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DEPARTMENT OF INFORMATION AND ELECTRONIC ENGINEERING

Master Thesis

«Study and standardization of communication technologies for Unmanned Aerial Vehicles (UAVs)/drones»

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Don’t stop when you’re tired. Stop when you’re done.

Περίληψη

Τα μη επανδρωμένα ιπτάμενα οχήματα γνωστά κατά των κόσμο και ως UAV, αποτελούν ένα αξιοσημείωτο επίτευγμα της σύγχρονης μηχανικής. Με το πέρας του χρόνου έχουν αποδείξει την τεράστια επιρροή τους στους τομείς όπου εφαρμόζονται, ενώ προβλέπεται πως θα αποτελέσουν βασικό εργαλείο για τις κοινωνίες του μέλλοντος, χάρη στις δυνατότητες και τις προοπτικές που προσφέρουν.

Η παρούσα διπλωματική καλύπτει πολλά πεδία ενδιαφέροντος των UAVs, όπως το ιστορικό τους υπόβαθρο, την προέλευσή τους, τις τεχνικές απαιτήσεις και προκλήσεις. Ο βασικός της στόχος ωστόσο είναι η δημιουργία μιας εκτενούς συλλογής προτύπων σχετικά με το κομμάτι των τηλεπικοινωνιών καθώς και μια πρόταση μεθοδολογίας κατηγοριοποίησής τους. Σκοπός αυτής της πρότασής είναι να καλύψει το σημαντικό κενό που παρατηρήσαμε στην βιβλιογραφία και να αποτελέσει μια αρχική πηγή γνώσης, η οποία θα μπορούσε να χρησιμοποιηθεί σε μεταγενέστερα βήματα έρευνας και εξέλιξης.

Στο πρώτο κεφάλαιο, πραγματοποιούμε μια ιστορική αναδρομή, εντοπίζοντας το σημείο εκκίνησης των UAV και καταγράφοντας την ραγδαία εξέλιξή τους με την πάροδο των χρόνων. Παρά την πρόοδο αυτή, εντοπίζονται σημαντικοί περιορισμοί, τόσο σε τεχνικό επίπεδο — λόγω των τεχνολογικών περιορισμών κάθε εποχής — όσο και σε νομοθετικό επίπεδο, καθώς η ανομοιογένεια των μεταρρυθμίσεως ανά χώρα συχνά αποτελούν ανασταλτικό παράγοντα στην ομαλή ανάπτυξη των UAV. Κλείνοντας το πρώτο κεφάλαιο, ο αναγνώστης έχει μια πλήρη εικόνα για την ιστορία των drone, τις δυσκολίες που αντιμετωπίζει τεχνικές και υλικές καθώς και τα νομοθετικά πλαίσια στα οποία πρέπει να προσαρμοστεί.

Στο δεύτερο κεφάλαιο, παρουσιάζουμε μια εκτενής συλλογή προτύπων για τα UAV, τα οποία συλλέξαμε από κάθε ένα από τους παγκόσμιους οργανισμούς οι οποίοι ασχολούνται με το κομμάτι της προτυποποίησης όπως ο IEEE, το ISO, το ASTM, η FAA κ.α. , καθώς και κάποιες περεταίρω σχετικές λεπτομέρειες, όπως η τρέχουσα έκδοση και η ημερομηνία δημοσίευσής τους. Συνεχίζοντας στο τρίτο κεφάλαιο, παραθέτουμε όλα τα ερωτήματα που τέθηκαν κατά την έναρξη της έρευνας, τα οποία αποτέλεσαν οδηγούς και οδήγησαν εν τέλη στα τελικά συμπεράσματα που αναλύονται στο τέταρτο και πέμπτο κεφάλαιο.

Τα δύο αυτά κεφάλαια αποτελούν και την ουσιαστική συνεισφορά της εργασίας μας στην υπάρχουσα βιβλιογραφία καθώς παρουσιάζεται μια πρόταση κατηγοριοποίησης των προτύπων, η οποία βασίστηκε σε κατηγοριοποιήσεις και πρακτικές τόσο του ANSI όσο και του EASA.

«Study and standardization of communication technologies for Unmanned Aerial Vehicles (UAVs)/drones»

Chrysostomos Sergios Tasios

Abstract

Unmanned Aerial Vehicles (UAVs), widely known as drones, represent a significant milestone in modern engineering. Over time, they have demonstrated substantial influence across various sectors where they are applied, and are expected to become essential tools for the societies of the future due to their wide-ranging capabilities and potential.

This thesis explores several aspects of UAVs, including their historical background, origin, technical requirements, and associated challenges. However, its primary objective is the creation of a comprehensive collection of standards specifically related to UAV communications, as well as the proposal of a methodology for their categorization. This effort aims to address a notable gap in existing literature and provide a starting point for future research and development in the field.

Chapter 1 provides a historical overview, tracing the origins and rapid evolution of UAV technology. Despite this progress, significant limitations persist—both technological, due to the constraints of each era, and regulatory, as legal frameworks have often lagged behind technological advancements. The chapter concludes with a comprehensive overview of the technical, material, and legislative challenges facing UAV deployment today.

Chapter 2 presents an extensive compilation of UAV communication standards, collected from major international standardization bodies such as IEEE, ISO, ASTM, FAA, and others. Each entry includes relevant metadata, such as version and publication date. This collection is intended to serve as a foundation for understanding the current fragmented landscape of UAV communication standards. In Chapter 3, the initial research questions are outlined, which guided the development of the methodology and the structure of the study, leading to the key outcomes discussed in Chapters 4 and 5.

The final two chapters represent the core contribution of this thesis. They present a proposed categorization of UAV communication standards, drawing on and adapting elements from existing frameworks such as those of ANSI and EASA, tailored to the specific needs of the UAV domain. Ultimately, this thesis aims to provide both an academic foundation and a practical reference point to support ongoing efforts in research, standardization, and regulation of UAV communication systems.

Acknowledgement

I want to thank me for believing in me, I want to thank me for doing all this hard work, I want to thank me for never quitting (even sometimes I was close enough). I want to thank myself as I always want to take a step further and not stay in a comfort zone. I want to thank myself for trying to be better. Last but not least, I want to thank me for just being me at all times.

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Abbreviations

3GPP	Third Generation Partnership Project
A2X	Air-to-Anything Communication
AIA	Aerospace Industries Association
ANSI	American National Standards Institute
ARC	Aerospace Research Central
ASTM	American Society for Testing and Materials
CAD	Civil Aviation Directorate
CAA	Civil Aviation Agency
CEN	Central European News
CTA	Consumer Technology Association
EASA	European Union Aviation Safety Agency
ETSI	European Telecommunications Standards Institute
EU	European Union
EUROCAE	European Organization for Civil Aviation Equipment
FAA	Federal Aviation Administration
FANET	Flying Ad-hoc Network
GPS	Global Positioning System
HAP	High Altitude Platform
I2V	Infrastructure-to-Vehicle Communication
IEEE	Institute of Electrical and Electronics Engineers
IETF	Internet Engineering Task Force
IoT	Internet of Things
ISO	International Organization for Standardization
ITU	International Telecommunication Union
JARUS	Joint Authorities for Rulemaking of Unmanned Systems
LAP	Low Altitude Platform
LiDAR	Light Detection and Ranging

MAC	Medium Access Control
MANET	Mobile Ad-hoc Network
MTOM	Maximum Take Off Mass
NATO	North Atlantic Treaty Organization
NFPA	National Fire Protection Association
PHY	Physical Layers
RFID	Radio Frequency Identification
RTCA	Radio Technical Committee for Aeronautics
SAE	Society of Automobile Engineers
SDN	Software Defined Networking
TIA	Telecommunication Industry Association
UA	Unmanned Aircraft
UAAN	Unmanned Aircraft Area Network
UAV	Unmanned Aircraft Vehicles
UAS	Unmanned Aircraft System
UL	Underwriters Laboratories
UTM	UAS Traffic Management
UWB	Ultra-Wide Band
V2V	Vehicle-to-Vehicle Communication
V2X	Vehicle-to-Everything Communication
VANET	Vehicular Ad-hoc Network
VTOL	Vertical Taker Off and Landing

Chapter 1: UAV Overview: Historical context, technical barriers and regulatory diversity

1.1 Brief history of UAVs: From war machines to saving humanity

The field of unmanned aerial vehicles has witnesses significant growth and innovation in recent years, reaching a milestone that may represent a peak in their development thus far. In order to locate the origins of drones, one does not need to look far back in human history; as early in the 1900s we had the first simple radio-controlled aircraft. Like many other ground breaking innovations that transformed our lives, such as nuclear energy, unmanned aerial vehicles were initially created and primarily used by the military in World War I for a wide range of applications. The first prototype came from Emler Sperry who modified a Curtis N-9 aircraft to fly autonomously. This early drone was given the code name "Kettering Bug".

Due to its limited accuracy, Kettering Bug was never deployed during the war. Though that was merely a glimpse of what the future would bring. After the war's end, the development of autonomous aerial vehicles accelerated rapidly, marked by the emergence of several innovative designs, such as the so-called "mother of drones" Queen Bee. The Queen Bee was a pilotless target aircraft developed and produced in the United Kingdom which was the first ever unmanned vehicle to be able to complete a mission and return without being destroyed. That was the time that the term "drone" began to take root in aviation history.

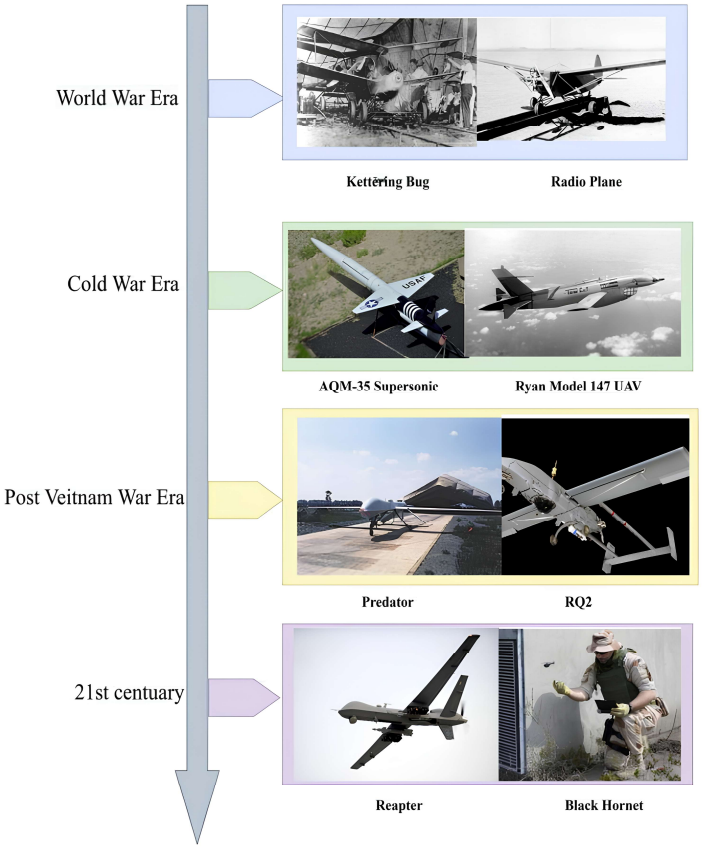

Fig. 1 History of drones [1]

The menace of the upcoming wars (World War II, Cold War, Vietnam), though a painful part in human history that many wish to leave behind, served as a catalyst for groundbreaking technological advancements. Among these, drones saw significant development. During this time, the United States began producing its own version of Reginald Denny's Radio plane series, which culminated in the OQ-14. At the same time, Germany introduce V-1 flying bomb, capable of carrying a warhead over half a ton across a range of 320km. Yet, even these innovations were not enough for the demands of modern warfare. As a result, in 1950's the development of UAVs took a new direction, focusing on achieving supersonic speeds. In 1953, the AQM-35 was introduced, a reconnaissance drone capable to reach 1.55 Mach. These UAVs significantly reduced the risk to human pilots by taking on high-risk surveillance missions.

The evolution of drone technology continues with the introduction of new models. Among them was BQM-34 Firebee, which as the authors in [1] highlight, offered significant advantage through live data transmission. Meanwhile Israel managed to take the lead of that "informal race" of equipment, with the introduction of Mastiff and Scout UAVs. This momentum carried on till the present day, where we see highly tech drones such as "Predator", "Pioneer", "Bayraktar", "MQ-9 Reapers". This cutting edge of modern weaponry, are designed to carry heavy load for extended periods even achieving supersonic speeds. The trend of our days though seems to be the application of the aforementioned technologies into much smaller carcass which will increase their maneuverability, make them harder to locate and target and much efficient from the existing once which they can reach the weight of a couple tons [2] .

Over the past two decades, the drone industry has experienced rapid growth, becoming an integral part of modern society. At the start of 2000's and most specifically in 2013, manufacturers recognized the opportunity to bring this technology to the commercial market. DJI led the way launching the Phantom series. These UAVs were low scale UAVs with limited capabilities but were user friendly requiring no special training to operate. Since then, the market has grown steadily, expanding into various sectors and significantly impacting both industry and everyday life. Nowadays, there is a vast collection of drones available, with different size, type and functionality accessible to anyone willing to invest into them. From basic mini drones designed for children, to heavy duty industrial drones to survey long areas or fields equipped and from simple cameras for casual videography to professional grade cameras used even in cinematography, the range is broader than ever. More details into the classification of drones we will discuss in the next subchapter.

To conclude this brief historical overview, it is important to point out that drones have evolved far beyond being mere tools for entertainment or commercial use. Today, they play a critical role in a variety of high-stakes operations such as search and rescue missions, where they are helpful for disaster response and crisis managements. Notable example is the devastating earthquake that struck Turkey in 2023, where drones equipped with thermal imaging and night vision capabilities were instrumental in helping rescue teams detect trapped people beneath the rubble by their thermal signature. Beyond disaster relief, drones have also proven valuable in urgent medical missions that demand speed and precision. A prominent case is the "Blood is Here" initiative in Rwanda, where fixed wing drones have been used to deliver essential medical supplies to remote or hard to reach areas, saving lives by overcoming logistical barriers.

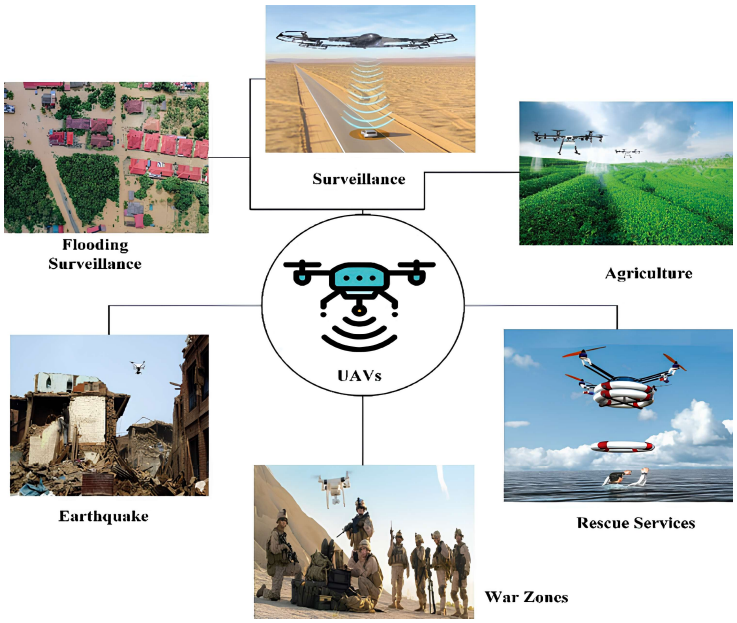

Fig. 2 Common UAV applications [20]

1.2 Categorization of drones

Over the years, as previously mentioned, a growing variety of drones have been developed, each with different sizes, weights, and other specifications designed for specific purposes and application. A review of the existing literature reveals that UAVs can be classified in many ways. Due to that, we will start with the classification based on aerodynamic configuration, as it is one of the most intuitive and widely recognized method. Aerodynamic design plays a key role in a drone's performance, flight time and operational versatility. Based on that, UAVs can be grouped into three main aerodynamic types:

- Fixed wing
- Rotary drones
- Hybrid

Fixed wing drones, as their name suggests, are small replicas of the traditional aircrafts. Major advantage of this kind of drones is their endurance as they can be airborne much longer than other types of drones. This makes them ideal for long distance missions, such as reconnaissance and heavier payload transporting thanks to their ability to glide and use less energy during flight perfect candidates. However, they are not suitable for operations that require for them to hover in one place, such as infrastructure inspection or monitoring a fixed location.

Next, we have a rotary-wing drones, with their main ambassador being the quadcopter, one of the most utilized and popular drones in our days. Rotary drones are well known for their exceptional maneuverability and ability to hover. Their greatest advantage, it their capability for vertical takeoff and

landing, making them perfect candidates for missions with limited space of action or situations that require rapid deployment. Most rotary drones are compact is size and generally more cost-effective. Though, one of their main drawbacks is the operation time, as they rely entirely on their rotors to stay airborne. A subcategory of rotary drones is the single rotor, which function similarly to helicopters. Despite being relatively easy to operate and have low maintenance, they tend to be mechanically complex and prone to challenges such as vibrations.

Subsequent categorization found in the literature is based on the operational altitude of drones. This factor significantly influences requirements such as quality of service, energy capacity and compliance with federal regulations. Based on this criterion, UAVs can be categorized in three main categories a) Low Altitude Platforms (LAPS), b) High Altitude Platforms (HAPs) and c) Satellites. LAPs refer to highly mobile aerial platforms, quick to deploy and operate at an altitude below the stratosphere. In that category we mostly find small drones from the family of rotary as they are fast to be deployed, cheap to be replaced in case of a failure and they're short line of sight communication link minimizes their energy consumption. Such UAVs equipped with transceivers, creating swarms, can form aerial cells around an area expanding the current cellular network in cases where we have high demand or when the ground infrastructure has been damaged. Additionally, they can function as communication relays, enabling wireless connections between multiple devices that lack a direct communication link.

Moving further, HAP represent another category of aerial platforms, designed for large scale drone operations, which has begun to attract more and more the interest of the communication community. HAPs typically consist of less flexible drones, often based on fixed-wing designs, with a strong emphasis on maximizing the operational time with operating altitude well above the stratosphere. With these characteristics, HAPs are capable of providing wide-area coverage, high data rates and low transmission power. Despite these advantages, HAPs have notable limitations, most significantly, their long takeoff and landing times, which reduce their responsiveness compared to lower-altitude systems.

Finally, we have satellites, a special type of UAVs launched into orbit around the Earth. That kind of drones could either be utilized for military, commercial or scientific purposes either as Global Positioning Systems, telescopes, weather forecasting or even satellite phones. As expected, these types of UAVs are vastly different from conventional drones as they weigh many tons, have exorbitant cost to create and maintain and operates at scales far beyond that of terrestrial UAVs.

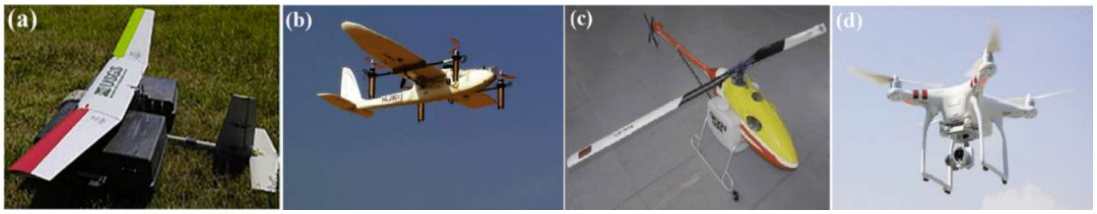

Fig. 3 Drone categories: a) Fixed wing, b) Fixed wing hybrid, c) Single rotor and d) Multirotor [6]

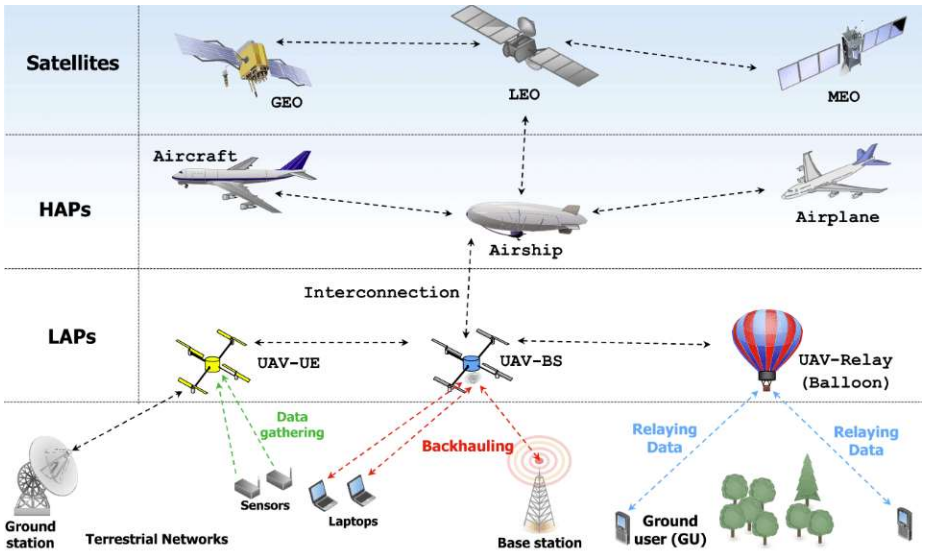

Fig. 4 UAV categorization per operational altitude [21]

The number of possible classifications is vast, as UAVs can be categorized based on various characteristics or even specific operational use cases. However, since the primary goal of this chapter is to provide foundational knowledge to help readers understand the challenges UAVs, which we will go deeper later on, we will not examine each classification type in detail. Instead, we will highlight key classification concepts found in the literature, offering readers the opportunity to explore them further as needed. With that in mind, additional classifications can be made based on the following criteria:

1. Sensor capabilities
2. Durability and weather resistance
3. Usage based
4. Autonomy level
5. Flight environment
6. Communication and control
7. Landing mechanisms

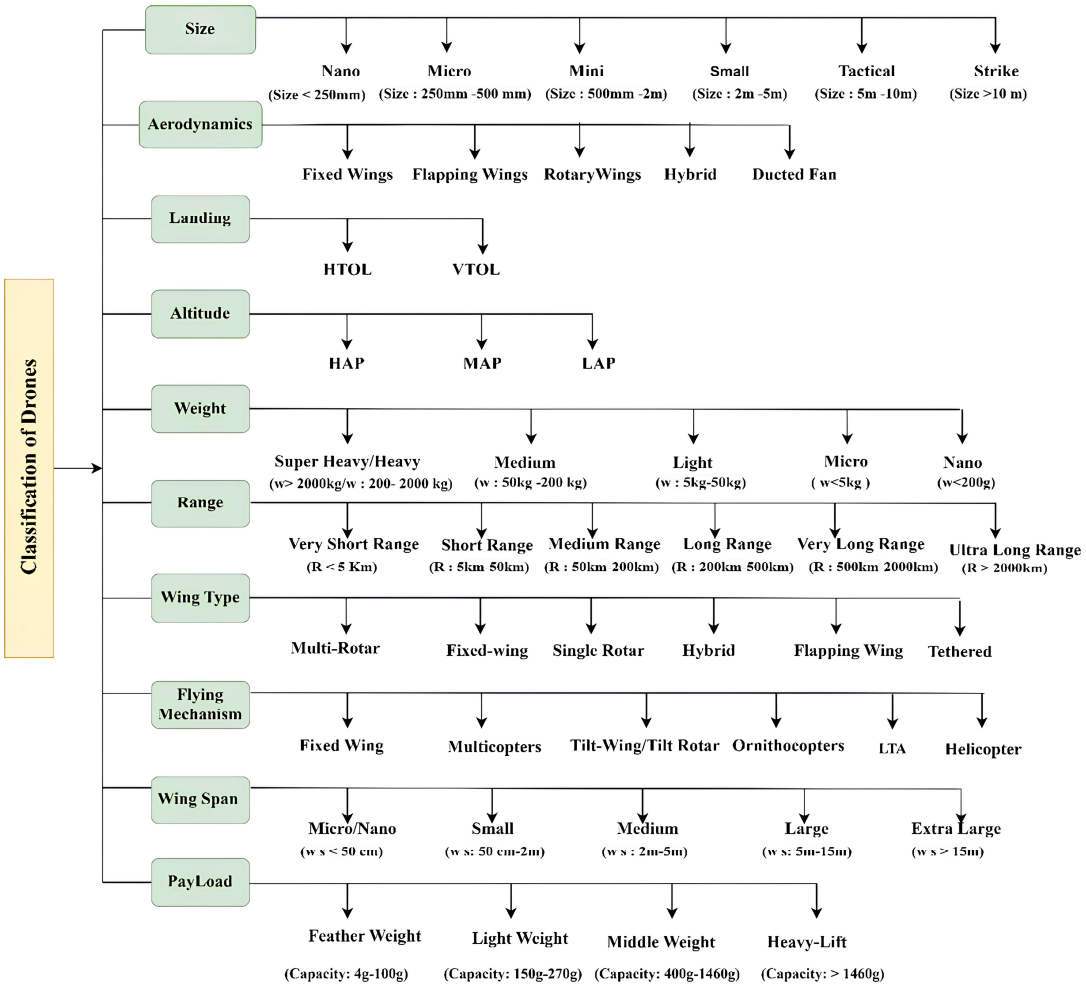

Fig. 5 Further UAV categorizations [1]

1.3 Technological challenges: Current state and the vision for years to come

Up to this point, we have explored various roles drones might have taken over time, from their early use in military reconnaissance and border patrol, to their application in construction and agricultural inspections, entertainment, as first responders in disaster scenarios with search and rescue missions, medical deliveries in remote areas and restoring communication networks. However, we have yet to discuss the challenges that had to be overcome to reach this level of capability, as well as the ongoing difficulties that still impact current operations.

In the following chapter, we will focus on key areas that require further development in order to overcome existing limitations. Additionally, we will explore the industry's vision for the future role of UAVs and the fundamental requirements that must be addressed before such advancements can even begin pilot testing. Given the broad scope of these challenges, our analysis will remain at a high level, without delving into the specifics of individual technologies.

1.3.1 Airborne time and energy efficiency

One of the most critical and widely recognized challenges in drone operations is the endurance limitations, how long a drone can stay airborne before it needs to recharge or refuel. While airborne, drones rely on limited energy supply, which must be carefully managed across different functions like movement control, communication and data processing. As a result, flight time and hove durations are immediately affected. However, several factors can also influence these limits, such as weather conditions, the type of mission and the equipment the drone carries.

In [3], the authors present several state-of-the-art frameworks designed to reduce energy consumption. These include algorithms for optimizing flight paths and innovative methods for energy harvesting, such as taking advantage of in-flight vibrations or solar power collection. A useful classification provided in that paper was the division of drone energy usage into two categories a) Communication energy and b) Propulsion energy. Due to the scope of this paper, we will not go into technical details of propulsion energy, such as lithium batteries specifications or mechanical energy-saving techniques. Instead, we will focus more on communication energy which includes the power used for signal transmission, data processing and computation.

As illustrated in the pie chart below, the most popular research fields in the past decade reveal a strong focus on overcoming energy limitations. The industry is actively seeking for effective solutions and Artificial Intelligence (AI) has emerged as a valuable tool. AI is especially promising in areas like route planning and spectrum allocation which we will discuss in upcoming sections.

Table 1 Operational time of UAVs [10]

Size	Weight	Example	Battery lifetime
Micro	< 100 g	Kogan Nano Drone	6-8 min
Very small	100 g – 2 kg	Parrot Disco	45 min
Small	2 kg – 25 kg	DJI Spreading Wings	18 min
Medium	25 kg – 150 kg	Scout B-330 UAV helicopter	180 min
Large	>150 kg	Predator B	1800 min

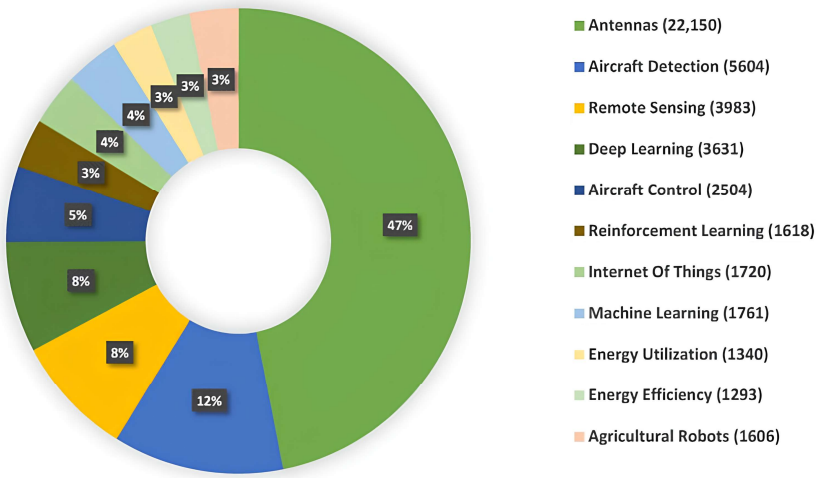

Fig. 6 UAV Research trends of the last decade [22]

To conclude this section, it is clear that improving the energy efficiency of UAVs is critical. This involves both building lighted, more efficient hardware and developing smart algorithms that will reduce all the necessary computations that needed to be onboard in the past, reducing at the same time any kind of delays.

1.3.2 Security of sensitive data and privacy

Another major challenge in the field of UAVs is the security of sensitive data, such as real-time location, imagery and audio. Many drones often operate without end-to-end encryption, which exposes their communication channels to various cyber threats. This lack of secure communication makes them particularly vulnerable to interception, data theft and unauthorized manipulation, which can have dire consequences, especially in critical applications such as military operation and surveillance [4][5].

The most common security threat UAVs have to face is GPS signal spoofing, where an attacker injects counterfeit signals into the drone's navigation system. By feeding false coordinates or route date, the adversary can hijack the UAV and potentially redirect or even crash it. This kind of spoofing can severely compromise mission integrity and safety while in more advanced scenarios, attackers might take full control of the UAV, leveraging it for illicit activities such as smuggling or espionage.

Moving forward, another serious threat is session hijacking. In this type of attack, an adversary intercept and takes control of the communication link between the drone and its ground control station or another airborne device (in cases of swarm deployment). This type of intrusion can cause significant disruptions, particularly in scenarios where drones are used for real-time monitoring, surveillance or reconnaissance. Session hijacking is often part of larger scale denial of service (DoS) or distributed denial of service (DDoS) attacks, in which adversaries overwhelm the UAV's communication or processing infrastructure with excessive traffic. These attacks can result in network congestion, depletion of power resources and ultimately a breakdown in normal operations.

In addition to software-based attacks, physical security should not be overlooked. Drones frequently operate over wide geographical areas and are often coordinated by Software Defined Networking (SDN) controllers, which can be left unattended or insufficiently secured. These components present attractive targets for malicious actors, making physical and infrastructure-level protection just as critical as cybersecurity defenses.

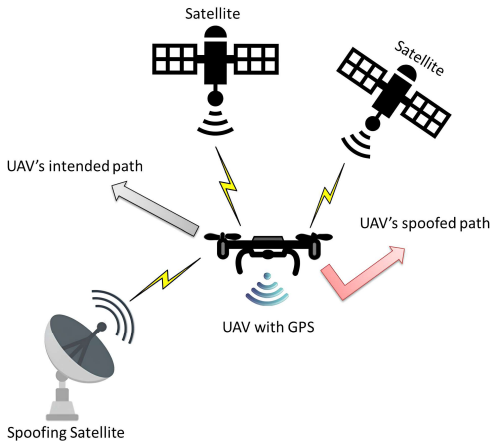

Fig. 7 GPS spoofing attack [6]

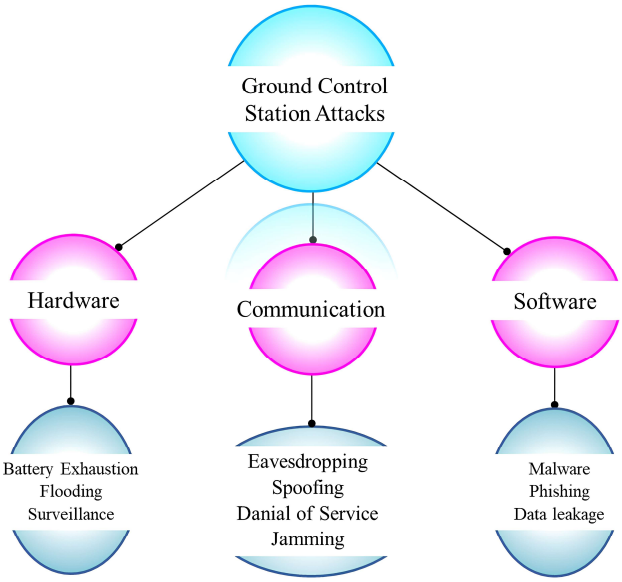

Fig. 8 Categories of possible attacks[6]

So far, by only taking a broad look at security vulnerabilities, and without even discussing other challenges UAVs are mandatory to surpass so as to have problem free operation, it is clear that the number of security and safety concerns are far greater than one might imagine. With that in mind, it is easy to see why we have not seen yet drones used as public or personal transportation means while at the same time, public skepticism and mistrust toward drones are not entirely unfounded as there have been numerous incidents where drones were used for spying, trespassing and invading people's privacy.

1.3.3 Resource management

In this section, we'll take a closer look at why managing resources is so important in drone communication systems. Since drones often operate in fast-changing and unpredictable environments, it's essential to have a system that can handle key resources like communication links, power, and flight paths in real time, especially during missions where people's safety is involved. We'll focus on some of the main challenges here, such as managing radio frequencies, planning routes, and dealing with signal interference.

Drones often use public frequency bands like 2.4 GHz and 5 GHz, which are already crowded with Wi-Fi, Bluetooth, and other devices. This creates a lot of interference, especially in cities where drones are most needed for things like emergencies or backup networks. As explained in [6], this makes it critical to choose the right frequencies and be able to switch them when needed, especially when many drones are flying together and need stable, uninterrupted communication.

Another big challenge is how signals behave between drones and the ground. These air-to-ground connections are very different from regular ground-based networks. Things like the drone's height, movement, and buildings below can affect how strong or clear the signal is. Because of this, drones need flexible systems that can adjust communication settings based on where they are and what the environment is like.

Planning drone routes is also tricky. Drones have limited battery life, and they need to stay in good positions to keep strong signals with each other and with the ground. This means figuring out flight

paths that save energy but still keep communication smooth and reliable. It's a delicate balance between staying in range, avoiding obstacles, and keeping the network working well[7][8].

Things get even more complicated when you have several drones in the air at once, especially in drone networks called FANETs (Flying Ad-Hoc Networks)[9][10]. These networks change shape constantly as drones move, which makes it hard to use standard routing methods. As mentioned in [11], keeping these networks, stable requires smarter tools, like using algorithms that can quickly adjust based on where drones are and how they're moving. Some systems may even use artificial intelligence or game theory to make fast decisions and avoid interference.

Finally, when drones are used in large teams, sometimes with different roles, like some acting as base stations and others as relays, managing their resources becomes even more difficult. These systems need to share the available bandwidth, avoid crashing into each other, and make sure each drone knows what it's supposed to do. This is even more important in critical situations like disaster recovery or military missions, where communication has to be fast and dependable.

To sum up, managing resources in drone communication networks is not easy. It requires balancing many factors at once such as saving energy, avoiding interference, staying connected, and adapting to changes quickly. As drones become a bigger part of future networks like 5G and beyond [12], it's going to be more important than ever to build smart, flexible systems that can handle all these challenges.

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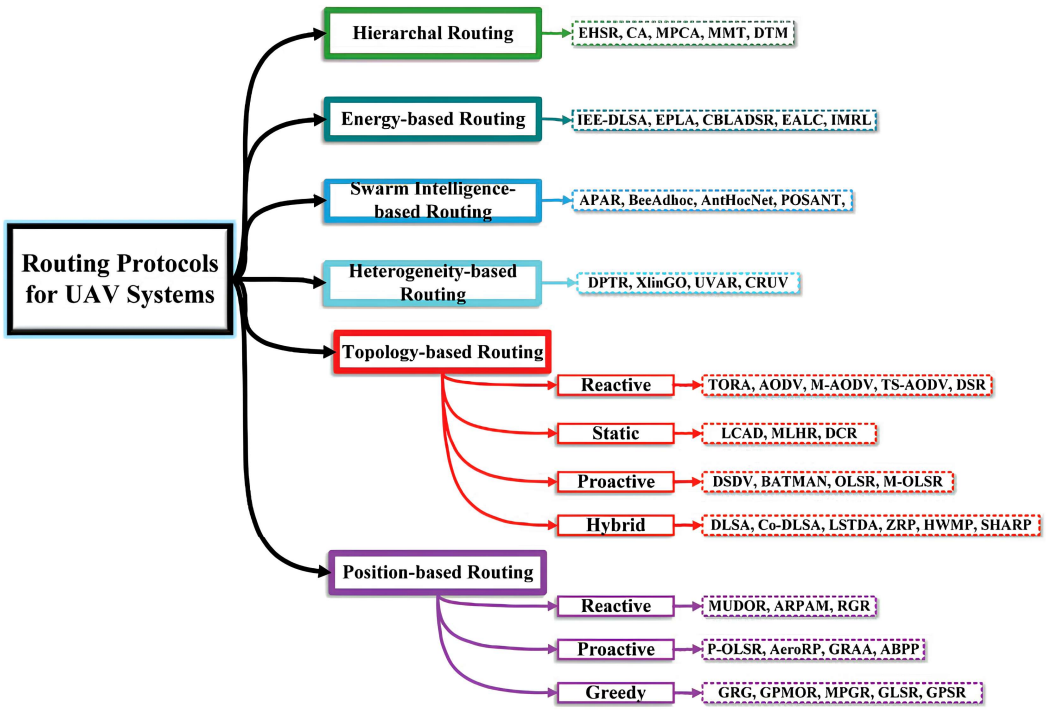

Fig. 9 Routing protocols taxonomy [20]

1.3.4 Scalability and multi-UAV communication

In the fable “The Bundle of Sticks”, Aesop, the ancient Greek storyteller, teaches the timeless lesson that strength lies in unity. This principle finds a modern parallel in the use of drones. The true potential of UAVs is unlocked when they are deployed not individually, but collectively, in formations commonly referred within the field as “drone swarms”.

A swarm, which we have not fully defined yet, is a group of drones working together simultaneously towards a common mission. The key ingredient for such a group to function flawlessly and behave as a single unit, is cooperation among its members. To achieve that kind of cooperation in the context of drones, the main challenge is to ensure that each group member remains within the communication range of its “teammates”, so a reliable communication link can be established. Traditional networks, such as Mobile Ad-hoc Networks (MANETs) and Vehicular Ad-hoc Networks (VANETs), are not suitable for drones due to their high mobility. As a result, a new type of ad-hoc network was needed. Researchers have named this model the FANET, which is essentially a specialized subclass of VANET, designed specifically to address the challenges of UAV communications.

The communication architectures of swarms, as presented in [13] follow different models that play a crucial role in the performance and collaboration among the drones within the swarm. In most cases, the number of the deployed drones is the main parameter that determines which architecture should be preferred. For reference, we will briefly describe this architecture to give readers a better understanding of the swarm nature before going deep dive with the challenges.

First, we have the centralized communication architecture, which is essentially a scalable version of single UAV systems. This architecture includes a single central unit, in most cases a ground station, with which all drones, referred to hereafter as nodes, must maintain communication in order to receive control commands. A key characteristic of this model is that each node is isolated from the others and communicates only with the control unit. Major disadvantage of this architecture is that if a single node fails, the reliability of the entire swarm is compromised.

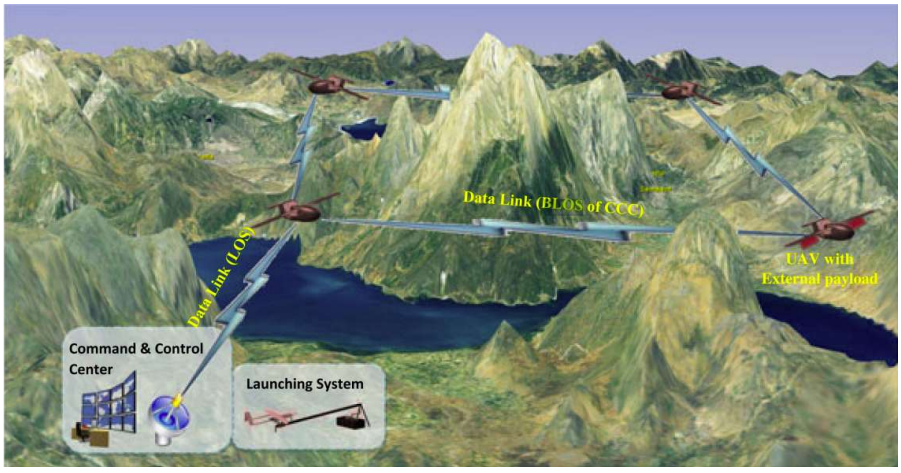

Fig. 10 Components of Unmanned Aerial System (infrastructure plus swarm) [23]

In real-life scenarios, it is clear that maintaining an uninterrupted connection with a central network is often unrealistic. As a result, ad-hoc networks are considered the most suitable option, as they allow UAVs to interact with each other in real time, making them independent from the infrastructure. In decentralized architectures, there are several variations, based on how the nodes are organized within the swarm. These include configurations such as single-group swarm ad-hoc networks, where all drones form one unified communication group, multi-group ad-hoc networks, where the swarm is divided into multiple clusters, each one potentially operating independently and multi-layer ad-hoc network which is suitable for mass variety of UAVs

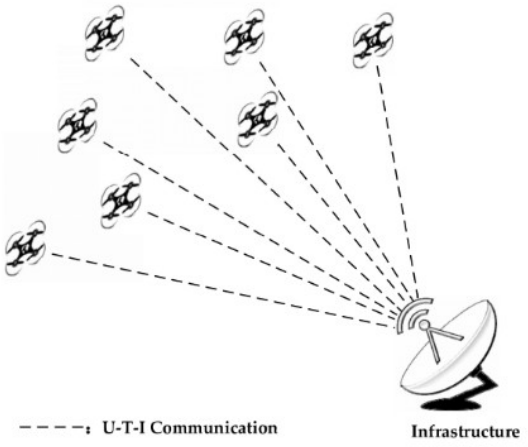

Fig. 11 Centralized communication architecture [13]

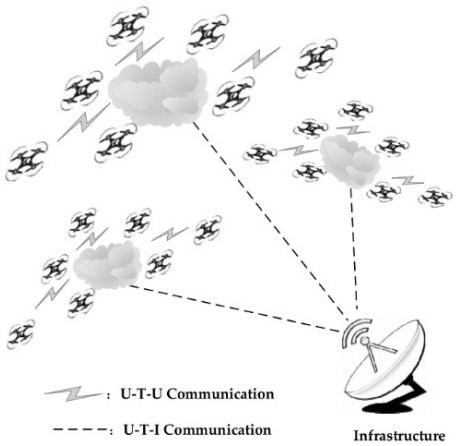

Fig. 12 Multi group ad-hoc network [13]

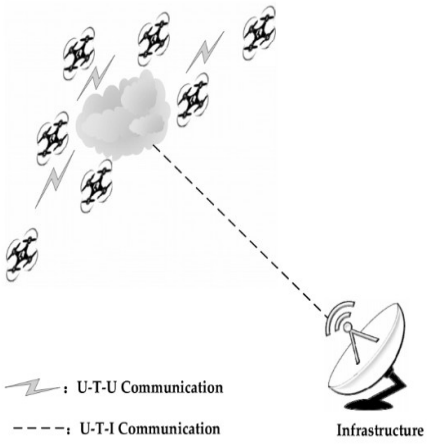

Fig. 13 Single group ad-hoc network [13]

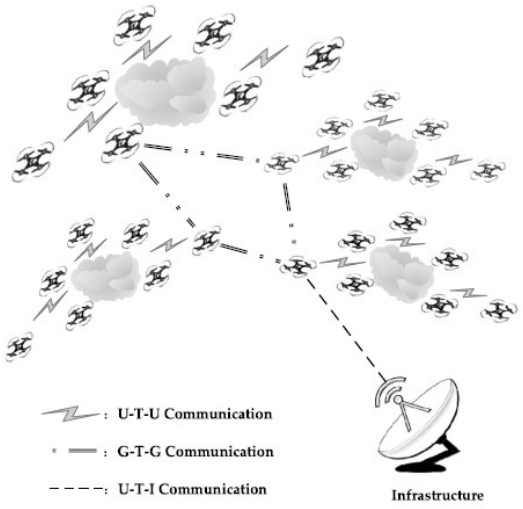

Fig. 14 Multi-layer ad-hoc network [13]

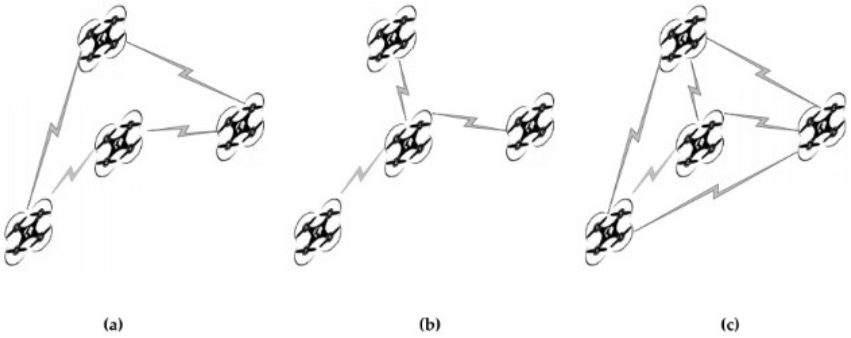

Fig. 15 Intra swarm communication topologies: a) Ring topology, b) Star topology, c) meshed topology [13]

In single group ad hoc networks, the communication between the swarm and infrastructure is handled solely through one node, referred to as gateway node. With this setup the remaining nodes do not need to carry the equipment required to connect with the central infrastructure. This results in lighter payload, reduced communication range requirements and longer airborne time. Given the diverse requirements of different missions, the intra-connection architecture within a swarm has also several variations. This defines whether each node can communicate with the other nodes, excluding the gateway, and in each case how many or who can be the gateway node.

While discussing the disadvantages of the centralized architecture, we noted that the failure of a single node can compromise the entire swarm. A similar issue can also arise in decentralized architectures, which is why intra-swarm topologies have undergone several adaptations over time. In Fig 14.a, we observe a ring intra-swarm topology. In this configuration, all nodes are capable of acting as gateway nodes and are connected via bidirectional communication links. This setup ensures that in case a communication link between two nodes fails, information can still be relayed through an alternative path using the second link. However, this topology is not recommended for large-scale

deployments, as it may introduce significant delays due to the increased number of hops required for data transmission.

Continuing with Fig.14 b, we observe a star topology, which even someone not familiar with the field could assume is error prone. If the central node fails the entire swarm will become nonfunctional, as the remaining of the nodes, will no longer receive commands to follow. The only notable advantage of this topology is that the gateway node not only maintains communication with the infrastructure but also directly with all the other nodes in swarm. Finally, in Fig.14 c, we reach Mesh topology, which according to authors is considered the standard intra-swarm communication topology. Mesh topology combines the advantages of ring and star topology. All nodes can function as gateway nodes and at the same time be able to communicate with the rest of the nodes directly. Each topology has its operational cost and for that reason, the choice of topology depends on the specific requirements of the mission.

A final point the authors emphasize is that deploying swarms presents important yet interesting challenges that need to be addressed. While the high speed of individual drones makes the design of effective routing protocols complex, managing communication within a cluster of drones multiplies both this complexity and the potential risks involved. Additionally, it is crucial to maintain a balanced approach, ensuring that performance improvements do not come at the expense of other critical factors, particularly security.

In conclusion, while significant progress has been made, the field of unmanned aerial vehicles is still in a premature stage. Much work remains in terms of standardizing technologies and overcoming key limitations, especially in breaking the barriers of energy efficiency.

Table 2 Summary of communication architectures [13]

Features	**Centralized Communication Architecture**	**Decentralized Communication Architecture**		
		Single Group	**Multi Group**	**Multi-layer**
Multi-hop Communication	X	√	√	√
UAVs Relay Traffic	X	√	√	√
Different Types of UAVs	X	X	√	√
Self-configuration	X	√	X	√
Limited Coverage	√	√	√	X
Single Point of Failure	√	X	√	X
Robustness	√	X	X	√

1.4 Regulation heterogeneity

In the previous subchapter we took a deep dive into the current challenges faced by drone applications today, as well as those anticipated for the future roles drones are expected to play. While this represents a major part of the puzzle, another, perhaps more 'silent' obstacle that needs to be addressed is regulation. Till the day this thesis is written there are no common regulation manuals regarding what UAVs can and cannot do around the globe, regardless the effort of authorities such as Federal Aviation Agency (FAA), European Union Aviation Safety Agency (EASA) and American National Standards Institute (ANSI) to establish one. As our residence area and therefore area of interest we are going to provide below the current state of regulations standards for European Union (EU), where even their heterogeneity is found between Country members and the differences that appear there

As we find in [14] EASA first established rules and standards in 2019 which applied to all EU member states including Norway, Liechtenstein, Switzerland and Iceland. Major point of interest of these regulations is related to UAS operations into the EU, providing a risk-based categorization of the operations, where in cooperation with national aviation authorities they established and continuously update rules regarding altitude restrictions, no-fly zones, operational limitations, distance from people etc. That way EASA tries to ensure the highest level of safety, mitigating any risk of potential collisions or privacy concerns, and harmonizing drone regulations all around EU member countries. Per EASA and most specifically after EU Regulations 2019/945 [15] and 2019/947 [16] the most important drone categorizations are a) Classification by performance and b) Risk based operation.

From the first of January 2024 when the risk-based operation went into force, all drones operating inside the EASA's area of authority had to comply with rules regarding technical and weight limitations regarding the class they belong or even operate with a remote identification transmitting information related to the drone when flying below 120 meters. Even though all of these regulations have taken place, there are a lot of cases where drones have been used for a malicious purpose. In 2020 three persons were accused in Georgia for trying to deliver drugs inside a prison, another case took place in Gatwick Airport in the United Kingdom where two people were arrested for operating a drone in a no-fly area leading to many delayed flights, affecting the life of more than 100.000 people that day. It's crucial to note here, that according to DeDrone, referenced by the authors, the number of unreported cases is far higher than those that went into public for reputational and security reasons.

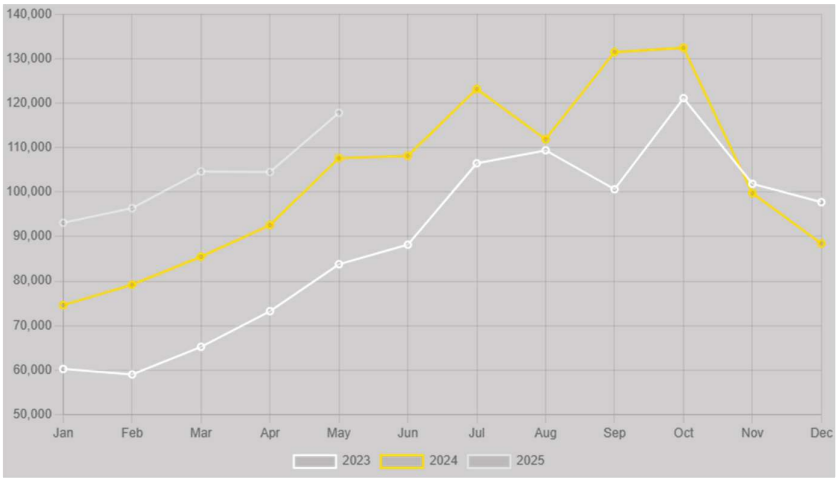

Fig. 16 Monthly drone incidents January 2023-Today (DeDrone) [24]

Despite EASA establishing a UAV operational rulebook that has been approved and implemented by the nations of the EU and even some that have not joined yet, such as Albania, Montenegro etc., there are still several some non-EU members with their own unique categorization, registration and licensing standards[17]. For some of these countries in the following paragraphs, we are going through a quick review of their point of view.

1.4.1 North Macedonia

Starting with North Macedonia, its government on December 12 2017 introduced the "Regulation regarding the conditions under which unmanned aircraft can fly in North Macedonia air space" which after many adaptations came into force in April 2019. Regarding that regulation they categorize drones a) Based on the purpose of use and b) Based on Maximum Takeoff Mass (MTOM).

Based on these two categorizations, commercial or personal drones need to be registered to the Civil Aviation Agency (CAA), while the operational limits define that the flight distance from people must be at least 50m, 100m from authority buildings with 100m maximum vertical altitude and 500m horizontal distance. In addition to that, it is prohibited to operate of drones in an area of 8 km around airports and there is the age restriction of 18.

Table 3 UAV Classification in North Macedonia [14]

Class	MTOM
Class 1	< 0.5 kg
Class 2	0.5 kg – 5 kg
Class 3	5 kg – 20 kg
Class 4	20 kg – 150kg
Class 5	>150 kg

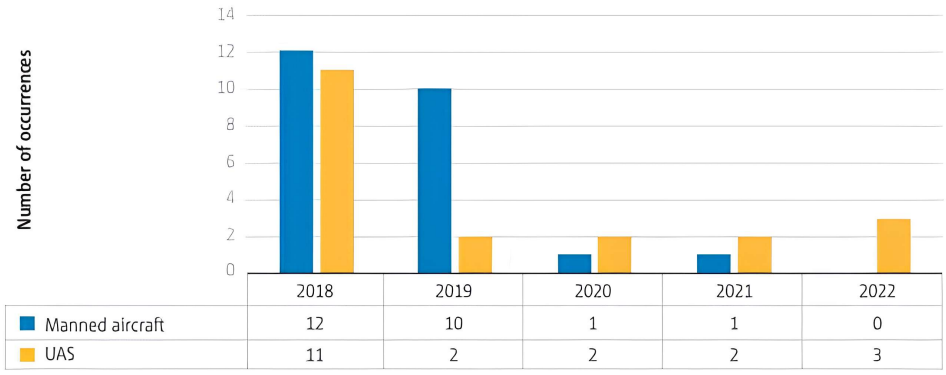

Fig. 17 Incidents of collisions and near collisions involving UAS and manned vehicles [14]

1.4.2 Serbia

Serbia in December 2019 adopted the "Regulation on unmanned aircraft" which came into force in February 2020. The regulation standard described the condition of safe use of drones and highlights that it is not applicable for drones with the following characteristics or applications:

1. MTOM less than 0.25kg or more than 150kg
2. The speed is ≤ 19m/s or have maximum kinetic energy of 80 Joule (kinetic energy is calculated with the following type *"Kinetic Energy = mass * speed ^{2}"*
3. Operated by state authorities or indoor activities

As expected, Serbia has different thresholds on classification of drones regarding their Maximum takeoff mass which can be found at the table below. UAVs of category 3 and 4 are mandatory to be registered by the Civil Aviation Directorate (CAD), while those of category 1 and 2 must also be registered if the drone activity will exceed the altitude of 100m or the horizontal distance of 500m over person. Here the minimum distance around airports is 5 km while the age restriction is the age of 15 or for operators of younger age the presence of an adult supervisor is mandatory.

1.4.3 Kosovo

Moving to Kosovo, the national CAA in January 2021, updated the regulation "01/2021" which updated its ancestor "01/2017". With the newly introduced regulation the nation of Kosovo, does not categorize drones only by their MOTM, but it also takes in consideration other parameters such as altitude speed and operational range as seen in the table below. It has to be noted that these regulations do not apply to UAVs with MOTM less than 0.5 kg, maximum speed of 20 m/s and their maximum operation range does not exceed 15m horizontal distance and 30m altitude. Some keynotes that it's likely to highlight, is that despite the category that each drone belongs to, all of them have to be registered to the Aviation authority. Also, it's highly prohibited to operate an UAV beyond the visual line of sight of the operator, transport any kind of goods and fly them near governmental buildings without official authorization. Last but not least the age restriction is set to 16 years old and the operators have to obtain a specific license before being able to operate their drones

Table 4 UAV Classification in Serbia [14]

Category	MTOM
Category 1	< 0.9 kg
Category 2	0.5 kg – 3.99 kg
Category 3	4 kg – 24.99 kg
Category 4	25 kg – 150 kg

Table 5 UAV Classification in Kosovo [14]

Category	MTOM	Altitude	Speed	Range
Category 1	< 1 kg	<50 m	< 30 m/s	< 100 m
Category 2	1 kg – 5 kg	< 150 m	< 30 m/s	< 2.5 km
Category 3	5 kg – 20 kg	< 500 m	< 55 m/s	< 2.5 km
Category 4	20 kg – 150 kg	No limit	No limit	No limit

1.4.4 Bosnia Herzegovina (BiH)

Finally, we find Bosnia and Herzegovina. The CAA, on August 2020 published the official regulation standard "Rulebook on the Requirements for Aerial Drone Operations 51/20" where despite its drone categorization felt similar with the one of North Macedonia and Serbia, with different MTOM thresholds, it also added the characteristic of operation type, dividing UAVs into non-commercial, commercial and working operation. We have to mention that BiH drones with weight outside of the range 0.25 kg and 25 kg do not violate these regulations such as drones used by state authorities. Below we are going to note down the restrictions for each subcategory:

1. Non-Commercial:
    a. Always into the Visual line of sight of the operator
    b. Maximum operating altitude is 30 m
    c. Minimum operation range from group of people is 30 m
    d. At least 50 m distance industrial zones and governmental buildings
    e. Mandatory Insurance
2. Commercial:
    a. Can be operated beyond the visual line of sight of the operator with maximum distance 1000 m
    b. For night operations light signaling is mandatory
    c. Minimum operation range from group of people is 5m
    d. At least 100 m distance from industrial zones and governmental buildings
3. Work Operation:
    a. Mandatory approval from CAA to perform any aerial work

Concluding this chapter, we have explored the evolution of drones, their impact on human history and their ever-growing role in our daily lives. We have outlined the vision of the industry and experts for the future of the UAVs, highlighting both the exciting possibilities alongside with the technical challenges that must be addressed. Finally, we examined the complexities surrounding global drone regulations with particular focus on the current state in the European area. These challenges make clear the critical necessity for greater standardization, regulation clarity and enhanced operational security. In the following chapter we will delve into the previous and ongoing efforts to meet these needs, presenting key standards related to drone communications, architectures, operations and regulations. We will also propose a structured categorization, aiming to build a comprehensive reference library that can support future research and industrial applications.

