Future Flight Standards Roadmap Report

Key themes and standardization recommendations for uncrewed aircraft systems (UAS) and electric vertical take-off and landing (eVTOL) aircraft.

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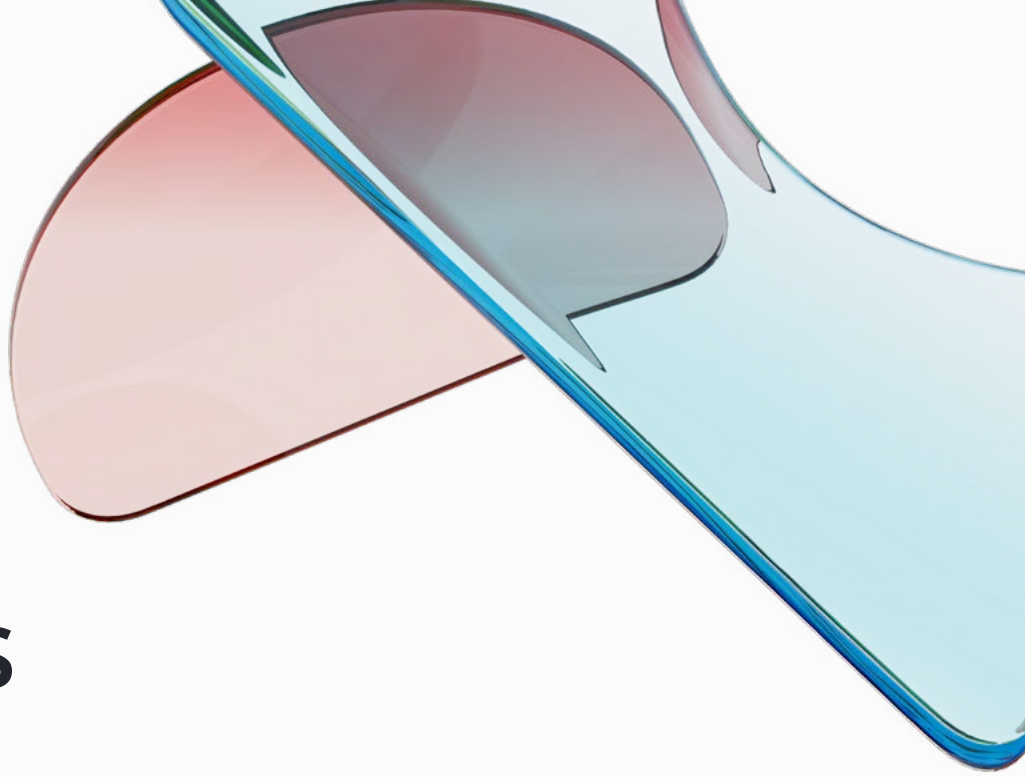

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1.1 Context and background

Aviation is being transformed by emerging technologies. Uncrewed aircraft systems (UAS) offer safer, cheaper and faster services. Piloted, zero-emissions, electric vertical take-off and landing (eVTOL) aircraft, designed to be quieter, aim to carry commercial passengers in the next 5 years. These emerging technologies have the potential to transform our economy and society in significant ways. The UAS sector alone could contribute up to £45 billion to the UK economy[1] by 2030, whilst eVTOL passenger and freight transportation services could bring up to £2.1 billion in socioeconomic benefits (including time savings, carbon emissions reduction and avoided accidents) by 2040[2].

To fully unlock this potential, these new aircraft need to be introduced and integrated into the existing airspace system in a safe, seamless and scalable way. This can only be achieved by demonstrating compliance with existing and emerging regulations and harmonization through internationally recognized standards. In addition, the public can be reassured that these new future flight technologies are safe to use[3], establishing their public acceptance and social licence[4].

Standards have a key role in enabling emerging technology and informing the development of new policy and regulation. The relationship between standards and regulation is described in Annex 3.

1. PWC Skies Without Limits v2.0, July 2022 – page 2.
2. PWC Advanced Air Mobility, UK Economic Impact Study, July 2023 – page 1.
3. YouGov The University of Birmingham and Future Flight Challenge: Future Flight Survey 2024 – page 19.
4. UKRI Framework for Future Flight in the UK: Principles from a deliberative Public Dialogue, July 2024 – pages 84-85.

BSI has developed a standards roadmap that aims to support the growth and industrialization of future flight in the UK. It identifies the most relevant standards for these emerging aviation technologies and sets out a forward-looking plan for standardization activity required to enable the UK strategy for future flight.

The standards roadmap consists of two distinct pathways – a UAS pathway and an eVTOL pathway, following the same framework defined in the future flight Industry Group (FFIG) action plan[5].

Continuous stakeholder engagement throughout the roadmap development process has confirmed that this framework is clear and understood by all stakeholders within the ecosystem. It is an effective framework to support the development of technologies and solutions to achieve the objectives for each pathway. Therefore, it has been incorporated into the roadmap.

For ease of navigation, the standards roadmap is structured around themes – 10 for the UAS pathway and 11 for the eVTOL pathway, as shown in Figure 1. These themes were identified and agreed through engagement with industry and broader stakeholders.

Some themes are common to both pathways, mainly those specific to enabling capabilities, such as safety management, operations, airspace integration, digital assurance, and detect and avoid (DAA).

Descriptions of the themes are provided in Section 2, and the methodology for developing the standards roadmap is described in Section 3.

For each theme, the standards roadmap outlines the most relevant standards already published and the standards that are in development. The roadmap provides a standards body “agnostic” view and collates activities from across all relevant aviation standards development organizations (SDOs).

