUAS) Used for Public Safety Operations*, complete work on the development of use cases by the ASTM/NFPA JWG." As noted above, the JWG is now inactive.	
Priority: High (Tier 2)	
Organization: NFPA, ASTM	
v2 Status of Progress: **Closed**	
v2 Update: APSAC standards, ASTM F3379, NFPA® 2400, NFPA 1500™	
Updates Since v2 was Published: • **5/24/2021, CF:** *NFPA 1500, Standard on Fire Department Occupational Safety, Health and Wellness Program*, currently the 2021 edition, will be consolidated into *NFPA 1550, Standard for Emergency Responder Health and Safety*, during its next revision cycle. NFPA 1550 will contain documents NFPA 1500, 1521, and 1561. Public input is now open until Nov 10, 2021. NFPA 1550 will be issued in 2023. **Comments Received on Gap for Future Consideration:** • **11/22/21, Comment from Ken Holland, NFPA**: I am not sure what the gap here is but I am not aware of anything that might have been added to the 1500 series regarding UAS's.	
New Published Standards **5/3/2023, CD:** ASTM F3262-17, *Standard Classification System for Small Unmanned Aircraft Systems (sUASs) for Land Search and Rescue* may be used to classify sUAS resources utilized for land search and rescue, developed by F32.01. • Classification of sUAS land search and rescue resources is based upon the complete sUAS including payload, communications systems. • This classification identifies the mechanical features of the sUAS platform and does not account for the pilot's/operator's skill in performing specific tasks. • UAS land search and rescue resources are classified by Category, Kind, and Type.	**New In-Development Standards**

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Gap S2: Hazardous Materials Response and Transport Using a UAS.	
Standards are needed to address the transportation of known or suspected HAZMAT by UAS and UAS being exposed to HAZMAT in a response environment.	
R&D Needed: Yes. Research to assist policy makers and practitioners in determining the feasibility of using UAS in emergency response situations.	
Recommendation: Create a standard(s) for UAS HAZMAT emergency response use, addressing the following issues: • The transport of HAZMAT when using UAS for detection and sample analysis • The design and manufacturing of ingress protection (IP) ratings when dealing with HAZMAT • The method of decontamination of a UAS that has been exposed to HAZMAT	
Priority: Medium	
Organization: ASTM, NFPA, OSHA, U.S. Army	
v2 Status of Progress: Not Started	
v2 Update: Numerous standards have been published.	
Updates Since v2 was Published: **Comments Received on Gap for Future Consideration:** • **11/22/21, Comment from Ken Holland, NFPA**: I am not aware of any work being done by the committee on this but there is a section on hazardous material response in chapter 4.	
New Published Standards	**New In-Development Standards**

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Gap S3: Transport and Post-Crash Procedures Involving Biohazards.	
No published or in-development standards have been identified that address UAS transport of biohazards and associated post-crash procedures and precautions.	
R&D Needed: Yes	
Recommendation: 1) Write standards to address UAS transportation of biohazards and post-crash procedures and containments 2) Encourage the development of standards to address and accommodate transport of biohazards and post-crash procedures and containments that cannot meet the current regulatory requirements and standards of manned aviation	
Priority: High (Tier 3)	
Organization: UN, WHO, ICAO, DOD, DHS, CDC, USDA, NIH, NFPA, SAE	
v2 Status of Progress: Unknown	
v2 Update: None provided at this time.	
Updates Since v2 was Published: **Comments Received on Gap for Future Consideration:** • **11/22/21, Comment from Ken Holland, NFPA**: While not specifically addressed in 2400 there is a blanket "catch all" statement at the end of chapter 4 that could cover this.	
New Published Standards	**New In-Development Standards**

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Gap S4: Forensic Investigations Photogrammetry.	
Standards are needed for UAS sensors used to collect digital media evidence. The equipment used to capture data needs to be able to survive legal scrutiny. Standards are also needed for computer programs performing post-processing of digital media evidence. Processing of the data is also crucial to introducing evidence into trial.	
R&D Needed: Yes. R&D will be needed to develop the technical standards to meet legal requirements for the admissibility of digital media evidence into court proceedings.	
Recommendation: Develop standards for UAS sensors used to collect digital media evidence and for computer programs performing post-processing of digital media evidence. These standards should take into account data, security and accountability.	
Priority: Medium	
Organization: OGC	
v2 Status of Progress: Green	
v2 Update: The OGC GeoTIFF standard was adopted as an OGC standard in 2019, and best practices are in development in OGC UxS DWG.	
Updates Since v2 was Published: • **6/10/2021:** OGC has additional work underway in Data Quality measures standardization to describe the quality/error propagation from collection through processing to delivery. See the OGC Discussion Paper “Standardizing a Framework for Spatial and Spectral Error Propagation” https://docs.ogc.org/dp/20-088.html **Comments Received on Gap for Future Consideration:**	
New Published Standards	**New In-Development Standards** **5/14/2025: S.Simmons**: OGC and ISO/TC 211 are in the process of publishing a data quality register based on ISO 19157-3.

