Asia-Pacific Reference Materials for Regulators to Facilitate Advanced Air Mobility Operations

FOREWORD

by Mr Ma Tao, Regional Director, Asia and Pacific Office, International Civil Aviation Organization (ICAO)

The last decade has seen rapid advancement in advanced air mobility (AAM) technologies, ushering an exciting era for aviation. Electric vertical take-off and landing (eVTOL) aircraft will revolutionalise urban mobility, with sustainable air taxi services potentially alleviating ground congestion while complementing traditional air transport systems. Likewise, unmanned aircraft systems (UAS) adoption has proliferated worldwide, serving diverse applications such as filming, surveillance, inspection, and delivery. These emerging technologies both enhance the aviation industry, and offer innovative solutions to long-standing challenges in various sectors.

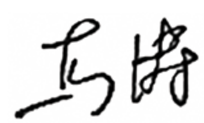
While their potential is immense, it is paramount that we tackle the challenge of integrating these new technologies into existing civil airspace and aviation frameworks. Safety and security considerations must remain at the forefront of our efforts. ICAO acknowledges these challenges, as highlighted during the Fourteenth Air Navigation Conference.

I am heartened to see the initiative of Asia-Pacific States and Administrations coming together to create these Reference Materials for Regulators to facilitate AAM Operations, with valuable inputs from the industry. This collaborative effort exemplifies the spirit of innovation and cooperation of the Asia-Pacific region, and underscores commitment to embracing new technologies whilst maintaining the highest standards of aviation safety and security.

These Reference Materials provide valuable information for possible reference by Asia-Pacific regulators to approach commercial eVTOL aircraft and complex UAS operations. Covering eight priority areas and incorporating best practices of States, it supports the development of implementation strategies and regulatory frameworks. I am confident that this resource will play a crucial role in shaping the future development of unmanned aviation technologies, facilitating their deployment in a safe, secure, efficient, and regular manner, ultimately benefiting communities worldwide.

I would also encourage transmission of these Reference Materials to ICAO's Advanced Air Mobility Study Group (AAM SG), which is the expert group tasked with developing a holistic framework and vision related to AAM, making recommendations for the development of ICAO provisions, and serving as a focal point for ICAO AAM-related work to ensure global interoperability and harmonization.

Looking ahead, let us advance innovation while upholding safety, for the betterment of global aviation and the communities we serve.



Mr Ma Tao
ICAO Regional Director for the Asia and Pacific Office

MESSAGES FROM ASIA-PACIFIC STATES AND ADMINISTRATIONS

On behalf of the Bhutan Civil Aviation Authority, I would like to express our sincere appreciation to the Civil Aviation Authority of Singapore for spearheading this important initiative, and to the Asia-Pacific Member States for their collective support in the development of this comprehensive reference material on AAM. This document represents a timely and forward-looking resource that provides much-needed guidance on the certification and validation of AAM, their safe entry into service, the formulation of enabling economic policies, and strategies to foster public and social acceptance. As AAM technologies rapidly evolve, such a harmonised and practical reference becomes essential for regulators across the region to ensure that their frameworks are adaptable, robust, and inclusive of emerging innovation.

For Bhutan, participation in this initiative has been both a privilege and a valuable learning opportunity. While our current regulatory environment is still at a nascent stage, the insights gained through this process will inform and inspire our future planning and policy development in this domain. With our challenging terrain and limited surface connectivity, AAM holds transformative potential for Bhutan's transport landscape—enhancing accessibility, improving emergency response, and contributing to equitable regional development.

We commend this reference material as a significant contribution to the global discourse on AAM, and we look forward to continued collaboration in shaping a safe, efficient, and sustainable future for aviation.

Kinley Wangchuk
Director
Bhutan Civil Aviation Authority

The Cook Islands welcomes the development of the AAM Reference Material as a timely and practical resource — especially for small island nations like ours that are only beginning to explore advanced air mobility. While we do not yet have state-of-the-art AAM operations, we are engaging in structured use of lightweight drones to support essential functions such as land and agricultural surveys, environmental monitoring, and infrastructure planning across our dispersed islands — modest in scale, yet deeply impactful in improving resilience and service delivery.

The AAM Reference Material provides us with a valuable foundation to grow from — offering not only technical guidance but also a sense of shared direction among diverse states in the region. For us, it is not just a resource, but a symbol of inclusion: that even small, remote nations can have a voice in shaping the future of air mobility. We are proud to contribute where we can and humbled to learn from others as we prepare for what lies ahead.

John Hosking
Secretary of Transport
Cook Islands

The development of the Asia-Pacific Reference Materials for Regulators to Facilitate Advanced Air Mobility Operations is a timely and important initiative that shows our region's strong commitment to safe and forward-looking aviation development. It offers clear and practical guidance for regulators as we navigate the unique challenges and opportunities posed by the introduction of new AAM technologies, including eVTOL aircraft and complex drone operations.