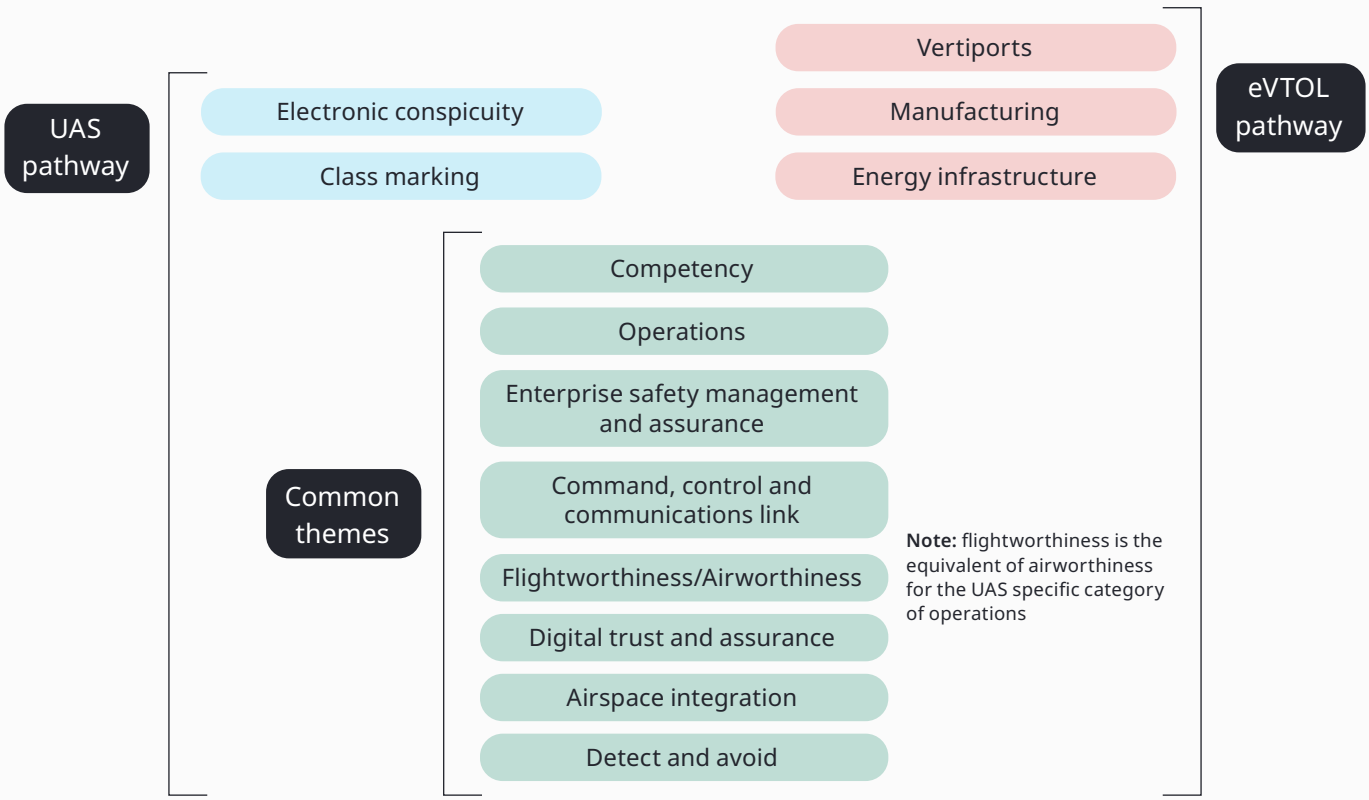
5. DfT UK Future of Flight Action Plan, March 2024 – page 15.

The UK Civil Aviation Authority is using the Joint Authorities for Rulemaking on Unmanned Systems' (JARUS) guidelines on Specific Operations Risk Assessment (SORA) v2.5[6] guidelines and framework to develop the UK SORA. This is a key enabler for the UAS pathway. Thus, the identified standards for the UAS pathway were prioritized based on their potential to be used as means of compliance to meet the requirements for SORA, such as its operational safety objectives (OSOs). This will enable beyond visual line of sight (BVLOS) at scale. The OSOs mentioned in this document are described in Annex 2. The UAS Pathway only addresses the specific category of operations and thus it does not address the certified (or certificated) category.

In addition to setting out the most relevant published and in development standards, the roadmap sets out a set of standardization recommendations for each theme.

Whilst the roadmap has a UK focus, it can be used to drive international standards alignment, and discussions have commenced with other SDOs about how to present a more holistic view of standardization activity across the sector.

Figure 1: Standards roadmap themes



6. JARUS guidelines on Specific Operations Risk Assessment (SORA) v2.5, May 2024.

1.2 Key takeaways and call to action

The following key takeaways summarize the lessons learned and overarching recommendations, derived from the BSI future flight Programme and the standards roadmap development.

1. Closer collaboration between BSI, Department for Transport (DfT) and the UK Civil Aviation Authority (CAA) will help accelerate innovation to market. For innovative technology and emerging policy areas, consensus through industry standards can be used to inform emerging policy and regulation.
2. Closer collaboration between BSI and CAA on emerging policy and regulation, to ensure better alignment between policy development and standards development. For example, standardization scoping aligned with regulatory sandboxes to address the gaps in standards required to support acceleration of innovation.
3. BSI to explore with the CAA how standards can be used more effectively as acceptable means of compliance (AMC) to provide greater certainty and consistency in demonstrating compliance with regulation.
4. Further engagement with start-ups, scale-ups and the wider future flight community is required to raise awareness of the importance of standards in a safety-critical, regulated environment. The BSI programme has provided the foundation for this.
5. There is a perception that standards are only applicable at higher technology readiness levels (TRLs). Standards support innovation at all TRLs and facilitate the transition of academic and industrial research and development into the commercial market for future flight.
6. Standards will play a key role in accelerating the next industrialization phase of future flight to create an effective and well-functioning commercial market:
    - 6.1 Creating harmonization and interoperability of new technology and services.
    - 6.2 Providing confidence to investors and insurers as the market scales.
    - 6.3 Building public trust and acceptance of new technologies and developing a social licence to operate[7].
7. The standards landscape for aviation is complex. BSI has developed a standards body “agnostic” UK lens into aviation standardization activity. This has led to engagement and collaboration agreements with aviation SDOs.
8. The foundational activities and impact delivered through the BSI Future Flight Standards Programme require investment to maintain and develop further.

7. UKRI Framework for Future Flight in the UK: Principles from a deliberative Public Dialogue, July 2024.

1.3 Recommendations

The standards roadmap produced a set of standardization recommendations for each theme based on industry prioritization required to deliver the UK's future flight strategy.

These recommendations support the delivery of the UK's strategic objectives for the UAS and eVTOL pathways, including the development of emerging policy and regulatory frameworks.

They range from specific areas where industry has identified that a new standard is required through to recommendations outlining where collaboration is required with government and the CAA to support emerging policy and regulation.

A common point throughout the recommendations is the need for closer collaboration between BSI and the CAA.

For themes common to both pathways, some recommendations diverge, particularly where UAS recommendations aim to support compliance with the UK SORA requirements.