Table 6 UAV Classification in BiH [14]

Category	MTOM
A1 Category	0.249 kg – 1 kg
A2 Category	1 kg – 2 kg
A3 Category	2 kg – 5 kg
A4 Category	5 kg – 25 kg

Chapter 2: In-depth compilation of UAV communication standards

2.1 Introduction

In chapter 1, we presented a general overview of drones, emphasizing both the technological and regulatory challenges they face. These challenges underscore the growing need for further standardization across both domains. Building on that foundation, we did a detailed investigation of the relevant standards, with a particular focus on communication protocols, architectural and regulatory frameworks. For each communication standard, we aim to present key information, including a brief description of its scope, as defined by the given organization and any previous versions. Our goal is to offer a clear and structured overview of each standard to support a deeper understanding of their role in UAV operations. In general, our target is to provide the following information for each one of our standards:

1. **Approval status:** Defining the current status of the standard
2. **Initial date:** The date when the communication standard was first created or introduced
3. **Current version:** Here if there are any previous versions of that standard, we are going to provide the latest of them
4. **Description:** A brief description of the standards scope and purpose
5. **Version history:** A list of all previous versions of a standard and if available, differences between versions
6. **Reference:** When available, a reference link to the standards page or work group page

2.2 Insight from major associations and notable authorities

2.2.1 IEEE

Standard	1920.1
Title	Aerial Communications and Networking Standards
Status	Active
Initial date	5-7-2020
Current version	1920.1-2023
Description	IEEE Std 1920.1 includes guidelines for air-to-air communications in self-organized aerial networks, covering network architecture, security, and data models. It is flexible and adaptable to various network types, including wireless and cellular. At the same time, it applies to a range of aircraft systems, from small unmanned drones to large commercial planes. It is the first in the IEEE P1920.X series and it lays the groundwork for future standards, providing a foundation for more specific and detailed specifications to be developed, enabling seamless communication among aerial vehicles. It is a crucial standard in the aviation industry because of its broad applicability.
Version history	-
Reference	https://standards.ieee.org/ieee/1920.1/10352/

Standard	1920.2
Title	Standard for Vehicle-to-Vehicle Communications for Unmanned Aircraft Systems

Status	Ongoing
Initial date	21-12-2018
Current version	-
Description	The IEEE 1920.2 standard refers to Vehicle-to-Vehicle Communications (V2V) and enables Unmanned Aircraft Systems to exchange critical information and facilitate communication beyond visual line of sight. It supports the sharing of data for command, control, and navigation, as well as application-specific purposes. IEEE 1920.2 through Beyond Line of Sight (BLOS) and Beyond Radio Line of Sight (BRLOS) communications, enhances the safety and efficiency of unmanned aircraft operations, paving the way for advanced aerial applications and services. Simultaneously it provides a foundation for reliable and seamless communication between aircraft.
Version history	-
Reference	https://standards.ieee.org/ieee/1920.2/7517/ https://sagroups.ieee.org/1920-2/

Standard	1936.1
Title	Standard for Drone Applications Framework
Status	Active
Initial date	12-10-2018
Current version	1936.1-2021
Description	The IEEE 1936.1 standard gives a foundational framework for drone applications by categorizing them into classes, scenarios, and execution environments. It outlines basic requirements for necessary facilities, including flight platforms, control systems, and communication links. Additionally, regulatory aspects such as airworthiness, airspace rules, operator qualifications and insurance are covered. Also it provides guidelines for operational processes, data management, and reporting, ensuring comprehensive records and compliance with regulations. This framework promotes safe, efficient and responsible drone operations, while providing a structured approach to data collection, analysis, and confidentiality.
Version history	-
Reference	https://standards.ieee.org/ieee/1936.1/7455/

Standard	1936.2
Title	Photogrammetric Technical Standard of Civil Light and Small Unmanned Aircraft Systems for Overhead Transmission Line Engineering
Status	Active
Initial date	3-11-2020
Current version	1936.2-2023
Description	This standard by using small, lightweight civil drones in power grid engineering surveys and design outlines operational methods, accuracy indicators, and technical requirements for photogrammetry The scope applies to drones with specific characteristics: fixed-wing or multi-rotor UAVs, powered by battery or fuel, weighing between 0.25kg and 25kg (without payload), and operating within a 15km radius and 1km altitude. With all the above it ensures accurate and reliable data collection for power grid surveys, promoting efficient and safe drone operations in this specialized application.
Version history	-
Reference	https://standards.ieee.org/ieee/1936.2/10521/

Standard	1936.3
Title	Standard for Drone Applications Framework
Status	Ongoing
Initial date	31-05-2022
Current version	-
Description	This standard defines the operational requirements for Unmanned Aerial Systems (UAS) equipped with LiDAR technology, used for surveying and designing high-voltage transmission lines above 110 kV. Workflow procedures, technical parameters, and quality control measures to ensure accurate Digital Elevation Models (DEMs) and land use surveys are outlined by the present standard. Also, it aims to optimize transmission line design, promoting efficient and reliable data collection for the energy sector by leveraging UAV-LiDAR combinations.
Version history	-
Reference	https://standards.ieee.org/ieee/1936.3/11009/

Standard	1936.4
Title	Standard for Technical Requirements for the Maintenance of Multi-rotor Unmanned Aircraft Systems Used for Power Grid Inspection
Status	Ongoing
Initial date	31-05-2022
Current version	-
Description	Maintenance procedures for multi-rotor unmanned aircraft systems used for power grid inspection are specified by this standard.
Version history	-
Reference	https://standards.ieee.org/ieee/1936.4/11010/

Standard	1936.5
Title	Standard for Technical Requirements for Intelligent Hangar Housing Unmanned Aircraft Systems Used for Power Grid Inspection
Status	Ongoing
Initial date	31-05-2022
Current version	-
Description	The IEEE 1936.5 standard provides a description of construction, functionality, performance, and environmental management criteria for hangars that house Unmanned Aircraft Systems (UAS) used for grid inspections. Additionally, it covers the battery needs for UAS and details storage conditions and specifies information management systems for hangar operations, guaranteeing safe and effective UAS maintenance. The standard seeks to optimize UAS hangar facilities by providing these requirements, hence facilitating dependable and efficient grid inspection operations. Finally, it facilitates a smooth integration with grid inspection operations by offering a thorough framework for UAS hangar design, operation, and management.
Version history	-
Reference	https://standards.ieee.org/ieee/1936.5/11011/

Standard	1936.6
Title	Standard for Unmanned Aircraft Systems based Oblique Photogrammetry Used for Survey and Design of 110 kV and Above Power Transmission and Transformation Projects
Status	Ongoing
Initial date	24-03-2024
Current version	-
Description	This standard refers to Unmanned Aircraft Systems (UAS) based oblique photogrammetry used to survey power transmission and transformation projects rated 110 kV and above and specifies the technical requirements for them. It includes operating methods, procedures, parameters, data and image processing, digital elevation model, and quality control procedures for the aforementioned content.
Version history	-
Reference	https://standards.ieee.org/ieee/1936.6/11621/

Standard	1936.7
Title	Standard for Mesh Deployment of Multi-Rotor Unmanned Aircraft Systems for Inspection of Overhead Transmission and Distribution, and Outdoor Substation Facilities
Status	Ongoing
Initial date	25-03-2024
Current version	-
Description	The IEEE 1936.7 standard describes the technical requirements for deploying multi-rotor Unmanned Aerial Systems (UAS) in a mesh network configuration for inspecting overhead transmission, distribution lines, and outdoor substation facilities. Also it specifies operational requirements related to workflow processes, procedures, technical specifications, segmentation of the inspection area, location selection for hangars, route planning for UAVs, application of the leapfrog method, and scheduling of inspection tasks.
Version history	-
Reference	https://standards.ieee.org/ieee/1936.7/11661/

Standard	1936.8
Title	Standard for Monitoring of Photovoltaic Power Stations Using Unmanned Aircraft Systems
Status	Ongoing
Initial date	25-03-2024
Current version	-
Description	This standard includes the technical requirements for Unmanned Aerial Systems (UAS) monitoring at photovoltaic power stations encompassing the hardware components and communication architecture of the monitoring system as well as mesh segment division of the patrol area. UAS hangar locations are selected based on specific criteria to optimize operations, while coordination among devices, route planning for UAS, and scheduling of monitoring tasks are also defined. Also, the classification, identification, and location of defective photovoltaic modules through analysis of optical and infrared images are addressed by this standard.
Version history	-
Reference	https://standards.ieee.org/ieee/1936.8/11662/

Standard	1936.9
Title	Standard for Technical Requirements for Electric Unmanned Aircraft Systems for Power Grid Material Lifting
Status	Ongoing
Initial date	25-03-2024
Current version	-
Description	Technical requirements for electrically driven Unmanned Aircraft Systems (UAS) for lifting and transporting material during the construction or maintenance of power grids are specified by this standard. The requirements include equipment specifications, operational procedures, inspection processes, and testing methodologies to ensure safe and efficient operations within this specialized context.
Version history	-
Reference	https://standards.ieee.org/ieee/1936.9/11622/

Standard	1936. 10
Title	Recommended Practice for Use of Electric Unmanned Aircraft Systems for Power Grid Material Lifting
Status	Ongoing
Initial date	-
Current version	25-03-2024
Description	This standard offers guidance to ensure the safe operation of Unmanned Aircraft Systems (UAS) which are used in lifting and transporting materials during the construction and maintenance of power grids. It includes recommendations for operator training, equipment pre-inspection, environmental assessments before flight, and airspace management strategies. The document also outlines a method for safely lifting materials, provides guidance on notifying operators about unusual conditions, and offers suggestions for maintaining accurate flight logs, effective system management, and monitoring critical operations to ensure optimal performance within the power grid context.
Version history	-
Reference	https://standards.ieee.org/ieee/1936.10/11623/

Standard	1936.11
Title	Standard for Requirements of Laying Out Pilot Ropes by Unmanned Aircraft Systems for Overhead Power Line Installations
Status	Ongoing
Initial date	23-04-2024
Current version	-
Description	This standard refers to Unmanned Aircraft Systems (UAS) operations involved in deploying pilot ropes during overhead power line installation and specifies technical requirements for them. It also defines the essential terminology, preparatory steps, operational procedures, and safety practices to ensure efficient execution of the task while prioritizing safety considerations.
Version history	-
Reference	https://standards.ieee.org/ieee/1936.11/11663/

Standard	1936.12
Title	Standard for Verification of Pilot Line Deployment Devices Based on Unmanned Aircraft Systems for Overhead Power Line Installations
Status	Ongoing
Initial date	-
Current version	23-04-2024
Description	This standard detail the testing conditions, the test items, and the verification requirements for Unmanned Aircraft Systems (UAS) based pilot deployment devices which are used in deploying pilot ropes during overhead power line installations. Furthermore, it outlines verification procedures to assess the emergency response capabilities of UAS systems in unexpected situations. These procedures ensure that during critical operations such as overhead power line installation, these technologies are efficient, reliable and capable of fulfilling their intended functions.
Version history	-
Reference	https://standards.ieee.org/ieee/1936.12/11664/

Standard	1936.13
Title	Recommended Practice for Image Collection during the Inspection of Overhead Distribution Lines by Unmanned Aircraft Systems
Status	Ongoing
Initial date	22-04-2024
Current version	-
Description	This recommended practice in order to ensure thorough and accurate inspections of overhead distribution lines by capturing images, specifies technical requirements for using Unmanned Aircraft Systems (UAS). To ensure comprehensive coverage and precision in the inspection process it provides guidelines for accurately imaging elements such as straight poles, tension poles, equipment poles, and line corridors. Though, the requirement is limited to visible light imaging only.
Version history	-
Reference	https://standards.ieee.org/ieee/1936.13/11665/

Standard	1936.14
Title	Unmanned Aircraft Systems in Power Grid Applications—UAS Multi-Spectral Scanning Operations for Overhead Transmission Lines (COM/AerCom-SC/UASPGA-MSSO)
Status	Ongoing
Initial date	22-04-2024
Current version	-
Description	This standard aims to improve the operational and maintenance management of overhead transmission lines rated at 110 kV or above by specifying technical requirements for Unmanned Aircraft Systems (UAS)-based multi-spectral scanning. Detailed guidelines are also included for operating methods, procedures, parameter settings, security protocols, data processing algorithms, and deliverables to ensure efficient and effective use of UAS technology in this specialized context.
Version history	-

Reference	https://standards.ieee.org/ieee/1936.14/11666/

Standard	1937.1
Title	Standard Interface Requirements and Performance Characteristics for Payload Devices in Drones
Status	Active
Initial date	12-10-2018
Current version	1937.1-2020
Description	This standard aims to establish a detailed framework for Drone interface to payload divided into mechanical (fixing payloads), electrical (power and communication), and data (communication protocols) components. It also provides performance characteristics include protection against extreme temperatures, humidity, dust, vibration/shock, mold, and salt spray Payloads are designed with varying interfaces to meet these demands, with examples illustrating typical interface needs for different payload types.
Version history	-
Reference	https://standards.ieee.org/ieee/1937.1/7456/ https://sagroups.ieee.org/1937-1/

Standard	1937.3
Title	Standard for Flight Data Transmission of Civil Unmanned Aerial Vehicle Based on Short Message Mechanisms
Status	Active
Initial date	21-11-2023
Current version	1937.3-2024
Description	For the oversight of UAV flight operations, this document outlines the requirements for Global Navigation Satellite System (GNSS) including the specific information it must contain. Additionally it specifies both the content of the data and the short message protocols and transmission methods used for communication during flights.
Version history	-
Reference	https://standards.ieee.org/ieee/1937.3/11512/

Standard	1937.6
Title	Standard for Unmanned Aerial Vehicle (UAV) Light Detection and Ranging (LiDAR) Remote Sensing Operation
Status	Ongoing
Initial date	12-08-2021
Current version	-
Description	This standard specifies the operational methods and data management for Unmanned Aerial Vehicle Light Detection and Ranging (LiDAR) remote sensing applications.
Version history	-
Reference	https://standards.ieee.org/ieee/1937.6/10682/

Standard	1937.7

Title	Standard for the Unmanned Aerial Vehicle (UAV) Polarimetric Remote Sensing Method for Earth Observation Applications
Status	Active
Initial date	11-08-2021
Current version	1937.7-2024
Description	This standard specifies the basic definitions of terms in the UAV Earth observation polarimetric remote sensing task. It specifies the basic process and method from three aspects: data acquisition preparation, data acquisition and correction, data processing and application. Additionally it provides instructive suggestions on elements in many specific dimensions, such as equipment status, parameter indicators, data calibration, data processing methods, etc. By doing so, this standard will enable vendors to supply various components for Drone-based polarimetric remote sensing systems and to help ensure interoperability in operations and data utilization of polarimetric remote sensing deployed in earth observation systems.
Version history	-
Reference	https://standards.ieee.org/ieee/1937.7/10683/

Standard	1937.8
Title	Recommended Practice for Functional and Interface Specifications for Unmanned Aerial Vehicle (UAV) Cellular Communication Terminals
Status	Active
Initial date	4-02-2024
Current version	1937.8-2024
Description	These standard details the functional and interface specifications for cellular communication terminals in Unmanned Aerial Vehicles (UAVs). . To ensure effective cellular communication capabilities within UAV operations, it provides comprehensive requirements for hardware components, signaling standards, data interfaces, environmental performance, reliability, security, and configuration management.
Version history	-
Reference	https://standards.ieee.org/ieee/1937.8/11573/

Standard	1937.9
Title	Requirements for External Power and Power Management Interfaces for Unmanned Aerial Vehicle
Status	Ongoing
Initial date	12-08-2021
Current version	-
Description	This standard defines 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.
Version history	-
Reference	https://standards.ieee.org/ieee/1937.9/10685/

Standard	1937.11

Title	Standard for Technical Requirements of Polar Coordinate Photogrammetry Based on Unmanned Aircraft System
Status	Active
Initial date	1-06-2022
Current version	1937.11-2023
Description	This standard defines 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.
Version history	-
Reference	https://standards.ieee.org/ieee/1937.11/11012/

Standard	1937.12
Title	Standard for Technical Requirements for Emergency Cellular Communication System Based on Fixed-Wing Unmanned Aircraft System
Status	Ongoing
Initial date	27-05-2022
Current version	-
Description	This standard focus on an emergency cellular communication system designed for fixed-wing Unmanned Aircraft Systems (UAS) and specifies the technical requirements for it. Also, it details the essential operational standards and provides a model of how air-to-ground communication operates in such systems.
Version history	-
Reference	https://standards.ieee.org/ieee/1937.12/11013/

Standard	1937.13
Title	Standard for Taxonomy and associated requirements for Unmanned Aircraft System's autonomy levels
Status	Ongoing
Initial date	9-08-2023
Current version	-
Description	This standard defines distinct levels of autonomy-basic, advanced, and expert- for unmanned aerial systems (UAS) and specifies the functional requirements, the technical specifications and the operational standards needed to achieve each level. Additionally it also provides guidance on how to evaluate an aircraft's autonomous capabilities effectively.
Version history	-
Reference	https://standards.ieee.org/ieee/1937.13/11372/

Standard	1937.15
Title	Standard for Communication Security Requirements for Drone Formation Flying Light Show
Status	Ongoing
Initial date	9-08-2023

Current version	-
Description	This standard defines distinct levels of autonomy-basic, advanced, and expert- for unmanned aerial systems (UAS) and specifies the functional requirements, the technical specifications and the operational standards needed to achieve each level. Additionally, it also provides guidance on how to evaluate an aircraft's autonomous capabilities effectively.
Version history	-
Reference	https://standards.ieee.org/ieee/1937.15/11373/

Standard	1937.16
Title	Standard for Civil Unmanned Aerial Systems (UAS) Cybersecurity Framework
Status	Ongoing
Initial date	8-08-2023
Current version	-
Description	This standard provides a comprehensive reference cybersecurity framework for Civil unmanned aircraft systems (UAS), encompassing various critical areas such as airspace security, device security, communication & network security, data security, privacy protection, and operational management security.
Version history	-
Reference	https://standards.ieee.org/ieee/1937.16/11374/

Standard	1937.17
Title	Standard for specifications for lithium-Ion cells and batteries used in Unmanned Aircraft Systems (UAS)
Status	Ongoing
Initial date	09-08-2023
Current version	-
Description	This standard outlines technical and safety specifications for lithium-ion cells and batteries used in Unmanned Aerial Systems (UAS), catering to both consumer-grade and industrial-grade applications. By these specifications it ensures reliable energy performance, safety compliance, and optimal functionality across various UAS operations.
Version history	-
Reference	https://standards.ieee.org/ieee/1937.17/11375/

Standard	1937.18
Title	Charger Used in Unmanned Aircraft Systems - Technical Specification
Status	Ongoing
Initial date	9-08-2023
Current version	-
Description	This standard outline technical requirements for chargers used in unmanned aerial systems (UAS), whether powered by mains electricity or batteries. To ensure reliable operation of both types of UAS systems it provides specifications such as general design, electrical safety standards, charging capacity, and component requirements.

Version history	-
Reference	https://standards.ieee.org/ieee/1937.18/11376/

Standard	1939.1
Title	Standard for a Framework for Structuring Low Altitude Airspace for Unmanned Aerial Vehicle (UAV) Operations
Status	Active
Initial date	2-12-2018
Current version	1939.1-2021
Description	This standard defines the framework for low-altitude airspace designed for the safe and efficient operation of unmanned aerial vehicles (UAVs). It outlines the required UAV capabilities and infrastructure to support their operations within these airspaces, ensuring regulatory compliance.
Version history	-
Reference	https://standards.ieee.org/ieee/1939.1/7482/ https://sagroups.ieee.org/1939-1/

Standard	1945
Title	Standard for Internet of Things (IoT) Computing Edge Computing on Unmanned Aircraft Systems-PART 1 General Requirements
Status	Ongoing
Initial date	9-08-2023
Current version	-
Description	This document defines terminology related to Internet of Things (IoT) and edge computing specifically within the context of Unmanned Aerial Systems (UAS). Furthermore, it also proposes system architecture and functional architecture for UAS edge computing, along with detailed functional requirements for various components involved in this technology
Version history	-
Reference	https://standards.ieee.org/ieee/1945/11371/

Standard	1954
Title	Standard for Self-Organizing Spectrum-Agile Unmanned Aerial Vehicles Communications
Status	Ongoing
Initial date	13-08-2021
Current version	-
Description	This standard defines an architecture and communication protocols that allow unmanned aerial vehicles (UAVs) to form self-organizing, spectrum-agile networks. It enables UAV networks to dynamically utilize available spectrum resources, supporting connectivity with terrestrial users/devices. The standard aims to speed up network deployment using UAS by combining existing communication standards with advanced system-level functionalities.
Version history	-
Reference	https://standards.ieee.org/ieee/1954/10686/ https://sagroups.ieee.org/1954/

Standard	N42.63
Title	Standard for Unmanned Aerial Radiation Measurement Systems (UARaMS)
Status	Active
Initial date	11-09-2022
Current version	N42.63-2023
Description	This standard establishes performance criteria and characterization techniques for radiation measurement systems incorporated onto unmanned aerial vehicles (UAS). It details the expected radiation responses under various environmental conditions like temperature changes, mechanical stress, and onboard vibrations. For radiation response expectations, the standard considers responses from distributed radioactive contamination sources and localized radioactive point source effects.
Version history	-
Reference	https://standards.ieee.org/ieee/N42.63/11092/

Standard	3327
Title	Recommended Practice for Use of an Unmanned Aerial Vehicle for Substation Inspection
Status	Ongoing
Initial date	26-09-2022
Current version	-
Description	This document provides a comprehensive recommended method for using unmanned aerial vehicles (UAVs) to conduct substation inspections. It details the composition, technical requirements, operation procedures, data processing methods, maintenance guidelines, and applicable objects of inspection for UAV systems used in substation inspections. The standard is designed to apply to UAVs inspecting substations and their surrounding environments.
Version history	-
Reference	https://standards.ieee.org/ieee/3327/11136/

Standard	2821
Title	Guide for Unmanned Aerial Vehicle-based Patrol Inspection System for Transmission Lines
Status	Active
Initial date	30-04-2019
Current version	2821-2020
Description	This document demonstrates the application of UAV-based patrol inspection systems in the operation and maintenance of transmission lines. It provides details on system compositions, applicable scenarios, functions, performance specifications, test methods, and usage guidelines for field operations. The standard applies to unmanned aerial vehicle (UAV)-based systems used for patrols inspecting overhead AC and DC transmission lines.
Version history	-
Reference	https://standards.ieee.org/ieee/2821/7642/

Standard	IEEE/ISO/IEC 90003

Title	Software Engineering -- Guidelines for the application of ISO 9001:2015 to computer software
Status	Active
Initial date	13-10-2017
Current version	90003-2018
Description	This document provides guidance for organizations on applying ISO 9001:2015 standards to the entire lifecycle of computer software and related support services. It addresses issues involved in acquiring, supplying, developing, operating, and maintaining such software while being independent of specific technologies, life cycle models, development processes, activity sequences or organizational structures used by an organization.
Version history	90003-2015: Guidance for organizations in the application of ISO 9001:2008 to the acquisition, supply, development, operation, and maintenance of computer software and related support services. 90003-2008: Guidance to users of IEEE standards as to how to meet the quality management expectations of ISO 9001:2000 clauses and sub-clauses in a software development context by adopting ISO/IEC 90003
Reference	https://standards.ieee.org/ieee/90003/7197/

Standard	802.15.4z-2020
Title	Standard for Low-Rate Wireless Networks Amendment: Enhanced Ultra-Wide-Band (UWB) Physical Layers (PHYs) and Associated Ranging Techniques
Status	Historical
Initial date	16-03-2020
Current version	-
Description	This standard defines the physical layer (PHY) and medium access control (MAC) sublayer specifications for low-data-rate wireless connectivity with fixed, portable, and moving devices with no battery or very limited battery consumption requirements. In addition, the standard provides modes that allow for precision ranging. PHYs are defined for devices operating various license-free bands in a variety of geographic regions.
Version history	-
Reference	https://standards.ieee.org/ieee/802.15.4z/10230/

2.2.2 ISO

Standard	ISO/IEC 4005-1
Title	Telecommunications and information exchange between – Systems – Unmanned aircraft area network (UAAN) Part 1: Communication model requirement
Status	Active
Initial date	09-02-2020
Current version	4005-1:2023
Description	This document outlines a communication model and establishes requirements for an Unmanned Aircraft Area Network (UAAN), which functions as a wireless distributed communication network designed to connect units involved in UA services operating at Level II. The document covers the following key aspects: - The architecture and functionality of the communication system.

	- The objectives and associated services of three distinct types of communication. - How these three communication types interact with one another. - Their integration with higher-level layers.
Version history	-
Reference	https://www.iso.org/standard/80627.html

Standard	ISO/IEC 4005-2
Title	Telecommunications and information exchange between systems – Unmanned aircraft area network (UAAN) Part 2: Physical and data link protocols for shared communication
Status	Active
Initial date	09-02-2020
Current version	4005-2:2023
Description	This document specifies communication protocols for the physical and data link layers within shared communication systems. These systems operate as wireless distributed communication networks designed to connect unites associated with Unmanned Aircraft functioning at Level II. The physical layer is defined by several key components, including: - The structure of frames. - Encoding processes. - Physical layer procedures. - Coexistence operations to ensure interoperability between devices. The data link layer encompasses a range of functionalities such as: - The allocation and management of channels and slots. - Resource management to optimize performance. - Broadcasting and exchanging data efficiently. - Synchronization mechanisms to maintain consistency. - Security measures to protect data integrity. - Interfacing with upper layers and other communication layers to ensure seamless integration
Version history	-
Reference	https://www.iso.org/standard/80628.html

Standard	ISO/IEC 4005-3
Title	Telecommunications and information exchange between systems – Unmanned aircraft area network (UAAN) Part 3: Physical and data link protocols for control communication
Status	Active
Initial date	09-02-2020
Current version	4005-3:2023
Description	ISO/IEC 4005-3 specifies communication protocols for the physical and data link layers tailored for control communication, which is a one-to-one interaction between an unmanned aircraft (UA) and its controller. This document focuses on wireless distributed communication networks designed for units associated with UAs operating at Level II. It details the protocols necessary to ensure reliable and efficient communication in this specific operational context.

Version history	-
Reference	https://www.iso.org/standard/80629.html

Standard	ISO/IEC 4005-4
Title	Telecommunications and information exchange between systems – Unmanned aircraft area network (UAAN) Part 4: Physical and data for video communication
Status	Active
Initial date	09-02-2020
Current version	4005-4:2023
Description	This document outlines communication protocols for the physical and data link layers of video transmission in wireless distributed networks for unmanned aircraft systems at Level II. This standard, addresses one-to-one video communication enabling a UA to transmit video to a single receiver. However, it also supports transmitting video from the UA to multiple receivers simultaneously, making it adaptable for various operational needs.
Version history	-
Reference	https://www.iso.org/standard/80630.html

Standard	4358
Title	Test methods for civil multi-copter unmanned aircraft system
Status	Active
Initial date	04-02-2020
Current version	4358:2023
Description	This standard defines test methods for civil electric multi-copter unmanned aircraft systems. It serves as a general standard to evaluate overall system functionality, including subsystem support. It applies to UAS with a maximum take-off mass (MTOM) categorized under Levels I to V according to ISO 21895. However, the document excludes configuration control and specific subsystem tests, such as energy or flight control systems. Additionally, it does not cover test methods for operations in snow or icing conditions, assuming manufacturers have established procedures for such scenarios.
Version history	-
Reference	https://www.iso.org/standard/79891.html

Standard	5015-2
Title	Unmanned aircraft systems Part 2: Operation of vertiports for vertical take-off and landing (VTOL) unmanned aircraft (UA)
Status	Active
Initial date	04-06-2020
Current version	5015-2:2022
Description	ISO 5015-2 establishes requirements for vertiport operations, addressing factors like contaminant removal and noise management, while interfacing with UAS/VTOL operators and UTM service providers. It applies to all vertiport types and supports compliance verification by aviation authorities or independent third parties under applicable regulations. The document ensures operator safety and data quality shared with entities

	such as UAS operators. However, it excludes requirements for UAS operational procedures, physical vertiport characteristics and UTM SP specifications
Version history	-
Reference	https://www.iso.org/standard/80606.html

Standard	ISO/IEC 5055
Title	Information technology – Software measurement – Software quality measurement - Automated source code quality measures
Status	Active
Initial date	18-01-2021
Current version	ISO/IEC 5055:2021
Description	This standard defines measures to detect violations of good architectural and coding practices in source code, addressing risks or excessive costs. Such standards are crucial as they fill a gap in providing international references for outsourcing and system development contracts. Unlike ISO/IEC 25000, which offers limited source code measures, this standard extends its applicability to embedded software due to the growing importance of IoT and the integration IT functionalities into embedded devices. Embedded software is not treated separately because the identified weaknesses apply universally across all software types.
Version history	-
Reference	https://www.iso.org/standard/80623.html

Standard	5109
Title	Evaluation method for the resonance frequency of the multi-copter UA (unmanned aircraft) by measurement of rotor and body frequencies
Status	Active
Initial date	09-06-2020
Current version	5109:2023
Description	This document outlines a methodology for assessing the resonance vibration frequency of multi-copter unmanned aircraft systems (UAS). It describes a design approach for these aircraft to prevent resonance issues caused by the natural frequency of the airframe aligning with the rotational speed of rotors. The scope of this document applies specifically to multicopter UAV with maximum takeoff mass of less than 150 kg.
Version history	-
Reference	https://www.iso.org/standard/80801.html

Standard	5110
Title	Test method for flight stability of a multi-copter unmanned aircraft systems (UAS) under wind and rain conditions
Status	Active
Initial date	04-06-2020
Current version	5110:2023
Description	Thid document establishes methods for evaluating the flight stability of multi-copter unmanned aircraft systems (UAS), with a focus on those that can take-off and land

	vertically. Target category of commercial multi-copter UAS, are those weighing over 250 grams and less than 150kg, though it is applicable for military UAS too.
Version history	-
Reference	https://www.iso.org/standard/80802.html

Standard	5286
Title	Flight performance of civil small and light fixed-wing unmanned aircraft systems (UAS) – Test methods
Status	Active
Initial date	12-09-2020
Current version	5286:2023
Description	This document specifies criteria and procedures for evaluating the defined flight performance aspects of civil fixed-wing unmanned aircraft systems (UAS). It pertains specifically to small and lightweight fixed-wing UAS, categorized under ISO 21895 covering maximum takeoff mass levels I through V.
Version history	-
Reference	https://www.iso.org/standard/81110.html

Standard	5305
Title	Noise measurements for UAS (Unmanned aircraft systems)
Status	Active
Initial date	12-09-2020
Current version	5305:2024
Description	This document specifies methods for recording the time history of instantaneous sound pressure around rotor-powered UAS with a maximum takeoff mass under 150 kg, as per ISO 21895. It applies to both electric and fuel-powered UAS but excludes tilt-rotor or tilt-wing types and does not address noise certifications. The document can be applied to single or multi-rotor UAS and it specifies: - Requirements for noise tests in anechoic chambers, wind tunnels and outdoor environments. - Configurations for measuring noise during hover, takeoff, landing and cruise. - Recommendations to minimize meteorological effects on measurements.
Version history	-
Reference	https://www.iso.org/standard/81111.html

Standard	5309
Title	Civil small and light unmanned aircraft systems (UAS) – Vibration test methods
Status	Active
Initial date	12-09-2020
Current version	5309:2023
Description	This document outlines the criteria and procedures for vibration testing of unmanned aircraft systems (UAS), including the aircraft and ground stations, pertaining the levels II through V as defined by ISO 21895.

Version history	-
Reference	https://www.iso.org/standard/81112.html

Standard	5312
Title	Civil small and light unmanned aircraft (UA) – Sharp injury to human body by rotor blades – Evaluation and test methods
Status	Active
Initial date	12-09-2020
Current version	5312:2023
Description	This document outlines the evaluation and testing methodology for sharp injuries caused by rotor blades of civil and light unmanned aircraft to the human body. It covers injury criteria, requirements, test procedures, results interpretation and related aspects. The scope applies to evaluating and testing injuries caused by rotor blades of civil small and light UAs, specifically those with maximum takeoff mass ranging from 0.25kg to 4kg (classified at Levels II and III under ISO 21895). This includes multi-copter UAs, unmanned helicopters and other types of rotor-based UAs.
Version history	-
Reference	https://www.iso.org/standard/81113.html

Standard	5332
Title	Civil small and light unmanned aircraft systems (UAS) under low-pressure conditions – Test methods
Status	Active
Initial date	12-09-2020
Current version	5332:2023
Description	This document outlines the evaluation and testing methodology for sharp injuries caused by rotor blades of civil and light unmanned aircraft to the human body. It covers injury criteria, requirements, test procedures, results interpretation and related aspects. The scope applies to evaluating and testing injuries caused by rotor blades of civil small and light UAs, specifically those with maximum takeoff mass ranging from 0.25kg to 4kg (classified at Levels II and III under ISO 21895). This includes multi-copter UAs, unmanned helicopters and other types of rotor-based UAs.
Version history	-
Reference	https://www.iso.org/standard/81114.html

Standard	ISO/IEC TR 5469
Title	Artificial Intelligence – Functional safety and AI systems
Status	Active
Initial date	09-06-2020
Current version	5469:2024
Description	This document examines the properties, associated risk factors, methodologies and processes related to:

	1. The integration of artificial intelligence (AI) within safety-related functions to achieve operational functionality. 2. The use of non-AI based safety functions to ensure the safe operation of equipment controlled by AI systems 3. The application of AI systems in the design and development of safety-related functions
Version history	-
Reference	https://www.iso.org/standard/81283.html

Standard	5491
Title	Vertiports – Infrastructure and equipment for vertical take-off and landing (VTOL) of electrically powered cargo unmanned aircraft systems (UAS)
Status	Active
Initial date	13-09-2020
Current version	5491:2023
Description	This document defines the requirements for constructing a vertiport. This document applies to vertiports of type A (micro) as defined in ISO 5015-2.
Version history	-
Reference	https://www.iso.org/standard/81313.html

Standard	AWI 5491
Title	Vertiports – Infrastructure and equipment for vertical take-off and landing (VTOL) of electrically powered cargo unmanned aircraft systems (UAS)
Status	Ongoing
Initial date	04-06-2024
Current version	-
Description	-
Version history	-
Reference	https://www.iso.org/standard/89706.html

Standard	ISO/IEC TS 5928
Title	Information technology – Cloud computing and distributed platforms – Taxonomy for digital platforms
Status	Active
Initial date	01-01-2021
Current version	5928:2023
Description	This document provides a taxonomy for digital platforms by offering clear definitions and explanatory information. It clarifies the various uses of the term “platform” within the context of digital services, such as cloud computing and other distributed computing systems.
Version history	-
Reference	https://www.iso.org/standard/81848.html

Standard	9001
Title	Quality management systems – Requirements
Status	Active
Initial date	05-10-2012
Current version	9001:2015
Description	ISO 9001 is a globally recognized quality management standard that helps organizations of any size and in any sector improve their performance, meet customer needs, and demonstrate their commitment to quality. It also provides a framework for establishing, implementing, maintaining, and continually enhancing a Quality Management System (QMS), enabling consistent delivery of high-quality products or services through effective processes and trained teams.
Version history	9001:2008 9001:2000 9001:1994 9001:1987
Reference	https://www.iso.org/standard/62085.html

Standard	9004
Title	Quality managements – Quality of an organization – Guidance to achieve sustained success
Status	Active
Initial date	03-12-2015
Current version	9004:2018
Description	ISO 9004:2018 aims to help organizations build their ability to achieve sustained success by offering relevant guidelines. Additionally, the present standard also includes a self-assessment tool for organizations to evaluate their adoption of its concepts.
Version history	9004:2009 9004:2000 9004-1:1994 9004:1987
Reference	https://www.iso.org/standard/70397.html

Standard	ISO/IEC TR 9789
Title	Information technology – Guidelines for the organization and representation of data elements for data interchange – Coding methods and principles
Status	Active
Initial date	01-06-1980
Current version	9789:1994
Description	This document provides general guidance on how data can be presented using codes. It outlines the objectives of coding, discusses the characteristics, advantages and disadvantages of various coding methods and identifies key features of cods. Additionally, for designing effective cods it offers relevant guidelines and examples of applications include ISO 9735:1988, ISO 8601:1988 and ISO 3166:1993
Version history	-

Reference	https://www.iso.org/standard/17651.html

Standard	ISO/IEC TR 10032
Title	Information technology – Reference Model of Data Management
Status	Active
Initial date	06-03-2003
Current version	10032:2003
Description	ISO/IEC TR 10032:2003 defines the ISO Reference Model of Data Management, providing a framework for coordinating the development of standards for managing persistent data in information systems. It establishes common terminology and concepts relevant to data manage, such as defining, storing, retrieving and updating data, while excluding operating system-specific services like physical storage or communication details. The scope includes processes for handling data across multiple systems, including distributed database management, but does not specify implementation protocols or conformance evaluation. This document focuses on conceptual data management services rather than technical specifics, serving as a foundational reference for future standardization efforts.
Version history	10032:1995
Reference	https://www.iso.org/standard/38607.html

Standard	14619
Title	Space systems – Space experiments – General requirements
Status	Active
Initial date	01-09-2020
Current version	14619:2023
Description	This document outlines procedures for preparing and conducting space experiments (SEs) on developmental space systems, including add-on components. It covers the analysis and processing of experimental findings. Applicable to both manned and unmanned space systems, the document can be adapted to meet the specific needs of various types of SEs.
Version history	14619:2003
Reference	https://www.iso.org/standard/81694.html

Standard	14620-3
Title	Space systems – Safety requirements Part 3: Flight safety systems
Status	Active
Initial date	28-08-2020
Current version	14620-3:2021
Description	This document focus on unmanned orbital or suborbital space vehicles and specifies minimum requirements for flight safety systems (FSSs), including flight termination systems (FTSs), tracking systems and telemetry data transmitting systems (TDTSs). Its goal is to minimize risks of injury, property damage, or environmental harm during launches. The document applies to commercial or non-commercial launch activities by any country, organization, agency, or operator unless stricter local regulations apply. It is intended for use by all participants in launch activities, including operations and launch authorities, ensuring safety standards are met globally.

Version history	14620-3:2005
Reference	https://www.iso.org/standard/81677.html

Standard	14711
Title	Space systems – Unmanned mission operations concepts – Guidelines for defining and assessing concept products
Status	Active
Initial date	10-03-2000
Current version	14711:2003
Description	ISO 14711:2003, provides guidelines for developing space systems mission operations concepts and defines the products to be generated during the process. It enables the creation of standardized mission operations concept products by industries, government agencies or universities, ensuring consistency across different organizations involved in space system development.
Version history	-
Reference	https://www.iso.org/standard/36217.html

Standard	ISO/IEC 14776-251
Title	Information technology – Small computer system interface (SCSI) Part 251: USB attached SCSI
Status	Active
Initial date	09-05-2011
Current version	14776-251:2014
Description	ISO/IEC 14776-251:2014€ defines a SCSI transport protocol for USB-2 and USB-3 devices. It provides mechanisms to send commands with any SCSI standard to a USB device while complying with the SCSI Architecture Model – 4 (SAM-4), including features like autosense and command queuing, as well as additional capabilities.
Version history	-
Reference	https://www.iso.org/standard/59526.html

Standard	ISO/IEC 14776-253
Title	Information technology – Small Computer System Interface (SCSI) Part 253: USB attached SCSI – 3
Status	Active
Initial date	29-09-2022
Current version	14776-253:2023
Description	This standard describes a SCI transport protocol (see SAM-6) for USB-2 and USB-3 with the following properties: A mechanism to send commands associated with any T10 command standard to a USB device Compliance with SCSI Architecture Model – 6 Other capabilities
Version history	-

Reference	https://www.iso.org/standard/85710.html

Standard	14950
Title	Space systems – Unmanned spacecraft operability
Status	Active
Initial date	24-10-2001
Current version	14950:2004
Description	ISO 14950:2003 specifies requirements and guidelines for unmanned spacecraft on-board functions to ensure they can be operated by a defined ground segment in both nominal and contingency situations. It defines essential properties, related to spacecraft operations, enabling effective management under any predefined conditions.
Version history	-
Reference	https://www.iso.org/standard/36466.html

Standard	ISO/IEC 15408-4
Title	Information security, cybersecurity and privacy protection – Evaluation criteria for IT security Part 4: Framework for the specification of evaluation methods and activities
Status	Active
Initial date	15-06-2017
Current version	15408-4:2022
Description	This document establishes a standardized framework for defining objective, repeatable and reproducible evaluation methods and activities. However, it does not specify how to implement, adopt or maintain these methods and activities; such details are left to the discretion of those responsible for their development in specific areas of interest.
Version history	-
Reference	https://www.iso.org/standard/72913.html

Standard	ISO/IEC DIS 15408-4
Title	Information security, cybersecurity and privacy protection – Evaluation criteria for IT security Part 4: Framework for the specification of evaluation methods and activities
Status	Ongoing
Initial date	27-10-2023
Current version	-
Description	-
Version history	-
Reference	https://www.iso.org/standard/88138.html

Standard	15864
Title	Space systems – General test, methods for spacecraft subsystems and units
Status	Active

Initial date	08-07-2019
Current version	15864:2021
Description	This document serves as the foundational standard for system, subsystem and unit-level testing applicable to unmanned spacecraft programs. It outlines the necessary requirements for documentation related to these testing activities. Additionally, it includes provisions for qualification, acceptance and proto-flight testing (PFT), assuming that hardware development has already been completed.
Version history	15864:2004
Reference	https://www.iso.org/standard/78975.html

Standard	ISO/DIS 15965
Title	Detection and avoidance system for unmanned aircraft systems
Status	Ongoing
Initial date	05-05-2022
Current version	-
Description	'Safety and quality' requirements are provided by this standard for Detection and Avoidance (DAA) systems. These systems used by Unmanned Aircraft Systems (UAS) are able to detect and avoid other objects, including manned aircraft. Additionally, it includes specific requirements for radar and optical sensors utilized in DAA systems. The standard was developed to align with the DAA operational requirements outlined in ISO 21384-3
Version history	-
Reference	https://www.iso.org/standard/84450.html

Standard	16126
Title	Space systems – Assessment of survivability of unmanned spacecraft against space debris and meteoroid impacts to ensure successful post-mission disposal
Status	Active
Initial date	30-1-2024
Current version	16126:2024
Description	This document defines requirements and procedures for analyzing the risk that an unmanned spacecraft fails as a result of a space debris or meteoroid impact.
Version history	16126:2014
Reference	https://www.iso.org/standard/78979.html

Standard	16458
Title	Space systems – Unmanned spacecraft transportation – General requirements
Status	Active
Initial date	15-06-1998
Current version	16458:2004
Description	ISO 16458:2004 sets transportation requirements for unmanned spacecraft, instruments, and supporting hardware via rail, road, air, and water. It includes guidelines for special

	containers and loading/unloading to ensure protection. Primarily for international transport, it can also be used nationally.
Version history	-
Reference	https://www.iso.org/standard/30989.html

Standard	ISO/CD 16746
Title	Unmanned aircraft systems – Counter UAS – Quality and safety for users
Status	Ongoing
Initial date	27-06-2022
Current version	-
Description	The proposed standard will guide the safe and legal use of Counter UAS (CUAS) technology in civilian and on-shore military settings. It covers user definitions, CUAS categories (fixed, mobile, DTIE), and key considerations such as safety, legal compliance, licensing, and installation. It also outlines user requirements, including essential system functions, performance metrics, and site-specific needs. Additionally, it addresses training, on-site exercises, and maintenance to ensure effective deployment. This standard aims to support users in implementing CUAS systems while meeting operational and regulatory requirements.
Version history	-
Reference	https://www.iso.org/standard/84801.html

Standard	ISO/CD 16747
Title	Unmanned aircraft systems – Counter UAS – Quality and safety for manufacturers
Status	Ongoing
Initial date	27-06-2022
Current version	-
Description	The proposed standard will guide the safe and legal use of Counter UAS (CUAS) technology in civilian and on-shore military settings. It covers user definitions, CUAS categories (fixed, mobile, DTIE), and key considerations such as safety, legal compliance, licensing, and installation. It also outlines user requirements, including essential system functions, performance metrics, and site-specific needs. Additionally, it addresses training, on-site exercises, and maintenance to ensure effective deployment. This standard aims to support users in implementing CUAS systems while meeting operational and regulatory requirements.
Version history	-
Reference	https://www.iso.org/standard/84802.html

Standard	ISO/AWI 17123-10
Title	Optics and optical instruments – Field procedures for testing geodetic and surveying instruments Part 10: UAV photogrammetry systems
Status	Ongoing
Initial date	19-06-2024
Current version	-

Description	This part of ISO 17123 defines test procedures for assessing UAV photo measurement systems used in surveying tasks like land surface mapping, earthwork monitoring, structural measurement, and volume calculation. The tests verify the suitability of a UAV system, including its camera and processing software, ensuring it meets accuracy requirements. Designed for simplicity, these procedures provide a quick assessment of system accuracy but are not for calibration. Both full and simplified tests require minimal ground markers with known coordinates, serving as control and check points.
Version history	-
Reference	https://www.iso.org/standard/83171.html

Standard	ISO/IEC 18000-63
Title	Information technology – Radio frequency identification for item management Part 63: Parameters for air interface communications at 860 MHz to 960 MHz Type C
Status	Active
Initial date	16-07-2019
Current version	18000-63:2021
Description	This document defines the air interface for RFID devices operating in the 860–960 MHz ISM band for item management applications. It establishes technical specifications to ensure compatibility and interoperability in the global RFID market. It details forward and returns link parameters, including frequency, bandwidth, power limits, modulation, and data coding. The document specifies the communication protocol for passive-backscatter, Interrogator-Talks-First (ITF) systems, where Interrogators (readers) transmit signals to tags (labels), which respond via backscatter. It covers physical interactions, logical operations, collision arbitration for multiple tags, and optional security commands using ISO/IEC 29167 crypto suites.
Version history	18000-63:2015 18000-63:2013
Reference	https://www.iso.org/standard/78309.html

Standard	18045
Title	Information security, cybersecurity and privacy protection – Evaluation criteria for IT security – Methodology for IT security evaluation
Status	Active
Initial date	15-06-2017
Current version	18045:2022
Description	This document outlines the minimum steps an evaluator must take to perform and evaluation in accordance with the ISO/IEC 15408 series, utilizing the criteria and evidence defined within that series.
Version history	18045:2008 18045:2005
Reference	https://www.iso.org/standard/72889.html

Standard	ISO/IEC DIS 18045

Title	Information security, cybersecurity and privacy protection – Evaluation criteria for IT security – Methodology for IT security evaluation
Status	Ongoing
Initial date	27-10-2023
Current version	-
Description	-
Version history	-
Reference	https://www.iso.org/standard/88141.html

Standard	ISO/IEC 18047-3
Title	Information technology – Radio frequency identification device conformance test methods Part 3: Test methods for air interface communications ta 13,56 MHz
Status	Active
Initial date	06-11-2020
Current version	18047-3:2022
Description	This document specifies test methods for verifying that RFID tags and interrogators comply with ISO/IEC 18000-3. It focuses on mandatory functions and any optional features implemented, allowing for additional application-specific criteria when needed. The tests cover mode-specific parameters (nominal values and tolerances) and factors affecting system functionality and interoperability. However, it excludes regulatory requirements and high-level data encoding tests (specified in ISO/IEC 15962).
Version history	ISO/IEC TR 18047-3:2011 ISO/IEC TR 18047-3:2004
Reference	https://www.iso.org/standard/81525.html

Standard	18047-63
Title	Information technology – Radio frequency identification device conformance test methods Part 63: Test methods for air interface communications at 860 MHz to 960 MHz
Status	Active
Initial date	06-05-2020
Current version	18047-63:2023
Description	This document specifies test methods for verifying RFID tags and interrogators comply with ISO/IEC 18000-63, focusing on mandatory functions and optional features implemented. It excludes regulatory conformity testing but includes type-specific parameters (nominal values and tolerances) and factors affecting system functionality and interoperability. Application-specific criteria can be added if needed. Parameters already covered by regulatory tests or high-level data encoding (ISO/IEC 15962) are excluded. Tests apply exclusively to RFID tags and interrogators defined in ISO/IEC 1800-63 unless otherwise specified.
Version history	-
Reference	https://www.iso.org/standard/80577.html

Standard	ISO/IEC 19086-1

Title	Information technology – Cloud computing – Service level agreement (SLA) framework Part 1: Overview and concepts
Status	Active
Initial date	22-09-2014
Current version	19086-1:2016
Description	ISO/IEC 19086-1:2016 provided common cloud SLA building blocks, including concepts, terms and definitions, to help create cloud Service Level Agreements (SLAs). It offers an overview of cloud SLAs, explains their relationship with cloud service agreements and defines terms for clarity. Aimed at both providers and customers, it avoids confusion and aids comparison of services. While it doesn't provide a standard structure or universal objectives, it allows flexibility for tailored SLAs. It does not supersede legal requirements.
Version history	-
Reference	https://www.iso.org/standard/67545.html

Standard	19941
Title	Information technology – Cloud computing – Interoperability and portability
Status	Active
Initial date	19-08-2014
Current version	19941:2017
Description	The ISO/IEC 19941:2017 standard establishes definitions for cloud computing and standard terminology. The standard addresses general aspects of cloud services through references to ISO/IEC 17788 and 17789 standards. The standard works to improve cloud computing interoperability and portability through a unified understanding for cloud service customers (CSCs), providers (CSPs) and partners (CSNs). The standard defines common concepts but avoids implementation requirements to maintain flexibility while creating clear understanding among stakeholders.
Version history	-
Reference	https://www.iso.org/standard/66639.html

Standard	ISO/IEC AWI 19941
Title	Information technology – Cloud computing – Interoperability and portability
Status	Ongoing
Initial date	25-09-2023
Current version	-
Description	-
Version history	-
Reference	https://www.iso.org/standard/87817.html

Standard	ISO/TS 20517
Title	Space systems – Cybersecurity managements and recommendations
Status	Active
Initial date	29-03-2023

Current version	20517:2024
Description	This document provides requirements and recommendations for managing cybersecurity in space systems, including spacecraft, launchers, payloads, ground equipment and related facilities. It outlines processes, techniques and responsibilities to prevent and mitigate cyber incidents, focusing on security engineering within systems
Version history	-
Reference	https://www.iso.org/standard/86305.html

Standard	20780
Title	Space systems – Fiber optic components – Design and verification requirements
Status	Active
Initial date	31-07-2015
Current version	20780:2018
Description	This document outlines requirements for designing and verifying fiber optic components in space sub-systems, ensuring their reliability and adaptability to harsh space environments. It covers applications like ground, unmanned and manned systems, providing a framework for selecting suitable components.
Version history	-
Reference	https://www.iso.org/standard/69067.html

Standard	21384-2
Title	Unmanned aircraft systems Part 2: UAS components
Status	Active
Initial date	05-12-2019
Current version	21384-2:2021
Description	This document specifies requirements for ensuring the quality and safety in designing and manufacturing unmanned aircraft systems (UAS), including unmanned aircraft (UA), remote pilot stations (RPS), datalinks, payloads and support equipment. It covers system document applies to UAS used where a Certificate of Air-worthiness isn't required or complements technical standards a C of A is needed. It offers an alternative compliance method acceptable to aviation authorities, ensuring safety and quality across various applications.
Version history	-
Reference	https://www.iso.org/standard/80123.html

Standard	21384-3
Title	Unmanned aircraft systems Part 3: Operational procedures
Status	Active
Initial date	05-12-2019
Current version	21384-3:2023
Description	This document specifies the requirements for safe commercial unmanned aircraft system (UAS) operations, including the external safety-critical service providing command and control (C2) link.

Version history	21384-3:2019
Reference	https://www.iso.org/standard/80124.html

Standard	ISO/CD 21384-3
Title	Unmanned aircraft systems Part 3: Operational procedures
Status	Ongoing
Initial date	27-11-2023
Current version	-
Description	-
Version history	-
Reference	https://www.iso.org/standard/88660.html

Standard	21384-4
Title	Unmanned aircraft systems Part 4: Vocabulary
Status	Active
Initial date	31-01-2019
Current version	21384-4:2020
Description	This document defines terms and definitions relating to unmanned aircraft systems that are widely used in science and technology.
Version history	-
Reference	https://www.iso.org/standard/76785.html

Standard	ISO/DIS 21384-4
Title	Unmanned aircraft systems Part 4: Vocabulary
Status	Ongoing
Initial date	06-05-2022
Current version	-
Description	-
Version history	-
Reference	https://www.iso.org/standard/85053.html

Standard	21895
Title	Categorization and classification of civil unmanned aircraft systems
Status	Active
Initial date	21-10-2016
Current version	21895:2020
Description	This document specifies requirements for classifying and grading civil unmanned aircraft systems (UAS), covering both heavier that air and lighter than air aircraft of any design. It applies throughout their lifecycle from conception to maintenance. Characteristics can be

	used individually or combined to meet specific classification needs. However, risk-based categorization of UAS operations is excluded, as it fails under aviation authority's jurisdiction
Version history	-
Reference	https://www.iso.org/standard/72093.html

Standard	ISO/CD 21895
Title	Categorization and classification of civil unmanned aircraft systems
Status	Ongoing
Initial date	28-11-2024
Current version	-
Description	-
Version history	-
Reference	https://www.iso.org/standard/91003.html

Standard	ISO/IEC 22123-3
Title	Information technology – Cloud computing Part 3: Reference architecture
Status	Active
Initial date	23-05-2022
Current version	22123-3:2023
Description	This document specifies the cloud computing reference architecture (CCRA).
Version history	ISO/IEC 17789:2014
Reference	https://www.iso.org/standard/82759.html

Standard	ISO/IEC 22460-1
Title	Cards and security devices for personal identification – ISO UAS license and drone/UAS security module. Part 1: Physical characteristics and basic datasets for UAS license
Status	Ongoing
Initial date	28-11-2022
Current version	-
Description	*This draft is in the approval phase.*
Version history	-
Reference	https://www.iso.org/standard/86142.html

Standard	ISO/IEC 22460-2
Title	Cards and security devices for personal identification – ISO UAS license and drone/UAS security module. Part 2: Drone/UAS security module
Status	Active
Initial date	28-11-2022

Current version	22460-2:2024
Description	This document specifies the cryptographic functions of a drone/UAS security module, which securely stores pilot and operator licenses personal IDs and optional elements. It ensures integrity validation, authentication and data encryption, providing robust security for unmanned aircraft systems.
Version history	-
Reference	https://www.iso.org/standard/86141.html

Standard	ISO/IEC CD 22460-3
Title	Cards and security devices for personal identification – ISO UAS license and drone/UAS security module. Part 3: Logical data structure, access control, authentication and integrity validation for drones
Status	Ongoing
Initial date	31-01-2024
Current version	-
Description	*This Draft International Standard is in the enquiry phase with ISO members.*
Version history	-
Reference	https://www.iso.org/standard/88973.html

Standard	ISO/IEC 22624
Title	Information technology – Cloud computing – Taxonomy based data handling for cloud services
Status	Active
Initial date	11-07-2017
Current version	22624:2018
Description	This document outlines a framework for expressing data policies and practices in cloud computing, based on ISO/IEC 19944's data taxonomy. It provides guidelines for handling data by subcategory and classification, covering geolocation, cross-border flow, access, portability, use, management and governance. The framework aids in developing codes of conduct for data at rest or in transit, including transfers and remote access. Use cases address challenges like data control, access and location according to the taxonomy. It primarily targets cloud providers, customers, users and those involved in legal or technical aspects of taxonomy-based data management, ensuring structured and secure data practices.
Version history	-
Reference	https://www.iso.org/standard/73614.html

Standard	23041:2018
Title	Space systems – Unmanned spacecraft operational procedures - Documentation
Status	Active
Initial date	18-01-2017
Current version	23041:2018

Description	ISO 23041:2018 minimizes duplication of effort across space operations by providing standardized practices for documentation development. It facilitates information sharing among customers, agencies, nations and commercial entities, ensuring smoother collaboration. The standard establishes a common interface that simplifies planning and reduces the learning curve for new programs or support organizations, promoting efficiency and consistency in space operations.
Version history	23041:2007
Reference	https://www.iso.org/standard/73170.html

Standard	ISO/AWI 23041
Title	Space systems – Unmanned spacecraft operational procedures - Documentation
Status	Ongoing
Initial date	26-01-2024
Current version	-
Description	-
Version history	-
Reference	https://www.iso.org/standard/88952.html

Standard	ISO/IEC 23053
Title	Framework for Artificial Intelligence (AI) Systems Using Machine Learning (ML)
Status	Active
Initial date	07-03-2018
Current version	23053:2022
Description	This document provides a framework for describing generic AI systems using ML technology, detailing components and functions within the AI ecosystem. Applicable to all types of organizations - either public or private, government and non-profit – it supports those implementing or utilizing AI systems, ensuring clarity and consistency in their structure and application.
Version history	-
Reference	https://www.iso.org/standard/74438.html

Standard	23117-1
Title	Agricultural and forestry machinery – Unmanned aerial spraying systems Part 1: Environmental requirements
Status	Active
Initial date	29-04-2020
Current version	23117-1:2023
Description	This document, used with ISO 16119-1, specifies design and performance requirements for unmanned aerial spraying systems (UASS) on UAS for applying plant protection products in agriculture and related areas. It focuses on minimizing environmental contamination risk, including foreseeable misuse. The document overrides ISO 16119-1's requirements but excludes human safety aspects or bystander/UAS safety. It applies only to UASS on UAS with maximum takeoff mass less or equal than 150 kg and does not cover systems

	manufactured before its publication date, ensuring targeted and efficient environmental protection in specific applications.
Version history	-
Reference	https://www.iso.org/standard/74600.html

Standard	ISO/FDIS 23117-2
Title	Agricultural and forestry machinery – Unmanned aerial spraying systems Part 2: Test methods to assess the horizontal transverse spray distribution
Status	Ongoing
Initial date	07-04-2021
Current version	-
Description	*Final production steps (up to seven weeks).*
Version history	-
Reference	https://www.iso.org/standard/81053.html

Standard	23135
Title	Space systems – Verification program and management process
Status	Active
Initial date	18-01-2018
Current version	23135:2022
Description	This document establishes requirements for planning and executing verification programs for manned and unmanned space systems, covering both commercial and non-commercial applications. It outlines a distributed approach starting from the unit level through delivery and launch activities. The program primarily addresses space, launch and ground segments but also supports related areas like range safety and ground equipment. This ensures comprehensive verification across all system aspects, promoting reliability and consistency in space system development.
Version history	-
Reference	https://www.iso.org/standard/74673.html

Standard	ISO/TR 23267
Title	Experiment results on test methods for detection and avoidance (DAA) systems for unmanned aircraft systems
Status	Active
Initial date	29-06-2023
Current version	23267:2024
Description	This report details tests conducted to verify the safety and quality of detection and avoidance (DAA) systems for UASs, ensuring that they interact safely with other objects like aircraft. The document outlines test methods and results that successfully validate a DAA system architecture incorporating radar and optical sensors, confirming their effectiveness in meeting specified requirements and enhancing operational safety
Version history	-
Reference	https://www.iso.org/standard/87386.html

Standard	ISO/TR 23629-1
Title	UAS traffic management (UTM) Part 1: Survey results on UTM
Status	Active
Initial date	07-09-2018
Current version	23629-1:2020
Description	This document presents survey results on Unmanned Traffic Management (UTM), aggregating data from respondents without detailed regional or organizational analysis. It highlights UTM's extensive commercial applications and underlying social systems. The findings aid in identifying benefits and gaps for potential future standardization efforts, particularly in collaboration with authorities like the International Civil Aviation Organization (ICAO). These insights driven approach supports informed decision making for advancing UTM frameworks effectively.
Version history	-
Reference	https://www.iso.org/standard/76453.html

Standard	23629-5
Title	UAS traffic management (UTM) Part 5: UTM functional structure
Status	Active
Initial date	05-02-2020
Current version	23629-5:2023
Description	This document defines the core functions and functional structure of Unmanned Traffic Management (UTM) within the framework's system layer. It provides a detailed description but excludes role-sharing among entities, which is left to implementation; technical communication methods between functions; and business models of UTM players. The focus is on establishing a common understanding of UTM's foundational elements while allowing flexibility in specific implementations and operational details.
Version history	-
Reference	https://www.iso.org/standard/78961.html

Standard	23629-7
Title	UAS traffic management (UTM) Part 7: Data model for spatial data
Status	Active
Initial date	11-01-2019
Current version	23629-7:2021
Description	This document outlines a standardized data model for spatial information sharing between UAS service providers and operational control systems such as UTM. It defines the names of data items essential for common use but does not address the communication architecture or the responsibilities of actors in defining these items. The focus is on establishing a consistent framework for data exchange, enabling seamless coordination and operation within the UAS ecosystem while allowing flexibility in implementation details
Version history	-
Reference	https://www.iso.org/standard/76973.html

Standard	23629-8
Title	UAS traffic management (UTM) Part 8: Remoted Identification
Status	Active
Initial date	30-06-2020
Current version	23629-8:2023
Description	This document establishes a generic framework and minimum performance standards for the direct remote identification of unmanned aircraft (UA) while in flight. It specifically addresses the electronic identification of UA but excludes requirements for onboard modules and network based remote identification. Additionally, it does not cover the identities of other IT entities such as remote pilot stations or fleet management workstations. The focus is on ensuring a standardized approach to direct remote ID, enhancing safety and accountability is UAS operations while allowing flexibility in related technologies and systems beyond its scope.
Version history	-
Reference	https://www.iso.org/standard/80126.html

Standard	23629-9
Title	UAS traffic management (UTM) Part 9: Interface between UTM service providers and users
Status	Active
Initial date	08-11-2021
Current version	23629-9:2023
Description	This document outlines the essential elements of information exchange between UAS Traffic Management (UTM) Service Providers (USP) and various users to facilitate relevant UTM services. It focuses on defining the data and interactions necessary for effective communication but does not address protocol or transmission details at the operational level. The scope excludes interfaces between different USPs and those between USPs and providers of operational support services. By establishing a clear framework for information exchange, it supports efficient and standardized communication within the UTM ecosystem while leaving implementation-specific details to other specifications.
Version history	-
Reference	https://www.iso.org/standard/82188.html

Standard	23629-12
Title	UAS traffic management (UTM) Part 12: Requirements for UTM service providers
Status	Active
Initial date	05-02-2020
Current version	23629-12:2023
Description	This document outlines the essential requirements for UAS Traffic Management (UTM) service providers, encompassing compliance monitoring, safety measures, security protocols, privacy standards and other organizational obligations necessary to ensure reliable and regulated UTM services.
Version history	-
Reference	https://www.iso.org/standard/78962.html

Standard	23665
Title	Unmanned aircraft systems – Training for personnel involved in UAS operations
Status	Active
Initial date	11-06-2021
Current version	23665:2023
Description	This document outlines the training procedures for UAS personnel, including pilots and support staff. It establishes criteria for knowledge, skills and qualifications required for both trainees and training organizations. Its details curriculum content and qualification standards for these organizations, along with general training protocols. Specific course may have additional, stricter requirements, ensuring comprehensive and standardized training tailored to UAS operations.
Version history	ISO 23665:2021
Reference	https://www.iso.org/standard/83175.html

Standard	ISO/CD 23665
Title	Unmanned aircraft systems – Training for personnel involved in UAS operations
Status	Ongoing
Initial date	27-11-2023
Current version	-
Description	-
Version history	-
Reference	https://www.iso.org/standard/88661.html

Standard	ISO/IEC TR 24027
Title	Information technology – Artificial Intelligence (AI) – Bias in AI systems and AI aided decision making
Status	Active
Initial date	19-12-2018
Current version	24027:2021
Description	This document addresses bias in AI systems, particularly in AI aided decision making. It describes measurement techniques and methods to assess and mitigate bias-related vulnerabilities across all phases of the AI system lifecycle, including data collection, training, continual learning, design, testing, evaluation and use. The aim is to ensure fairness and reliability by systematically addressing and treating biases throughout the entire AI development and deployment process.
Version history	-
Reference	https://www.iso.org/standard/77607.html

Standard	ISO/IEC TR 24028
Title	Information technology – Artificial Intelligence – Overview of trustworthiness in artificial intelligence
Status	Active

Initial date	19-12-2018
Current version	24028:2020
Description	This document explores trustworthiness in AI systems through approaches like transparency, explainability and controllability to establish trust. It identifies engineering pitfalls, associated threats and risks and suggests mitigation techniques. The document also covers methods to assess and ensure availability, resiliency, reliability, accuracy, safety, security and privacy of AI Systems. Notably, it does not specify levels of trustworthiness for AI systems.
Version history	-
Reference	https://www.iso.org/standard/77608.html

Standard	ISO/CD 24243
Title	Test methods for civil small and light multi-copter unmanned aircraft dock system
Status	Ongoing
Initial date	29-02-2024
Current version	-
Description	This document outlines test methods for small and light civil multi-copter unmanned aircraft (UA) dock systems, applicable to those with a maximum takeoff mass of up to 25kg. While primarily designed for these specific systems, the standard can also be adapted for use in other UA dock systems, ensuring comprehensive testing across various applications.
Version history	-
Reference	https://www.iso.org/standard/87782.html

Standard	24352
Title	Technical requirements for small unmanned aircraft electric systems
Status	Active
Initial date	16-11-2019
Current version	24352:2023
Description	This document provides technical requirements and test methods for electric energy systems (EESs) of small unmanned aircraft (UA) with a maximum takeoff mas (MTOM) under 25 kg, corresponding to UAS Levels I-IV as defined in ISO 21895:2020. It applies to EESs using secondary lithium batteries and is adaptable for future battery technologies
Version history	-
Reference	https://www.iso.org/standard/78481.html

Standard	24354
Title	General requirements for the payload interface of civil unmanned aircraft systems
Status	Active
Initial date	19-11-2019
Current version	24354:2023
Description	This document outlines the composition, functional and performance requirements for payload interfaces in civil UAS with a maximum takeoff mass (MTOM) ranging from 0.25

	kg to 25kg, corresponding to ISO 21895 levels II-IV. It applies to the design and manufacture of physically independent interfaces that connect external payloads to unmanned aircraft (UA).
Version history	-
Reference	https://www.iso.org/standard/78482.html

Standard	24355
Title	Flight control system for civil small and light multi-copter unmanned aircraft system (UAS) – General requirements
Status	Active
Initial date	16-11-2019
Current version	24355:2023
Description	This document specifies requirements for flight controls in civil multi-copter UAs with a maximum takeoff mass less than or equal to 25 kg, corresponding to ISO 21895 levels I-IV, excluding fully autonomous flights. The system includes components like flight control, navigation, fault diagnosis, planning and recording units. It applies to the design and manufacture of the UA flight control systems or subsystems
Version history	-
Reference	https://www.iso.org/standard/78483.html

Standard	24356
Title	General requirements for tethered unmanned aircraft systems
Status	Active
Initial date	19-11-2019
Current version	24356:2022
Description	This document outlines general and manufacturing requirements for tethered UAS (tUAS), including heavier than air tUA powered by ground equipment via a tether that also provides mechanical restraint. It applies to the development, manufacturing, industrial use and delivery of tUAS. While ISO 21384-2 covers UAs restrained solely by the tether without power, this document includes clauses on tethering equipment like winches and cables.
Version history	-
Reference	https://www.iso.org/standard/78484.html

Standard	ISO/CD 25009
Title	Unmanned aircraft systems – General requirements and test methods for the hydrogen fuel gas pipes of gaseous hydrogen fuel cell powered UAV
Status	Ongoing
Initial date	09-04-2024
Current version	-
Description	This document specifies the performance requirements for the fuel gas piping (excluding the stack) for hydrogen UAVs.
Version history	-

Reference	https://www.iso.org/standard/88779.html

Standard	ISO/CD 25013
Title	Unmanned aircraft systems- General requirements and test methods for the attachable hydrogen cylinders of gaseous hydrogen fuel cell powered UAV
Status	Ongoing
Initial date	10-04-2024
Current version	-
Description	This document specifies the fixed performance of detachable hydrogen containers for hydrogen UAVs. It applies to the fixed performance regulations for the safety and integrity of hydrogen containers, which are key components of hydrogen UAVs, to ensure safe flight and intended performance.
Version history	-
Reference	https://www.iso.org/standard/88780.html

Standard	ISO/IEC 25030
Title	Systems and software engineering – Systems and software quality requirements and evaluation (SQuaRE) – Quality requirements framework
Status	Active
Initial date	09-12-2016
Current version	25030:2019
Description	The document provides a framework for defining, using and managing quality requirements. It's intended for acquirers, developers, testers, project managers and independent evaluators. It aligns with ISO/IEC/IEEE 15288 processes and uses quality models from ISO/IEC 25010 and 25012 to categorize and quantify quality but does not cover other types of requirements or specify measures or development processes.
Version history	ISO/IEC 25030:2007
Reference	https://www.iso.org/standard/72116.html

Standard	ISO/AWI 25132
Title	Classification of civil unmanned aircraft system (UAS) autonomous flight control levels
Status	Ongoing
Initial date	18-09-2024
Current version	-
Description	This document defines the classification of civil unmanned aircraft system (UAS) autonomous flight control levels. Based on the human machine role allocation, this document defines 6 UAS autonomous levels, from no autonomy (level 0) to full autonomy (level 5).
Version history	-
Reference	https://www.iso.org/standard/89095.html

Standard	ISO/AWI 25215

Title	Civil small and light multi-copter unmanned aircraft docking system – General requirements
Status	Ongoing
Initial date	07-10-2024
Current version	-
Description	This document defines general requirements for civil small and light multi-copter unmanned aircraft docking system, including structure and composition, function requirements, performance requirements for the take-off and landing reliability and environmental adaptability. This document is applicable to the civil small and light multi-copter unmanned aircraft docking system with maximum take-off mass (MTOM) level I through IV according to ISO 21895.
Version history	-
Reference	https://www.iso.org/standard/89452.html

Standard	ISO/AWI 25216
Title	Categorization and classification of unmanned aircraft (UA) detection and countermeasure system
Status	Ongoing
Initial date	28-10-2024
Current version	-
Description	This document defines the classification and grading requirements for unmanned aircraft detection and countermeasure system. This document is applicable to the development, production, sale, delivery, use, and supervision of unmanned aircraft detection and countermeasure system.
Version history	-
Reference	https://www.iso.org/standard/89453.html

Standard	ISO/AWI 25248
Title	Unmanned Aircraft System Type of Identifier Code and Graphical symbol
Status	Ongoing
Initial date	07-10-2024
Current version	-
Description	This document provides graphic symbols (pictograms) for each UA configuration, enabling remote pilots and traffic management personnel to visually identify them. These symbols facilitate compatible system use and identification across various platforms. They appear in public information materials, safety signs, technical documents like manuals, RPS displays, fleet manager stations, ATM/UTM systems, and UAS licenses (ISO 22460-1). The pictograms help convey nonverbal information about UA presence, restrictions, or prohibitions in areas such as parks or streets, ensuring clear communication for operational safety and compliance.
Version history	-
Reference	https://www.iso.org/standard/89567.html

Standard	ISO/IEC 27005

Title	Information security, cybersecurity and privacy protection – Guidance on managing information security risks
Status	Active
Initial date	27-01-2020
Current version	27005:2022
Description	This document provides guidance for organizations to fulfill ISO/IEC 27001 requirements by addressing information security risks through risk assessments and treatments. It is applicable to all organizations, irrespective of their type, size or sector.
Version history	ISO/IEC 27005:2018 ISO/IEC 27005:2011 ISO/IEC 27005:2008 ISO/IEC TR 13335-3:1998
Reference	https://www.iso.org/standard/80585.html

Standard	ISO/IEC 27032
Title	Cybersecurity – Guidelines for Internet security
Status	Active
Initial date	13-12-2018
Current version	27032:2023
Description	This document aims to clarify the connections between Internet security, web security, network security, and cybersecurity. For this purpose, provides an overview of Internet security and identifies key stakeholders. At the same time, it outlines their roles, and offers high-level guidance for addressing common security challenges. Especially for organizations that utilize the Internet, it serves as a resource to enhance their security practices.
Version history	ISO/IEC 27032:2012
Reference	https://www.iso.org/standard/76070.html

Standard	27875
Title	Space systems – Re-entry risk management for unmanned spacecraft and launch vehicle orbital stages
Status	Active
Initial date	08-10-2017
Current version	27875:2019
Description	This document offers a framework to assess, mitigate, and manage risks associated with spacecraft re-entering Earth's atmosphere. It applies to mission planning, design, and review for controlled or uncontrolled re-entries. The scope covers objects under ISO 24113, launch vehicles per ISO 14620-2, and interplanetary spacecraft returning to Earth. It aligns with ISO 14620-1 and ISO 17666 but excludes nuclear-powered spacecraft and winged systems designed for targeted landings.
Version history	ISO 27875:2010
Reference	https://www.iso.org/standard/74251.html

Standard	ISO/CD 27875

Title	Space systems – Re-entry risk management for unmanned spacecraft and launch vehicle orbital stages
Status	Ongoing
Initial date	16-08-2023
Current version	-
Description	-
Version history	-
Reference	https://www.iso.org/standard/87629.html

Standard	ISO/IEC 23894
Title	Information technology – Artificial Intelligence – Guidance on risk management
Status	Active
Initial date	06-06-2019
Current version	23894:2023
Description	This document offers guidance for organizations developing or utilizing AI products and services to manage AI-specific risks effectively. It aids in integrating risk management into their operations and outlines processes for successful implementation. The guidance can be tailored to fit any organization's unique context.
Version history	-
Reference	https://www.iso.org/standard/77304.html

Standard	29061-5
Title	Road vehicles – Methods and criteria for usability evaluation of child restraint systems and their interface with vehicle anchorage systems. Part 5: Installation and securing of child in a booster system
Status	Active
Initial date	09-10-2014
Current version	29061-5:2017
Description	ISO 29061-5:2017 establishes criteria for assessing the usability of booster seat child restraint systems (CRS) during installation and securing a child. It evaluates factors such as the availability of instructions, clarity of manuals and labels, and ease of using design features related to vehicle installation. The standard also applies to evaluating integrated booster systems within vehicles. Notably, while ISOFIX is traditionally defined as a rigid system in ISO 13216-1, this document extends its scope to include flexible CRS attachments like LATCH and UAS.
Version history	-
Reference	https://www.iso.org/standard/64044.html

Standard	ISO/DIS 29061-5
Title	Road vehicles — Methods and criteria for usability evaluation of child restraint systems and their interface with vehicle anchorage systems. Part 5: Installation and securing of child in a booster system
Status	Ongoing

Initial date	29-11-2022
Current version	-
Description	-
Version history	-
Reference	https://www.iso.org/standard/83101.html

Standard	ISO/IEC TR 29119-11
Title	Software and systems engineering – Software testing. Part 11: Guidelines on the testing of AI-based systems
Status	Active
Initial date	12-07-2019
Current version	29119-11:2020
Description	This document introduces AI-based systems, which are often complex (e.g. deep neural networks), reliant on big data and can be non-deterministic, presenting new challenges for testing. It explains the unique characteristics of these systems that complicate the specification of acceptance criteria. A primary challenge is the test oracle problem, where determining expected test results is difficult. The document covers testing across the system lifecycle, offering guidelines for black-box approaches and introducing white-box testing specifically for neural networks. It also explores test environments and scenarios tailored for AI-based systems, defining such systems as those incorporating at least one AI component.
Version history	-
Reference	https://www.iso.org/standard/79016.html

Standard	29167-11
Title	Information technology – Automatic identification and data capture techniques. Part 11: Crypto suite PRESENT-80 security services for air interface communications
Status	Active
Initial date	18-11-2020
Current version	29167-11:2023
Description	This document defines the crypto suite for PRESENT-80 within the ISO/IEC 18000 series, specifying security standards for RFID devices. It aligns with existing air interface standards, providing a common security solution using the lightweight block cipher PRESENT-80 and its 128-bit key variant. The document outlines basic security services and various implementation methods, allowing Tags and Interrogators to support one, some, or all specified options. This flexibility ensures compatibility while addressing diverse RFID application needs.
Version history	ISO/IEC 29167-11:2014
Reference	https://www.iso.org/standard/81489.html

Standard	ISO/IEC DIS 29167-11
Title	Information technology – Automatic identification and data capture techniques. Part 11: Crypto suite PRESENT-80 security services for air interface communications
Status	Ongoing

