June 2022 Progress Report on ANSI UASSC Roadmap v2 Gaps

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 deadline for input (12/13/2021) on the December 2021 progress report which was published 12/14/2021**. 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.

Updates, corrections, and suggested edits should be sent to uassc@ansi.org.

Navigational links:

- Control + click in table of contents takes you to the chapter list of gaps
- Control + click in the chapter list of gaps (organized by high, medium, low priority) takes you to the gap
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Medium Priority

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

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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)

Commented [GU1]: **6/1/2022 Brandon Suarez**

Suggest that ANSI add a new GAP:

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.

Commented [rh2]: 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.

Commented [CB3]: Lissa Bern, Collins, 5/31/22

Has "regular" been defined or should it be removed? Should a specific CONOPS be used for definition or example explained for regular part 107?

Commented [rh4]: Use of "regular" when referencing Part 107 suggests other Part 107 operations are exempt. Recommend definition of regular and its intent to operations.

Organization: ASTM, SAE, ISO, EUROCAE
v2 Status of Progress: Green
v2 Update: • SAE S-18A Autonomy WG/EUROCAE WG-63 SG-1 AIR7121 • SAE S-18/EUROCAE WG-63: AS7209, ARP4754B, ARP4761A • SAE A-6A3: ARP94910A • ASTM F38: F3563-22, WK72958, WK72960 • 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

New Published Standards	New In-Development Standards
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. **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. 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.	**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* **6/10/2021, JM:** In development in ISO/TC 20/SC16: *ISO/AWI 5309, Vibration test methods for lightweight and small civil UAS ISO/AWI 5332, Test methods for civil lightweight and small UAS under low pressure conditions* **5/24/2021, AS:** RTCA expects to have a version A of DO-380 published in the 2025 timeframe.

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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: • 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

Commented [rh5]: 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.?

• 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: **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

New Published Standards	New In-Development Standards
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.	**5/24/2022 - RTCA** *DO-346A AeroMACS MOPS* update to address the required changes to ensure compatibility with other communication systems and standards Expected Publication December 2022. **5/24/2022 - RTCA** *MASPS for the Internet Protocol Suite for avionics certification*. Expected Publication March 2023. **5/24/2022 - RTCA** - *Certification profiles for TCP / UDP / IP / DHCP / Routing / Mobility / Multilink protocols based on IETF RFCs* Expected Publication March 2023. **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:

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

New Published Standards

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. It should be useful to designers, manufacturers, installers, service providers and users for systems. Compliance with this standard is recommended as one means of assuring that the system and each subsystem will perform its intended function(s) satisfactorily under all conditions normally encountered in routine aeronautical operations for the environments intended. One potential use of the MASPS is to support early system/application development and prototyping. Additionally, the MASPS may be implemented by one or more regulatory documents and/or advisory documents (e.g., certifications, authorizations, approvals, commissioning, advisory circulars, notices, etc.) and may be implemented in part or in total.

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.

New In-Development Standards

4/22/2021, JM: According to the **ISO/IEC JTC1 AG2 Technology Trend Report on Drone**, there are four drone standards being developed at present by ISO/IEC JTC1/SC6, Telecommunications and information exchange between systems:
1) ***ISO/IEC AWI 4005-1**: Telecommunications and information exchange between systems — Low altitude drone area network (LADAN) — Part 1: Communication model and requirements*
*2) **ISO/IEC AWI 4005-2**: Telecommunications and information exchange between systems — Low altitude drone area network (LADAN) — Part 2: Physical and data link protocols for shared communication*
*3) **ISO/IEC AWI 4005-3**: Telecommunications and information exchange between systems — Low altitude drone area network (LADAN) — Part 3: Physical and data link protocols for control communication.*
*4) **ISO/IEC AWI 4005-4**: Telecommunications and information exchange between systems — Low altitude drone area network (LADAN) — Part 4: Physical and data link protocols for video communication.*

9/25/2020, MW: ASTM *WK74215 - Standard Specification for Detect and Avoid System Performance Requirements* is a work item revision to existing standard F3442/F3442M-20 developed by Committee F38.01.

Commented [rh6]: 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.)