The recommendations are presented in three tables – the common recommendations that apply to both pathways, and the recommendations that are specific to the UAS pathway and the eVTOL pathway, respectively.

1.3.1 Recommendations common to both UAS and eVTOL pathways

Note: We reference operational safety objectives (OSOs) as described in the JARUS SORA documentation[8]. These OSOs are also listed in Annex 2.

Theme	Recommendations
Digital trust and assurance	1. Conduct pre-scoping work to understand gaps in standards on the use of artificial intelligence (AI) to enable routine UAS BVLOS operations and autonomous eVTOL operations in integrated airspace at scale (e.g. Detect and Avoid (DAA), Air Traffic Management (ATM), Air Traffic Control, airspace change/integration). 2. Conduct pre-scoping work to understand gaps in standards on security of federated architectures communicating across the public network infrastructure. 3. Conduct pre-scoping work to understand gaps in standards for particular use cases as defined in the European Union Aviation Safety Agency (EASA) AI Concept paper[9], and from industry needs (eVTOL specific).
Airspace integration	1. Collaborate with the CAA to identify gaps in standards required as AMC for UAS traffic management (UTM) services and service provision. 2. Develop standards for UTM service definitions, performance and assurance to facilitate interoperability as the UTM ecosystem matures, including for associated 24/7 cloud-based operations (security, privacy, health monitoring, etc.).
Command and control/ and communications (C2/C3) link	1. Collaborate with the CAA to identify gaps in assurance standards required to support the implementation of certified C2 service providers. 2. Develop standards for the C2 link characteristics and performance proportionate to the operation, and, for the UAS pathway, specifically to meet the requirements for OSO #06.
Detect and avoid	1. Collaborate with the CAA to identify gaps in standards required as AMC for DAA. 2. Develop standards for DAA solutions not relating to aircraft-to-aircraft hazards, including hazardous weather, terrain and other obstacles (e.g. buildings and birds), and during ground manoeuvres.

8. JARUS guidelines on Specific Operations Risk Assessment (SORA) v2.5, May 2024.
9. EASA Artificial Intelligence (AI) Concept Paper Issue 2, March 2024.

1.3.2 Recommendations specific to the UAS pathway

Theme	Recommendations
Competency	1. Collaborate with the CAA to understand the minimum assurance requirements for recognized assessment entities in relation to established industry standards (e.g. ISO 9001). 2. Collaborate with the CAA to identify gaps in BVLOS remote crew competency standards needed to meet the requirements of OSO #09. 3. Substantiate maintenance competency standards to meet the requirements of OSO #03. 4. Develop competency standards to meet the requirements of specific use cases and/or industry sectors. 5. Develop standards to meet the requirements for approved UAS simulators, including BVLOS-specific training requirements.
Operations	1. Collaborate with the CAA to identify where standards are required to address gaps in *CAP 722* and *CAP 371* to meet the requirements of OSO #17 (e.g. crew fitness to operate and medical). 2. Collaborate with the CAA to identify gaps in operational standards needed to complement the Light UAS Operator Certificate to meet requirements of specific use case/industry sectors to inform the development of new pre-defined risk assessments (PDRAs)[10]. 3. Conduct pre-scoping work on multi-crew operational procedure standards needed to meet the requirements of OSO #16. 4. Develop operational standards for human factors in UAS operations focused on interaction between human operators and automated UAS flight systems to meet the requirements of OSO #20.
Enterprise safety management and assurance	1. Collaborate with the CAA to understand the proportionate safety management and assurance required for the UAS ecosystem. 2. Adapt existing standards or develop new standards to meet the safety management and design assurance requirements for emerging technologies.
Flightworthiness	1. Collaborate with the CAA to identify gaps in standards to meet the requirements for Flightworthiness OSO #04. 2. Develop specific design standards for individual system components, (e.g. navigation system, flight control system). 3. Develop standards for UAS-specific hazard mitigation systems to meet the design and test requirements of OSO #24 (e.g. icing, water ingestion, hail damage, etc). 4. Continue development of BSI Flex 1904[11] to define environmental conditions in a standardized format to meet the requirements of OSO #23.
Electronic conspicuity	1. Collaborate with the CAA to identify gaps in standards to meet regulatory requirements for the carriage, use and performance of electronic conspicuity devices.
Class marking	1. CAA, in conjunction with DfT, to confirm the outcome of the *CAP 2610* regulatory review to provide clarity on the requirements for class marking standards.

10. EASA Special Condition Light Unmanned Aircraft Systems - High Risk, December 2021.
11. BSI Flex 1904 Operational Design Domain (ODD) Taxonomy for Future Flight.

1.3.3 Recommendations specific to the eVTOL pathway

Theme	Recommendations
Competency	1. Collaborate with the CAA to understand how standards will support the skills development required for the Advanced Air Mobility (AAM) ecosystem, and align with DfT's skills gap analysis for the AAM ecosystem. 2. Conduct pre-scoping work to develop a standardized approach for providing operational suitability data for pilot competency that address specific aircraft design and characteristics. 3. Develop maintenance competency standards specific to ratings needed to address particular aircraft systems and technologies. 4. Conduct pre-scoping work to develop a standardized approach for developing flight simulation training devices.
Operations	1. Develop standards for automated processes for electric aircraft ground handling, e.g. robotic loading/unloading, to ensure smooth transition from human-driven airport procedures to fully uncrewed airport operations. 2. Conduct pre-scoping work to understand gaps in human factors standards when applied to eVTOL operations, particularly the interaction between human operators and automated/autonomous eVTOL flight systems, including procedures, task design and tools. 3. Conduct pre-scoping work to understand gaps in noise measurement standards when applied to eVTOLs at vertiports and in urban areas.
Enterprise safety management and assurance	1. As it is expected that eVTOLs will need certification, it is recommended that existing safety assurance and aviation recommended practices and standards are followed.
Airworthiness	1. Collaborate with the CAA to identify gaps in standards required to supplement the EASA's SC-VTOL[12] and related AMC[13] for airworthiness requirements. 2. Collaborate with industry to propose to the CAA a standardized approach to aggregate original equipment manufacturer (OEM) performance data to inform standards development and regulatory AMC.
Vertiports	1. Collaborate with CAA, DfT, Ministry of Housing, Communities and Local Government to define standards required to support the design, build and operations of vertiports. Also, to support planning policy that could be built on existing frameworks. 2. Collaborate with the CAA and Fire Protection Association to identify gaps in standards required to support fire safety regulations at vertiports. 3. Collaborate with the CAA, Home Office and DfT to identify gaps in standards required to support security regulations at vertiports. 4. Develop global interoperability standards for vertiport operator's role and responsibilities within the ATM/UTM ecosystem, including standard procedures and communication protocols. 5. Develop standards for eVTOL ground handling at vertiports, including operational management of battery charging and swap out procedure.