For a Small Island Developing State like Fiji, these materials are especially helpful as they provide valuable insights and practical guidance to support our efforts to adopt advanced air mobility solutions. Fiji is exploring the use of AAM technologies to improve inter-island connectivity, enhance emergency response, and increase access to remote and underserved communities. We are grateful for the inclusive and collaborative approach taken in developing this publication and look forward to continued partnership in advancing safe and sustainable AAM operations across the region.

Theresa Levestam
Chief Executive
Civil Aviation Authority of Fiji

As the proverb says, "A single tree cannot make a forest". This timeless wisdom highlights the importance of teamwork and collective effort, and is clearly exemplified in this "Asia-Pacific Reference Materials for Regulators to Facilitate Advanced Air Mobility Operations" document, by uniting regional efforts and expertise in consolidating essential references and guidance on AAM certification, regulation, and capability development, thereby paving the way for facilitating safe AAM operations in our skies.

Hong Kong, China is committed to embracing this new era of aviation by establishing a robust regulatory framework while leveraging regional synergy to foster innovation, uphold safety, and ensure sustainability. This reference document will be useful in assisting regulators in assessing and navigating the complexities of AAM, thus serving as a vital resource in shaping forward-looking policies that have to be adaptive to technological advancements. We look forward to the continued collaboration across the region to transform these references into actionable strategies, positioning our region at the forefront of the global AAM revolution — where innovation takes flight, safety charts the course, and future generations will reap the benefits of our shared vision.

Captain Victor Liu Chi-yung, JP
Director-General of Civil Aviation
Hong Kong Civil Aviation Department

MESSAGES FROM ASIA-PACIFIC STATES AND ADMINISTRATIONS

The Asia-Pacific Reference Materials for Regulators to Facilitate Advanced Air Mobility Operations has been a very helpful resource for the Civil Aviation Authority of the Philippines as we prepare for the safe and effective integration of advanced air mobility and unmanned aircraft operations. The Reference Material's comprehensive guidance on certification, regulatory frameworks, interagency coordination, and capability building has enabled us to benchmark our approaches against international best practices and to address emerging challenges. By drawing on the collective expertise of regional regulators and industry, the Reference Material has created a collaborative approach and accelerated our readiness ensuring that safety and innovation progress in parallel. We are grateful for this initiative, which has strengthened our regulatory capacity and enhanced alignment with global standards.

Captain Florendo Jose C. Aquino III
Acting Assistant Director General II —
Flight Standards Inspectorate Service
Civil Aviation Authority of the Philippines

Advanced Air Mobility (AAM) has tremendous potential to improve human lives and transform the way we work, move and live. The technologies, use cases and business models are fast developing. Regulators and regulations need to keep pace, to facilitate industry development and allow timely deployment of transformative technology while ensuring safety. The Reference Materials will help support this.

The Reference Materials are the result of a joint effort involving 24 States and Administrations and 48 companies and organisations. It is testament to what can be achieved through strong regional and public-private partnerships. Singapore is honoured to have helped facilitate this. We thank all partners for their strong support in this important initiative.

Han Kok Juan
Director-General
Civil Aviation Authority of Singapore

These reference materials provide valuable guidance for States in formulating forward-looking policies and regulatory frameworks for AAM and UAS. For Thailand, we recognise their importance in fostering regional collaboration and advancing the development of AAM and UAS, in alignment with our commitment to innovation, public safety, and regulatory harmonisation across the Asia-Pacific region.

Air Chief Marshal Manat Chavanaprayoon
Director-General
Civil Aviation Authority of Thailand