Commented [rh7]: *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.*

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, 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. 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. **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.* The Detect and Avoid (DAA) system was specified to assist the remote pilot with operating an aircraft safely in the NAS. All aircraft flying in the NAS must comply with the operating rules of 14 CFR, specifically, §§ 91.3, 91.111, 91.113, 91.123 and 91.181(b), which address see and avoid, collision avoidance, right of way rules, and remaining well clear. The DAA equipment may also be used to comply with the duties in International Civil Aviation Organization (ICAO) Annex 2 to the Convention on International Civil Aviation, specifically Chapter 2, Paragraph 2.3.1. These operating regulations assumed that a pilot would be onboard the aircraft and would be able to fully comply with these rules. 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. Payload communications specifically include communications associated with the UA mission payloads, which do not contain safety-of-flight information. **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). Volume I contains system characteristics that should be of value to users, designers, manufacturers, and installers. These characteristics are intended to accommodate the requirements of various users. Vol II provides the Algorithm Design Description (ADD) for the Surveillance and Tracking Module (STM) and the Threat Resolution Module (TRM) of the next generation Airborne Collision Avoidance System (ACAS X). The algorithms are described at a sufficiently high level to allow for implementation in a variety of software languages and hardware platforms, thereby providing maximum freedom to manufacturers while ensuring the intended output from the system.	
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. The intended function of the radar is to detect and generate tracks for all airborne traffic within the radar detection volume. The onboard radar complements other airborne surveillance sensors by providing detection of non-cooperative traffic. The track should be established at sufficient range and with sufficient accuracy to enable the system to plan and execute a maneuver to keep the Unmanned Aircraft (UA) well clear of other traffic and avoid collisions. This document has the detailed performance and environmental requirements of the radar along with their verification methods. Verification includes bench tests, flight tests and environmental tests. Recommendations and flight tests for installed performance are also provided.	

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. Compliance with these MASPS does not ensure that the equipment will be approved for operation. These MASPS do not address the functionality or performance of CAS beyond the requirement of interoperability between CAS. Minimum Operational Performance Standards (MOPS) address safety and operational suitability performance criteria. Any MOPS that are developed for a future CAS should use these MASPS as guidance for its interoperability with existing CAS. Regulatory application of this document is the sole responsibility of the appropriate regulatory authority.	
7/21/2020, JM: ASTM *F3442/F3442M - Standard Specification for Detect and Avoid System Performance Requirements* is a new standard, now available	

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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	
v2 Status of Progress: Green	
v2 Update: Numerous standards are in development.	
Updates Since v2 was Published: **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)*	
New Published Standards **03/2022, PM: 3GPP** *TS 23.256, Support of Uncrewed Aerial Systems (UAS) connectivity, identification and tracking; Stage 2 (R17)*	**New In-Development Standards** **5/24/2022, RTCA SC-228:** Joint development with EUROCAE WG-105 of a MOPS for Cellular C2 Link. Estimated publication date March, 2023

Commented [rh8]: 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.

03/2022, PM: 3GPP *TS 23.255, Application layer support for Uncrewed Aerial System (UAS); Functional architecture and information flows (R17)* **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.	**6/2/2022, PM: 3GPP** *TR 23.700-58 (Ongoing work for R18) Study on Security Aspects of UAS. 3GPP (Post-R17) Study of Further Architecture Enhancement for UAV and UAM*. This work will include broadcast remote ID over cellular, and detect and avoid capability using PC5 direct cellular communications. **6/2/2022, PM: 3GPP** *(Agreed work for R18 to commence 2H22) 5G New Radio (NR) Enhancements for UAS/UAV*. This work will port LTE enhancements for UAS/UAV to 5G NR and will include support for PC5 direct cellular communications. **11/28/2021, JM: IEEE** *P1937.8, Standard for Functional and Interface Requirements for Unmanned Aerial Vehicle (UAV) Cellular Communication Terminals*. This standard specifies functional requirements and interface requirements for cellular communication terminals in Unmanned Aerial Vehicles. It provides specifications for hardware, signaling, data interfaces, environmental characteristics, performance, reliability, security, and configuration management.