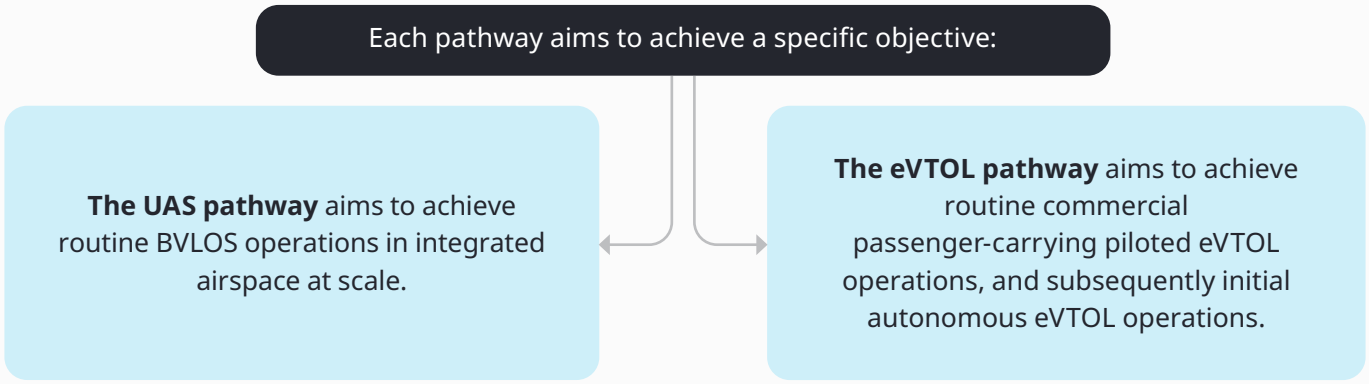
12. EASA Special Condition for small-category VTOL-capable aircraft- Issue 2 (SC-VTOL-02), June 2024.
13. EASA Fourth Publication of Proposed Means of Compliance with the Special Condition VTOL Issue 1 (MOC-4 SC-VTOL), December 2023.

Theme	Recommendations
Energy infrastructure	1. Develop standards to meet the requirements for the supply, storage and distribution of energy at vertiports. 2. Develop standards that enable interoperability and harmonization for charging of different battery technologies to meet breadth of requirements of OEMs.
Manufacturing	1. Conduct pre-scoping work to understand gaps in standards for additive manufacturing quality management systems that meet safety-critical components' requirements. 2. Conduct pre-scoping work to understand gaps in standards for testing the performance characteristics of safety-critical components produced through additive manufacturing techniques. 3. Conduct pre-scoping work to understand gaps in standards for the repair and maintenance of the new materials used for safety-critical components.

The next sections describe the roadmap structure and themes in detail, as well as the methodology followed to develop and produce the final output, together with the stakeholder engagement.

2 Scope, structure and description of themes

The standards roadmap developed by BSI consists of two distinct pathways – a UAS pathway and an eVTOL pathway.



The BSI future flight Roadmap is presented as a visualization[14]. To make it easy to navigate and guide stakeholders to the standards relevant to their needs and specific areas of interest, the roadmap is structured around themes, aligning with the regulatory framework and industry needs.

The themes for each pathway are shown in Figure 1 and are described in detail in the next sections.

For each theme, the roadmap presents the standards that have been published and those that are in development. For themes where there are limited published standards, and are expected to be addressed by emerging regulations, the roadmap signposts to relevant UK and international regulation (e.g. for the eVTOL competency and vertiports themes).

The roadmap themes are consistent with the topics presented at the International Civil Aviation Organization (ICAO) AAM Symposium event in September 2024, aligning with the international vision for UAS and eVTOLs. As it shown in Figure 2 and its related table, the themes map to the ICAO regulations that relate to:

- individuals and their competency, typically addressed under the term “licensing”, which facilitates individuals’ ability to manage and demonstrate their capability;
- organizations and recognized capability, typically addressed using terms that reflect an “approval”, “permission” or “authorization”; and
- products or services provided by these organizations typically addressed using terms that reflect an “approval” or “certification”.

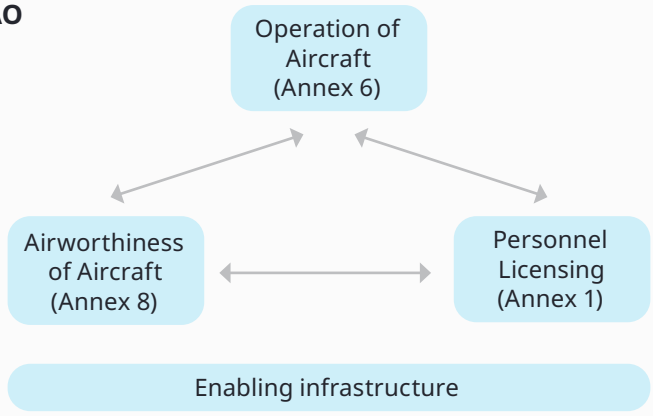
The themes align with the ICAO aircraft elements that are needed for operations, e.g. the operator governance aspects, the aircraft capability and airworthiness, and the competency of the operational personnel.

The themes also align with domestic UK policy, as illustrated by the pillars defined in the CAA’s recently published *CAP 3038*[15].

Finally, the roadmap produces specific recommendations for each theme calling for industry to prioritize activities to collaboratively expedite and efficiently achieve the objectives set for each pathway.

14. BSI Future Flight Programme Roadmap.
15. UK CAA CAP3038: Delivering Scalable UAS BVLOS in the Specific Category, September 2024 – page 9.