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ACRONYMS AND ABBREVIATIONS

ACRONYM	MEANING
AAM	Advanced Air Mobility
AAM SG	AAM Study Group
AC	Advisory Circular
AD	Airworthiness Directive
AGL	Above Ground Level
AI	Artificial Intelligence
AMC	Acceptable Means of Compliance
AML	Aircraft Maintenance Licence
AMO	Approved Maintenance Organisation
AMS	Aircraft Maintenance Schedule
ANAC	Agência Nacional de Aviação Civil (National Civil Aviation Authority of Brazil)
ANSP	Air Navigation Service Provider
AOC	Air Operator Certificate
API	Application Programming Interface
APUAS/TF	Asia/Pacific Unmanned Aircraft System Task Force
ARFF	Aerodrome Rescue and Fire Fighting
ASI	Aviation Safety Inspector
ATC	Air Traffic Control
ATM	Air Traffic Management
ATO	Aviation Training Organisation
ATPL	Airline Transport Pilot License
BDS	BeiDou Navigation Satellite System
BVLOS	Beyond Visual Line of Sight
C2	Command and Control
CAAC	Civil Aviation Administration of China
CFR	Code of Federal Regulations
CNS	Communications, Navigation, and Surveillance
CoA	Certificate of Airworthiness
CPL	Commercial Pilot License
CNPC	Control and Non-Payload Communications
CRM	Crew Resource Management
DAA	Detect and Avoid
DAL	Design Assurance Levels
DGCA	Director General of Civil Aviation
DGPS	Differential GPS
DO	Design Organisation
DOA	Design Organisation Approvals
EAR	Easy Access Rules for Small Category VCA
EASA	European Union Aviation Safety Agency
EHPS	Electric/Hybrid Propulsion Systems
EIS	Entry into Service
EMC	Electromagnetic Compatibility
EMI	Electromagnetic Interference
EPTS	Environmental Protection Technical Specifications
ERP	Emergency Response Plan
EUROCAE	European Organisation for Civil Aviation Equipment
EV	Electric Vehicle
eVTOL	Electrical Vertical Take-off and Landing
EWIS	Electrical Wiring Interconnect System
FAA	Federal Aviation Administration
FATO	Final Approach and Take-off Area (FATO)
FDAL	Functional Development Assurance Level
FOD	Foreign Object Debris
GCS	Ground Control Station
GNSS	Global Navigation Satellite Systems
GPS	Global Positioning System
GSE	Ground Support Equipment
HVDC	High Voltage Direct Current
IATA	International Air Transport Association
ICA	Instructions for Continued Airworthiness
ICAO	International Civil Aviation Organization
IFR	Instrument Flight Rules
INS	Inertial Navigation System
IoT	Internet of Things
ISO	International Organization for Standardization
ITU	International Telecommunications Union
ITU-R	International Telecommunications Union Radiocommunication Sector
JARUS	Joint Authorities for Rulemaking on Unmanned Systems
LiDAR	Light Detection and Ranging
LRU	Line Replaceable Units
MCM	Maintenance Control Manual
MEL	Minimum Equipment List
MMEL	Master MEL
MoC	Means of Compliance
MRO	Maintenance and Repair Organisation
OECD	Organisation for Economic Co-operation and Development
OEM	Original Equipment Manufacturer
OSD	Operational Suitability Data
PDRA	Predefined Risk Assessments
PEFCR	Product Environmental Footprint Category Rules
PO	Production Organisation
POA	Production Organisation Approvals
R&T	Research and Technology
RACI	Responsible, Accountable, Consulted, and Informed
RFF	Rescue and Firefighting
ROC	RPAS Operator Certificate
RPA	Remotely Piloted Aircraft
RPAS	Remotely Piloted Aircraft System
RPS	Remote Pilot Station
RTCA	Radio Technical Commission for Aeronautics
SAE	Society of Automotive Engineers
SAIL	Specific Assurance and Integrity Level
SARP	Standards and Recommended Practices
SC-VTOL	Special Condition for Small Category VTOL Aircraft
SFAR	Special Federal Aviation Regulation
SMS	Safety Management System
SoA	State of the Aerodrome
SoD	State of Design
SoO	State of the Operator
SoR	State of Registry
SORA	Specific Operations Risk Assessment
SSA	System Safety Assessment
STOL	Short Take-off and Landing
SWaP-C	Size, Weight, Power, and Cost
TC	Type Certificate
TI	Technical Instructions
TLOF	Touchdown and Liftoff Area
TLOS	Target Level of Safety
UA	Unmanned Aircraft
UAM	Urban Air Mobility
UAS	Unmanned Aircraft Systems
UAS-AG	Unmanned Aircraft Systems Advisory Group
UN SDG	United Nations Sustainable Development Goals
UTM	Unmanned Aircraft Systems Traffic Management
VCA	VTOL Capable Aircraft
VFR	Visual Flight Rules
VLOS	Visual Line of Sight
VTOL	Vertical Take-off and Landing
WOG	Whole-of-Government
WRC	World Radiocommunication Conference

Asia-Pacific Reference Materials for Regulators to Facilitate Advanced Air Mobility Operations

EXECUTIVE SUMMARY

The development of the Asia-Pacific Reference Materials for Regulators to Facilitate Advanced Air Mobility Operations was initiated during the inaugural Meeting of Asia-Pacific Regulators on Advanced Air Mobility (AAM) and Unmanned Aircraft Systems (UAS). The Materials are designed as a descriptive and non-legally binding resource for regulators in the region to consider, adapt, and use to prepare for and facilitate the commercial operations of electric vertical take-off and landing (eVTOL) aircraft and the implementation of complex UAS operations within their respective States.

