APEX STANDARDS
Unmanned Aerial Systems (UAS) Standards Cross-Referencing

Unmanned Aerial Systems (UAS) standardization has been underway for just five years. In comparison to the maturity in other industries such as semiconductor, telecommunication, banking, transportation and supply chains, and energy, UAS standardization is still in its early stages. As illustrated by the heatmap below, various U.S. government agencies have invested heavily in UAS-standard development.

Application Driven

UAS functional standards are being driven by applications that were previously dangerous, expensive, or outright unimaginable. The FAA, DOT, and NTSB may be responsible for updating airspace regulations to meet safety standards. The participation of agencies such as the CDC (medical aid distribution), DOD (intelligence, surveillance, reconnaissance (ISR) and counter-drone defense), DOJ (forensic evidence photogrammetry), DHS (border patrol), the EPA (pollution monitoring), FEMA (search and rescue), NOAA (weather monitoring), OSHA (workplace safety monitoring), and the USDA (precision farming) depicts the roles that the US government has assumed.

Professional associations, which are typically non-profit organizations, such as ASSHTO (highway condition monitoring), AREMA (railroad condition monitoring), NAAA (precision farming), NACE (3D modeling and construction site monitoring), and PRCI (energy infrastructure monitoring), also make contributions.

Mission Possible

A thorough structural survey of energy pipelines, highways and railroads used to take many weeks of human effort. Nowadays, a fleet of UAVs (Unmanned Aerial Vehicle or Drone, a component of the UAS) can complete the same set of missions in a matter of hours. Modern AI allows for pattern recognition from UAV data that enables automatic, timely, and detailed documentation of issues. Better yet, given historical training data, the AI can detect and flag precursors of a problem, sending a warning to field engineers before a disaster occurs.

Advancing science, in 2020, geologists at the GFZ German Research Centre for Geosciences sent UAVs equipped with thermal imaging cameras to demonstrate temporal activity changes of the Santa Maria volcano in Guatemala, which was otherwise dangerous to access. On Sep 30, 2021, NOAA navigated a saildrone to pierce Hurricane Sam's eyewall as the Category 4 storm barreled through the Atlantic Ocean for the first time.

Standard Development

Focusing on the Standard Development Organizations (SDO) on top of the heatmap, we observe full-scale engagements by ASTM (F38 Series), EUROCAE (ED 26X, 27X, 28X Series), IEEE (P 1936, 1937, 1939 Series), ISO (TC-20/SC-16 Series), RTCA (SC-228 Series), and SAE (S-18 Series), which take up the most blue blocks vertically—they set key electrical, mechanical, aeronautical, functional, control and performance standards.