Figure 2: Aligning with ICAO



	Standards and Regulated Practices (SARPs)			Enabling infrastructure
Roadmap themes	**Operation of Aircraft**	**Personnel Licensing**	**Airworthiness of Aircraft**	
Competency		X		
Enterprise safety management and assurance	X	X		
Operations	X			
Digital trust and assurance	X		X	
Airworthiness			X	
Flightworthiness				
Airspace integration				X
Detect and avoid			X	X
Command, control and communications link				X
Electronic conspicuity				X
Class marking			X	
Vertiports				X
Energy infrastructure				X
Manufacturing			X	

2.1 Description of the themes common to both pathways

Theme	Standard need	Description
Competency	**Competency requirements to enable more complex and scalable UAS/eVTOL operations**	
	Pilot	Pilot competency requirements for new types of remotely piloted aircraft/eVTOL and operations
	Maintenance	Maintenance competency requirements for new types of remotely piloted aircraft/eVTOL and operations
	Associated crew	Competency requirement for all other crew associated with the new types of remotely piloted aircraft/eVTOL and flight operations
Operations	**Covers all operational requirements and procedures for flying and maintenance of a UAS/eVTOL**	
	Flight operating procedures	Requirements for standardized instructions and guidelines to operate a UAS/eVTOL during flight
	Maintenance procedures	Requirements for systematic processes and schedules to keep a UAS/eVTOL in safe and operational condition
	Operations over people	Requirements for UAS/eVTOL flights conducted in areas where there are individuals who are not directly participating in the operation
Enterprise safety management and assurance	**Organization-wide safety management and assurance systems applicable to new types of aircraft and operations**	

Theme	Standard need	Description
Flightworthiness (UAS) **Airworthiness (eVTOL)**	**Initial and ongoing flightworthiness (for UAS) and airworthiness (for eVTOL) certification of new types of aircraft. It includes design assurance requirements for aircraft, systems and system components and related system safety assurance**	
	Design assurance	Requirements for processes and procedures to assure design and construction of aircraft, systems and system components
	System safety and reliability	Requirement for safety assessment of aircraft, systems and system components, that identify, assess, and mitigate risks associated with the UAS/eVTOL operations
	Software assurance	Requirements to ensure that all software components of the UAS/eVTOL are free from vulnerabilities, perform as intended, and comply with relevant standards
	Navigation system	Requirements for design of components and software that enables the vehicle to determine its position, velocity and trajectory
	Flight control system	Requirements for design of components that manage UAS/eVTOL flight dynamics and control surfaces
	Flight data and voice recorders	Requirements for design of components used for post-flight analysis and accident investigation (e.g. aircraft systems, performance and flight parameters)
	Display and controls	Requirements related to the interface used by the UAS/eVTOL operator to monitor and control the vehicle
	Battery technology	Requirements for specific design and characteristics of battery systems that power the aircraft
	Electric propulsion system	Requirements covering the complete assembly of electrical components that generate thrust and enable flight, including electric motors, power electronics, energy storage (batteries), and control systems that work together to propel the aircraft
	Electrical management system (high voltage)	Requirements covering the advanced electrical architecture required to manage and distribute high voltage electrical power throughout the aircraft, including cabling
Digital trust and assurance	**Covers requirements for the assurance of digital infrastructure, focusing on emerging AI technologies and the security of complex federated architectures**	
	AI assurance and trustworthiness	Requirements for standardized instructions and guidelines to operate a UAS and autonomous eVTOL during flight
	Cybersecurity	Requirements for systematic processes and schedules to keep a UAS and eVTOL in safe and operational condition

Theme	Standard need	Description
Airspace integration	**Covers requirements for services and technologies that enable and support an integrated airspace, where crew and uncrewed aircraft co-exist seamlessly**	
	UTM technology and services	Deployment of UTM to enable integration of new types of aircraft with existing airspace users
	Data interoperability	Secure and reliable data exchange in a complex, federated ecosystem
	Deconfliction	Process of ensuring that UAS/eVTOL flights are planned and conducted in a manner that avoids conflicts with other air traffic, obstacles, and restricted areas
	Supplemental data provision services	Data services that enhance the primary UTM services, providing critical information (e.g. data on temporary flight restrictions, real-time traffic information, weather updates, and other relevant airspace conditions)
	Geo-awareness, geo-fencing	Provides UAS/eVTOL operators with real-time information about the geographic location of the UAS/eVTOL relative to predefined zones, boundaries and airspace structures. Geo-fencing is a specific application of geo-awareness where virtual boundaries are established around certain areas, restricting UAS/eVTOL from entering or leaving these zones
	Common information system providers	Entities that offer standardized and centralized data services that support UTM and UAS operations. These providers collect, aggregate and disseminate critical information such as airspace status, flight plans and real-time traffic data to all stakeholders
	Localized weather data services	Provide detailed and real-time weather information specific to the area where UAS/eVTOL operations are being conducted and in a higher resolution than normal air traffic (e.g. data on wind speed and direction, temperature, precipitation, visibility, and other atmospheric conditions that can impact flight safety)
	Terrain modelling	Provide accurate and detailed digital representations of the Earth's surface in high resolution, including elevation data and topographical features
	Maps (buildings, obstacles, power lines)	Provide accurate and detailed digital representations of man-made structures and natural obstacles within the operational area (e.g. buildings, obstacles and power lines) at high resolution, including their locations and heights
C2/C3 link	**Covers requirements for C2/C3 links used in UAS/eVTOL operations, including secure and reliable communication over open infrastructure, e.g. internet**	
DAA	**Supports the development and approval of a proposed DAA solution**	
	Airborne DAA	Requirements for the capability of the UAS or eVTOL to detect and respond to other airborne objects, such as aircraft, helicopters or other UAS, in its vicinity, thereby avoiding potential collisions
	Ground-based DAA	Requirements for the ground systems designed to detect and track other aircraft, both crewed and uncrewed, in the vicinity of the UAS or eVTOL operation, and alert the operator(s) to potential mid-air collisions
	Surveillance system	Requirements for the technologies to monitor, track and manage aircraft movements to enhance situational awareness

2.2 Description of UAS-specific themes

Theme	Description
Electronic conspicuity	Requirements for the technology that helps pilots, UAS users and air traffic services be more aware of what is operating in surrounding airspace
Class marking	Unique identifier assigned to an aircraft, engine or other aviation product to identify its compliance with specific safety standards and regulations