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Gap S5: Payload Interface and Control for Public Safety Operations.
Standards are needed for public safety UAS payload interfaces including: • Hardware • Electrical connections (power and communications) • Software communications protocols • Cybersecurity of payload systems Additional standards development may be required to define location, archiving, and broadcast of information which will grow in need as data analytics plays a larger role in public safety missions.

There currently are no published standards that define the expected capabilities, performance, or control of sUAS payload drop mechanisms.
R&D Needed: Yes. Need to examine available options in universal payload mounting as well as electrical connections and communications. Stakeholders including end users and manufacturers of drones should be engaged to contribute to the process of defining acceptable standards. For payloads intending to be jettisoned, eExisting payload drop and control systems should be researched with attention to weight, degree of operator control, and interoperability considered in defining standards that are useful for both public safety and commercial operators.
Recommendation: Develop ~~standard~~cybersecurity standards practice~~s~~ for the UAS-to-sensor integrated payload interface (e.g., camera), which includes hardware mounting, electrical connections, RF communications, and software message sets. Develop a standard for a UAS payload drop control mechanism that includes weight, control, safety and risk metrics, and remote status reporting.
Priority: High (Tier 3)
Organization: ASTM, DOJ, NFPA, DHS, NIST, IEEE, ISO
v2 Status of Progress: Green
v2 Update: IEEE P1937.1, ISO/WD 24354
Updates Since v2 was Published: **Comments Received on Gap for Future Consideration:** • **5/31/2022, Phil Mattson per MITRE HSSEDI:** Add to current Gap a bullet on "Cybersecurity of payload systems". Cybersecurity of payloads, and sensor payloads in general, are not covered in standards today and is a critical risk to public safety operations. Many of these payloads are highly integrated into the UAS (e.g., flight controller data injected onto the video recording) and could expose a UAS to a cyber risk entry point, especially if not on a protected control channel (e.g., when using CNPC links). • **11/22/21, Comment from Ken Holland, NFPA:** While not specifically addressed in 2400 there is a blanket "catch all" statement in 4.1.4.9 that might cover this.

New Published Standards	New In-Development Standards
2/12/2021, SK: IEEE 1937.1-2020, *IEEE Standard Interface Requirements and Performance Characteristics of Payload Devices in Drones*, was published on February 12, 2021.	

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Gap S6: sUAS Forward-Looking Infrared (IR) Camera Sensor Capabilities.
UAS standards are needed for IR camera sensor capabilities. A single standard could be developed to ensure IR technology meets the needs of public safety missions, which would be efficient and would ensure an organization purchases a single camera to meet operational objectives.
R&D Needed: Yes. R&D (validation/testing) is needed to identify IR camera sensor sensitivity, radiometric capabilities, zoom, and clarity of imagery for identification of a person/object for use in public safety/SAR missions.
Recommendation: Complete work on standards in development related to IR camera sensor specifications for use in public safety and SAR missions.
Priority: Medium
Organization: NIST, NFPA, ASTM
v2 Status of Progress: Green
v2 Update: ASTM E54.09
Updates Since v2 was Published: **Comments Received on Gap for Future Consideration:** • **11/22/21, Comment from Ken Holland, NFPA**: I am not aware of this being worked on by the committee but this would seem to be a design item and 2400 does not address the design of drones.

New Published Standards	New In-Development Standards
6/17/2021, JM: RTCA DO-387 *Minimum Operational Performance Standards (MOPS) for Electro-Optical/Infrared (EO/IR) Sensors for Traffic Surveillance*. This document contains Minimum Operational Performance Standards (MOPS) for Electro-Optical/Infrared (EO/IR) Sensors for Traffic Surveillance. The EO/IR sensor system is a surveillance source for non-cooperative intruders for a Detect and Avoid (DAA) system used in Unmanned Aircraft Systems (UAS) transiting through Class B, C, D, E and G airspace and performing extended operations higher than 400' Above Ground Level (AGL) in Class D, E (up to Flight Level 180	

(FL180)), and G airspace. It includes equipment to enable UAS operations in Terminal Areas during approach and departure in Class C, D, E and G airspace and off-airport locations. It does not apply to small UAS (sUAS) operating in low level environments (below 400') or other segmented areas. Likewise, it does not apply to operations in the Visual Flight Rules (VFR) traffic pattern of an airport or to surface operations.	