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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), 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

New Published Standards	New In-Development Standards
	6/1/2022, CBD: RTCA SC-228: WG4: Guidance on Navigation for UAS. This guidance document is currently in FRAC process at RTCA, will be published by RTCA as early as October 2022 **05/20/2022, AF**: **EUROCAE WG-105** is finalizing ED-301: “Guidelines for the Use of Multi-GNSS Solutions for UAS Specific Category – Low Risk Operations SAIL I & II”- Publication expected in July, 2022 **11/10/2021**: EUROCAE WG-105 is developing Guidelines on the use of multi-GNSS for low-risk operations with the intent to provide guidance on how to determine navigation error when using multi-GNSS source **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. **5/28/2021**, OGC GeoPose Standard: https://www.ogc.org/projects/groups/geoposeswg. 6-degree of freedom pose of position and orientation in Earth coordinates; forecast publication in Q3 2021. **2/18/2021, JM:** ASTM WK75923 -Specification for Positioning Assurance, Navigation, and Time

Commented [CB9]: Alexandra Florin, Wing – November 10, 2021
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

	Synchronization for Unmanned Aircraft Systems developed by Committee F38.01

Commented [CB10]: 5/24/2022 Phil Kenul, ASTM

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 for Scope.

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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	
New Published Standards **5/24/2022:** RTCA SC-159 DO-235C Interference Report L1 Report published March 2022	**New In-Development Standards** **5/24/2022:** RTCA SC-159 is producing DO292A Interference L5 Report estimated Publication September 2022. **5/25/2021**, RTCA SC-228 WG4 is developing Guidance Material for UAS Navigation

Commented [fl11]: 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

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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

Commented [rh12]: The scope of this activity should include both on-board DAA and ground-based DAA as architectural alternatives to address SWAP and cost constraints.

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-20 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

New Published Standards	**New In-Development Standards**
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. These standards specify the GBSS characteristics that should be useful for designers, manufacturers, installers and users of the equipment. Note that in this context, surveillance "systems" includes one or more networked non-cooperative sensors (e.g., radar and lidar), Electro-Optical/Infrared (EO/IR), etc.) needed to meet these MOPS. Also note that these MOPS do not address cooperative ground-based sensors (e.g., radar beacon, Mode Select (Mode S), Automatic Dependent Surveillance-Broadcast (ADS B), multilateration, etc.). **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 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. 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	**6/1/2022: RTCA SC-147** has kicked off development of ACAS Xr, which focuses on DAA for rotorcraft and eVTOLs, building on work in ACAS sXU. **05/2022, PM: 3GPP** *TR 23.700-58 (Ongoing work for R18) Study of Further Architecture Enhancement for UAV and UAM.* This work will include broadcast remote ID over cellular, and detect and avoid capability using PC5 direct cellular communications. **5/17/2022, 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 is in last call for comments. **5/17/2022, RM:** IETF draft-ietf-drip-auth - *DRIP Entity Tag Authentication Formats & Protocols for Broadcast Remote ID* is in final RFC editor comments. **5/17/2022, RM:** *RFC 9153 Drone Remote Identification Protocol (DRIP) Requirements and Terminology*, informational but essential. Under review. **11/10/2021:** In 2022, EUROCAE WG-105 will develop a European industry position report on RTCA SC-147 ACAS sXu to analyze whether the RTCA SC-147 ACAS sXu solution would be implementable in certain airspace or taking into account certain constraints in Europe. As well EUROCAE WG-105 is currently developing **Minimum Operational Performance Standard (MOPS) for DAA in Very Low-Level operations** and taking into account U-Space services laid down by regulation (EU) 2021/664. **9/25/2020, MW: ASTM** *WK74215 - Standard Specification for Detect and Avoid System Performance Requirements* is a work item revision to existing standard F3442/F3442M-20 developed by Committee F38.01.