2.3 Description of eVTOL-specific themes

Theme	Standard need	Description
Manufacturing	**Covers requirements and procedures for the production certification of aircraft and aircraft parts**	
	Serial production	Requirements for standardized processes for the construction, assembly and integration of various components and systems to serially build certified aircraft or aircraft parts
	Additive manufacturing	Requirements for standardized processes that build objects layer by layer from a digital model (e.g. a three-dimensional object from a digital file), to serially build certified aircraft or aircraft parts
Vertiports	**Covers requirements for facilities that provide the necessary infrastructure for the take-off, landing and/or servicing of VTOL aircraft**	
	Design and build	Requirements for planning, architectural design, engineering and construction processes involved in creating a vertiport
	Security	Requirements for systems and processes that ensure safety and security of the vertiport, its users, and the surrounding area, including access control, passenger and cargo screening, surveillance and monitoring and emergency response
	Fire safety	Requirements for systems and processes that prevent, detect and respond to fire emergencies at the vertiport
	Noise	Requirements for methods to assess, quantify and/or mitigate the noise environmental impact of new types of aircraft
Energy infrastructure	**Covers requirements and procedures for the facilities, technologies and services required to generate, store, distribute and manage the electrical energy required for the operation of electric aircraft**	
	Energy storage and distribution	Requirements for systems and technologies used to store and distribute electrical energy that can be used to power electric aircraft operations
	Charging infrastructure	Requirements for facilities and technologies designed to supply electrical energy to electric aircraft efficiently and reliably

3 Methodology

3.1 Standardization drivers

Before starting to develop the roadmap, the main drivers for standardization were considered.

The starting point was the FFIG action plan, which was published while the roadmap work was initiated. The action plan identified two pathways – UAS and eVTOL – and their respective building blocks that need to be prioritized for standards development. These were incorporated into the roadmap.

The second driver considered was the rapidly developing regulation (see examples in Figure 3).

Finally, the third main consideration was how best to achieve the transition from proof-of-concept to routine live commercial operations for the future flight use cases and capabilities demonstrated during the programme. Standards should enable the solutions and use cases to be interoperable, repeatable and scalable.

Figure 3: Main drivers considered during the standards roadmap development process

FFIG action plan

- UAS and eVTOL pathways
- Standards a key building block within the strategy
- Specific areas of standardization required to achieve strategic outcomes

Emerging regulation

- Drone class marking
- Implementation of SORA
- Flightworthiness
- eVTOL certification
- AMS and airspace integration
- Non-aviation regulation, e.g. Ofcom, Health and Safety Executive

Industrialization

- Transition from demonstrations to commercial operations
- Interoperability and harmonization
- Repeatable and scalable

3.2 Roadmap development process

Whilst considering the main drivers for standardization, the roadmap was developed through desktop-based research and industry engagement using a phased approach, as illustrated in Figure 4. Stakeholders were consulted at critical iteration phases to review and comment as the roadmap was maturing.

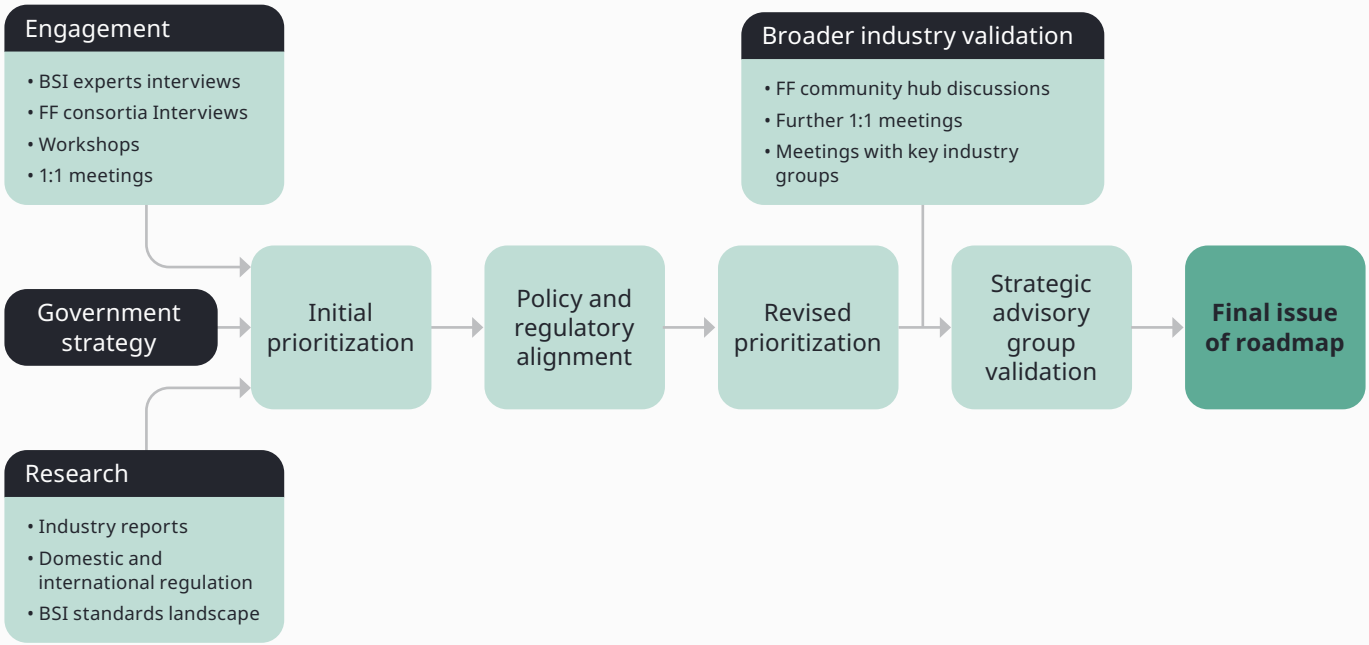
The major aim of the standards roadmap was to address the needs of the various stakeholders within the ecosystem, to enable the use cases defined by the future flight Programme[16] and to ultimately achieve the FFIG strategic objectives defined for each pathway.

Initial desktop-based research was conducted to gather the latest knowledge of existing and in-development standards that could be used to enable each pathway's objective. This included the results from UK and international projects, and the relevant documentation produced by regulatory and industry working groups and SDOs.

Inputs to the research included:

- reviews of projects that assessed standards for their fitness to be used as AMC, e.g. EASA Project Shepherd[17], which assessed standards against SORA requirements, as well as the latest BSI Flex 1906 standard in development[18];
- results from major studies, such as ANSI UAS Gaps Report[19], the BSI landscape[20] and the roadmaps from other SDOs; and
- policy and regulation both in the UK and internationally, where relevant.