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Gap S7: Need for Command and Control Software Specifications for Automated Missions during Emergency Response.	
While standards exist for software specifications to complete automated missions, there remains a need to encourage the user community to purchase professional grade equipment that is compliant with these standards, rather than using low-cost, consumer grade equipment.	
R&D Needed: No	
Recommendation: Encourage UAS OEMs to adopt existing standards. Encourage public safety agencies to consider equipment that is compliant with industry standards, and NIST/FEMA guidelines, prior to acquiring UAS. See section 7.6 on data handling and processing and 6.4.4 on software considerations and approval.	
Priority: Low	
Organization: NIST, NFPA, ASTM, RTCA, EUROCAE, OGC, UAS OEMs, public safety agencies/organizations	
v2 Status of Progress: Green	
v2 Update: • RTCA DO-178, DO-278; RTCA SC-240/EUROCAE WG-117 • ASTM F32; ASTM F38: F3201, WK68098; ASTM E54: WK58938 • Standards exist for software specifications to complete automated missions. Other standards are under development. **Comments Received on Gap for Future Consideration:** • **11/22/21, Comment from Ken Holland, NFPA**: This is not something that is nor should be addressed by 2400 since it is a minimum standard and we stay away from anything dealing with "cost"	
Updates Since v2 was Published:	
New Published Standards	**New In-Development Standards** **4/20/2023 BT: RTCA, SC-240** Integration of COTS, Open Source and Service History into Software is expected to be published in 2025. **12/5/2022, RFM: RTCA SC-240** will update the plan for the Lower Risk Software Considerations document. The new plan will be updated at PMC on December 15, 2022. **5/24/2021, AS:** *RTCA DO-178C Software Considerations in Airborne Systems and Equipment Certification* and *RTCA DO-278A Guidelines For Communication, Navigation, Surveillance, and Air Traffic Management (CNS/ATM) Systems Software Integrity Assurance* which are being examined by RTCA SC-240 and EUROCAE WG 117 for additional material to aid software developers, including UAS SW developers

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Gap S8: UAS Response Robots.
There is a need for standardized test methods and performance metrics to quantify key capabilities of sUAS robots used in emergency response operations and remote pilot proficiencies.
R&D Needed: Yes
Recommendation: Complete work on UAS response robot standards in development in ASTM E54.09 and reference them in NFPA® 2400, *Standard for Small Unmanned Aircraft Systems (sUAS) Used for Public Safety Operations*
Priority: Medium
Organization: NIST, ASTM E54.09, NFPA, DHS

v2 Status of Progress: Green	
v2 Update: ASTM E54.09, ASTM F38: ASTM WK70877, NFPA® 2400.	
Updates Since v2 was Published: **Comments Received on Gap for Future Consideration:** • **11/22/21, Comment from Ken Holland, NFPA**: Robots are not within the scope of the document and I am not aware of anything the committee is working on to address this.	
New Published Standards	**New In-Development Standards**

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Gap S9: UAS Mitigation.

Given the imperative that C-UAS technologies be available for use by the proper authorities, user identification, design, performance, safety, and operational standards are needed. User identification ensures accountability and provides a necessary tool to public safety officials. Design, performance, and safety standards can reduce the likelihood of harming or disrupting innocent or lawful communications and operations.

Today's C-UAS technologies are often the result of an immediate need for a life-saving measure that was neither originally anticipated, nor given time to mature. Regarding test and evaluation (T&E) of C-UAS technologies, the goals, methods, data collected, and results output are generally not uniform. A comprehensive evaluation approach and template for testing C-UAS systems is needed. The test and evaluation (T&E) community must have clear guidance on what to look for in order to test and evaluate to the needs of the acquisition community; the model, simulation, and analysis (MS&A) community; the systems engineering community; and the end user. Model Based Systems Engineering (MBSE) and Interchange of data and results will benefit from standardizing the data formats for: the data collected, the aggregated performance, and the metrics. Clearly defined metrics and standards require foundational criteria upon which to build.

R&D Needed: Yes	
Recommendation: Encourage the development of Counter-UAS standards addressing user identification, design, performance, safety, operational aspects, and various available technological methods for C-UAS. For example, laser-based systems will follow a different standards protocol than a kinetic, acoustic, or RF-based solution. Encourage the T&E community to collaborate.	
Priority: High (Tier 1)	
Organization: DOD, DHS, DOJ, DOE, FCC, NTIA, EUROCAE, RTCA	
v2 Status of Progress: Green	
v2 Update: RTCA SC-238/EUROCAE WG-115	
Updates Since v2 was Published: • **8/17/2020, JM**: On 17 August 2020, the Department of Justice (DOJ), the Federal Aviation Administration (FAA), the Department of Homeland Security (DHS), and the Federal Communications Commission (FCC) issued an advisory guidance document to help non-federal public and private entities better understand the federal laws and regulations that may apply to the use of capabilities to detect and mitigate threats posed by Unmanned Aircraft Systems (UAS) operations. See: https://www.fcc.gov/document/federal-agencies-release-advisory-drone-detection-mitigation-tech **Comments Received on Gap for Future Consideration:**	
New Published Standards	**New In-Development Standards**

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New Gap S10: Use of Tethered UAS for Public Safety Operations.