Initial date	01-03-2024
Current version	-
Description	-
Version history	-
Reference	https://www.iso.org/standard/88957.html

Standard	ISO/IEC 29167-16
Title	Information technology — Automatic identification and data capture techniques Part 16: Crypto suite ECDSA-ECDH security services for air interface communications
Status	Active
Initial date	21-01-2021
Current version	29167-16:2022
Description	This document describes a crypto suite based on elliptic curve cryptography (ECC) for the ISO/IEC 18000 series of standards for radio frequency identification (RFID) devices. It specifies the use of elliptic curve Diffie-Hellman (ECDH) key agreement and elliptic curve digital signature algorithm (ECDSA) for secure channel establishment and authentication, respectively. The suite is designed to align with existing air interfaces, providing mutual authentication methods and various cipher implementations. Tags and Interrogators can support one, a subset, or all specified options. Key updates are not supported in this document. The ECDSA-ECDH cipher offers high-security capabilities, particularly for active RFID systems requiring robust security features.
Version history	ISO/IEC 29167-16:2015
Reference	https://www.iso.org/standard/81524.html

Standard	ISO/IEC TR 29181-9
Title	Information technology -- Future Network — Problem statement and requirements — Part 9: Networking of everything
Status	Active
Initial date	06-06-2014
Current version	29181-9:2017
Description	ISO/IEC TR 29189-9:2017 defines Networking of Everything (NoE), applicable to Future Networks and Internet of Things (IoT). It details a conceptual model, addresses conventional networking challenges, reviews other organizations' standardization efforts, outlines IoT-specific NoE requirements, and covers technical aspects. Noting that networking is central to IoT and Future Networks, while standards are under development elsewhere, this document focuses on integrating diverse networking techniques to fulfill user and device needs.
Version history	-
Reference	https://www.iso.org/standard/66800.html

Standard	ISO/IEC 30147
Title	Information technology – Internet of things – Methodology for trustworthiness of IoT system/service
Status	Active

Initial date	08-05-2018
Current version	30147:2021
Description	-
Version history	-
Reference	https://www.iso.org/standard/53267.html

Standard	ISO/IEC TR 30164
Title	Internet of Things (IoT) – Edge Computing
Status	Active
Initial date	18-01-2019
Current version	30165:2020
Description	ISO/IEC TR 30164:2020 outlines common concepts, terminologies, characteristics, and use cases of edge computing tailored for IoT systems. It covers essential technologies such as data management, coordination, processing, network functionality, heterogeneous computing, security measures, and hardware/software optimization. This document also serves to identify potential areas for standardization in edge computing within the IoT domain.
Version history	-
Reference	https://www.iso.org/standard/53284.html

Standard	ISO/IEC 42001
Title	Information technology – Artificial Intelligence – Management system
Status	Active
Initial date	26-8-2020
Current version	42001:2023
Description	ISO/IEC 42001 is an international standard that specifies requirements for establishing, implementing, maintaining, and continually improving an Artificial Intelligence Management System (AIMS) within organizations. It is designed for entities providing or utilizing AI-based products or services, ensuring responsible development and use of AI systems.
Version history	-
Reference	https://www.iso.org/standard/81230.html

2.2.3 ASTM

Standard	F2245
Title	Standard Specification for Design and Performance of a Light Sport Airplane
Status	Active
Initial date	08-08-2023
Current version	F2245-23
Description	This specification outlines airworthiness requirements for powered fixed-wing light sport aircraft, covering both flight performance and structural aspects. It requires evaluations of load distribution, stalling speed, takeoff, climb, controllability, vibrations, ground stability

	and various structural loads, including flight, control surfaces, stabilizing surfaces, and ground conditions. The design must incorporate specific instruments such as an airspeed indicator, altimeter, fuel quantity indicator, tachometer, engine kill switch, master switch, overload protection device, safety belts, and a Pilot Operating Handbook (POH). Applicable to VFR flight under relevant regulations, it specifies SI units with others provided for reference. Users are responsible for ensuring safety practices and regulatory compliance. The standard adheres to WTO TBT guidelines.
Version history	F22455-20 F2245-18 F2245-16C F2245-16B F2245-16A F2245-16 F2245-15 F2245-14 F2245-13B F2245-13A F2245-13 F2245-12D F2245-12C F2245-12B F2245-12A F2245-12 F2245-11 F2245-10C F2245-10B F2245-10A F2245-10 F2245-09 F2245-08 F2245-07A F2245-06 F2245-04
Reference	https://www.astm.org/f2245-23.html

Standard	F2490
Title	Standard Guide for Aircraft Electrical Load and Power Source Capacity Analysis
Status	Active
Initial date	27-07-2020
Current version	F2490-20
Description	This guide provides instructions for preparing an Electrical Load Analysis (ELA) in compliance with FAA regulations, focusing on aircraft-level electrical systems. It does not cover electric propulsive power load analysis. SI units are the standard measurement system used throughout. Users are responsible for ensuring safety practices and adhering to regulatory limitations when applying this standard. This document aligns with international standardization principles set by the World Trade Organization's TBT Committee.
Version history	F2490-05R13 F2490-05E01 F2490-05
Reference	https://www.astm.org/f2490-20.html

Standard	F2639
Title	Standard Practice for Design, Alteration, and Certification of Aircraft Electrical Wiring Systems
Status	Active
Initial date	07-11-2018
Current version	F2639-18
Description	This standard outlines definitions, design standards, materials, electrical load considerations, and component installations for aircraft electrical systems. It includes guidelines for wiring, circuit protection devices, connectors, soldering, and corrosion prevention. The document covers system components like alternators, generators, inverters, and their installation requirements. Both inch-pound and SI units are provided, with a reference to an appendix for SI-based prefixes. Safety practices and environmental considerations are emphasized, along with international standardization principles to prevent technical barriers to trade. Additionally, it addresses alterations, certifications,

	maintenance procedures, grounding, bonding, and electromagnetic interference (EMI/RFI), ensuring comprehensive system integrity and performance.
Version history	F2639-15 F2639-07E01 F2639-07
Reference	https://www.astm.org/f2639-18.html

Standard	F2696
Title	Standard Practice for Inspection of Aircraft Electrical Wiring Systems
Status	Active
Initial date	05-06-2019
Current version	F2696-14
Description	This practice outlines basic inspection procedures for electrical wiring interconnect systems in aircraft, emphasizing adherence to manufacturer guidelines. It specifies the use of inch-pound units as standard, with SI units provided for reference. Users are responsible for ensuring safety practices and environmental considerations. The document is an international standard developed to align with global norms, facilitating trade without creating barriers.
Version history	F2696-14 F2696-08
Reference	https://www.astm.org/f2696-14r19.html

Standard	F2799
Title	Standard Practice for Maintenance of Aircraft Electrical Wiring Systems
Status	Active
Initial date	05-06-2019
Current version	F2799-14R19
Description	This document defines acceptable practices and processes for maintaining, preventing maintenance, and repairing electric systems in general aviation aircraft without altering or deviating from existing regulations. It applies to air carriers, operators, maintenance providers, repair stations, and anyone performing maintenance or repairs. The document emphasizes protecting electrical wiring interconnection systems (EWIS) during work, advocating a "Protect and Clean as You Go" philosophy to prevent contamination and damage, especially during structural repairs or alterations, ensuring debris removal. Inch-pound units are standard, with SI units provided for reference. Users are responsible for safety practices, and the standard aligns with WTO principles for international applicability
Version history	F2799-14 F2799-09
Reference	https://www.astm.org/f2799-14r19.html

Standard	F2840
Title	Standard Practice for Design and Manufacture of Electric Propulsion Units for Light Sport Aircraft
Status	Active

Initial date	06-01-2023
Current version	F2840-14R23
Description	This practice sets minimum requirements for designing and manufacturing Electric Propulsion Units (EPU) for light sport aircraft in VFR conditions. The EPU must include an electric motor, controllers, wiring, disconnects, energy storage devices (like batteries), and monitoring systems. Optional features may include charging devices. Users are responsible for ensuring safety practices comply with regulations. This standard follows WTO principles to support international standardization.
Version history	F2840-14 F2840-11
Reference	https://www.astm.org/f2840-14r23.html

Standard	F2849
Title	Standard Practice for Handling of Unmanned Aircraft Systems at Divert Airfields
Status	Active
Initial date	05-02-2019
Current version	F2849-10R19
Description	This practice outlines equipage and procedures for safely managing unmanned aircraft forced to land at alternate airfields where trained personnel may not be available. It applies to fixed-wing unmanned aircraft in non-visual line-of-sight operations. The standard establishes common equipment locations, labeling, and functions for safe power-down without damage. It includes procedures for untrained individuals to contact the owner and covers mission planning, automated functions, and manual handling across preflight, in-flight, and post-flight phases. Developed following WTO principles, this international standard promotes fair trade practices.
Version history	F2849-10
Reference	https://www.astm.org/f2849-10r19.html

Standard	F2851
Title	Standard Practice for UAS Registration and Marking (Excluding Small Unmanned Aircraft Systems)
Status	Active
Initial date	11-04-2023
Current version	F2851-10R18
Description	This practice provides guidelines for displaying marks on Unmanned Aircraft Systems (UAS) to indicate registration and ownership, excluding small UAS (sUAS) as defined by regulatory authorities. It aids in determining nationality when UAS cross international boundaries. The standard does not apply to sUAS or model aircraft, with ICAO leaving sUAS regulations to individual states. Users are responsible for ensuring safety practices and adhering to regulatory limitations. Developed according to WTO principles, this standard promotes fair trade without creating unnecessary barriers.
Version history	F2851-10
Reference	https://www.astm.org/f2851-10r18.html

Standard	F2908

Title	Standard Specification for Unmanned Aircraft Flight Manual (UFM) for an Unmanned Aircraft System (UAS)
Status	Active
Initial date	16-08-2023
Current version	F2908-23
Description	This specification outlines the minimum requirements for an Unmanned Aircraft Flight Manual (UFM) for UAS in the light category as defined by a Civil Aviation Authority (CAA). It may include maintenance instructions and is part of Committee F38's library, designed to avoid redundancy. Users must integrate all relevant F38 standards for comprehensive implementation. When seeking compliance approval, consult the oversight authority regarding its acceptance. The specification applies to UAS requiring CAA approvals like airworthiness certificates. Manufacturers must provide essential UFM information during transfers. Any modifications affecting UFM accuracy require manufacturer approval and regulatory notification. This standard adheres to WTO principles to promote fair trade practices without creating unnecessary barriers.
Version history	F2908-18 F2908-16 F2908-14
Reference	https://www.astm.org/f2908-23.html

Standard	F2909
Title	Standard Specification for Continued Airworthiness of Lightweight Unmanned Aircraft Systems
Status	Active
Initial date	07-10-2019
Current version	F2909-19
Description	This specification establishes the standard practice for maintaining and ensuring the continued airworthiness of lightweight unmanned aircraft systems (UAS). A UAS is defined as encompassing the aircraft, subsystems, control station, crew, command and control links, and any necessary launch and recovery equipment. It supports civil aviation authority (CAA), self-, or third-party assessments of airworthiness and provides core requirements for lightweight UAS under risk-based categories for operational approvals. This specification complements aircraft developed in accordance with Specifications F2910, F3002, F3005, and F3298. While it aids in UAS operations where risks vary based on factors like environment and operation concept, the absence of onboard humans may reduce certain hazards. Users are responsible for establishing safety practices and checking regulatory limitations before use. This standard adheres to World Trade Organization principles to promote fair trade without unnecessary barriers.
Version history	F2909-14
Reference	https://www.astm.org/f2909-19.html

Standard	F2910
Title	Standard Specification for Design and Construction of a Small Unmanned Aircraft System (sUAS)
Status	Active
Initial date	08-12-2022
Current version	F2910-22

Description	This standard gives a focus and outlines the design, the construction, and the testing requirements for small unmanned aircraft systems (sUAS), although it is not addressing all safety concerns associated with its use. Because of that, users are responsible for establishing appropriate safety, health, and environmental practices while ensuring compliance with regulatory limitations before utilizing the standard. Aiming to promote fair trade without creating unnecessary barriers, this international standard, was developed in accordance with principles recognized by the World Trade Organization's Technical Barriers to Trade Committee.
Version history	F2910-14
Reference	https://www.astm.org/f2910-22.html

Standard	F2972
Title	Standard Specification for Light Sport Aircraft Manufacturer’s Quality Assurance System
Status	Active
Initial date	15-08-2024
Current version	F2972-24
Description	This specification sets the minimum requirements for quality assurance systems for manufacturers of light sport aircraft or kits. It applies to aircraft seeking civil aviation authority (CAA) approval in the form of flight certificates, permits, or similar documentation. Users are responsible for establishing safety practices and complying with regulatory limitations before use, as this standard does not address all safety concerns. The document adheres to World Trade Organization principles on standardization to ensure fair trade without unnecessary barriers.
Version history	F2972-15 F2972-14E01 F2972-14 F2972-12
Reference	https://www.astm.org/f2972-24.html

Standard	F3002
Title	Standard Specification for Design of the Command-and-Control System for Small Unmanned Aircraft Systems (sUAS)
Status	Active
Initial date	08-12-2022
Current version	F3002-22
Description	This specification is a consensus standard for supporting applications who permits to operate small unmanned aircraft systems (sUAS) commercially or publicly with a nation's aviation authority. It does not address all safety concerns, and users are responsible for establishing appropriate safety practices and complying with regulatory limitations before use. The standard was developed in alignment with World Trade Organization principles on standardization to promote fair trade without unnecessary barriers.
Version history	F3002-14A F3002-14
Reference	https://www.astm.org/f3002-22.html

Standard	F3005

Title	Standard Specification for Batteries for Use in Small Unmanned Aircraft Systems (sUAS)
Status	Active
Initial date	08-12-2022
Current version	F3005-22
Description	This standard outlines requirements for batteries used in small Unmanned Aircraft Systems (sUAS). At the same time does not define requirements for the systems utilizing these battery packs. It is subordinate to Specification F2910. If permitted by a nation's governing aviation authority (GAA), certain sUAS may use commercial off-the-shelf (COTS) batteries in non-safety-critical payloads, excluding lithium chemistries, provided air transport regulations are followed for shipping COTS cells or batteries in bulk. Users remain responsible for establishing appropriate safety practices and complying with regulatory limitations before use, as this standard does not address all safety concerns. The document adheres to World Trade Organization principles on standardization to ensure fair trade without unnecessary barriers.
Version history	F3005-14A F3005-14
Reference	https://www.astm.org/f3005-22.html

Standard	F3061/F3061M
Title	Standard Specification for Systems and Equipment in Aircraft
Status	Active
Initial date	16-12-2024
Current version	F3061/F3061M-24
Description	This specification outlines airworthiness and design requirements for aircraft systems and equipment, developed by international experts with a focus on Normal Category airplanes (Levels 1-4). It covers various topics such as electrical systems, environmental requirements, flight controls, instrumentation, lighting, oxygen systems, and more. Applicants must validate broader applicability beyond the specified scope. Guidance from civil aviation authorities is essential for using this document as a Means of Compliance; refer to ASTM F44's webpage for accepted authorities. Units are presented in SI or English Engineering, and combining them may lead to nonconformance. The standard does not address all safety concerns, so users must establish appropriate safety practices and adhere to regulations. It aligns with World Trade Organization principles on standardization to promote fair trade without unnecessary barriers.
Version history	F3061/F3061M-24A F3061/F3061M-23C F3061/F3061M-23B F3061/F3061M-23A F3061/F3061M-23 F3061/F3061M-22B F3061/F3061M-22A F3061/F3061M-22 F3061/F3061M-20 F3061/F3061M-19A F3061/F3061M-19 F3061/F3061M-17 F3061/F3061M-16B F3061/F3061M-16A F3061/F3061M-15
Reference	https://www.astm.org/f3061_f3061m-24.html

Standard	F3153
Title	Standard Specification for Verification of Aircraft Systems and Equipment
Status	Active
Initial date	27-04-2022

Current version	F3153-22
Description	This specification outlines a process for verifying aircraft systems and equipment with software and Airborne Electronic Hardware (AEH), particularly where traditional methods fall short. It aids in demonstrating regulatory compliance by ensuring intended functionality and safety mitigations for failure conditions. Although focused on certification levels 1 and 2, broader applicability is possible with proper substantiation and CAA approval. System safety regulations still apply, potentially requiring additional architectural safeguards. Verification activities intensify with the severity of failure conditions, especially for hazardous scenarios. Early CAA involvement is recommended. The process covers function definition, identification, and verification but may not meet all external requirements. Inch-pound units are standard. Users must address safety practices and regulatory adherence independently. The specification aligns with WTO principles to avoid trade barriers.
Version history	F3153-15
Reference	https://www.astm.org/f3153-22.html

Standard	F3178
Title	Standard Practice for Operational Risk Assessment of Small Unmanned Aircraft Systems (sUAS)
Status	Active
Initial date	17-12-2024
Current version	F3178-24
Description	This practice provides guidance on preparing Operational Risk Assessments (ORAs) for unmanned aircraft systems (UAS) to support design, airworthiness, and regulatory approval for low-altitude operations below 400 ft AGL. It focuses on unintentional incidents, excluding malicious acts. The ORA requires a clear understanding of the intended mission, often documented as a concept of operations (CONOPS), to assess safety for CAA approval. While this standard does not address all potential safety concerns, users are responsible for establishing appropriate safety practices and considering regulatory limitations. Developed in accordance with WTO principles, it ensures international standardization without creating trade barriers.
Version history	F3178-16
Reference	https://www.astm.org/f3178-24.html

Standard	F3196
Title	Standard Practice for Seeking Approval for Beyond Visual Line of Sight (BVLOS) Small Unmanned Aircraft System (sUAS) Operations
Status	Active
Initial date	16-10-2018
Current version	F3196-18
Description	This practice offers guidance for seeking CAA approval to operate small UAS beyond visual line of sight (BVLOS), with its application subject to the discretion of the relevant CAA. It specifies that inch-pound units are standard, while SI conversions are provided for informational purposes only. Users are responsible for establishing appropriate safety practices and considering regulatory limitations. The standard adheres to WTO principles to promote international standardization without creating trade barriers.
Version history	F3196-17

Reference	https://www.astm.org/f3196-18.html

Standard	F3201
Title	Standard Practice for Ensuring Dependability of Software Used in Unmanned Aircraft Systems (UAS)
Status	Active
Initial date	03-12-2024
Current version	F3201-24
Description	This standard practice aims to ensure the dependability—encompassing safety and security—of software integral to unmanned aircraft (UA) and associated elements within a UAS. It is intended for entities designing UA or related components, focusing on their specific responsibilities and interfaces. The practice addresses assurance of externally developed software (EDS) by component manufacturers and integration aspects beyond its scope. Key areas include organizational controls, software usage in system architecture, metrics, code review techniques, quality assurance, and testing. The standard supports VLOS and BVLOS operations typically under 400 ft AGL with a maximum weight of 1320 lb, adaptable based on operational risks. It does not cover all safety concerns; users must establish appropriate practices and consider regulatory limitations. Developed per WTO principles to ensure international standardization without trade barriers.
Version history	F3201-16
Reference	https://www.astm.org/f3201-24.html

Standard	F3227/F3227M
Title	Standard Specification for Environmental Systems in Aircraft
Status	Active
Initial date	11-02-2025
Current version	F3227/F3227M-25
Description	This specification outlines international standards for environmental system aspects of airworthiness and design for small aircraft. Applicants must consult their respective CAA for guidance on using this specification in certification plans. It aligns with EASA CS-23 and FAA Part 23 regulations, as detailed in Annex A1. Both SI and inch-pound units are provided separately; they aren't exact equivalents and should be used independently. Users must address safety concerns and establish practices beyond the standard's scope. Developed per WTO principles to ensure international standardization without trade barriers.
Version history	F3227/F3227M-24 F3227/F3227M-22 F3227/F3227M-21A F3227/F3227M-21 F3227/F3227M-20 F3227/F3227M-17
Reference	https://www.astm.org/f3227_f3227m-25.html

Standard	F3228
Title	Standard Specification for Flight Data and Voice Recording in Small Aircraft

Status	Active
Initial date	27-09-2021
Current version	F3228-21
Description	This standard outline international requirements for flight recording in small aircraft design and airworthiness. Design approval applicants must consult their respective civil aviation authority (CAA) for guidance on incorporating this specification into certification plans. A list of CAAs recognizing this standard is available on the ASTM F44 webpage. Annex A1 aligns compliance measures with EASA CS-23 (Amendment 5+) and FAA 14 CFR Part 23 (Amendment 64+). Users must assess safety, health, and environmental factors before application. Developed per global standardization principles, this standard follows the WTO Technical Barriers to Trade (TBT) Committee's guidelines.
Version history	F3228-17
Reference	https://www.astm.org/f3228-21.html

Standard	F3230
Title	Standard Practice for Safety Assessment of Systems and Equipment in Small Aircraft
Status	Active
Initial date	12-02-2025
Current version	F3230-25
Description	This standard defines internationally accepted methods for assessing the safety of systems and equipment in small aircraft. Developed primarily for certification levels 1-4 in normal category airplanes, its broader applicability must be justified by the applicant. For level 1, low-speed, day VFR aircraft, requirements apply only to systems with hazardous or catastrophic failure conditions. Design approval applicants should consult their civil aviation authority (CAA) for certification guidance. Accepted CAAs are listed on the ASTM F44 webpage. Values are stated in inch-pound units. Developed under WTO Technical Barriers to Trade (TBT) principles, users must ensure compliance with safety, health, and environmental regulations.
Version history	F3230-24A F3230-24 F3230-21A F3230-21 F3230-20A F3230-20 F3230-17
Reference	https://www.astm.org/f3230-25.html

Standard	F3231/F3231M
Title	Standard Specification for Electrical Systems for Aircraft with Combustion Engine Electrical Power Generation
Status	Active
Initial date	01-11-2024
Current version	F3231/F3231M-24
Description	This specification defines airworthiness and design requirements for electrical systems, equipment, and power distribution in airplanes with combustion engine-generated power. Developed through international expert consensus, it primarily applies to Normal Category Airplanes, though broader use must be justified by applicants. Those seeking to use this as

	a Means of Compliance should consult their civil aviation authority (CAA) for guidance. Accepted authorities are listed on the ASTM F44 webpage. The standard presents values in SI and English units, which should not be combined. Developed under WTO Technical Barriers to Trade (TBT) principles, users must ensure compliance with relevant safety, health, and environmental regulations.
Version history	F3231/F3231M-23 F3231/F3231M-22 F3231/F3231M-21 F3231/F3231M-20 F3231/F3231M-19 F3231/F3231M-17
Reference	https://www.astm.org/f3231_f3231m-24.html

Standard	F3232/F3232M
Title	Standard Specification for Flight Controls in Small Aircraft
Status	Active
Initial date	10-12-2024
Current version	F3232/F3232M-24
Description	This specification defines international standards for flight control aspects in the airworthiness and design of small aircraft. Design approval applicants should consult their respective civil aviation authority (CAA) for certification guidance. A list of CAAs recognizing this standard is available on the ASTM F44 webpage. Annex A1 aligns compliance measures with EASA CS-23 (Amendment 5+) and FAA 14 CFR Part 23 (Amendment 64+). Values are provided in SI and inch-pound units, which should not be combined. Developed under WTO Technical Barriers to Trade (TBT) principles, users must ensure compliance with relevant safety, health, and environmental regulations before application.
Version history	F3232/F3232M-23A F3232/F3232M-23 F3232/F3232M-20 F3232/F3232M-19AE01 F3232/F3232M-19A F3232/F3232M-19 F3232/F3232M-17
Reference	https://www.astm.org/f3232_f3232m-24.html

Standard	F3233/F3233M
Title	Standard Specification for Flight and Navigation Instrumentation in Aircraft
Status	Active
Initial date	21-05-2024
Current version	F3233/F3233M-23B
Description	This specification defines airworthiness and design requirements for flight and navigation instrumentation, developed through international expert consensus. It primarily applies to Level 1-4 Normal Category airplanes but may have broader applicability. Covered instruments include airspeed, altitude, attitude, heading, free air temperature, and speed warning systems. Design approval applicants must consult their civil aviation authority (CAA) for certification guidance. A list of accepted CAAs is available on the ASTM F44 webpage. Values are stated in SI and inch-pound units, which should not be combined. Developed under WTO Technical Barriers to Trade (TBT) principles, users must ensure compliance with relevant safety, health, and environmental regulations.
Version history	F3233/F3233M-23 F3233/F3233M-21

	F3233/F3233M-17
Reference	https://www.astm.org/f3233_f3233m-23b.html

Standard	F3234/F3234M
Title	Standard Specification for Exterior Lighting in Small Aircraft
Status	Active
Initial date	27-09-2021
Current version	F3234/F3234M-21
Description	This specification establishes international standards for exterior lighting in the airworthiness and design of small aircraft. Applicants seeking design approval should consult their respective civil aviation authority (CAA) for certification guidance. A list of CAAs recognizing this standard is available on the ASTM F44 webpage. Annex A1 aligns compliance measures with EASA CS-23 (Amendment 5+) and FAA 14 CFR Part 23 (Amendment 64+). Values are provided in SI and inch-pound units, which should not be combined. Developed under WTO Technical Barriers to Trade (TBT) principles, users must ensure compliance with relevant safety, health, and environmental regulations before application.
Version history	F3234/F3234M-17
Reference	https://www.astm.org/f3234_f3234m-21.html

Standard	F3235
Title	Standard Specification for Aircraft Storage Batteries
Status	Active
Initial date	08-08-2022
Current version	F3235-22
Description	This specification defines airworthiness and design standards for electrical storage batteries in airplanes, developed through international expert consensus. Primarily focused on Normal Category airplanes, it covers Nickel Cadmium and Rechargeable Lithium Batteries but may have broader applicability, subject to applicant justification. Those seeking to use this as a Means of Compliance must consult their respective civil aviation authority (CAA) for guidance. A list of accepted oversight authorities is available on the ASTM F44 webpage. Developed under WTO Technical Barriers to Trade (TBT) principles, users must ensure compliance with relevant safety, health, and environmental regulations before application.
Version history	F3235-21 F3235-17A F3235-17E01 F3235-17
Reference	https://www.astm.org/f3235-22.html

Standard	F3236
Title	Standard Specification for High Intensity Radiated Field (HIRF) Protection in Small Aircraft
Status	Active
Initial date	21-12-2021

Current version	F3236-21A
Description	This specification defines international standards for High Intensity Radiated Field (HIRF) protection in the airworthiness and design of small aircraft. Applicants seeking design approval should consult their respective civil aviation authority (CAA) for certification guidance. A list of CAAs recognizing this standard is available on the ASTM F44 webpage. Annex A1 aligns compliance measures with EASA CS-23 (Amendment 5+) and FAA 14 CFR Part 23 (Amendment 64+). SI units are used exclusively in this standard. Developed under WTO Technical Barriers to Trade (TBT) principles, users must ensure compliance with relevant safety, health, and environmental regulations before application.
Version history	F3236-21 F3236-17
Reference	https://www.astm.org/f3236-21a.html

Standard	F3245
Title	Standard Guide for Aircraft Electronics Technician Personnel Certification
Status	Active
Initial date	20-05-2019
Current version	F3245-19
Description	This guide provides fundamental knowledge and a structured framework for essential competencies in the field of Aircraft Electronics Technician (AET). Also, it outlines, task performance, and key functions required for avionics professionals seeking the title. Users must independently ensure compliance with applicable safety, health, and environmental regulations, as this standard does not cover all potential safety concerns. This guide follows the guidelines set by the World Trade Organization (WTO) Technical Barriers to Trade (TBT) Committee.
Version history	F3245-17
Reference	https://www.astm.org/f3245-19.html

Standard	F3246
Title	Standard Specification for Quality Assurance for Manufacturers of Aircraft Systems
Status	Active
Initial date	30-11-2023
Current version	F3246-18R23
Description	This standard refers to manufacturers producing aircraft articles within the scope of Committee F39 on Aircraft Systems and defines the minimum requirements for a Quality Assurance System (QAS). By applying and outlining criteria it establishes and maintain a quality system. Users must ensure compliance with applicable safety, health, and environmental regulations, as this standard does not cover all potential safety concerns. Developed in accordance with internationally recognized standardization principles, this specification follows the guidelines set by the World Trade Organization (WTO) Technical Barriers to Trade (TBT) Committee.
Version history	F3246-18
Reference	https://www.astm.org/f3246-18r23.html

Standard	F3262

Title	Standard Classification System for Small Unmanned Aircraft Systems (sUAS's) for Land Search and Rescue
Status	Active
Initial date	28-07-2017
Current version	F3262-17
Description	This classification defines small Unmanned Aircraft System (sUAS) resources for land search and rescue based on their capabilities. It does not apply to urban search and rescue or disaster response. Designed to assist emergency managers in resource allocation, this classification helps convey operational capabilities to incident responders at local and state levels, excluding federal or military use. It does not establish performance or training standards, which fall under ASTM Committee F38 and related subcommittees. Compliance with ASTM Committee F32 applies to sUAS-specific search and rescue training. Users must ensure adherence to safety and regulatory requirements. Developed under WTO Technical Barriers to Trade (TBT) principles.
Version history	-
Reference	https://www.astm.org/f3262-17.html

Standard	F3266
Title	Standard Guide for Training for Remote Pilot in Command of Unmanned Aircraft Systems (UAS) Endorsement
Status	Active
Initial date	11-06-2023
Current version	F3266-23
Description	This guide serves educators developing curricula and pilots seeking advanced knowledge for unmanned aircraft operations. It outlines required skills for safe commercial UAS use and may assist civil aviation authorities (CAAs) in regulation development. Covering powered fixed-wing, vertical-takeoff, and rotorcraft UAS, it integrates with ASTM F38 standards. Compliance seekers should consult their CAA. The guide supports training evaluation but does not provide specific mission training. Knowledge and skills should align with regulatory and operational needs. Values are stated in inch-pound units, with SI conversions for reference. Developed under WTO Technical Barriers to Trade (TBT) principles, users must ensure adherence to safety and regulatory requirements
Version history	F3266-18
Reference	https://www.astm.org/f3266-23.html

Standard	F3269
Title	Standard Practice for Methods to Safely Bound Behavior of Aircraft Systems Containing Complex Functions Using Run-Time Assurance
Status	Active
Initial date	19-11-2021
Current version	F3269-21
Description	This practice defines the components, requirements, and best practices for a Run-Time Assurance (RTA) system, ensuring safe boundaries and system coverage. It includes appendices with examples demonstrating key concepts. RTA components must meet design assurance levels based on safety assessments (e.g., ARP4754A, ARP4761). Initially developed for UAS, it may also apply to manned aircraft certification and aviation ground systems. Hardware/software integration is outside its scope. Values are stated in inch-

	pound units. Developed under WTO Technical Barriers to Trade (TBT) principles, users must ensure compliance with safety, health, and regulatory requirements before implementation.
Version history	F3269-17
Reference	https://www.astm.org/f3269-21.html

Standard	F3298
Title	Standard Specification for Design and Construction of Lightweight Unmanned Aircraft Systems (UAS)
Status	Active
Initial date	14-08-2024
Current version	F3298-24
Description	This specification outlines airworthiness requirements for the design of light unmanned aircraft systems (UAS), establishing baseline design and construction standards. A UAS includes the unmanned aircraft, onboard subsystems, payload, control station, crew, and command and control (C2) links. Intended for CAA, self-, or third-party airworthiness determinations, it supports certification of lightweight UAS, with additional requirements for expanded operations. Risk varies based on operational context. Users should consult their civil aviation authority (CAA) for compliance. Values are stated in Imperial units. Developed under WTO Technical Barriers to Trade (TBT) principles, users must ensure adherence to relevant safety, health, and environmental regulations.
Version history	F3298-19 F3298-18
Reference	https://www.astm.org/f3298-24.html

Standard	F3309/F3309M
Title	Standard Practice for Simplified Safety Assessment of Systems and Equipment in Small Aircraft
Status	Active
Initial date	15-08-2024
Current version	F3309/F3309M-24a
Description	This practice outlines methods for conducting a simplified safety assessment of aircraft systems and equipment, developed through international expert consensus in general aviation. Primarily focused on Level 1 and Level 2 Normal Category aeroplanes with conventional systems, its broader applicability must be justified by applicants. If deemed unsuitable for a specific application, the safety assessment process in Practice F3230 should be used. Covered topics include failure condition identification, safety objectives, qualitative analysis, and documentation. Compliance seekers should consult their civil aviation authority (CAA). Values are provided in SI and English units, which should not be combined. Developed under WTO Technical Barriers to Trade (TBT) principles, users must ensure regulatory compliance.
Version history	F3309/F3309M-24 F3309/F3309M-21 F3309/F3309M-20 F3309/F3309M-18
Reference	https://www.astm.org/f3309_f3309m-24a.html

Standard	F3316/F3316M
Title	Standard Specification for Electrical Systems for Aircraft with Electric or Hybrid-Electric Propulsion
Status	Active
Initial date	19-12-2019
Current version	F3316/F3316M-19
Description	This specification defines airworthiness and design requirements for electrical systems, equipment, and power distribution in aircraft with Electric or Hybrid-Electric Propulsion. Focused on conventional electric propulsion layouts, it does not fully address hybrid-electric configurations, which may require additional compliance with Specification F3231/F3231M. Developed through international expert consensus, it primarily applies to Normal Category Airplanes, though broader use must be justified by applicants. Those seeking to use this as a Means of Compliance should consult their civil aviation authority (CAA). Values are stated in SI and English units, which should not be combined. Developed under WTO Technical Barriers to Trade (TBT) principles, users must ensure regulatory compliance.
Version history	F3316/F3316M-18
Reference	https://www.astm.org/f3316_f3316m-19.html

Standard	F3322
Title	Standard Specification for Small Unmanned Aircraft System (sUAS) Parachutes
Status	Active
Initial date	07-02-2025
Current version	F3322-24a
Description	This specification defines design, manufacturing, and testing requirements for deployable parachutes in small Unmanned Aircraft Systems (sUAS). Parachute Recovery Systems (PRS) aim to reduce impact energy in case of system failure. Compliance supports applicants in obtaining Civil Aviation Authority (CAA) approval for flights over people. PRS must meet Section 5 and Section 6 requirements to be considered compliant. Prior testing under Specifications F3322-18 or F3322-22 may support certification. This standard integrates with ASTM F38 standards and requires consultation with oversight authorities. Values are stated in SI units. Developed under WTO Technical Barriers to Trade (TBT) principles, users must ensure regulatory compliance.
Version history	F3322-24 F3322-22 F3322-18
Reference	https://www.astm.org/f3322-24a.html

Standard	F3330
Title	Standard Specification for Training and the Development of Training Manuals for the UAS Operator
Status	Active
Initial date	17-02-2023
Current version	F3330-23
Description	This specification outlines requirements for training and training manual development for unmanned aircraft systems (UAS) operators. It establishes best practices for organizing

	professional training programs, both internally and for public offerings. Designed to support professional entities seeking Civil Aviation Authority (CAA) certification, it also provides audit standards for UAS operators. While developed for light UAS (below 1320 lb/600 kg per EASA), it may apply to larger aircraft using alternative classification methods. Training manuals must meet all minimum requirements to be considered compliant. Values are stated in inch-pound units. Developed under WTO Technical Barriers to Trade (TBT) principles, users must ensure regulatory compliance.
Version history	F3330-18
Reference	https://www.astm.org/f3330-23.html

Standard	F3341/F3341M
Title	Standard Terminology for Unmanned Aircraft Systems
Status	Active
Initial date	26-06-2024
Current version	F3341/F3341M-24
Description	This terminology standard defines terms and concepts related to unmanned aircraft systems (UAS) to promote consistency across all ASTM UAS standards. It complements F3060 Standard Terminology for Aircraft, without duplicating its definitions. Terms adapted from ASTM F38 standards are not restricted to those documents, and additional terms specific to a given standard may be defined within that document. Unit definitions follow NIST SP 330, with values provided in SI and inch-pound units, which should not be combined. Developed under WTO Technical Barriers to Trade (TBT) principles, users must ensure compliance with relevant safety, health, and environmental regulations.
Version history	F3341/F3341M-23 F3341/F3341M-22 F3341/F3341M-20A F3341/F3341M-20
Reference	https://www.astm.org/f3341_f3341m-24.html

Standard	F3361
Title	Standard Guide for Classifying Alterations for In-Service Aircraft under FAA Authority Oversight
Status	Active
Initial date	23-08-2019
Current version	F3361-18e1
Description	This guide applies to Part 23 and predecessor aircraft (CAR 3) and aircraft subject to Part 43 regulations. It covers both initial installation and replacement of aircraft articles and provides a framework for classifying alterations. This guide assists individuals responsible for evaluating alterations to ensure regulatory compliance by categorizing modifications. Users must ensure adherence to applicable safety, health, and environmental regulations, as this standard does not address all potential safety concerns. Developed in accordance with WTO Technical Barriers to Trade (TBT) principles, this standard aligns with internationally recognized guidelines for regulatory compliance and industry best practices.
Version history	F3361-18
Reference	https://www.astm.org/f3361-18e01.html

Standard	F3364
Title	Standard Practice for Independent Audit Program for Unmanned Aircraft Operators
Status	Active
Initial date	16-08-2023
Current version	F3364-23
Description	This practice defines minimum requirements for an Unmanned Aircraft Systems (UAS) Operator Independent Audit Program, in compliance with Practice F3365. Designed within the broader ASTM F38 framework, it eliminates redundancies by integrating relevant standards for comprehensive implementation. Applicants seeking to use this as a Means of Compliance for operational or design approval must consult their respective civil aviation authority (CAA). A list of accepted oversight authorities is available on the ASTM F38 webpage. Developed under WTO Technical Barriers to Trade (TBT) principles, users must ensure compliance with applicable safety, health, and environmental regulations before application.
Version history	F3364-19
Reference	https://www.astm.org/f3364-23.html

Standard	F3365
Title	Standard Practice for Compliance Audits to ASTM Standards on Unmanned Aircraft Systems
Status	Active
Initial date	16-08-2023
Current version	F3365-23
Description	This practice defines the minimum requirements for auditing programs, methods, and systems related to Unmanned Aircraft Systems (UAS), including responsibilities and auditor qualifications. Developed within the ASTM F38 framework, it integrates relevant standards for comprehensive implementation. It ensures structured and consistent compliance evaluations, benefiting the UAS industry and consumers. Those seeking to use this as a Means of Compliance for operational or design approval must consult their civil aviation authority (CAA). A list of accepted oversight authorities is available on the ASTM F38 webpage. Developed under WTO Technical Barriers to Trade (TBT) principles, users must ensure compliance with applicable safety, health, and environmental regulations.
Version history	F3365-19
Reference	https://www.astm.org/f3365-23.html

Standard	F3366
Title	Standard Specification for General Maintenance Manual (GMM) for a small Unmanned Aircraft System (sUAS)
Status	Active
Initial date	11-06-2019
Current version	F3366-19
Description	This specification outlines the minimum requirements for a General Maintenance Manual (GMM) for unmanned aircraft systems (UAS) within the small UAS category, as defined by a Civil Aviation Authority (CAA). It supports professional entities seeking CAA operator certification and establishes standards for self- or third-party audits of UAS

	operators. Values are stated in inch-pound units, with SI conversions provided for reference only. Developed under WTO Technical Barriers to Trade (TBT) principles, this standard does not address all safety concerns; users must ensure compliance with applicable safety, health, and environmental regulations before application.
Version history	-
Reference	https://www.astm.org/f3366-19.html

Standard	F3379
Title	Standard Guide for Training for Public Safety Remote Pilot of Unmanned Aircraft Systems (UAS) Endorsement
Status	Active
Initial date	25-02-2020
Current version	F3379-20
Description	This guide outlines the minimum training requirements for public safety remote pilots (PS-RPs) regarding general, field, and search-specific knowledge and skills. It does not cover training for operations in collapsed structures, water, confined spaces, or underground environments. Basic remote piloting skills are addressed in Guide F3266. PS-RPs trained under this guide are not qualified for leadership roles outside UAS teams and may require additional training based on local regulations. The guide applies regardless of UAS type or protective equipment, with compliance expected per Specifications F3298 or F2910. Developed under WTO Technical Barriers to Trade (TBT) principles, users must ensure regulatory compliance.
Version history	-
Reference	https://www.astm.org/f3379-20.html

Standard	F3389/F3389M
Title	Standard Test Method for Assessing the Safety of Small Unmanned Aircraft Impacts
Status	Active
Initial date	18-11-2021
Current version	F3389/F3389M-21
Description	This test method applies to small unmanned aircraft (sUA) under 55 lbs., as defined by 14 CFR § 107.3, providing a standardized approach for assessing impact safety on individuals. It supports applicants seeking Civil Aviation Authority (CAA) approval for flights over people. Based on FAA and ASSURE research, it outlines four evaluation methods, considering probable failure conditions. The test method supplements ASTM Specifications F3298, F3322, and F2910. SI and inch-pound units are used separately. Developed under WTO Technical Barriers to Trade (TBT) principles, users must ensure compliance with applicable safety, health, and regulatory requirements before application.
Version history	F3389/F3389M-20
Reference	https://www.astm.org/f3389_f3389m-21.html

Standard	F3411
Title	Standard Specification for Remote ID and Tracking
Status	Active
Initial date	13-07-2022

Current version	F3411-22a
Description	This standard defines performance requirements for Remote Identification (Remote ID) of unmanned aircraft systems (UAS). The definition allows governmental and civil identification for safety, security, and regulatory compliance. Remote ID enhances pilot accountability while preserving operational privacy and supports advanced operations like beyond visual line of sight (BVLOS) and flights over people. The standard defines the formats of messages and methods of transmission and performance requirements for broadcast and network-based Remote ID. The standard applies to very low-level (VLL) airspace but does not cover UAS that use ADS-B or transponders. Users must follow WTO Technical Barriers to Trade (TBT) principles when developing this standard while ensuring safety, health and regulatory compliance.
Version history	F3411-22 F3411-19
Reference	https://www.astm.org/f3411-22a.html

Standard	F3442/F3442M
Title	Standard Specification for Detect and Avoid System Performance Requirements
Status	Active
Initial date	28-02-2023
Current version	F3442/F3442M-23
Description	This specification applies to uncrewed aircraft (UA) with a maximum dimension of ≤25 ft, operating below 100 knots in low- and medium-risk airspace, typically Class G and E below 1200 ft AGL, and within designated controlled airspace at lower altitudes. It addresses crewed aircraft avoidance but not UA-to-UA, terrain, or hazard avoidance. Architecture-agnostic, it defines safety performance thresholds for detect and avoid (DAA) systems. It guides system integrators, developers, and service suppliers. Values are provided in SI and inch-pound units separately. Developed under WTO Technical Barriers to Trade (TBT) principles, users must ensure compliance with safety, health, and regulatory requirements.
Version history	F3442/F3442M-20
Reference	https://www.astm.org/f3442_f3442m-23.html

Standard	F3478
Title	Standard Practice for Development of a Durability and Reliability Flight Demonstration Program for Low-Risk Unmanned Aircraft Systems (UAS) under FAA Oversight
Status	Active
Initial date	09-11-2020
Current version	F3478-20
Description	This standard practice applies to low-risk unmanned aircraft systems (UAS) seeking type certification under FAA 14 CFR Part 21.17(b) using the durability and reliability (D&R) means of compliance (MOC). The term "low-risk UAS" aligns with FAA-defined criteria in the G-1 Issue Paper, including operational and kinetic energy thresholds. It establishes a methodology for developing minimum flight plans to assess aircraft reliability. The scope covers D&R planning, data collection, and reporting. SI units are standard, but aviation conventions apply for altitude and airspeed. Developed under WTO Technical Barriers to Trade (TBT) principles, users must ensure compliance with relevant safety, health, and regulatory requirements.
Version history	-

Reference	https://www.astm.org/f3478-20.html

Standard	F3532
Title	Standard Practice for Protection of Aircraft Systems from Intentional Unauthorized Electronic Interactions
Status	Active
Initial date	17-01-2024
Current version	F3532-23
Description	This practice outlines methods for mitigating Aircraft System Information Security Protection (ASISP) risks from Intentional Unauthorized Electronic Interactions (IUEIs). Developed for Level 1–4 normal category airplanes, it may apply more broadly, subject to applicant justification. It covers threat identification, security measures, risk assessment, and documentation. Those using this as a Means of Compliance for design approval must consult their civil aviation authority (CAA). A list of accepted authorities is available on the ASTM F44 webpage. Developed under WTO Technical Barriers to Trade (TBT) principles, users must ensure compliance with applicable safety, health, and regulatory requirements before application.
Version history	F3532-22
Reference	https://www.astm.org/f3532-23.html

Standard	F3547
Title	Standard Specification for Fuel Cell Power Systems for Use in Small Unmanned Aircraft Systems (sUAS)
Status	Active
Initial date	07-06-2024
Current version	F3547-24
Description	This specification establishes requirements for fuel cells and fuel cell-based power systems, including hydrogen storage and refueling systems used in electric small Unmanned Aircraft Systems (sUAS). While some requirements may apply to larger UAS and manned aircraft, additional safety considerations are beyond this document's scope. Fuel cells for ground operations are not covered. Compliance is typically declared by the integrator, as requirements apply to both the fuel cell and its interaction with the UAS and operator. SI units are standard, with non-SI units used for clarity. Developed under WTO Technical Barriers to Trade (TBT) principles, users must ensure compliance with safety and regulatory requirements.
Version history	-
Reference	https://www.astm.org/f3547-24.html

Standard	F3548
Title	Standard Specification for UAS Traffic Management (UTM) UAS Service Supplier (USS) Interoperability
Status	Active
Initial date	08-03-2022
Current version	F3548-21

Description	This specification provides a global framework for Unmanned Traffic Management (UTM), defining performance and interoperability requirements for UAS Service Suppliers (USSs) supporting strategic aspects of UAS operations. It covers conflict detection, conformance monitoring, constraint awareness, and situational awareness for operations in connected environments. The specification is architecture-agnostic and allows flexible USS implementations while ensuring compliance with regulatory requirements. It does not address tactical conflicts, airspace authorization, or non-participating UAS operations. SI units are standard, and the document aligns with WTO Technical Barriers to Trade (TBT) principles. Future versions may introduce expanded operational capabilities and refinements based on evolving regulatory needs.
Version history	-
Reference	https://www.astm.org/f3548-21.html

Standard	F3563
Title	Standard Specification for Design and Construction of Large Fixed Wing Unmanned Aircraft Systems
Status	Active
Initial date	07-05-2022
Current version	F3563-22
Description	This specification defines industry standards for demonstrating compliance with Unmanned Aircraft Systems (UAS) requirements but does not apply to passenger-carrying UAS, VTOL/hybrid aircraft, seaplanes, acrobatic-certified UAS, or recreational UAS. Only mature standards accepted by committee consensus and suitable for certification projects are included. Civil Aviation Authorities (CAAs) may accept this as a Means of Compliance (MoC), with variations based on regulatory differences. Applicants must consult their CAA for approval or propose alternative MoCs. Built on ASTM F44 General Aviation guidelines, this specification incorporates UAS-specific modifications where necessary. Developed under WTO Technical Barriers to Trade (TBT) principles, users must ensure compliance with safety, health, and regulatory requirements.
Version history	-
Reference	https://www.astm.org/f3563-22.html

Standard	F3586
Title	Standard Practice for Remote ID Means of Compliance to Federal Aviation Administration Regulation 14 CFR Part 89
Status	Active
Initial date	26-07-2022
Current version	F3586-22
Description	This practice provides a Means of Compliance (MOC) for Unmanned Aircraft System (UAS) and Broadcast Module manufacturers to develop Remote ID (RID) Systems (RIDS) that comply with FAA 14 CFR Part 89. Submitting a Declaration of Compliance (DOC) under this MOC satisfies FAA requirements. The FAA offers three Remote ID compliance options: Standard RID UAS, RID Broadcast Modules, and FAA-recognized identification areas (FRIAs). This MOC covers Standard RID and RID Broadcast Modules but excludes FRIAs, as they do not require technical RID compliance. SI and non-SI units are used based on aviation standards. Developed under WTO Technical Barriers to Trade (TBT) principles, users must ensure compliance with safety and regulatory requirements.
Version history	-

Reference	https://www.astm.org/f3586-22.html

Standard	E456
Title	Standard Terminology Relating to Quality and Statistics
Status	Active
Initial date	16-04-2024
Current version	E456-13AR22E01
Description	This standard serves as the general terminology reference for terms defined within the standards of Committee E11 on Quality and Statistics. Terms attributed to an E11 technical standard are considered normative, and any updates to definitions in the respective standard will be reflected editorially in this document. New terms introduced in E11 standards will also be incorporated accordingly. While similar definitions from ISO 3534 are noted, they are not considered normative for E11 terms. Developed under internationally recognized standardization principles, this standard aligns with the guidelines set by the WTO Technical Barriers to Trade (TBT) Committee.
Version history	E456-13AR22 E456-13AR17E06 E456-13AR17E05 E456-13AR17E04 E456-13AR17E03 E456-13AR17E02 E456-13AR17E01 E456-13AE04 E456-13AE03 E456-13AE02 E456-13AE01 E456-13A E456-13 E456-12E01 E456-12 E456-08E04 E456-08E03 E456-08E02 E456-08E01 E456-08 E456-06E01 E456-06 E456-04E01 E456-04 E456-02E01 E456-02 E456-96
Reference	https://www.astm.org/e0456-13ar22e01.html

Standard	E2555
Title	Standard Practice for Factors and Procedures for Applying the MIL-STD-105 Plans in Life and Reliability Inspection
Status	Active
Initial date	02-02-2022
Current version	E2555-21e1
Description	This practice provides a procedure and factor tables for adapting Practice E2234 (aligned with MIL-STD-105) for acceptance sampling inspection when evaluating item quality based on life length or reliability. It includes factors for three evaluation criteria: mean life, hazard rate, and reliable life. Sampling inspection is conducted using attribute testing, truncated at a predetermined time. The Weibull distribution, with the exponential distribution as a special case, serves as the statistical model. No specific system of units is designated. Developed under WTO Technical Barriers to Trade (TBT) principles, users must ensure compliance with applicable safety, health, and regulatory requirements.
Version history	E2555-21 E2555-07R18E01 E2555-07R18 E2555-07R12 E2555-07
Reference	https://www.astm.org/e2555-21e01.html

Standard	E3159

Title	Standard Guide for General Reliability
Status	Active
Initial date	23-07-2021
Current version	E3159-21
Description	The guide explains basic concepts and applications and mathematical relationships of reliability in industrial settings for simple components and processes and systems and complex final products. The guide does not specify any particular system of units because all quantities function as illustrative examples instead of industry-specific requirements. The standard does not cover all possible safety issues so users need to create suitable safety protocols and health and environmental practices and meet relevant regulatory requirements. This guide follows internationally recognized standardization principles and meets the requirements of the WTO Technical Barriers to Trade (TBT) Committee.
Version history	E3159-18
Reference	https://www.astm.org/e3159-21.html

Standard	E2696
Title	Standard Practice for Life and Reliability Testing Based on the Exponential Distribution
Status	Active
Initial date	05-07-2021
Current version	E2696-21
Description	This practice provides standardized sampling procedures and tables for life and reliability testing in procurement, supply, maintenance quality control, and research and development. It defines general procedures, key terms, and specific applications for life test sampling plans to assess conformance with reliability requirements. Adapted from the Quality Control and Reliability Handbook H-108 (1960), this practice is based on the exponential distribution model. No specific system of units is designated. Developed under WTO Technical Barriers to Trade (TBT) principles, users must ensure compliance with applicable safety, health, and regulatory requirements.
Version history	E2696-09R18 E2696-09R13 E2696-09E01 E2696-09
Reference	https://www.astm.org/e2696-21.html

Standard	F3600
Title	Standard Guide for Unmanned Aircraft System (UAS) Maintenance Technician Qualification
Status	Active
Initial date	25-01-2023
Current version	F3600-22
Description	This guide outlines fundamental knowledge, task performance, and technical competencies required for unmanned aircraft system (UAS) professionals designated as UAS technicians. It defines qualifications, including type ratings for specific systems and the minimum knowledge, skills, and abilities necessary for maintaining Class 1, Class 2, and Class 3 UAS. SI units are used as the standard. This guide does not address all safety concerns; users must establish appropriate safety, health, and environmental practices while ensuring compliance with applicable regulations. Developed in alignment with

	internationally recognized standardization principles, it follows the guidelines of the WTO Technical Barriers to Trade (TBT) Committee.
Version history	-
Reference	https://www.astm.org/f3600-22.html

Standard	F3657
Title	Standard Specification for Verification of Lightweight Unmanned Aircraft Systems (UAS)
Status	Active
Initial date	25-01-2024
Current version	F3657-23
Description	This specification outlines airworthiness requirements for the design of light unmanned aircraft systems (UAS), establishing baseline verification criteria. A UAS consists of the unmanned aircraft, onboard subsystems, payload, control station, off-board subsystems, launch and recovery equipment, crew members, and command and control (C2) links. This standard supports airworthiness determinations by civil aviation authorities (CAAs), self-assessments, or third-party evaluations, using risk-based certification categories. It acknowledges varying operational risks and allows CAA discretion in broader applications. Imperial units are standard, with SI units provided for reference. Developed under WTO Technical Barriers to Trade (TBT) principles, users must ensure compliance with applicable safety, health, and regulatory requirements.
Version history	-
Reference	https://www.astm.org/f3657-23.html

Standard	F3686
Title	Standard Practice for Production Approval of Unmanned Aircraft Systems (UAS)
Status	Active
Initial date	28-10-2024
Current version	F3686-24A
Description	The practice defines production approval standards for unmanned aircraft systems manufacturers to meet civil aviation authority airworthiness requirements for UAS without crew members. The framework of this practice follows the risk-based approach of Joint Authorities for Rulemaking of Unmanned Systems (JARUS) Specific Operations Risk Assessment (SORA) by organizing operations into Open, Specific and Certified tiers. The Specific category includes three risk levels which determine the necessary production rigor. The practice offers a standardized approach for manufacturers to obtain production approval while following ASTM F38 standards. Users need to verify their CAA compliance while maintaining safety standards and health regulations and regulatory requirements.
Version history	F3686-24
Reference	https://www.astm.org/f3686-24a.html

Standard	WK56255
Title	New Guide for Design and Production of Energy Storage Systems to Power Aircraft Propulsion
Status	Ongoing

Initial date	17-10-2016
Current version	-
Description	This document provides guidance to assist in understanding the process and means for showing compliance to regulatory requirements for rechargeable energy storage systems sized for aircraft propulsion
Version history	-
Reference	https://www.astm.org/products-services/standards-and-publications/standards/workitem-wk56255

Standard	WK61549
Title	New Specification for Indirect Flight Control Systems in Aircraft
Status	Ongoing
Initial date	21-12-2017
Current version	-
Description	This internationally recognized industry specification defines the design requirements for indirect flight control systems, such as fly-by-wire systems, in aircraft. Initially developed for Level 1, 2, 3, and 4 Normal Category airplanes, its applicability may extend beyond these categories. The document covers functional requirements, basic and automatic flight control system performance, automatic navigation and guidance functional requirements, maintainability requirements, methods for compliance demonstration, and documentation
Version history	-
Reference	https://www.astm.org/products-services/standards-and-publications/standards/workitem-wk61549

Standard	WK61763
Title	New Guide for Training for Remote Pilot Instructor (RPI) of Unmanned Aircraft Systems (UAS) Endorsement
Status	Ongoing
Initial date	10-01-2018
Current version	-
Description	The ASTM standard defines the training requirements for Remote Pilot Instructors who want to obtain Unmanned Aircraft Systems (UAS) endorsement. The standard defines the essential knowledge and skills and abilities which remote pilots need to learn for commercial UAS operations. Civil aviation authorities (CAAs) may use this guide at their discretion to help create relevant regulations.
Version history	-
Reference	https://www.astm.org/workitem-wk61763

Standard	WK62734
Title	New Specification for Specification for the Development of Manufacturers Maintenance Data for Lightweight UAS
Status	Ongoing
Initial date	12-02-2018

Current version	-
Description	This practice outlines the qualifications required for performing various levels of maintenance on lightweight unmanned aircraft systems (UAS). It also defines the content and structure of maintenance manuals and Instructions for Continued Airworthiness (ICA) for UAS and their components operated as lightweight unmanned aircraft.
Version history	-
Reference	https://www.astm.org/products-services/standards-and-publications/standards/workitem-wk62734

Standard	WK62669
Title	New Test Method for Detect and Avoid
Status	Ongoing
Initial date	07-03-2018
Current version	-
Description	The objective is to establish test methods for Detect and Avoid (DAA) systems and sensors applicable to smaller UAS Beyond Visual Line of Sight (BVLOS) operations, ensuring the protection of manned aircraft in lower-altitude airspace.
Version history	-
Reference	https://www.astm.org/products-services/standards-and-publications/standards/workitem-wk62669

Standard	WK62744
Title	New Practice for General Operations Manual for Professional Operator of Light Unmanned Aircraft Systems (UAS)
Status	Ongoing
Initial date	13-03-2018
Current version	-
Description	This standard establishes requirements for a General Operations Manual for professional operators of light unmanned aircraft systems (UAS). It outlines best practices for documentation and organization for operators engaged in commercial activities. Designed to support professional entities seeking certification from a civil aviation authority (CAA), it also provides standards for self- or third-party audits. This standard helps fill regulatory gaps by offering guidance for remote pilots in jurisdictions without separate operator certification, operators seeking voluntary compliance with industry standards, and public agencies developing UAS programs.
Version history	-
Reference	https://www.astm.org/products-services/standards-and-publications/standards/workitem-wk62744

Standard	WK66135
Title	Revision of F3005-14a Standard Specification for Batteries for Use in Small Unmanned Aircraft Systems (sUAS)
Status	Ongoing
Initial date	06-12-2018

Current version	-
Description	Cell manufacturers previously certified their cells to UL2054 and UL1642; this requirement has now been updated to UL62133 and UN38.3. Additionally, the FAA has requested further support for recovery efforts in the event of an incident. An update has been prepared, with work limited to review and minor revisions.
Version history	-
Reference	https://www.astm.org/products-services/standards-and-publications/standards/workitem-wk66135

Standard	WK68098
Title	Revision of F3201-16 Standard Practice for Ensuring Dependability of Software Used in Unmanned Aircraft Systems (UAS)
Status	Ongoing
Initial date	06-05-2019
Current version	-
Description	Renew standard to keep it from being withdrawn, with a focus on updating scope and terminology.
Version history	-
Reference	https://www.astm.org/products-services/standards-and-publications/standards/workitem-wk68098

Standard	WK75923
Title	New Specification for Positioning Assurance, Navigation, and Time Synchronization for Unmanned Aircraft Systems
Status	Ongoing
Initial date	15-02-2021
Current version	-
Description	This standard is part of a broader suite of approximately twenty essential functions supporting a standards-based approach for widespread and routine Beyond Line of Sight (BLOS) operations. It aligns with the ASTM AC478 committee's Technical Report on BLOS Strategy & Road mapping. The specification defines Positioning Assurance, Navigation, and Time Synchronization, establishing minimum requirements for UAS to determine its position, navigation accuracy, and trusted time synchronization. While these functions are essential for BLOS safety, they also benefit many Visual Line of Sight (VLOS) missions. The standard prioritizes performance measures, level of service evaluation, latency considerations, and transparency requirements while remaining technology-agnostic. Airworthiness and maintenance guidelines are also included.
Version history	-
Reference	https://www.astm.org/products-services/standards-and-publications/standards/workitem-wk75923

Standard	WK82110
Title	Revision of F3178-16 Standard Practice for Operational Risk Assessment of Small Unmanned Aircraft Systems (sUAS)
Status	Ongoing

Initial date	06-06-2022
Current version	-
Description	Renewed standard to keep it from being withdrawn with focus on aligning with more recent regulatory guidance.
Version history	-
Reference	https://www.astm.org/products-services/standards-and-publications/standards/workitem-wk82110

Standard	WK82124
Title	Revision of F2908-18 Standard Specification for Unmanned Aircraft Flight Manual (UFM) for an Unmanned Aircraft System (UAS)
Status	Ongoing
Initial date	08-06-2022
Current version	-
Description	The FAA issued AIR600-21-AIR-600-PM01, "FAA Approval of Unmanned Aircraft Systems (UAS) Special Class UA Projects and their Associated Elements," in July 2021, altering the certification process by focusing only on the aircraft and onboard appliances while removing certain "associated elements" from the system. As a result, several F38 Standards require revision to align with these changes. For F2908, updates will include the creation of an Annex to define stand-alone manuals for Associated Elements, an Appendix outlining an alternative compliance method for UAS with components classified as Associated Elements, and a description of a Quick Reference Handbook (QRH) for both the UA and its Associated Elements.
Version history	-
Reference	https://www.astm.org/products-services/standards-and-publications/standards/workitem-wk82124

Standard	WK82782
Title	Revision of F3002-14a Standard Specification for Design of the Command-and-Control System for Small Unmanned Aircraft Systems (sUAS)
Status	Ongoing
Initial date	15-07-2022
Current version	-
Description	Terminology updates
Version history	-
Reference	https://www.astm.org/products-services/standards-and-publications/standards/workitem-wk82782

Standard	WK84631
Title	New Guide for Device-to-Device Certificate-based Communications Security Framework for UAS/UAM
Status	Ongoing
Initial date	22-12-2022

Current version	-
Description	This task defines a security framework for aerial V2X (A2X) communications, identifying key properties and evaluating candidate frameworks. A selected framework will guide secure aircraft device-to-device communications. The ASTM Communications Security Framework Guide will outline encapsulation methods, certificate-based authentication, and integration with ICAO IATF policies. An Authenticated Broadcast Remote ID method will be standardized within ASTM F3411-22, ensuring compatibility with existing Remote ID implementations. The project includes drafting, balloting, and publishing the standard and guide, followed by coordination with the FAA or other CAAs to obtain a Notice of Availability (NOA), supporting widespread adoption of secure, authenticated UAS communications.
Version history	-
Reference	https://www.astm.org/products-services/standards-and-publications/standards/workitem-wk84631

Standard	WK85104
Title	New Practice for Supporting Compliance with Requirements for sUAS Operations over People
Status	Ongoing
Initial date	31-01-2023
Current version	-
Description	This task focuses on establishing a Means of Compliance (MOC) for small UAS (sUAS) Operations over People, aligning with ASTM standards F3389-21, F3322-22, and F3411-22a. It includes evaluating aircraft injury potential, verifying the absence of exposed rotating parts that could cause lacerations, and assessing aircraft designs for safety defects. The Working Group will also consider methods to reduce pilot workload and skill requirements for these operations. While primarily addressing FAA compliance, international harmonization will be pursued by involving other Civil Aviation Authorities (CAAs). Additionally, relevant ASTM standards will be reviewed for applicability to UAS production approval.
Version history	-
Reference	https://www.astm.org/products-services/standards-and-publications/standards/workitem-wk85104

Standard	WK85153
Title	New Specification for Vertiport Automation Supplemental Data Service Provider (SDSP) Performance
Status	Ongoing
Initial date	02-02-2023
Current version	-
Description	This standard establishes minimum performance-based requirements for Vertiport Automation Supplemental Data Service Provider (SDSP) data and services within the UAS Traffic Management (UTM) and Urban Air Mobility (UAM) ecosystems. It defines data services for UAS Service Suppliers/Providers (USS/USP) and Providers of Services for UAM (PSU), offering real-time and forecasted facility information to support VLOS and BVLOS UAS operations. Additionally, Vertiport Automation services will enhance capabilities such as geofencing and flight planning for UAS and Advanced Aerial Mobility. The standard will also cover spectrum radionavigation equipment and

	installation approvals, ensuring interoperability and safety in automated vertiport operations.
Version history	-
Reference	https://www.astm.org/products-services/standards-and-publications/standards/workitem-wk85153

Standard	WK85414
Title	Revision of F3548-21 Standard Specification for UAS Traffic Management (UTM) UAS Service Supplier (USS) Interoperability
Status	Ongoing
Initial date	23-02-2023
Current version	-
Description	This revision will address gaps identified in demonstrations and regulatory mapping to U-space regulations, ensuring alignment with evolving industry needs. Key updates will focus on increased flexibility in handling operational intent conflicts where regulations permit, along with enhancements in priority and preemption, negotiation mechanisms, and fairness principles. These revisions aim to improve interoperability, efficiency, and regulatory adaptability within UAS Traffic Management (UTM) ecosystems.
Version history	-
Reference	https://www.astm.org/products-services/standards-and-publications/standards/workitem-wk85414

Standard	WK85415
Title	New Specification for UAM PSU Interoperability
Status	Ongoing
Initial date	23-02-2023
Current version	-
Description	This standard defines interoperability protocols, APIs, and functional requirements for digital traffic management systems in Advanced Air Mobility (AAM), focusing on Providers of Services for UAM (PSU) and their necessary functions. It builds upon the UTM Draft Standard, adapting it to AAM-specific needs such as vertiport integration, constrained waypoints, legacy ATM/UTM interfaces, and contingency events. Key areas include operation lifecycle management, demand/capacity balancing, prioritization frameworks, resource sharing, and conformance monitoring. The standard will establish a secure and scalable PSU interoperability network, supporting flight planning, coordination, and execution within the prevailing AAM Concept of Operations (CONOPS) while ensuring safety, efficiency and seamless integration into the broader airspace system.
Version history	-
Reference	https://www.astm.org/products-services/standards-and-publications/standards/workitem-wk85415

Standard	WK87943
Title	Revision of F3322-22 Standard Specification for Small Unmanned Aircraft System (sUAS) Parachutes
Status	Ongoing

Initial date	20-09-2023
Current version	-
Description	This new revision is intended to improve compliance, safety, and transparency for all stakeholders
Version history	-
Reference	https://www.astm.org/products-services/standards-and-publications/standards/workitem-wk87943

Standard	WK88791
Title	New Terminology for Standard Terminology Related to Pesticide Application with Drones
Status	Ongoing
Initial date	01-12-2023
Current version	-
Description	This standard applies to unmanned vehicles used for pesticide application and defines terminology relevant to test methods, specifications, guides, and practices related to pesticide products. Developed in accordance with internationally recognized standardization principles, it aligns with the World Trade Organization (WTO) Technical Barriers to Trade (TBT) Committee's guidelines.
Version history	-
Reference	https://www.astm.org/products-services/standards-and-publications/standards/workitem-wk88791

Standard	WK90326
Title	New Practice for UAS Ground Control System Human Factors
Status	Ongoing
Initial date	16-04-2024
Current version	-
Description	This task evaluates human factors guidance from both manned and unmanned aviation to establish minimum requirements for Ground Control Stations (GCS) where the crewmember operates Beyond Visual Line of Sight (BVLOS) of an automated Unmanned Aircraft (UA). Additional requirements for multi-UAS and specialized operations will be addressed separately. The activity will ensure compatibility with existing ASTM F38 standards, noting and justifying any necessary deviations.
Version history	-
Reference	https://www.astm.org/products-services/standards-and-publications/standards/workitem-wk90326

Standard	WK91696
Title	Revision of F3686-24 Standard Practice for Production Approval of Unmanned Aircraft Systems (UAS)
Status	Ongoing
Initial date	22-07-2024
Current version	-

Description	-
Version history	-
Reference	https://www.astm.org/products-services/standards-and-publications/standards/workitem-wk91696