Commented [JM13]: 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

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. **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. 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. **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.* The Detect and Avoid (DAA) system was specified to assist the remote pilot with operating an aircraft safely in the NAS. All aircraft flying in the NAS must comply with the operating rules of 14 CFR, specifically, §§ 91.3, 91.111, 91.113, 91.123 and 91.181(b), which address see and avoid, collision avoidance, right of way rules, and remaining well clear. The DAA equipment may also be used to comply with the duties in International Civil Aviation Organization (ICAO) Annex 2 to the Convention on International Civil Aviation, specifically Chapter 2, Paragraph 2.3.1. These operating regulations assumed that a pilot would be onboard the aircraft and would be able to fully comply with these rules. 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-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). Volume I contains system characteristics that should be of value to users, designers, manufacturers, and installers. These characteristics are intended to accommodate the requirements of various users. Vol II provides the Algorithm Design Description (ADD) for the Surveillance and Tracking Module (STM) and the Threat Resolution Module (TRM) of the next generation Airborne Collision Avoidance System (ACAS X). The algorithms are described at a sufficiently high level to allow for implementation in a variety of software languages and hardware platforms, thereby providing maximum freedom to manufacturers while ensuring the intended output from the system. **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. Payload communications specifically include communications associated with the UA mission payloads, which do not contain safety-of-flight information.	
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. Compliance with these MASPS does not ensure that the equipment will be approved for operation. These MASPS do not address the functionality or performance of CAS beyond the requirement of interoperability between CAS. Minimum Operational Performance Standards (MOPS) address safety and operational suitability performance criteria. Any MOPS that are developed for a future CAS should use these MASPS as guidance for its interoperability with existing CAS. Regulatory application of this document is the sole responsibility of the appropriate regulatory authority.	
9/10/2020, JM: RTCA *DO-366A-Minimum Operational Performance Standards (MOPS) for Air-to-Air Radar for Traffic Surveillance*	

7/21/2020, JM: ASTM *F3442/F3442M - Standard Specification for Detect and Avoid System Performance Requirements* is a new standard, now available	

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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 WK68098 Revision of F3201-16 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

New Published Standards	New In-Development Standards
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*	**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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Commented [CB14]: 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

[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 • SAE ITC, ARINC IA System Architecture and Interfaces subcommittee

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
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.
Priority: High (Tier 1)
Organization: RTCA, EUROCAE, SAE, ASTM, JARUS, AIA, IETF, ICAO IATF, SAE ITC ARINC IA, 3GPP
v2 Status of Progress: Green
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)
Updates Since v2 was Published: **Other Committees with Relevant Work:** • SAE ITC, ARINC IA Network Infrastructure and Security subcommittee

New Published Standards	New In-Development Standards

Commented [CB15]: 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."

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.* See https://shop.cta.tech/collections/standards/products/baseline-cybersecurity-for-small-unmanned-aerial-systems-cta-2088-1. 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, will be published. Scope: 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. This standard is not intended to replace any other cybersecurity guidance but to augment protections for UAS. This standard also does not cover safety of UAS flight. The standard is intended for manufacturers to inform users on how their data is disseminated. Users of UAS can make informed decisions on how to manage their data. 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.	**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 **05/17/2022 RGM:** IETF *DRIP Entity Tag Registration & Lookup* draft-ietf-drip-registries - DRIP Registries secure registration for UAS and Operators by the DRIP workgroup. Formerly draft-wiethuechter-drip-registries. **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. **5/17/2022, RGM:** IETF *DRIP Entity Tag (DET) for Unmanned Aircraft System Remote ID (UAS RID)* draft-ietf-drip-rid - is a work item to provide trustworthy Remote ID by the DRIP workgroup. In last call for comments. **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, UL, IEC, IEEE, ISO, 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 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

New Published Standards	**New In-Development Standards**
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.	**6/22/2021, MPD: SAE:** *ARP8689 Endurance tests for Aircraft Electric Engine* **5/24/2021, AS: RTCA** expects to have a version A of DO-380 published in the 2025 timeframe. **11/20/2020, MD: SAE** *AIR7357, Megawatt and Extreme Fast Charging for Aircraft*

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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, UL, IEC, IEEE, ISO
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 AE-7F Hydrogen and Fuel Cells