Training and operational standards are needed on the use of Actively Tethered sUAS by public safety agencies.	
R&D Needed: Yes	
Recommendation: Develop standards for Actively Tethered Public Safety sUAS operations	
Priority: Medium	
Organization: ISO, NFPA, APSAC, ASTM	
v2 Status of Progress: New	
v2 Update: None provided	
Updates Since v2 was Published: **Comments Received on Gap for Future Consideration:** • **11/22/21, Comment from Ken Holland, NFPA**: 2400 does address, maybe not to the degree or concept that is stated here, multiple aircraft operations as part of 4.6.2. I am not aware of the committee expanding upon this.	
New Published Standards	**New In-Development Standards**

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New Gap S11: UAS Detection.	
No standards exist for the performance of UAS detection systems that might be used by operators of critical infrastructure or public safety agencies. Given the importance of drone detection capabilities, standards must be developed for user identification, design, performance, safety, and operations. User identification ensures accountability and provides a necessary tool to public safety officials and operators of critical infrastructure. Design, performance, and safety standards can ensure that risk management decisions are based on reliable and valid data. A comprehensive evaluation template for testing UAS detection systems is needed to: (1) identify current capabilities and anticipated advancement for C-UAS technologies and (2) forecast trends in the C-UAS burgeoning market. The test and evaluation (T&E) community must have clear guidance and a framework to test and evaluate the needs of the end user.	
R&D Needed: Yes	
Recommendation: Encourage the development of detection standards addressing user identification, design, performance, safety, operational aspects, and various available technological methods for detecting UAS. For example, RF detection-based systems will follow a different standards protocol than electro-optical or infra-red based systems.	
Priority: High (Tier 1)	
Organization: DOD, DHS, DOJ, DOE, FCC, NTIA, EUROCAE, RTCA	
v2 Status of Progress: New	
v2 Update: None provided	
Updates Since v2 was Published: • **8/17/2020, JM**: On 17 August 2020, the Department of Justice (DOJ), the Federal Aviation Administration (FAA), the Department of Homeland Security (DHS), and the Federal Communications Commission (FCC) issued an advisory guidance document to help non-federal public and private entities better understand the federal laws and regulations that may apply to the use of capabilities to detect and mitigate threats posed by Unmanned Aircraft Systems (UAS) operations. See: https://www.fcc.gov/document/federal-agencies-release-advisory-drone-detection-mitigation-tech **Comments Received on Gap for Future Consideration:**	
New Published Standards **03/10/2024, BT: RTCA,** *DO-403 System Performance and Interoperability Requirements for Non-Cooperative UAS Detection Systems* was published December 2023. This document is intended to summarize the different aspects of the Counter UAS (C-UAS) system and to have a better understanding of the C-UAS system components at the detection level. This document will identify performance requirements parameters of the Counter UAS detection system as it has been defined in the ED-286 / DO-389 Operational Services and Environment Definition (OSED) for Counter UAS in Controlled Airspace. **12/3/2021, JM:** RTCA DO-389 – *OSED for Counter UAS in Controlled Airspace, Counter Unmanned Aircraft System*, was issued 3/18/2021. The OSED document provides a detailed description of the operational services of a C-UAS system, and the environment in which such a system will operate. It proposes operational requirements and associated assumptions that will be further detailed in the complementary standard documents: Safety and Performance Requirements (SPR) and Interoperability Requirements (INTEROP). **6/17/2021, AS: RTCA** DO-387 *Minimum Operational Performance Standards (MOPS) for Electro-Optical/Infrared*	**New In-Development Standards**

(EO/IR) Sensors for Traffic Surveillance. This document contains Minimum Operational Performance Standards (MOPS) for Electro-Optical/Infrared (EO/IR) Sensors for Traffic Surveillance. The EO/IR sensor system is a surveillance source for non-cooperative intruders for a Detect and Avoid (DAA) system used in Unmanned Aircraft Systems (UAS) transiting through Class B, C, D, E and G airspace and performing extended operations higher than 400' Above Ground Level (AGL) in Class D, E (up to Flight Level 180 (FL180)), and G airspace. It includes equipment to enable UAS operations in Terminal Areas during approach and departure in Class C, D, E and G airspace and off-airport locations	

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New Gap S12: Integration of UAS into FEMA ICS Operations Section, Air Operations Branch.	
The FEMA NIMS does not fully address UAS operations. FEMA's ICS does not presently contain official guidance surrounding the use of UAS within the Operation Section, Air Operations Branch.	
R&D Needed: Yes, limited	
Recommendation: The NIMS should be revised to integrate the use of UA of all types as part of the ICS. Specific recommendations include: 1) Air Operations Summary (ICS 220) should be updated to incorporate UAS as an aviation resource. 2) FEMA, Resource Typing Definition for Response, should be expanded to include such positions as UAS Coordinator and UAS Base Manager, or similar positions necessary to manage UAS operations under the Air Operations Branch (e.g., sUAS airbase manager, sUAS air operations supervisor, etc.) including taskbooks and training. 3) Update FEMA, National Training and Education Division, Course Number AWR-345, "Unmanned Aircraft Systems in Disaster Management."	
Priority: Medium	
Organization: FEMA NIMS, National Wildfire Coordinating Group (NWCG)	
v2 Status of Progress: New	
v2 Update: None provided	
Updates Since v2 was Published: Discussions with FEMA are ongoing without substantive progress. **Comments Received on Gap for Future Consideration:**	
New Published Standards	**New In-Development Standards**