Figure 4: Standards roadmap development process



16. UKRI Future Flight Use Cases, 9 ways Future Flight will transform aviation, July 2024.
17. EASA.2022.C05 Standards Evaluation Project supporting European Regulations for Drones (Project SHEPHERD), D4.3 - Final Report, 30 April 2024.
18. BSI Flex 1906, Acceptable means of compliance to Specific Operation Risk Assessment (SORA).
19. ANSI Unmanned Aircraft Systems Standardization Collaborative Roadmap v2 Gaps Progress Report, 19 March 2024.
20. BSI Future Flight Standards Landscape, February 2024.

3.2.1 Stakeholder engagement and input

Engagement with, input from, and alignment with industry, government and relevant SDOs underpinned the development of the roadmap. This engagement occurred throughout the standards roadmap development process and consisted of:

- initial interviews with the Future Flight Consortia, to gauge their awareness of standards, if they are using any in their projects and, if not, what standards would be useful for their use case but are not available;
- a roundtable for each pathway, with major stakeholder groups as shown in the following table; and
- alignment with other SDOs, such as International Organization for Standardization (ISO), ASTM International, European Organisation for Civil Aviation Equipment (EUROCAE), Radio Technical Commission for Aeronautics (RTCA) and SAE International, to ensure the list of standards represented in the roadmap incorporated standards currently in development.

Through these activities, an initial draft of the roadmap was developed and shared with the DfT, the CAA and UK Research and Innovation (UKRI) to ensure that it aligned with UK policy and emerging regulatory frameworks.

A first version of the standards roadmap was shared in the BSI Community Hub, launching a wider consultation process with industry. This was further promoted through a joint UKRI Business Connect, BSI and CAA "Lunch and learn" webinar on 10 October 2024[21].

The consultation ran until October 2024 and a final version of the roadmap was published in January 2025.

UAS roundtable	**eVTOL roundtable**
• UTM and ground-based solution providers • UAS operators, tech developers, training organizations • Association of Remotely Piloted Aircraft Systems-UK representative • Regulator	• eVTOL OEM and operators • Vertiport designers and operators • Infrastructure developer • Regulator • Academia

21. UKRI/BSI Demystifying Standards and Regulation in Future Flight, 10 October 2024.

Annex 1 Acronyms and abbreviations

AAM	advanced air mobility
AI	artificial intelligence
AMC	acceptable means of compliance
ARPAS-UK	Association of Remotely Piloted Aircraft Systems, UK
BVLOS	beyond visual line of sight
CAA	UK Civil Aviation Authority
C2/C3	command and control/and communications
DAA	detect and avoid
DfT	Department for Transport
EASA	European Union Aviation Safety Agency
EUROCAE	European Organisation for Civil Aviation Equipment
eVTOL	electric vertical take-off and landing
FAA	Federal Aviation Administration
FF	Future Flight
FFIG	Future Flight Industry Group

ICAO	International Civil Aviation Organization
ISO	International Organization for Standardization
JARUS	Joint Authorities for Rulemaking on Unmanned Systems
OEM	original equipment manufacturer
OSO	operational safety objectives
RTCA	Radio Technical Commission for Aeronautics
SC	special condition
SDO	standards development organization
SORA	specific operations risk assessment
TRL	technology readiness level
UAS	uncrewed/unmanned aircraft system(s)
UK	United Kingdom
UKRI	UK Research and Innovation
UTM	UAS traffic management
VTOL	vertical take-off and landing

Annex 2 Definitions of operational safety objectives

Although not all the OSOs are referred to in the Recommendations, for completeness, the table below provides the complete list as they are described in the JARUS SORA documentation[22].

OSO #01	Ensure the Operator is competent and/or proven
OSO #02	UAS manufactured by competent and/or proven entity
OSO #03	UAS maintained by competent and/or proven entity
OSO #04	UAS components essential to safe operations are designed to an Airworthiness Design Standard (ADS)
OSO #05	UAS is designed considering system safety and reliability
OSO #06	C3 link characteristics (e.g. performance, spectrum use) are appropriate for the operation
OSO #07	Conformity check of the UAS configuration
OSO #08	Operational procedures are defined, validated and adhered to, to address normal, abnormal and emergency situations potentially resulting from technical issues with the UAS or external systems supporting UAS operation, human errors or critical environmental conditions
OSO #09	Remote crew trained and current
OSO #13	External services supporting UAS operations are adequate to the operation
OSO #16	Multi crew coordination
OSO #17	Remote crew is fit to operate
OSO #18	Automatic protection of the flight envelope from human errors
OSO #19	Safe recovery from Human Error
OSO #20	A Human Factors evaluation has been performed and the Human-Machine Interface (HMI) found appropriate for the mission
OSO #23	Environmental conditions for safe operations defined, measurable and adhered to
OSO #24	UAS designed and qualified for adverse environmental conditions (e.g. adequate sensors, DO-160 qualification)

22. JARUS guidelines on Specific Operations Risk Assessment (SORA) v2.5, May 2024.

Annex 3 What are the differences between standards and regulations?

Standards in aviation are detailed technical guidelines or specifications established to ensure the safety, reliability, interoperability and efficiency of aviation systems and components. These standards are developed by SDOs, such ISO, BSI, ASTM International, SAE International, EUROCAE and RTCA. SDOs bring together experts from industry, academia and government to create consensus-based standards that define specifications, test methods and best practices. In the context of future flight – which encompasses advancements such as UAS, eVTOL aircraft and advanced avionics – standards help guide technological development and ensure interoperability, repeatability and scalability across different systems and platforms.

Regulations are legally binding rules established and enforced by government agencies or regulatory bodies to ensure compliance with legislation and to maintain public safety, security and environmental protection. In aviation, regulatory bodies include the CAA, Federal Aviation Administration (FAA) in the United States, EASA in the European Union, and the ICAO at the international level. Regulations set mandatory requirements for aircraft design, manufacturing, operation, maintenance and personnel certification. They are enforced through oversight mechanisms such as inspections, certifications and enforcement actions. In the realm of future flight, regulatory bodies are responsible for developing and updating regulations to accommodate new technologies and operational concepts while maintaining safety.

The major difference between standards and regulations are the following.

1 Legally binding nature.

- Standards are generally voluntary and serve as guidelines or recommended practices. They become mandatory only when incorporated by reference into regulations or contractual agreements.
- Regulations are legally binding requirements that must be followed. Non-compliance can result in legal penalties, fines or operational prohibitions.