New Published Standards	**New In-Development Standards**
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*	**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 • *ARP8689 Endurance tests for Aircraft Electric Engine AS6679 Liquid Hydrogen Storage for Aviation* • *AIR6387 Aircraft Electrical Power Systems. Modeling and Simulation. Validation and Verification Methods*. Noted in roadmap v2 • *SAE AS6968 Connection Set of Conductive Charging for Light Electric Aircraft.* Noted in roadmap v2 **3/8/2021, MPD:** SAE E-40 Electrified Propulsion Committee launched ***ARP8689 Endurance tests for Aircraft Electric Engine*** **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.	
Updates Since v2 was Published:	
New Published Standards	**New In-Development Standards** **11/29/2021: JR: SAE** • *ARP4721/1A Monitoring Aircraft Noise and Operations: System Description, Acquisition, and Operation* • *ARP4721/2A Monitoring Aircraft Noise and Operations: System Validation*

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Gap A16: Mitigation Systems for Various 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:**

Commented [rh16]: 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.

• 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

New Published Standards	New In-Development Standards

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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:	
New Published Standards **7/15/2020, JM**: **ASTM** *F3389/F3389M - Standard Test Method for Assessing the Safety of Small Unmanned Aircraft Impacts* is a new standard, now available.	**New In-Development Standards** **3/23/2021, JM: ASTM** *WK76302 - Standard Test Method for Assessing the Safety of Small Unmanned Aircraft Impacts* is a work item revision to existing standard F3389/F3389M-20 developed by Committee F38.01 **7/17/2020, JM: ASTM** *WK73601 - Standard Specification for Small Unmanned Aircraft System (sUAS) Parachutes* is a work item revision to existing standard F3322-18 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	
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), UL, 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 • Underwriters Laboratories: UL 4600
Updates Since v2 was Published: **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"

New Published Standards	New In-Development Standards
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*	**6/1/2022, DK, ARPAC AC:** Upcoming products of the ARPAC AC, targeted for CY22 are: • 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. **6/22/2021, MPD: SAE** *AIR6987, Artificial Intelligence in Aeronautical Systems: Taxonomy* **SA**E *AS6983, Process Standard for Development and Certification/Approval of Aeronautical Safety-Related Products Implementing AI* Both of the above are listed as in development in 6.11 in v2. **02/01/2021, RG: SAE** *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).

Commented [CB17]: Deborah Kirkman, Flight Safety Foundation, June 1, 2022

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.

	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)	
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**

Commented [rh18]: The scope of this activity should include both on-board DAA and ground-based DAA as architectural alternatives to address SWAP and cost constraints.

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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).	
New Published Standards	**New In-Development Standards**

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.	**5/17/2022 RM: IETF DRIP WG:** draft-ietf-drip-registries proposes methodologies for blockchain ledgers for UAS registration actions. **6/22/2021, MPD: SAE** • *AIR7123 eARC – Electronic Authorized Release Certificate* • *AIR7356 Blockchain for Unmanned Aircraft Systems and Advanced Air Mobility* • *AIR7367 Requirements, Specifications and Framework of a Digital Thread in Aircraft Life Cycle Management*

Other Chapter 6 Activity – Relevance to Gaps Not Yet Determined

New Published Standards

New In-Development Standards
6/10/2021, JM: In development in ISO/TC 20/SC16:
ISO/WD TR 5337, Environmental engineering program guideline for UA

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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

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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)

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:

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: **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) **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

New Published Standards	**New In-Development Standards**
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.	**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. **2/18/2021, JM:** ASTM *WK75923 -Specification for Positioning Assurance, Navigation, and Time Synchronization for Unmanned Aircraft Systems* developed by Committee F38.01

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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 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)

New Published Standards	**New In-Development Standards**
7/15/2020, JM: ASTM *F3389/F3389M - Standard Test Method for Assessing the Safety of Small Unmanned Aircraft Impacts* is a new standard, now available.	**3/23/2021, JM:** ASTM *WK76302 - Standard Test Method for Assessing the Safety of Small Unmanned Aircraft Impacts* is a work item revision to existing standard F3389/F3389M-20 developed by Committee F38.01 **7/17/2020, JM:** ASTM *WK73601 - Standard Specification for Small Unmanned Aircraft System (sUAS) Parachutes* is a work item revision to existing standard F3322-18 developed by Committee F38.01