Developed through the collaboration of representatives of 24 States and Administrations, this publication provides guidance to States of Registry (SoRs), States of the Operator (SoOs), and States of the Aerodrome (SoAs) on eight topics identified as priorities to address for eVTOL aircraft and UAS:

eVTOL Aircraft

→ Certification, Validation, and Acceptance
→ Regulations for eVTOL Aircraft Entry into Service (EIS)
→ Cooperation Among National Agencies
→ Economic Policies and Regulations
→ Capability Development
→ Social Acceptance

UAS

→ Technical Guidance for the Implementation of Beyond Visual Line of Sight (BVLOS) UAS Operations
→ Capability Building (UAS Personnel Training)

Each topic is addressed as an individual part in this publication, and each part consists of five sections:

(1) Introduction — a brief overview of the part's content;

(2) Background — setting the context of the topic through historical precedents or current practices;

(3) Key Considerations — insights related to the topic, compiled through literature reviews, surveys, workshops, or brainstorming;

(4) Action Plan — guidance for regulators on potential steps to address and prepare for in the respective topic; and

(5) References — sources used in developing the content. Where applicable, annexes are included to guide the implementation of each part.

Overall, this publication serves as a resource for States to consider, adapt, and use to facilitate the commercial operations of eVTOL aircraft and the implementation of complex UAS operations.

INTRODUCTION

Advanced Air Mobility (AAM), as espoused by the ICAO AAM Study Group, is described as:

A developing form of aviation ultimately operating within a highly automated and collaborative environment. AAM operations will be enabled by a range of innovative technologies. These include, inter alia, automated traffic management, digital ecosystems, and sustainable solutions, as well as new aircraft designs, means of communications, and types of infrastructure.

AAM services will include transport of passengers, cargo, parcels and mail as well as other aerial services benefiting society, and will occur in urban, regional and inter-regional areas, as well as internationally. It is widely believed that the introduction of AAM can bring significant social and economic benefits, and can positively impact how society works, moves, and lives.

Developments in AAM are advancing rapidly, and regulators and regulations need to keep pace to fully reap the benefits of AAM while ensuring public and aviation safety and security. This is challenging given the speed of development, especially considering the technological novelties and competing priorities from conventional aviation. Collaboration among regulators, and between regulators and the industry, is essential to help overcome these challenges. By pooling expertise and resources, regulators can more rapidly and efficiently prepare for and oversee the safe and effective adoption of AAM.

In this spirit, this publication was initiated during the inaugural Meeting of Asia-Pacific Regulators on AAM and UAS on 9 November 2023 (APAC Regulators' Meeting). It was agreed at the meeting to form workstreams (working groups) to develop a set of reference materials that regulators can consider, adapt, and use to facilitate the commercial operation of eVTOL aircraft and complex UAS operations. This development aligns with the objectives of the ICAO AAM SG, given that these reference materials address the key intent of facilitating both eVTOL aircraft and UAS.

With respect to eVTOL aircraft, the scope of this publication focuses primarily on piloted eVTOL aircraft with brief mentions of remotely piloted eVTOL aircraft, a topic identified for future work. With respect to UAS, the material focuses on BVLOS operations, and acknowledges that additional categories of complex UAS operations may be addressed in future work.

This publication is not intended as a legally binding document, nor does it seek to prescribe regulatory requirements or standards upon members of the APAC Regulators' Meeting. Instead, the objectives of this publication are twofold:

→ To raise awareness of eVTOL aircraft and UAS technologies, and regulatory approaches and practices; and
→ To highlight considerations in facilitating the safe and effective integration of eVTOL aircraft and complex UAS operations, serving as a reference to support regulatory preparedness and capability development.

The contents of this publication were developed by designated workstreams through a structured process comprising literature review, surveys, workshops, and collective brainstorming. These efforts involved representatives from 24 States and Administrations as shown in **Table 1**.

While developing this publication, the International Air Transport Association (IATA) and the eVTOL aircraft and UAS industries were consulted to incorporate their expertise on the ongoing developments in these technologies and operations.

Table 1:

WORKSTREAM LEADS

China	Cook Islands	Indonesia	Malaysia
Philippines	Singapore	Thailand	

WORKSTREAM MEMBERS

Australia	Bhutan	Cambodia	China
Hong Kong, China	Cook Islands	Fiji	India
Indonesia	Japan	Kiribati	Malaysia
Maldives	Micronesia	Mongolia	Nepal
New Zealand	Papua New Guinea	Philippines	Republic of Korea
Samoa	Singapore	Sri Lanka	Thailand

The publication is organised into eight distinct parts. Each part contains an introduction, contextual background, key considerations, and a section for one or more proposed action plans. An overview of each part is set out below.

eVTOL Aircraft

→ **Part 1 — Certification, Validation, and Acceptance:** Technological advancements have allowed the development of new eVTOL aircraft that promise greater efficiency, lower operating and maintenance costs, lower noise, and greater flexibility to operate in confined spaces. However, certifying these eVTOL aircraft under existing certification requirements and standards for conventional manned aircraft presents challenges, given their novel designs and technologies. Some States of Design (SoDs) have received applications for aircraft type approval, and a few have already certified or are now certifying the first eVTOL aircraft types. However, the regulatory frameworks and requirements for aircraft design and manufacturing assurance are different amongst the SoDs. Part 1 outlines the approach, rationale, and key considerations adopted by SoDs in the categorisation and certification of eVTOL aircraft. This contextual information is intended to assist SoRs and SoOs in determining how they may certify, validate, or accept such aircraft when required. The action plan in this Part describes the key steps expected of a SoR in preparing for eVTOL aircraft. These include establishing clear definitions and classifications of eVTOL aircraft types, and airworthiness design standards.