2.2.4 ITU

Standard	Y.2256
Title	Overview of unmanned smart farms based on networks
Status	Active
Initial date	29-10-2017
Current version	-
Description	Recommendation ITU-T Y.4116 outlines requirements for transportation safety services. More specific it details use cases and service scenarios for various IoT-based applications. These requirements focus on risks from defective vehicles, environmental conditions, infrastructure disruptions, and human errors, all of which impact lives and property. By leveraging IoT technologies, transportation safety services can prevent accidents, mitigate disasters, and enhance emergency response, ultimately reducing casualties and damage in cases of natural disasters.
Version history	-
Reference	https://www.itu.int/ITU-T/recommendations/rec.aspx?rec=13385&lang=en

Standard	Y.3207
Title	Fixed, mobile and satellite convergence – Integrated network control architecture framework for IMT-2020 networks and beyond
Status	Active
Initial date	29-04-2024
Current version	-
Description	Recommendation ITU-T Y.3207 defines an integrated network control architecture for fixed, mobile, and satellite convergence within the control plane of IMT-2020 and future networks. It outlines scenarios and architecture frameworks for both integrated and individual network domains, covering end-to-end service design, orchestration, performance monitoring, and resource control. The standard ensures unified management across terrestrial and non-terrestrial networks, optimizing efficiency and interoperability.
Version history	-
Reference	https://www.itu.int/ITU-T/recommendations/rec.aspx?rec=15872&lang=en

Standard	Y.3540
Title	Edge computing – Overview and high-level requirements
Status	Active
Initial date	22-10-2023
Current version	-

Description	Recommendation ITU-T Y.3540 provides an overview and high-level requirements for edge computing, defining key terminology, concepts, characteristics, and operational ecosystems. It outlines main roles, orchestration aspects, and the relationship between edge computing and other technologies. The standard also presents high-level requirements derived from various use cases, ensuring a structured approach to deployment and management.
Version history	-
Reference	https://www.itu.int/ITU-T/recommendations/rec.aspx?rec=15538&lang=en

Standard	Y.4116
Title	Requirements of transportation safety services including use cases and service scenarios
Status	Active
Initial date	29-10-2017
Current version	-
Description	Recommendation ITU-T Y.4116 defines requirements for transportation safety services, outlining use cases and service scenarios to establish criteria for IoT-based applications. It addresses risks which threaten lives and property and posed by defective vehicles, environmental conditions, infrastructure disruptions, and human errors. By leveraging IoT technologies, transportation safety services can reduce accidents, mitigate disasters, and enhance emergency response, ultimately improving safety and minimizing damage in critical situations.
Version history	-
Reference	https://www.itu.int/ITU-T/recommendations/rec.aspx?rec=13385&lang=en

Standard	Y.4215
Title	Use cases, requirements and capabilities of unmanned aircraft systems for the Internet of things
Status	Active
Initial date	03-02-2022
Current version	-
Description	Recommendation ITU-T Y.4215 defines use cases, requirements, and capabilities of unmanned aircraft systems (UASs) in the Internet of Things (IoT). It classifies use cases into four categories based on wireless communication scenarios: UAS-aided offloading, emergency response, relaying, and information dissemination/data collection. The recommendation outlines both common and specific requirements for UASs to effectively support these IoT applications.
Version history	-
Reference	https://www.itu.int/ITU-T/recommendations/rec.aspx?id=14825&lang=en

Standard	Y.4218
Title	Internet of things and information and communication technology requirements for deployment of smart services in rural communities
Status	Active
Initial date	07-05-2023

Current version	-
Description	The ITU-T Y.4218 Recommendation establishes ICT and IoT requirements to deploy smart services in rural communities through e-government and telehealth and tele-education and precision agriculture. Smart city development continues to progress but smart rural community initiatives face significant challenges in developing countries where agriculture and livestock farming serve as main economic activities. Rural-to-urban migration occurs because people in rural areas lack access to healthcare services and educational opportunities and financial services. The development of ICT infrastructure through high-speed Internet and telephony services leads to better quality of life while generating new possibilities that benefit local economic growth. Universal smartphone access with Internet connectivity enables better digital service access which minimizes the differences between rural and urban areas.
Version history	-
Reference	https://www.itu.int/ITU-T/recommendations/rec.aspx?rec=15481&lang=en

Standard	Y.4421
Title	Functional architecture for unmanned aerial vehicles and unmanned aerial vehicle controllers using IMT-2020 networks
Status	Active
Initial date	11-10-2021
Current version	-
Description	Recommendation ITU-T Y.4421 addresses the growing communication and network demands of civilian unmanned aerial vehicles (UAVs), including seamless coverage, low latency, high data rates, and precise positioning. Current UAVs rely on direct radio links, which limit service distance and quality. To overcome these limitations, IMT-2020 networks can be utilized for UAV communications, requiring new types of user terminals tailored for aerial operations. Since IMT-2020 was originally designed for ground coverage, specialized functionalities are needed to ensure interoperability between UAVs and IMT-2020 networks. This Recommendation defines a functional architecture for UAVs and controllers, outlining application, service, and security capabilities to enhance UAV operations over IMT-2020 networks.
Version history	-
Reference	https://www.itu.int/ITU-T/recommendations/rec.aspx?rec=14738&lang=en

Standard	Y.4504
Title	Service framework of prediction for intelligent Internet of things
Status	Active
Initial date	29-08-2024
Current version	-
Description	Recommendation ITU-T Y.4504 defines a service framework for prediction-based intelligent IoT services, integrating artificial intelligence (AI) technologies to meet market demands. It introduces the concept, requirements, and functional architecture of predictive IoT services. As AI advances, its integration into IoT enables enhanced intelligent services, with a focus on machine learning-driven inference rather than training. The Recommendation emphasizes the need for efficient AI service deployment that ensures accurate, real-time predictions for practical applications, allowing AI-powered IoT services to be effectively delivered to end users.
Version history	-

Reference	https://www.itu.int/ITU-T/recommendations/rec.aspx?rec=16057&lang=en

Standard	Y.4559
Title	Requirements and functional architecture of base station inspection services using unmanned aerial vehicles
Status	Active
Initial date	16-12-2020
Current version	-
Description	Recommendation ITU-T Y.4559 defines the requirements and functional architecture for Base Station Inspection (BSI) services using Unmanned Aerial Vehicles (UAVs). It outlines how to efficiently conduct inspection services for base stations with BSI-dedicated UAVs (BSI-UAVs), ensuring optimized operations and improved maintenance processes.
Version history	-
Reference	https://www.itu.int/ITU-T/recommendations/rec.aspx?id=14424&lang=en

Standard	F.749.10
Title	Requirements for communication services of civilian unmanned aerial vehicles
Status	Active
Initial date	14-05-2019
Current version	-
Description	Recommendation ITU-T F.749.10 defines communication service requirements for civilian unmanned aerial vehicles (CUAVs), covering both industrial and consumer applications. It provides a general communication service framework, specifying requirements for communication systems, flight control, flight data transport, and mission payload services. These include audio/video/image transmission, sensor data transport, and communication signal relay, ensuring reliable and efficient CUAV operations.
Version history	-
Reference	https://www.itu.int/ITU-T/recommendations/rec.aspx?id=13900&lang=en

Standard	F.749.11
Title	Requirements for civilian unmanned aerial vehicles enabled mobile edge computing
Status	Active
Initial date	29-11-2019
Current version	-
Description	Recommendation ITU-T F.749.11 defines the framework and requirements for Civilian Unmanned Aerial Vehicle (CUAV)-enabled Mobile Edge Computing (MEC). It leverages CUAVs as MEC platforms to provide flexible, efficient, and on-demand computing services that can be rapidly deployed and repositioned based on real-time service needs. The recommendation outlines functional, service, and security requirements to ensure reliable CUAV-MEC operations.
Version history	-
Reference	https://www.itu.int/ITU-T/recommendations/rec.aspx?id=14104&lang=en

Standard	F.749.12
Title	Framework for communication application of civilian unmanned aerial vehicles
Status	Active
Initial date	13-08-2020
Current version	-
Description	Recommendation ITU-T F.749.12 defines the general framework for communication applications of civilian unmanned aerial vehicles (CUAVs), detailing functional entities, reference points, and system interactions to support seamless and efficient CUAV communication.
Version history	-
Reference	https://www.itu.int/ITU-T/recommendations/rec.aspx?id=14331&lang=en

Standard	F.749.13
Title	Framework and requirements for civilian unmanned aerial vehicle flight control using artificial intelligence
Status	Active
Initial date	13-06-2021
Current version	-
Description	Recommendation ITU-T F.749.13 defines a framework for civilian unmanned aerial vehicle (CUAV) flight control using artificial intelligence (AI). It covers both navigation control for CUAVs and mission-specific flight control based on vertical industry applications. The Recommendation addresses key challenges such as obstacle avoidance, autonomous navigation, tracking, and flight path execution to enable partial or full autonomy. It also outlines a flight control framework and functional requirements, guiding product and system integrators in designing CUAV solutions that align with industry needs.
Version history	-
Reference	https://www.itu.int/ITU-T/recommendations/rec.aspx?id=14684&lang=en

Standard	F.749.14
Title	Requirements of coordination for civilian unmanned aerial vehicles
Status	Active
Initial date	13-06-2021
Current version	-
Description	The ITU-T F.749.14 standard defines the requirements for civilian unmanned aerial vehicle (CUAV) coordination which allows multiple CUAVs to work together through network communication. The standard defines three essential elements which include creating dependable network connections and secure data transmission for perception and control and coordination information and developing collaborative task execution strategies to boost efficiency and effectiveness. The recommendation outlines the essential network requirements and data exchange protocols and coordination standards needed to maximize CUAV teamwork performance across different applications.
Version history	-
Reference	https://www.itu.int/ITU-T/recommendations/rec.aspx?id=14685&lang=en

Standard	F.749.15
Title	Requirements for inspection and examination services using civilian unmanned aerial vehicles
Status	Active
Initial date	16-03-2022
Current version	-
Description	Recommendation ITU-T F.749.15 defines requirements for high-definition (HD) and virtual reality (VR) inspection and examination (IaE) services using civilian unmanned aerial vehicles (CUAVs). It covers fore-end devices for HD image and video capture, network communication, service support, and playback. CUAV-based IaE is essential for inspecting power lines, oil pipelines, bridges, viaducts, waterways, and disaster-affected areas. Equipped with HD cameras, panoramic cameras, and infrared sensors, CUAVs enable fast, efficient, and high-quality inspections, improving accuracy and response capabilities in various monitoring applications.
Version history	-
Reference	https://www.itu.int/ITU-T/recommendations/rec.aspx?id=14964&lang=en

Standard	F.749.16
Title	Requirements for logistics express delivery based on civilian unmanned aerial vehicles
Status	Active
Initial date	10-07-2023
Current version	-
Description	Recommendation ITU-T F.749.16 defines requirements for the service system and management of civilian unmanned aerial vehicle (CUAV) logistics express delivery. CUAV-based transportation offers low costs, flexible scheduling, and complements traditional water, land, and air transport. As logistics drone delivery expands globally, it is transforming consumer behavior and supply chain efficiency. This recommendation ensures effective service operations and regulatory management for CUAV logistics.
Version history	-
Reference	https://www.itu.int/ITU-T/recommendations/rec.aspx?id=15173&lang=en

Standard	F.749.18
Title	Framework and requirements for emergency services using civilian unmanned aerial vehicles
Status	Active
Initial date	13-06-2024
Current version	-
Description	Recommendation ITU-T F.749.18 defines the framework and requirements for emergency services using civilian unmanned aerial vehicles (CUAVs). In crisis situations, locating survivors and minimizing losses are critical, but direct human intervention can be dangerous and challenging. CUAVs equipped with base stations, cameras, and sensors enable administrators to analyze situations and make informed decisions quickly. This Recommendation ensures that CUAVs effectively support emergency response operations across various scenarios.
Version history	-

Reference	https://www.itu.int/ITU-T/recommendations/rec.aspx?id=15918&lang=en

Standard	F.760.1
Title	Requirements and reference framework for emergency rescue systems
Status	Active
Initial date	14-12-2022
Current version	-
Description	Recommendation ITU-T F.760.1 defines the application scenarios, functional requirements, and reference architecture for pre-hospital emergency rescue. It guides the planning and design of emergency rescue systems in emergency centers, hospitals, and medical institutions. The Recommendation includes an appendix with use cases demonstrating the implementation of the proposed system.
Version history	-
Reference	https://www.itu.int/ITU-T/recommendations/rec.aspx?rec=15202&lang=en

Standard	X.677
Title	Identification mechanism for unmanned aerial vehicles using object identifiers
Status	Active
Initial date	08-03-2020
Current version	-
Description	Recommendation ITU-T X.677 defines requirements for full life-cycle management and identity recognition of unmanned aerial vehicles (UAVs) with security considerations. It specifies an identification mechanism using object identifiers (OIDs), detailing assignment rules and registration procedures to ensure secure and standardized UAV identification.
Version history	-
Reference	https://www.itu.int/ITU-T/recommendations/rec.aspx?id=14039&lang=en

Standard	X.1713
Title	Security requirements for the protection of quantum key distribution nodes
Status	Active
Initial date	29-04-2024
Current version	-
Description	Recommendation ITU-T X.1713 provides guidance for the secure implementation and operation of Quantum Key Distribution (QKD) nodes in QKD networks. QKD enables two remote parties to share a secure binary key, with trusted QKD nodes extending key distribution distances and supporting applications. The Recommendation identifies security threats, defines security requirements, and outlines specific techniques to ensure the trustworthiness and overall security of QKD nodes.
Version history	-
Reference	https://www.itu.int/ITU-T/recommendations/rec.aspx?rec=15885&lang=en

Standard	ITU-R M2171

Title	Characteristics of UAS and spectrum requirements to support their safe operation in non-segregated airspace
Status	Active
Initial date	12-2009
Current version	-
Description	This report presents spectrum requirement estimates for unmanned aircraft systems (UAS) based on two independent methodologies outlined in the annexes. Despite using different approaches, both methodologies yield comparable results. The analysis separately addresses terrestrial and satellite spectrum needs, as UAS deployments rely on both. The maximum spectrum required is 34 MHz for terrestrial systems and 56 MHz for satellite systems.
Version history	-
Reference	https://www.itu.int/pub/R-REP-M.2171

Standard	ITU-R M.2204-0
Title	Characteristics and spectrum considerations for sense and avoid systems use on Unmanned Aircraft Systems (UAS)
Status	Active
Initial date	11-2010
Current version	-
Description	The rapid growth of unmanned aircraft (UA) applications worldwide necessitates adequate spectrum allocation to support operations. As UA integration into non-segregated airspace approaches, securing sufficient spectrum for critical functions, including sense and avoid (S&A) systems, is essential to ensure safe and efficient operations.
Version history	-
Reference	https://www.itu.int/pub/R-REP-M.2204-2010

2.2.5 SAE

Standard	J2735
Title	V2X Communications Message Set Dictionary
Status	Revised
Initial date	16-09-2024
Current version	J2735_202409
Description	This SAE Standard defines a message set, including its data frames and elements, for applications utilizing vehicle-to-everything (V2X) communication systems.
Version history	J2735_202309 J2735_202211 J2735_202007 J2735_201603 J2735_201601 J2735_201509 J2735_200911 J2735_200612
Reference	https://www.sae.org/standards/content/j2735_202409/

Standard	J2940

Title	Use of Model Verification and Validation in Product Reliability and Confidence Assessments
Status	Active
Initial date	10-02-2020
Current version	J2940-202002
Description	This SAE standard details the procedures, recognized methodologies, and standards for integrating Model V&V with model-based product reliability assessments. It emphasizes that quantified reliability values must be paired with a quantified confidence level for the model to be considered "Verified and Validated." This is essential for supporting business and investment decisions influenced by quantitative second-order risk and cost-benefit analyses.
Version history	J2940_201111
Reference	https://www.sae.org/standards/content/j2940_202002/

Standard	J2945/2_201810
Title	Dedicated Short Range Communications (DSRC) Performance Requirements for V2V Safety Awareness
Status	Active
Initial date	30-10-2018
Current version	-
Description	This SAE Document defines DSRC interface requirements for V2V Safety Awareness applications, supported by detailed Systems Engineering documentation that maps needs and requirements to relevant message exchanges. These applications cover Emergency Vehicle Alerts, Roadside Alerts, and Safety Awareness Alerts for objects and adverse road conditions. It expands the V2V communication capabilities established in J2945/1 to support these functions and align with the National ITS Architecture. The primary goal of this document is to ensure interoperability for V2V Safety Awareness communications.
Version history	-
Reference	https://www.sae.org/standards/content/j2945/2_201810/

Standard	J2945/3
Title	Requirements for Road Weather Applications
Status	Active
Initial date	24-01-2022
Current version	J2945/3_202201
Description	Inclement weather can significantly affect surface transportation systems, creating hazardous conditions due to poor visibility or wet and icy roads. Weather applications can enhance data collection for infrastructure owners and operators, improving their ability to assess weather impacts and manage transportation systems. These applications can: • Gather road weather data from connected vehicles and mobile devices, expanding data sources. • Provide travelers with road weather information through connected devices, indicating hazardous conditions. • Support targeted road weather response management.

	This SAE Standard outlines interface requirements between vehicles and infrastructure for weather applications, including detailed systems engineering documentation. Its goal is to ensure interoperability across various communication technologies.
Version history	J2945/3__202003
Reference	https://www.sae.org/standards/content/j2945/3_202201/

Standard	J2945/5
Title	Service Specific Permissions and Security Guidelines for Connected Vehicle Applications
Status	Active
Initial date	05-02-2020
Current version	J2945/5_202002
Description	SAE is developing standards, including the SAE J2945/x and SAE J3161/x series, which define applications using message sets from the SAE J2735 data dictionary. Here, "application" refers to a collection of activities involving interactions between entities to achieve related goals, linked to a specific IEEE Provider Service Identifier (PSID). Communication authenticity and integrity are secured through digital signatures and IEEE 1609.2 digital certificates, which also define sender permissions using PSIDs and Service Specific Permissions (SSPs). If an application involves multiple activities with varying security impacts or roles, the SSP structure should specify which actions a certificate holder can perform.
Version history	-
Reference	https://www.sae.org/standards/content/j2945/5_202002/

Standard	J2945/6
Title	Performance Requirements for Cooperative Adaptive Cruise Control (CACC) and Platooning
Status	Active
Initial date	26-10-2023
Current version	J2945/6_202310
Description	This standard outlines guidelines for enhancing adaptive cruise control (ACC) through wireless communication from other vehicles (V2V) and infrastructure (I2V) to support ACC's active sensing capabilities. The Cooperative Adaptive Cruise Control (CACC) system operates under driver supervision and is limited to: • Providing only longitudinal vehicle control. • Employing a time gap control strategy similar to ACC. The standard applies to both light and heavy motor vehicles. It also covers message elements necessary for implementing CACC and platooning. The initial release defines CACC and platooning concepts and sets requirements for CACC, while a future release will address platooning requirements.
Version history	-
Reference	https://www.sae.org/standards/content/j2945/6_202310/

Standard	J3016

Title	Taxonomy and Definitions for Terms Related to Driving Automation Systems for On-Road Motor Vehicles
Status	Active
Initial date	30-04-2021
Current version	J3016_202104
Description	This document outlines motor vehicle driving automation systems that handle part or all of the dynamic driving task (DDT) on a sustained basis. It presents a taxonomy with six defined automation levels, from no automation (Level 0) to full automation (Level 5): • **Level 0:** No Driving Automation • **Level 1:** Driver Assistance • **Level 2:** Partial Driving Automation • **Level 3:** Conditional Driving Automation • **Level 4:** High Driving Automation • **Level 5:** Full Driving Automation These levels describe automation features during on-road operations, including public roads, parking areas, and accessible private campuses. The engaged feature(s) determine the automation level exhibited at any moment. The document identifies three primary actors: the human user, the driving automation system, and other vehicle components (excluding the automation system, despite potential shared hardware/software). Automation levels are defined by the roles these actors play in DDT execution and fallback tasks. Systems like electronic stability control (ESC), automatic emergency braking (AEB), and lane-keeping assistance (LKA) are excluded, as they offer momentary interventions rather than sustained automation. Informational systems that alert drivers to hazards also fall outside this taxonomy. However, vehicles equipped with automated driving systems (ADS) at Levels 3–5 incorporate crash mitigation and avoidance functions as part of their core capabilities.
Version history	J3016_201806 J3016_201609 J3016_201401
Reference	https://www.sae.org/standards/content/j3016_202104/

Standard	J3018
Title	Safety-Relevant Guidance for On-Road Testing of Prototype Automated Driving System
Status	Active
Initial date	04-12-2020
Current version	J3018_202012
Description	This document offers preliminary safety guidance for in-vehicle fallback test driver (IFTD) training and on-road testing of prototype vehicles equipped with conditional, high, or full automated driving systems (ADS) at Levels 3 to 5, as defined by SAE J3016. It does not cover performance evaluations for post-production ADS-equipped vehicles and focuses solely on testing overseen by IFTDs. The guidelines exclude: • Remote driving or remote fallback test driving, though future updates may address this. • Testing of driver support features (Levels 1 and 2) that require human supervision and DDT involvement. • Closed-course testing. • Simulation testing (except for training).

	• Component-level testing. Data collection and retention are also outside the scope but should consider legal, privacy, and risk management factors, including maintaining auditable procedures, adhering to privacy laws, and ensuring data integrity for post-crash analysis.
Version history	J3018_201909 J3018_201503
Reference	https://www.sae.org/standards/content/j3018_202012/

Standard	J3061
Title	Cybersecurity Guidebook for Cyber-Physical Vehicle Systems
Status	Active
Initial date	15-12-2021
Current version	J3061_202112
Description	This recommended practice offers guidance on vehicle cybersecurity, expanding on existing industry, government, and academic practices. It presents flexible, pragmatic, and adaptable best practices for the vehicle industry and other cyber-physical systems (e.g., commercial and military vehicles, trucks, buses). While proprietary cybersecurity processes may exist for specific manufacturers, this document can help refine in-house methods. It establishes high-level principles by: • Defining a lifecycle framework adaptable to organizational development, from concept to decommissioning. • Offering information on common tools and methods for designing, verifying, and validating systems. • Providing basic cybersecurity guidance and a foundation for future standards. The appendices cover threat analysis, risk assessment, design practices, existing standards, vulnerability databases, and security tools, encouraging research to enhance cybersecurity in vehicle systems.
Version history	J3061_201601
Reference	https://www.sae.org/standards/content/j3061_202112/

Standard	J3131
Title	Definitions for Terms Related to Automated Driving Systems Reference Architecture
Status	Active
Initial date	02-03-2022
Current version	J3131_202203
Description	This document provides an overview of Automated Driving System (ADS) function principles based on information from SAE J3016. It presents information about automated driving functions, using terminology from the field and introduces new concepts to prevent misunderstandings. SAE J3131 describes the automated driving system features that operate vehicles at level 4 or 5 autonomy
Version history	-
Reference	https://www.sae.org/standards/content/j3131_202203/

Standard	JA6678
Title	Guidelines for Establishing and Maintaining Cyber-Physical-Systems' Cyber-Resilience

Status	Ongoing
Initial date	08-11-2019
Current version	-
Description	This document standardizes practices to: a. Identify and reduce software problems in a cyber -physical system by using system engineering methods to keep the system secure and strong throughout its life. b. Review and check the software to understand how changes or problems might affect the system's software, hardware and firmware c. Looks into different risk areas such as system interfaces, network links and control paths that could be misused through physical actions or by tampering with data flow
Version history	-
Reference	https://www.sae.org/standards/content/ja6678/

Standard	JA6801
Title	Cyber Physical Systems Security Hardware Assurance
Status	Ongoing
Initial date	08-04-2020
Current version	-
Description	This SAE document standardizes practices to: a. Find and fix hardware problems, especially in electrical, electronic and electromechanical (EEE) parts of a cyber-physical system, using systems engineering to keep the system secure and reliable over is entire life b. Check and analyze EEE components to see how issues might affect the system's hardware, software and firmware c. Look at risks in areas like system interfaces, networks and control systems that could be attacked through physical actions or by changing how data flows or is processed. d. Test and confirm the design to make sure the system is secure, strong and works as intended
Version history	-
Reference	https://www.sae.org/standards/content/ja6801/

Standard	JA7496
Title	Cyber-Physical Systems Security Engineering Plan (CPSSEP)
Status	Active
Initial date	02-06-2022
Current version	JA7496_202206
Description	This SAE Standard outlines practices to: a. Manage risk and ensure the security of a cyber-physical system (CPS) throughout its lifecycle using systems engineering principles. b. Evaluate the impact of cyber-physical system security (CPSS) objectives and requirements. c. Assess security risks affecting the CPS's technical effectiveness and functions, addressing weaknesses and vulnerabilities.

	d. Consider various domains, including operating conditions, command and control, and configuration management (as referenced in SAE EIA649), that could compromise CPSS or the system's intended purpose. e. Conduct design validation and verification to evaluate the CPS's security and risk levels.
Version history	-
Reference	https://www.sae.org/standards/content/ja7496_202206/

Standard	AIR4094A
Title	Aircraft Flight Control Systems Descriptions
Status	Active
Initial date	18-07-2016
Current version	AIR4094A
Description	This SAE Aerospace Information Report (AIR) provides details on flight control systems used in various current and historical fixed-wing, rotary-wing, and tiltrotor aircraft. It includes a brief overview of each aircraft, followed by descriptions of the flight control system, key components, internal arrangement drawings, block diagrams, and schematics. The report also also covers system operation and redundancy management.
Version history	AIR4094
Reference	https://www.sae.org/standards/content/air4094a/

Standard	AIR4982A
Title	Aerospace Fly-by-Light Actuation Systems
Status	Active
Initial date	18-12-2014
Current version	AIR4982A
Description	This SAE Aerospace Information Report (AIR) provides information on options for optical control of fluid power actuation devices, serving as a foundation for future standard development rather than establishing standards. It explores approaches for command and communication with actuation devices via electro-optic means. The report aims to encourage industry-wide collaboration to ensure interface commonality, reliability, and practical application readiness. It offers potential users insights into the technology's current development status, production readiness prospects, and challenges. Topics include interfacing photonics with hydraulic power control actuators in aerospace applications, covering power and signal interfaces (e.g., control, status, and built-in tests), mechanical interfaces like optical connectors and fibers, benefits of optics, component reliability, and system architectures. Contributions come from experts in photonics, hydraulic actuation, and aerospace fluid control systems, including input from the A-6D Committee.
Version history	AIR4982
Reference	https://www.sae.org/standards/content/air4982a/

Standard	AIR5273A
Title	Aircraft Flight Control Actuation System Failure-Detection Methods
Status	Active

Initial date	16-12-2022
Current version	AIR5273A
Description	This SAE Aerospace Information Report (AIR) describes methods for detecting failures in aircraft flight control actuation systems. It focuses on fault-detection techniques used for both ground and in-flight monitoring of failures in electrohydraulic actuation systems for primary flight controls.
Version history	AIR5273
Reference	https://www.sae.org/standards/content/air5273a/

Standard	AIR5561
Title	Lithium Battery Powered Portable Electronic Devices
Status	Active
Initial date	04-10-2013
Current version	-
Description	This SAE Aerospace Information Report (AIR) covers portable electronic devices powered by rechargeable lithium batteries used in aircraft operations. It includes devices like laptops, electronic tablets, and e-book readers, particularly when used as Electronic Flight Bags (EFBs) or in similar applications.
Version history	-
Reference	https://www.sae.org/standards/content/air5561/

Standard	AIR5601
Title	A Guideline for Application of RF Photonics to Aerospace Platforms
Status	Active
Initial date	29-06-2005
Current version	-
Description	This SAE Aerospace Information Report (AIR) focuses on the challenges of applying optics to advanced RF analog systems, excluding digital data link applications, which are addressed in other protocol-specific documents like Fibre Channel, ATM, Ethernet, and SONET. The document has four primary goals: 1. Outline current capabilities and limitations of fiber optics in meeting various advanced RF system requirements. 2. Discuss upcoming advancements aimed at matching the capabilities of copper coax systems. 3. Highlight the benefits of using fiber optics for RF systems. 4. Identify future development challenges.
Version history	-
Reference	https://www.sae.org/standards/content/air5601/

Standard	AIR5645A
Title	JAUS Transport Considerations
Status	Active
Initial date	05-09-2014

Current version	AIR5645A
Description	This SAE Aerospace Information Report (AIR) outlines data communication characteristics for the Joint Architecture for Unmanned Systems (JAUS). It offers guidance on transport media, unmanned systems, and specific JAUS features relevant to defining a JAUS transport specification.
Version history	AIR5645
Reference	https://www.sae.org/standards/content/air5645a/

Standard	AIR5664A
Title	JAUS History and Domain Model
Status	Active
Initial date	16-08-2012
Current version	AIR5664A
Description	The purpose of this SAE Aerospace Information Report (AIR) is twofold: to inform readers about the extensive efforts behind the development of the Joint Architecture for Unmanned Systems (JAUS) and to document the domain analysis that forms the foundation of the AS-4 Committee's (Unmanned Systems) work.
Version history	AIR5664
Reference	https://www.sae.org/standards/content/air5664a/

Standard	AIR5665C
Title	Architecture Framework for Unmanned Systems
Status	Active
Initial date	01-05-2024
Current version	AIR5665C
Description	This SAE Aerospace Information Report (AIR) explains the Architecture Framework for Unmanned Systems (AFUS), which includes three main parts: a. Conceptual View: Explains important terms and ideas related to unmanned systems. b. Capabilities View: Describes what unmanned systems and related parts can do, based on the key concepts. c. Interoperability View: Gives advice on how to design and build systems so they can work well with each other
Version history	AIR5665B AIR5665A AIR5665
Reference	https://www.sae.org/standards/content/air5665c/

Standard	AIR6110A
Title	Contiguous Aircraft/System Development Process Example
Status	Active
Initial date	12-03-2024
Current version	AIR6110A

Description	This SAE Aerospace Information Report (AIR) presents a detailed example of aircraft and system development for a function of a hypothetical S18 aircraft. A specific function, "Decelerate Aircraft on Ground," was selected for analysis using methodologies from ARP4754A/ED-79A, focusing on the braking system. This function was chosen for its balance of complexity and clarity, illustrating process flow effectively. The interaction between the braking system and aircraft functions is analyzed, considering system availability and implied interactions. Validation and verification of aircraft-level hazards are not covered, though the principles applied to the braking system can extend to higher aircraft levels.
Version history	AIR6110
Reference	https://www.sae.org/standards/content/air6110a/

Standard	AIR6127
Title	Managing Higher Voltages in Aerospace Electrical Systems
Status	Active
Initial date	14-03-2023
Current version	-
Description	This SAE Aerospace Information Report (AIR) addresses design guidance for high-voltage electrical systems in aerospace applications, focusing on electrical discharge mechanisms, such as partial discharge, without covering personnel safety. Key concerns include power conversion devices, electrical machines, connectors, and cabling/wiring, along with interactions between components and subsystems. The report applies to aerospace vehicles operating at altitudes up to 30,000 m (approximately 100,000 feet) with maximum voltages below 1500 VRMS (AC) or 1500 V peak (DC). These limits target the extension of non-propulsive electrical system voltages beyond those of current aerospace systems, though electrical propulsion systems may exceed these voltage thresholds.
Version history	-
Reference	https://www.sae.org/standards/content/air6127/

Standard	AIR6139
Title	Ways of Dealing with Power Regeneration onto an Aircraft Electrical Power System Bus
Status	Active
Initial date	14-01-2014
Current version	-
Description	This SAE Aerospace Information Report (AIR) addresses power regeneration into an aircraft's Electrical Power System (EPS). It examines various solutions for managing regenerative power, categorizing them with their respective advantages and disadvantages, including existing approaches. Validated simulation results from representative EPS models are presented to demonstrate solution performance and power quality maintenance during regeneration. The report also highlights the effects of changes to the electrical generation system, considering their potential impact on solution deployment and broader design implications for engines and auxiliaries. While excluding detailed power system design discussions, it focuses on concepts applicable to More Electric Aircraft for both AC and DC systems under normal operation and fault mitigation conditions.
Version history	-

Reference	https://www.sae.org/standards/content/air6139/

Standard	AIR6218
Title	Constructing Development Assurance Plan for Integrated Systems
Status	Active
Initial date	22-10-2018
Current version	-
Description	This SAE Aerospace Information Report (AIR) supplements ARP4754A by highlighting key elements to consider when developing assurance plans outlined in Chapter 3 (Development Planning) of ARP4754A for integrated systems. It compiles lessons learned from previous certification programs involving integrated systems. This document does not provide guidance on system integration technologies.
Version history	-
Reference	https://www.sae.org/standards/content/air6218/

Standard	AIR6219
Title	Development of Atmospheric Neutron Single Event Effects Analysis for Use in Safety Assessments
Status	Active
Initial date	24-07-2023
Current version	-
Description	This document presents an example process for analyzing neutron Single Event Effects (SEE) in electronic-based airborne systems for use in system safety assessments. It serves as a reference when SEE analysis is required within the safety assessment process.
Version history	-
Reference	https://www.sae.org/standards/content/air6219/

Standard	AIR6258
Title	Fiber Optic Sensors for Aerospace Applications
Status	Active
Initial date	30-01-2020
Current version	-
Description	This document outlines technologies, application needs, and operational requirements for using fiber optic sensing systems on aerospace platforms. It aims to: a. Define standard terminology for describing fiber optic sensing systems and their performance. b. Identify current interfaces used in fiber optic sensing systems. c. Specify environmental, reliability, and maintainability capabilities of system components. d. Describe the current state-of-the-art fiber optic sensor and instrumentation technologies. e. Highlight current and future unmet measurement needs within the aerospace industry for fiber optic sensors.
Version history	-

Reference	https://www.sae.org/standards/content/air6258/

Standard	AIR6276
Title	Use of modeling tools for aircraft systems development – A strategy for development assurance aspects with examples
Status	Ongoing
Initial date	30-04-2013
Current version	-
Description	This SAE Aerospace Information Report (AIR) focuses on the use of software tools to support or automate human activities in system development, excluding hardware or software items within those systems. If a development tool is also used for hardware or software item development, it becomes subject to the guidance of DO-254 for hardware and DO-178B/C for software.
Version history	-
Reference	https://www.sae.org/standards/content/air6276/

Standard	AIR6326
Title	Aircraft Electrical Power Systems Modeling and Simulation Definitions
Status	Active
Initial date	04-04-2023
Current version	-
Description	The objective of this document is to establish basic terms and definitions and offer general guidance for modeling and simulation (M&S) of aircraft Electrical Power Systems (EPS).
Version history	-
Reference	https://www.sae.org/standards/content/air6326/

Standard	AIR6343
Title	Design and Development of Rechargeable Lithium Battery Systems for Aerospace Applications
Status	Active
Initial date	21-01-2020
Current version	-
Description	This SAE Aerospace Information Report (AIR) provides an overview of methodologies for designing and developing rechargeable lithium battery systems for aerospace applications. The battery system includes cells, monitoring and control electronics, and, when applicable, a battery charger. The methodologies apply to "installed" equipment, relevant to original or supplemental type certification or military airframe qualification.
Version history	-
Reference	https://www.sae.org/standards/content/air6343/

Standard	AIR6464

Title	EUROCAE/SAE WG80/AE-7AFC Hydrogen Fuel Cells Aircraft Fuel Cell Safety Guidelines
Status	Active
Initial date	05-02-2020
Current version	-
Description	This document outlines technical guidelines for the safe integration of Proton Exchange Membrane (PEM) Fuel Cell Systems (FCS), including liquid and compressed hydrogen fuel storage, fuel distribution, and relevant electrical systems into aircraft.
Version history	-
Reference	https://www.sae.org/standards/content/air6464/

Standard	AIR6514
Title	UxS Control Segment (UCS) Architecture: Interface Control Document (ICD)
Status	Active
Initial date	20-12-2016
Current version	-
Description	This Interface Control Document (ICD) defines all software services within the Unmanned Systems (UxS) Control Segment Architecture, covering interfaces, messages, and the data model.
Version history	-
Reference	https://www.sae.org/standards/content/air6514/

Standard	AIR6540
Title	Fundamentals in Wire Selection and Sizing for Aerospace Applications
Status	Active
Initial date	09-04-2024
Current version	AIR6540C
Description	This report outlines fundamental principles for selecting wire sizes in aerospace applications, following the method in AS50881, along with additional calculations to ensure proper performance under specific physical and environmental conditions. It focuses on wire selection and sizing for Electrical Wire Interconnection Systems (EWIS) used in aerospace vehicles, including manned and unmanned airplanes, helicopters, lighter-than-air vehicles, missiles, and external pods. It excludes wiring inside airborne electronic equipment but applies to externally connected wiring. Wire selection must consider physical and environmental factors to ensure sufficient mechanical strength, acceptable voltage drop, appropriate protection, and adequate current-carrying capacity. While the report offers basic principles and guidelines, it simplifies some calculations for demonstration purposes. More detailed evaluations should be conducted for accurate wire size validation.
Version history	AIR6540B AIR6540A AIR6540
Reference	https://www.sae.org/standards/content/air6540c/

Standard	AIR6808
Title	Aerospace Vehicle Wiring, Lessons Learned
Status	Active
Initial date	04-03-2024
Current version	AIR6808A
Description	This SAE Aerospace Information Report (AIR) focuses on the requirements of AS50881, providing the rationale behind them. AS50881 applies specifically to an aircraft's Electrical Wire Interconnection System (EWIS). While it does not cover wiring inside airborne electronic equipment, it does apply to wiring externally attached to such equipment and the interface between the aircraft and connected devices, such as pods. Section 3.3.5 addresses components like antennas and similar equipment, previously categorized as Government Furnished Aeronautical/Aerospace Equipment (GFAE).
Version history	AIR6808
Reference	https://www.sae.org/standards/content/air6808a/

Standard	AIR6900
Title	Applicable Aircraft Integrated Vehicle Health Management (IVHM) Regulations, Policy, and Guidance
Status	Active
Initial date	14-01-2019
Current version	-
Description	This SAE Aerospace Information Report (AIR) lists and explains key rules, policies and guidelines that should be considered by design approval applicants, aircraft operators and maintenance organizations when installing Integrated Vehicle Health Management (IVHM) technology for aircraft maintenance. While helpful, these guidelines do not cover everything needed for full IVHM system certification
Version history	-
Reference	https://www.sae.org/standards/content/air6900/

Standard	AIR6904
Title	Rationale, Considerations, and Framework for Data Interoperability for Health Management within the Aerospace Ecosystem
Status	Active
Initial date	21-04-2020
Current version	-
Description	This SAE Aerospace Information Report (AIR) presents an overview of the most important considerations in setting up data sharing, secure business practices and technology infrastructure to support Prognostics and Health Management (PHM) in today's world. It covers issues like the protection of intellectual property (IP), regulations and compliance, choosing business models and implementing the correct technologies. Though it's focuses on aerospace, specifically commercial aviation, the principles can be utilized within other industries that rely on data for health monitoring and control
Version history	-
Reference	https://www.sae.org/standards/content/air6904/

Standard	AIR6913
Title	Using System-Theoretic Process Analysis (STPA) During Development and Safety Assessment of Civil Aircraft
Status	Ongoing
Initial date	13-02-2018
Current version	-
Description	This SAE Aerospace Information Report (AIR) offers a basic understanding of System-Theoretic Process Analysis (STPA) and its application in the development and safety assessment of civil aircraft. Through an example, it explains the information required to initiate STPA, the expected outputs, and the phases of aircraft development and safety assessment where STPA can provide support.
Version history	-
Reference	https://www.sae.org/standards/content/air6913/

Standard	AIR6915
Title	Human Factor Considerations in the Implementation of IVHM
Status	Active
Initial date	20-03-2020
Current version	-
Description	This SAE Aerospace Information Report (AIR) provides guidance on incorporating human factors into the development and implementation of Integrated Vehicle Health Management (IVHM) systems for military and civil fixed-wing aircraft. It addresses how flight crews and maintenance personnel perceive, analyze, and respond to IVHM outputs—real-time for flight crews and post-fight for maintenance teams. While not a design guideline, this document highlights key considerations for developing future IVHM systems.
Version history	-
Reference	https://www.sae.org/standards/content/air6915/

Standard	AIR6962
Title	Ice Protection for Unmanned Aerial Vehicles
Status	Ongoing
Initial date	22-09-2017
Current version	-
Description	This document provides an educational review of icing materials relevant to designing ice protection systems for unmanned aerial vehicles (UAVs). It also examines the differences between unmanned and manned ice protection systems and discusses strategies for addressing these distinctions in system design.
Version history	-
Reference	https://www.sae.org/standards/content/air6962/

Standard	AIR6987
Title	Artificial Intelligence in Aeronautical Systems: Taxonomy

Status	Active
Initial date	12-12-2024
Current version	-
Description	The main purpose of this document is to categorize AI techniques that can be used in AI-based systems in aeronautical products including those in Airborne, Air Traffic Management (ATM), and Air Navigation Systems (ANS) for both crewed and uncrewed aircraft. It aims to improve the understanding of the AI landscape which is expected to change over time. This document does not provide guidance, objectives, or safety considerations.
Version history	-
Reference	https://www.sae.org/standards/content/air6987/

Standard	AIR6988
Title	Artificial Intelligence in Aeronautical Systems: Statement of Concerns
Status	Active
Initial date	30-04-2021
Current version	-
Description	This document reviews existing aerospace software, hardware, and system development standards used in the certification and approval of safety-critical airborne and ground-based systems. It evaluates the compatibility of these standards with typical Artificial Intelligence (AI) and Machine Learning (ML) development approaches. The document also outlines the requirements for creating a standard that supports the integration of ML-enabled subsystems into safety-critical systems and details the next steps for developing such a standard.
Version history	-
Reference	https://www.sae.org/standards/content/air6988/

Standard	AIR6994
Title	Artificial Intelligence in Aeronautical Systems: Use Cases
Status	Ongoing
Initial date	01-02-2021
Current version	-
Description	This document outlines AI technologies, architectures, validation methods, and safety concerns for each use case.
Version history	-
Reference	https://www.sae.org/standards/content/air6994/

Standard	AIR7121
Title	Applicability of Existing Development Assurance and System Safety Practices to Unmanned Aircraft Systems
Status	Ongoing
Initial date	02-01-2020

Current version	-
Description	This AIR examines the applicability of ARP 4754 and ARP 4761 to UAS, identifying shortcomings in both practices concerning the specific technical requirements for UAS development.
Version history	-
Reference	https://www.sae.org/standards/content/air7121/

Standard	AIR7123
Title	eARC - Electronic Authorized Release Certificate
Status	Active
Initial date	21-01-2025
Current version	-
Description	This document provides an overview, process, and implementation guidance for using blockchain technology to create a secure, immutable, and traceable digital authorized release certificate. It does not standardize the process or serve as an authority-recognized method for recording data from authorized release certificate (ARC) tags.
Version history	-
Reference	https://www.sae.org/standards/content/air7123/

Standard	AIR7128
Title	Integration and Certification Considerations for Electrified Propulsion Aircraft
Status	Ongoing
Initial date	03-10-2022
Current version	-
Description	This document compiles relevant practices, standards, regulations, and guidance for developing electrified propulsion systems, including aircraft integration. It highlights unique considerations of the technology and supports applicants in building their certification approach but does not propose a Means of Compliance with any specific regulation.
Version history	-
Reference	https://www.sae.org/standards/content/air7128/

Standard	AIR7209
Title	Development Assurance Principles for Aerospace Vehicles and Systems
Status	Active
Initial date	07-10-2022
Current version	-
Description	This SAE Aerospace Information Report (AIR) outlines high-level principles to support aerospace projects requiring a formal development assurance process, such as ARP4754/ED-79, for regulatory compliance. It targets projects with significant functional interactions or products that cannot be fully analyzed or tested. The document does not mandate specific processes but offers a flexible framework for users to develop and present their assurance approach to certification authorities.

Version history	-
Reference	https://www.sae.org/standards/content/air7209/

Standard	AIR7356
Title	Opportunities, Challenges, and Requirements for Use of Blockchain in Unmanned Aircraft Systems Operating Below 400 Feet Above Ground Level for Commercial Use
Status	Active
Initial date	25-01-2023
Current version	-
Description	This SAE Aerospace Information Report (AIR) investigates the possibilities and obstacles and necessary conditions for blockchain implementation in commercial Unmanned Aircraft Systems (UAS) operating at or below 400 feet AGL. The document investigates blockchain solutions for certification problems and airspace management and operations and supply chain and maintenance issues while discussing adoption barriers. The report defines essential lifecycle requirements and establishes the need for standardized blockchain-enabled processes.
Version history	-
Reference	https://www.sae.org/standards/content/air7356/

Standard	AIR7357
Title	MegaWatt and Extreme Fast Charging for Aircraft
Status	Ongoing
Initial date	20-11-2020
Current version	-
Description	The proposed SAE Aerospace Information Report (AIR) will outline power requirements for future electric aircraft, focusing on design considerations and use cases for megawatt and extreme fast charging. It will also map relevant industry standards and highlight technology gaps and future design considerations.
Version history	-
Reference	https://www.sae.org/standards/content/air7357/

Standard	AIR7367
Title	Considerations for Requirements, Specifications, and Framework of a Digital Thread in Aircraft Data Life Cycle Management
Status	Active
Initial date	14-12-2023
Current version	-
Description	This SAE Aerospace Information Report (AIR) outlines considerations for requirements, specifications, and the framework of the digital thread in aircraft product lifecycle management. It does not define implementation-dependent features related to software or architecture.
Version history	-
Reference	https://www.sae.org/standards/content/air7367/

Standard	AIR7501
Title	Aircraft Asset Lifecycle and Digital Data Standards Overview
Status	Active
Initial date	18-09-2020
Current version	-
Description	This SAE Aerospace Information Report (AIR) reviews the exchange of technical, operational, and maintenance data among key stakeholders in the aerospace asset lifecycle, along with available data standards. It identifies gaps in data standards, focusing on aircraft operations, maintenance, and disposal stages, excluding interactions during the build phase.
Version history	-
Reference	https://www.sae.org/standards/content/air7501/

Standard	AIR7502
Title	Aircraft Electrical Voltage Level Definitions
Status	Ongoing
Initial date	19-10-2021
Current version	-
Description	This report documents various voltage levels and provides the rationale for each, as discussed and agreed upon by the AE-7 committee.
Version history	-
Reference	https://www.sae.org/standards/content/air7502a/

Standard	AIR7765
Title	Considerations for Hydrogen Fuel Cells in Airborne Applications
Status	Active
Initial date	18-11-2019
Current version	-
Description	This joint EUROCAE/SAE report compiles considerations for the airborne application of hydrogen fuel cells. It analyzes hydrogen use as a fuel, drawing from existing applications and experiences in non-aviation sectors. The report highlights hydrogen's potential to support aviation environmental targets and enable efficient electric propulsion. Insights from terrestrial fuel cell applications and gas handling in aviation aim to address safety concerns and promote the adoption of hydrogen in aerospace.
Version history	-
Reference	https://www.sae.org/standards/content/air7765/

Standard	AIR8012
Title	Prognostics and Health Management Guidelines for Electro-Mechanical Actuators
Status	Active

Initial date	12-11-2020
Current version	-
Description	The development of next-generation aircraft requires power consumption reduction and fuel burn minimization through electrical actuation systems. The implementation of electro-mechanical actuators (EMAs) provides multiple benefits over hydraulic systems because they reduce power distribution losses and offer weight reduction potential and improved reliability and maintainability and lower life-cycle expenses. The main obstacles to EMA implementation in safety-critical applications stem from motor winding and power electronics temperature increases and the risk of mechanical seizures caused by system failures. The development of jam-free or jam-tolerant EMAs continues as research focus but these solutions typically lead to increased weight and volume and higher costs and reduced reliability. A well-designed Prognostics and Health Management (PHM) system would make EMAs suitable for primary flight control by providing fault detection and remaining useful life assessment and unscheduled maintenance reduction and troubleshooting support and supply chain simplification. System design requires the complete integration of EMAs together with PHM algorithms for extensive use.
Version history	-
Reference	https://www.sae.org/standards/content/air8012/

Standard	AIR8678
Title	Architecture Examples for Electrified Propulsion Aircraft
Status	Active
Initial date	01-08-2022
Current version	-
Description	This document explores various forms of electric propulsion for aircraft, from partial to full electric systems, offering new design flexibility through diverse electricity generation and energy storage methods. It aims to establish a common design language for electrified propulsion while encouraging innovation by providing reference architectures and examples. The document defines: 1. Elements of electrified propulsion architectures, including power generation, distribution, and energy storage. 2. Interfaces to and from the electrified propulsion system. 3. Internal interfaces within the system. 4. Electrical energy management and storage architecture. It serves as a reference for future SAE work and industry guidance. Thermal management, though essential, is outside the document's scope.
Version history	-
Reference	https://www.sae.org/standards/content/air8678/

Standard	AS1212
Title	Electric Power, Aircraft, Characteristics and Utilization
Status	Active
Initial date	05-12-2012
Current version	AS1212A
Description	This standard defines the characteristics of electric power supplied to airborne equipment at the equipment terminals and outlines the requirements for its utilization by the airborne equipment.

Version history	AS1212
Reference	https://www.sae.org/standards/content/as1212a/

Standard	AS35091
Title	Receptacles, electric, aircraft storage battery
Status	Active
Initial date	02-08-2012
Current version	AS35091A
Description	N/A
Version history	AS35091
Reference	https://www.sae.org/standards/content/as35091a/

Standard	AS50881
Title	Wiring Aerospace Vehicle
Status	Active
Initial date	13-01-2023
Current version	AS50881H
Description	This specification covers all aspects of Electrical Wiring Interconnection Systems (EWIS), from selection to installation of wiring, wiring devices, optical cabling, and termination devices used in aerospace vehicles, including manned and unmanned airplanes, helicopters, lighter-than-air vehicles, missiles, and external pods.
Version history	AS50881G AS50881F AS50881E AS50881D AS50881C AS50881B_A1 AS50881B AS50881A AS50881
Reference	https://www.sae.org/standards/content/as50881h/

Standard	AS5669
Title	JAUS / SDP Transport Specification
Status	Active
Initial date	22-04-2019
Current version	AS5669A
Description	This SAE Aerospace Standard (AS) defines a data communications layer for transporting messages from the Joint Architecture for Unmanned Systems (JAUS) or other Software Defined Protocols (SDP). It outlines formats and protocols for communication across various link-layer protocols and media. While JAUS is used as the primary example, AS5669 applies to any SDP meeting the required capabilities. An SDP serves as an application data interface for communication between software elements, functioning independently of the underlying communications protocol, whether entities are co-located or separated by long distances.
Version history	AS5669
Reference	https://www.sae.org/standards/content/as5669a/

Standard	AS6040
Title	JAUS HMI Service Set
Status	Active
Initial date	09-12-2020
Current version	AS6040A
Description	This document defines standard application layer interfaces known as JAUS HMI Services, enabling communication and coordination between software entities in unmanned systems or systems of unmanned systems. These platform-independent Human Machine Interface (HMI) services are applicable across various domains and unmanned system types. The document outlines five services: Drawing, Pointing Device, Keyboard, Digital Control, and Analog Control.
Version history	AS6040
Reference	https://www.sae.org/standards/content/as6040a/

Standard	AS6062
Title	JAUS Mission Spooling Service Set
Status	Active
Initial date	18-03-2024
Current version	AS6062A
Description	This document defines standard application layer interfaces known as JAUS Mission Spooling Services, which enable communication and coordination between software entities in unmanned systems or systems of unmanned systems. These platform-independent services apply across various domains and unmanned system types. Currently, the document defines one service: **Mission Spooler**, which stores, manages, and executes task lists. Future versions are expected to introduce additional services.
Version history	AS6062
Reference	https://www.sae.org/standards/content/as6062a/

Standard	AS6091
Title	JAUS Unmanned Ground Vehicle Service Set
Status	Active
Initial date	22-04-2019
Current version	-
Description	This document defines standard application layer interfaces known as JAUS Unmanned Ground Vehicle Services, enabling communication and coordination between software entities in unmanned systems or systems of unmanned systems. These services represent platform-specific capabilities commonly found in Unmanned Ground Vehicles (UGVs) and complement the platform-agnostic Mobility Service Set defined in AS6009.
Version history	-
Reference	https://www.sae.org/standards/content/as6091/

Standard	AS6111

Title	JAUS Unmanned Maritime Vehicle Service Set
Status	Active
Initial date	28-09-2023
Current version	-
Description	This SAE Aerospace Standard (AS) defines standard application layer interfaces known as JAUS Unmanned Maritime Vehicle (UMV) Services, facilitating communication and coordination between software entities in unmanned systems or systems of unmanned systems. These services represent platform-specific capabilities for UMVs and complement the platform-agnostic Mobility Service Set from AS6009. The document defines 12 services, categorized as follows: • **Platform Description Services:** Provides vehicle platform information, including mobility limits and geometric properties. o Platform Specification Service • **Propulsion and Driver Services:** Offers control and monitoring for propulsion systems, enabling primitive mobility teleoperation. o Propulsion Service o Bucket Driver Service o Control Surface Service • **Auxiliary Services:** Interfaces with auxiliary sensors and devices, such as depth sensors and pumps. o Annunciator Service o CTD Sensor Service o Compartment Sensor Service o Sea State Sensor Service o Bilge Pump Control Service o Ballast Tank Control Service o Power Plant Service o Anchor Service
Version history	-
Reference	https://www.sae.org/standards/content/as6111/

Standard	AS6254
Title	Minimum Performance Standard for Low Frequency Underwater Locating Devices (Acoustic) (Self-Powered)
Status	Active
Initial date	06-12-2015
Current version	AS6254A
Description	
Version history	AS6254
Reference	https://www.sae.org/standards/content/as6254a/

Standard	AS6512
Title	Unmanned Systems (UxS) Control Segment (UCS) Architecture: Architecture Description
Status	Active

Initial date	16-03-2022
Current version	AS6512B
Description	This SAE Aerospace Standard (AS) describes Underwater Locator Devices (ULDs) which serve to locate submerged aircraft. The ULDs are installed in aircraft structures to prevent separation during crash conditions. The low-frequency ULD should be installed on the airframe according to the manufacturer's instructions to achieve the maximum underwater detection range. ARINC Standard 677 contains additional installation information.
Version history	AS6512A AS6512
Reference	https://www.sae.org/standards/content/as6512b/

Standard	AS6513
Title	Unmanned Systems (UxS) Control Segment (UCS) Architecture: Conformance Specification
Status	Active
Initial date	16-03-2022
Current version	AS6513B
Description	This revision of AS6513 addresses conformance to the SAE Unmanned Systems (UxS) Control Segment (UCS) Architecture Revision B, designated AS6512B (or later), replacing AS6513A, which aligned with the earlier AS6512A. It serves as the authoritative specification for establishing conformance requirements for UCS products. Conformance is determined by evaluating the UCS Product Description, including test artifacts, against the UCS Architecture.
Version history	AS6513A AS6513
Reference	https://www.sae.org/standards/content/as6513b/

Standard	AS6518
Title	Unmanned Systems (UxS) Control Segment (UCS) Architecture: UCS Architecture Model
Status	Active
Initial date	16-03-2022
Current version	AS6518B
Description	This User Guide summarizes the content of the AS6518B UCS Architectural Model. The model serves as the authoritative source for other models and products within the UCS Architecture, as outlined in the AS6512B UCS Architecture: Architecture Description.
Version history	AS6518A AS6518
Reference	https://www.sae.org/standards/content/as6518b/

Standard	AS6522
Title	Unmanned Systems (UxS) Control Segment (UCS) Architecture: Architecture Technical Governance
Status	Active
Initial date	27-02-2024

Current version	AS6522B
Description	This Technical Governance document, part of the SAE UCS Architecture Library, focuses on the UCS Architecture Model (AS6518) starting from Revision A and its user extensions. Users may extend the model per AS6513 to meet the requirements of their UCS products, including software components, configurations, and systems that provide or consume UCS services. For more details, refer to AS6513 Revision A or later.
Version history	AS6522A AS6522
Reference	https://www.sae.org/standards/content/as6522b/

Standard	AS6849
Title	Performance Standards for Passenger and Crew Seats in Advanced Air Mobility (AAM) Aircraft
Status	Active
Initial date	07-10-2022
Current version	-
Description	This SAE Aerospace Standard (AS) establishes qualification and documentation requirements for forward and aft-facing seats in Advanced Air Mobility (AAM) aircraft. It focuses on occupant protection under normal operational loads and defines testing and evaluation criteria for static ultimate loads and dynamic conditions. Responsibility is shared between the seat manufacturer, who must meet seat system performance requirements, and the installation applicant, who ensures safe installation compliance. This AS is dependent on AS8049D, providing revisions and additions specific to AAM aircraft seats. Modifications update existing AS8049D sections, while new sections are incorporated where necessary. Test pulse evaluation follows the method outlined in AS8049D, Appendix A.
Version history	-
Reference	https://www.sae.org/standards/content/as6849/

Standard	AS6858
Title	Installation of Fuel Cell Systems in Large Civil Aircraft
Status	Active
Initial date	21-04-2023
Current version	-
Description	This joint SAE/EUROCAE document will be released as both an SAE Aerospace Specification (AS) and a EUROCAE Minimum Aviation System Performance Standard (MASPS). It outlines the technical requirements for the safe integration of gaseous hydrogen-fueled Proton Exchange Membrane (PEM) Fuel Cell Systems (FCS) within aircraft.
Version history	-
Reference	https://www.sae.org/standards/content/as6858/

Standard	AS6999

Title	Standard Test Method for Measuring Impact Forces and Pressures of a Soft Projectile on an Inclined Rigid Flat Surface
Status	Active
Initial date	16-01-2024
Current version	-
Description	This document outlines methods for measuring dynamic forces, pressures, and projectile fragment distribution during the impact of a soft or frangible projectile with a rigid, inclined surface. It details the necessary hardware, setup, and instrumentation.
Version history	-
Reference	https://www.sae.org/standards/content/as6999/

Standard	AS7062
Title	Pilot Training and Qualification for VTOL-Capable Aircraft
Status	Ongoing
Initial date	21-06-2022
Current version	-
Description	This standard defines the training and qualification requirements for the certification and licensing of pilots operating VTOL-capable aircraft, including Advanced Air Mobility (AAM), electric Vertical Takeoff and Landing (eVTOL), and Small Vertical Operations (SVO) aircraft.
Version history	-
Reference	https://www.sae.org/standards/content/as7062/

Standard	AS7091
Title	Technical Standards for VTOL-Capable aircraft Training Devices to support evaluation
Status	Ongoing
Initial date	12-07-2022
Current version	-
Description	This document establishes technical standards for training devices used with VTOL-capable powered aircraft platforms, including Advanced Air Mobility (AAM), Small Vertical Operations (SVO), and electric Vertical Takeoff and Landing (eVTOL) systems, where conventional Flight Simulation Training Device (FSTD) standards are not applicable.
Version history	-
Reference	https://www.sae.org/standards/content/as7091/

Standard	AS7371
Title	Standard Test Method for Normal Impact of a Soft Projectile on a Hemispherical Leading Edge
Status	Ongoing
Initial date	25-05-2021
Current version	-

Description	This document outlines a method for measuring deformations and fragment distribution patterns during the impact of a soft or frangible projectile with a regular helispherical leading edge. It details the required hardware, setup, and instrumentation. In this test, the projectile impacts the leading edge symmetrically along the curvature and is centered in the transversal direction.
Version history	-
Reference	https://www.sae.org/standards/content/as7371/

Standard	AS7372
Title	Standard Test Method for Normal Impact of a Soft Projectile on a Clamped Plate
Status	Ongoing
Initial date	01-07-2021
Current version	-
Description	This document outlines a method for measuring deformations resulting from a normal impact between a soft or frangible projectile and a clamped plate. It details the necessary hardware, setup, and instrumentation for conducting the test.
Version history	-
Reference	https://www.sae.org/standards/content/as7372/

Standard	AS8024
Title	JAUS Autonomous Capabilities Service Set
Status	Active
Initial date	10-06-2019
Current version	-
Description	This document defines standard application layer interfaces known as JAUS Autonomous Capabilities Services, enabling communication and coordination between software entities in unmanned systems or systems of unmanned systems. These services represent platform-independent capabilities commonly found across various domains, including air, maritime, and ground platforms.
Version history	-
Reference	https://www.sae.org/standards/content/as8024/

Standard	AS8033
Title	Nickel Cadmium Vented Rechargeable Aircraft Batteries (Non-Sealed, Maintainable Type)
Status	Active
Initial date	26-10-2017
Current version	-
Description	This Aerospace Standard covers Nickel Cadmium batteries used primarily for engine starting in turbine-powered aircraft and Auxiliary Power Units (APUs). These batteries provide high power for short engine starts and serve as an emergency power source for essential equipment for up to 60 minutes. The battery consists of cells in a plastic case, ventilated to expel gases produced during overcharge, either through a closed air circuit or natural diffusion. It is charged via direct

	connection to the D.C. bus or a dedicated current source, with temperature compensation to optimize charging and reduce water loss. Some batteries include heaters, thermal switches, and air passages for better temperature management.
Version history	-
Reference	https://www.sae.org/standards/content/as8033/

Standard	AS9100
Title	Quality Management Systems - Requirements for Aviation, Space, and Defense Organizations
Status	Active
Initial date	20-09-2016
Current version	AS9100D
Description	This standard includes ISO 9001:2015 quality management system requirements and specifies additional requirements, definitions, and notes for the aviation, space, and defense industries.
Version history	AS9100C AS9100B AS9100A AS9100
Reference	https://www.sae.org/standards/content/as9100d/

Standard	ARP1870
Title	Aerospace Systems Electrical Bonding and Grounding for Electromagnetic Compatibility and Safety
Status	Active
Initial date	10-08-2012
Current version	ARP1870A
Description	This document sets the minimum requirements for electrical bonding and grounding of electric, avionic, armament, communication, and electronic equipment in aeronautical and aerospace applications. These requirements ensure a low-resistance return path that withstands operating conditions and corrosion, reducing electromagnetic field coupling, controlling static charges, and suppressing hazardous effects.
Version history	ARP1870
Reference	https://www.sae.org/standards/content/arp1870a/

Standard	ARP4087
Title	Wing Inspection Lights - Design Criteria
Status	Active
Initial date	06-02-2023
Current version	ARP4087D
Description	This SAE Aerospace Recommended Practice (ARP) covers external lights on fixed-wing aircraft for illuminating the wing leading edge, engine nacelles, and upper wing surfaces. It recommends adding an ice detection system when these areas are not visible from the

	cockpit. The practice does not mandate the use of any specific light source, such as halogen, LED, or other lamp designs.
Version history	ARP4087C ARP4087B ARP4087A ARP4087
Reference	https://www.sae.org/standards/content/arp4087d/

Standard	ARP4392
Title	Lighting, Aircraft Exterior, Night Vision Imaging System (NVIS) Compatible
Status	Active
Initial date	23-09-2022
Current version	-
Description	This SAE Aerospace Recommended Practice (ARP) outlines recommended performance levels for exterior aircraft equipment that emits radiant energy, providing information visible through NVIS goggles. The performance intensities, typically measured in candelas for visible light, are adjusted for the goggle spectral response range. Equipment location on the aircraft is specified where needed. The emission characteristics may include visible light or not, but all such equipment is referred to as "lights" in this document.
Version history	-
Reference	https://www.sae.org/standards/content/arp4392/

Standard	ARP4721/1
Title	Monitoring Aircraft Noise and Operations in the Vicinity of Airports: System Description, Acquisition, and Operation
Status	Ongoing
Initial date	28-01-2020
Current version	-
Description	This SAE Aerospace Recommended Practice (ARP) provides engineering methods for monitoring aircraft noise and operations near airports using attended or unattended systems, as well as methods for validating data from permanent systems. Part 1 offers guidance on the components, installation, and administration of permanent systems, and data analysis from temporary noise monitoring. Part 2, in a separate document, outlines system screening tests and validation methods for permanently installed systems. This guide is intended to establish standard practices and may evolve with experience and technical advances.
Version history	-
Reference	https://www.sae.org/standards/content/arp4721/1a/

Standard	ARP4721/2
Title	Monitoring Aircraft Noise and Operations in the Vicinity of Airports: System Validation
Status	Ongoing
Initial date	28-01-2020
Current version	-

Description	This SAE Aerospace Recommended Practice (ARP) outlines engineering methods for monitoring aircraft noise and operations near airports using attended or unattended systems, as well as methods for validating data from permanent systems. Part 1 covers components, installation, administration, and data analysis from temporary monitoring. Part 2, this section, details system screening tests and validation methods for data from permanently installed systems. This document serves as a guide to standard practice and may evolve with experience and technical advancements.
Version history	-
Reference	https://www.sae.org/standards/content/arp4721/2a/

Standard	ARP4754
Title	Guidelines for Development of Civil Aircraft and Systems
Status	Active
Initial date	20-12-2023
Current version	ARP4754B
Description	This SAE Aerospace Recommended Practice (ARP) offers recommendations for developing aircraft and systems, considering aircraft functions and the operating environment. It provides practices to ensure overall aircraft safety, demonstrate regulatory compliance, and help companies meet internal standards. These practices include validating requirements and verifying design implementation for safety, certification, and product assurance.
Version history	ARP4754A ARP4754
Reference	https://www.sae.org/standards/content/arp4754b/

Standard	ARP4761
Title	Guidelines for Conducting the Safety Assessment Process on Civil Aircraft, Systems, and Equipment
Status	Active
Initial date	20-12-2023
Current version	ARP4761A
Description	ARP4761A and its EUROCAE counterpart, ED-135, provide guidelines for safety assessments of civil aircraft, systems, and equipment, supporting compliance with certification requirements (e.g., 14 CFR/CS Parts 23, 25, 27, 29, 33, 35, CS-E, and CS-P). These guidelines can also assist companies in meeting internal safety standards. While primarily focused on civil aircraft, the processes are applicable to other domains. The document presents a systematic safety assessment process, though other methods may be effective. These processes apply to new designs or existing designs affected by changes. For derivative applications, service experience may complement the safety assessment. ARP4761A/ED-135 does not cover in-service product safety assessments, which are addressed in ARP5150A and ARP5151A. Security threat considerations are not included.
Version history	ARP4761
Reference	https://www.sae.org/standards/content/arp4761a/

Standard	ARP5007

Title	Development Process - Aerospace Fly-By-Wire Actuation System
Status	Active
Initial date	09-10-2020
Current version	ARP5007A
Description	This document describes a process for developing fly-by-wire actuation systems, including: (1) development of requirements for servo-actuator hardware and electronics hardware and software, (2) actuator and servo-electronics interface definitions, and (3) required communications and interactions between servo-actuator and servo-electronics designers.
Version history	ARP5007
Reference	https://www.sae.org/standards/content/arp5007a/

Standard	ARP5061
Title	Guidelines for Testing and Support of Aerospace, Fiber Optic, Inter-Connect Systems
Status	Active
Initial date	16-08-2018
Current version	ARP5061A
Description	ARP5061A provides guidelines for optical performance testing of short-haul fiber optic interconnection systems in aerospace vehicles. It focuses on introducing proper testing tools and establishing common pre- and post-installation test methods and troubleshooting approaches.
Version history	ARP5061
Reference	https://www.sae.org/standards/content/arp5061a/

Standard	ARP5150
Title	Safety Assessment of Transport Airplanes in Commercial Service
Status	Active
Initial date	02-01-2019
Current version	ARP5150A
Description	This document outlines guidelines, methods, and tools for performing ongoing safety assessments for transport airplanes in commercial service. The process supports a safety management program, helping ensure compliance with regulations and internal company standards. The methods provided offer a systematic approach, though alternative methods may also be effective for assessing ongoing safety.
Version history	ARP5150
Reference	https://www.sae.org/standards/content/arp5150a/