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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)? 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?
Recommendation: Encourage relevant research, amending of existing standards, and drafting of new standards (where applicable).
Priority: High (Tier 2)
Organization: RTCA, SAE, NOAA, WMO, NASA, universities, National Science Foundation (NSF) National Center for Atmospheric Research (NCAR), ASTM, SAE ITC ARINC IA
v2 Status of Progress: Yellow
v2 Update: NASA, ASTM F38 Weather Supplemental Data Service Provider Sub-Group
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

New Published Standards	**New In-Development Standards**
11/8/2021, Scott Simmons: *OGC 19-086r4: OGC API – Environmental Data Retrieval Standard* was published 8/13/2021. Standard permits extraction of multidimensional data (focus on weather) along a flight corridor or operational volume.	**5/11/2021, JM**: *ASTM WK73142, New Specification for Weather Supplemental Data Service Provider (SDSP) Performance.* WK73142 is mentioned in v2 in relation to this gap.

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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: **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 here: https://www.ogc.org/pressroom/pressreleases/4593 **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

New Published Standards	New In-Development Standards
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	6/3/2022: SS: OGC is finalizing the Cloud Optimized GeoTIFF (COG) Standard for publication in Q3 2022.

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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.
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:

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.	**2/23/2021, JM:** ASTM *WK75981 -Specification for Vertiport Automation Supplemental Data Service Provider (SDSP)* developed by Committee F38.02

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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

Commented [JM19]: 6/3/2022, SS: The Command and Control project is still underway, but a draft specification is expected in 2022.

Commented [CB20]: **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."

Commented [JM21]: Brent Klavon, ANRA.

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.

Commented [CB22]: **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.

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)

New Published Standards	**New In-Development Standards**
5/24/2022, Phil Kenul: ASTM *F3586-22 Standard Practice for Remote ID Means of Compliance to Federal Aviation Administration Regulations Part 89* developed by Committee F38.02. **5/23/2022, Phil Kenul:** ASTM WK76077 is now approved as *F3411-22 Standard Specification for Remote ID and Tracking* developed by Committee F38.02. Revisions published since the 2019 version.	**05/2022, PM: 3GPP** *TR 23.700-58 (Ongoing work for R18) Study of Further Architecture Enhancement for UAV and UAM.* This work will include broadcast remote ID over cellular, and detect and avoid capability using PC5 direct cellular communications. **5/31/2021, RGM:** IETF draft-ietf-drip-rid - UAS Remote ID is a work item to provide trustworthy Remote ID by the DRIP workgroup **5/31/2021, RGM:** IETF draft-ietf-drip-auth - DRIP Authentication Formats is a work item to provide authentication for all Remote ID broadcast messages by the DRIP workgroup

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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
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)

New Published Standards	New In-Development Standards
5/23/2022, Phil Kenul: ASTM WK76077 was approved as *F3411-22 Standard Specification for Remote ID and Tracking* developed by Committee F38.02. Revisions published since the 2019 version. **03/2022, PM: 3GPP** *TS 23.256, Support of Uncrewed Aerial Systems (UAS) connectivity, identification and tracking*; Stage 2 (R17) **3/31/2021, PM: 3GPP** *TR 23.754, Study on supporting UAS connectivity, ID, and tracking (R17)*	**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 & SC:** *IETF draft-ietf-drip-rid - UAS Remote ID* is a work item to provide trustworthy Remote ID by the DRIP workgroup. Also, gateways between Direct Broadcast and Network Publishing, e.g. IETF DRIP Crowd Sourced RID. **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

Commented [is23]: ... And 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: **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.	
New Published Standards **5/31/2022 PM, AIA:** *NAS9948 UAS Data Protection and Privacy Standard Practice*	**New In-Development Standards** 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.

Commented [CB24]: 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.

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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: **6/10/2021,** OGC Command and Control data exchange format Interoperability Experiment. Will include geofence data exchange and provisioning	
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:

New Published Standards	New In-Development Standards
	11/12/2021, PK: ASTM *WK59317, Vertiport Design*. Mentioned in v2. **6/10/2021, JM:** In development in ISO/TC 20/SC17, on airport infrastructure: *ISO/AWI 5491, Vertiports — Infrastructure and equipment for Vertical Take-Off and Landing (VTOL) of electrically powered cargo Unmanned Aircraft System (UAS)*

Commented [JM25]: 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.