→ **Part 2 — Regulations for eVTOL Aircraft Entry into Service:** The full-scale, safe, efficient, and reliable integration of eVTOL aircraft operations into the aviation ecosystem hinges on a holistic yet pragmatic regulatory framework and implementation for their Entry into Service (EIS). While existing regulations for conventional manned aviation — covering areas such as aircraft registration, air operator certification, and licensing of technical crew (pilots and aircraft maintenance engineers and technicians) — provide a foundation, they do not yet fully address eVTOL aircraft and their associated operations. This Part reviews each component relevant to the EIS process, articulating current regulatory differences and associated gaps arising from the novel design and operational profiles of eVTOL aircraft. The action plan laid out in this Part offers guidance to Civil Aviation Authorities (CAAs) on approaches they may consider, whether through the development of new dedicated regulations or the adaptation of existing manned aircraft regulations to accommodate eVTOL aircraft operations effectively.

→ **Part 3 — Cooperation Among National Agencies:** The complex nature of eVTOL aircraft operations is such that the means of governance to ensure public safety and security typically involve domains that may be in the jurisdictions of several different governmental entities. With a need to ensure close and effective cooperation among the governmental entities to manage eVTOL aircraft, this Part describes methods and tools of cooperation that could be considered when a SoR interacts with its domestic national agencies and potential stakeholders. To support the coordination of governmental actions related to eVTOL aircraft and operations, this Part identifies examples of activities that typically involve multiple agencies. These include the regulation of technological developments and safety, operational oversight, economic policy and governance, and initiatives to foster social acceptance. It also identifies the types of national agencies that may be involved and outlines their possible roles in these areas. The action plan in this Part provides a structured guide that CAAs may use to define their respective scope of activities, identify stakeholders, and clarify the roles of each stakeholder involved.

→ **Part 4 — Economic Policies and Regulations:** Economic policies and regulations are key tools to address market growth, attract investment, foster innovation, and promote market openness. In doing so, they help underpin markets, protect the rights of citizens, and ensure the delivery of public goods and services in commercial businesses. To date, commercial operations involving eVTOL aircraft are still nascent, and economic policy instruments have largely focused on investment-related measures — such as the establishment of test centres and sandboxes — and incentives. Nevertheless, this Part draws on existing approaches in international air transport, with a dedicated section outlining key considerations in areas such as market access, consumer protection, and competition. The action plan presents a process flow to guide the creation of transport strategies, including the identification of appropriate economic policy instruments, their development and implementation, and mechanisms for reviewing their effectiveness.

- **Part 5 — Capability Development:** The CAAs of SoRs and SoOs will likely need to enhance or establish new organisational capabilities to support the development of policies and regulations, and to train personnel for the safety oversight of eVTOL aircraft. This Part outlines key considerations in building capabilities related to personnel, organisation, and procedures of the CAA. It also describes possible steps and processes that may assist SoRs and SoOs in developing an action plan to strengthen both the organisational and personnel capabilities within their respective CAAs.
- **Part 6 — Social Acceptance:** Social acceptance will be a key condition for enabling commercial eVTOL aircraft operations to scale and develop into a viable market. This Part provides considerations on the target audience for social acceptance and the various methods for obtaining social assurance. The action plan suggests a strategic approach to fostering social acceptance through a range of initiatives focused on public participation, acceptance-focused policy making, and measurement of public acceptance.

UAS

- **Part 7 — Technical Guidance for the Implementation of BVLOS UAS Operations:** UAS are already widely employed in operations that pose low risk to public and aviation safety. Although UAS are capable of supporting more complex operations, such operations typically carry higher levels of risk — particularly those involving BVLOS UAS operations. This Part reviews the literature on methodologies for managing BVLOS UAS operational approvals and identifies key considerations in the assessment of risk and associated mitigations. These considerations are organised under the domains of airworthiness, crew, organisations, and environment. The action plan describes a process flow that CAAs may consider when adapting existing UAS regulations to accommodate BVLOS UAS operations.
- **Part 8 — Capability Building (UAS Personnel Training):** This Part provides guidance on the preparation and training of CAA inspectors responsible for evaluating BVLOS UAS operations. It highlights potential differences between UAS and existing manned aviation that may give rise to a gap in personnel competencies. The action plan suggests steps that may be taken to strengthen capability building and includes a list of typically expected competencies of UAS safety inspectors. Finally, this Part presents the recording and sharing of training course evaluations as a recommended practice, and suggests a method for documenting these evaluations to support continued capability development.