2 Purpose.

- Standards aim to harmonize practices, ensure interoperability, and promote efficiency and innovation within the industry whilst ensuring safety. This is particularly important for new and emerging technologies, when regulations are not yet developed or mature enough.
- Regulations aim to protect public interest by setting out the mandatory requirements for safety, security, environmental protection and fair competition.

3 Development process.

- Standards are developed through a consensus-driven process involving various stakeholders, including industry experts, academics, government and sometimes regulators. Standards support innovation at all TRLs and facilitate the transition of academic and industrial research and development into the commercial market for emerging and new technologies.
- Regulations are developed by regulatory bodies through legislative processes, which may include public consultations, rulemaking procedures and adherence to administrative laws. Regulations provide the legal framework and overarching requirements but may be less detailed and slower to adapt due to the formal rulemaking process.

Standards and regulations are complementary tools that collectively ensure the safe and efficient operation of aviation activities.

1 Incorporation by reference.

Regulatory bodies can incorporate standards by reference into regulations through designation of standards. Conforming with designated standards can be accepted as presumed conformance with regulation. For new technologies and before regulations are formally issued, some preliminary guidance may refer to standards to be assessed for their fitness of use. For example, the CAA DAA Policy Concept consultation[23] suggests standards that may influence future policy and regulation.

2 Guidance for compliance.

Standards provide the technical means to achieve the safety objectives outlined in regulations. They offer detailed methodologies, specifications and test procedures that help manufacturers and operators comply with regulatory requirements.

3 Facilitating innovation.

As new technologies emerge in future flight, standards can be developed more rapidly than regulations. Regulators may rely on these standards to inform interim policies or special conditions, ensuring that innovation is not stifled while maintaining safety.

4 International harmonization.

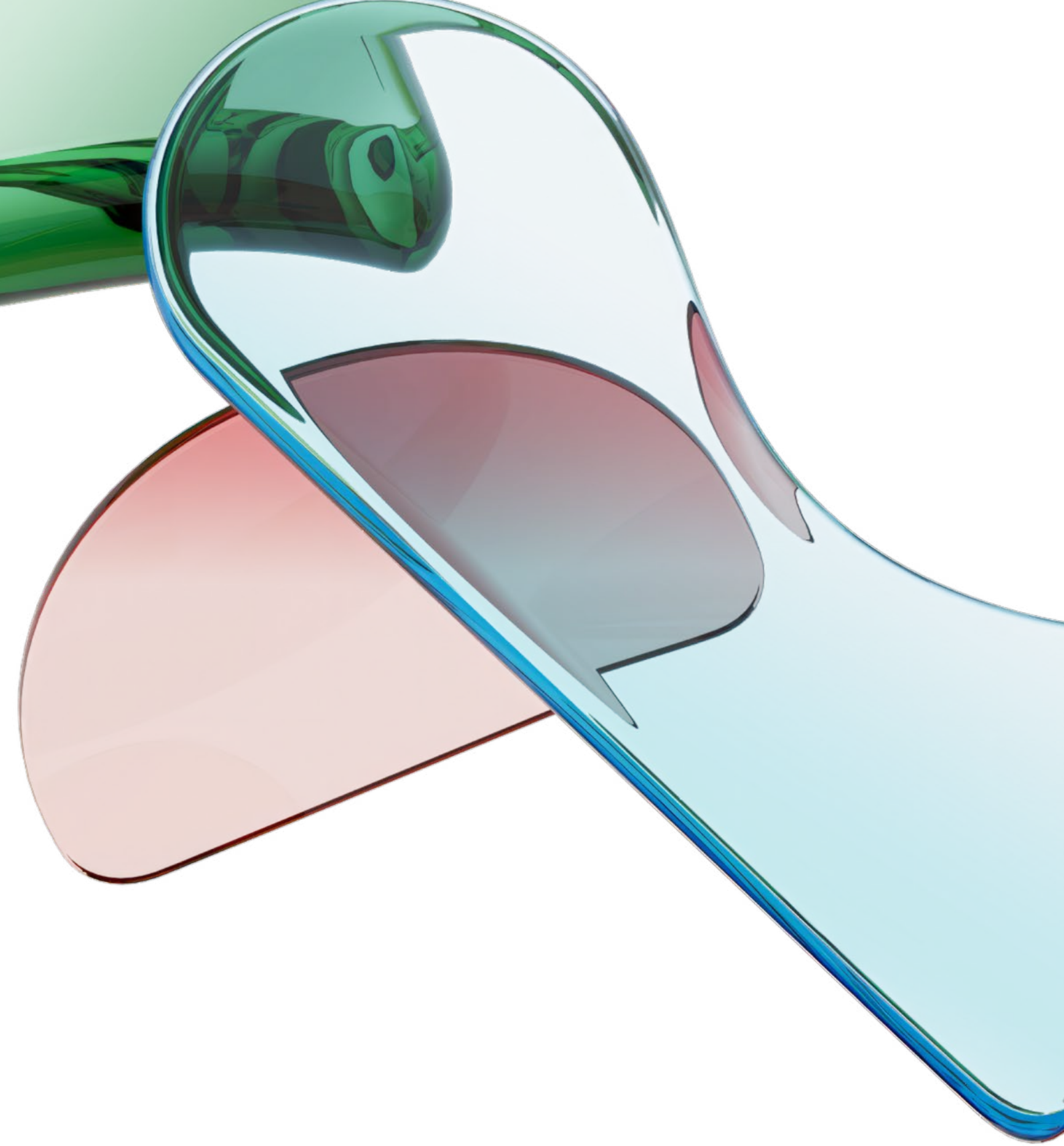
Standards contribute to global harmonization by providing common technical criteria recognized across different jurisdictions. This facilitates international operations and reduces barriers to trade.

5 Feedback loop.

The practical application of standards can inform regulatory updates. Experiences gained from implementing standards may highlight the need for regulatory changes or new regulations to address gaps or emerging risks.

In summary, while regulations establish the mandatory safety and operational requirements in aviation, standards provide the detailed technical means to meet those requirements. Together, they ensure that the aviation industry operates safely, efficiently and in compliance with legal obligations, even as new technologies and concepts such as those in future flight continue to evolve.

23. UK CAA CAP 3015 DAA Policy Concept Consultation document, July 2024.



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