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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:

New Published Standards	New In-Development Standards

Other Chapter 7 Activity – Relevance to Gaps Not Yet Determined

New Published Standards

New In-Development Standards

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

High Priority (Tier 1) (Most Critical)

High Priority (Tier 2) (Critical)

High Priority (Tier 3) (Least Critical)

Medium Priority

Low Priority

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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:	
New Published Standards	**New In-Development Standards** **11/18/2021, LF**: *AMPP 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 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:	
New Published Standards	**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:	
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:

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:

New Published Standards	**New In-Development Standards**
	11/18/2021, LF: *AMPP 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:

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:

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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)	
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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:	
New Published Standards **11/25/2020, SK,** *IEEE P2821, Guide for Unmanned Aerial Vehicle-based Patrol Inspection System for Transmission Lines,* was published.	**New In-Development Standards** **11/25/21 JM:** *IEEE P1936.2, 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

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

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:	
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 AMPP (formerly NACE) SP21435 and AMPP (formerly NACE) SP21436 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:	
New Published Standards	**New In-Development Standards**

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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**

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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:	
New Published Standards **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.	**New In-Development Standards** 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:	
New Published Standards **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	**New In-Development Standards** RTCA SC-228 WG-1 OSED for Surface Operations, Small Package Delivery, Air Taxi Operations

(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.	

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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:	
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:	
New Published Standards	**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. *IEEE P1937.7, 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.

Commented [JM26]: 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

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

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Other Chapter 8 Activity – Relevance to Gaps Not Yet Determined

New Published Standards

New In-Development Standards

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Chapter 9. Flight Operations Standards: Public Safety – WG4

High Priority (Tier 1) (Most Critical)

- **Gap S9: UAS Mitigation (8/17/2020)**
- **New Gap S11: UAS Detection (12/3/2021)**

High Priority (Tier 2) (Critical)

- **Gap S1: Use of sUAS for Public Safety Operations (Closed) (11/22/2021)**
- **New Gap S13: Data Format for Public Safety sUAS Operations (11/22/2021)**

High Priority (Tier 3) (Least Critical)

- **Gap S3: Transport and Post-Crash Procedures Involving Biohazards (11/22/2021)**
- **Gap S5: Payload Interface and Control for Public Safety Operations (11/22/2021)**

Medium Priority

- **Gap S2: Hazardous Materials Response and Transport Using a UAS (11/22/2021)**
- **Gap S4: Forensic Investigations Photogrammetry (6/10/2021)**
- **Gap S6: sUAS Forward-Looking Infrared (IR) Camera Sensor Capabilities (11/22/2021)**
- **Gap S8: UAS Response Robots (11/22/2021)**
- **New Gap S10: Use of Tethered UAS for Public Safety Operations (11/22/2021)**
- **New Gap S12: Integration of UAS into FEMA ICS Operations Section, Air Operations Branch**

Low Priority

- **Gap S7: Need for Command and Control Software Specifications for Automated Missions during Emergency Response (11/22/2021)**

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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.	
New Published Standards	**New In-Development Standards** **2/11/2021, JM:** *ASTM WK75861 - Standard Guide for Training for Public Safety Remote Pilot of Unmanned Aircraft Systems (UAS) Endorsement* is a work item revision to existing standard F3379-20 developed by Committee F38.03

Commented [JM27]: 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.

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

Commented [JM28]: 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.

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

Commented [JM29]: 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.

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

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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. Existing 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 standards for the UAS-to-payload interface, which includes hardware mounting, electrical connections, 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

Commented [CB30]: 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).

Commented [JM31]: 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.

Updates Since v2 was Published:	
New Published 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.	**New In-Development Standards**

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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:	
New Published 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.	**New In-Development Standards**

Commented [JM32]: 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.

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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

Commented [JM33]: 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"

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.	
Updates Since v2 was Published:	
New Published Standards	**New In-Development Standards** **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:	
New Published Standards	**New In-Development Standards**

Commented [JM34]: 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.

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

Commented [JM35]: 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.