The action plans in each Part can be considered individually or pursued in parallel. However, in relation to eVTOL aircraft operations, it is recommended that CAAs first consider the actions of Parts 1 and 5 prior to Part 2, as building up the capability of the CAA and having clearly defined design definitions and airworthiness requirements can impact the scope of areas required for EIS and support the subsequent implementation. The actions outlined in Parts 3, 4, and 6 can then support the other areas related to implementation, especially when interagency cooperation is expected or required to achieve the intended outcomes.

Ultimately, this publication should be treated as a reference for CAAs, guiding their efforts to prepare and adapt existing regulations to facilitate commercial eVTOL aircraft and complex UAS operations. The contents of this publication have been developed through the concerted efforts of participating States and Administrations, supplemented by industry feedback. Nonetheless, certain considerations may have been overlooked, and parts of the content may be superseded as eVTOL aircraft or UAS technologies continue to evolve. For this reason, periodic updates on this publication is foreseen, to keep abreast of the developments, especially in areas such as type certification, where an international consensus on standards has yet to be reached.

As the eVTOL aircraft market continues to develop with technologies and operational requirements dynamically evolving, this publication aims to capture these advancements to support regulatory development, raise awareness of eVTOL aircraft technologies and regulatory practices, and facilitate alignment among member States. Likewise, for UAS, as regulators gain experience in approving a growing number of BVLOS UAS operations, new insights and learnings may be incorporated — along with developments related to more complex UAS operations — to ensure continued relevance and utility.

Electric Vertical Take-off and Landing (eVTOL) Aircraft

EVTOL AIRCRAFT: PART 01

Certification, Validation, and Acceptance

INTRODUCTION

For every aircraft engaged in international civil aviation, Article 31 of the International Civil Aviation Organization (ICAO) Convention prescribes that a Certificate of Airworthiness (CoA) be issued or rendered valid by the State in which the aircraft is registered. ICAO Annex 8 further stipulates that the issuance or validation of CoA must be based on satisfactory evidence that the aircraft design complies with relevant airworthiness standards and requirements of the State of Registry (SoR) (ICAO, 2020). The aircraft Type Certificate (TC) has become the de facto evidence for this purpose, providing assurance that the design of the aircraft meets stringent safety and performance standards. Some States may also issue TCs for engines and propellers, and ICAO Annex 16 provides recommended standards for noise certification (ICAO, 2017).

Electric vertical take-off and landing (eVTOL) aircraft are generally expected to follow the above-mentioned regime of certification to assure the safety of passengers, crew, and the populace and property it overflies, thereby instilling confidence in the platform and facilitating successful commercial operations. However, as eVTOL aircraft are expected to incorporate new technologies, new aircraft designs, and operate in urban environments that differ from existing mainstream air transport, the existing regime for type certification and the standards used in the process will need to evolve to address these novel features. In view of the emergent nature of eVTOL aircraft, this Part aims to raise awareness among SoRs regarding the developments in eVTOL aircraft type certification and potentially unique considerations that may arise in the issuance, acceptance, or validation of TCs. Steps and actions are also detailed that may assist and guide SoRs in preparing for eVTOL aircraft certification, validation, and acceptance when such aircraft are introduced to their State.

BACKGROUND

Type Certification

In civil aviation, a Type Certificate (TC) is a formal document issued by a State of Design (SoD) for the approval of a type design of whole entities of an aeronautical product such as aircraft, engines, and propellers. The existing treatment of type certification is detailed in the ICAO Airworthiness Manual, Doc 9760 (ICAO, 2020), and States should refer to this document for details and the principles of type certification.

For aircraft TCs, it has been a formal requirement in ICAO Annex 8 that a SoD issues an aircraft TC as evidence of approval for applications of any new aircraft certification on or after 2 March 2004. In this regard, the TC serves as a formal document issued by the SoD as evidence that the design of the aircraft type has been reviewed and found to comply with airworthiness standards (of the SoD). It confirms that the design has undergone the required analyses, ground and flight tests, and that — based on these evaluations — no unsafe characteristics are known or suspected when assessed against the applicable standards to which compliance has been demonstrated. The key elements involved in the process leading up to the issuance of a TC are as follows:

- → Identification and establishment of the type certification basis, where the airworthiness criteria and standards that the aircraft needs to show compliance against are identified.
- → Demonstration of compliance where the manufacturer, through tests and analysis, will demonstrate that the design of the aircraft meets the airworthiness criteria and standards.
- → Documentation of compliance findings and its review by the SoD or an organisation approved by the SoD (i.e., design organisation or manufacturer) affirming its compliance against the certification basis.
- → Approval issuance, which is done after all the necessary steps have been completed to demonstrate that the aircraft design complies with the applicable airworthiness standards.