Standard	ARP5151
Title	Safety Assessment of General Aviation Airplanes and Rotorcraft in Commercial Service
Status	Active
Initial date	20-08-2019
Current version	ARP5151A

Description	This document outlines a process for ongoing safety assessment of GAR aircraft and components, as well as commercial operators of GAR aircraft. It supports a safety management program to help companies meet internal standards, offering a systematic approach for assessing continuing airworthiness. The process focuses on safety problem identification, corrective action, tracking issues, applying lessons learned, and reducing the time to implement corrective actions. ARP5150 is the recommended practice for safety assessments of transport airplanes in commercial service, while ARP5151 is specifically for GAR aircraft in commercial services. Although similar, the implementation of these processes differs due to operational factors, data availability, and the scale of operations.
Version history	ARP5151A
Reference	https://www.sae.org/standards/content/arp5151a/

Standard	ARP5415
Title	User's Manual for Certification of Aircraft Electrical/Electronic Systems for the Indirect Effects of Lightning
Status	Active
Initial date	05-03-2020
Current version	ARP5415B
Description	The ARP delivers comprehensive details and instructions to help users meet the requirements of FAA Advisory Circular (AC) 20-136 which supports compliance with FAA regulations (14 CFR 23.1306, 23.2515, 25.1316, 27.1316, and 29.1316) and EASA certification specifications (CS 23.1306, 23.2515, 25.1316, 27.1316, and 29.1316). The document outlines acceptance standards for indirect lightning effects and presents verification approaches that include analysis and testing for multiple strokes and burst as well as system immunity design recommendations and airworthiness maintenance guidance for lightning protection systems. The document examines equipment risks from indirect lightning strikes that affect exterior and interior systems and wiring while offering supplemental guidance on lightning tests according to DO-160/ED-14 Section 22. For direct lightning effects, refer to ARP5577.
Version history	ARP5415A ARP5415
Reference	https://www.sae.org/standards/content/arp5415b/

Standard	ARP5583
Title	Guide to Certification of Aircraft in a High-Intensity Radiated Field (HIRF) Environment
Status	Active
Initial date	04-06-2010
Current version	ARP5583A
Description	The guide delivers complete details about FAA Advisory Circular (AC) 20-158 and EASA draft Advisory Material Joint (AMJ) which share the title "The Certification of Aircraft Electrical and Electronic Systems for Operation in the High-Intensity Radiated Fields (HIRF) Environment." The AC establishes acceptable methods for complying with 14 CFR 23.1308, 25.1317, 27.1317 and 29.1317 regulations which focus on protecting aircraft systems from external transmitter hazards. The guide provides the same information to support EASA's current HIRF certification requirements.
Version history	ARP5583
Reference	https://www.sae.org/standards/content/arp5583a/

Standard	ARP5707
Title	Pilot Training Recommendations for Unmanned Aircraft Systems (UAS) Civil Operations
Status	Active
Initial date	03-04-2016
Current version	-
Description	This document provides an approach for developing training topics for Unmanned Aircraft Systems (UAS) pilots, aimed at operators, manufacturers, and regulators. Training topics are initially based on Practical Test Standard (PTS) topics for manned aircraft pilots and could form the basis for UAS commercial pilot operations and instrument rating PTS. The UAS commercial pilot rating would include operation restrictions based on the UAS type, influencing specific training topics. This document does not address requirements for other crewmembers or pilot authority levels and assumes UAS pilot certification won't require manned certification as a prerequisite. It also does not cover recurrent training, medical requirements, or instructor certification.
Version history	-
Reference	https://www.sae.org/standards/content/arp5707/

Standard	ARP5879
Title	Recommended Test Requirements for Electro-hydrostatic Actuators
Status	Active
Initial date	09-05-2024
Current version	ARP5879A
Description	This SAE Aerospace Recommended Practice (ARP) outlines recommended test requirements for electro hydrostatic actuators (EHAs).
Version history	ARP5879
Reference	https://www.sae.org/standards/content/arp5879a/

Standard	ARP6012
Title	JAUS Compliance and Interoperability Policy
Status	Active
Initial date	05-09-2014
Current version	ARP6012A
Description	This document, the JAUS Compliance and Interoperability Policy (ARP6012), recommends an approach for documenting the complete interface of an unmanned system or component according to the standard set. While non-SAE AS-4 JAUS documents are referenced, they are outside the scope of this document and should be considered as examples only.
Version history	ARP6012
Reference	https://www.sae.org/standards/content/arp6012a/

Standard	ARP6128

Title	Unmanned Systems Terminology Based on the ALFUS Framework
Status	Active
Initial date	22-04-2019
Current version	-
Description	This SAE Aerospace Recommended Practice (ARP) defines terminology specific to unmanned systems (UMSs), focusing on terms related to their development, testing, and operations, especially regarding autonomy and performance measures. It is based on the Autonomy Levels for Unmanned Systems (ALFUS) Framework and reflects collaboration with AIR5665. Terms with common dictionary definitions are excluded, and further efforts to expand the terminology scope are planned.
Version history	-
Reference	https://www.sae.org/standards/content/arp6128/

Standard	ARP6154
Title	Aerospace Fluid Power Electro-Hydrostatic Module, Design, Performance and Test Recommendations
Status	Active
Initial date	15-03-2017
Current version	-
Description	This Aerospace Recommended Practice provides general requirements for Electro hydrostatic Modules (EHMs) used in Electro hydrostatic Actuators (EHAs) for aerospace applications. It covers design, performance, and test requirements, including both production and qualification tests.
Version history	-
Reference	https://www.sae.org/standards/content/arp6154/

Standard	ARP6216
Title	EWIS Wiring Insulation Breakdown Testing
Status	Active
Initial date	30-09-2022
Current version	-
Description	This SAE Aerospace Recommended Practice (ARP) outlines minimum testing requirements for insulated electrical wiring in on-aircraft, aeronautical, and aerospace applications. It ensures that wire faults can be safely detected using a high potential voltage tester (hipot) to find breaches in wire insulation, not to measure insulation resistance. The test method is limited to equipment with a maximum DC output of 1500 VDC, designed to trip on current leakage rather than arc detection. It aims to identify significant insulation damage or degradation. Additional information and related test methods are referenced in Section 2 for further guidance.
Version history	-
Reference	https://www.sae.org/standards/content/arp6216/

Standard	ARP6290

Title	Guidelines for the Development of Architectures for Integrated Vehicle Health Management Systems
Status	Active
Initial date	10-05-2023
Current version	-
Description	This SAE Aerospace Recommended Practice (ARP) provides guidance for creating Integrated Vehicle Health Management (IVHM) system architecture, which encompasses a vehicle's monitoring and data processing functions, as well as tools and processes to manage and restore its health. Based on experience from both defense and commercial IVHM initiatives, the document outlines a step-by-step methodology to identify functional and non-functional requirements, mature the architecture, and support organizational business goals and objectives.
Version history	-
Reference	https://www.sae.org/standards/content/arp6290/

Standard	ARP6336
Title	Lighting Applications for Unmanned Aircraft Systems (UAS)
Status	Active
Initial date	05-12-2019
Current version	-
Description	The SAE Aerospace Recommended Practice (ARP) provides technical recommendations for UAS lighting applications. The document explains the necessary trade-offs to stay compliant with U.S. Federal Aviation Regulations (FARs) for aerospace lighting. The recommendations help designers create lighting systems for Unmanned Aircraft (UA) based on their dimensions and operational scope and provide specialized lighting solutions for particular UAS operational concepts.
Version history	-
Reference	https://www.sae.org/standards/content/arp6336/

Standard	ARP6538
Title	Dynamic Modeling of Aerospace Systems (DyMAS)
Status	Active
Initial date	24-05-2019
Current version	-
Description	The objective of this document is to provide a recommended practice for developing aerospace EPS dynamic models to ensure compatibility and interconnectivity across models from different companies, industries, and governments. This is essential for integrated vehicle optimization in the aerospace industry. The document focuses on model interfaces and their interconnection, without addressing the internal workings of individual component models.
Version history	-
Reference	https://www.sae.org/standards/content/arp6538/

Standard	ARP6539

Title	Validation and Verification Process Steps for Monitors Development in Complex Flight Control and Related Systems
Status	Active
Initial date	10-08-2022
Current version	-
Description	This SAE Aerospace Recommended Practice (ARP) outlines a process for the verification and validation of monitors used in highly integrated and complex aircraft flight control and related systems.
Version history	-
Reference	https://www.sae.org/standards/content/arp6539/

Standard	ARP6407
Title	IVHM Design Guidelines
Status	Active
Initial date	29-07-2019
Current version	-
Description	This Aerospace Recommended Practice (ARP) provides guidance for designing an integrated vehicle health management (IVHM) system to enhance the vehicle's design for health management of the platform and its components. The guidance is technology-independent and applicable to various IVHM design scenarios, including both "clean sheet" designs and retrofit designs. It covers the design process from feasibility assessment to conceptual design analysis and development, with considerations for trade studies, metrics, and life cycle impacts.
Version history	-
Reference	https://www.sae.org/standards/content/arp6407/

Standard	AIR6520
Title	Unmanned Systems (UxS) Control Segment (UCS) Architecture: Version Description Document
Status	Active
Initial date	23-02-2024
Current version	AIR6520A
Description	Governance of the Unmanned Aircraft System (UAS) Control Segment (UCS) Architecture was transferred from the U.S. Office of the Secretary of Defense (OSD) to SAE International in April 2015. As a result, a subset of UCS Architecture Library Release 3.4(PR) has been published under SAE as the Unmanned Systems (UxS) Control Segment (UCS) Architecture, AS6512. This Version Description Document (VDD) explains the correspondence and differences between the two architecture libraries.
Version history	AIR6520
Reference	https://www.sae.org/standards/content/air6520a/

Standard	ARP6803
Title	IVHM Concepts, Technology and Implementation Overview

Status	Ongoing
Initial date	12-10-2022
Current version	-
Description	This SAE Aerospace Recommended Practice (ARP) examines the overall construct of an Integrated Vehicle Health Management (IVHM) capability, offering a top-level view of the concepts, technology, and implementation practices associated with IVHM. As the key document of the SAE HM-1 Committee, it is not intended as a legal document and does not provide detailed implementation steps, but it addresses general implementation concerns and potential benefits.
Version history	-
Reference	https://www.sae.org/standards/content/arp6803a/

Standard	ARP6823
Title	Electronic Transactions for Aerospace Systems: An Overview
Status	Active
Initial date	01-03-2021
Current version	-
Description	This SAE Aerospace Recommended Practice (ARP) provides an overview of key processes being transformed as the aerospace industry rapidly digitalizes. The G-31 Electronic Transactions in Aerospace committee has been established to develop standards related to these processes. This report, known as the committee's "cornerstone" document, offers a comprehensive look at processes in commercial aviation, with technologies described that are also applicable to other domains due to their universal convergence.
Version history	-
Reference	https://www.sae.org/standards/content/arp6823/

Standard	ARP6883
Title	Guidelines for Writing IVHM Requirements for Aerospace Systems
Status	Active
Initial date	03-12-2019
Current version	-
Description	The Aerospace Recommended Practice (ARP) provides instructions for creating requirements for systems that use Integrated Vehicle Health Management (IVHM) capabilities. IVHM technology appears in both military aircraft such as F-35 and AH-64 Apache and commercial aircraft including B787 and A350XWB. The document presents a structured method for creating IVHM-related requirements which includes unique elements for IVHM and detailed instructions for creating improved requirements. The document provides requirements gathering process guidance through real-life examples that demonstrate good IVHM requirements. The document avoids repeating standard requirements writing guidelines to focus on IVHM-specific requirements.
Version history	-
Reference	https://www.sae.org/standards/content/arp6883/

Standard	ARP6971

Title	Power and Torque Determination for UAS Engines Having Maximum Power Ratings at or Below 22.4 kW
Status	Active
Initial date	07-04-2021
Current version	-
Description	This recommended practice applies to reciprocating engines powering unmanned aerial vehicles (UAVs) with rated power values less than 22.4 kW, and which are not intended for human transport.
Version history	-
Reference	https://www.sae.org/standards/content/arp6971/

Standard	ARP6983
Title	Process Standard for Development and Certification/Approval of Aeronautical Safety-Related Products Implementing AI
Status	Ongoing
Initial date	26-06-2023
Current version	-
Description	This document provides guidelines for developing aircraft systems utilizing AI capabilities, considering the overall operating environment and functions. It covers the validation of requirements, design verification for certification, product assurance, and safety assessment. The document helps demonstrate regulatory compliance and assists companies in meeting internal standards by following the outlined practices.
Version history	-
Reference	https://www.sae.org/standards/content/arp6983/

Standard	ARP6984
Title	Determination of Cost Benefits from Implementing a Blockchain Solution
Status	Active
Initial date	19-08-2021
Current version	-
Description	The SAE Aerospace Recommended Practice (ARP) provides guidance on how to conduct a Cost Benefit Analysis (CBA) to determine the Return on Investment (ROI) from implementing a blockchain solution in a business process. It focuses on enterprise blockchain, which offers standardized cryptography, legal enforceability, and regulatory compliance. The document analyzes the complexity of blockchain technology, explores different CBA approaches, and distinguishes between public and private distributed networks. It is intended for individuals without deep technical knowledge, helping them qualify and quantify the economic benefits (value proposition) of blockchain solutions.
Version history	-
Reference	https://www.sae.org/standards/content/arp6984/

Standard	ARP8676
Title	Nomenclature and Definitions for Electrified Propulsion Aircraft

Status	Active
Initial date	01-08-2022
Current version	-
Description	This document provides a list of relevant terms and abbreviations related to electrified propulsion in aircraft, along with brief summary descriptions. It aims to establish consistent technical language for use throughout the standards developed by the E-40 committee. Detailed explanations, diagrams, and in-depth technical descriptions are addressed in other documents.
Version history	-
Reference	https://www.sae.org/standards/content/arp8676/

Standard	ARP8689
Title	Endurance tests for Aircraft Electric Engine
Status	Ongoing
Initial date	08-03-2021
Current version	-
Description	This ARP provides guidance for testing the durability and integrity requirements of electric engines intended for type certification for installation in aircraft. It offers a means to demonstrate compliance with engine certification requirements independently of aircraft certification requirements.
Version history	-
Reference	https://www.sae.org/standards/content/arp8689/

Standard	ARP94910
Title	Aerospace - Vehicle Management Systems - Flight Control Design, Installation and Test of, Military Unmanned Aircraft, Specification Guide
Status	Active
Initial date	19-12-2012
Current version	-
Description	This document establishes recommended practices for specifying performance, design, test, development, and quality assurance requirements for the flight control functions of Vehicle Management Systems (VMS) in military Unmanned Aircraft (UA), the airborne element of Unmanned Aircraft Systems (UAS). It is intended for military unmanned aircraft primarily used in military operational areas and provides a foundation for safe flight considerations in all airspace classes.
Version history	-
Reference	https://www.sae.org/standards/content/arp94910/

Standard	ARP94910A
Title	Aerospace - Vehicle Management Systems - Flight Control Design, Installation and Test of, Military Unmanned Aircraft, Specification Guide
Status	Ongoing
Initial date	24-10-2019

Current version	-
Description	This document establishes recommended practices for specifying the performance, design, test, development, and quality assurance requirements for the flight control functions of the Vehicle Management Systems (VMS) in military Unmanned Aircraft (UA), as defined by ASTM F 2395-07. It is intended for military unmanned aircraft used primarily in military operational areas and also provides a foundation for safe flight considerations across all airspace classes.
Version history	-
Reference	https://www.sae.org/standards/content/arp94910a/

Standard	ARINC413A
Title	Guidance for aircraft electrical power utilization and transient protection
Status	Active
Initial date	01-10-1989
Current version	-
Description	This standard provides guidance to airframe manufacturers on the utilization of aircraft electrical power. It covers basic power characteristics and offers detailed guidance on transient protection, interference control, and equipment installation considerations.
Version history	-
Reference	https://www.sae.org/standards/content/arinc413a/

Standard	ARINC424-23
Title	Navigation system database
Status	Active
Initial date	08-07-2022
Current version	-
Description	This standard provides a database of standards used for preparing a navigation system database. The data can be utilized with operational flight software across a wide range of navigational equipment.
Version history	-
Reference	https://www.sae.org/standards/content/arinc424-23/

Standard	ARINC428
Title	Considerations for avionics network design
Status	Active
Initial date	09-10-1995
Current version	-
Description	This standard provides the framework for developing requirements for an avionics data bus network. It offers system-level considerations for creating such a network, which may include a combination of standard and private data buses.
Version history	-
Reference	https://www.sae.org/standards/content/arinc428/

Standard	ARINC561-11
Title	Air Transport Inertial Navigation System (INS)
Status	Active
Initial date	17-01-1975
Current version	-
Description	This standard defines the requirements for an Inertial Navigation System (INS), which provides sensor and steering command outputs. The INS includes inertial sensing and delivers outputs for aircraft attitude, present position, and steering signals for operating the pilot's instruments. The basic INS offers complete, self-contained horizontal navigation capability, intended as the sole means of worldwide navigation.
Version history	-
Reference	https://www.sae.org/standards/content/arinc561-11/

Standard	ARINC562
Title	Terrain Awareness and Warning System (TAWS) - Analog
Status	Active
Initial date	12-12-2001
Current version	-
Description	Terrain Awareness and Warning System (TAWS) Analog addresses the need for standard TAWS installations in older aircraft with analog equipment interfaces. The analog unit serves as a replacement for ARINC Characteristic 594: Ground Proximity Warning System (GPWS) equipment. This document complements ARINC Characteristic 762: Terrain Awareness and Warning System (TAWS) for newer aircraft with digital equipment interfaces.
Version history	-
Reference	https://www.sae.org/standards/content/arinc562/

Standard	ARINC594-4
Title	Ground Proximity Warning System
Status	Active
Initial date	12-03-1984
Current version	-
Description	This standard defines the characteristics of a Ground Proximity Warning System (GPWS) for commercial aircraft installation. The GPWS provides audible and visible warnings or alerts when the aircraft approaches terrain or deviates below the ILS glide slope beyond the system's preset limits.
Version history	-
Reference	https://www.sae.org/standards/content/arinc594-4/

Standard	ARINC595
Title	Barometric Altitude Rate Computer (BARC)

Status	Active
Initial date	20-09-2010
Current version	-
Description	This standard provides general guidance for designing and installing a BARC to be used with a GPWS. The BARC generates an electrical rate signal from pneumatic pressure supplied by the aircraft's static pressure system. It is primarily intended for aircraft without a suitable electrical signal for altitude rate, supporting ground proximity warning equipment.
Version history	-
Reference	https://www.sae.org/standards/content/arinc595/

Standard	ARINC600-20
Title	Air Transport Avionics Equipment Interfaces
Status	Active
Initial date	11-07-2017
Current version	-
Description	ARINC 600 represents a mechanical packaging standard which operates with digital avionics equipment from the ARINC 700-series. The standard outlines mechanical and electrical and environmental interfaces which connect Line Replaceable Units (LRUs) to their installation racks or cabinets. The standard contains specifications for connector shells as well as connector insert layouts and mounting dimensions.
Version history	-
Reference	https://www.sae.org/standards/content/arinc600-20/

Standard	ARINC609
Title	Design Guidance for Aircraft Electrical Power Systems
Status	Active
Initial date	05-01-1987
Current version	-
Description	This standard outline electrical power system design and performance standards driven by the widespread use of digital avionics. It provides guidelines for designers of aircraft power system components and power utilization components, including avionics and power converters like motors and heaters.
Version history	-
Reference	https://www.sae.org/standards/content/arinc609/

Standard	ARINC618-8
Title	Air/Ground Character-Oriented Protocol Specification
Status	Active
Initial date	10-08-2016
Current version	-

Description	This standard defines the Aircraft Communications Addressing and Reporting System (ACARS), a VHF data link that transfers character-oriented data between aircraft systems and ground systems. It enables the aircraft to function as part of the airline's command, control, and management system.
Version history	-
Reference	https://www.sae.org/standards/content/arinc618-8/

Standard	ARINC619-5
Title	ACARS Protocols for Avionic end systems
Status	Active
Initial date	29-11-2017
Current version	-
Description	This document outlines, in an organized manner, the protocols used by Aircraft Communication Addressing and Reporting System (ACARS) Management Units (MU) defined in ARINC Characteristic 724B and Communications Management Units (CMU) defined in ARINC Characteristic 758, detailing their interactions with other onboard avionics equipment.
Version history	-
Reference	https://www.sae.org/standards/content/arinc619-5/

Standard	ARINC620-10
Title	Datalink Ground Systems Standard and Interface Specification (DGSS/IS)
Status	Active
Initial date	31-07-2020
Current version	-
Description	ARINC Specification 620 defines the interfaces between the Datalink Service Provider (DSP) and the aircraft, other ground-based datalink services, and users. It supports traditional ACARS and AOA protocols, as well as Media Independent Aircraft Messaging (MIAM) defined by ARINC Specification 841, allowing for much larger messages (5 MB versus 3.3 kB per ACARS message). Supplement 10 enhances Controller-Pilot Data Link Communications (CPDLC) by introducing a “Deliver By (DB)” period, allowing the DSP to intercept and discard messages not delivered on time. It also adds a Media Advisory code for ACARS over IP (AoIP) and new Reason Codes for undeliverable messages. Additionally, Supplement 10 provides clarification on the ACARS character set.
Version history	-
Reference	https://www.sae.org/standards/content/arinc620-10/

Standard	ARINC622-5
Title	ATS Data Link Applications over ACARS Air-Ground Network
Status	Active
Initial date	23-08-2017
Current version	-

Description	This standard specifies ATS applications that enhance the functionality of the ACARS system. It provides design guidance to developers to ensure interoperability between different implementations of these applications.
Version history	-
Reference	https://www.sae.org/standards/content/arinc622-5/

Standard	ARINC631-8
Title	VHF Digital Link (VDL) Mode 2 Implementation Provisions
Status	Active
Initial date	15-07-2020
Current version	-
Description	This document describes the functions of airborne and ground components of the VDLM2 for transferring messages between VHF ground networks and aircraft avionics systems, with data encoded in a code- and byte-independent format. VDLM2's compatibility with the OSI model is ensured by defining services and protocols aligned with the OSI basic reference model. Compatibility with ATN protocols is achieved by defining interfaces between the VDLM2 subnetwork protocol and the Mobile Subnetwork Dependent Convergence Function (MSNDCF), as specified in the ICAO ATN SARPs.
Version history	-
Reference	https://www.sae.org/standards/content/arinc631-8/

Standard	ARINC633
Title	AOC Air-Ground Data and Message Exchange Format
Status	Active
Initial date	09-01-2024
Current version	ARINC633-5
Description	The purpose of ARINC 633 is to specify the format and exchange of Aeronautical Operational Control (AOC) communications. Examples of AOC structures/messages include flight plans, load planning (e.g., weight and balance, cargo planning), NOTAMs, airport and route weather data, and Minimum Equipment Lists (MEL) messages. Standardizing AOC messages allows for the development of applications shared across multiple airlines and aircraft types, resulting in improved dispatchability and reduced operator costs.
Version history	ARINC633-4 ARINC633-3 ARINC633-2 ARINC633-1
Reference	https://saemobilus.sae.org/standards/arinc633-5-633-5-aoc-air-ground-data-message-exchange-format

Standard	ARINC634
Title	ARINC Report 634 HF Data Link System Design Guidance Material
Status	Active
Initial date	30-08-1996

Current version	-
Description	This report provides material to enhance understanding of high-frequency data links. It offers guidance used in the development of ARINC 753, HF Data Link System, and ARINC 635, HF Data Link Protocols.
Version history	-
Reference	https://www.sae.org/standards/content/arinc634/

Standard	ARINC635-4
Title	HF Data Link Protocols
Status	Active
Initial date	22-12-2003
Current version	-
Description	This standard outlines the functions of the airborne components of the HFDL to successfully transfer messages between HF ground stations and aircraft avionics systems, with data encoded in a bit-oriented format. ARINC 634 and ARINC 753 are companion standards.
Version history	-
Reference	https://www.sae.org/standards/content/arinc635-4/

Standard	ARINC650
Title	Integrated Modular Avionics Packaging and Interfaces
Status	Active
Initial date	01-07-1994
Current version	-
Description	This standard defines the packaging details for Integrated Modular Avionics (IMA). It provides recommendations for the design and installation of Line Replaceable Modules (LRMs) in cabinet assemblies, including mechanical installation and interchangeability guidelines for LRM interfaces with the cabinet frame and wire integration/backplane assembly. It also defines connectors recommended for use with IMA systems.
Version history	-
Reference	https://www.sae.org/standards/content/arinc650/

Standard	ARINC652
Title	Guidance for Avionics Software Management
Status	Active
Initial date	15-01-1993
Current version	-
Description	The standard functions as a top-level design guide which directs the development and maintenance of avionics software. The standard provides design and development instructions for avionics software that applies to both traditional ARINC 700-series equipment and Integrated Modular Avionics (IMA) systems. The standard reflects the airline's goal to enable software modifications by users.

Version history	-
Reference	https://www.sae.org/standards/content/arinc652/

Standard	ARINC653P3A
Title	Avionics Application Software Standard Interface, Part 3A, Conformity Test Specification for ARINC 653 Required Services
Status	Active
Initial date	15-11-2021
Current version	-
Description	ARINC 653, Part 3A is the Compliance Test Specification for ARINC 653 Required Services defined in ARINC 653, Part 1. It specifies a set of stimuli and expected responses for testing. Future updates to the ARINC 653 document set will focus on defining Operating System services for multi-core processor environments, with the Compliance Test Specification being updated accordingly.
Version history	-
Reference	https://www.sae.org/standards/content/arinc653p3a-2/

Standard	ARINC653P3BC1
Title	Avionics Application Software Standard Interface Part 3B Conformity Test Specifications for ARINC 653 Extended Services
Status	Active
Initial date	18-07-2019
Current version	-
Description	ARINC 653, Part 3B is the Compliance Test Specification for ARINC 653 Extended Services defined in ARINC 653, Part 2. It specifies a set of stimuli and expected responses for testing. Future updates to the ARINC 653 document set will include defining Operating System services for multi-core processor environments, with the Compliance Test Specification being updated in parallel with ARINC 653, Part 2.
Version history	-
Reference	https://www.sae.org/standards/content/arinc653p3bc1/

Standard	ARINC653P4
Title	Avionics Application Software Standard Interface Part 4 – Subset Services
Status	Active
Initial date	28-06-2012
Current version	-
Description	ARINC Specification 653 Part 4 was developed to support controllers and simpler avionics systems. It is a true subset of the services specified in ARINC 653 Part 1. In Part 4, partition scheduling is restricted to a single time window within a partition's period, simplifying process release point management. Process management uses a dual-process model, allowing at most two processes within a partition, such as foreground and background processes.
Version history	-

Reference	https://www.sae.org/standards/content/arinc653p4/

Standard	ARINC653P5-1
Title	Avionics Application Software Standard Interface Part 5 – Core Software Recommended Capabilities
Status	Active
Initial date	07-08-2019
Current version	-
Description	Part 5 of ARINC 653 defines additional core software capabilities to facilitate integration on various Integrated Modular Avionics (IMA) hardware platforms, allowing platform suppliers to extend and customize it for their specific hardware. Supplement 1 expands on the guidance for resource profiling and execution profiling, specifically addressing the use of multi-core processors in avionics systems.
Version history	-
Reference	https://www.sae.org/standards/content/arinc653p5-1/

Standard	ARINC654
Title	Environmental Design Guidelines for Integrated Modular Avionics Packaging and Interfaces
Status	Active
Initial date	09-12-1994
Current version	-
Description	This standard focuses on electromagnetic compatibility, shielding, thermal management, vibration, and shock for Integrated Modular Avionics (IMA) systems. It emphasizes the design of IMA components and their electrical, optical, and electro-mechanical interfaces.
Version history	-
Reference	https://www.sae.org/standards/content/arinc654/

Standard	ARINC658
Title	Internet Protocol Suite (IPS) for Aeronautical Safety Services Roadmap Document
Status	Active
Initial date	18-12-2017
Current version	-
Description	ARINC 658 was developed to address the growing role of data communication technology and its evolution from ACARS protocols to ATN/OSI protocols, and eventually to ATN/IPS protocols using highly secure networks. The ATN/IPS network will be implemented onboard aircraft and within ground infrastructure to support safety services, including Air Traffic Services (ATS) and Aeronautical Operational Control (AOC). It provides a "roadmap" for the development of aviation standards for ATN/IPS services, with ongoing evolution and coordination with international standards organizations like ICAO, EUROCAE, and RTCA.
Version history	-
Reference	https://www.sae.org/standards/content/arinc658/

Standard	ARINC660A
Title	CNS/ATM Avionics, functional allocation and recommended architectures
Status	Active
Initial date	15-01-2001
Current version	-
Description	This standard expands ARINC 660 to include industry-defined architectures for the CNS/ATM operating environment, designed to meet long-term requirements (e.g., ADS-B, CPDLC) and provide future growth. Airlines support the implementation of these architectures for long-term use. The standard reflects broad airline consensus on developing avionics equipment that provides CNS/ATM operating capabilities.
Version history	-
Reference	https://www.sae.org/standards/content/arinc660a/

Standard	ARINC660B
Title	CNS/ATM Avionics architectures supporting next GEN/SESAR concepts
Status	Active
Initial date	10-01-2014
Current version	-
Description	This document identifies and describes the avionics capabilities required for operation in the evolving Communications Navigation Surveillance/Air Traffic Management (CNS/ATM) environment, as expected in the FAA NextGen program, SESAR, and the Japan CARATS program. These capabilities are designed to meet the industry's long-term CNS/ATM operational objectives.
Version history	-
Reference	https://www.sae.org/standards/content/arinc660b/

Standard	ARINC664P1-2
Title	Aircraft data network, Part 1, systems concepts and overview
Status	Active
Initial date	20-06-2019
Current version	-
Description	The purpose of this document is to provide an overview of data networking standards recommended for use in commercial aircraft installations. These standards adapt commercially defined networking protocols to the aircraft environment. It covers devices such as bridges, switches, routers, and hubs, and their role in optimizing data transfer and overall avionics performance within a network topology.
Version history	-
Reference	https://www.sae.org/standards/content/arinc664p1-2/

Standard	ARINC664P2-3
Title	Aircraft data network, Part 2, ethernet physical and data link layer specification

Status	Active
Initial date	24-10-2018
Current version	-
Description	The specification defines Ethernet physical characteristics together with data link layer requirements for commercial aircraft systems. The document provides recommendations for implementing IEEE 802.3 compliant Ethernet (2000 edition) to achieve OSI Reference Model compatibility which enables the use of standard hardware and software components. The Ethernet Physical layer specification outlines electrical and optical requirements for 10BASE-T, 100BASE-TX and 100BASE-FX implementations while it also references ARINC Specification 600 for copper-based Ethernet Physical layer implementations.
Version history	-
Reference	https://saemobilus.sae.org/standards/arinc664p2-3-664p2-3-aircraft-data-network-part-2-ethernet-physical-data-link-layer-specification

Standard	ARINC664P3-2
Title	Aircraft data network Part 3, internet-based protocols and services
Status	Active
Initial date	16-02-2009
Current version	-
Description	This specification defines the Network and Transport layer provisions for data networks installed on commercial aircraft. The definitions are based on Internet Engineering Task Force (IETF) Internet protocols and service standards published as Request for Comments (RFC). In some cases, these protocols and services are tailored for aircraft use. The specification identifies two types of networks: the Compliant Aircraft Data Network, which fully adheres to applicable Internet specifications, and the Profiled Aircraft Data Network, where industry standard protocols are extended for the unique aircraft environment. It defines Internet protocol functionality to ensure interoperability of components connected to onboard data networks, with minimal restrictions on component designers.
Version history	-
Reference	https://www.sae.org/standards/content/arinc664p3-2/

Standard	ARINC664P4-2
Title	Aircraft data network Part 4, internet-based address structure & assigned numbers
Status	Active
Initial date	21-12-2007
Current version	-
Description	This specification defines the addressing plan and rules for use in Aircraft Data Networks (ADN), organized according to the seven-layer Open Systems Interconnection (OSI) Reference Model. It outlines the structure of addresses in the ADN and provides guidance for address determination. This ensures that all applications using this address structure to send messages can identify the destination address structure at configuration time.
Version history	-
Reference	https://www.sae.org/standards/content/arinc664p4-2/

Standard	ARINC664P5
Title	Aircraft data network Part 5, network domain characteristics and interconnection
Status	Active
Initial date	12-04-2005
Current version	-
Description	ARINC 664, Part 5 provides design and implementation guidelines for networks installed in aircraft, enabling network devices to communicate within the aircraft and with external networks. It defines a set of domains within the aircraft, based on the services they provide, the security within their boundaries, and the connections required to other domains and external networks. The specification offers general guidelines that, when implemented by aircraft devices and configured by the system integrator, ensure the necessary connectivity, quality of service, safety, and security.
Version history	-
Reference	https://www.sae.org/standards/content/arinc664p5/

Standard	ARINC664P7-1
Title	Aircraft data network Part 7, avionics full-duplex switched ethernet network
Status	Active
Initial date	23-09-2009
Current version	-
Description	The purpose of this document is to define the deterministic network, Avionics Full Duplex Switched Ethernet (AFDX), a trademark of Airbus used with permission. It also highlights the additional performance requirements for avionics systems within the context of AFDX.
Version history	-
Reference	https://www.sae.org/standards/content/arinc664p7-1/

Standard	ARINC664P8-1
Title	Aircraft data network Part 8, interoperation with NON-IP protocols and services
Status	Active
Initial date	12-11-2010
Current version	-
Description	This specification was created to support future aeronautical applications and services beyond those using Transmission Control Protocol/Internet Protocol (TCP/IP). Its initial focus is on air/ground applications using the Aeronautical Telecommunications Network (ATN), including Controller-Pilot Data Link Communication (CPDLC), Flight Information System (FIS), and Context Management Application (CMA). Supplement 1 was developed to enable interoperation with non-IP protocols and services, as well as upper layer services in alignment with the OSI reference model. Supplement 1 incorporates ICAO Aeronautical Communication Panel recommendations.
Version history	-
Reference	https://www.sae.org/standards/content/arinc664p8-1/

Standard	ARINC665-5

Title	Loadable software standards
Status	Active
Initial date	13-08-2019
Current version	-
Description	This document defines the aircraft industry's standards for Loadable Software Parts (LSPs) and Media Set Parts (MSPs). It outlines the principles and rules to ensure compatibility and interoperability of software parts in data load systems. It covers part numbering, content, labeling, and formatting for both LSPs and Media Sets containing LSPs. Supplement 5 refers to the companion document, ARINC Report 645: Common Terminology and Functions for Software Distribution and Loading.
Version history	-
Reference	https://www.sae.org/standards/content/arinc665-5/

Standard	ARINC667-3
Title	Guidance for the management of field loadable software
Status	Active
Initial date	01-11-2022
Current version	-
Description	This document outlines effective methods for managing and distributing operational flight software programs, aeronautical databases, and other software used within an airline organization. Topics covered include software acquisition, receiving, distribution, and necessary documentation. The FLS management process described in ARINC 667 aligns with published FAA/EASA guidance on this subject, making it a practical and effective guide for software suppliers, airline users, and regulators.
Version history	-
Reference	https://www.sae.org/standards/content/arinc667-3/

Standard	ARINC675
Title	Guidance for the management of aircraft support data
Status	Active
Initial date	26-06-2017
Current version	-
Description	The purpose of this document is to establish guidance for Aircraft Support Data Management (ASDM), intended for operators of transport aircraft, including pilots-in-command, maintenance activities, renter-pilots, and air carrier certificate holders.
Version history	-
Reference	https://www.sae.org/standards/content/arinc675/

Standard	ARINC676
Title	Guidance for assignment, accomplishment and reporting of special (Engineering) investigation for aircraft components
Status	Active

Initial date	19-12-2016
Current version	-
Description	The purpose of this document is to provide guidance for the assignment, accomplishment, and reporting of investigations that go beyond regular workshop analysis and repair processes for components. It is intended for use by operators, repair shops, and component manufacturers to support special investigations for aircraft components requiring additional attention to meet reliability and authority requirements. The document covers the assignment process, scope of work, and content/style of the final report.
Version history	-
Reference	https://www.sae.org/standards/content/arinc676/

Standard	ARINC677
Title	Installation standards for low frequency underwater locator beacon (LF-ULB)
Status	Active
Initial date	15-07-2015
Current version	-
Description	This document provides aircraft installation requirements for a Low Frequency Underwater Locator Beacon (LF-ULB) transmitting at 8.8 kHz. ICAO Annex 6 Amendment 36 mandates the installation of an LF-ULB on aircraft with a maximum certified take-off mass over 27,000 kg, operating over water at specific distances from land suitable for an emergency landing. The amendment also requires the installation of an LF-ULB by January 1, 2018.
Version history	-
Reference	https://www.sae.org/standards/content/arinc677/

Standard	ARINC679
Title	Aircraft server, communications and interface standard
Status	Active
Initial date	10-11-2021
Current version	-
Description	ARINC Report 679 defines the functional characteristics of an airborne server that supports Electronic Flight Bags (EFBs) and similar peripherals used in the flight deck, cabin, and maintenance applications. It outlines how EFBs will connect efficiently, safely, securely, and effectively to the airborne server, offering expanded capabilities to aircraft operators. The server serves two main functions: providing specific services to connected systems and centralizing security for the EFB and its data. This document focuses on the functional definition of the airborne server, not its physical characteristics.
Version history	-
Reference	https://www.sae.org/standards/content/arinc679/

Standard	ARINC680
Title	Aircraft autonomous distress tracking (ADT)
Status	Active
Initial date	26-08-2019

Current version	-
Description	This document outlines the technical requirements, architectural options, and recommended interface standards for an Autonomous Distress Tracking (ADT) System, designed to meet global regulatory requirements for locating aircraft in distress situations and after an accident. It is prepared in response to initiatives from the International Civil Aviation Organization (ICAO) and individual Civil Aviation Authorities (CAAs).
Version history	-
Reference	https://www.sae.org/standards/content/arinc680/

Standard	ARINC681
Title	Timely recovery of flight data (TRFD)
Status	Active
Initial date	06-08-2021
Current version	-
Description	The difficulty in locating crash sites has led to international efforts to quickly recover flight data. This document outlines the technical requirements and architectural options for the Timely Recovery of Flight Data (TRFD) in commercial aircraft, in response to ICAO and individual Civil Aviation Authorities (CAAs) regulations. The ICAO Standards and Recommended Practices (SARPs) and CAA regulations address both aircraft-level and on-ground systems. This report also covers additional system-level requirements based on the evaluation of ICAO, CAA, and relevant industry documents, as well as potential TRFD system architectures. It presents two TRFD architectures within a common framework and identifies associated requirements, along with implementation recommendations from an airplane-level perspective.
Version history	-
Reference	https://www.sae.org/standards/content/arinc681/

Standard	ARINC704-7
Title	Inertial reference system
Status	Active
Initial date	19-03-1999
Current version	-
Description	This standard defines the characteristics of Inertial Reference Systems (IRS), specifying the desired performance of inertial measuring devices and associated electronics designed for installation in commercial transport aircraft. The system provides basic outputs for aircraft angular rate and acceleration, as well as computed outputs for altitude, true heading, velocity, and present position, all within a 10 MCU form factor.
Version history	-
Reference	https://www.sae.org/standards/content/arinc704-7/

Standard	ARINC705-5
Title	Attitude and Heading Reference System
Status	Active
Initial date	30-04-1985

Current version	-
Description	This standard outlines the basic requirements for an Attitude and Heading Reference System (AHRS) designed for installation in commercial transport aircraft. The AHRS serves as an attitude and heading sensor, providing digital outputs for guidance and display, and replaces traditional vertical and directional gyros.
Version history	-
Reference	https://www.sae.org/standards/content/arinc705-5/

Standard	ARINC706-4
Title	MARK 5 Subsonic Air Data System
Status	Active
Initial date	11-01-1988
Current version	-
Description	This standard defines the characteristics of a digital Air Data System (ADS) intended for installation in subsonic commercial transport aircraft. It provides essential air data information for pilot displays and uses by other aircraft systems. The system consists of a computer unit located in the aircraft's electronics rack and appropriate indicators in the cockpit.
Version history	-
Reference	https://www.sae.org/standards/content/arinc706-4/

Standard	ARINC707-7
Title	Radio Altimeter
Status	Active
Initial date	06-04-2009
Current version	-
Description	This standard defines the desired characteristics of a Radio Altimeter (RALT) intended for installation in all types of commercial transport aircraft. Its primary function is to determine the aircraft's height above terrain, providing a visual display to the pilot (from ground level to 2500 feet) and supporting the Automatic Flight Control System (AFCS) during automatically controlled approaches and landings.
Version history	-
Reference	https://www.sae.org/standards/content/arinc707-7/

Standard	ARINC708A-3
Title	Airborne Weather Radar with Forward Looking Windshear Detection Capability
Status	Active
Initial date	15-11-1999
Current version	-
Description	This standard defines an airborne pulse Doppler weather radar system for weather detection and ranging. It enhances the ARINC 708 system by including forward-looking windshear prediction capabilities. Additionally, it provides ground-mapping features to aid navigation through the display of significant land contours.

Version history	-
Reference	https://www.sae.org/standards/content/arinc708a-3/

Standard	ARINC708-6
Title	Airborne Weather Radar
Status	Active
Initial date	15-11-1991
Current version	-
Description	This standard defines the characteristics of Weather Radar (WXR) equipment intended for installation in commercial transport aircraft. Its primary function is weather detection, ranging, and analysis, while its secondary purpose is ground mapping to assist navigation by displaying significant land contours.
Version history	-
Reference	https://www.sae.org/standards/content/arinc708-6/

Standard	ARINC712-7
Title	Airborne ADF System
Status	Active
Initial date	15-07-1992
Current version	-
Description	This standard defines the characteristics of an Automatic Direction Finder (ADF) system for installation in commercial transport aircraft. The system receives and processes signals from non-directional range and other transmitters in the frequency range of 190 kHz to 1750 kHz, providing serial digital outputs for bearing and aural identification of the selected station.
Version history	-
Reference	https://www.sae.org/standards/content/arinc712-7/

Standard	ARINC714-6
Title	MARK 3 Airborne SELCAL System
Status	Active
Initial date	15-08-1990
Current version	-
Description	This standard defines the characteristics of a ground-to-air selective calling system. The system enables the selective calling of individual aircraft over radio communication circuits linking the ground station to the aircraft. The system components include the ground selecting calling unit (coder), ground-to-air transmitter (HF or VHF), airborne receiver (HF or VHF), airborne selective calling unit (decoder), and a code selection panel.
Version history	-
Reference	https://www.sae.org/standards/content/arinc714-6/

Standard	ARINC714A

Title	MARK 4 SELECTIVE CALLING (SELCAL)
Status	Active
Initial date	04-11-2015
Current version	-
Description	
Version history	-
Reference	https://www.sae.org/standards/content/arinc714a/

Standard	ARINC718A-5
Title	MARK 4 Air Traffic Control Transponder (ATCRBS/MODE S)
Status	Active
Initial date	07-10-2022
Current version	-
Description	This document introduces significant improvements to existing Selective Calling (SELCAL) standards used with HF and VHF voice communications, aiming to prevent multiple aircraft from responding to the same radio call. The Mark 4 SELCAL system definition provides: guidance for integrated and federated audio systems, 32 audio tones (16+16) offering up to 215,760 unique codes, SELCAL form, fit, and function definition, inter wiring and installation details, and decoding requirements in the presence of significant signal degradation.
Version history	-
Reference	https://www.sae.org/standards/content/arinc718a-5/

Standard	ARINC720-1
Title	Digital Frequency/Function Selection for Airborne Electronic Equipment
Status	Active
Initial date	01-07-1980
Current version	-
Description	This standard defines the air transport industry's recommended standards for a digital frequency selection system (DFS). It addresses two extremes of DFS integration: a fully centralized system and a federated system. This approach ensures that radio interface specifications are sufficient to accommodate a range of DFS integration options.
Version history	-
Reference	https://www.sae.org/standards/content/arinc720-1/

Standard	ARINC723-3
Title	Ground Proximity Warning System
Status	Active
Initial date	11-01-1988
Current version	-
Description	This standard defines the characteristics of a Ground Proximity Warning System (GPWS) designed for installation in commercial aircraft. It assists pilots by providing audible and

	visible warnings or alerts when the aircraft approaches terrain too closely or deviates downward from an ILS glide slope beyond the system's preset limits.
Version history	-
Reference	https://www.sae.org/standards/content/arinc723-3/

Standard	ARINC724B-6
Title	Aircraft Communications Addressing and Reporting System (ACARS)
Status	Active
Initial date	24-02-2012
Current version	-
Description	This standard describes the 724B version of the airborne components of ACARS, intended for use with the existing VHF radio equipment on the aircraft. This ACARS enhancement improves the system's ability to provide air-to-ground and ground-to-air data communications.
Version history	-
Reference	https://www.sae.org/standards/content/arinc724b-6/

Standard	ARINC725-2
Title	Electronic Flight Instruments (EFI)
Status	Active
Initial date	01-06-2013
Current version	-
Description	This standard defines the features of a color Electronic Flight Instrument (EFI) system for installation in commercial transport aircraft. The EFI provides display functions such as Attitude Director Indicator (ADI), Horizontal Situation Indicator (HSI), air data, map display, weather display, radio altitude data, flight control mode annunciation, flight path information, and flight warning display.
Version history	-
Reference	https://www.sae.org/standards/content/arinc725-2/

Standard	ARINC726-1
Title	Flight Warning Computer System
Status	Active
Initial date	10-09-1981
Current version	-
Description	This standard defines the characteristics of a Flight Warning and Caution System (FWCS) intended for use in commercial transport aircraft. It processes caution and warning inputs for visual and/or audible presentation to the flight crew.
Version history	-
Reference	https://www.sae.org/standards/content/arinc726-1/

Standard	ARINC735A-1
Title	Mark 2 Traffic Alert and Collision Avoidance System (TCAS)
Status	Active
Initial date	15-01-2003
Current version	-
Description	This update to the TCAS system standard introduces changes to ensure compliance with RTCA Document DO-185A, which includes TCAS software version 7.0.
Version history	-
Reference	https://saemobilus.sae.org/standards/arinc735a-1-735a-1-mark-2-traffic-alert-collision-avoidance-system-tcas

Standard	ARINC735B-2
Title	Guidance for Tool and Test Equipment (TTE) Equivalency
Status	Active
Initial date	01-08-2015
Current version	-
Description	This document defines a Traffic Surveillance capability for NextGen and SESAR airspace environments. Supplement 2 adds hybrid surveillance functionality, aligning with recent updates to FAA Airworthiness Circular AC 20-151B - Airworthiness Approval of Traffic Alert and Collision Avoidance Systems (TCAS II), and Technical Standard Order TSO-119d, which requires annunciation of a hybrid surveillance failure. Supplement 2 also includes strobe program pinning, updates TCAS input status, improves aircraft troubleshooting, and supports recent updates to the central maintenance computer function block points.
Version history	-
Reference	https://www.sae.org/standards/content/arinc735b-2/

Standard	ARINC735C
Title	Traffic Computer, ACAS-X and ADS-B Functionality
Status	Active
Initial date	02-11-2022
Current version	-
Description	The document explains how the Airborne Collision Avoidance System X (ACAS X) operates while defining all required interface specifications and communication protocols to fulfill RTCA DO-385 standards for ACAS Xa and ACAS Xo and RTCA DO-386 standards for ACAS X. The document explains interfaces and protocols for the Cockpit Display of Traffic Information (CDTI) which uses Automatic Dependent Surveillance-Broadcast (ADS-B) and Traffic Information Services–Broadcast (TIS-B) data. The system transforms into ACAS X according to RTCA DO-317C: Minimum Operational Performance Standards for Aircraft Surveillance Applications (ASA) Systems when ADS-B IN applications are integrated.
Version history	-
Reference	https://www.sae.org/standards/content/arinc735c/

Standard	ARINC741P1-15
Title	Aviation satellite communication systems Part 1 Aircraft installation provisions
Status	Active
Initial date	23-12-2019
Current version	-
Description	
Version history	-
Reference	https://www.sae.org/standards/content/arinc741p1-15/

Standard	ARINC741P2-11
Title	Aviation Satellite Communication System Part 2 System Design and Equipment Functional Description
Status	Active
Initial date	27-06-2012
Current version	-
Description	This ARINC Standard defines the installation characteristics for first-generation L-band satellite communication systems, detailing the form, fit, function, and interfaces for installing satcom equipment in all types of aircraft. It includes descriptions of avionics equipment such as the Satellite Data Unit (SDU) and antennas. Supplement 15 adds references to new Diplexer/Low Noise Amplifiers (DLNAs) defined in Supplement 8 to ARINC Characteristic 781: Mark 3 Aviation Satellite Communication Systems. These five new DLNAs are designed to protect Inmarsat Classic Aero and SwiftBroadband (SBB) satcom equipment from ground-based cellular sources like LTE and Ancillary Terrestrial Component (ATCt). The DLNAs are categorized by features and service (e.g., new DLNA versus drop-in replacement, LTE and/or ATCt protection, Classic Aero and/or SBB service).
Version history	-
Reference	https://www.sae.org/standards/content/arinc741p2-11/

Standard	ARINC743A-6
Title	GNSS Sensor
Status	Active
Initial date	22-06-2018
Current version	-
Description	This document defines the characteristics of the integrated Global Positioning System (GPS)/Global Orbiting Navigation Satellite System (GLONASS) sensor unit (GNSSU) component of a GNSS system intended for installation in commercial aircraft. It provides both general and specific design guidance for developing GNSS sensors for airline use, outlining the desired operational capabilities of the GNSS system and the standards required to ensure interchangeability.
Version history	-
Reference	https://www.sae.org/standards/content/arinc743a-6/

Standard	ARINC743B-1

Title	GNSS Landing System Sensor Unit (GLSSU)
Status	Active
Initial date	22-06-2018
Current version	-
Description	This document defines the characteristics of the GNSS Landing System Sensor Unit (GLSSU) intended for installation in commercial aircraft. It provides both general and specific design guidance for developing the GLSSU for airline use, detailing the desired operational capabilities and the standards required to ensure interchangeability.
Version history	-
Reference	https://www.sae.org/standards/content/arinc743b-1/

Standard	ARINC743C
Title	GNSS Landing System Sensor Unit (GLSSU) with VHF Data Broadcast (VDB) Receiver
Status	Active
Initial date	22-06-2018
Current version	-
Description	This document defines the characteristics of the Global Navigation Satellite System (GNSS) Landing System Sensor Unit (GLSSU) with an integrated VHF Data Broadcast (VDB) receiver. It provides general and specific design guidance for developing the GLSSU for airline use, outlining the desired operational capabilities and the standards required to ensure interchangeability.
Version history	-
Reference	https://www.sae.org/standards/content/arinc743c/

Standard	ARINC752-1
Title	Terrestrial Flight Telephone System (TFTS) Airborne Radio Subsystem
Status	Active
Initial date	11-12-1995
Current version	-
Description	This standard defines the characteristics of a full-duplex telephone service for Aeronautical Passenger Communications via a network of ground stations. It specifies that the frequency band of 1670-1675 MHz is used for receiving, while the band of 1800-1805 MHz is used for transmitting.
Version history	-
Reference	https://www.sae.org/standards/content/arinc752-1/

Standard	ARINC753-3
Title	HF Data Link System
Status	Active
Initial date	16-02-2001
Current version	-

Description	This standard defines the characteristics of a High Frequency Data Link (HFDL) communications system, including avionics system components and the associated HF ground system. ARINC 634 and ARINC 635 are companion standards to this document.
Version history	-
Reference	https://www.sae.org/standards/content/arinc753-3/

Standard	ARINC755-5
Title	Multi-Mode Receiver (MMR) - Digital
Status	Active
Initial date	25-01-2018
Current version	-
Description	ARINC Characteristic 755 defines a multi-mode receiver that provides flight path deviation guidance (corrections) to the aircraft during the approach and landing phases. The data sources may include an Instrument Landing System (ILS), a Microwave Landing System (MLS), or a GNSS Landing System (GLS). Supplement 5 introduces annunciations defined in RTCA/DO-253D – MOPS for GPS LAAS Airborne Equipment. It also updates GNSS Data and GLS Config Validity ARINC 429 labels, and corrects the range for Selected Glide Path Angle.
Version history	-
Reference	https://www.sae.org/standards/content/arinc755-5/

Standard	ARINC756-3
Title	GNSS Navigation and Landing Unit (GNLU)
Status	Active
Initial date	27-02-2004
Current version	-
Description	This standard describes the function of the GNLS (Global Navigation Landing System), which includes the GNLU (Global Navigation Landing Unit) capable of providing enroute/terminal navigation, non-precision approach, and precision approach capabilities. The GNLS system consists of the GNLU, associated controls and displays, antenna, and interfaces with other aircraft systems.
Version history	-
Reference	https://www.sae.org/standards/content/arinc756-3/

Standard	ARINC760-1
Title	GNSS Navigation Unit (GNU)
Status	Active
Initial date	20-03-2000
Current version	-
Description	This standard defines the desired characteristics of a Global Navigation Unit (GNU). The GNU provides enroute/terminal navigation and non-precision approach capabilities. It is designed to support near-term CNS/ATM functions and provide growth potential for long-term applications.

Version history	-
Reference	https://www.sae.org/standards/content/arinc760-1/

Standard	ARINC761-6
Title	Second Generation Aviation Satellite Communication Systems, Aircraft Installation Provisions
Status	Active
Initial date	23-12-2019
Current version	-
Description	This ARINC Standard defines the installation characteristics of second-generation L-band satellite communication systems, detailing the traditional form, fit, function, and interfaces for installing satcom equipment in all types of aircraft. It includes descriptions of avionics equipment such as the Satellite Data Unit (SDU) and antennas. Supplement 6 adds references to new Diplexer/Low Noise Amplifiers (DLNAs) defined in Supplement 8 to ARINC Characteristic 781: Mark 3 Aviation Satellite Communication Systems. The five new DLNAs are designed to protect Inmarsat Classic Aero and Swift Broadband (SBB) satcom equipment from ground-based cellular sources, such as LTE and Ancillary Terrestrial Component (ATCt). The DLNAs are categorized by desired features and service (e.g., new DLNA versus drop-in replacement, LTE and/or ATCt protection, Classic Aero and/or SBB service).
Version history	-
Reference	https://www.sae.org/standards/content/arinc761-6/

Standard	ARINC762-1
Title	Terrain Awareness and Warning System (TAWS)
Status	Active
Initial date	15-09-2000
Current version	-
Description	This standard defines the characteristics of a terrain awareness and warning system (TAWS) intended for installation in aircraft with digital signal interfaces. It outlines the desired operational capabilities of the equipment, the standards required to ensure interchangeability, form factor, and pin assignments.
Version history	-
Reference	https://www.sae.org/standards/content/arinc762-1/

Standard	ARINC763A
Title	MARK 2 Network Server System (NSS) Form and Fit Definition
Status	Active
Initial date	09-12-2008
Current version	-
Description	This document defines both wired and wireless Network and System Services (NSS) components that facilitate the creation of airborne networks that are scalable, interchangeable, upgradeable, and remotely manageable at minimal cost. It also describes aircraft equipment configurations and wiring recommendations to allow for network

	growth through the simple addition or replacement of NSS components. The hardware characteristics of standardized components are detailed, without specifying equipment capacity or the operational functions of those components.
Version history	-
Reference	https://www.sae.org/standards/content/arinc763a/

Standard	ARINC766
Title	Aeronautical Mobile Airport Communication System (AEROMACS) Transceiver and Aircraft Installation Standards
Status	Active
Initial date	07-07-2017
Current version	-
Description	This document defines the installation characteristics of an airborne radio transceiver capable of broadband wireless communication with an Airport Surface Network. The Aeronautical Mobile Airport Communications System (AeroMACS) Radio Unit (ARU) operates in the aeronautical protected frequency range of 5091 MHz to 5150 MHz, utilizing the IEEE 802.16e WiMAX protocol. It is designed to offload some of the congested narrowband VHF airport traffic used for ATS and AOC communications. The document includes descriptions of the ARU and antenna form, fit, function, and interfaces.
Version history	-
Reference	https://www.sae.org/standards/content/arinc766/

Standard	ARINC771
Title	Low-Earth Orbiting Aviation Satellite Communication Systems
Status	Active
Initial date	26-06-2024
Current version	ARINC771-3
Description	This document defines the desired characteristics of the Iridium Low-Earth Orbiting (LEO) Aviation Satellite Communication (Satcom) System avionics, intended for installation in various aircraft types, including commercial transport, business, and general aviation aircraft. It describes the system components, aircraft interfaces, and satellite communication functions, outlining the desired system performance and operational capabilities. The equipment specified supports Air Traffic Safety Services and operates with the next generation of Iridium satellites, known as Iridium NEXT, in the L band. The Iridium Certus® services, offered based on maximum baud rates and antenna configurations, replace the legacy Iridium Block 1 satellite network.
Version history	ARINC771-2 ARINC771-1 ARINC771
Reference	https://saemobilus.sae.org/standards/arinc771-3-771-3-low-earth-orbiting-aviation-satellite-communication-systems

Standard	ARINC781-9
Title	Mark 3 Aviation Satellite Communication Systems
Status	Active

Initial date	31-07-2024
Current version	ARINC781-9
Description	This document defines the desired characteristics of an aviation satellite communication (satcom) system intended for installation in all types of commercial transport and business aircraft. It provides general and specific guidance on the form factor and pin assignments for avionics installation, primarily for airline use. The document describes the desired operational capabilities of the equipment for providing data and voice communications, along with additional standards necessary to ensure interchangeability. This characteristic specifies equipment using Inmarsat satellites operating in L-band, while Ku-band and Ka-band equipment are specified in ARINC Characteristics 791, 792, and 793.
Version history	ARINC781-8
Reference	https://saemobilus.sae.org/standards/arinc781-9-781-9-mark-3-aviation-satellite-communication-systems

Standard	ARINC791P1-3
Title	Mark I Aviation Ku-Band and Ka-Band Satellite Communication System, Part 1, Physical Installation and Aircraft Interfaces
Status	Active
Initial date	19-09-2019
Current version	-
Description	This standard defines the desired characteristics of Aviation Ku-band and Ka-band Satellite Communication (Satcom) Systems intended for installation in all types of commercial air transport aircraft. It provides guidance on the interfaces, form, fit, and function of the systems. The document also outlines the desired operational capabilities of the equipment required to provide a broadband transport link for data, video, and voice communications, typically used for passenger communications and/or entertainment. The systems described in this characteristic are not qualified for aviation safety functions as of this writing.
Version history	-
Reference	https://saemobilus.sae.org/standards/arinc791p1-3-791p1-3-mark-aviation-ku-band-ka-band-satellite-communication-system-part-1-physical-installation-aircraft-interfaces

Standard	ARINC791P2
Title	Mark I Aviation Ku-Band and Ka-Band Satellite Communication System, Part 2, Electrical Interfaces and Functional Equipment Description
Status	Active
Initial date	29-01-2024
Current version	ARINC791P2-2
Description	This document (ARINC Characteristic 791, Part 2) provides the non-networking interface definition for the Mark I (ARINC 791) and Mark II (ARINC 792) Ku-Band and Ka-Band Satellite Communication (satcom) systems, intended for passenger entertainment on commercial transport aircraft.
Version history	ARINC791P2-1
Reference	https://saemobilus.sae.org/standards/arinc791p2-2-791p2-2-mark-aviation-ku-band-ka-band-satellite-communication-system-part-2-electrical-interfaces-functional-equipment-description

Standard	ARINC792
Title	Second-Generation Ku-Band and Ka-Band Satellite Communication System
Status	Active
Initial date	25-08-2023
Current version	ARINC792-2
Description	This standard defines the desired characteristics of a second-generation aviation Ku-band and Ka-band satellite communication (satcom) system intended for installation in all types of aircraft.
Version history	ARINC792-1 ARINC792
Reference	https://saemobilus.sae.org/standards/arinc792-2-792-2-second-generation-ku-band-ka-band-satellite-communication-system

Standard	ARINC811
Title	Commercial Aircraft Information Security Concepts of Operation and Process Framework
Status	Active
Initial date	20-12-2005
Current version	-
Description	The purpose of this document is to promote a common understanding of aircraft information security and develop operational concepts for it. This is essential as various subcommittees and working groups within the aeronautical industry address aircraft information security. The document provides a process framework for aircraft information security, tailored to airline operational needs. When implemented by airlines and their suppliers, this framework enables the safe and secure dispatch of aircraft in a timely manner. It also facilitates the development of cost-effective security measures and provides a common language for addressing security requirements.
Version history	-
Reference	https://www.sae.org/standards/content/arinc811/

Standard	ARINC816-3
Title	Embedded Interchange Format for Airport Mapping Database
Status	Active
Initial date	31-08-2016
Current version	-
Description	This document defines an open encoding format for airport databases (AMDB) loaded into airborne systems. The format is designed to enable quick, economical, and efficient use of AMDB. However, since industry applications are not required to be standardized, data interpretation is not addressed in this document.
Version history	-
Reference	https://www.sae.org/standards/content/arinc816-3/

Standard	ARINC816-2C1
Title	Embedded Interchange Format for Airport Mapping Database

Status	Active
Initial date	31-08-2016
Current version	-
Description	This document defines an open encoding format for airport databases (AMDB) loaded into airborne systems. The format aims to enable quick, economical, and efficient use of AMDB. However, since the industry does not require standardized applications, data interpretation is not covered in this document.
Version history	-
Reference	https://www.sae.org/standards/content/arinc816-2c1/

Standard	ARINC821
Title	Aircraft Network Server System (NSS) Functional Definition
Status	Active
Initial date	09-12-2008
ARINC823P1	-
Description	This document outlines a collection of Aircraft Network Services (ANS) and Network Server System (NSS) functions suitable for installation in all types of aircraft. It defines network services for both aircraft and cabin installations that manage and maintain the NSS in a consistent manner. The document also describes methods for effective communication between the aircraft and ground-based information management systems.
Version history	-
Reference	https://www.sae.org/standards/content/arinc821/

Standard	ARINC823P1
Title	Datalink Security, Part 1 - ACARS Message Security Current
Status	Active
Initial date	10-12-2007
Current version	-
Description	The purpose of this document is to establish an industry standard for ACARS Message Security (AMS), enabling ACARS datalink messages to be exchanged securely and authenticated between aircraft and ground systems using a uniform security framework. The security framework outlined is based on open international standards, adapted to the ACARS datalink communications environment.
Version history	-
Reference	https://saemobilus.sae.org/standards/arinc823p1-823p1-datalink-security-part-1-acars-message-security

Standard	ARINC823P2
Title	Datalink Security, Part 2 - Key Management
Status	Active
Initial date	10-03-2008

Current version	-
Description	The purpose of this document is to provide recommended guidance and provisions for ACARS Message Security (AMS) key management. The key management framework outlined is based on open international standards, specifically adapted to the ACARS datalink communications environment.
Version history	-
Reference	https://saemobilus.sae.org/standards/arinc823p2-823p2-datalink-security-part-2-key-management

Standard	ARINC826-1
Title	Software Data Loader Using CAN Interface
Status	Active
Initial date	20-12-2013
Current version	-
Description	The purpose of this standard is to provide a simple and efficient protocol for loading software parts to line replaceable units (LRUs) on a CAN bus, offering an alternative to ARINC Report 615A or ARINC Report 615. It is not intended to be the only CAN software loading option, but rather for avionics devices that are software loadable.
Version history	-
Reference	https://www.sae.org/standards/content/arinc826-1/

Standard	ARINC830
Title	Aircraft/Ground Information Exchange (AGIE) Using Internet Protocol
Status	Active
Initial date	15-09-2014
Current version	-
Description	The purpose of this document is to define a general-purpose, non-proprietary information exchange framework and protocol for Internet Protocol-based message traffic between aircraft and airline ground infrastructure. This standard aims to simplify information processing management for airlines by replacing multiple dissimilar implementations with a single universal system, thereby creating a more economical environment.
Version history	-
Reference	https://saemobilus.sae.org/standards/arinc830-830-aircraft-ground-information-exchange-agie-using-internet-protocol

Standard	ARINC834-8
Title	Aircraft Data Interface Function (ADIF)
Status	Active
Initial date	21-07-2020
Current version	-
Description	This document defines an Aircraft Data Interface Function (ADIF) for aircraft installations incorporating network components based on commercially available technologies. It outlines a set of protocols and services for exchanging avionics data across aircraft

	networks. The document describes a common set of services that can access specific avionics parameters. The ADIF may be implemented as a generic network service or as a dedicated service within an ARINC 759 Aircraft Interface Device (AID), such as those used with an Electronic Flight Bag (EFB).
Version history	-
Reference	https://saemobilus.sae.org/standards/arinc834-8-834-8-aircraft-data-interface-function-adif

Standard	ARINC834A
Title	Internet Protocol Based Aircraft Data Interface Function (ADIF)
Status	Active
Initial date	27-02-2023
Current version	-
Description	This standard defines the Secure Open Data and Avionics Services (SODAS), transport layers, and suggested security mechanisms to facilitate communication between aircraft systems and an Electronic Flight Bag (EFB). It outlines a set of protocols and services for exchanging avionics data across aircraft networks. The goal is to establish a common set of services to access specific avionics data, thereby enhancing EFB applications.
Version history	-
Reference	https://saemobilus.sae.org/standards/arinc834a-arinc-834a-internet-protocol-based-aircraft-data-interface-function-adif

Standard	ARINC835-1
Title	Guidance for Security of Loadable Software Parts Using Digital Signatures
Status	Active
Initial date	02-01-2014
Current version	-
Description	This document provides background and detailed technical information on existing methods for securing loadable software parts.
Version history	-
Reference	https://www.sae.org/standards/content/arinc835-1/

Standard	ARINC839
Title	Function Definition of Airborne Manager of Air-Ground Interface Communications (MAGIC)
Status	Active
Initial date	12-09-2014
Current version	-
Description	This standard defines an Internet Protocol (IP)-based communication management function called the Manager of Air/Ground Interface Communications (MAGIC). It acknowledges the expanding availability of off-board communication links, such as broadband satellite, broadband terrestrial, and Gatelink, each provided by different service providers. These links may be accessible to the aircraft during specific flight phases and geographic locations. As the industry increasingly adopts IP-based communications, this standard aims

	to define an aircraft routing function that provides standardized access for all aircraft subnets to available communication links.
Version history	-
Reference	https://saemobilus.sae.org/standards/arinc839-839-function-definition-airborne-manager-air-ground-interface-communications-magic

Standard	ARINC841-3
Title	Media Independent Aircraft Messaging (MIAM)
Status	Active
Initial date	20-07-2016
Current version	-
Description	The purpose of this document is to establish an industry standard for Media Independent Aircraft Messaging (MIAM), which enables the exchange of large volumes of data over Aircraft Communications Addressing and Reporting System (ACARS) subnetworks or broadband Internet Protocol (IP) subnetworks.
Version history	-
Reference	https://www.sae.org/standards/content/arinc841-3/

Standard	ARINC842-3
Title	Guidance for Usage of Digital Certificates
Status	Active
Initial date	01-07-2022
Current version	-
Description	The purpose of this document is to provide operational guidance for key life-cycle management, covering the phases through which digital certificates and cryptographic keys progress, from creation to usage and retirement. It also offers implementation guidance for online certificate provisioning of aircraft systems. The scope includes both onboard (aircraft system) and ground components (PKI provider and Ground Infrastructure). By considering both onboard and ground, the document ensures that security is integrated into the process flow and chain of custody. The guidance is based on open international standards tailored to the aviation environment, acknowledging the complexity and regulation of commercial aircraft and the involvement of multiple stakeholders. Adopting a standardized key management approach, as outlined, helps reduce design, implementation, and operational costs across a diverse fleet.
Version history	-
Reference	https://www.sae.org/standards/content/arinc842-3/

Standard	ARINC843-1
Title	Aircraft Software Common Configuration Reporting
Status	Active
Initial date	13-08-2019
Current version	-
Description	The standard establishes a universal configuration report format which aircraft systems can provide to ground tools and maintenance staff. The reports use Extensible Markup

	Language (XML) format to generate structured data according to the specifications found in this document. The standard includes multiple optional elements and attributes which enable individual reports to have flexibility. The standard enables aircraft manufacturers and regulatory agencies and airlines to use a single format for aircraft configuration reporting which supports automated comparison of configuration data reports (e.g., authorized vs. actual configurations).
Version history	-
Reference	https://www.sae.org/standards/content/arinc843-1/

Standard	ARINC847
Title	Product Development Guidance for Maintainability and Testability (PMDMAT)
Status	Active
Initial date	10-07-2015
Current version	-
Description	ARINC Report 847: Product Development Guidance for Maintainability and Testability (PDMaT) provides guidance to enhance the design of avionic equipment, with a focus on maintainability and testability characteristics. It is a parallel standard to ARINC Report 607: Design Guidance for Avionic Equipment. While not a complete formula for designing and manufacturing avionics, this document reflects the airline community's vision based on extensive operational experience. It offers useful information for establishing a foundation to develop superior products, focusing on design philosophy and recommended practices. This guidance is beneficial not only to equipment manufacturers but also to airframe manufacturers incorporating avionic equipment into aircraft systems.
Version history	-
Reference	https://www.sae.org/standards/content/arinc847/

Standard	ARINC852
Title	Guidance for Security Event Logging in an IP Environment
Status	Active
Initial date	21-06-2017
Current version	-
Description	This report provides guidance for IP-based onboard networks and systems within the Airline Information Services (AIS) and Passenger Information and Entertainment Services (PIES) domains. It establishes a common set of security-related data elements and formats produced by aircraft systems, which are suitable for use by airline IT and/or avionics supplier analytical ground tools.
Version history	-
Reference	https://www.sae.org/standards/content/arinc852/

Standard	ARINC858P1
Title	Internet Protocol Suite (IPS) for Aeronautical Safety Services Part 1 Airborne IPS System Technical Requirements
Status	Active
Initial date	21-06-2021

Current version	-
Description	ARINC 858 Part 1 defines the airborne data communication network infrastructure for aviation safety services using the Internet Protocol Suite (IPS). It builds upon ICAO Doc 9896, the Manual on the Aeronautical Telecommunication Network (ATN) using IPS Standards and Protocols. IPS extends the life of existing data communication services like VDL, Inmarsat SBB, and Iridium NEXT. This standard outlines the evolutionary transition from ACARS and ATN/OSI to ATN/IPS, incorporating advanced capabilities such as aviation security and mobility.
Version history	-
Reference	https://www.sae.org/standards/content/arinc858p1/

Standard	ARINC858P2
Title	Internet Protocol Suite (IPS) for Aeronautical Safety Services Part 2 IPS Gateway Air-Ground Interoperability
Status	Active
Initial date	21-06-2021
Current version	-
Description	ARINC 858 Part 2 outlines the aviation ground system gateway considerations necessary for transitioning to the Internet Protocol Suite (IPS). It describes the operational principles of an IPS gateway that facilitates the exchange of ACARS application messages between an IPS-equipped aircraft and a ground ACARS host. Additionally, it covers the principles of operation for an IPS gateway enabling the exchange of OSI-based application messages between an IPS host and an OSI end system. This document was developed in coordination with ICAO WG-I, RTCA SC-223, and EUROCAE WG-108.
Version history	-
Reference	https://www.sae.org/standards/content/arinc858p2/

Standard	GEIASTD0010
Title	Standard Best Practices for System Safety Program Development and Execution
Status	Active
Initial date	18-10-2018
Current version	GEIASTD0010A
Description	The document presents standard procedures for system safety assessment which other specific commodity standards like commercial aircraft and automobiles standards may contain. Commercial aircraft manufacturers need to consult SAE ARP4754 or SAE ARP4761 to fulfill system safety-related FAA regulatory requirements. The defined system safety practice provides a uniform method for risk evaluation which focuses on identifying and assessing and reducing mishap risks to the lowest achievable level. The appropriate authority must approve the risks while ensuring they follow all relevant laws and regulations and agreements. The document functions as part of project solicitation for complex systems to direct risk assessments and verify safety requirements with additional details located in the Appendices.
Version history	GEIASTD0010
Reference	https://www.sae.org/standards/content/geiastd0010a/

Standard	SAE1001

Title	Integrated Project Processes for Engineering a System
Status	Active
Initial date	09-10-2018
Current version	-
Description	This standard is applicable to the engineering or reengineering of various systems, whether commercial or non-commercial, small or large, simple or complex, and software-intensive or not. It covers systems made up of hardware, software, firmware, personnel, facilities, data, materials, services, techniques, or processes, including combinations of these elements. The standard applies to both new and legacy systems, or portions thereof. Its requirements, or a subset thereof, are intended for projects to establish policies and procedures for implementing the adopted process and its elements. The requirements of this standard can be tailored in the following ways: • **Processes**: Tailored for specific project types or systems. For example, System Utilization Processes may not apply in the same way for prototype systems as for production systems. • **Activities**: Tailored to reflect the specific approach of a project, ensuring the intended Process Purpose and Outcomes are still met. • **Tasks, Inputs, and Outputs**: Tailored to reflect specific approaches or methods, including different life cycle approaches, ensuring the Activity's intended purpose is achieved.
Version history	-
Reference	https://www.sae.org/standards/content/sae1001/

Standard	SAE1003
Title	Glossary of System Safety Engineering and Management
Status	Ongoing
Initial date	08-05-2018
Current version	-
Description	This SAE Aerospace Information Report will compile system safety engineering and management terms and definitions, covering concepts used across multiple products and disciplines.
Version history	-
Reference	https://www.sae.org/standards/content/sae1003/

Standard	SAE1005
Title	Model Based Functional Safety
Status	Ongoing
Initial date	17-05-18
Current version	-
Description	This standard provides guidance on major tasks and activities for implementing and managing Functional Safety and software system safety aspects within Model-Based System Engineering (MBSE). The focus is on safety-critical functions (SCFs) of complex, software-intensive systems, which are modeled and depicted graphically as part of MBSE and software engineering. The goal is to ensure safety engineering aspects are tracked and captured in the models, enhancing safety documentation and producing objective safety evidence.