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

12/3/2021, JM: *[RTCA DO-389 – OSED for Counter UAS in Controlled Airspace, Counter Unmanned Aircraft System](#),* was issued 3/18/2021. To prevent disruptions from unauthorized Unmanned Aircraft System (UAS), the airspace around an airport needs to be protected and these activities need to be detected and reported at the earliest possible stage to flight crews, Air Traffic Control, airports and responsible authorities. In accordance with national regulations, neutralization of the UAS, through the Unmanned Aircraft (UA), the Command & Control Datalink (C2 Link), the Remote Pilot Station (RPS) or even the Remote Pilot (RP), could be considered as part of a risk-based response. The scope of this Operational Services and Environment Definition (OSED) is to introduce the overall capability of a C-UAS System, including the detection capabilities of unauthorized UAS in a protected area of influence around an airport and address the resulting hazard or threat, in a risk-based balanced manner. 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 (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.	RTCA SPR and INTEROP for Counter UAS Systems

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

Commented [JM36]: 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.

Other Chapter 9 Activity – Relevance to Gaps Not Yet Determined

New Published Standards

New In-Development Standards

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

High Priority (Tier 2) (Critical)
- **Gap P2: Manuals (11/22/2021)**
- **Gap P3: Instructors and Functional Area Qualification (6/10/2021)**
- **Gap P5: UAS Maintenance Technicians (6/10/2021)**
- **Gap P9: Human Factors in UAS Operations (11/22/2021)**

High Priority (Tier 3) (Least Critical)
- **Gap P1: Terminology (6/10/2021)**
- **Gap P6: Compliance and Audit Programs (Closed) (6/10/2021)**
- **Gap P7: Displays and Controls (6/10/2021)**

Medium Priority
- **Gap P4: Training and Certification of UAS Flight Crew Members Other Than the Remote Pilot (11/29/2021)**

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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	
New Published Standards **6/10/2021, JM:** *ISO 21384-4:2020, Unmanned aircraft systems — Part 4: Vocabulary* was published in May 2020 **11/17/2020, MW:** *ASTM F3341/F3341M, Standard Terminology for Unmanned Aircraft Systems* has been revised to F3341/F3341M-20a developed by Committee F38.03, ASTM BOS Volume 15.09.	**New In-Development Standards** **10/12/2020, MW:** *ASTM WK73458, WK73459, WK73789 – WK3794 and WK73797 – WK73802, Standard Terminology for Unmanned Aircraft Systems* are work items revising existing standard F3341/F3341M-20 developed by Committee F38.03

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

Commented [JM37]: 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.

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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:	
New Published Standards **6/10/2021, JM:** *ISO 23665:2021, Unmanned aircraft systems — Training for personnel involved in UAS operations,* was published in January 2021.	**New In-Development Standards** **2/11/2021, JM:** *ASTM WK75861 - Standard Guide for Training for Public Safety Remote Pilot of Unmanned Aircraft Systems (UAS) Endorsement* is a work item revision to existing standard F3379-20 developed by Committee F38.03

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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

New Published Standards	New In-Development Standards
6/10/2021, JM: *ISO 23665:2021, Unmanned aircraft systems — Training for personnel involved in UAS operations*, was published in January 2021.	**2/11/2021, JM:** *ASTM WK75861 - Standard Guide for Training for Public Safety Remote Pilot of Unmanned Aircraft Systems (UAS) Endorsement* is a work item revision to existing standard F3379-20 developed by Committee F38.03

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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: Green
v2 Update: ASTM WK60659
Updates Since v2 was Published:

New Published Standards	New In-Development Standards

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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:	
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: 1) 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. 2) 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). 3) 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)

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

[2] Ibid

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

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Gap P9: Human Factors in UAS Operations.[3] Standards are needed to address human factors-related issues in UAS operations.	
R&D Needed: Yes	
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.	
Priority: High (Tier 2)	
Organization: RTCA, NFPA, MITRE, NASA, ICAO, SAE ITC ARINC IA	
v2 Status of Progress: Unknown	
v2 Update: None provided at this time.	
Updates Since v2 was Published:	
New Published Standards	**New In-Development Standards**

Commented [JM38]: 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.

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Other Chapter 10 Activity – Relevance to Gaps Not Yet Determined

New Published Standards

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

[4] Ibid

New In-Development Standards

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