Depending on its respective legislative framework, a SoR may choose to accept or validate the original TC, or issue its own TC based on the original. ICAO recommends that, where practical and without prejudice to a State's own unique national requirements, maximum credit be given to the type certification work already done by the SoD, and that unnecessary duplication or redundant testing be avoided. The overarching aim is to minimise the effort needed to accomplish the approval of an aircraft type design, therefore facilitating the issuance of a CoA by the SoR in accordance with Annex 8. Issuance, acceptance, or validation of TC should be achieved, as much as possible, through regulations, policy, or bilateral agreements and cooperation between the SoD and SoR.

Noise Certification

In 1968, the ICAO Assembly officially recognised that "the problem of aircraft noise is so serious in the vicinity of many of the world's airports that public reaction is mounting to a degree that gives cause for great concern and requires urgent solution." This led to the development of the International Standards and Recommended Practices (SARP) for Aircraft Noise in the form of ICAO Annex 16 (ICAO, 2017), which specifies noise evaluation methods and maximum noise levels for aircraft certification. In accordance with ICAO Annex 16, a noise certificate should be granted or validated by the SoR of the aircraft based on satisfactory evidence that the aircraft complies with noise requirements that are at least equal to the standards specified in Annex 16. As of the latest edition of ICAO Annex 16 (8th Edition), SARP are detailed for subsonic jet aeroplanes, propeller-driven aeroplanes, propeller-driven Short Take-off and Landing (STOL) aeroplanes, helicopters, and supersonic aeroplanes. While ICAO Annex 16 includes guidelines on noise evaluation and certification for tilt-rotor aircraft, formal SARP for noise certification of tilt-rotor aircraft have yet to be fully developed.

eVTOL Aircraft Type Certification

There is significant momentum in the development of eVTOL aircraft, and robust aircraft type certification is essential in mitigating the occurrence of incidences or accidents that could pose significant setbacks for the industry. These aircraft are expected to incorporate novel technologies — such as electric and distributed propulsion, automated and digitalised systems, and electric and hydrogen battery technology — each of which introduce potential hazards that must be addressed through new certification processes and associated airworthiness standards.

At the ICAO level, substantial effort is underway to study and develop guidance for AAM. However, SARP specific to aircraft type certification of eVTOL aircraft have yet to be developed. Existing guidance material, such as ICAO Doc 10103 (ICAO, 2019), address aircraft with tilt-rotors, but were originally developed for gas turbine-powered tilt-rotor aircraft and may not be sufficient to address the characteristics of emerging eVTOL aircraft.

In the absence of any specific ICAO SARP, many SoDs have begun developing their own frameworks to certify eVTOL aircraft according to the needs of their respective nation's industry. Some SoDs have studied the performance, hazards, and risk mitigation strategies associated with eVTOL aircraft and proposed associated airworthiness standards (e.g., airworthiness criteria, special conditions, etc.), typically on a case-by-case basis according to each aircraft type certification project initiated within their respective States. With sufficient technological and operational maturity and experience, it can be expected that these standards will eventually converge to some level of international harmonisation.

The Civil Aviation Administration of China (CAAC), the European Union Aviation Safety Agency (EASA), and the United States Federal Aviation Administration (FAA) are among the Civil Aviation Authorities / Agencies that have either issued TCs or accepted applications for TC of eVTOL aircraft. These authorities have made substantial progress in developing the necessary standards to support certification. An overview of their developments is further described in **Annexes A to C**.

KEY CONSIDERATIONS

With individual SoDs devising and implementing different approaches to tackle the aircraft type certification of emerging eVTOL aircraft designs, SoRs may find the lack of harmonisation to be a potential challenge while trying to develop their own regulations. To aid States in understanding key aspects of eVTOL aircraft and operations as they develop their regulations, this section aims to raise awareness of the more commonly and internationally accepted views in the following areas:

- → Potential applications of eVTOL Aircraft and Mission Characteristics
- → eVTOL Aircraft Classification
- → Airworthiness Design Standards for eVTOL Aircraft

Potential Applications of eVTOL Aircraft and Mission Characteristics

eVTOL aircraft are envisioned to perform a diverse range of missions, depending on their operational concepts. These may range from the carriage of passengers and other payloads (e.g., cargo or other mission equipment) in urban environments (Urban Air Mobility), to transport between cities and across regions (Regional Air Mobility). The characteristics of these missions directly inform the design requirements for eVTOL aircraft and hence influence the aircraft type certification requirements.

The potential types of eVTOL aircraft missions and their key characteristics are as follows:

Urban Air Mobility

Urban Air Mobility (UAM) involves short-range air transport within, into or out of cities and metropolitan areas. UAM is aimed at being a more time-efficient alternative to ground-based transport in urban areas, with the main use cases being passenger and cargo transport. In passenger transport, UAM may serve, for example, VIP transport, tourism activities, or public air-taxi services, with some operations possibly being integrated with ridesharing or Mobility-as-a-Service (MaaS) platforms. Other applications may include air ambulance services, emergency response, and services for public safety and security. In cargo transport, with the pilot compartment remaining intact, the rest of the cabin space may be reconfigured to accommodate additional cargo, enabling the aircraft to serve as an alternative to traditional delivery truck services, with potential applications in medical supply transport and delivery to areas that are difficult to access due to limited or damaged ground transport infrastructure

→ Payload and Range:

UAM is expected to involve the movement of one or more passengers (approximately 80 kg per passenger) or the equivalent weight in cargo or other mission equipment across cities or metropolitan areas. The range depends on the size of the city but is expected to be short.