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New Gap S13: Data Format for Public Safety sUAS Operations.	
Standards are needed for the formatting and storage of UAS data for the public safety community, especially to foster inter-agency cooperation and interoperability, and to help guide industry product development.	
R&D Needed: No	
Recommendation: Develop standards for accepted format of live video and still imagery and associated GIS data for use in sUAS public safety operations.	
Priority: High (Tier 2)	
Organization: NFPA, ASTM, Airborne Public Safety Association (APSA), DRONERESPONDERS, AIRT, OGC	
v2 Status of Progress: New	
v2 Update: None provided	
Updates Since v2 was Published: **Comments Received on Gap for Future Consideration:** • **11/22/21, Comment from Ken Holland, NFPA**: 2400 does discuss data, how it is to be collected, protected, and in what format but again maybe not to the degree sought by this gap. Keeping in mind the AHJ could always exceed what is in the standard if they wanted to.	
New Published Standards	**New In-Development Standards**

Chapter 9 Recommendations/Comments Since v2 was Published:

- No recommendations received relation of publication of this report.

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Chapter 10. Personnel Training, Qualifications, and Certification Standards: General – WG2

High Priority (Tier 2) (Critical)

High Priority (Tier 3) (Least Critical)

Medium Priority

General Personnel Standards Feedback

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Gap P1: Terminology.	
Standards for UAS terminology are needed. Several are in development and will satisfy the market need for consumer and commercial UAS terminology.	
R&D Needed: No	
Recommendation: Complete work on terminology standards in development.	
Priority: High (Tier 3)	
Organization: ASTM, IEEE, ISO, RTCA, SAE ITC ARINC IA	
v2 Status of Progress: Green	
v2 Update: Numerous standards have been published and are in-development.	
Updates Since v2 was Published: **Other Committees with Relevant Work:** • SAE ITC, ARINC IA Software Distribution and Loading subcommittee **Comments Received on Gap for Future Consideration:**	
New Published Standards	**New In-Development Standards**
5/5/2023, CB, ASTM: ASTM F3341/F3341M, *Standard Terminology for Unmanned Aircraft Systems* has been revised to F3341/F3341M-23 developed by Committee F38.03. **6/10/2021, JM:** ISO 21384-4:2020, *Unmanned aircraft systems — Part 4: Vocabulary* was published in May 2020	**5/5/2023, CB, ASTM:** F38.03 is working on several revisions to F3341: – See WK72798 – See WK72799 – See WK72800 – See WK72801 – See WK72802 – See WK72803 – See WK72804 – See WK73790 – See WK73791 – See WK73794 – See WK82567

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Gap P2: Manuals.	
Several published UAS standards have been identified for various manuals. Several more are in development and will satisfy the market need for civil and public operators.	
R&D Needed: No	
Recommendation: Complete existing work on manual standards in development	
Priority: High (Tier 2)	
Organization: ASTM, JARUS, NPTSC, NFPA, SAE ITC ARINC IA	
v2 Status of Progress: Green	
v2 Update: ASTM F2908-18, F3330-18, F3366-19; ASTM WK62734, WK62744, WK63407	
Updates Since v2 was Published: **Comments Received on Gap for Future Consideration:** • **11/22/21, Comment from Ken Holland, NFPA**: So annex A.4.5.3(10) does suggest that manuals be provided from the manufacturer but I am not sure what manuals are being sought by this gap.	
New Published Standards	**New In-Development Standards**

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Gap P3: Instructors and Functional Area Qualification.
Several published UAS standards have been identified for various crewmember roles. Several are in development and will satisfy the market need for remote pilot instructors and functional area qualification.
R&D Needed: No
Recommendation: Complete work on UAS standards currently in development
Priority: High (Tier 2)
Organization: SAE, ASTM, AUVSI, PPA, ISO, SAE ITC ARINC IA
v2 Status of Progress: Green
v2 Update: ASTM F3330-18, ASTM F3379-20, ASTM WK61763, WK62741; ISO/DIS 23665
Updates Since v2 was Published: **Comments Received on Gap for Future Consideration:**

New Published Standards	New In-Development Standards
03/14/2024, M.Carlson: *ISO 23665:2023, Unmanned aircraft systems — Training for personnel involved in UAS operations.* The 2021 version has been revised and published in September 2023.	**03/14/2024, M.Carlson:** *ISO 23665:2023, Unmanned aircraft systems — Training for personnel involved in UAS operations.* An revision was initiated in November 2023 under ISO/WD 23665.