Work Items (WI) related to "Avionics and Subsystems," "Data Handling," "Enterprise Operations," "Biohazards," "UAS Flight Crew," and "UAS Traffic Management" receive relatively more attention from SDOs, agencies, and associations when compared horizontally in the heatmap.
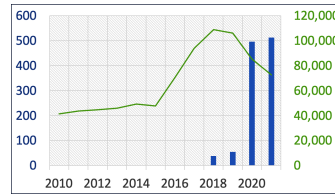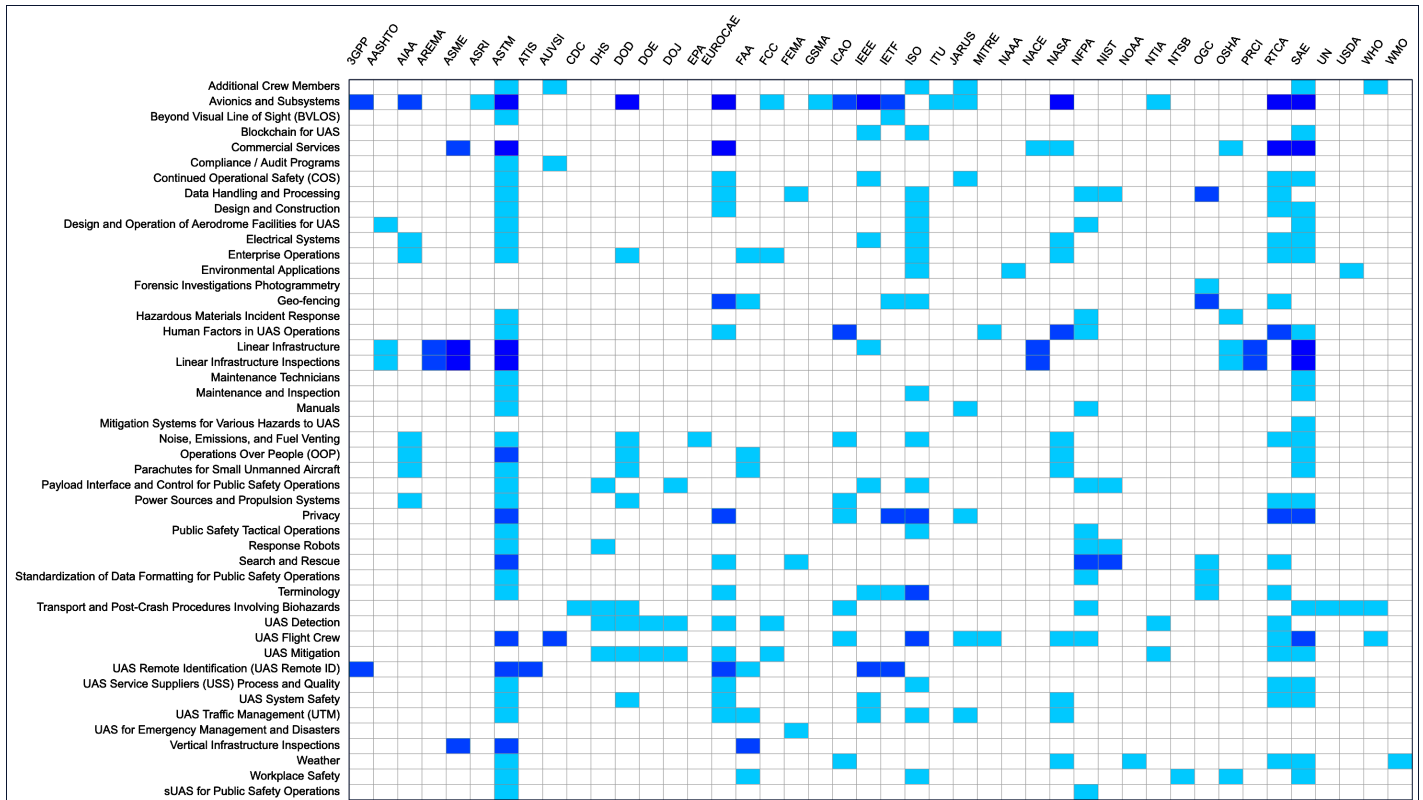

3GPP TDoc data from Jan 1, 2010 to Sep 30, 2021 (all Working Groups). The left axis represents the total number of UAS-related TDocs (for the blue bars). The right axis represents the total number of TDocs (for the green line). Regarding the green line, it is worth noting that the 5G standards discussion began in Release 15 in 2015, triggering a steady increase of TDocs since that year. A slight decline in 2019 could be attributed to the completion of the core 5G-NR standards. In 2020, COVID-19 hits globally, forcing the 3GPP meetings to go virtual. Note that in 2021, the data count ends at the end of Q3 by the time of release of this report. Extrapolating, we expect similar numbers of TDoc counts in 2020 and 2021 as the E-Meetings prolong. Despite the pandemic or a 9-month proration, UAS-related TDoc counts have continued to rise since their inclusion in 3GPP in 2018.

3GPP, the largest telecommunication SDO that defines 5G, engages in "Avionics and Subsystems," which may provide cellular connectivity between the controller and the UAV for real time, high-fidelity information gathering enabled by 5G's high bandwidth, agile maneuvering enabled by 5G's low latency, and ultrawide service coverage enabled by 5G's NTN (Non-Terrestrial Network) and low-orbit satellites.

Owing to the UAS capabilities yet despite the standards, **Country of Origin** may well become a critical factor for adoption, whether governmental or commercial. ∎

Standard Development Orgs. and Contributing Governmental Agencies or Professional Assocs.