Version history	-
Reference	https://www.sae.org/standards/content/sae1005/

2.2.6 IETF

Standard	RFC 9153
Title	Drone Remote Identification Protocol (DRIP) Requirements and Terminology
Status	Active
Initial date	10-02-2022
Current version	-
Description	This document established the terms and requirements for solutions created by the Drone Remote Identification Protocol Working Group. These solutions help with the Unmanned Aircraft System Remote Identification (UAS RID) for purposes such as security, safety and other uses like identity-based network sessions for UAS services. DRIP seeks to leverage the existing Internet resources to support RID, enhance related services and provide ways to verify RID information both online and offline in order to ensure the trustworthiness.
Version history	-
Reference	https://datatracker.ietf.org/doc/rfc9153/ https://www.rfc-editor.org/info/rfc9153

Standard	RFC 9434
Title	Drone Remote Identification Protocol (DRIP) Architecture
Status	Active
Initial date	17-07-2023
Current version	-
Description	This document outlines an architecture for protocols and services designed to support Unmanned Aircraft System Remote Identification and Tracking (UAS RID), along with related communications. This architecture complies with the requirements specified in the Drone Remote Identification Protocol (DRIP) Requirements document (RFC 9153).
Version history	-
Reference	https://datatracker.ietf.org/doc/rfc9434/ https://www.rfc-editor.org/info/rfc9434

Standard	RFC 9374
Title	DRIP Entity Tag (DET) for Unmanned Aircraft System Remote ID (UAS RID)
Status	Active
Initial date	12-12-2023
Current version	-
Description	This document explains the use of Hierarchical Host Identity Tags (HHITs) as self-asserting IPv6 addresses, making them reliable identifiers for Unmanned Aircraft System Remote Identification (UAS RID) and tracking.

	In the context of RID, HHITs are referred to as DRIP Entity Tags (DETs). HHITs offer claims to an embedded explicit hierarchy, enabling registry discovery (through mechanisms such as DNS or RDAP) for third-party identifier endorsement.
Version history	-
Reference	https://datatracker.ietf.org/doc/rfc9374/

Standard	RFC 9575
Title	DRIP Entity Tag (DET) Authentication Formats and Protocols for Broadcast Remote Identification (RID)
Status	Active
Initial date	26-06-2024
Current version	-
Description	The Drone Remote Identification Protocol (DRIP), along with trust policies and periodic registry access, enhances Unmanned Aircraft System (UAS) Remote Identification (RID). It enables local, real-time evaluation of the trustworthiness of received RID messages and observed UAS, even for observers without Internet access. This document specifies DRIP message types and formats used in Broadcast RID Authentication Messages to verify that both attached and recently detached messages were signed by the registered owner of the claimed DRIP Entity Tag (DET).
Version history	-
Reference	https://datatracker.ietf.org/doc/rfc9575/ https://www.rfc-editor.org/info/rfc9575

2.2.7 RTCA

Standard	DO-160G
Title	Environmental Conditions and Test Procedures for Airborne Equipment
Status	Active
Initial date	08-12-2010
Current version	-
Description	DO-160G establishes standardized procedures and environmental test criteria for evaluating airborne equipment across a wide range of aircraft, from light general aviation planes and helicopters to large commercial jets and supersonic transport (SST) aircraft.
Version history	-
Reference	https://products.rtca.org/21811e0/

Standard	DO-178C
Title	Software Considerations in Airborne Systems and Equipment Certification
Status	Active
Initial date	13-12-2011
Current version	-
Description	This document offers guidelines for developing software for airborne systems and equipment, ensuring it performs its intended function with a level of safety confidence that

	meets airworthiness standards. Adhering to the objectives of DO-178C is the primary method for obtaining approval for software used in civil aviation products. Errata has been issued for DO-178C.
Version history	-
Reference	https://products.rtca.org/2181fb0/

Standard	DO-181E
Title	Minimum Operational Performance Standards for Air Traffic Control Radar Beacon System/Mode Select (ATCRBS/Mode S) Airborne Equipment
Status	Active
Initial date	17-03-2011
Current version	-
Description	This document replaces DO-181D, published in 2008, and sets standards for Mode S airborne equipment, combining ATCRBS and Mode S capabilities. It outlines system characteristics beneficial for users, designers, manufacturers, and installers, considering configurations that include a transponder, control panel, antenna, and interconnecting cables. It covers transponder Levels 1–5, offering test procedures and optional feature details. The document incorporates feedback from the ICAO Aeronautical Surveillance Panel Technical Subgroup and Civil Aviation Authorities since 2008. Developed in coordination with EUROCAE WG-49, it integrates changes from DO-260B (ADS-B MOPS, 2009). Appendix E highlights the updates from DO-181D to DO-181E.
Version history	-
Reference	https://products.rtca.org/21dimcr/

Standard	DO-229F
Title	MOPS for Global Positioning System/Satellite-Based Augmentation System Airborne Equipment
Status	Active
Initial date	11-06-2020
Current version	-
Description	This document replaces DO-181D from 2008 and sets standards for Mode S airborne equipment, combining ATCRBS and Mode S functions. It specifies system characteristics for users, designers, manufacturers and installers, covering configurations with a transponder, control panel, antenna and cables. It includes transponder Levels 1-5, test procedures and optional features. The document reflects input from the ICAO Aeronautical Surveillance Panel and Civil Aviation Authorities since 2008 and was developed with EUROCAE WG-49, incorporating updates from DO-260B (ADS-B MOPS, 2009).
Version history	-
Reference	https://products.rtca.org/21dionq/

Standard	DO-248C
Title	Supporting Information for DO-178C and DO-278A
Status	Active
Initial date	13-12-2011

Current version	-
Description	This document responds to questions from both industry and regulatory bodies, featuring FAQs, discussion papers (DPs) and rationale. Despite many FAQs and DPs are retained from DO-248B, some have been updated to reflect changes from DO-178B to DO-178C and to apply to DO-278A. New FAQs and DPs have been added to clarify aspects of DO-178C and DO-278A. Errata from DO-178B, previously in Section 2 of DO-248B, are now included in DO-178C and DO-248C
Version history	-
Reference	https://products.rtca.org/21dirnv/

Standard	DO-253D Change1
Title	Minimum Operational Performance Standards for GPS Local Area Augmentation System Airborne Equipment
Status	Active
Initial date	27-06-2019
Current version	-
Description	This document complements ICAO Annex 10 Volume I GBAS standards for Approach Service Types C (GAST C) and D (GAST D), and the Differentially Corrected Positioning Service (DCPS). GAST C and D support all approach, landing, and guided takeoff operations with vertical and lateral guidance, while DCPS provides horizontal positioning in airport and terminal areas. RTCA DO-253D Change 1 updates GBAS VHF Data Broadcast (VDB) receiver adjacent channel rejection requirements (Section 2.2.8), test procedures (Section 2.5), and rationale (Appendix K) following ICAO coordination. It also corrects the embedded synchronization test message (Table 2-26) and supersedes RTCA DO-253D.
Version history	-
Reference	https://products.rtca.org/21dis8l/

Standard	DO-254
Title	Design Assurance Guidance for Airborne Electronic Hardware
Status	Active
Initial date	19-04-2000
Current version	-
Description	This document guides aircraft manufacturers and electronic system suppliers in ensuring airborne equipment safely performs its intended function. It outlines design life cycle processes for hardware, including line replaceable units, circuit board assemblies, ASICs, and programmable logic devices. Additionally, it defines the objectives of these processes and provides a framework for meeting certification requirements.
Version history	-
Reference	https://products.rtca.org/21dis94/

Standard	DO-262F
Title	Minimum Operational Performance Standards for Avionics Supporting Next Generation Satellite Systems (GNSS)
Status	Active

Initial date	17-06-2021
Current version	-
Description	This document outlines Minimum Operational Performance Standards (MOPS) for avionics supporting Aeronautical Mobile Satellite (R) Services (AMS(R)S) using satellite communication technologies set for deployment in global and regional ATM and CNS modernization efforts (e.g., ICAO Global Air Navigation Plan, Europe's SESAR, US NextGen). These technologies are collectively referred to as "Next Generation Satellite System" (NGSS), a term used throughout the document. It does not cover avionics compliant with AMS(R)S standards defined in ICAO Annex 10, Part I, Volume III, Chapter 4 (Chapter 4 SARPS), which are specified in RTCA DO-210D.
Version history	-
Reference	https://standards.globalspec.com/std/14395047/do-262f

Standard	DO-278
Title	Guidelines For Communication, Navigation, Surveillance, and Air Traffic Management (CNS/ATM) Systems Software Integrity Assurance
Status	Active
Initial date	05-03-2002
Current version	-
Description	This document offers guidelines for ensuring software integrity in non-airborne CNS/ATM systems. It interprets the objectives of DO-178B/ED-12B, which where originally for airborne software and adapts them for non-airborne CNS/ATM systems where applicable.
Version history	-
Reference	https://products.rtca.org/21dj7vv/

Standard	DO-289 Change 1
Title	Minimum Aviation System Performance Standards (MASPS) for Aircraft Surveillance Applications (ASA)
Status	Active
Initial date	13-12-2006
Current version	-
Description	This update to DO-289 primarily clarifies the definitions of several parameters transmitted by aircraft in ADS-B messages, which inform recipients about the quality of the transmitted position data. The changes are designed to align with commonly available aircraft position sources and should not affect ADS-B equipment previously certified under RTCA DO-260A for 1090 MHz Extended Squitter or RTCA DO-282A for the Universal Access Transceiver (UAT).
Version history	-
Reference	https://my.rtca.org/productdetails?id=a1B36000001IcheEAC

Standard	DO-292
Title	Assessment of Radio Frequency Interference Relevant to the GNSS L5/E5A Frequency Band
Status	Active

Initial date	29-07-2004
Current version	-
Description	DO-292 focuses on potential radio frequency interference (RFI) affecting the future GNSS L5 signal used for aeronautical radio navigation. Where applicable, it also considers RFI impacts on the Galileo E5A signal.
Version history	-
Reference	https://products.rtca.org/21dj8up/

Standard	DO-304A
Title	Guidance Material and Considerations for Unmanned Aircraft Systems
Status	Active
Initial date	17-06-2021
Current version	-
Description	This updated version of DO-304 provides guidance for Unmanned Aircraft Systems (UAS) operations in the US National Airspace System. DO-304A expands it predecessor with new use cases like cargo missions, survey missions, high altitude platforms and urban air mobility. It aims to educate the aviation community and support future UAS standard discussions, defining UAS, outlining the operation environment and provides a functional overview. Though it is not intender for airworthiness certification or operation approval
Version history	-
Reference	https://products.rtca.org/21dj91e/

Standard	DO-316
Title	Minimum Operational Performance Standards for Global Positioning System/Aircraft Base Augmentation System
Status	Active
Initial date	14-04-2009
Current version	-
Description	This document establishes Minimum Operational Performance Standards (MOPS) for single-frequency airborne navigation sensor equipment not supported by ground or space-based augmentation. It sets minimum performance, functions, and features for GPS sensors that provide position data to multi-sensor or separate navigation systems. It also covers Area Navigation (RNAV) for end route, terminal, and Lateral Navigation (LNAV) phases. Based on RTCA/DO-229D for GPS/WAAS Class Beta 1 receivers without SBAS, it updates the signal operating environment, accounts for the removal of Selective Availability (disabled in 2001), enhances RAIM capabilities, and includes optional GPS receiver velocity accuracy and velocity FOM computation.
Version history	-
Reference	https://products.rtca.org/21dj9vr/

Standard	DO-326B
Title	Airworthiness Security Process Specification
Status	Active

Initial date	26-09-2024
Current version	-
Description	This document expands existing aircraft certification guidance to address the threat of Intentional Unauthorized Electronic Interaction (IUEI) to aircraft safety. It introduces data requirements and compliance objectives, structured around generic activities for aircraft development and certification. This guidance supports certification related to aircraft information security under EASA AMC 20-42 for CS-E 50, CS-P 230, and CS 25.1319, as well as upcoming FAA regulations for 14 CFR 25.1319, 33.28, and 35.23.
Version history	-
Reference	https://products.rtca.org/235l0eb/1

Standard	DO-343
Title	Minimum Aviation System Performance Standard for AMS(R)S Data and Voice Communications Supporting Required Communications Performance (RCP) and Required Surveillance Performance (RSP)
Status	Active
Initial date	26-03-2020
Current version	-
Description	This document outlines Minimum Aviation System Performance Standards (MASPS) for Aeronautical Mobile Satellite (Route) Services (AMS(R)S), supporting safety communications in airspace with either procedural separation or ATS surveillance services. It defines performance requirements for (1) data communication services that meet RCP130/A1, RCP240/A1, RCP400/A1, or RCP400/A2 standards for two-way Controller Pilot Data Link Communications (CPDLC) and RSP160/A1, RSP180/A1, or RSP400/A1 standards for one-way surveillance data, and (2) voice communication services that comply with RCP400/V for two-way pilot-controller communications and RSP400/V for one-way voice transmissions.
Version history	-
Reference	https://standards.globalspec.com/std/14281993/rtca-do-343

Standard	DO-346A
Title	Minimum Operational Performance Standards (MOPS) for the Aeronautical Mobile Airport Communication System (AeroMACS)
Status	Active
Initial date	23-06-2022
Current version	-
Description	This document defines the minimum operational performance standards for both the airborne and ground-based components of the Aeronautical Mobile Airport Communication System (AeroMACS). Compliance with these standards ensures reliable performance under typical aeronautical conditions. Regulatory use of these standards is determined by relevant authorities and provides guidance for designers, manufacturers, installers and users
Version history	-
Reference	https://store.accuristech.com/standards/rtca-do-346a?product_id=2258968

Standard	DO-355A
Title	Information Security Guidance for Continuing Airworthiness
Status	Active
Initial date	10-09-2020
Current version	-
Description	This joint document offers guidance that serves as an Acceptable Means of Compliance for approving information security aspects related to Continuing Airworthiness activities carried out by Design Approval Holders and Operators.
Version history	-
Reference	https://products.rtca.org/21djd2g/

Standard	DO-356A
Title	Airworthiness Security Methods and Considerations
Status	Active
Initial date	21-06-2018
Current version	-
Description	This document is a collaborative effort between two industry committees: the EUROCAE Working Group WG-72, "Aeronautical Systems Security," and the RTCA Special Committee SC-216, also titled "Aeronautical Systems Security."
Version history	-
Reference	https://products.rtca.org/21djdi5/

Standard	DO-362A
Title	Command and Control (C2) Data Link Minimum Operational Performance Standards (MOPS) (Terrestrial)
Status	Active
Initial date	17-12-2020
Current version	-
Description	This document outlines the Minimum Operational Performance Standards (MOPS) for the Unmanned Aircraft Systems (UAS) Command and Control (C2) Data Link, referred to as the Control and Non-Payload Communication (CNPC) Link System. It supports UAS Command and Control functions, including remote pilot-to/from-ATC voice communications, also known as ATC relay. Payload communications, which relate to mission-specific data and exclude safety-of-flight information, are not covered. As such, they are prohibited from using the CNPC Link System, which operates on aviation safety-protected spectrum, as specified in this MOPS.
Version history	-
Reference	https://store.accuristech.com/standards/rtca-do-362a?product_id=2258972

Standard	DO-362 with Errata
Title	Command and Control (C2) Data Link Minimum Operational Performance Standard (MOPS) (Terrestrial)

Status	Active
Initial date	22-09-2016
Current version	-
Description	The Command and Control (C2) Data Link Minimum Operating Performance Standard (MOPS) (Terrestrial) sets performance requirements for the safety-of-flight Control and Non-Payload Communications (CNPC) function, enabling UAS pilots to maneuver aircraft safely from the ground. It focuses on technical standards for spectrum-sharing compatibility without specifying waveforms. Interoperability requirements are excluded since they pertain to internal UAS interfaces. The International Telecommunications Union (ITU) has identified potential spectrum bands, including L-Band, C-Band, and SATCOM. This MOPS defines performance requirements for L-Band and C-Band terrestrial networks and outlines a verification and validation program, covering both airborne and ground equipment, along with supporting assumptions and derived requirements in its appendices.
Version history	-
Reference	https://my.rtca.org/productdetails?id=a1B36000001y1BVEAY

Standard	DO-365C
Title	Minimum Operational Performance Standards (MOPS) for Detect and Avoid (DAA) Systems
Status	Active
Initial date	15-09-2022
Current version	-
Description	This document outlines Minimum Operational Performance Standards (MOPS) for Detect and Avoid (DAA) systems used by aircraft operating in Class D, E, and G airspace, as well as transiting through Class B and C airspace. It covers equipment enabling UAS operations near Terminal Areas during approach and departure in Class C, D, E, and G airspace and off-airport locations but excludes operations in the visual traffic pattern or on the surface. The standards do not apply to small UAS (under 55 lbs.) operating in low-level environments below 400 feet or in other designated segmented areas.
Version history	-
Reference	https://products.rtca.org/21djqhn/

Standard	DO-366A
Title	Minimum Operational Performance Standards (MOPS) for Air-to-Air Radar for Traffic Surveillance
Status	Active
Initial date	10-09-2020
Current version	-
Description	This document presents the first update to the Minimum Operational Performance Standards (MOPS) for air-to-air radar used in traffic surveillance, supporting Detect and Avoid (DAA) operations, including collision avoidance, for detecting intruders below 10,000' Mean Sea Level (MSL). It outlines radar system characteristics relevant to designers, manufacturers, installers, and users. The radar's purpose is to detect and track airborne traffic within its detection volume, complementing other sensors by identifying non-cooperative targets. Tracks must be established with sufficient range and accuracy for safe maneuvering. The document details performance and environmental requirements, including verification methods through bench, flight, and environmental tests.

Version history	-
Reference	https://products.rtca.org/21djqiu/

Standard	DO-377B
Title	Minimum Aviation System Performance Standards for C2 Link Systems Supporting Operations of Unmanned Aircraft Systems in U.S. Airspace
Status	Active
Initial date	14-12-2023
Current version	-
Description	This document defines and justifies the Minimum Aviation System Performance Standards (MASPS) for a Command and Control (C2) Link System used to monitor and control an Uncrewed Aircraft System (UAS), facilitating information exchange between a Control Station (CS) and an Uncrewed Aircraft (UA). While not the only standard, it represents a viable approach developed by Special Committee SC-228. This B version of DO-377 builds on previous efforts, adding a new CONOPS for Low Altitude Delivery supporting small package delivery and five new scenarios, including two air taxi, two surface taxi, and one small package delivery using advanced technologies. Expanded appendices and new requirements are included in Section 3.
Version history	-
Reference	https://products.rtca.org/21djt5o/

Standard	DO-380
Title	Environmental Conditions and Test Procedures for Ground Based Equipment
Status	Active
Initial date	11-06-2020
Current version	-
Description	This document establishes minimum standard environmental test conditions and applicable procedures for ground-based equipment, including stationary, mobile/portable, and sea-based systems. The tests aim to evaluate equipment performance in laboratory settings under environmental conditions that simulate those likely encountered during ground-based operation.
Version history	-
Reference	https://standards.globalspec.com/std/14281958/rtca-do-380

Standard	DO-381A
Title	MOPS for GBSS for Traffic Surveillance
Status	Active
Initial date	14-12-2023
Current version	-
Description	This document outlines the Minimum Operational Performance Standards (MOPS) for the Ground Based Surveillance System (GBSS) used in Traffic Surveillance for Unmanned Aircraft Systems (UAS) operating in Class C, D, E, G, and transiting Class B airspace. It covers equipment supporting UAS operations near terminal areas during approach, departure, and off-airport locations. The standards exclude small UAS (sUAS) defined

	under Title 14 CFR Chapter 107, Visual Flight Rules (VFR) traffic pattern operations, and surface activities. These requirements detail surveillance system characteristics useful for designers, manufacturers, installers, and users.
Version history	-
Reference	https://products.rtca.org/21dk01f/

Standard	DO-382
Title	Minimum Aviation System Performance Standards CAS Interoperability
Status	Active
Initial date	10-09-2020
Current version	-
Description	This document sets out key requirements, called Minimum Aviation System Performance Standards (MASPS), to make sure different airborne Collision Avoidance Systems (CAS) work well together. The main goal is to stop new, systems from interfering with existing ones. It gives useful info for designers, manufacturers, installers and users while at the same time offers extra guidance when some requirements are not fully clear yet. Following these standards does not automatically mean a system is approved for use. The focus here is just on how these systems interact instead of their overall performance, which is covered by other standards. Whether these rules apply is up to the relevant authorities
Version history	-
Reference	https://my.rtca.org/productdetails?id=a1B1R00000GshldUAB

Standard	DO-386
Title	Vol I Minimum Operational Performance Standards for Airborne Collision Avoidance System Xu (ACAS Xu) (Vol I), andDO-386 Vol II Minimum Operational Performance Standards for Airborne Collision Avoidance System Xu (ACAS Xu) (Vol II: Algorithm Design
Status	Active
Initial date	17-12-2020
Current version	-
Description	This document includes the minimum operation performance standards (Volume I) and algorithm design descriptions (Volume II) for Airborne Collision Avoidance System Xu (ACAS Xu) equipment, made for platforms with different surveillance tech and capabilities. In volume I system features useful for users, designers, manufacturers and installers covering various needs are described. Volume II explains the Algorithm Design Description (ADD) for the surveillance and tracking module and threat resolution module. The algorithms are shown in a general way, allowing flexible implementation in different software and hardware while keeping consistent system results.
Version history	-
Reference	https://products.rtca.org/21dk0ig/

Standard	DO-387
Title	Minimum Operational Performance Standards (MOPS) for Electro-Optical/Infrared (EO/IR) Sensors System for Traffic Surveillance.
Status	Active

Initial date	17-06-2021
Current version	-
Description	This document outlines the Minimum Operational Performance Standards (MOPS) for Electro-Optical/Infrared (EO/IR) sensors used in Traffic Surveillance for Detect and Avoid (DAA) systems. It applies to UAS that flying in airspace of class B, C, D, E and G while it also includes flights above 400' AGL in class D, E (up to FL180) and G airspace. Finally, it covers UAS operations near airports during approach, departure and off-airport areas. These standards do no apply to small UAS flying below 400', flight in Visual Flight Rules (VFR) traffic patterns or ground operations
Version history	-
Reference	https://products.rtca.org/21dk0iv/

Standard	DO-389
Title	OSED for Counter UAS in Controlled Airspace, Counter Unmanned Aircraft System
Status	Active
Initial date	18-03-2021
Current version	-
Description	This document outlines the Operational Services and Environment Definition (OSED) for Counter-Unmanned Aircraft Systems (C-UAS) to safeguard airport airspace by detecting and reporting unauthorized UAS activity early to flight crews, Air Traffic Control, airports, and relevant authorities. In line with national regulations, neutralization methods—targeting the UAS, Command & Control Datalink (C2 Link), Remote Pilot Station (RPS), or Remote Pilot (RP)—may be part of a risk-based response. The OSED details the C-UAS system's operational capabilities and environment, proposing operational requirements and assumptions to be further refined in related standards: Safety and Performance Requirements (SPR) and Interoperability Requirements (INTEROP).
Version history	-
Reference	https://products.rtca.org/21dk146/

Standard	DO-397
Title	Guidance Material: Navigation Gaps for Unmanned Aircraft Systems (UAS)
Status	Active
Initial date	15-09-2022
Current version	-
Description	This document establishes the foundation for identifying gaps in navigation systems and standards that, if addressed, could enhance support for UAS operations. To narrow the scope and prioritize near-term needs, it specifically focuses on navigation gaps related to planned IFR and VFR-like paths for higher-risk category fixed-wing UAS operating in and out of traditional airports.
Version history	-
Reference	https://products.rtca.org/21dk1ro/

Standard	DO-246
Title	GNSS-Based Precision Approach Local Area Augmentation System (LAAS) Signal-in-Space Interface Control Document (ICD) Change 1

Status	Active
Initial date	27-06-2019
Current version	-
Description	N/A
Version history	-
Reference	https://standards.globalspec.com/std/14369515/rtca-do-246

2.2.8 FAA

Standard	TSO-C213a
Title	Unmanned Aircraft Systems Control and Non-Payload Communications Terrestrial Link System
Status	Active
Initial date	19-08-2022
Current version	-
Description	FAA Technical Standard Order (TSO) C213a specifies the minimum performance standards for Unmanned Aircraft Systems (UAS) terrestrial Control and Non-Payload Communications (CNPC) Link Systems operating in the 5030-5091 MHz frequency band. Issued on December 20, 2022, this TSO supersedes the original TSO-C213 and incorporates aspects of the RTCA DO-362
Version history	-
Reference	https://www.faa.gov/draftdocs/tso/draft-tso-c213a-unmanned-aircraft-systems-control-and-non-payload-communications

Standard	TSO-C118
Title	Traffic Alert and Collision Avoidance System (Tcas) Airborne equipment, Tcas I
Status	Active
Initial date	27-10-2014
Current version	-
Description	This Technical Standard Order (TSO), sets the minimum performance standards for active Traffic Alert and Collision Avoidance System (TCAS) equipment in order to meet the TSO certification. Any TCAS equipment made on or after the TSO's effective date must follow the standards in RTCA document No. RTCA/DO-197, Minimum Operational Performance Standards for an Active Traffic Alert and Collision Avoidance System I, Section Two, from March 20, 1987
Version history	-
Reference	https://www.document-center.com/standards/show/FAA-TSO-C118

Standard	TSO C119
Title	Traffic Alert and Collision Avoidance System (TCAS) Airborne Equipment, TCAS II
Status	Active
Initial date	N/A

Current version	-
Description	N/A
Version history	-
Reference	https://standards.globalspec.com/std/14368112/TSO%20C119

Standard	TSO C151
Title	TERRAOM Awareness and Warning System
Status	Active
Initial date	N/A
Current version	-
Description	N/A
Version history	-
Reference	https://standards.globalspec.com/std/1957410/tso-c151

Standard	TSO-C169a
Title	VHF Radio Communications Transceiver Equipment Operating Within Radio Frequency Range 117.975 To 137.000 Megahertz
Status	Active
Initial date	28-09-2007
Current version	-
Description	FAA Technical Standard Order (TSO) C169a sets the basic rules for how well Very High Frequency (VHF) radio communication transceivers must work when used between 117.974 and 137.000 MHz's. Such equipment must follow the guidelines in RTCA document DO-186B to make sure they are good enough for use in civil aviation communications
Version history	-
Reference	https://www.scribd.com/document/641272662/TSO-C169a

Standard	TSO-C211
Title	Detect and Avoid (DAA) Systems
Status	Active
Initial date	25-09-2017
Current version	-
Description	Technical Standard Order (TSO) C211 defines the minimum performance standard for Detect and Avoid (DAA) systems used in Unmanned Aircraft Systems (UAS). DAA systems help UAS flights by detecting and responding to any air traffic to provide UAS the ability to fly safely in controlled airspace. Meeting TSO-C211 ensures that the DAA devices are safe and perform as per their standard
Version history	-
Reference	https://drs.faa.gov/browse/excelExternalWindow/2507451EFFF4AC09862581AE004F95B1.0001?modalOpened=true

2.2.9 TIA

Standard	1008
Title	IP OVER SATELLITE (IPOS)
Status	Active
Initial date	NA
Current version	-
Description	NA
Version history	-
Reference	https://standards.globalspec.com/std/1523951/tia-1008

Standard	1073.002
Title	Satellite Network Modem System (SNMS) Encryption Requirements
Status	Active
Initial date	01-07-2006
Current version	-
Description	TIA/EIA-1073 is a multi-part standard that outlines the requirements for a Satellite Network Modem System (SNMS) utilizing Time Division Multiplexing (TDM) and Multi-Frequency Time Division Multiple Access (MF-TDMA) signaling. It establishes technical specifications necessary to fulfill the functional capabilities described in TIA/EIA-157. The SNMS standard covers both Hub-Spoke and Mesh satellite network topologies operating over transponder or transparent satellite systems. The full scope of the standard is divided into several parts, as illustrated in Figure 1, each addressing different aspects of system functionality and performance.
Version history	-
Reference	https://store.accuristech.com/standards/tia-tia-1073-002?product_id=2591749&srsltid=AfmBOopJxjW4o7v5bOBfWQsA09S59Dj7qub715DhbcwUhhrzqpRXxaj-

Standard	5041
Title	Future Advanced SATCOM Technologies (FAST) Open Standard Digital- If Interface (OSDI) for SATCOM Systems
Status	Active
Initial date	20-04-2016
Current version	-
Description	This Interface Control Document (ICD) outlines the communication interfaces and message content for digital intermediate frequency (IF), or "all digital," strategic or large fixed satellite communications (SATCOM) terminals. It serves as an Open Standard Digital-IF Interface (OSDI) to support cost-effective subsystem development by various vendors, ensuring interoperability through standardized open interfaces. The document begins with an overview of the Future Advanced SATCOM Technologies (FAST) architecture, detailing processing subsystems and interface objects/classes. It then provides subsystem overviews, outlining functional requirements, interface decompositions, messaging types, communication roles, and specific message content to govern subsystem interoperability.
Version history	-

Reference	https://standards.globalspec.com/std/10011268/tia-5041

2.2.10 UL

Standard	2900-1
Title	Software Cybersecurity for Network-Connectable Products, Part 1: General Requirements
Status	Active
Initial date	13-12-20023
Current version	-
Description	This standard applies to network-connectable products that must undergo evaluation and testing for vulnerabilities, software weaknesses, and malware. It outlines: a) Requirements for the software developer's (vendor or supply chain member) risk management process. b) Methods for evaluating and testing products for vulnerabilities, software weaknesses, and malware. c) Requirements for incorporating security risk controls in a product's architecture and design. This standard does not cover: • Functional testing to verify if the product performs as intended. • Requirements related to the hardware components of a product
Version history	-
Reference	https://www.shopulstandards.com/ProductDetail.aspx?productId=UL2900-1_2_S_20231213

Standard	3030
Title	Standard for Unmanned Aircraft Systems
Status	Active
Initial date	30-08-2024
Current version	-
Description	These specifications apply to electrical systems of unmanned aircraft systems (UAS) for commercial or business use. Subject UAS shall be operated by certified pilots according to Federal Regulations, with the airplane weighing less than 25 kg. Such systems utilize internally mounted lithium-ion batteries externally charged with operating voltages up to 100 V DC. These requirements address risks like electrical shock, fire and explosion, including those related to battery and charger system. Commercial applications include agriculture, research, government, law enforcement, search and rescue operations and media use. Business flights involve activities like roof inspection, construction surveys and real estate photography.
Version history	-
Reference	https://www.shopulstandards.com/ProductDetail.aspx?productId=UL3030

Standard	4600
Title	Evaluation of Autonomous Products
Status	Active
Initial date	17-03-2023
Current version	-

Description	This standard outline safety principles, risk mitigation strategies, tools, techniques, and lifecycle processes for constructing and evaluating safety arguments for autonomous vehicles, whether operating individually or as part of a team (e.g., a platoon). It assumes operations occur without human supervision or intervention during dynamic driving tasks, though human involvement in areas like maintenance or interaction with non-operators (e.g., pedestrians) is considered. The term "item" is used instead of "system" or "product" to account for external factors—such as infrastructure and support processes—that impact safety. The standard focuses on fully autonomous operations, excluding scenarios where humans perform or supervise control tasks. While information security specifics are out of scope, the standard requires a Security Plan and considers potential misuse, abuse, and physical attacks. The requirements aim to establish a sufficiently complete safety case but expect design teams to address additional relevant factors within the operational design domain.
Version history	-
Reference	https://www.shopulstandards.com/ProductDetail.aspx?productId=UL4600_3_S_20230317

2.2.11 3GPP

Standard	21.900	
Title	Technical Specification Group working methods	
Status	Active	
Initial date	27-03-2024	
Current version	18.2.0	
Description	This document outlines the working methods used by 3GPP Technical Specification Groups, their sub-groups, and the 3GPP Support Team for document management, including handling specifications, updating procedures, change requests, version control, and status information. It complements existing 3GPP rules and procedures but does not detail the internal workings of TSG sub-groups. From the Technical Specification Group's perspective, tasks and responsibilities are assigned to a Working Group (WG) that reports directly to the TSG. In practice, these tasks may be carried out by a subgroup within the WG.	
Version history	18.1.0 18.0.0 17.2.0 17.1.0 17.0.0	16.4.0 16.3.0 16.2.0 16.1.0 16.0.0
Reference	https://portal.3gpp.org/desktopmodules/Specifications/SpecificationDetails.aspx?specificationId=555	

Standard	22.125	
Title	Unmanned Aerial System (UAS) support in 3GPP	
Status	Active	
Initial date	28-06-2024	
Current version	19.2.0 (Release 19)	
Description	NA	
Version history	19.1.0 19.0.0	17.2.0 17.1.0

	18.1.0 18.0.0 17.7.0 17.6.0 17.5.1 17.5.0 17.4.0 17.3.0	17.0.0 16.4.0 16.3.0 16.2.0 16.1.0 16.0.0 1.0.0 0.2.0
Reference	https://portal.3gpp.org/desktopmodules/Specifications/SpecificationDetails.aspx?specificationId=3545	

Standard	22.261			
Title	Service requirements for the 5G system			
Status	Active			
Initial date	10-01-2025			
Current version	20.1.0			
Description	This document outlines the service and operational requirements for a 5G system, covering UE, NG-RAN, and the 5G Core network. Requirements for 5G E-UTRA-NR Dual Connectivity in E-UTRAN connected to EPC are detailed in TS 22.278			
History	20.0.0 19.9.0 19.8.0 19.7.0 19.6.0 19.5.0 19.4.0 19.3.0 19.2.0 19.1.0 19.0.0 18.16.0 18.15.0 18.14.0 18.13.0 18.12.0 18.11.0 18.10.0 18.9.0 18.8.0	18.7.0 18.6.1 18.6.0 18.5.0 18.4.0 18.3.0 18.2.0 18.1.1 18.1.0 18.0.0 17.13.0 17.12.0 17.11.0 17.10.0 17.9.0 17.8.0 17.7.0 17.6.0 17.5.0 17.4.0	17.3.0 17.2.0 17.1.0 17.0.1 17.0.0 16.17.0 16.16.0 16.15.0 16.14.0 16.13.0 16.12.0 16.11.0 16.10.0 16.9.0 16.8.0 16.7.0 16.6.0 16.5.0 16.4.0 16.3.0	16.2.0 16.1.0 16.0.0 15.9.0 15.8.0 15.7.0 15.6.0 15.5.0 15.4.0 15.3.0 15.2.0 15.1.0 15.0.0 2.0.0 1.2.0 1.1.0 1.0.0 0.2.0 0.1.1
Reference	https://portal.3gpp.org/desktopmodules/Specifications/SpecificationDetails.aspx?specificationId=3107			

Standard	22.281
Title	Mission Critical (MC) video
Status	Active
Initial date	05-04-2024
Current version	18.0.1
Description	This document outlines the service requirements for operating the MCVideo service. MCVideo utilizes features from Group Communication System Enablers, Proximity Services, and Isolated E-UTRAN operation for Public Safety, along with Mission Critical

	Services Common Requirements, supplemented by MCVideo-specific requirements. It supports public safety, maritime safety, and commercial applications, including utilities, railways, and maritime industries. These specifications do not apply to GSM or UMTS networks.
Version history	18.0.0 17.0.0 16.0.0 15.1.0 15.0.0 14.4.1 14.4.0 14.3.0 14.2.0 14.1.0 14.0.0 2.0.0 1.0.0 0.1.0
Reference	https://portal.3gpp.org/desktopmodules/Specifications/SpecificationDetails.aspx?specificationId=3018

Standard	22.282
Title	Mission Critical (MC) data
Status	Active
Initial date	05-04-2024
Current version	18.0.1
Description	This document defines the service requirements for operating the MCData service. MCData leverages features from Group Communication System Enablers, Proximity Services, and Isolated E-UTRAN operation for Public Safety, along with Mission Critical Services Common Requirements, with additional MCData-specific requirements. It supports public safety, maritime safety, and commercial applications, including utilities, railways, and maritime industries. These specifications do not apply to GSM or UMTS networks.
Version history	18.0.0 17.0.0 16.4.0 16.3.0 16.2.0 16.1.0 16.0.0 15.1.0 15.0.0 14.3.0 14.2.0 14.1.0 14.0.0 2.2.0 2.0.0 1.0.0 0.1.0
Reference	https://portal.3gpp.org/desktopmodules/Specifications/SpecificationDetails.aspx?specificationId=3019

Standard	22.825
Title	Study on Remote Identification of Unmanned Aerial Systems (UAS)
Status	Active
Initial date	21-09-2018
Current version	16.0.0
Description	This document outlines use cases and potential requirements to address business, security, and public safety needs for remotely identifying and tracking UAS connected to a 3GPP subscription.
Version history	1.0.0 0.1.0 0.0.0

Reference	https://portal.3gpp.org/desktopmodules/Specifications/SpecificationDetails.aspx?specificationId=3527

Standard	22.829
Title	Enhancement for Unmanned Aerial Vehicles (UAVs)
Status	Active
Initial date	27-09-2019
Current version	17.1.0
Description	This document presents use cases and analyzes UAV capabilities that may require enhanced support from 3GPP.
Version history	17.0.1 17.0.0 2.0.0 1.1.0 1.0.0 0.3.0 0.1.0
Reference	https://portal.3gpp.org/desktopmodules/Specifications/SpecificationDetails.aspx?specificationId=3557

Standard	22.843
Title	Study on Additional capabilities of mobile networks for drone operations and managements
Status	Active
Initial date	22-12-2023
Current version	19.2.0
Description	This document presents additional UAV use cases and identifies potential requirements to enhance 5G system support for UAV applications, operations, and management. It aims to provide UAV operators and USS with improved pre-flight and inflight information, such as flight mission applications, flight path recommendations, and monitoring and control capabilities. The document also discusses how the 5G systems can improve UAV flight and route management by using network capacity and QoS information along planned routes. It emphasizes how 5G can enhance UAV safety and security, including support for UTM, UAV detection and Detect and Avoid (DAA) systems. Also, it looks into potential new security, charging and regulatory requirements for UAS operations over 5G, along with the need for redundancy and reliability in UAV command and control (C2) communications
Version history	19.1.0 19.0.0 2.0.0 1.1.0 1.0.0 0.3.0 0.2.0 0.1.0
Reference	https://portal.3gpp.org/desktopmodules/Specifications/SpecificationDetails.aspx?specificationId=4090

Standard	23.255
Title	Application layer support for Uncrewed Aerial System (UAS); Functional architecture and information flows;
Status	Active
Initial date	10-01-2025

Current version	19.4.0		
Description	This document defines the functional architecture, procedures, and information flows for the UAS application enabler layer. It outlines the application layer capabilities required for the efficient use and deployment of UAS over 3GPP systems. These capabilities apply to both EPS and 5GS networks.		
Version history	19.3.0 19.2.0 19.1.0 19.0.0 18.2.0 18.1.0 18.0.0	17.5.0 17.4.0 17.3.0 17.2.0 17.1.0 17.0.1 17.0.0	1.0.0 0.5.0 0.4.0 0.3.0 0.2.1 0.2.0 0.1.0
Reference	https://portal.3gpp.org/desktopmodules/Specifications/SpecificationDetails.aspx?specificationId=3843		

Standard	23.256		
Title	Support of Uncrewed Aerial Systems (UAS) connectivity, identification and tracking; Stage 2		
Status	Active		
Initial date	20-12-2024		
Current version	19.1.0		
Description	This document outlines architectural updates to support UAS connectivity, identification and tracking based on use case and service needs highlighted in TS 22.125. It addresses UAV identification, authentication and authorization as well as tracking within the 3GPP system. It also details how the system enables UAV-to-ground identification for authorized third parties, such as law enforcement and management of unauthorized UAVs.		
Version history	19.0.0 18.3.0 18.2.0 18.1.0 18.0.0 17.8.0 17.7.0	17.6.0 17.5.0 17.4.0 17.3.0 17.2.0 17.1.0 17.0.0	2.0.0 1.1.0 1.0.0 0.3.0 0.2.0 0.1.0 0.0.0
Reference	https://portal.3gpp.org/desktopmodules/Specifications/SpecificationDetails.aspx?specificationId=3853		

Standard	23.700-91
Title	Study on enablers for network automation for the 5G System (5GS); Phase 2
Status	Active
Initial date	17-12-2020
Current version	17.0.0
Description	This Technical Report explores enhancements for analytics and NWDAF, focusing on several key objectives. It addresses unresolved issues from Release 16, including UE-driven analytics, ensuring slice SLA guarantees, and identifying usable data from UPF, such as application-related and other user data characteristics. The report examines NWDAF architecture improvements, such as multiple NWDAF instances within a single PLMN, hierarchical structures, roles, and inter-instance cooperation. It also considers feature enhancements, including real-time or near real-time NWDAF communication, optimized data collection mechanisms, service MOS-based NWDAF-assisted UP

	optimization, and minimizing the load generated by data collection. Additionally, it explores new use cases and key issues, particularly the interaction between NWDAF and the ML Model & Training Service managed by the operator.		
Version history	2.0.0 1.2.0 1.1.0 1.0.0	0.5.0 0.4.0 0.3.0	0.2.0 0.1.0 0.0.0
Reference	https://portal.3gpp.org/desktopmodules/Specifications/SpecificationDetails.aspx?specificationId=3657		

Standard	23.754		
Title	Study on supporting Unmanned Aerial Systems (UAS) connectivity, Identification and tracking		
Status	Active		
Initial date	31-03-2021		
Current version	17.1.0		
Description	This study item focuses on system enablers for supporting Unmanned Aerial Systems connectivity, identification, and tracking. It includes mechanisms for identifying and tracking UAV controllers and UAVs within the 3GPP system, including support for UAV-to-ground identification for authorized third parties, such as law enforcement. It also defines a framework for UAV controller and UAV authentication and authorization by UTM. Additionally, it addresses handling unauthorized UAVs and revoking authorization due to factors such as loss of connectivity for command-and-control messages or denied registration, ensuring the system can monitor and manage UAV operations effectively.		
Version history	17.0.0 2.0.0 1.2.0	1.1.0 1.0.0 0.3.0	0.2.0 0.1.0 0.0.0
Reference	https://portal.3gpp.org/desktopmodules/Specifications/SpecificationDetails.aspx?specificationId=3575		

Standard	23.755		
Title	Study on application layer support for Unmanned Aerial Systems (UAS)		
Status	Active		
Initial date	01-04-2021		
Current version	17.0.0		
Description	This technical report identifies application architecture aspects and corresponding solutions to support UAS. It examines the architectural requirements necessary for the efficient use and deployment of UAS services and applications over 3GPP systems.		
Version history	2.0.0 1.2.1 1.2.0 1.1.0 1.0.0 0.12.0	0.11.0 0.10.0 0.9.0 0.8.0 0.7.0 0.6.0	0.5.0 0.4.0 0.3.0 0.2.0 0.1.0
Reference	https://portal.3gpp.org/desktopmodules/Specifications/SpecificationDetails.aspx?specificationId=3588		

Standard	24.257		
Title	Uncrewed Aerial System (UAS) Application Enabler (UAE) layer; Protocol aspects; Stage 3		
Status	Active		
Initial date	10-01-2025		
Current version	19.1.0		
Description	This document specifies the protocols for application layer support for UAS services as defined in 3GPP TS 23.255. It covers UAS application communication between the UE and the UAE server over the U1-AE interface, as well as communication among UEs using unicast Uu over the same interface. The specification outlines procedures for these communications, detailing the interaction of the UAE layer with SEAL services. It also defines message formats, contents, error handling, and system parameters applied by the protocols within the UAE layer.		
Version history	19.0.0 18.4.0 18.3.0 18.2.0 18.1.0 18.0.0	17.4.0 17.3.0 17.2.0 17.1.0 17.0.0 2.0.0	1.0.0 0.4.0 0.3.0 0.2.0 0.1.0
Reference	https://portal.3gpp.org/desktopmodules/Specifications/SpecificationDetails.aspx?specificationId=3900		

Standard	29.255		
Title	Uncrewed Aerial System Service Supplier (USS) Services; Stage 3		
Status	Active		
Initial date	19-12-2024		
Current version	19.0.0		
Description	This document defines the stage 3 protocol and data model for the UAS-specific Naf Service-Based Interface. It includes protocol definitions, message flows, and API specifications for each service provided by the UAS-specific AF. The 5G System stage 2 architecture and procedures are detailed in TS 23.501, TS 23.502, and TS 23.256, while the technical realization of the Service-Based Architecture and service definition guidelines is outlined in TS 29.500 and TS 29.122. The UAS Service Supplier (USS) delivers UAS-specific AF services to NF service consumers, such as NEF (UAS-NF), functioning as part of the AF.		
Version history	18.4.0 18.3.1 18.3.0 18.2.0 18.1.0 18.0.0	17.3.0 17.2.0 17.1.0 17.0.0 2.0.0 1.2.0	1.1.0 1.0.0 0.3.0 0.2.0 0.1.0
Reference	https://portal.3gpp.org/desktopmodules/Specifications/SpecificationDetails.aspx?specificationId=3904		

Standard	29.256
Title	Uncrewed Aerial Systems Network Function (UAS-NF); Aerial Management Services; Stage 3
Status	Active

Initial date	07-01-2025		
Current version	19.0.0		
Description	This document defines the stage 3 protocol and data model for the UAS-NF functionality of the Nnef Service-Based Interface. It includes protocol definitions, message flows, and API specifications for each service provided by the NEF (UAS-NF). The 5G System stage 2 architecture and procedures are detailed in 3GPP TS 23.501 and TS 23.502, while the technical realization of the Service-Based Architecture and service definition guidelines is outlined in 3GPP TS 29.500 and TS 29.501. The Uncrewed Aerial System Network Function (UAS-NF) delivers UAS-specific NEF services to NF service consumers, such as AMF and SMF, operating as part of the NEF.		
Version history	18.4.0 18.3.0 18.2.0 18.1.0 17.6.0 17.5.0 17.4.0	17.3.0 17.2.0 17.1.0 17.0.0 2.0.0 1.2.0 1.1.0	1.0.0 0.5.0 0.4.0 0.3.0 0.2.0 0.1.0 0.0.0
Reference	https://portal.3gpp.org/desktopmodules/Specifications/SpecificationDetails.aspx?specificationId=3866		

Standard	29.257		
Title	Application layer support for Uncrewed Aerial System (UAS); UAS Application Enabler (UAE) Server Services; Stage 3		
Status	Active		
Initial date	19-12-2024		
Current version	19.1.0		
Description	This document defines the stage 3 protocol and data model for UAS Application Enabler (UAE) Server services, enabling support for UAS applications over 3GPP networks. It includes protocol definitions, message flows, and API specifications for each service provided by the UAE Server. The stage 2 application layer architecture, functional requirements, procedures, and information flows necessary for supporting UAS applications over 3GPP networks are specified in 3GPP TS 23.255.		
Version history	19.0.0 18.4.0 18.3.0 18.2.0 18.1.0 18.0.0	17.2.0 17.1.0 17.0.0 2.0.0 1.2.0	1.0.0 0.4.0 0.3.0 0.2.0 0.1.0
Reference	https://portal.3gpp.org/desktopmodules/Specifications/SpecificationDetails.aspx?specificationId=3901		

Standard	33.256
Title	Security aspects of Uncrewed Aerial Systems (UAS)
Status	Active
Initial date	27-03-2024
Current version	18.2.0

Description	This document defines the security features supporting architectural enhancements for UAS connectivity, identification, tracking, and pairing authorization, as specified in TS 23.256. It aligns with the use cases and service requirements outlined in TS 22.125.		
Version history	18.1.0 18.0.0 17.6.0 17.5.0 17.4.0 17.3.0	17.2.0 17.1.0 17.0.0 2.0.0 1.1.0	1.0.0 0.3.0 0.2.0 0.1.0 0.0.0
Reference	https://portal.3gpp.org/desktopmodules/Specifications/SpecificationDetails.aspx?specificationId=3930		

Standard	33.854		
Title	Study on security aspects of Uncrewed Aerial Systems (UAS)		
Status	Active		
Initial date	23-12-2021		
Current version	17.1.0		
Description	This document presents a study on the security aspects of Uncrewed Aerial Systems (UAS). It builds on service requirements outlined in TS 22.125, as well as ongoing studies in TR 23.754 on UAS connectivity, identification, and tracking, and TR 23.755 on UAV services and application layer features. The study identifies key security issues, including threats and potential requirements, in relation to these specifications. It also analyzes and develops solutions to address these issues and concludes with recommendations for potential normative work.		
Version history	17.0.0 1.0.0 0.7.0 0.6.0 0.5.0	0.4.0 0.3.0 0.2.0 0.1.0	
Reference	https://portal.3gpp.org/desktopmodules/Specifications/SpecificationDetails.aspx?specificationId=3763		

Standard	33.891		
Title	Study on security of phase 2 for Uncrewed Aerial System (UAS), Uncrewed Aerial Vehicle (UAV) and Urban Air Mobility (UAM)		
Status	Active		
Initial date	29-03-2023		
Current version	18.0.0		
Description	This document examines security and privacy threats and defines corresponding security requirements for Uncrewed Aerial Vehicles (UAVs) and Urban Air Mobility (UAM) based on the architectural and system-level enhancements studied in TR 23.700-58. It also evaluates potential solutions, analyzing them to provide recommendations for possible normative work, considering the conclusions of TR 23.700-58.		
Version history	1.1.0 1.0.0 0.6.0 0.5.1 0.5.0	0.4.0 0.3.0 0.2.0 0.1.0 0.0.0	

Reference	https://portal.3gpp.org/desktopmodules/Specifications/SpecificationDetails.aspx?specificationId=4083

Standard	33.889	
Title	Study on security aspects of Machine-Type Communications (MTC) architecture and feature enhancements	
Status	Active	
Initial date	25-09-2015	
Current version	13.0.0	
Description	This document outlines the requirements, solution alternatives, evaluations, and conclusions for the SA2-led Release 13 features: GROUPE (Group-Based Enhancements), MONTE (Monitoring Enhancements), and AESE (Architecture Enhancements for Service Capability Exposure). It captures the findings of the study on security and privacy implications for the requirements identified in Stage 1 and Stage 2 specifications for these MTC features. Based on the study's outcome, any new normative text will be incorporated into TS 33.187 and/or other relevant SA3 specifications.	
Version history	1.0.0 0.6.0 0.5.0	0.4.0 0.3.0 0.2.0
Reference	https://portal.3gpp.org/desktopmodules/Specifications/SpecificationDetails.aspx?specificationId=2333	

Standard	36.777	
Title	Enhanced LTE support for aerial vehicles	
Status	Active	
Initial date	06-01-2018	
Current version	15.0.0	
Description	This document presents the results and findings from the study item “Study on Enhanced Support for Aerial Vehicles.” It captures the understanding of TSG RAN WG1 and WG2 regarding the performance of Release-14 LTE networks in serving aerial vehicles such as drones. It also documents identified performance-enhancing solutions aimed at optimizing LTE connectivity for aerial vehicles. This study focuses on the Radio Access aspects of 3GPP systems and has implications for both Mobile Equipment and Access Networks. As a ‘living’ document, it is continuously updated and presented at TSG-RAN meetings.	
Version history	1.1.0 1.0.0 0.5.0 0.4.0	0.3.1 0.3.0 0.1.0 0.0.1
Reference	https://portal.3gpp.org/desktopmodules/Specifications/SpecificationDetails.aspx?specificationId=3231	

2.2.12 CEN

Standard	4709-001
Title	Aerospace series - Unmanned Aircraft Systems - Part 001: Product requirements and verification

Status	Active
Initial date	06-2024
Current version	-
Description	This document outlines the technical specifications and verification methods needed to comply with the product harmonization rules in Chapter II of Commission Delegated Regulation (EU) 2019/945, dated 12 March 2019, for unmanned aircraft systems and third-country operators. It does not apply to lighter-than-air UAS, such as airships and balloons, and is limited to unmanned aircraft powered by electro-chemical energy sources.
Version history	-
Reference	https://stan-shop.org/en/catalog/item/75627?search=4709

Standard	prEN 4709-002 P1
Title	Aerospace series-Unmanned Aircraft Systems — Part 002: Direct Remote Identification
Status	Active
Initial date	10-2021
Current version	-
Description	This document defines compliance with the "Direct Remote Identification" requirements in Regulation (EU) 2019/945 for Unmanned Aircraft Systems. It specifies a system for real-time, local broadcast of drone information without requiring connectivity or ground infrastructure, using an open and documented transmission protocol. This enhances security, ensures regulatory compliance, and allows law enforcement, critical infrastructure managers, and the public to access drone details such as serial number, navigation data, operational status, and operator registration. As the regulation mandates an open protocol, this standard does not include measures to protect data confidentiality. The system supports privacy and data protection obligations while addressing security concerns.
Version history	-
Reference	https://stan-shop.org/en/catalog/item/75040?search=4709

Standard	4709-003 P1
Title	Aerospace series — Unmanned Aircraft Systems — Part 003: Geo-awareness requirements
Status	Active
Initial date	02-2023
Current version	-
Description	This document defines means to comply with the "geo-awareness" requirements in Part 2, Part 3, and Part 4 of Commission Delegated Regulation (EU) 2019/945, as well as the smooth interaction of the optional geofencing function with the UA flight control system. It specifies the minimum performance required for geo-awareness without prescribing specific design or implementation. Compliance is recommended to ensure reliable performance under routine aeronautical conditions. The “smooth interaction” requirement is largely addressed by sub clause 6.3 on safe controllability in EN 4709-001:2023, to which this document refers extensively. It distinguishes “function” for system capabilities and “equipment” for physical implementations.
Version history	-
Reference	https://stan-shop.org/en/catalog/item/75419

Standard	4709-004 P1
Title	Aerospace series — Unmanned Aircraft Systems — Part 004: Lighting requirements
Status	Active
Initial date	02-2023
Current version	-
Description	This document defines means of compliance for lighting-related requirements in Part 2 to 4 of the Annex to Commission Delegated Regulation (EU) 2019/945 on unmanned aircraft and third-country UAS operators. It ensures that a UA is equipped with lights for controllability (effectiveness covered under EN 4709-001) and nighttime conspicuity, allowing ground observers to distinguish it from manned aircraft. The document specifies types, technical requirements, and parameters of UA lights, including position and intensity for different categories and operation modes. It also outlines the purpose, test procedures, requirements, and compliance rules for evaluating UA lighting systems.
Version history	-
Reference	https://stan-shop.org/en/catalog/item/75302?search=4709

2.2.13 NATO

Standard	AEP-77
Title	Interoperable Command-and-Control Data Link for Unmanned Systems (IC2DL) – Operational Physical Layer/Signal in Space Description
Status	Active
Initial date	14-11-2016
Current version	-
Description	N/A
Version history	-
Reference	https://quicksearch.dla.mil/qsDocDetails.aspx?ident_number=281889

Standard	AEP-80
Title	Rotary Wing UAS Airworthiness
Status	Active
Initial date	24-11-2016
Current version	-
Description	This document outlines technical airworthiness requirements for certifying rotary-wing military UAV systems with a maximum takeoff weight between 150 and 3175 kg, intended for regular operation in non-segregated airspace. Certifying Authorities may extend these requirements beyond these limits as needed. It establishes the minimum acceptable standards for design and construction but allows for additional Special Conditions as required by national regulatory frameworks.
Version history	-
Reference	https://standards.globalspec.com/std/10059387/aep-80

Standard	AEP-101

Title	Guidance on Sense and Avoid for Unmanned Aircraft Systems
Status	Active
Initial date	23-02-2017
Current version	-
Description	This allied publication offers guidance and best practices for developing Sense and Avoid (SAA) systems, referencing existing standards without setting specific operational or equipment requirements. It connects operational needs with technical specifications, aligning system development with established guidelines like the ICAO RPAS Manual (Doc 10019) for operations and EUROCAE/RTCA MOPS for equipment. Targeted at program managers, engineers, and stakeholders, it supports various system architectures with different levels of automation and operator control. It also establishes common NATO terminology and concepts related to operational needs, potentially laying the groundwork for future NATO SAA requirements under a STANAG.
Version history	-
Reference	https://standards.globalspec.com/std/10280992/AEP-101

Standard	STANAG 4586
Title	Standard Interface of UAV Control System for NATO UAV Interoperability
Status	Active
Initial date	-
Current version	
Description	Unmanned Air Vehicles (UAVs) are transforming military and civilian operations, though the proliferation of models and suppliers creates interoperability issues. STANAG 4586 addresses this, through interface standardization to achieve the required Level of Interoperability (LOI) between UAV systems, following NATO's operational concepts. It defines a functional architecture for Unmanned Aerial Vehicle Control Systems (UCS) comprising key elements such as the Air Vehicle (AV), Vehicle Specific Module (VSM), Data Link Interface (DLI), Core UCS (CUCS), Command and Control Interface (CCI), Human-Computer Interface (HCI) and Command and Control Interface Specific Module (CCISM). STANAG 4568 is not an interoperability solution but a stepping stone towards UAV integration standardization that paves the way for future development
Version history	-
Reference	https://www.sto.nato.int/publications/STO%20Educational%20Notes/STO-EN-SCI-271/EN-SCI-271-03.pdf

Standard	STANAG 4671
Title	UAVs Systems Airworthiness Requirements
Status	Active
Initial date	02-04-2019
Current version	-
Description	The aim of this NATO standardization agreement (STANAG) is to respond to the following interoperability requirements.
Version history	-
Reference	https://standards.globalspec.com/std/13430067/stanag-4671

Standard	STANAG-4702
Title	Rotary wing UAS Airworthiness requirements
Status	Active
Initial date	24-11-2016
Current version	-
Description	N/A
Version history	-
Reference	https://quicksearch.dla.mil/qsDocDetails.aspx?ident_number=280612

Standard	STANAG-4703
Title	Light UAS Air worthiness requirements
Status	Active
Initial date	24-11-2016
Current version	-
Description	N/A
Version history	-
Reference	https://quicksearch.dla.mil/qsDocDetails.aspx?ident_number=280613

2.2.14 US ARMY

Standard	TOP-7-1-003
Title	Unmanned Aircraft Systems (UAS) Sensor and Targeting
Status	Active
Initial date	27-07-2010
Current version	-
Description	This Test Operations Procedure (TOP) 07-1-003 outlines the unique requirements and technologies for testing Unmanned Aircraft Systems (UASs). Unlike manned aircraft, UASs operate at different altitudes and employ distinct methods, posing unique test challenges. Many UASs fly at significantly higher altitudes, affecting sensor-to-target slant range and angular perspective. Additionally, the threat landscape for UASs in the Global War on Terrorism differs from traditional mechanized threats faced by manned aircraft. A standardized approach for sensor and target testing ensures consistency across all systems. This TOP complements the overarching TOP 07-1-001, which is currently under development.
Version history	-
Reference	https://quicksearch.dla.mil/qsDocDetails.aspx?ident_number=277513

Standard	TOP-7-2-032
Title	Unmanned Aircraft Systems (UAS) Navigation System Test
Status	Active
Initial date	27-07-2010

Current version	-
Description	This Test Operations Procedure (TOP) outlines general procedures and references for testing and evaluating navigation systems used in U.S. Army Unmanned Aircraft Systems (UAS).
Version history	-
Reference	https://quicksearch.dla.mil/qsDocDetails.aspx?ident_number=277514

Standard	ATP-3.3.7
Title	Guidance for the Training of Unmanned Aircraft Systems (UAS) Operators
Status	Active
Initial date	22-03-2014
Current version	-
Description	N/A
Version history	-
Reference	https://quicksearch.dla.mil/qsDocDetails.aspx?ident_number=279838

Standard	DOD-STD-2168
Title	Defense System Software Quality Program
Status	Active
Initial date	29-04-1988
Current version	-
Description	This standard defines requirements for a software quality program to be implemented during the acquisition, development, and support of software systems.
Version history	-
Reference	https://www.product-lifecycle-management.com/download/DOD-STD-2168A.pdf

Standard	DOD MIL-STD-882
Title	Department of Defense Standard Practice: System Safety
Status	Active
Initial date	05-2012
Current version	DOD MIL-STD-882E
Description	MIL-STD-882E establishes the Department of Defense (DoD) system safety standard practice, outlining a Systems Engineering (SE) approach to eliminating hazards where possible and minimizing risks when elimination is not feasible. It aligns with DoD Instruction 5000.02, which defines risk acceptance authorities. The standard applies to hazards in systems, products, equipment, and infrastructure—including hardware and software—throughout their lifecycle, from design and development to disposal. When included in a solicitation or contract without specific tasks, only Sections 3 and 4 are mandatory, with Section 3.2 and all of Section 4 defining the minimum requirements for an acceptable system safety effort for any DoD system.
Version history	DOD MIL-STD-882D DOD MIL-STD-882C_NOTICE-1