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Gap P4: Training and Certification of UAS Flight Crew Members Other Than the Remote Pilot.

There is a standards gap with respect to the training and/or certification of aircrew other than the RPIC specifically around the following:

- Functional duties of the crew member
- Crew resource management principles
- Human factors
- General airmanship and situational awareness, and
- Emergency procedures

R&D Needed: No

Recommendation:

1. Develop a framework to classify additional UAS crew members around common flight activities identifying in particular those who directly or indirectly influence safety-of-flight.
2. Develop a standard(s) around training, evaluation, and best practices for the relevant UAS crew members other than the RPIC for UAS >55Lbs for activities affecting safety-of-flight.
3. Consider the possibility of recommending – through best practices or a standard – that all flight crew members actively participating in flight activities on UAS > 55Lbs meet the minimum training of a remote pilot for the applicable UA.

Priority: Medium

Organization: SAE, ASTM, AUVSI, JARUS, ISO, SAE ITC ARINC IA

v2 Status of Progress: Green

v2 Update: ASTM F3330-18, ASTM F3379-20, ASTM WK61763, WK62741; ISO/DIS 23665

Updates Since v2 was Published:

Other Committees with Relevant Work:

- **11/29/2021, JR**: New SAE G-35 Modeling, Simulation & Training for Emerging Aviation Technologies and Concepts Committee. Standards will be developed for the use of modeling and simulation to train and certify the flight crew to safely operate the aircraft (on-board, off-board, autonomous). Utilizing modeling and simulation to define new aviator type ratings for eVTOL/VTOL/CTOL and novel aircraft. It will also cover the use of modeling and simulation to certify an FSTD (Flight Simulator Training Device)
- SAE ITC, ARINC IA Systems Architecture and Interfaces subcommittee

Comments Received on Gap for Future Consideration:

New Published Standards	New In-Development Standards
03/14/2024, M.Carlson: *ISO 23665:2023, Unmanned aircraft systems — Training for personnel involved in UAS operations.* The 2021 version has been revised and published in September 2023. This document describes the procedures for training personnel who will be involved in the operation of unmanned aircraft systems (UAS). This document defines: a. knowledge, skill, attitude and qualification criteria that are needed for UAS pilots and training organizations that provide training to UAS remote pilots and other personnel involved in UAS operations; b. training curriculum and contents for specific learning courses; c. qualification and confirmation criteria for the training organizations; d. general procedures for providing training of UAS personnel; the requirements for a specific course as	**03/14/2024, M.Carlson:** *ISO 23665:2023, Unmanned aircraft systems — Training for personnel involved in UAS operations.* An revision was initiated in November 2023 under ISO/WD 23665. **12/04/2022, DF**: SAE AIR6850 - *Taxonomy for Emerging Aviation Technologies*: This document lists all relevant terms for G-35. For each term an accurate definition is included. The Terms of Reference document is used for collecting all relevant terms and their definition, which are necessary during the creation of the standards documents of G-35. **12/04/2022, DF**: SAE AS7062 - *Pilot Training and Qualification for VTOL-Capable Aircraft*: The scope of this standard will define the training and qualification necessary for certification/licensing of pilots operating VTOL-Capable Aircraft (AAM, eVTOL, SVO, etc.). This document will address the pilot training and qualification for licensing/certification necessary to operate

described in Annex A can be more restrictive in some cases.	VTOL-Capable Aircraft (also referred to as AAM, SVO, eVTOL, etc.).Regulatory guidance does not currently exist to address the pilot training and qualification criteria for on-board, off-board and autonomous operations of these new entrant aircraft, VTOL-Capable Aircraft. **12/04/2022, DF**: SAE AS7091 - *Technical Standards for VTOL-Capable aircraft Training Devices to support evaluation*: Develop Technical Standards for VTOL-Capable powered aircraft platform (AAM/SVO/eVTOL, etc.) training devices when conventional FSTD standards are not applicable. VTOL-Capable powered aircraft platforms that utilize unconventional methods and/or designs, use emerging technology require standards for training devices for operational usage. **12/04/2022, DF**: SAE AS7094 - *Modeling and Simulation to support certification of aircraft and avionics*: Develop standards for simulation/model-based certification of new (AAM/SVO/eVTOL variant) aircraft, simulation/model-based certification for new and supplemental systems, qualification methods for validating simulations. The use of digital twins in aerospace and other communities has opened up the ability to validate the performance of aircraft and avionics earlier, and to a higher level of fidelity.