3GPP: The 3rd Generation Partnership Project
AASHTO: Amer. Assoc. of St. Highway & Transp.
AIAA: Amer. Inst. of Aeronautics & Astronautics
AREMA: Amer. Rail. Eng. & Maint.-of-Way Assoc.
ASME: Amer. Society of Mechanical Engineers
ASRI: Aviation Spectrum Resources Inc
ASTM: Amer. Society for Testing & Materials
ATIS: Alliance for Telecom Ind. Sol.
AUVSI: Assoc. for Unmanned Vehicle Sys. Intl.
CDC: U.S. Ctr. for Disease Control & Prevention
DHS: U.S. Dept. of Homeland Security
DOD: U.S. Dept. of Defense
DOE: U.S. Dept. of Energy
DOJ: U.S. Dept. of Justice
EPA: U.S. Environmental Protection Agy.
EUROCAE: EU Org. for Civil Aviation Equip.
FAA: U.S. Federal Aviation Admin.
FCC: U.S. Federal Communications Comm.
FEMA: U.S. Federal Emergency Mgmt. Agy.
GSMA: Gl. Sys. for Mobile Communications Assoc.
ICAO: Intl. Civil Aviation Org.
IEEE: Inst. of Electrical & Electronics Engineers
IETF: Internet Eng. Task Force
ISO: Intl. Org. for Standardization
ITU: Intl. Telecom Union
JARUS: Jt. Auth. for Rulemaking Unmanned Sys.
MITRE: MITRE Corporation
NAAA: Natl. Agricultural Aviation Assoc.
NACE: Natl. Assoc. of Corrosion Engineers
NASA: U.S. Natl. Aeronautics & Space Admin.
NFPA: Natl. Fire Protection Assoc.
NIST: U.S. Natl. Inst. of Standards & Technology
NOAA: U.S. Natl. Oceanic & Atmospheric Admin.
NTIA: U.S. Natl. Telecom & Info. Admin.
NTSB: U.S. Natl. Transportation Safety Board
OGC: Open Geospatial Consortium
OSHA: U.S. Occupational Safety & Health Admin.
PRCI: Pipeline Research Council Intl.
RTCA: Radio Technical Comm. for Aeronautics
SAE: Society of Automotive Engineers
UN: United Nations
USDA: U.S. Dept. of Agriculture
WHO: World Health Org.
WMO: World Meteorological Org.

UAS Work Items (rows), cross-referenced against Standard Development Organizations, governmental agencies and professional associations (columns): 3GPP, AASHTO, AIAA, AREMA, ASME, ASRI, ASTM, ATIS, AUVSI, CDC, DHS, DOD, DOE, DOJ, EPA, EUROCAE, FAA, FCC, FEMA, GSMA, ICAO, IEEE, IETF, ISO, ITU, JARUS, MITRE, NAAA, NACE, NASA, NFPA, NIST, NOAA, NTIA, NTSB, OGC, OSHA, PRCI, RTCA, SAE, UN, USDA, WHO, WMO. Work Items: Additional Crew Members; Avionics and Subsystems; Beyond Visual Line of Sight (BVLOS); Blockchain for UAS; Commercial Services; Compliance / Audit Programs; Continued Operational Safety (COS); Data Handling and Processing; Design and Construction; Design and Operation of Aerodrome Facilities for UAS; Electrical Systems; Enterprise Operations; Environmental Applications; Forensic Investigations Photogrammetry; Geo-fencing; Hazardous Materials Incident Response; Human Factors in UAS Operations; Linear Infrastructure; Linear Infrastructure Inspections; Maintenance Technicians; Maintenance and Inspection; Manuals; Mitigation Systems for Various Hazards to UAS; Noise, Emissions, and Fuel Venting; Operations Over People (OOP); Parachutes for Small Unmanned Aircraft; Payload Interface and Control for Public Safety Operations; Power Sources and Propulsion Systems; Privacy; Public Safety Tactical Operations; Response Robots; Search and Rescue; Standardization of Data Formatting for Public Safety Operations; Terminology; Transport and Post-Crash Procedures Involving Biohazards; UAS Detection; UAS Flight Crew; UAS Mitigation; UAS Remote Identification (UAS Remote ID); UAS Service Suppliers (USS) Process and Quality; UAS System Safety; UAS Traffic Management (UTM); UAS for Emergency Management and Disasters; Vertical Infrastructure Inspections; Weather; Workplace Safety; sUAS for Public Safety Operations.

UAS standardization Work Items (UAS WI) are cross-referenced and aggregated over major Standard Development Organizations, contributing governmental agencies and professional associations. This heatmap visualizes the relationships between the UAS WIs and these entities. The stronger the engagement, the darker the color. **Data constraints**: 1. this report excludes academic research and private sector presence; 2. only English-language documents are reviewed; regional or domestic standardization activities in nations with certain control of the UAS manufacturing supply chain, e.g., Europe, China, Japan, S. Korea or Taiwan, are not taken into account.