	DOD MIL-STD-882C
Reference	http://everyspec.com/MIL-STD/MIL-STD-0800-0899/MIL-STD-882E_41682/

2.2.15 Eurocae

Standard	ED-301
Title	Guidelines for the Use of Multi-GNSS Solutions for UAS Specific Category - Low Risk Operations SAIL I and II
Status	Active
Initial date	08-2022
Current version	-
Description	This document aims to enhance the management of external services impacting UAS operations to support safety in the Specific Category. Given that GNSS receivers serve as the primary navigation sensor for most UAS, the performance of GNSS services, particularly multi-GNSS, directly affects flight safety in both normal and abnormal conditions, depending on the operational context. The term "multi-GNSS" refers to the multiple GNSS constellations available for UAS positioning. Specific constellations, systems, and signals are detailed based on legacy considerations, global coverage, and public accessibility. The resulting standards will help UAS operators secure approval for specific operations by addressing safety risks associated with GNSS services.
Version history	-
Reference	https://eshop.eurocae.net/eurocae-documents-and-reports/ed-301/

Standard	ED-271
Title	Minimum Aviation System Performance Standard for Detect and Avoid (Traffic) in Class A-C airspaces
Status	Active
Initial date	11-05-2022
Current version	-
Description	This document defines the Detect and Avoid (DAA) function necessary for Remote Pilots to operate RPAs in airspace classes A-C under IFR, as outlined in the OSED, excluding ground-based DAA. It specifies system characteristics, as the function comprises multiple components, and serves as a reference for designers, manufacturers, installers, service providers, and users. Compliance with this standard is recommended to ensure that the system and its subsystems perform reliably under typical aeronautical conditions. The MASPS can support early system development and prototyping and may be incorporated into regulatory and advisory documents for certification, authorization, approval, commissioning, and related processes.
Version history	-
Reference	https://www.eurocae.net/news/posts/2022/may/ed-271-minimum-aviation-system-performance-standard-for-detect-and-avoid-traffic-in-class-a-c-airspaces/

Standard	ED-279
Title	Generic Functional Hazard Assessment (FHA) for UAS and RPAS
Status	Active

Initial date	25-10-2020
Current version	-
Description	This document focuses on developing a UAS/RPAS Functional Hazard Assessment (FHA) to accommodate a wide range of configurations, providing system developers with a framework to assist designers in the FHA process. It identifies core UAS functions, adapted from the draft ARP4761-A for manned platforms, and evaluates them independently. Due to the significant variability in UAS configurations, some essential functions cannot always be assessed in isolation. To address this, additional rules have been established to support the creation of an FHA tailored to specific implementations.
Version history	-
Reference	https://www.eurocae.net/news/posts/2020/october/ed-279-generic-functional-hazard-assessment-fha-for-uas-and-rpas/

Standard	ED-280
Title	Guidelines for UAS safety analysis for the Specific category (low and medium levels of robustness)
Status	Active
Initial date	10-12-2020
Current version	-
Description	This document provides guidelines for UAS operators and manufacturers to obtain evidence that a UAS is designed with system safety and reliability in mind. It outlines the necessary safety analyses to meet part of OSO#5 requirements for low and medium robustness levels as part of the SORA risk assessment, in accordance with AMC1 to Article 11 of the operational risk assessment rules. These guidelines apply to the Specific category under EASA drone regulation, ensuring compliance with safety and reliability standards.
Version history	-
Reference	https://www.eurocae.net/news/posts/2020/december/ed-280-guidelines-for-uas-safety-analysis-for-the-specific-category-low-and-medium-levels-of-robustness/

2.2.16 ARC

Standard	AIAA R-103-2004
Title	Terminology for Unmanned Aerial Vehicles and Remotely Operated Aircraft
Status	Active
Initial date	-
Current version	-
Description	This recommended practice intends to foster awareness of the vocabulary and acronyms used between various groups of the UAV/ROA community. It includes approximately 400 terms and over 1100 acronyms taken from reliable sources of unmanned aviation. It is periodically revised as a living document in order to keep up with the evolving terminology of this rapidly changing field
Version history	-
Reference	https://arc.aiaa.org/doi/book/10.2514/4.477072

2.2.17 AIA/NAS

Standard	NAS9948
Title	UAS Data Protection and Privacy
Status	Active
Initial date	16-12-2021
Current version	-
Description	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 are used, recorded, and protected from origin to destruction internal to the platform and external to the platform (i.e. the cloud).
Version history	-
Reference	https://standards.globalspec.com/std/14485260/nas9948

2.2.18 CTA

Standard	ANSI/CTA-2088.1
Title	Baseline Cybersecurity for Small Unmanned Aerial Systems
Status	Active
Initial date	12-2020
Current version	-
Description	This standard defines baseline security capabilities for devices and device systems, including connected devices, endpoint devices, hardware modules, chips, software, sensors, and other operational components. It also outlines related organizational security capabilities and recommendations to enhance overall device security.
Version history	-
Reference	https://iotsecuritymapping.com/wp-content/uploads/2022/05/ANSI-CTA-2088-Final.pdf

2.2.19 NFPA

Standard	2400
Title	Standard for Small Unmanned Aircraft Systems (sUAS) Used for Public Safety Operations
Status	Active
Initial date	2024
Current version	-
Description	NFPA 2400 establishes the minimum requirements for the safe operation, deployment, and implementation of small Unmanned Aircraft Systems (sUAS). It covers organizational program criteria, professional qualifications for safety personnel, and key elements of a maintenance program.
Version history	-
Reference	https://www.nfpa.org/codes-and-standards/nfpa-2400-standard-development/2400

2.2.20 EASA

Standard	NPA 2021-09
Title	Regular update of the acceptable means of compliance and guidance material to Regulation (EU) 2019/947 on the rules and procedures for the operation of unmanned aircraft
Status	Active
Initial date	09-2021
Current version	-
Description	-
Version history	-
Reference	https://www.easa.europa.eu/sites/default/files/dfu/npa_2021-09.pdf

Standard	SC-RPAS.1309-01
Title	Equipment, systems, and installations
Status	Active
Initial date	12/10/2015
Current version	-
Description	This AMC provides acceptable methods for demonstrating compliance with SC-RPAS.1309 requirements. It offers guidance to supplement the engineering and operational judgment necessary for a comprehensive compliance demonstration.
Version history	-
Reference	https://www.easa.europa.eu/sites/default/files/dfu/SC-RPAS.1309-01_Iss02.pdf

2.2.21 JARUS

Standard	CS-LUAS
Title	Recommendations for Certification Specification for Light Unmanned Aircraft Systems
Status	Active
Initial date	11-09-2016
Current version	-
Description	This JARUS-CS-LUAS Recommendation provides guidance for States to incorporate into their national legislation regarding Certification Specifications for Light Unmanned Aircraft Systems. It consolidates best practices from previous RPAS approvals and input from JARUS-WG-3 (Airworthiness) experts.
Version history	-
Reference	http://jarus-rpas.org/wp-content/uploads/2023/06/jar_07_doc_CS_LUAS.pdf

Standard	CS-LURS
Title	Certification Specification for Light Unmanned Rotorcraft Systems
Status	Active

Initial date	-
Current version	-
Description	N/A
Version history	-
Reference	https://wpo-altertechnology.com/jarus-certification-specification-light-unmanned-rotorcraft-systems/

Standard	CS-UAS
Title	Recommendations for Certification Specification for Unmanned Aircraft Systems
Status	Active
Initial date	06-09-2019
Current version	-
Description	This JARUS-CS-UAS Recommendation provides guidance for States to incorporate into their national legislation regarding Certification Specifications for Unmanned Aircraft Systems. It consolidates best practices from previous UAS approvals and input from JARUS-WG-3 (Airworthiness) experts.
Version history	-
Reference	http://67.217.59.217/jarus/wp-content/uploads/2023/06/jar_13_doc_CS_UAS-1.pdf

2.2.22 ETSI

Standard	TR 121 917
Title	Digital cellular telecommunications system (Phase 2+) (GSM); Universal Mobile Telecommunications System (UMTS);
Status	Active
Initial date	01-2023
Current version	-
Description	This document provides a summary of each Release 17 Feature or significant Work Item, offering an overview of their purpose and system behavior. It presents the "initial state" of the features at the time of publication, acknowledging that they may be modified or enhanced over time through Change Requests (CRs). To obtain the most up-to-date details on a feature, it is recommended to review relevant CRs, as outlined in Annex C.
Version history	-
Reference	https://www.etsi.org/deliver/etsi_tr/121900_121999/121917/17.00.01_60/tr_121917v170001p.pdf

Standard	TS 122 125
Title	Unmanned Aerial System (UAS) support in 3GPP
Status	Active
Initial date	05-2024
Current version	-

Description	This document defines the operational requirements for Uncrewed Aerial Vehicles (UAVs) using the 3GPP system. It includes specifications for remote identification and tracking of UAS linked to a 3GPP subscription, addressing business, security, and public safety needs.
Version history	-
Reference	https://www.etsi.org/deliver/etsi_ts/122100_122199/122125/18.01.00_60/ts_122125v180100p.pdf

Standard	TS 123 255
Title	Application layer support for Uncrewed Aerial System (UAS); Functional architecture and information flows;
Status	Active
Initial date	05-2024
Current version	-
Description	This document defines the functional architecture, procedures, and information flows for the UAS application enabler layer. It specifies the application layer capabilities required for the efficient use and deployment of UAS over 3GPP systems, applicable to both EPS and 5GS.
Version history	-
Reference	https://www.etsi.org/deliver/etsi_ts/123200_123299/123255/18.02.00_60/ts_123255v180200p.pdf

Standard	TS 123 256
Title	Support of Uncrewed Aerial Systems (UAS) connectivity, identification and tracking; Stage 2
Status	Active
Initial date	07-2024
Current version	-
Description	This document defines architecture enhancements for Uncrewed Aerial Systems (UAS) connectivity, identification, and tracking, based on the use cases and service requirements in TS 22.125. It specifies UAV identification, authentication, and authorization, along with UAV tracking within the 3GPP system. This includes support for UAV-to-ground identification for authorized third parties, such as law enforcement, and mechanisms for handling unauthorized UAVs and revoking authorization.
Version history	-
Reference	https://www.etsi.org/deliver/etsi_ts/123200_123299/123256/18.03.00_60/ts_123256v180300p.pdf

Standard	TS 124 257
Title	Uncrewed Aerial System (UAS) Application Enabler (UAE) layer; Protocol aspects; Stage 3
Status	Active
Initial date	10-2024
Current version	-

Description	This document specifies the protocols for application layer support for UAS services as defined in 3GPP TS 23.255. It covers UAS application communication between the UE and the UAE server over the U1-AE interface and among UEs using unicast Uu. It defines the procedures for these communications, the interactions of the UAE layer with SEAL services, and the message format, contents, error handling, and system parameters for the UAE layer.
Version history	-
Reference	https://www.etsi.org/deliver/etsi_ts/124200_124299/124257/18.04.00_60/ts_124257v180400p.pdf

Standard	TS 129 255
Title	Uncrewed Aerial System Service Supplier (USS) Services; Stage 3
Status	Active
Initial date	09-2024
Current version	-
Description	This document defines the stage 3 protocol and data model for the UAS-specific Naf Service-Based Interface. It specifies protocol definitions, message flows, and APIs for UAS-specific AF services. The 5G System stage 2 architecture and procedures are outlined in TS 23.501, TS 23.502, and TS 23.256, while the technical realization of the Service-Based Architecture follows TS 29.500 and TS 29.122. The UAS Service Supplier (USS) provides UAS-specific AF services to NF service consumers, such as NEF (UAS-NF), operating as a function within the AF.
Version history	-
Reference	https://www.etsi.org/deliver/etsi_ts/129200_129299/129255/18.04.00_60/ts_129255v180400p.pdf

Standard	TS 129 256
Title	Uncrewed Aerial Systems Network Function (UAS-NF); Aerial Management Services; Stage 3
Status	Active
Initial date	07-2023
Current version	-
Description	This document defines the stage 3 protocol and data model for the UAS-NF functionality within the Nnef Service-Based Interface. It specifies protocol definitions, message flows, and APIs for the UAS-specific NEF services. The 5G System stage 2 architecture and procedures are outlined in 3GPP TS 23.501 and TS 23.502, while the technical realization of the Service-Based Architecture follows TS 29.500 and TS 29.501. The Uncrewed Aerial System Network Function (UAS-NF) delivers UAS-specific NEF services to NF service consumers, such as AMF and SMF, functioning as part of the NEF.
Version history	-
Reference	https://www.etsi.org/deliver/etsi_ts/129200_129299/129256/18.04.00_60/ts_129256v180400p.pdf

Standard	TS 129 257
Title	Application layer support for Uncrewed Aerial System (UAS); UAS Application Enabler (UAE) Server Services; Stage 3

Status	Active
Initial date	07-2024
Current version	-
Description	This document defines the stage 3 protocol and data model for UAS Application Enabler (UAE) Server services, supporting Uncrewed Aerial System (UAS) applications over 3GPP networks. It specifies protocol definitions, message flows, and APIs for UAE Server services. The stage 2 application layer architecture, functional requirements, procedures, and information flows for UAS applications are outlined in 3GPP TS 23.255, while common protocol and interface aspects for API definitions follow clause 5.2 of 3GPP TS 29.122.
Version history	-
Reference	https://www.etsi.org/deliver/etsi_ts/129200_129299/129257/18.04.00_60/ts_129257v180400p.pdf

Standard	TS 133 256
Title	Security aspects of Uncrewed Aerial Systems (UAS)
Status	Active
Initial date	05-2024
Current version	-
Description	This document defines the security features supporting architecture enhancements for Uncrewed Aerial Systems (UAS) connectivity, identification, tracking, and pairing authorization, as specified in TS 23.256. It aligns with the use cases and service requirements outlined in TS 22.125.
Version history	-
Reference	https://www.etsi.org/deliver/etsi_ts/133200_133299/133256/18.02.00_60/ts_133256v180200p.pdf

Standard	EN 301 473 V2.1.2
Title	Satellite Earth Stations and Systems (SES); Harmonized Standard for Aircraft Earth Stations (AES) providing Aeronautical Mobile Satellite Service (AMSS)/Mobile Satellite Service (MSS) and/or the Aeronautical Mobile Satellite on Route Service (AMS(R)S)/Mobile Satellite Service (MSS), operating in the frequency band below 3 GHz covering the essential requirements of article 3.2 of the Directive 2014/53/EU
Status	Active
Initial date	02-2017
Current version	-
Description	N/A
Version history	-
Reference	https://www.nlfnorm.cz/en/ehn/5434

Standard	ETR 270
Title	Satellite Earth Stations and Systems (SES); Survey on the need for an ETS for Aircraft Earth Stations (AES) in the Aeronautical Mobile Satellite Service (AMSS)
Status	Active

Initial date	05-1996
Current version	-
Description	This technical report provides an introduction to standardization activities related to Aircraft Earth Stations (AES). It identifies the most significant international, regional and national standard organizations involved in developing and publishing AES standards. In addition, it provides a summary of the background and membership of the organizations
Version history	-
Reference	https://www.etsi.org/deliver/etsi_etr/200_299/270/01_60/etr_270e01p.pdf

Chapter 3: Research methodology and UAV communication protocols categorization

Drones and the scientific field related to its communication systems and standards, represent a relatively new area of study. As the primary objective of this research, to (1) collect and (2) categorize all the available prototypes related to drones and Unmanned Aircraft Systems (UAS), was really challenging due to its nascent nature, we had to enhance our research approach. To comprehensively survey the past and current state of drone's communication protocols, properly organize, evaluate and categorize them, we conducted a systematic mapping study. With the past of this chapter there will be presented deep in detail the procedure during our search methodology alongside with the outcome of our work.

3.1 Normal systematic study

Systematic mapping study is a widely used research methodology, designed to provide an overview of specific research areas. Its main purpose is to identify, categorize and analyze the existing literature. As described, a systematic mapping study is divided into 5 phases, which we applied into our study as well. The first and most crucial is the research planning. Here, we are going to clarify specific questions we aim to answer during the course of our study that will structure the whole idea around our subject and with the completion of them we can justify that our research is complete. In addition, at the same phase we predefine the resource databases we are going to use, keeping our search structured, organized and always in scope.

The second step of our process, which was the most time consuming, involved the execution of the actual search. During this phase conducted an extensive web-based investigation, exploring all available data sources and navigating through official organizational websites to collect every UAV-related protocol we could find. As the collection of protocols was only a part of this research, an even further investigation took place, into the scientific library. In order to find any information related to the background of the drones, every information regarding newer or past technologies applied on them, applications that thrived or greatly failed and of course any proposed categorization of those protocols. This step proved particularly challenging. Despite the plethora of information, experiments and research that took place regarding the history of the drones, present and past technologies, we could not find any relative categorization. This lack of information complicated our efforts even further and highlighted the need for a more structured approach.

Third phase or so called "primary studies selection" consist of a major part of the normal systematic study that includes the further evaluation of the collected documents. In advance we had to further classify the extracted data keeping only the information needed in order to properly build our research study. The last two steps focus on how such information will be processed and presents the way that it's going to be visualized.

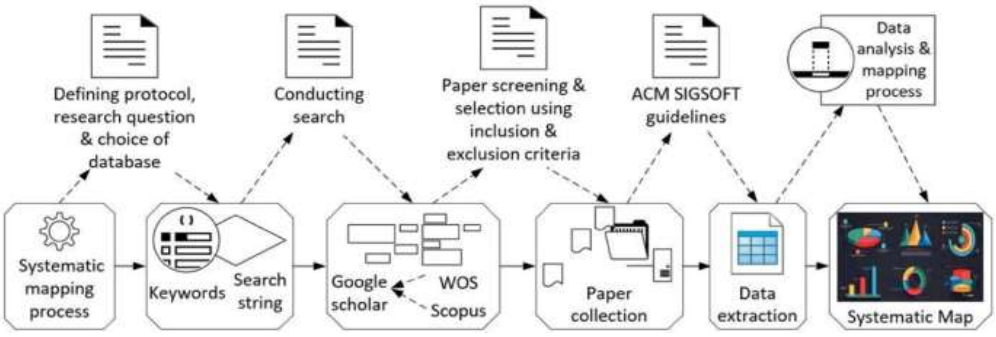

Fig. 18 Systematic mapping process. Scientific diagram

3.2 Research questions

Our first task during the first phase of our research was to deconstruct our subject of study, better understand its components, identify which fields we would like to process even further and search about them, set the major questions that will allow us to identify with ease what we are looking through and, in the end, start searching into the web. This procedure was recursive, as each pass provided us some extra information from perspectives that we did not think about, or even raised hurdles that we could not overcome in order to succeed in the work we really wanted to be noted down. Having that in mind and throughout many recursions we reached the point that we were actually ready to imprint the research questions that we would like to answer during our study.

3.2.1 Related question 1

(RQ1) Which communication standards and protocols are used on UAVs?

The search of the protocols related to drones was not an easy task. Even though visiting various organizations associated with the communication community or those that it is said that are currently working on, or they had in the past, UAV communication protocols, it was not enough to collect them all. Except for well-known organizations such as IEEE, 3GPP, ITU etc. protocols from other organizations or even those purposed for military use and related information about them, was hard to find. That question was the ground point of this research, as its answer would provide a much more discrete and organized overview regarding which communication protocols there are.

3.2.2 Related question 2

(RQ2) How can we categorize the communication standards and protocols for UAVs according to their area of use?

Speaking of communications categories, we have to recognize its vast range of applications. As the reach of such categories lies from design and construction of communication systems architectures, to “enhancing” communication security to even further use cases, it is clear that our work to provide a discrete categorization in such a chaotic area, is mandatory. By doing that we will allow other researchers or readers to understand each communication standard or protocol use into the development of UASs. Although, except from the categorization provided by ANSI’s roadmaps, which due to the number of the protocols had a more generic approach, we found no other proposed categorization.

3.2.3 Related question 3

(RQ3) How can we categorize the communication standards and protocols for UAVs according to the EASA's registration regulations?

As the regulations in each country might defer, we aimed to proceed with a categorization of protocols and standards according from the UAVs hardware perspective. In general, we wanted to align protocols with their specific type-category of drones and necessary certifications that users must obtain prior to operation. Addressing this question will clarify their implementation in EASA's categorization of drones, for countries members under its authority while it will stimulate further exploration of these protocols' application.

3.3 Search terms and literature selection criteria

As it is easy to understand through our study multiple keywords have been used to describe drones and its ecosystem. In order to extract all the necessary knowledge to understand the nature, history and study the communication protocols implemented for them, we seek the domain relevant papers with the subject, UAVs, Drones, UASs. Despite the large number of papers that we had to filter, evaluating their authenticity and how relevant and produced information was. With that in mind our target material was basically books, papers, prototype standards and journals. As our criteria justify, we selected two widely known databases for the collection of general information regarding drones. The first one that is mostly used through our search is Google Scholar (https://scholar.google.com). Except for the user-friendly interface that allows the finding of relevant literature much easier, Google due to the capabilities of the parent Google search engine, covers a wide range of subjects including science, technology and more. Hence, in order to widen even further the domain of our database resources, we selected to use in addition IEEE Xplore (https://ieeexplore.ieee.org). The organization's engagement with similar types of issues like interconnection, communication protocols, wireless networks etc, with its relevant indexing, provided us further material that was not available from Google Scholar.

Our research extended even further from the research of papers, but pressed forward into review and access standards. During that phase we have accessed the related database of IEEE standards (https://standards.ieee.org/) where we were able to find standards even from the early of 2015, major literature resource found from ANSI (https://www.ansi.org/) which also provided the one and only protocol categorization through its roadmap and its later revisions. Last but not least a large amount of communication protocols and information regarding them was retrieved through the ARINC Industry Activities (https://aviation-ia.sae-itc.com/) , ITU (https://www.itu.int/en/ITU-T/Pages/default.aspx), SAE International (https://www.sae.org/), ISO (https://www.iso.org/home.html) and 3GPP (https://www.3gpp.org/) .

Having our database already selected, we had to move forward to define the search term definitions. As either our resource databases provide tools where we can adjust keywords that are actually used as Boolean operators, we provided such search terms in order to widen our research as far as possible to our relevant topic.

- (UAV OR Drones) AND Communication Protocols
- (Uncrewed Aerial Vehicles OR UAS) AND Communication technologies.
- (Unmanned Aircraft Systems OR UAS) AND (Command and Control OR C2)
- Drones AND EASA regulations

The idea behind the first two is to identify and collect all the research studies related to drones, as in the literature drones, as commonly called even as Unmanned Aircraft Vehicles, Uncrewed Aircraft

Systems or even refer to them as Unmanned Aircraft Systems. Our third search term was selected in order to further investigate the communication field between drones, drones and base stations or even drones with other facilities. Last but not least our fourth term was selected as we desired to investigate whether we can provide such categorization, matching the regulation of EASA's regarding the structure of each one drone with every single communication protocol.

3.4 Threat to validity

In this section we present a risk assessment of our work against our research execution process. As mentioned, multiple times, our goal was to make a centralized database of communication protocols related to drones. However, through the implementation, several risk factors could potentially impact the quality, reliability and completeness of our work.

The first threat to validity, is the omission of a significant number of protocols, from our source databases. Due to the fact that most of these protocols are closed and we could not have any access further than their description, we might have surpassed various protocols that despite their appliance on drones was not clearly justified through its title or the short description. In addition, there were multiple databases which we didn't have access to for understandable reasons, such as NATO and military related information. Although we did identify a few protocols explicitly intended for military use, there was neither sufficient description nor even official titles available to allow for proper classification. Given the extremely limited visibility into this domain and due to the fact that we only find a small amount of such protocols, we decided to remove them completely from our study.

The second possible threat which is closely related with the first one, is making mistakes in how we judged and categorized the protocols. Human nature and personal bias can sometimes lead to wrong decisions. The same risk applies in our study too. To reduce the possibility of human error during this research, we tried to search in as many sources as possible to gather accurate information about each protocol.

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Chapter 4: ANSI: Communication protocol categorization and areas of appliance

As this chapter goes along, we are going to deep dive into the work already accomplished by ANSI and the other organizations that collaborated to create such a useful source of knowledge into the communication area of drones, with the UAS roadmap. As said, we are going to present their journey till now, what information we extracted that allowed us to proceed with our investigation and at the end create our own categorization for communication protocols.

4.1 ANSI's UAS roadmap

ANSI, is a private non-profitable organization founded in 1918, of which main purpose is to coordinate and oversee the development and use of standards and guidelines as it is not by itself a standard development organization. Despite being the standardization body mostly for U.S, ANSI is the main representative on United States in multiple committees such as the International Organization for Standardization (ISO), the International Electrotechnical Commission (IEC), the Pacific Area Standards Congress (PASC) and the Pan American Standards Commission (COPANT).

They're journey on unmanned aerial systems started early in 2017 where they launched an unmanned aircraft systems standardization collaborative mission in order to coordinate and accelerate the development of the standards and their safe integration of unmanned aircraft systems. As their goal was to establish a worldwide effect, they collaborated with a vast organization around the world with main focus the growth of the UAS market, with emphasis on the civil, commercial and public safety applications. First publication landed at the end of 2018 where exactly some months later started the UASSC for the second version of the roadmap. Since then, we see a second publication in June 2020 and till now as we can see in the roadmap below, almost a yearly gaps report was published.

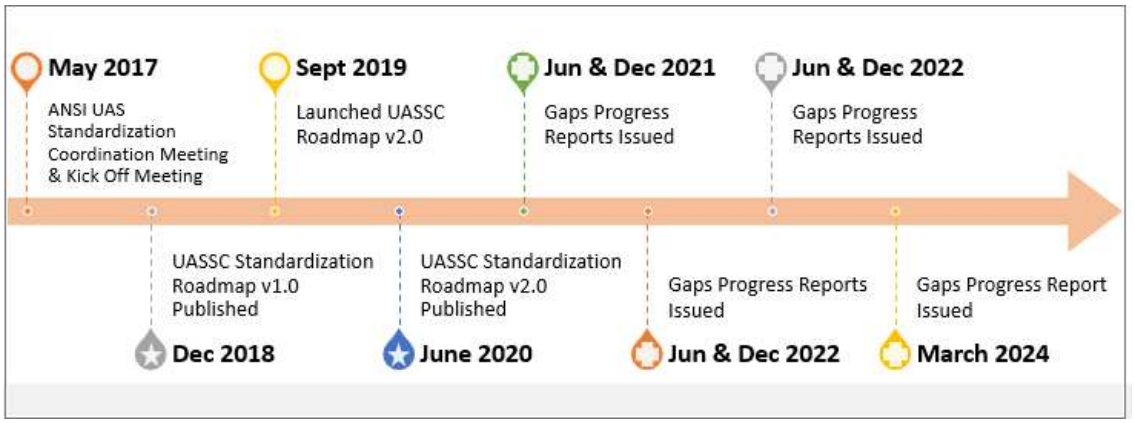

Fig. 19 ANSIs Road map timeline [25]

Our first encounter with ANSI's roadmap was at its second revision, so before proceeding with our main subject we have to highlight some facts and points of interest regarding the information extracted from the UASSC roadmap. During that roadmap ANSI along with their collaborators looked into 78 areas from which identified more than 70 open gaps where improvements were needed, along with some recommendations. Given the wide range of application areas and the large number of related communication protocols, our initial pass involved not only collecting these protocols but also documenting their categorization, which served as a reference point for later stages of our research. When our search reached its limits, in terms of accessibility, we came to the result that the only available source of information and categorization for UAV related protocols was by these roadmaps.

The categories that we ended up with that we will also see in extend later are the following:

- Design & Construction
- Command & Control
- Security & Safety
- Quality Assurance

While some extra categories that we also included except from those presented from ANSI, are Swarms, Military and one more generic category that applies to protocols that could not be specifically categorized or their purpose is more generally focused.

4.1.1 Design & construction protocols

Design and Construction category includes, as its name suggests, essential for Unmanned Aircraft Systems (UAS) standards for their full integration into the National Airspace System (NAS). Due to its criticality the full implementation of standards supporting design and production approvals must be established in advance before further operational standards are developed and even more accepted, such as operating over people, beyond visual line of sight or other advanced operations. These standards will set the stepping stone for the society, build a level of confidence and assurance and accept drones even further in their daily life, moving away any second thoughts and fears, something that is not currently required for sUAS. In order to achieve that, design and construction acceptance criteria similar to manned aircraft should be established, which will cover use cases not only for sUAS but also for UAS larger than 25kg. Although as some standards developed mostly larger scaled drones as ANSI mentions should be scaled according the following criteria:

1. Aircrafts size
2. Risks to other entities
3. Threat to environment
4. Complexity of the expected operation

As the description of the related category reaches its end, as in most of their reports, ANSI provides a summary of gaps that need to be covered for each section, in order to construct a durable and established industry standard. Here ASNI highlights that despite the existence of multiple standards that apply in design and construction, none of them can be applied into the area of unmanned aircraft vehicles, as crucial aspects such as BVLOS flight, Command and Control link etc. are not be addressed. This gap was noted with the highest priority that needs to be addressed. With the passing of years to the latest version of the roadmap, we can see that a large number of standards have been published, where a notable number of new ones are in development procedures. The recommendations made at that moment from the cooperation of the organizations, is first and foremost to complete the development of the ongoing standards, while at the same time thinking beyond and developing standards for UA and CS that can either weigh more than 8 tons and flight capabilities above 400ft.

Following a small presentation of the details of the current category and the roadmap of the related gaps, we are going to present the list of protocols that we categorized here.

Table 7 Design and construction protocols

1936.1-2021	Standard for Drone Applications Framework	IEEE
1936.2-2023	Photogrammetric Technical Standard of Civil Light and Small Unmanned Aircraft Systems for Overhead Transmission Line Engineering	IEEE
1936.3	Standard for Unmanned Aircraft Systems (UAS) using Light Detection and Ranging (LiDAR) for above 110 kV Overhead Transmission Line Survey and Design	IEEE
1937.1-2020	Standard Interface Requirements and Performance Characteristics for Payload Devices in Drones	IEEE
1937.3-2024	Standard for Flight Data Transmission of Civil Unmanned Aerial Vehicle Based on Short Message Mechanisms	IEEE
1937.6	Standard for Unmanned Aerial Vehicle (UAV) Light Detection and Ranging (LiDAR) Remote Sensing Operation	IEEE
1937.8	Recommended Practice for Functional and Interface Specifications for Unmanned Aerial Vehicle (UAV) Cellular Communication Terminals	IEEE
1937.12	Standard for Technical Requirements for Emergency Cellular Communication System Based on Fixed-Wing Unmanned Aircraft System	IEEE
1939.1	Standard for a Framework for Structuring Low Altitude Airspace for Unmanned Aerial Vehicle (UAV) Operations	IEEE
1945	Standard for Internet of Things (IoT) Computing Edge Computing on Unmanned Aircraft Systems-Part 1 General Requirements	IEEE
1954	Standard for Self-Organizing Spectrum-Agile Unmanned Aerial Vehicles Communications	IEEE
16747	Unmanned aircraft systems – Counter UAS – Quality and safety for manufacturers	ISO/CD
20780:2018	Space systems – Fiber optic components – Design and verification requirements	ISO
21384-2	Unmanned aircraft systems Part 2: UAS Components	ISO
23629-5:2023	UAS traffic management – Part 5: UTM functional structure	ISO
24354	General requirements for the payload interface of civil unmanned aircraft systems	ISO
24355	Flight control system for civil small and light multi-copter unmanned aircraft system (UAS) – General requirements	ISO
24356	General requirements for tethered unmanned aircraft systems	ISO
25215	Civil small and light multi-copter unmanned aircraft docking system – General requirements	ISO/AWI
F2245-23	Standard Specification for Design and Performance of a Light Sport Airplane	ASTM
F2639-18	Standard Practice for Design Alteration, and Certification of Aircraft Electrical Wiring Systems	ASTM

F2840-14(2023)	Standard Practice for Design and Manufacture of Electric Propulsion Units for Light Sport Aircraft	ASTM
F2910-22	Standard Specification for Design and Construction of a Small Unmanned Aircraft System (sUAS)	ASTM
F3002-22	Standard Specification for Design of the Command-and-Control System for Small Unmanned Aircraft Systems (sUAS)	ASTM
F3231/F3231M-24	Standard Specification for Electrical Systems for Aircraft with Combustion Engine Electrical Power Generation	ASTM
F3232/F3232M-23a	Standard Specification for Flight Controls in Small Aircraft	ASTM
F3269-21	Standard Practice for Methods to Safely Bound Behavior of Aircraft Systems Containing Complex Functions Using Run-Time Assurance	ASTM
F3298-24	Standard Specification for Design and Construction of Lightweight Unmanned Aircraft Systems (UAS)	ASTM
F3322-25	Standard Specification for Design and Construction of Lightweight Unmanned Aircraft Systems (UAS)	ASTM
F3563-22	Standard Specification for Design and Construction of Large Fixed Wing Unmanned Aircraft Systems	ASTM
F3657-23	Standard Specification for Verification of Lightweight Unmanned Aircraft Systems (UAS)	ASTM
WK56255	New Guide for Design and Production of Energy Storage Systems to Power Aircraft Propulsion	ASTM
WK87943	Revision of F3322-22 Standard Specification for Small Unmanned Aircraft System (sUAS) Parachutes	ASTM
Y.3207	Fixed, mobile and satellite convergence – Integrated network control architecture framework for IMT-2020 networks and beyond	ITU
Y.4421	Functional architecture for unmanned aerial vehicles and unmanned aerial vehicle controllers using IMT-2020 networks	ITU
Y.4559	Requirements and functional architecture of base station inspection services using unmanned aerial vehicles	ITU
F.749.10	Requirements for communication services of civilian unmanned aerial vehicles	ITU
F.749.11	Requirements for civilian unmanned aerial vehicles enabled mobile edge computing	ITU
F.749.12	Framework for communication application of civilian unmanned aerial vehicles	ITU
F.749.13	Framework and requirements for civilian unmanned aerial vehicle flight control using artificial intelligence	ITU
RFC 9434	Drone Remote Identification Protocol (DRIP) Architecture	IETF
DO-254	Design Assurance Guidance for Airborne Electronic Hardware	RTCA
23.255	Application layer support for Uncrewed Aerial System (UAS); Functional architecture and information flows;	3GPP
23.700-91	Study on enablers for network automation for the 5G System (5GS); Phase 2	3GPP
33.889	Study on security aspects of Machine-Type Communications (MTC) architecture and feature enhancements	3GPP

TS 123 255	Application layer support for Uncrewed Aerial System (UAS); Functional architecture and information flows;	ETSI
ED-271	Minimum Aviation System Performance Standard for Detect and Avoid (Traffic) in Class A-C airspaces	EUROCAE
ED-279	Generic Functional Hazard Assessment (FHA) for UAS and RPAS	EUROCAE
J2945/2_201810	Dedicated Short Range Communications (DSRC) Performance Requirements for V2V Safety Awareness	SAE
J2945/3_202201	Requirements for Road Weather Applications	SAE
JA7496	Cyber-Physical Systems Security Engineering Plan (CPSSEP)	SAE
AIR5665C	Architecture Framework for Unmanned Systems	SAE
AIR6258	Fiber Optic Sensors for Aerospace Applications	SAE
AIR6276	Use of modeling and tools for aircraft systems development – A strategy for development assurance aspects with examples	SAE
AIR6343	Design and Development of Rechargeable Lithium Battery Systems for Aerospace Applications	SAE
AIR6514	Unmanned Systems Control Segment Architecture: Interface Control Document	SAE
AIR6913	Using System-Theoretic Process Analysis (STPA) During Development and Safety Assessment of Civil Aircraft	SAE
AIR6915	Human Factor Considerations in the Implementation of IVHM	SAE
AIR8678	Architecture Examples for Electrified Propulsion Aircraft	SAE
AS50881H	Wiring Aerospace Vehicle	SAE
AS6512B	Unmanned Systems (UxS) Control Segment (UCS) Architecture: Architecture Description	SAE
AS6513B	Unmanned Systems (UxS) Control Segment (UCS) Architecture: Conformance Specification	SAE
AS6518B	Unmanned Systems (UxS) Control Segment (UCS) Architecture: UCS Architecture Model	SAE
AS6522B	Unmanned Systems (UxS) Control Segment (UCS) Architecture: Architecture Technical Governance	SAE
AS6858	Installation of Fuel Cell Systems in Large Civil Aircraft	SAE
ARP6154	Aerospace Fluid Power Electro-Hydrostatic Module, Design, Performance and Test Recommendations	SAE
ARP6290	Guidelines for the Development of Architectures for Integrated Vehicle Health Management Systems	SAE
ARP6407	IVHM Design Guidelines	SAE
AIR6520A	Unmanned Systems (UxS) Control Segment (UCS) Architecture: Version Description Document	SAE
ARP6538	Dynamic Modeling of Aerospace Systems (DyMAS)	SAE
ARP6983	Process Standard for Development and Certification/Approval of Aeronautical Safety-Related Products Implementing AI	SAE
ARP94910	Aerospace - Vehicle Management Systems - Flight Control Design, Installation and Test of, Military Unmanned Aircraft, Specification Guide	SAE

ARP94910A	Aerospace - Vehicle Management Systems - Flight Control Design, Installation and Test of, Military Unmanned Aircraft, Specification Guide	SAE
ARINC413A	Guidance for aircraft electrical power utilization and transient protection	SAE
ARINC609	Design guidance for aircraft electrical power	SAE
ARINC650	Integrated modular avionics packaging and interfaces	SAE
ARINC660A	CNS/ATM Avionics, functional allocation and recommended architectures	SAE
ARINC660B	CNS/ATM Avionics architectures supporting NEXTGEN/SESAR concepts	SAE
ARINC677	Installation standards for low frequency underwater locator beacon (LF-ULB)	SAE
ARINC680	Aircraft autonomous distress tracking (ADT)	SAE
ARINC741P1-15	Aviation satellite communication systems PART 1: Aircraft installation provisions	SAE
ARINC741P2-11	Aviation satellite communication system PART 2: System design and equipment functional description	SAE
ARINC761-6	Second generation aviation satellite communication systems, aircraft installation provisions	SAE
ARINC791P1-3	Mark I Aviation Ku-Band and Ka-Band Satellite Communication System, Part 1, Physical Installation and Aircraft Interfaces	SAE
ARINC791P2-2	Mark I Aviation Ku-Band and Ka-Band Satellite Communication System, Part 2, Electrical Interfaces and Functional Equipment Description	SAE
ARINC792-2	Second-Generation Ku-Band and Ka-Band Satellite Communication System	SAE
ARINC821	Aircraft network server system (NSS) functional definition	SAE
ARINC839	Function Definition of Airborne Manager of Air-Ground Interface Communications (MAGIC)	SAE

4.1.2 Command and control protocols

Moving further away from the construction and design guidelines, we reach into the second crucial part to build up the environment on which UAS will thrive and that is Communication and Control (C2). More specifically C2 represents a collection of systems and processes that will be used to direct and manage the operation of all UAS either remotely piloted or autonomous, including both the hardware and software components. That way a reliable but first and foremost secure communication link is created between the UAS to another entity, in terms of tracking, aircraft awareness or relay telemetry.

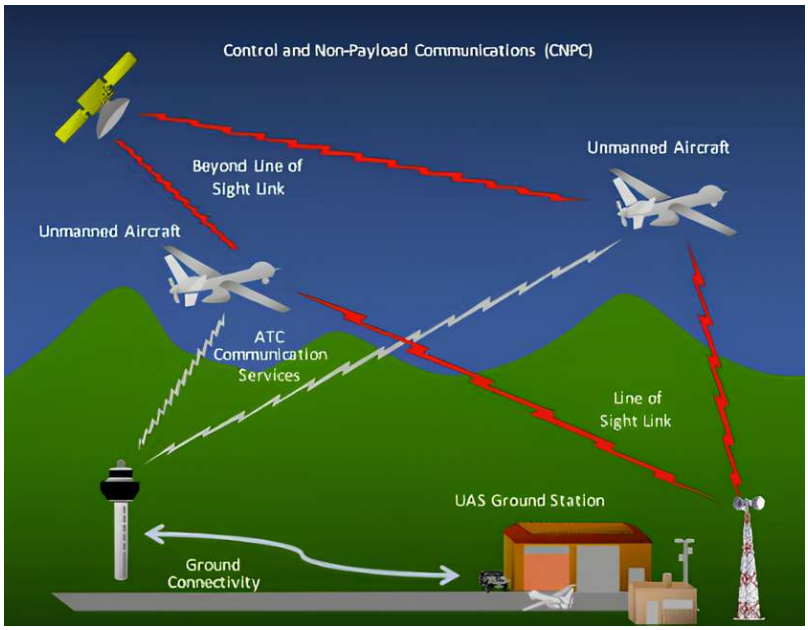

Fig. 20 Terrestrial base command and control operational concepts [26]

Continuing our research through ANSI's roadmap we see a series of applicable rules and regulations that due to the origin of the organization refer only between the scope of Federal Communication Commission (FCC) and FAA rules, and do not refer to our continent. In contrast with the existing rule base between FCC and FAA, the rule book and regulations regarding C2 communication link, are far more fluent, as they are governed between various standards and protocols introduced from NATO, combined with EU's cybersecurity and regulations and finally each country has different national military guidelines and spectrum allocation policies.

Starting with gaps mentioned in the first of our version of the roadmap regarding the category of C2 communication links we find the need for an alignment between the aviation and cellular communities. Despite the progress already made by the telecommunication community, with 3GPP leading the way, there are still a lot of real-life use cases that require further standardization. In the latest version of ANSI's roadmap though we see that numerous standards are in development while joint authorities for rulemaking on UAS have been published. Although we have to highlight here that despite all the progress mentioned that is gone through there is a major inconvenience. As mentioned, the cellular industry publishes a fix whenever a problem is located, something that is contrary to the operation of the avionics sector, where things go much slower and already established specs are really hard to be changed.

Except for that though, another gap that needs to be addressed, is the unpredictable nature of the unlicensed spectrum's interference. During 2020, the existence of some enhancing modeling and prediction approaches, were not something to be mentioned, as there were a lot of workloads to be covered. Since the latest version of ANSI's roadmap, no further updates have been provided.

Similarly with the previous category we are going to present a compilation of all the protocols gathered through the years, related to that specific category

Table 8 Command and control protocols

1920.2	Standard for Vehicle-to-Vehicle Communications for Unmanned Aircraft Systems	IEEE
1936.1:2021	Standard for Drone Applications Framework	IEEE
21384-2:2021	Unmanned aircraft systems Part 2: UAS components	ISO
21384-3:2023	Unmanned aircraft systems Part 3: Operational procedures	ISO
F2909-19	Standard Specification for continued Airworthiness of lightweight UAS	ASTM
F3002-22	Standard Specification for Design of the Command-and-Control System for Small Unmanned Aircraft Systems (sUAS)	ASTM
F3298-24	Standard Specification for Design and Construction of Lightweight Unmanned Aircraft Systems (UAS)	ASTM
WK82782	Revision of F3002-14a Standard Specification for Design of the Command-and-Control System for Small Unmanned Aircraft Systems (sUAS)	ASTM
F.749.10	Requirements for communication services of civilian unmanned aerial vehicles	ITU
F.749.13	Framework and requirements for civilian unmanned aerial vehicle flight control using artificial intelligence	ITU
F.749.14	Requirements of coordination for civilian unmanned aerial vehicles	ITU
M2171	Characteristics of UAS and spectrum requirements to support their safe operation in non-segregated airspace	ITU-R
DO-362A	Command and Control (C2) Data Link Minimum Operational Performance Standards (MOPS) (Terrestrial)	RTCA
DO-362 with Errata	Command and Control (C2) Data Link Minimum Operational Performance Standard (MOPS) (Terrestrial)	RTCA
DO-377B	Minimum Aviation System Performance Standards for C2 Link Systems Supporting Operations of Unmanned Aircraft Systems in U.S. Airspace	RTCA
DO-389	OSED for Counter UAS in Controlled Airspace, Counter Unmanned Aircraft System	RTCA
TSO-C213a	Unmanned Aircraft Systems Control and Non-Payload Communications Terrestrial Link System	FAA
AEP-77	Interoperable Command and Control data link for Unmanned Systems (IC2DL) - Operational physical layer/signal in space description	NATO
JA7496	Cyber-Physical Systems Security Engineering Plan (CPSSEP)	SAE
AIR4094A	Aircraft Flight Control Systems Descriptions	SAE
AIR6514	UxS Control Segment (UCS) Architecture: Interface Control Document (ICD)	SAE
AIR6520A	Unmanned Systems (UxS) Control Segment (UCS) Architecture: Version Description Document	SAE
AS6040A	JAUS HMI Service Set	SAE
AS6062A	JAUS Mission Spooling Service Set	SAE
AS6091	JAUS Unmanned Ground Vehicle Service Set	SAE
AS6111	JAUS Unmanned Maritime Vehicle Service Set	SAE

AS6512B	Unmanned Systems (UxS) Control Segment (UCS) Architecture: Architecture Description	SAE
AS6513B	Unmanned Systems (UxS) Control Segment (UCS) Architecture: Conformance Specification	SAE
AS6518B	Unmanned Systems (UxS) Control Segment (UCS) Architecture: UCS Architecture Model	SAE
AS6522B	Unmanned Systems (UxS) Control Segment (UCS) Architecture: Architecture Technical Governance	SAE
AS8024	JAUS Autonomous Capabilities Service Set	SAE
ARINC618-8	Air/Ground character – oriented protocol specification	SAE
ARINC619-5	ACARS protocols for avionic end systems	SAE
ARINC620-10	Datalink ground systems standard and interface specification (DGSS/IS)	SAE
ARINC622-5	ATS data link applications over ACARS Air-Ground network	SAE
ARINC658	Internet protocol suite (IPS) for aeronautical safety services roadmap document	SAE
ARINC724B-6	Aircraft communications addressing and reporting systems (ACARS)	SAE

4.1.3 Security and safety

During the previous category of command and control, we repetitively mentioned that all of these protocols' target is to construct a safe and secure environment so all UAVs can be operated without any chance of malfunction. Safety though does not only cover use cases through the communication process between an unmanned aircraft vehicle with another entity neither command and control link between the drone and the operator. As for safety we can define a rulebook which derives from a list of acceptable risks and the related set of appropriate mitigation handling in order to protect both people and their properties from any possible harm.

Through the first version of the roadmap is highly recommended that instead of going straightforward and create new safety system processes; to further examine the already existing ones so they can be able to determine whether they cover any existing gaps while at the same time implement an aerospace information report or standard which will map any of the existing safety method with the according size and type of UAS. Since that first report of ANSI, in the following version it has been mostly enriched with further use cases that need to be covered, in addition with a large number of regulations and standards that have been either published or they are under development.

As our research is communication centric, the provided collection of protocols on safety and security might lack a lot of related protocols, but for consistency reasons we are going to include them as follows.

Table 9 Security and safety protocols

1936.1	Standard for Drone Applications Framework	IEEE
1937.15	Standard for Communication Security Requirements for Drone Formation Flying Light Show	IEEE
1937.16	Standard for Civil Unmanned Aerial Systems (UAS) Cybersecurity Framework	IEEE

TR 5469	Artificial intelligence — Functional safety and AI systems	ISO/IEC
14620-3:2021	Space systems — Safety requirements Part 3: Flight safety systems	ISO
15408-4:2022	Information security, cybersecurity and privacy protection — Evaluation criteria for IT security - Part 4: Framework for the specification of evaluation methods and activities	ISO/IEC
DIS 15408-4	Part 4: Framework for the specification of evaluation methods and activities	ISO/IEC
15964	Detection and avoidance system for unmanned aircraft systems	ISO/DIS
16746	Unmanned aircraft systems — Counter UAS — Quality and safety for users	ISO/CD
18045:2022	Information security, cybersecurity and privacy protection — Evaluation criteria for IT security — Methodology for IT security evaluation	ISO/IEC
DIS 18045	Information security, cybersecurity and privacy protection — Evaluation criteria for IT security — Methodology for IT security evaluation	ISO/IEC
20517	Space systems — Cybersecurity management requirements and recommendations	ISO/TS
21384-3	Unmanned aircraft systems Part 3: Operational procedures	ISO
22460-2:2024	Part 2: Drone/UAS security module	ISO/IEC
23629-12:2023	Part 12: Requirements for UTM service providers	ISO
25216	Categorization and classification of unmanned aircraft (UA) detection and countermeasure system	ISO/AWI
27005:2022	Information security, cybersecurity and privacy protection — Guidance on managing information security risks	ISO/IEC
27032:2023	Cybersecurity — Guidelines for Internet security	ISO/IEC
TR 29119-11:2020	Software and systems engineering — Software testing Part 11: Guidelines on the testing of AI-based systems	ISO/IEC
29167-11:2023	Information technology — Automatic identification and data capture techniques Part 11: Crypto suite PRESENT-80 security services for air interface communications	ISO/IEC
DIS 29167-11	Information technology — Automatic identification and data capture techniques Part 11: Crypto suite PRESENT-80 security services for air interface communications	ISO/IEC
F3230-25	Standard Practice for Safety Assessment of Systems and Equipment in Small Aircraft	ASTM
F3309/F3309M-24a	Standard Practice for Simplified Safety Assessment of Systems and Equipment in Small Aircraft	ASTM
F3389/F3389M-21	Standard Test Method for Assessing the Safety of Small Unmanned Aircraft Impacts	ASTM
F3411-22a	Standard Specification for Remote ID and Tracking	ASTM
F3442/F3442M-23	Standard Specification for Detect and Avoid System Performance Requirements	ASTM

WK62669	New Test Method for Detect and Avoid	ASTM
WK84631	New Guide for Device-to-Device Certificate-based Communications Security Framework for UAS/UAM	ASTM
Y.2256	Overview of unmanned smart farms based on networks	ITU
Y.4116	Requirements of transportation safety services including use cases and service scenarios	ITU
F.749.11	Requirements for civilian unmanned aerial vehicles enabled mobile edge computing	ITU
X.677	Identification mechanism for unmanned aerial vehicles using object identifiers	ITU
X.1713	Security requirements for the protection of quantum key distribution nodes	ITU
M.2204-0	Characteristics and spectrum considerations for sense and avoid systems use on Unmanned Aircraft Systems (UAS)	ITU-R
RFC 9153	Drone Remote Identification Protocol (DRIP) Requirements and Terminology	IETF
RFC 9374	DRIP Entity Tag (DET) for Unmanned Aircraft System Remote ID (UAS RID)	IETF
RFC 9575	DRIP Entity Tag (DET) Authentication Formats and Protocols for Broadcast Remote Identification (RID)	IETF
DO-278	Guidelines For Communication, Navigation, Surveillance, and Air Traffic Management (CNS/ATM) Systems Software Integrity Assurance	RTCA
DO-326B	Airworthiness Security Process Specification	RTCA
DO-355A	Information Security Guidance for Continuing Airworthiness	RTCA
DO-356A	Airworthiness Security Methods and Considerations	RTCA
DO-362 with Errata	Command and Control (C2) Data Link Minimum Operational Performance Standard (MOPS) (Terrestrial)	RTCA
DO-365C	Minimum Operational Performance Standards (MOPS) for Detect and Avoid (DAA) Systems	RTCA
DO-366A	Minimum Operational Performance Standards (MOPS) for Air-to-Air Radar for Traffic Surveillance	RTCA
DO-386	Vol I Minimum Operational Performance Standards for Airborne Collision Avoidance System Xu (ACAS Xu) (Vol I), andDO-386 Vol II Minimum Operational Performance Standards for Airborne Collision Avoidance System Xu (ACAS Xu) (Vol II: Algorithm Design	RTCA
DO-389	OSED for Counter UAS in Controlled Airspace, Counter Unmanned Aircraft System	RTCA
TSO-C118	Traffic Alert and Collision Avoidance System (Tcas) Airborne equipment, Tcas I	FAA
TSO C119	Traffic alert and collision avoidance system (TCAS) airborne equipment, TCAS II	FAA
TSO-C211	Detect and Avoid (DAA) Systems	FAA
22.825	Study on Remote Identification of Unmanned Aerial Systems (UAS)	3GPP

23.700-91	Study on enablers for network automation for the 5G System (5GS); Phase 2	3GPP
33.256	Security aspects of Uncrewed Aerial Systems (UAS)	3GPP
33.854	Study on security aspects of Uncrewed Aerial Systems (UAS)	3GPP
33.891	Study on security of phase 2 for Uncrewed Aerial System (UAS), Uncrewed Aerial Vehicle (UAV) and Urban Air Mobility (UAM)	3GPP
33.889	Study on security aspects of Machine-Type Communications (MTC) architecture and feature enhancements	3GPP
1073.002	Satellite Network Modem System (SNMS) Encryption Requirements	TIA
2900-1	Software Cybersecurity for Network-Connectable Products, Part 1: General Requirements	UL
AEP-77	Interoperable command and control data link for unmanned systems (IC2DL) – Operational physical layer/signal in space description	NATO
AEP-101	Guidance on sense and avoid for unmanned aircraft systems	NATO
TS 133 256	Security aspects of Uncrewed Aerial Systems (UAS)	ETSI
prEN 4709-002 P1	Aerospace series-Unmanned Aircraft Systems — Part 002: Direct Remote Identification	CEN
ED-280	Guidelines for UAS safety analysis for the Specific category (low and medium levels of robustness)	CEN
ED-301	Guidelines for the Use of Multi-GNSS Solutions for UAS Specific Category - Low Risk Operations SAIL I and II	EUROCAE
NAS9948	UAS data protection and privacy	AIA/NAS
ANSI/CTA-2088.1	Baseline Cybersecurity for Small Unmanned Aerial Systems	CTA
2400	Standard for Small Unmanned Aircraft Systems (sUAS) Used for Public Safety Operations	NFPA
NPA 2021-09	Regular update of the acceptable means of compliance and guidance material to Regulation (EU) 2019/947 on the rules and procedures for the operation of unmanned aircraft	EASA
J2945/5_202002	Service Specific Permissions and Security Guidelines for Connected Vehicle Applications	SAE
J3018	Safety-Relevant Guidance for On-Road Testing of Prototype Automated Driving System	SAE
J3061	Cybersecurity Guidebook for Cyber-Physical Vehicle Systems	SAE
JA6678	Guidelines for Establishing and Maintaining Cyber-Physical-Systems' Cyber-Resilience	SAE
JA6801	Cyber Physical Systems Security Hardware Assurance	SAE
JA7496	Cyber-Physical Systems Security Engineering Plan (CPSSEP)	SAE
AIR5273A	Aircraft Flight Control Actuation System Failure-Detection Methods	SAE
AIR6464	EUROCAE/SAE WG80/AE-7AFC Hydrogen Fuel Cells Aircraft Fuel Cell Safety Guidelines	SAE

AIR6913	Using System-Theoretic Process Analysis (STPA) During Development and Safety Assessment of Civil Aircraft	SAE
ARP5150A	Safety Assessment of Transport Airplanes in Commercial Service	SAE
ARP5151A	Safety Assessment of General Aviation Airplanes and Rotorcraft in Commercial Service	SAE
ARINC562	Terrain awareness and warning system (TAWS) – ANALOG	SAE
ARINC594-4	Ground proximity warning system	SAE
ARINC595	Barometric altitude rate computer (BARC)	SAE
ARINC650	Integrated modular avionics packaging and interfaces	SAE
ARINC679	Aircraft server, communications and interface standard	SAE
ARINC712-7	Airborne ADF system	SAE
ARINC723-3	Ground proximity warning system	SAE
ARINC735A-1	Mark 2 Traffic Alert and Collision Avoidance System (TCAS)	SAE
ARINC735C	Traffic computer, ACAS-X, and ADS-B functionality	SAE
ARINC762-1	Terrain awareness and warning system (TAWS)	SAE
ARINC811	Commercial aircraft information security concepts of operation and process framework	SAE
ARINC823P1	Datalink Security, Part 1 - ACARS Message Security	SAE
ARINC823P2	Datalink Security, Part 2 - Key Management	SAE
ARINC835-1	Guidance for security of loadable software parts using digital signatures	SAE
ARINC852	Guidance for security event logging in an IP environment	SAE
ARINC858P1	Internet protocol suite (IPS) for aeronautical safety services PART 1: Airborne IPS system technical requirements	SAE
ARINC858P2	Internet protocol suite (IPS) for aeronautical safety services PART 2: IPS gateway Air-Ground interoperability	SAE
GEIASTD0010A	Standard Best Practices for System Safety Program Development and Execution	SAE
SAE1005	Model Based Functional Safety	SAE

4.1.4 Quality assurance/ Quality control

Finally, one last categorization according to ANSI's Road map, is quality and assurance and quality control. In order to avoid any confusion between these two terms, quality assurance represents the overall guidelines used anywhere while quality control focuses on the production process. With that knowledge we can understand the crucial role such processes have in order to support airworthiness and create reliable and safe UAS operation inside the NAS. There are already hundreds of quality assurance and quality control standards that have already been applied to UAS and ANSI claims that no gaps have been recorded into this category.

Similarly with the collection provided for safety and security, we have to highlight that due to the nature of our research, the number of protocols provided might differ a lot from the actual number of standards and protocols related to the QA-QC category.

Table 10 Quality assurance/ Quality control protocols

1936.4	Standard for Technical Requirements for the Maintenance of Multi-rotor Unmanned Aircraft Systems Used for Power Grid Inspection	IEEE
1936.12	Standard for Verification of Pilot Line Deployment Devices Based on Unmanned Aircraft Systems for Overhead Power Line Installations	IEEE
4358:2023	Test methods for civil multi-copter unmanned aircraft system	ISO
5055:2021	Information technology — Software measurement — Software quality measurement — Automated source code quality measures	ISO/IEC
5109:2023	Evaluation method for the resonance frequency of the multi-copter UA (unmanned aircraft) by measurement of rotor and body frequencies	ISO
5110:2023	Test method for flight stability of a multi-copter unmanned aircraft system (UAS) under wind and rain conditions	ISO
5286:2023	Flight performance of civil small and light fixed-wing unmanned aircraft systems (UAS) — Test methods	ISO
5309:2023	Civil small and light unmanned aircraft systems (UAS) — Vibration test methods	ISO
5332:2023	Civil small and light unmanned aircraft systems (UAS) under low-pressure conditions — Test methods	ISO
9001:2015	Quality managements systems — Requirements	ISO
15864:2021	Space systems — General test methods for spacecraft, subsystems and units	ISO
15964	Detection and avoidance system for unmanned aircraft systems	ISO/DIS
16746	Unmanned aircraft systems — Counter UAS — Quality and safety for users	ISO/CD
17123-10	Optics and optical instruments — Field procedures for testing geodetic and surveying instruments Part 10: UAV photogrammetry systems	ISO/AWI
18047-3:2022	Information technology — Radio frequency identification device conformance test methods Part 3: Test methods for air interface communications at 13,56 MHz	ISO/IEC
18047-63:2023	Information technology — Radio frequency identification device conformance test methods Part 63: Test methods for air interface communications at 860 MHz to 960 MHz	ISO/IEC
24243	Test methods for civil small and light multi-copter unmanned aircraft dock system	ISO/CD
24352	Technical requirements for small unmanned aircraft electric energy systems	ISO
25030:2019	Systems and software engineering — Systems and software quality requirements and evaluation (SQuaRE) — Quality requirements framework	ISO/IEC
F2972-24	Standard Specification for Light Sport Aircraft Manufacturer's Quality Assurance System	ASTM
F3153-22	Standard Specification for Verification of Aircraft Systems and Equipment	ASTM
F3246-18	Standard Specification for Quality Assurance for Manufacturers of Aircraft Systems	ASTM
F3389/F3389M-21	Standard Test Method for Assessing the Safety of Small Unmanned Aircraft Impacts	ASTM

F3532-23	Standard Practice for Protection of Aircraft Systems from Intentional Unauthorized Electronic Interactions	ASTM
E2696-21	Standard Practice for Life and Reliability Testing Based on the Exponential Distribution	ASTM
F3686-24a	Standard Practice for Production Approval of Unmanned Aircraft Systems (UAS)	ASTM
WK85104	New Practice for Supporting Compliance with Requirements for sUAS Operations over People	ASTM
DO-160G	Environmental Conditions and Test Procedures for Airborne Equipment	RTCA
DO-380	Environmental Conditions and Test Procedures for Ground Based Equipment	RTCA
4600	Evaluation of Autonomous Products	UL
TOP-7-2-032	Unmanned Aircraft Systems (UAS) Navigation System Test	US-ARMY
DOD-STD-2168	Defense System Software Quality Program	US-ARMY
J2940_202002	Use of Model Verification and Validation in Product Reliability and Confidence Assessments	SAE
AIR6218	Constructing Development Assurance Plan for Integrated Systems	SAE
AIR6219	Development of Atmospheric Neutron Single Event Effects Analysis for Use in Safety Assessments	SAE
AIR6913	Using System-Theoretic Process Analysis (STPA) During Development and Safety Assessment of Civil Aircraft	SAE
AIR7121	Applicability of Existing Development Assurance and System Safety Practices to Unmanned Aircraft Systems	SAE
AIR7209	Development Assurance Principles for Aerospace Vehicles and Systems	SAE
AS6849	Performance Standards for Passenger and Crew Seats in Advanced Air Mobility (AAM) Aircraft	SAE
AS6999	Standard Test Method for Measuring Impact Forces and Pressures of a Soft Projectile on an Inclined Rigid Flat Surface	SAE
AS7371	Standard Test Method for Normal Impact of a Soft Projectile on a Hemispherical Leading Edge	SAE
AS7372	Standard Test Method for Normal Impact of a Soft Projectile on a Clamped Plate	SAE
AS9100D	Quality Management Systems - Requirements for Aviation, Space, and Defense Organizations	SAE
ARP5061A	Guidelines for Testing and Support of Aerospace, Fiber Optic, Inter-Connect Systems	SAE
ARP5150A	Safety Assessment of Transport Airplanes in Commercial Service	SAE
ARP5151A	Safety Assessment of General Aviation Airplanes and Rotorcraft in Commercial Service	SAE
ARP5879A	Recommended Test Requirements for Electro-Hydrostatic Actuators	SAE
ARP6154	Aerospace Fluid Power for Electro-Hydrostatic Module, Design, Performance and Test Recommendations	SAE
ARP6216	EWIS Wiring Insulation Breakdown Testing	SAE

ARP6539	Validation and Verification Process Steps for Monitors Development in Complex Flight Control and Related Systems	SAE
ARP8689	Endurance tests for Aircraft Electric Engine	SAE
ARP94910	Aerospace - Vehicle Management Systems - Flight Control Design, Installation and Test of, Military Unmanned Aircraft, Specification Guide	SAE
ARP94910A	Aerospace - Vehicle Management Systems - Flight Control Design, Installation and Test of, Military Unmanned Aircraft, Specification Guide	SAE
ARINC735B-2	Guidance for tool and test equipment (TTE) equivalency	SAE

As our research went through, we found in the literature various different categorizations for specific use cases and experiments which despite not fully expanding by including the whole bunch of available standards and protocols, we believed that they could fit into our categorization. Some of them were the military protocols, personnel training, UAS swarms, while due to the generic description of some standards we thought about a general categorization, as some standards could fit into any of all the aforementioned categories. Although the case of the military protocols had to be abandoned, as despite that we have already found some protocols, we know that due to the confidentiality level that is into military documentation many more could be already published, leading us to avoid any categorization so we will not provide any false information.

Swarm or fleet of UAVs is something that it's been extensively discussed in recent years. According to the Defense Systems Information Analysis Center (DSIAC), a drones fleet typically consists of a group of 40 or more small drones [18]. These flees could be effectively utilized in a variety of scenarios with most prominent being disaster scenarios. In such cases drone fleets could be either used as communication relays where the related ground infrastructures have been created, for search and rescue, while they can also be used in agriculture, engineering and so many other fields. However, due to the distinct nature of operating multiple coordinated UAVs, which differs significantly from deploying a single unmanned aerial vehicle, not all previously discussed protocols can be applied to these scenarios.

With that information we decided to try to make a collection of protocols either for swarms of UAS, personnel training, including information on how to properly get the full advantage of such technologies and provide all of these protocols that they can be utilized in more than one category.