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Gap P5: UAS Maintenance Technicians.	
Standards are needed for UAS maintenance technicians. Ensure that maintenance requirements are appropriate for the scale and risk of the UAS.	
R&D Needed: No	
Recommendation: Complete work on UAS maintenance technician standards currently in development	
Priority: High (Tier 2)	
Organization: ASTM, SAE, SAE ITC ARINC IA	
v2 Status of Progress: **Closed** ~~Green~~	
v2 Update: ASTM F3600-22 was published ~~WK60659~~	
Updates Since v2 was Published: **Comments Received on Gap for Future Consideration:**	
New Published Standards	**New In-Development Standards**
5/3/2023 PK: ASTM F3600-22 *Standard Guide for Unmanned Aircraft System (UAS) Maintenance Technician Qualification* (formerly WK60659*). The* purpose is to address the basic fundamental subject knowledge, task performance, and task knowledge activities and functions for UAS maintenance professionals to be titled UAS Maintenance Technicians.	**09/02/2024, PK: ASTM** WK88720 New Specification for Standard Guide for Advanced Air Mobility (AAM) Maintenance Technician Qualification. The purpose of this standard is to address the fundamental subject knowledge, task performance, and task knowledge activities and functions for Advanced Air Mobility (AAM) and other next generation aircraft maintenance professionals. With regards to this standard AAM are aircraft systems with innovative capabilities, including aircraft that use 2 or more lift or thrust units to generate powered lift and control during vertical takeoff or landing, that may be piloted, remotely piloted, or autonomous, including those powered by alternative propulsion and related systems.

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Gap P6: Compliance and Audit Programs.
The version 1.0 gap stated "No published UAS standards have been identified for UAS-specific compliance/audit programs. However, several are in development and will satisfy the market need."

R&D Needed: No	
Recommendation: The version 1.0 recommendation stated "Complete work on compliance and audit program standards currently in development."	
Priority: High (Tier 3)	
Organization: ASTM, AUVSI, SAE ITC ARINC IA	
v2 Status of Progress: **Closed**	
v2 Update: ASTM F3364-19, ASTM F3365-19	
Updates Since v2 was Published: **Comments Received on Gap for Future Consideration:**	
New Published Standards	**New In-Development Standards**

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Gap P7: Displays and Controls.1

Standards are needed for the suite of displays, controls, and onboard sensors that provide the UAS pilot with the range of sensory cues considered necessary for safe unmanned flight in the NAS.

The UAS pilot is deprived of a range of sensory cues that are available to the pilot of a manned aircraft. Hence, compared to the pilot of a manned aircraft, a UAS pilot must perform in relative "sensory isolation" from the aircraft under his/her control. Of particular interest are recent developments in the use of augmented reality and/or synthetic vision systems (SVS) to supplement sensor input. Such augmented reality displays can improve UAS flight control by reducing the cognitive demands on the UAS pilot.
The quality of visual sensor information presented to the UAS pilot will also be constrained by the bandwidth of the communications link between the aircraft and its CS. Data link bandwidth limits, for example, will limit the temporal resolution, spatial resolution, color capabilities and field of view of visual displays, and data transmission delays will delay feedback in response to operator control inputs.

R&D Needed: Yes

Recommendation:

2) Develop Minimum Operational Performance Standards (MOPS) for the suite of displays, controls, and onboard sensors that provide the UAS pilot with the range of sensory cues considered necessary for safe operation in the NAS.
3) Conduct further research and development in several areas, specifically, to:[2]
   a. Explore advanced display designs which might compensate for the lack of direct sensory input from the environment.
   b. Examine the potential use of multimodal displays in countering UAS pilot sensory isolation, and to determine the optimal design of such displays for offloading visual information processing demands. A related point is that multimodal operator controls (e.g., speech commands) may also help to distribute workload across sensory and response channels, and should also be explored.
   c. Determine the effects of lowered spatial and/or temporal resolution and of restricted field of view on other aspects of UAS and payload sensor control (e.g., flight control during takeoff and landing, traffic detection).
4) Examine the design of displays to circumvent such difficulties, and the circumstances that may dictate levels of tradeoffs between the different display aspects (e.g., when can a longer time delay be accepted if it provides higher image resolution). For example, research indicates that a UAS pilot's ability to track a target with a payload camera is impaired by low temporal update rates and long transmission delays.

Priority: High (Tier 3)	
Organization: RTCA, NASA, SAE, INCOSE, ASTM, EUROCAE, ICAO, SAE ITC ARINC IA	
v2 Status of Progress: Unknown	
v2 Update: ICAO, EUROCAE	
Updates Since v2 was Published: **Comments Received on Gap for Future Consideration:**	
New Published Standards	**New In-Development Standards**

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[1] Adapted from McCarley, J. & Wickens, C. (2005): pp1-3
[2] Ibid