Table 11 Swarm protocols

1920.1	Aerial Communications and Networking Standards	IEEE
1920.2	Standards for V2V communications for UAS	IEEE
1936.7	Standard for Mesh Deployment of Multi-Rotor Unmanned Aircraft Systems for Inspection of Overhead Transmission and Distribution, and Outdoor Substation Facilities	IEEE
1936.8	Standard for Monitoring of Photovoltaic Power Stations Using Unmanned Aircraft Systems	IEEE
1937.15	Standard for Communication Security Requirements for Drone Formation Flying Light Show	IEEE
1954	Standard for Self-Organizing Spectrum-Agile Unmanned Aerial Vehicles Communications	IEEE
F.749.14	Requirements of coordination for civilian unmanned aerial vehicles	ITU

23.700-91	Study on enablers for network automation for the 5G System (5GS); Phase 2	3GPP
J2945/6	Performance Requirements for Cooperative Adaptive Cruise Control (CACC) and Platooning	SAE
AS6091	JAUS Unmanned Ground Vehicle Service Set	SAE
AS6111	JAUS Unmanned Maritime Vehicle Service Set	SAE

Table 12 Training personnel

23665:2023	Unmanned aircraft systems — Training for personnel involved in UAS operations	ISO
23665	Unmanned aircraft systems — Training for personnel involved in UAS operations	ISO/CD
F2849-10(2019)	Standard Practice for Handling of Unmanned Aircraft Systems at Divert Airfields	ASTM
F3245-19	Standard Guide for Aircraft Electronics Technician Personnel Certification	ASTM
F3266-23	Standard Guide for Training for Remote Pilot in Command of Unmanned Aircraft Systems (UAS) Endorsement	ASTM
F3330-23	Standard Specification for Training and the Development of Training Manuals for the UAS Operator	ASTM
F3364-23	Standard Practice for Independent Audit Program for Unmanned Aircraft Operators	ASTM
F3379-20	Standard Guide for Training for Public Safety Remote Pilot of Unmanned Aircraft Systems (UAS) Endorsement	ASTM
F3600-22	Standard Guide for Unmanned Aircraft System (UAS) Maintenance Technician Qualification	ASTM
WK61763	New Guide for Training for Remote Pilot Instructor (RPI) of Unmanned Aircraft Systems (UAS) Endorsement	ASTM
WK62744	New Practice for General Operations Manual for Professional Operator of Light Unmanned Aircraft Systems (UAS)	ASTM
ATP-3.3.7	GUIDANCE FOR THE TRAINING OF UNMANNED AIRCRAFT SYSTEMS (UAS) OPERATORS	US-ARMY
AS7062	Pilot Training and Qualification for VTOL-Capable Aircraft	SAE
ARP5415B	User's Manual for Certification of Aircraft Electrical/Electronic Systems for the Indirect Effects of Lightning	SAE
ARP5707	Pilot Training Recommendations for Unmanned Aircraft Systems (UAS) Civil Operations	SAE

Table 13 General UAS protocols

1936.5	Standard for Technical Requirements for Intelligent Hangar Housing Unmanned Aircraft Systems Used for Power Grid Inspection	IEEE
1936.6	Standard for Unmanned Aircraft Systems based Oblique Photogrammetry Used for Survey and Design of 110 kV and Above Power Transmission and Transformation Projects	IEEE
1936.9	Standard for Technical Requirements for Electric Unmanned Aircraft Systems for Power Grid Material Lifting	IEEE

1936.10	Recommended Practice for Use of Electric Unmanned Aircraft Systems for Power Grid Material Lifting	IEEE
1936.11	Standard for Requirements of Laying Out Pilot Ropes by Unmanned Aircraft Systems for Overhead Power Line Installations	IEEE
1936.13	Recommended Practice for Image Collection during the Inspection of Overhead Distribution Lines by Unmanned Aircraft Systems	IEEE
1936.14	Unmanned Aircraft Systems in Power Grid Applications—UAS Multi-Spectral Scanning Operations for Overhead Transmission Lines (COM/AerCom-SC/UASPGA-MSSO)	IEEE
1937.7	Standard for the Unmanned Aerial Vehicle (UAV) Polarimetric Remote Sensing Method for Earth Observation Applications	IEEE
1937.9	Requirements for External Power and Power Management Interfaces for Unmanned Aerial Vehicle	IEEE
1937.11	Standard for Technical Requirements of Polar Coordinate Photogrammetry Based on Unmanned Aircraft System	IEEE
1937.13	Standard for Taxonomy and associated requirements for Unmanned Aircraft System's autonomy levels	IEEE
1937.17	Standard for specifications for lithium-ion cells and batteries used in Unmanned Aircraft Systems (UAS)	IEEE
1937.18	Charger Used in Unmanned Aircraft Systems - Technical Specification	IEEE
N.42.63	Standard for Unmanned Aerial Radiation Measurement Systems (UARaMS)	IEEE
3327	Recommended Practice for Use of an Unmanned Aerial Vehicle for Substation Inspection	IEEE
2821	Guide for Unmanned Aerial Vehicle-based Patrol Inspection System for Transmission Lines	IEEE
90003-2018	Software Engineering -- Guidelines for the application of ISO 9001:2015 to computer software	IEEE/ISO/IEC
802.15.4z-2020	Standard for Low-Rate Wireless Networks Amendment: Enhanced Ultra-Wide-Band (UWB) Physical Layers (PHYs) and Associated Ranging Techniques	IEEE
4005-1	Telecommunications and information exchange between systems — Unmanned aircraft area network (UAAN) Part 1: Communication model and requirements	ISO/IEC
4005-2	Part 2: Physical and data link protocols for shared communication	ISO/IEC
4005-3	Part 3: Physical and data link protocols for control communication	ISO/IEC
4005-4	Part 4: Physical and data link protocols for video communication	ISO/IEC
5015-2	Unmanned aircraft systems Part 2: Operation of vertiports for vertical take-off and landing (VTOL) unmanned aircraft (UA)	ISO
5305	Noise measurements for UAS (unmanned aircraft systems)	ISO
5312	Civil small and light unmanned aircraft (UA) — Sharp injury to human body by rotor blades — Evaluation and test method	ISO
5491:2023	Vertiports — Infrastructure and equipment for vertical take-off and landing (VTOL) of electrically powered cargo unmanned aircraft systems (UAS)	ISO
5491	Vertiports — Infrastructure and equipment for vertical take-off and landing (VTOL) of electrically powered cargo unmanned aircraft systems (UAS)	ISO/AWI

TS 5928	Information technology — Cloud computing and distributed platforms — Taxonomy for digital platforms	ISO/IEC
9004	Quality management — Quality of an organization — Guidance to achieve sustained success	ISO
TR 9789	Information technology — Guidelines for the organization and representation of data elements for data interchange — Coding methods and principles	ISO/IEC
TR 10032	Information technology — Reference Model of Data Management	ISO/IEC
14619	Space systems — Space experiments — General requirements	ISO
14711	Space systems — Unmanned mission operations concepts — Guidelines for defining and assessing concept products	ISO
14776-251	Information technology — Small computer system interface (SCSI) Part 251: USB attached SCSI (UAS)	ISO/IEC
14776-253	Information technology — Small Computer System Interface (SCSI) Part 253: USB attached SCSI - 3 (UAS-3)	ISO/IEC
14950	Space systems — Unmanned spacecraft operability	ISO
16126:2004	Space systems — Assessment of survivability of unmanned spacecraft against space debris and meteoroid impacts to ensure successful post-mission disposal	ISO
16126	Space systems — Survivability of unmanned spacecraft against space debris and meteoroid impacts for the purpose of space debris mitigation	ISO
16458	Space systems — Unmanned spacecraft transportation — General requirements	ISO
18000-63	Information technology — Radio frequency identification for item management Part 63: Parameters for air interface communications at 860 MHz to 960 MHz Type C	ISO/IEC
19086-1	Information technology — Cloud computing — Service level agreement (SLA) framework Part 1: Overview and concepts	ISO/IEC
19941:2017	Information technology — Cloud computing — Interoperability and portability	ISO/IEC
19941	Information technology — Cloud computing and distributed platforms — Interoperability and portability	ISO/IEC/ AWI
21384-4	Unmanned aircraft systems Part 4: Vocabulary	ISO
21895	Categorization and classification of civil unmanned aircraft systems	ISO/CD
22123-3	Information technology — Cloud computing Part 3: Reference architecture	ISO/IEC
22460-1	Cards and security devices for personal identification — ISO UAS license and drone/UAS security module Part 1: Physical characteristics and basic data sets for UAS license	ISO/IEC
22460-3	Part 3: Logical data structure, access control, authentication and integrity validation for drone license	ISO/IEC/ CD
22624	Information technology — Cloud computing — Taxonomy based data handling for cloud services	ISO/IEC
23041:2018	Space systems — Unmanned spacecraft operational procedures — Documentation	ISO

23041	Space systems — Unmanned spacecraft operational procedures — Documentation	ISO/AWI
23053	Framework for Artificial Intelligence (AI) Systems Using Machine Learning (ML)	ISO/IEC
23117-1	Agricultural and forestry machinery — Unmanned aerial spraying systems Part 1: Environmental requirements	ISO
23117-2	Part 2: Test methods to assess the horizontal transverse spray distribution	ISO/FDIS
23135	Space systems — Verification program and management process	ISO
TR 23267	Experiment results on test methods for detection and avoidance (DAA) systems for unmanned aircraft systems	ISO
TR 23629-1	UAS traffic management (UTM) Part 1: Survey results on UTM	ISO
23629-7	Part 7: Data model for spatial data	ISO
23629-8	Part 8: Remote identification	ISO
23629-9	Part 9: Interface between UTM service providers and users	ISO
23894	Information technology — Artificial intelligence — Guidance on risk management	ISO/IEC
TR 24027	Information technology — Artificial intelligence (AI) — Bias in AI systems and AI aided decision making	ISO/IEC
TR 24028	Information technology — Artificial intelligence — Overview of trustworthiness in artificial intelligence	ISO/IEC
25009	Unmanned aircraft systems — General requirements and test methods for the hydrogen fuel gas pipes of gaseous hydrogen fuel cell powered UAV	ISO/CD
25013	Unmanned aircraft systems — General requirements and test methods for the attachable hydrogen cylinders of gaseous hydrogen fuel cell powered UAV	ISO/CD
25132	Classification of civil unmanned aircraft system (UAS) autonomous flight control levels	ISO/AWI
25248	Unmanned Aircraft System Type of Identifier Code and Graphical symbol	ISO/AWI
27875:2019	Space systems — Re-entry risk management for unmanned spacecraft and launch vehicle orbital stages	ISO
27875	Space systems — Re-entry risk management for unmanned spacecraft and launch vehicle orbital stages	ISO/CD
29061-5	Road vehicles — Methods and criteria for usability evaluation of child restraint systems and their interface with vehicle anchorage systems Part 5: Installation and securing of child in a booster system	ISO
TR 29181-9	Information technology -- Future Network — Problem statement and requirements — Part 9: Networking of everything	ISO
30147	Information technology — Internet of things — Methodology for trustworthiness of IoT system/service	ISO/IEC
30164	Internet of things (IoT) — Edge computing	ISO/IEC
42001	Information technology — Artificial intelligence — Management system	ISO/IEC
F2490-20	Standard Guide for Aircraft Electrical Load and Power Source Capacity Analysis	ASTM
F2696-14	Standard Practice for Inspection of Aircraft Electrical Wiring Systems	ASTM

F2799-14	Standard Practice for Maintenance of Aircraft Electrical Wiring Systems	ASTM
F2851-10	Standard Practice for UAS Registration and Marking (Excluding Small Unmanned Aircraft Systems)	ASTM
F2908-23	Standard Specification for Unmanned Aircraft Flight Manual (UFM) for an Unmanned Aircraft System (UAS)	ASTM
F3005-22	Standard Specification for Batteries for Use in Small Unmanned Aircraft Systems (sUAS)	ASTM
F3061/F3061M-24	Standard Specification for Systems and Equipment in Aircraft	ASTM
F3178-24	Standard Practice for Operational Risk Assessment of Small Unmanned Aircraft Systems (sUAS)	ASTM
F3196-18	Standard Practice for Seeking Approval for Beyond Visual Line of Sight (BVLOS) Small Unmanned Aircraft System (sUAS) Operations	ASTM
F3201-24	Standard Practice for Ensuring Dependability of Software Used in Unmanned Aircraft Systems (UAS)	ASTM
F3227/F3227M-25	Standard Specification for Environmental Systems in Aircraft	ASTM
F3228-21	Standard Specification for Flight Data and Voice Recording in Small Aircraft	ASTM
F3233/F3233M-23b	Standard Specification for Flight and Navigation Instrumentation in Aircraft	ASTM
F3234/F3234M-21	Standard Specification for Exterior Lighting in Small Aircraft	ASTM
F3235-22	Standard Specification for Aircraft Storage Batteries	ASTM
F3236-21a	Standard Specification for High Intensity Radiated Field (HIRF) Protection in Small Aircraft	ASTM
F3262-17	Standard Classification System for Small Unmanned Aircraft Systems (sUASs) for Land Search and Rescue	ASTM
F3316/F3316M-19	Standard Specification for Electrical Systems for Aircraft with Electric or Hybrid-Electric Propulsion	ASTM
F3341/F3341M-24	Standard Terminology for Unmanned Aircraft Systems	ASTM
F3361-18e1	Standard Guide for Classifying Alterations for In-Service Aircraft under FAA Authority Oversight	ASTM
F3365-23	Standard Practice for Compliance Audits to ASTM Standards on Unmanned Aircraft Systems	ASTM
F3366-19	Standard Specification for General Maintenance Manual (GMM) for a small Unmanned Aircraft System (sUAS)	ASTM
F3478-20	Standard Practice for Development of a Durability and Reliability Flight Demonstration Program for Low-Risk Unmanned Aircraft Systems (UAS) under FAA Oversight	ASTM
F3547-24	Standard Specification for Fuel Cell Power Systems for Use in Small Unmanned Aircraft Systems (sUAS)	ASTM
F3548-21	Standard Specification for UAS Traffic Management (UTM) UAS Service Supplier (USS) Interoperability	ASTM
F3586-22	Standard Practice for Remote ID Means of Compliance to Federal Aviation Administration Regulation 14 CFR Part 89	ASTM

E456-13a(2022)e1	Standard Terminology Relating to Quality and Statistics	ASTM
E2555-21e1	Standard Practice for Factors and Procedures for Applying the MIL-STD-105 Plans in Life and Reliability Inspection	ASTM
E3159-21	Standard Guide for General Reliability	ASTM
WK61549	New Specification for Indirect Flight Control Systems in Aircraft	ASTM
WK62734	New Specification for Specification for the Development of Manufacturers Maintenance Data for Lightweight UAS	ASTM
WK66135	Revision of F3005-14a Standard Specification for Batteries for Use in Small Unmanned Aircraft Systems (sUAS)	ASTM
WK68098	Revision of F3201-16 Standard Practice for Ensuring Dependability of Software Used in Unmanned Aircraft Systems (UAS)	ASTM
WK75923	New Specification for Positioning Assurance, Navigation, and Time Synchronization for Unmanned Aircraft Systems	ASTM
WK82110	Revision of F3178-16 Standard Practice for Operational Risk Assessment of Small Unmanned Aircraft Systems (sUAS)	ASTM
WK82124	Revision of F2908-18 Standard Specification for Unmanned Aircraft Flight Manual (UFM) for an Unmanned Aircraft System (UAS)	ASTM
WK85153	New Specification for Vertiport Automation Supplemental Data Service Provider (SDSP) Performance	ASTM
WK85414	Revision of F3548-21 Standard Specification for UAS Traffic Management (UTM) UAS Service Supplier (USS) Interoperability	ASTM
WK85415	New Specification for UAM PSU Interoperability	ASTM
WK88791	New Terminology for Standard Terminology Related to Pesticide Application with Drones	ASTM
WK90326	New Practice for UAS Ground Control System Human Factors	ASTM
WK91696	Revision of F3686-24 Standard Practice for Production Approval of Unmanned Aircraft Systems (UAS)	ASTM
Y.3540	Edge computing – Overview and high-level requirements	ITU
Y.4215	Use cases, requirements and capabilities of unmanned aircraft systems for the Internet of things	ITU
Y.4218	Internet of things and information and communication technology requirements for deployment of smart services in rural communities	ITU
Y.4504	Service framework of prediction for intelligent Internet of things	ITU
F.749.15	Requirements for inspection and examination services using civilian unmanned aerial vehicles	ITU
F.749.16	Requirements for logistics express delivery based on civilian unmanned aerial vehicles	ITU
F.749.18	Framework and requirements for emergency services using civilian unmanned aerial vehicles	ITU
F.760.1	Requirements and reference framework for emergency rescue systems	ITU
DO-178C	Software Considerations in Airborne Systems and Equipment Certification	RTCA
DO-181E	Minimum Operational Performance Standards for Air Traffic Control Radar Beacon System/Mode Select (ATCRBS/Mode S) Airborne Equipment	RTCA

DO-229F	MOPS for Global Positioning System/Satellite-Based Augmentation System Airborne Equipment	RTCA
DO-248C	Supporting Information for DO-178C and DO-278A	RTCA
DO-246	GNSS-Based Precision Approach Local Area Augmentation System (LAAS) Signal-in-Space Interface Control Document (ICD) Change 1	RTCA
DO-253D Change1	Minimum Operational Performance Standards for GPS Local Area Augmentation System Airborne Equipment	RTCA
DO-262F	Minimum Operational Performance Standards for Avionics Supporting Next Generation Satellite Systems (GNSS)	RTCA
DO-289 Change 1	Minimum Aviation System Performance Standards (MASPS) for Aircraft Surveillance Applications (ASA)	RTCA
DO-292	Assessment of Radio Frequency Interference Relevant to the GNSS L5/E5A Frequency Band	RTCA
DO-304A	Guidance Material and Considerations for Unmanned Aircraft Systems	RTCA
DO-316	Minimum Operational Performance Standards for Global Positioning System/Aircraft Base Augmentation System	RTCA
DO-343	Minimum Aviation System Performance Standard for AMS(R)S Data and Voice Communications Supporting Required Communications Performance (RCP) and Required Surveillance Performance (RSP)	RTCA
DO-346A	Minimum Operational Performance Standards (MOPS) for the Aeronautical Mobile Airport Communication System (AeroMACS)	RTCA
DO-381A	MOPS for GBSS for Traffic Surveillance	RTCA
DO-382	Minimum Aviation System Performance Standards CAS Interoperability	RTCA
DO-387	Minimum Operational Performance Standards (MOPS) for Electro-Optical/Infrared (EO/IR) Sensors System for Traffic Surveillance.	RTCA
DO-397	Guidance Material: Navigation Gaps for Unmanned Aircraft Systems (UAS)	RTCA
TSO C151	TERRAOM AWARENESS AND WARNING SYSTEM	FAA
TSO-C169a	VHF Radio Communications Transceiver Equipment Operating Within Radio Frequency Range 117.975 to 137.000 MHz	FAA
21.900	Technical Specification Group working methods	3GPP
22.125	Unmanned Aerial System (UAS) support in 3GPP	3GPP
22.261	Service requirements for the 5G system	3GPP
22.281	Mission Critical (MC) video	3GPP
22.282	Mission Critical (MC) data	3GPP
22.829	Enhancement for Unmanned Aerial Vehicles (UAVs)	3GPP
22.843	Study on Additional capabilities of mobile networks for drone operations and managements	3GPP
23.256	Support of Uncrewed Aerial Systems (UAS) connectivity, identification and tracking; Stage 2	3GPP
23.754	Study on supporting Unmanned Aerial Systems (UAS) connectivity, Identification and tracking	3GPP
23.755	Study on application layer support for Unmanned Aerial Systems (UAS)	3GPP
24.257	Uncrewed Aerial System (UAS) Application Enabler (UAE) layer; Protocol aspects; Stage 3	3GPP

29.255	Uncrewed Aerial System Service Supplier (USS) Services; Stage 3	3GPP
29.256	Uncrewed Aerial Systems Network Function (UAS-NF); Aerial Management Services; Stage 3	3GPP
29.257	Application layer support for Uncrewed Aerial System (UAS); UAS Application Enabler (UAE) Server Services; Stage 3	3GPP
36.777	Enhanced LTE support for aerial vehicles	3GPP
1008	IP OVER SATELLITE (IPOS)	TIA
5041	Future Advanced SATCOM Technologies (FAST) Open Standard Digital- If Interface (OSDI) for SATCOM Systems	TIA
3030	Standard for Unmanned Aircraft Systems	UL
AEP-80	Rotary Wing UAS Airworthiness	NATO
STANAG 4586	Standard Interface of UAV Control System for NATO UAV Interoperability	DOD-NATO
STANAG 4671	UAV Systems Airworthiness Requirements	DOD-NATO
STANAG-4702	Rotary wing UAS Airworthiness requirements	DOD-NATO
STANAG-4703	Light UAS Air worthiness requirements	DOD-NATO
TOP-7-1-003	Unmanned Aircraft Systems (UAS) Sensor and Targeting	US-ARMY
DOD MIL-STD-882E	Department of Defense Standard Practice: System Safety	US-ARMY
TR 121 917	Digital cellular telecommunications system (Phase 2+) (GSM) - Universal Mobile Telecommunications System (UMTS)	ETSI
TS 122 125	Unmanned Aerial System (UAS) support in 3GPP	ETSI
TS 123 256	Support of Uncrewed Aerial Systems (UAS) connectivity, identification and tracking - Stage 2	ETSI
TS 124 257	Uncrewed Aerial System (UAS) Application Enabler (UAE) layer - Protocol aspects - Stage 3	ETSI
TS 129 255	Uncrewed Aerial System Service Supplier (USS) Services - Stage 3	ETSI
TS 129 256	Uncrewed Aerial Systems Network Function (UAS-NF) - Aerial Management Services - Stage 3	ETSI
TS 129 257	Application layer support for Uncrewed Aerial System (UAS) - UAS Application Enabler (UAE) Server Services - Stage 3	ETSI
EN 301 473 V2.1.2	Satellite Earth Stations and Systems (SES); Harmonized Standard for Aircraft Earth Stations (AES) providing Aeronautical Mobile Satellite Service (AMSS)/Mobile Satellite Service (MSS) and/or the Aeronautical Mobile Satellite on Route Service (AMS(R)S)/Mobile Satellite Service (MSS), operating in the frequency band below 3 GHz covering the essential requirements of article 3.2 of the Directive 2014/53/EU	ETSI
ETR 270	Satellite Earth Stations and Systems (SES) - Survey on the need for an ETS for Aircraft Earth Stations (AES) in the Aeronautical Mobile Satellite Service (AMSS)	ETSI
4709-001	Aerospace series - Unmanned Aircraft Systems - Part 001: Product requirements and verification	CEN

4709-003 P1	Aerospace series — Unmanned Aircraft Systems — Part 003: Geo-awareness requirements	CEN
4709-004 P1	Aerospace series — Unmanned Aircraft Systems — Part 004: Lighting requirements	CEN
AIAA R-103-2004	Terminology for Unmanned Aerial Vehicles and Remotely Operated Aircraft	ARC
SC-RPAS.1309-01	Equipment, systems and installations	EASA
CS-LUAS	Recommendations for Certification Specification for Light Unmanned Airplane Systems	JARUS
CS-LURS	Certification Specification for Light Unmanned Rotorcraft Systems	JARUS
CS-UAS	Recommendations for Certification Specification for Unmanned Aircraft Systems	JARUS
J2735	V2X Communications Message Set Dictionary	SAE
J3016	Taxonomy and Definitions for Terms Related to Driving Automation Systems for On-Road Motor Vehicles	SAE
J3131	Definitions for Terms Related to Automated Driving Systems Reference Architecture	SAE
AIR4982A	Aerospace Fly-by-Light Actuation Systems	SAE
AIR5561	Lithium Battery Powered Portable Electronic Devices	SAE
AIR5601	A Guideline for Application of RF Photonics to Aerospace Platforms	SAE
AIR5645A	JAUS Transport Considerations	SAE
AIR5664A	JAUS History and Domain Model	SAE
AIR6110A	Contiguous Aircraft/System Development Process Example	SAE
AIR6127	Managing Higher Voltages in Aerospace Electrical Systems	SAE
AIR6139	Ways of Dealing with Power Regeneration onto an Aircraft Electrical Power System Bus	SAE
AIR6326	Aircraft Electrical Power Systems Modeling and Simulation Definitions	SAE
AIR6540C	Fundamentals in Wire Selection and Sizing for Aerospace Applications	SAE
AIR6808A	Aerospace Vehicle Wiring, Lessons Learned	SAE
AIR6900	Applicable Aircraft Integrated Vehicle Health Management (IVHM) Regulations, Policy, and Guidance	SAE
AIR6904	Rationale, Considerations, and Framework for Data Interoperability for Health Management within the Aerospace Ecosystem	SAE
AIR6962	Ice Protection for Unmanned Aerial Vehicles	SAE
AIR6987	Artificial Intelligence in Aeronautical Systems: Taxonomy	SAE
AIR6988	Artificial Intelligence in Aeronautical Systems: Statement of Concerns	SAE
AIR6994	Artificial Intelligence in Aeronautical Systems: Use Cases	SAE
AIR7123	eARC - Electronic Authorized Release Certificate	SAE
AIR7128	Integration and Certification Considerations for Electrified Propulsion Aircraft	SAE

AIR7356	Opportunities, Challenges, and Requirements for Use of Blockchain in Unmanned Aircraft Systems Operating Below 400 Feet Above Ground Level for Commercial Use	SAE
AIR7357	Megawatt and Extreme Fast Charging for Aircraft	SAE
AIR7367	Considerations for Requirements, Specifications, and Framework of a Digital Thread in Aircraft Data Life Cycle Management	SAE
AIR7501	Aircraft Asset Lifecycle and Digital Data Standards Overview	SAE
AIR7502	Aircraft Electrical Voltage Level Definitions	SAE
AIR7765	Considerations for Hydrogen Fuel Cells in Airborne Applications	SAE
AIR8012	Prognostics and Health Management Guidelines for Electro-Mechanical Actuators	SAE
AS1212A	Electric Power, Aircraft, Characteristics and Utilization	SAE
AS35091A	Receptacles, Electric, Aircraft storage battery	SAE
AS5669A	JAUS / SDP Transport Specification	SAE
AS6254A	Minimum Performance Standard for Low Frequency Underwater Locating Devices (Acoustic) (Self-Powered)	SAE
AS7091	Technical Standards for VTOL-Capable aircraft Training Devices to support evaluation	SAE
AS8033	Nickel Cadmium Vented Rechargeable Aircraft Batteries (Non-Sealed, Maintainable Type)	SAE
ARP1870A	Aerospace Systems Electrical Bonding and Grounding for Electromagnetic Compatibility and Safety	SAE
ARP5007A	Development Process - Aerospace Fly-By-Wire Actuation System	SAE
ARP5583A	Guide to Certification of Aircraft in a High-Intensity Radiated Field (HIRF) Environment	SAE
ARP6012A	JAUS Compliance and Interoperability Policy	SAE
ARP6128	Unmanned Systems Terminology Based on the ALFUS Framework	SAE
ARP6336	Lighting Applications for Unmanned Aircraft Systems (UAS)	SAE
ARP6803	IVHM Concepts, Technology and Implementation Overview	SAE
ARP6823	Electronic Transactions for Aerospace Systems: An Overview	SAE
ARP6883	Guidelines for Writing IVHM Requirements for Aerospace Systems	SAE
ARP6971	Power and Torque Determination for UAS Engines Having Maximum Power Ratings at or Below 22.4 kW	SAE
ARP6984	Determination of Cost Benefits from Implementing a Blockchain Solution	SAE
ARP8676	Nomenclature and Definitions for Electrified Propulsion Aircraft	SAE
ARINC424-23	Navigation system database	SAE
ARINC428	Considerations for avionics network design	SAE
ARINC561-11	Air transport Inertial Navigation System (INS)	SAE
ARINC600-20	Air transport avionics equipment interfaces	SAE

ARINC631-8	VHF Digital Link (VDL) mode 2 implementation provisions	SAE
ARINC633-5	AOC Air-Ground Data and Message Exchange Format	SAE
ARINC634	ARINC report 634 HF data link system design guidance material	SAE
ARINC635-4	HF data link protocols	SAE
ARINC652	Guidance for avionics software management	SAE
ARINC653 P3A	Avionics application software standard interface, Part 3A, Conformity test specification for ARINC 653 required services	SAE
ARINC653 P3BC1	Avionics application software standard interface, Part 3B, Conformity test specifications for ARINC 653 extended services	SAE
ARINC653 P4	Avionics application software standard interface, Part 4, Subset services	SAE
ARINC653 P5-1	Avionics application software standard interface, Part 5, Core software recommended capabilities	SAE
ARINC654	Environmental design guidelines for integrated modular avionics packaging and interfaces	SAE
ARINC664 P1-2	Aircraft data network, Part 1, Systems concepts and overview	SAE
ARINC664 P2-3	Aircraft Data Network, Part 2, Ethernet Physical and Data Link Layer Specification	SAE
ARINC664 P3-2	Aircraft data network, Part 3, Internet-based protocols and services	SAE
ARINC664 P4-2	Aircraft data network, Part 4, Internet-based address structure & assigned numbers	SAE
ARINC664 P5	Aircraft data network, Part 5, Network domain characteristics and interconnection	SAE
ARINC664 P7-1	Aircraft data network, Part 7, Avionics Full-Duplex switched ethernet network	SAE
ARINC664 P8-1	Aircraft data network, Part 8, Interoperation with Non-IP protocols and services	SAE
ARINC665-5	Loadable software standards	SAE
ARINC667-3	Guidance for the management of field loadable software	SAE
ARINC675	Guidance for the management of aircraft support data	SAE
ARINC676	Guidance for assignment, accomplishment, and reporting of special (engineering) investigation for aircraft components	SAE
ARINC681	Timely recovery of flight data (TRFD)	SAE
ARINC704-7	Inertial reference systems	SAE
ARINC705-5	Attitude and heading reference system	SAE
ARINC706-4	MARK 5 Subsonic air data system	SAE

ARINC707-7	Radio altimeter	SAE
ARINC708A-3	Airborne weather radar with forward looking windshear detection capability	SAE
ARINC708-6	Airborne weather radar	SAE
ARINC714-6	MARK 3 Airborne SELCAL system	SAE
ARINC714A	MARK 4 Selective Calling (SELCAL)	SAE
ARINC718A-5	MARK 4 Air Traffic Control Transponder (ATCRBS/MODE S)	SAE
ARINC720-1	Digital frequency/function selection for airborne electronic equipment	SAE
ARINC725-2	Electronic Flight Instruments (EFI)	SAE
ARINC743A-6	GNSS Sensor	SAE
ARINC743B-1	GNSS Landing System Sensor Unit (GLSSU)	SAE
ARINC743C	GNSS Landing System Unit (GLSSU) with VHF Data Broadcast (VDB) receiver	SAE
ARINC752-1	Terrestrial Flight Telephone System (TFTS) airborne radio subsystem	SAE
ARINC753-3	HF Data link system	SAE
ARINC755-5	Multi-Mode Receiver (MMR) – Digital	SAE
ARINC756-3	GNSS Navigation and Landing Unit (GNLU)	SAE
ARINC760-1	GNSS Navigation Unit (GNU)	SAE
ARINC763A	MARK 2 Network Server System (NSS) form and fit definition	SAE
ARINC766	Aeronautical Mobile Airport Communication System (AEROMACS) Transceiver and Aircraft Installation Standards	SAE
ARINC771-3	Low-Earth Orbiting Aviation Satellite Communication Systems	SAE
ARINC781-9	Mark 3 Aviation Satellite Communication Systems	SAE
ARINC816-3	Embedded Interchange Format for Airport Mapping Database	SAE
ARINC816-2C1	Embedded Interchange Format for Airport Mapping Database	SAE
ARINC826-1	Software data loader using CAN interface	SAE
ARINC830	Aircraft/Ground Information Exchange (AGIE) Using Internet Protocol	SAE

ARINC834-8	Aircraft Data Interface Function (ADIF)	SAE
ARINC834A	Internet Protocol Based Aircraft Data Interface Function (ADIF)	SAE
ARINC841-3	Media Independent Aircraft Messaging (MIAM)	SAE
ARINC842-3	Guidance for Usage of Digital Certificates	SAE
ARINC843-1	Aircraft Software Common Configuration Reporting	SAE
ARINC847	Product Development Guidance for Maintainability and Testability (PMDMAT)	SAE
SAE1001	Integrated Project Processes for Engineering a System	SAE
SAE1003	Glossary of System Safety Engineering and Management	SAE

Chapter 5: EASA: Flying certificates, drones and protocols categorization

During this chapter we are going to present our categorization of UAVs communication protocols, according to which type of drones they are applied. In order to understand what types of drones there are, it is important to fully embody the regulations that are provided from the related agencies-organizations that created them. As we mentioned from the start of our study, there isn't a common path regarding the UAV regulations across the globe, meaning that different agencies across continents might apply different regulations. Such an example is the FAA that has jurisdiction in the United States, while the EASA is located in Europe. Henceforth, as Greece is a country member of the EU our categorization will be according to the standards provided from EASA.

5.1 EASA: Categorization and related

EASA, established in 2002 as the need for an agency ensuring the safety and environmental protection was highly demanded. EASA has more than 27 European Countries members with the main purpose the creation of a single European Aviation market harmonizing regulations and certifications, promoting EU and global Safety Standards. Despite the existence of the EASA still there isn't a common line on guidelines and regulations in each country. More specifically no-fly zones are differently predefined in each country, while in many others like UK and Serbia EU-EASA's certificates are not recognized as they have their own regulations.

5.1.1 Open Category: Certificates and low risk Drone classes

Our approach will focus on the common guidelines followed regarding EASA's rules and so we are going to further explain what each certificate is, which terms of use it is allowed, to whom it is for and finally provide the protocols that fit to that related category. First, we are going to investigate the most widely spreader category "Open Category" which according to EASA (https://www.easa.europa.eu/en/domains/drones-air-mobility/operating-drone/open-category-low-risk-civil-drones) refers to low risk drones allowed to be used by civilians. Most drones that can be found in the market refer to this category, as they are meant mostly for leisure and low-risk commercial activities. In order to fly one of these drones each user must have one of the following EASA's certificates A1-A2-A3, each of which will be explained respectively.

The further subdivision of the open category into smaller ones happens due to the fact that there can be various combinations of where each user is going to fly his drone and even more each drone capabilities and size may vary. With that in mind we have the A1 certificate that allows its owner to fly their drone over people but not assemblies of people. Furthermore, we have restrictions on drones as it is. With A1 certificates users are allowed to own and operate C0, most likely toy drones, and C1 class drones which corresponds to weight limit of 250gr and 900gr respectively and a maximum flight altitude of 120m.

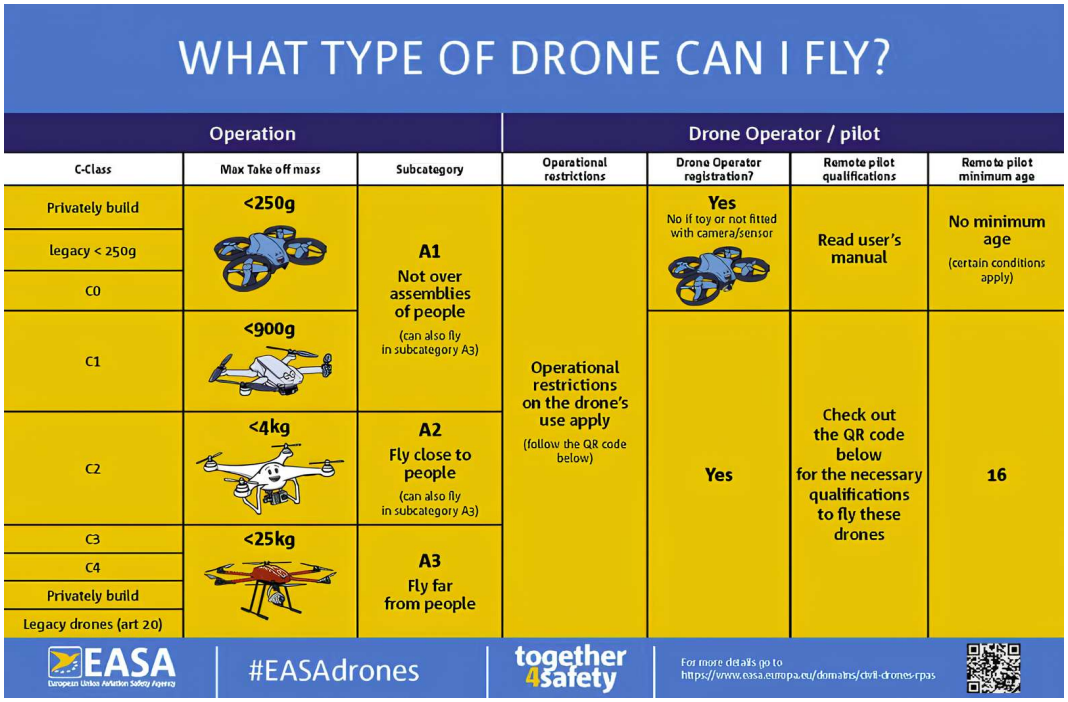

Fig. 21 Open Category-Low Risk Drones [27]

Moving further using larger drones we have the A2 certificate. With that type of certificate, users are allowed to operate heavier drones close to people. Under the umbrella of A2 certificate we meet drones of class 2 (C2) which have a maximum weight of 4 kilograms, while their operation area cannot exceed the altitude of 120 meters and the horizontal distance between the operator and itself of 30 meters. All drones including the previous two classes mentioned in A1 certificate, are not allowed to carry any dangerous goods while they should not fly above people who are uninvolved to its flight path and specifically in C2 drones the user is obliged to maintain his drone at a horizontal distance of 30 meters from uninvolved people which can be reduced to 5 meters when the flight speed is reduced respectively.

Last but not least we have the A3 EASA's certification. This type of certification targets hobbyists and professionals who enjoy flying a drone and they also can use it as part of their work. In this category, fall all drones between the weight limit of 250 grams to 25 kilograms which belong to class 3 and 4 (C3, C4) where the maximum flight attitude is still at 120 meters while the prerequisite horizontal distance between the drone and any uninvolved people and generally urban areas has been increased to 150 meters. Concluding the presentation of low-risk drones' specification it would be helpful for the reader to provide some extra information about the drone classes C0-C4. For all the aforementioned classes except C0, the operator is obliged to be registered drone operator, obtain a proof of completion for each subcategory and has the minimum age of 16 years old.

Despite all that specified subcategorization, our collection of communication protocols could not be matched in that detail. At the following table, we are going to provide a list of all of the communication protocols alongside with their mini description and their published organizations.

Table 14 Open Category - Low risk drone protocols

1936.2-2023	Photogrammetric Technical Standard of Civil Light and Small Unmanned Aircraft Systems for Overhead Transmission Line Engineering	IEEE
1936.3	Standard for Unmanned Aircraft Systems (UAS) using Light Detection and Ranging (LiDAR) for above 110 kV Overhead Transmission Line Survey and Design	IEEE
1937.3-2024	Standard for Flight Data Transmission of Civil Unmanned Aerial Vehicle Based on Short Message Mechanisms	IEEE
1937.6	Standard for Unmanned Aerial Vehicle (UAV) Light Detection and Ranging (LiDAR) Remote Sensing Operation	IEEE
1937.16	Standard for Civil Unmanned Aerial Systems (UAS) Cybersecurity Framework	IEEE
1937.17	Standard for specifications for lithium-ion cells and batteries used in Unmanned Aircraft Systems (UAS)	IEEE
1937.18	Charger Used in Unmanned Aircraft Systems - Technical Specification	IEEE
4005-1	Telecommunications and information exchange between systems — Unmanned aircraft area network (UAAN) Part 1: Communication model and requirements	ISO/IEC
4005-2	Part 2: Physical and data link protocols for shared communication	ISO/IEC
4005-3	Part 3: Physical and data link protocols for control communication	ISO/IEC
4005-4	Part 4: Physical and data link protocols for video communication	ISO/IEC
4358:2023	Test methods for civil multi-copter unmanned aircraft system	ISO
5110:2023	Test method for flight stability of a multi-copter unmanned aircraft system (UAS) under wind and rain conditions	ISO
5286:2023	Flight performance of civil small and light fixed-wing unmanned aircraft systems (UAS) — Test methods	ISO
5305:2024	Noise measurements for UAS (unmanned aircraft systems)	ISO
5309:2023	Civil small and light unmanned aircraft systems (UAS) — Vibration test methods	ISO
5312:2023	Civil small and light unmanned aircraft (UA) — Sharp injury to human body by rotor blades — Evaluation and test method	ISO
5332:2023	Civil small and light unmanned aircraft systems (UAS) under low-pressure conditions — Test methods	ISO
TR 5469	Artificial intelligence — Functional safety and AI systems	ISO/IEC
9001:2015	Quality management systems — Requirements	ISO
16746	Unmanned aircraft systems — Counter UAS — Quality and safety for users	ISO/CD
16747	Unmanned aircraft systems — Counter UAS — Quality and safety for manufacturers	ISO/CD
21384-2	Unmanned aircraft systems Part 2: UAS components	ISO
21384-3	Unmanned aircraft systems Part 3: Operational procedures	ISO
21895:2020	Categorization and classification of civil unmanned aircraft systems	ISO
21895	Categorization and classification of civil unmanned aircraft systems	ISO/CD
22460-2	Part 2: Drone/UAS security module	ISO/IEC

24243	Test methods for civil small and light multi-copter unmanned aircraft dock system	ISO
24352	Technical requirements for small unmanned aircraft electric energy systems	ISO
24354	General requirements for the payload interface of civil unmanned aircraft systems	ISO
24355	Flight control system for civil small and light multi-copter unmanned aircraft system (UAS) — General requirements	ISO
25215	Civil small and light multi-copter unmanned aircraft docking system — General requirements	ISO/AWI
F2908-23	Standard Specification for Unmanned Aircraft Flight Manual (UFM) for an Unmanned Aircraft System (UAS)	ASTM
F2909-19	Standard Specification for Continued Airworthiness of Lightweight Unmanned Aircraft Systems	ASTM
F2910-22	Standard Specification for Design and Construction of a Small Unmanned Aircraft System (sUAS)	ASTM
F3002-22	Standard Specification for Design of the Command-and-Control System for Small Unmanned Aircraft Systems (sUAS)	ASTM
F3005-22	Standard Specification for Batteries for Use in Small Unmanned Aircraft Systems (sUAS)	ASTM
F3153-22	Standard Specification for Verification of Aircraft Systems and Equipment	ASTM
F3178-24	Standard Practice for Operational Risk Assessment of Small Unmanned Aircraft Systems (sUAS)	ASTM
F3269-21	Standard Practice for Methods to Safely Bound Behavior of Aircraft Systems Containing Complex Functions Using Run-Time Assurance	ASTM
F3298-24	Standard Specification for Design and Construction of Lightweight Unmanned Aircraft Systems (UAS)	ASTM
F3322-25	Standard Specification for Small Unmanned Aircraft System (sUAS) Parachutes	ASTM
F3366-19	Standard Specification for General Maintenance Manual (GMM) for a small Unmanned Aircraft System (sUAS)	ASTM
F3389/F3389M-21	Standard Test Method for Assessing the Safety of Small Unmanned Aircraft Impacts	ASTM
F3442/F3442M-23	Standard Specification for Detect and Avoid System Performance Requirements	ASTM
F3478-20	Standard Practice for Development of a Durability and Reliability Flight Demonstration Program for Low-Risk Unmanned Aircraft Systems (UAS) under FAA Oversight	ASTM
F3547-24	Standard Specification for Fuel Cell Power Systems for Use in Small Unmanned Aircraft Systems (sUAS)	ASTM
F3657-23	Standard Specification for Verification of Lightweight Unmanned Aircraft Systems (UAS)	ASTM
WK66135	Revision of F3005-14a Standard Specification for Batteries for Use in Small Unmanned Aircraft Systems (sUAS)	ASTM
WK82110	Revision of F3178-16 Standard Practice for Operational Risk Assessment of Small Unmanned Aircraft Systems (sUAS)	ASTM

WK82124	Revision of F2908-18 Standard Specification for Unmanned Aircraft Flight Manual (UFM) for an Unmanned Aircraft System (UAS)	ASTM
WK82782	Revision of F3002-14a Standard Specification for Design of the Command-and-Control System for Small Unmanned Aircraft Systems (sUAS)	ASTM
WK87943	Revision of F3322-22 Standard Specification for Small Unmanned Aircraft System (sUAS) Parachutes	ASTM
Y.4421	Functional architecture for unmanned aerial vehicles and unmanned aerial vehicle controllers using IMT-2020 networks	ITU
F.749.10	Requirements for communication services of civilian unmanned aerial vehicles	ITU
F.749.11	Requirements for civilian unmanned aerial vehicles enabled mobile edge computing	ITU
F.749.13	Framework and requirements for civilian unmanned aerial vehicle flight control using artificial intelligence	ITU
F.749.14	Requirements of coordination for civilian unmanned aerial vehicles	ITU
M2171	Characteristics of UAS and spectrum requirements to support their safe operation in non-segregated airspace	ITU-R
3030	Standard for Unmanned Aircraft Systems	UL
NPA 2021-09	Regular update of the acceptable means of compliance and guidance material to Regulation (EU) 2019/947 on the rules and procedures for the operation of unmanned aircraft	EASA

5.1.2 Specified and certified drones' certification

When a drone is operated outside the limitation of the open category presented below, it belongs either to a specific or certified category. Their major difference lies in the risk the operator might face during his flight alongside with me maximum takeoff mass, the application area and other factors that we are going to mention as we go on. To keep consistency, we are going to present first the specific category which consists of the medium risk drones and finally the highest risk drones and certified category.

In contrast with some drone classes mentioned in open category, when a user operates a drone that lies under the specific category, he is obliged to be a registered operator with the related certification. We assume that a drone lies in the specific category, when it is operated beyond the visual line of sight of the operator, the maximum take of mass surpasses the 25 kilograms and its flying capabilities exceed 120 meters above ground level.

With this type of categorization, the limitations are going a step further. In specific categories are drones that are dropping materials alongside drones that operate inside urban environments and above concentrated people with MTOM of 4 kilograms. In order to clarify some information provided, as the border between specific and certified is a little bit dull, drones that carry dangerous material do not lie under the umbrella of specific category, but for certified instead.

Finally, according to EASA's official regulation on the drone operation procedure, before operating a drone in a specific category, the operator has the responsibility to develop an operational manual and submit it to his country's National Aviation Authority. These applications need to be done

only once and it might be needed for resubmission only when there are changes into the geographical area that is going to be applied.

Our approach on categorizing communication protocols, which was the same for certified as we are going to see next, was mostly based on our understanding. Through the available documentation there was no relation between protocols and drone categories, while at the same time, the available descriptions provided from each protocol, again did not clarify where it would fit better. For the last reason mentioned, some protocols might be either in the specific and certified category.

Table 15 Specific category drone protocols

1920.1	Aerial Communications and Networking Standards	IEEE
1920.2	Standard for Vehicle-to-Vehicle Communications for Unmanned Aircraft Systems	IEEE
1936.4	Standard for Technical Requirements for the Maintenance of Multi-rotor Unmanned Aircraft Systems Used for Power Grid Inspection	IEEE
1936.5	Standard for Technical Requirements for Intelligent Hangar Housing Unmanned Aircraft Systems Used for Power Grid Inspection	IEEE
1936.6	Standard for Unmanned Aircraft Systems based Oblique Photogrammetry Used for Survey and Design of 110 kV and Above Power Transmission and Transformation Projects	IEEE
1936.7	Standard for Mesh Deployment of Multi-Rotor Unmanned Aircraft Systems for Inspection of Overhead Transmission and Distribution, and Outdoor Substation Facilities	IEEE
1936.8	Standard for Monitoring of Photovoltaic Power Stations Using Unmanned Aircraft Systems	IEEE
1936.13	Recommended Practice for Image Collection during the Inspection of Overhead Distribution Lines by Unmanned Aircraft Systems	IEEE
1936.14	Unmanned Aircraft Systems in Power Grid Applications—UAS Multi-Spectral Scanning Operations for Overhead Transmission Lines (COM/AerCom-SC/UASPGA-MSSO)	IEEE
1937.1	Standard Interface Requirements and Performance Characteristics for Payload Devices in Drones	IEEE
1937.6	Standard for Unmanned Aerial Vehicle (UAV) Light Detection and Ranging (LiDAR) Remote Sensing Operation	IEEE
1937.7	Standard for the Unmanned Aerial Vehicle (UAV) Polarimetric Remote Sensing Method for Earth Observation Applications	IEEE
1937.8	Recommended Practice for Functional and Interface Specifications for Unmanned Aerial Vehicle (UAV) Cellular Communication Terminals	IEEE
1937.9	Requirements for External Power and Power Management Interfaces for Unmanned Aerial Vehicle	IEEE
1937.11	Standard for Technical Requirements of Polar Coordinate Photogrammetry Based on Unmanned Aircraft System	IEEE
1937.12	Standard for Technical Requirements for Emergency Cellular Communication System Based on Fixed-Wing Unmanned Aircraft System	IEEE
1937.13	Standard for Taxonomy and associated requirements for Unmanned Aircraft System's autonomy levels	IEEE

1937.15	Standard for Communication Security Requirements for Drone Formation Flying Light Show	IEEE
1937.17	Standard for specifications for lithium-ion cells and batteries used in Unmanned Aircraft Systems (UAS)	IEEE
1937.18	Charger Used in Unmanned Aircraft Systems - Technical Specification	IEEE
1939.1	Standard for a Framework for Structuring Low Altitude Airspace for Unmanned Aerial Vehicle (UAV) Operations	IEEE
1945	Standard for Internet of Things (IoT) Computing Edge Computing on Unmanned Aircraft Systems-PART 1 General Requirements	IEEE
1954	Standard for Self-Organizing Spectrum-Agile Unmanned Aerial Vehicles Communications	IEEE
3327	Recommended Practice for Use of an Unmanned Aerial Vehicle for Substation Inspection	IEEE
2821	Guide for Unmanned Aerial Vehicle-based Patrol Inspection System for Transmission Lines	IEEE
4005-1	Telecommunications and information exchange between systems — Unmanned aircraft area network (UAAN) Part 1: Communication model and requirements	ISO/IEC
4005-2	Part 2: Physical and data link protocols for shared communication	ISO/IEC
4005-3	Part 3: Physical and data link protocols for control communication	ISO/IEC
4005-4	Part 4: Physical and data link protocols for video communication	ISO/IEC
5015-2	Unmanned aircraft systems Part 2: Operation of vertiports for vertical take-off and landing (VTOL) unmanned aircraft (UA)	ISO
5109	Evaluation method for the resonance frequency of the multi-copter UA (unmanned aircraft) by measurement of rotor and body frequencies	ISO
5110	Test method for flight stability of a multi-copter unmanned aircraft system (UAS) under wind and rain conditions	ISO
5305	Noise measurements for UAS (unmanned aircraft systems)	ISO
TR 5469	Artificial intelligence — Functional safety and AI systems	ISO/IEC
5928	Information technology — Cloud computing and distributed platforms — Taxonomy for digital platforms	ISO/IEC
9001	Quality managements systems — Requirements	ISO
15964	Detection and avoidance system for unmanned aircraft systems	ISO/DIS
16746	Unmanned aircraft systems — Counter UAS — Quality and safety for users	ISO/CD
16747	Unmanned aircraft systems — Counter UAS — Quality and safety for manufacturers	ISO/CD
17123-10	Optics and optical instruments — Field procedures for testing geodetic and surveying instruments Part 10: UAV photogrammetry systems	ISO/AWI
21384-2	Unmanned aircraft systems Part 2: UAS components	ISO
23117-1	Agricultural and forestry machinery — Unmanned aerial spraying systems Part 1: Environmental requirements	ISO
23135	Space systems — Verification program and management process	ISO
F2245-23	Standard Specification for Design and Performance of a Light Sport Airplane	ASTM

F2840-14	Standard Practice for Design and Manufacture of Electric Propulsion Units for Light Sport Aircraft	ASTM
F2851-10	Standard Practice for UAS Registration and Marking (Excluding Small Unmanned Aircraft Systems)	ASTM
F2909-19	Standard Specification for Continued Airworthiness of Lightweight Unmanned Aircraft Systems	ASTM
F2972-24	Standard Specification for Light Sport Aircraft Manufacturer's Quality Assurance System	ASTM
F3061/F3061M-24	Standard Specification for Systems and Equipment in Aircraft	ASTM
F3153-22	Standard Specification for Verification of Aircraft Systems and Equipment	ASTM
F3196-18	Standard Practice for Seeking Approval for Beyond Visual Line of Sight (BVLOS) Small Unmanned Aircraft System (sUAS) Operations	ASTM
F3227/F3227M-25	Standard Specification for Environmental Systems in Aircraft	ASTM
F3228-21	Standard Specification for Flight Data and Voice Recording in Small Aircraft	ASTM
F3230-25	Standard Practice for Safety Assessment of Systems and Equipment in Small Aircraft	ASTM
F3231/F3231M-24	Standard Specification for Electrical Systems for Aircraft with Combustion Engine Electrical Power Generation	ASTM
F3232/F3232M-23a	Standard Specification for Flight Controls in Small Aircraft	ASTM
F3233/F3233M-23b	Standard Specification for Flight and Navigation Instrumentation in Aircraft	ASTM
F3234/F3234M-21	Standard Specification for Exterior Lighting in Small Aircraft	ASTM
F3235-22	Standard Specification for Aircraft Storage Batteries	ASTM
F3236-21a	Standard Specification for High Intensity Radiated Field (HIRF) Protection in Small Aircraft	ASTM
F3262-17	Standard Classification System for Small Unmanned Aircraft Systems (sUASs) for Land Search and Rescue	ASTM
F3269-21	Standard Practice for Methods to Safely Bound Behavior of Aircraft Systems Containing Complex Functions Using Run-Time Assurance	ASTM
F3298-24	Standard Specification for Design and Construction of Lightweight Unmanned Aircraft Systems (UAS)	ASTM
F3322-25	Standard Specification for Small Unmanned Aircraft System (sUAS) Parachutes	ASTM
F3389/F3389M-21	Standard Test Method for Assessing the Safety of Small Unmanned Aircraft Impacts	ASTM
F3442/F3442M-23	Standard Specification for Detect and Avoid System Performance Requirements	ASTM
F3563-22	Standard Specification for Design and Construction of Large Fixed Wing Unmanned Aircraft Systems	ASTM
F3657-23	Standard Specification for Verification of Lightweight Unmanned Aircraft Systems (UAS)	ASTM

WK62734	New Specification for Specification for the Development of Manufacturers Maintenance Data for Lightweight UAS	ASTM
WK62669	New Test Method for Detect and Avoid	ASTM
F.749.14	Requirements of coordination for civilian unmanned aerial vehicles	ITU
F.749.15	Requirements for inspection and examination services using civilian unmanned aerial vehicles	ITU
F.749.18	Framework and requirements for emergency services using civilian unmanned aerial vehicles	ITU
F.760.1	Requirements and reference framework for emergency rescue systems	ITU
DO-365C	Minimum Operational Performance Standards (MOPS) for Detect and Avoid (DAA) Systems	RTCA
TSO-C213a	Unmanned Aircraft Systems Control and Non-Payload Communications Terrestrial Link System	FAA
ED-301	Guidelines for the Use of Multi-GNSS Solutions for UAS Specific Category - Low Risk Operations SAIL I and II	EUROCAE
NPA 2021-09	Regular update of the acceptable means of compliance and guidance material to Regulation (EU) 2019/947 on the rules and procedures for the operation of unmanned aircraft	EASA
AIR7356	Opportunities, Challenges, and Requirements for Use of Blockchain in Unmanned Aircraft Systems Operating Below 400 Feet Above Ground Level for Commercial Use	SAE

Finally, the certified category includes the highest number of risks during operations. As the area of drones is still really new, the allowance of certified operations is really low and is allowed mostly from big organizations and governmental and military reasons. In order to fully allow such operations, all the existing aviation regulations need to be amended so they include drones into them, which leads to mostly theoretical operations that will constitute the certified category.

According to EASA, the first operation type for certified category, will include all the international flights of cargo drones that will operate in the similar airspaces with the rest of the air vehicles and they will be taking off and landing at aerodromes. Such an example provided through EASA is an unmanned A320 transporting cargo from Paris to New York.

Next operation type, the usage of unmanned drones into urban areas either for passenger or cargo transport. The closest to our life cases are the tests made by amazon to deliver their goods using drones, and the imaginary picture of flying automated vehicles still is an image from scientific movies. Last but not least, the third operation type is similar to the previous one we already mentioned but now with the presence of a pilot on board.

Similarly to specific categorization, we matched our communication protocols regarding their description content as follows.

Table 16 Certified category drone protocols

1920.2	Aerial Communications and Networking Standards	IEEE
1936.1	Standard for Drone Applications Framework	IEEE

1936.2	Photogrammetric Technical Standard of Civil Light and Small Unmanned Aircraft Systems for Overhead Transmission Line Engineering	IEEE
1936.6	Standard for Unmanned Aircraft Systems based Oblique Photogrammetry Used for Survey and Design of 110 kV and Above Power Transmission and Transformation Projects	IEEE
1936.7	Standard for Mesh Deployment of Multi-Rotor Unmanned Aircraft Systems for Inspection of Overhead Transmission and Distribution, and Outdoor Substation Facilities	IEEE
1936.8	Standard for Monitoring of Photovoltaic Power Stations Using Unmanned Aircraft Systems	IEEE
1936.9	Standard for Technical Requirements for Electric Unmanned Aircraft Systems for Power Grid Material Lifting	IEEE
1936.10	Recommended Practice for Use of Electric Unmanned Aircraft Systems for Power Grid Material Lifting	IEEE
1936.11	Standard for Requirements of Laying Out Pilot Ropes by Unmanned Aircraft Systems for Overhead Power Line Installations	IEEE
1936.12	Standard for Verification of Pilot Line Deployment Devices Based on Unmanned Aircraft Systems for Overhead Power Line Installations	IEEE
1936.13	Recommended Practice for Image Collection during the Inspection of Overhead Distribution Lines by Unmanned Aircraft Systems	IEEE
1936.14	Unmanned Aircraft Systems in Power Grid Applications—UAS Multi-Spectral Scanning Operations for Overhead Transmission Lines (COM/AerCom-SC/UASPGA-MSSO)	IEEE
1937.1	Standard Interface Requirements and Performance Characteristics for Payload Devices in Drones	IEEE
1937.6	Standard for Unmanned Aerial Vehicle (UAV) Light Detection and Ranging (LiDAR) Remote Sensing Operation	IEEE
1937.8	Recommended Practice for Functional and Interface Specifications for Unmanned Aerial Vehicle (UAV) Cellular Communication Terminals	IEEE
1937.9	Requirements for External Power and Power Management Interfaces for Unmanned Aerial Vehicle	IEEE
1937.11	Standard for Technical Requirements of Polar Coordinate Photogrammetry Based on Unmanned Aircraft System	IEEE
1937.17	Standard for specifications for lithium-ion cells and batteries used in Unmanned Aircraft Systems (UAS)	IEEE
1937.18	Charger Used in Unmanned Aircraft Systems - Technical Specification	IEEE
5015-2	Unmanned aircraft systems Part 2: Operation of vertiports for vertical take-off and landing (VTOL) unmanned aircraft (UA)	ISO
5109	Evaluation method for the resonance frequency of the multi-copter UA (unmanned aircraft) by measurement of rotor and body frequencies	ISO
5110	Test method for flight stability of a multi-copter unmanned aircraft system (UAS) under wind and rain conditions	ISO
5305	Noise measurements for UAS (unmanned aircraft systems)	ISO
TR 5469	Artificial intelligence — Functional safety and AI systems	ISO/IEC

5491	Vertiports — Infrastructure and equipment for vertical take-off and landing (VTOL) of electrically powered cargo unmanned aircraft systems (UAS)	ISO
5928	Information technology — Cloud computing and distributed platforms — Taxonomy for digital platforms	ISO/IEC
9001	Quality managements systems — Requirements	ISO
14619	Space systems — Space experiments — General requirements	ISO
14620-3	Space systems — Safety requirements Part 3: Flight safety systems	ISO
14950	Space systems — Unmanned spacecraft operability	ISO
15864	Space systems — General test methods for spacecraft, subsystems and units	ISO
15964	Detection and avoidance system for unmanned aircraft systems	ISO/DIS
16126	Space systems — Assessment of survivability of unmanned spacecraft against space debris and meteoroid impacts to ensure successful post-mission disposal	ISO
16458	Space systems — Unmanned spacecraft transportation — General requirements	ISO
16746	Unmanned aircraft systems — Counter UAS — Quality and safety for users	ISO/CD
16747	Unmanned aircraft systems — Counter UAS — Quality and safety for manufacturers	ISO/CD
20517	Space systems — Cybersecurity management requirements and recommendations	ISO
20780	Space systems — Fiber optic components — Design and verification requirements	ISO
21384-2	Unmanned aircraft systems Part 3: Operational procedures	ISO
21895	Categorization and classification of civil unmanned aircraft systems	ISO/CD
22460-2	Part 2: Drone/UAS security module	ISO/IEC
23041	Space systems — Unmanned spacecraft operational procedures — Documentation	ISO/AWI
23135	Space systems — Verification program and management process	ISO
24356	General requirements for tethered unmanned aircraft systems	ISO
27875	Space systems — Re-entry risk management for unmanned spacecraft and launch vehicle orbital stages	ISO/CD
F2851-10	Standard Practice for UAS Registration and Marking (Excluding Small Unmanned Aircraft Systems)	ASTM
F3061/F3061M-24	Standard Specification for Systems and Equipment in Aircraft	ASTM
F3153-22	Standard Specification for Verification of Aircraft Systems and Equipment	ASTM
F3227/F3227M-25	Standard Specification for Environmental Systems in Aircraft	ASTM
F3228-21	Standard Specification for Flight Data and Voice Recording in Small Aircraft	ASTM

F3230-25	Standard Practice for Safety Assessment of Systems and Equipment in Small Aircraft	ASTM
F3231/F3231M-24	Standard Specification for Electrical Systems for Aircraft with Combustion Engine Electrical Power Generation	ASTM
F3232/F3232M-23a	Standard Specification for Flight Controls in Small Aircraft	ASTM
F3233/F3233M-23b	Standard Specification for Flight and Navigation Instrumentation in Aircraft	ASTM
F3234/F3234M-21	Standard Specification for Exterior Lighting in Small Aircraft	ASTM
F3235-22	Standard Specification for Aircraft Storage Batteries	ASTM
F3236-21a	Standard Specification for High Intensity Radiated Field (HIRF) Protection in Small Aircraft	ASTM
F3269-21	Standard Practice for Methods to Safely Bound Behavior of Aircraft Systems Containing Complex Functions Using Run-Time Assurance	ASTM
F3309/F3309M-24a	Standard Practice for Simplified Safety Assessment of Systems and Equipment in Small Aircraft	ASTM
F3563-22	Standard Specification for Design and Construction of Large Fixed Wing Unmanned Aircraft Systems	ASTM
Y.2256	Overview of unmanned smart farms based on networks	ITU
Y.4116	Requirements of transportation safety services including use cases and service scenarios	ITU
Y.4559	Requirements and functional architecture of base station inspection services using unmanned aerial vehicles	ITU
F.749.16	Requirements for logistics express delivery based on civilian unmanned aerial vehicles	ITU
DO-362 with Errata	Command and Control (C2) Data Link Minimum Operational Performance Standard (MOPS) (Terrestrial)	RTCA
DO-365C	Minimum Operational Performance Standards (MOPS) for Detect and Avoid (DAA) Systems	RTCA
DO-366A	Minimum Operational Performance Standards (MOPS) for Air-to-Air Radar for Traffic Surveillance	RTCA
DO-381A	MOPS for GBSS for Traffic Surveillance	RTCA
DO-382	Minimum Aviation System Performance Standards CAS Interoperability	RTCA
DO-387	Minimum Operational Performance Standards (MOPS) for Electro-Optical/Infrared (EO/IR) Sensors System for Traffic Surveillance.	RTCA
DO-397	Guidance Material: Navigation Gaps for Unmanned Aircraft Systems (UAS)	RTCA
1008	IP OVER SATELLITE (IPOS)	TIA
3030	Standard for Unmanned Aircraft Systems	UL
AEP-77	INTEROPERABLE COMMAND AND CONTROL DATA LINK FOR UNMANNED SYSTEMS (IC2DL) - OPERATIONAL PHYSICAL LAYER/SIGNAL IN SPACE DESCRIPTION	NATO
AEP-80	Rotary Wing UAS Airworthiness	NATO

AEP-101	GUIDANCE ON SENSE AND AVOID FOR UNMANNED AIRCRAFT SYSTEMS	NATO
STANAG 4586	Standard Interface of UAV Control System for NATO UAV Interoperability	NATO
STANAG 4671	UAV Systems Airworthiness Requirements	NATO
STANAG-4702	Rotary wing UAS Airworthiness requirements	NATO
STANAG-4703	Light UAS Air worthiness requirements	NATO
TOP-7-1-003	Unmanned Aircraft Systems (UAS) Sensor and Targeting	US ARMY
TOP-7-2-032	Unmanned Aircraft Systems (UAS) Navigation System Test	US ARMY
ARP94910	Aerospace - Vehicle Management Systems - Flight Control Design, Installation and Test of, Military Unmanned Aircraft, Specification Guide	SAE
ARP94910A	Aerospace - Vehicle Management Systems - Flight Control Design, Installation and Test of, Military Unmanned Aircraft, Specification Guide	SAE
ARINC677	Installation standards for low frequency underwater locator beacon (LF-ULB)	SAE

Chapter 6: Conclusions and Future work

The aim of this thesis, guided by the initial research questions, was to collect, study and categorize existing UAV standards. Based on the outcome of our research, I believe we have successfully addressed these questions to a significant extent, considering the limited level of access to related resources. Summarizing our questions, in terms of communication standards and protocols used in UAVs, we were able to identify and compile over 500 protocols. While many of these are directly related to communication, some also pertain to personnel training requirements and regulatory frameworks. We chose to include these in our research, as excluding them would have resulted in the omission of critical information.

Furthermore, we presented five communication specific categories regarding their area of use, along with an additional category addressing personnel training needs as we mentioned before and a general category for protocols that could not be assigned to a single application area. Finally, after extensive research we categorized our protocol collection in alignment with EASA's licensing levels taking into account drone size and operational use.

At that point we had to watch drones from a greater point of view, from a generic perspective and leave the cleansed scientific point of view so to provide a realistic update of the current state of drones in our lives. Our research revealed various security vulnerabilities which have been exposed repeatedly, in some cases leading to fatal accidents and that despite their global impact there is still no unified approach on a common regulatory framework. That fact comes at the opposite side of the continuous improvement of drones, which without any thought they will be a life changing vendor in the future.

Standardization, beyond being critical to the development and sustainability of technological ecosystems, also serves as the first line of defense in responding to incidents and failures mentioned before. Among the wide array of standards we have reviewed, a significant portion directly addresses security concerns, operational frameworks and the design of proper infrastructures for UASs. Though, our research has demonstrated that the area remains highly fragmented. As emphasized in our research methodology, there is a noticeable lack of related literature on the categorization and presentation of such standards. This, combined with the limited accessibility to the core documents of these standards, creates significant challenges for both academia and industry. We strongly urge for increased collaboration between standardization bodies, academic institutions and researchers of the fields so to follow the initiative of ANSI's roadmap and fill the literature gap making the area more transparent, inclusive and efficient

Another pressing concern is the global inconsistency in regulatory environments. In our research, we focused on regulatory data from European countries, where we observed that a significant number of member states continue to follow their own national regulatory frameworks. Although these often align closely with the standards proposed by the EASA, there are still notable differences, particularly in the applicability of specific standards. When considered on a global scale, such discrepancies multiply. This fragmentation creates substantial challenges for standardization bodies attempting to establish unified frameworks, often resulting in duplicated efforts and conflicting standards. At this point, I would like to present a personal opinion based on the extensive study undertaken during the construction of this thesis. From my point of view, "true" breakthroughs in standardization will remain out of reach until there is a globally unified regulatory framework much like

the international harmonization achieved in the airline industry. Until that day, if I may say, we are only witnessing localized breakthroughs and isolated achievements. Without global alignments, these efforts remain fragmented and limited in their broader impact.

Another critical aspect of drone technology that we need to have our attention at in security [19]. Incidents such as data breaches, malicious manipulation of connected systems, personal space intrusions and even targeted attacks, are a small number of incidents from what really happen as highlighted by DeDrone. Security challenges in this domain are highly complex and the belief that advancing technology will naturally solve them is far from reality. In fact, as technology evolves, so does the nature of potential threats. In response to these challenges, the integration of AI has emerged as a promising approach. Over the last decade, AI has demonstrated impressive capabilities in various domains. In the literature, we encountered numerous experimental scenarios where AI was successfully applied, for instance in flight path optimization, automated drone deployment and retrieval based on battery level and a range of operational efficiencies.

Moreover, AI has shown significant potential in security specific functions, such as threat detection. While AI offers powerful tools, its integration into security architectures must not be blindly. Over reliance on such systems, is risky as their decision making is not yet fully trustworthy. Therefore, standards in this area must evolve to not only include AI based solutions but also ensure that these systems are designed with transparency, audibility and human oversight. Responsible and ethical integration of AI is essential to build trust and resilience in drone security systems, but also to help shift public perception reducing the suspicion with which both drones and AI are often viewed.

Next in line is hardware, which technological progress remains uneven. In an era dominated by compact, remotely connected devices, mostly on the move, the demand for power efficiency has never been greater. Despite continuous efforts, hardware manufacturers are struggling to consistently deliver smaller, more powerful and energy efficient units year after year. Future standardization efforts must account for these needs, encouraging innovations in battery chemistry, chip design, and materials science. Standardizing around energy efficiency metrics and low-power protocols could also spur hardware manufacturers to adopt more sustainable design principles.

6.1 Future Work

As a final note, our research led us to the clear conclusion that drones, in all their forms, and particularly those capable of autonomous operation, represent a remarkable achievement of modern engineering. Their capabilities have already been demonstrated in impactful ways, such as humanitarian missions, search and rescue operations and accessing remote or dangerous areas with speed and precision. These applications often stand in contrast to the negative perception associated with their military use, highlighting the dual nature of this technology. We fully support the stance of researchers who advocate that future standardization efforts must place people and their safety at the center, rather than prioritizing performance alone. It is essential to respect individual privacy, promote a sense of safety and encourage the public to see drones and UAVs in general as tools designed to improve lives, not as sources of fear.

To achieve this, additional certifications should be introduced, each country should take an active role in educating its citizens about the role and purpose of drones and at the same time providing the needed patrolling. Ultimately, what is most needed is clarity, open access to information and a transparent and inclusive standardization process.

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