<table>
<tr><td colspan="2">Gap P9: Human Factors in UAS Operations.[3]</td></tr>
<tr><td colspan="2">Standards are needed to address human factors-related issues in UAS operations.</td></tr>
<tr><td colspan="2">R&D Needed: Yes</td></tr>
<tr><td colspan="2">Recommendation:
1) Complete in-development standards, and develop new standards for UAS human factors-related issues, including those relevant to the composition, selection, and training of UAS flight crews.
2) Conduct further research to:[4]
a. Determine the crew size and structure necessary for various categories of UAS missions in the NAS, and to explore display designs and automated aids that might reduce crew demands and potentially allow a single pilot to operate multiple UASs simultaneously.
b. Develop techniques to better understand and facilitate crew communications, with particular focus on inter-crew coordination during the hand off of UAS control from one team of operators to another.
c. Identify specific ways in which sensory isolation affects UAS pilot performance in various tasks and stages of flight.
d. Examine the concept of “shared fate,” as related to UAS operations. There might be negative consequences from the pilot not having a shared fate with the aircraft, but whether an exocentric viewpoint diminishes the feeling of shared fate or not is unknown.
e. Determine the circumstances (e.g., low time delay vs. high time delay, normal operations vs. conflict avoidance and/or system failure modes) under which each form of UAS control is optimal. Of particular importance will be research to determine the optimal method of UAS control during takeoff and landing, as military data indicate that a disproportionate number of the accidents for which human error is a contributing factor occur during these phases of flight.
f. Examine the interaction of human operators and automated systems in UAS flight. For example, allocation of flight control to an autopilot may improve the UAS pilot’s performance on concurrent visual mission and system fault detection tasks.
g. Determine which of the UAS pilot’s tasks (e.g., flight control, traffic detection, system failure detection, etc.) should be automated and what levels of automation are optimal.</td></tr>
<tr><td colspan="2">Priority: High (Tier 2)</td></tr>
<tr><td colspan="2">Organization: RTCA, NFPA, MITRE, NASA, ICAO, SAE ITC ARINC IA</td></tr>
<tr><td colspan="2">v2 Status of Progress: Unknown</td></tr>
<tr><td colspan="2">v2 Update: None provided at this time.</td></tr>
<tr><td colspan="2">Updates Since v2 was Published:
Comments Received on Gap for Future Consideration:
• 11/22/21, Comment from Ken Holland, NFPA: Some of this is already covered in 2400 but what isn't covered doesn’t prohibit the AHJ from doing any of these items.</td></tr>
<tr><td>New Published Standards</td><td>New In-Development Standards

09/02/2024, PK: ASTM WK90326 New Practice for UAS Ground Control System Human Factors will evaluate existing manned and unmanned aviation guidance on human factors to define the minimum set of requirements that should be applied to GCS where the crewmember is beyond visual line of sight of an automated Unmanned Aircraft (UA). Additional requirements specific to multi-UAS, or other specialized operations will be addressed in other documentation.</td></tr>
</table>

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Chapter 10 Recommendations/Comments Since v2 was Published:

- No recommendations received relation of publication of this report.

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[3] Adapted from McCarley, J. & Wickens, C. (2005): pp3-4

[4] Ibid

General Comments and Updates Related to the UASSC Roadmap v2

Recommendations/Comments Since v2 was Published
• **05/19/2023, Renee Stevens**: Regarding the title of the UASSC Activity - Progress to the updated term uncrewed. The Pentagon, European Union, Canada, Australia, and Industry have already progressed toward updating the term unmanned to more appropriate terms i.e., *uncrewed*, *crewless*, or *autonomous.*

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ANSI UNMANNED AIRCRAFT SYSTEMS STANDARDIZATION COLLABORATIVE

UASSC Overview

The ANSI UASSC's mission is to coordinate and accelerate the development of the standards and conformity assessment programs needed to facilitate the safe integration of unmanned aircraft systems (UAS) – commonly known as drones – into the national airspace system (NAS) of the United States. The collaborative is also focused on international coordination and adaptability. The overarching goal is to foster the growth of the UAS market, with emphasis on civil, commercial, and public safety applications. The aim is to describe the current and desired future standardization landscape, articulate standardization needs, drive coordinated standards activity, minimize duplication of effort, and inform resource allocation for standards participation.

UASSC Standardization Roadmap

The UASSC released version 1.0 of its standardization roadmap in December 2018, and version 2.0 in June 2020. Like its predecessor, **version 2.0 of the roadmap** identifies existing standards and standards in development, defines where gaps exist, and makes recommendations for priority areas where there is a perceived need for additional standardization including pre-standardization research and development (R&D). The roadmap includes proposed timelines for completion of the work and lists organizations that potentially can perform the work.

Issues are addressed under the broad headings of: Airworthiness; Flight Operations; Personnel Training, Qualifications, and Certification; Infrastructure Inspections; Environmental Applications; Commercial Services; Workplace Safety; and Public Safety Operations. The document also includes brief overviews of the UAS activities of the FAA, other U.S. federal government agencies, standards developing organizations (SDOs), and various industry groups.

ANSI

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