→ Infrastructure:

UAM operations may involve dedicated vertiports, rooftop hubs, or take-off and landing sites at logistics distribution centres within cities. Such infrastructure should ideally facilitate quick turnarounds (e.g., passenger embarkation/disembarkation, cargo loading/unloading, recharging, and through-flight maintenance) to enable frequent and efficient operations in high-demand areas. Given the low-altitude operational conditions and urban context, additional ground infrastructure may be required to support recharging, communications, navigation, and surveillance functions for eVTOL aircraft.

→ Airspace:

UAM flights over metropolitan and urban areas are expected to operate within low-level airspace and are envisioned to fly within a few hundred meters above ground level in cities. Initial operations are expected to follow Visual Flight Rules (VFR) and subsequently be expanded to Instrument Flight Rules (IFR) operations. Airspace structures for eVTOL aircraft and associated application of rules of the air are still being studied, and emerging concepts include integrating eVTOL aircraft into the existing airspace system, flying eVTOL aircraft along prescribed airspace flight routes, or allocating low-altitude airspace or segmented airspace exclusively for eVTOL aircraft.

→ Noise and Aircraft Emission Management:

The management of noise and emissions will be a critical requirement for UAM operations, particularly when operations are conducted near or over residential or commercial areas. UAM operations in such environments will likely be subject to stringent noise and environmental protection requirements.

Regional Air Mobility

Regional Air Mobility (RAM) refers to medium- to long-range air transport between cities or across broader regions. RAM could improve connectivity between urban areas and communities that are otherwise remote and underserved by existing ground transport infrastructure. RAM may serve regional business travel, commuter services between remote areas and urban centres, and tourism. Additionally, RAM may also play a role in connecting regional airports that are underserved by traditional commercial aviation. In cargo transport, RAM could serve remote areas, such as islands or mountainous regions, where access via traditional ground or maritime transport is limited or unreliable.

→ Payload and Range:

eVTOL aircraft may possibly be used for RAM, and if so, may carry a similar payload as in UAM — approximately 80 kg per passenger or equivalent weight in cargo or mission equipment. These eVTOL aircraft would be optimised for longer flight ranges and could involve covering medium-range distances.

→ Infrastructure:

While RAM may also operate from vertiports, some RAM concepts involve operations into and out of smaller regional airports.

→ Airspace:

RAM flights may be segregated from UAM operations, possibly at higher altitude and with higher cruise speeds to cover the longer distances more efficiently. Some eVTOL aircraft to date cruise at altitudes up to 4000 feet above mean sea level. Like UAM, RAM operations are expected to initially follow VFR and ultimately allow IFR operations. RAM flights are more likely than UAM to require integration into existing airspace and airspace management systems due to their operating areas and altitudes.

→ Noise and Aircraft Emission Management:

Where RAM operations are conducted close to or over residential and commercial areas (e.g., for city-to-city operations), similar noise and emissions requirements to UAM would apply.

eVTOL Aircraft Classification

The classification of aircraft is essential to the certification process. Clear classification helps in the selection of appropriate airworthiness design standards and establishment of an appropriate type certification basis, ensuring that each aircraft type meets the required safety and performance standards, both internationally and nationally. Furthermore, classification informs requirements for other areas, such as crew, maintenance, and infrastructure.

VTOL-capable aircraft (VCA) are not assigned a distinct classification under the ICAO SARP. Under ICAO Annex 7 (ICAO, 2012), heavier-than-air power-driven aircraft are classified as either aeroplanes, rotorcrafts, or ornithopters. While not identified in Annex 7, the powered-lift aircraft is defined in ICAO Annex 1 (ICAO, 2022). Various eVTOL aircraft design configurations have emerged to achieve vertical and forward flight. As shown in **Table 1**, these aircraft are expected to be classified as either a powered-lift aircraft or rotorcraft. The key difference between the two is that powered-lift aircraft generate lift using non-rotating aerofoil(s) during horizontal flight.

Examples of eVTOL Aircraft Design Configurations	Most Suited Aircraft Classification and Definition of Classification (ICAO, 2012; ICAO, 2022)
→ Tilt Wing → Tilt Fan → Tilt Prop → Tilt Rotor → Tilt Body → Tilt Frame → Lift + Cruise → Slowed-Rotor → Stopped-Rotor	**Powered-lift** Heavier-than-air aircraft capable of vertical take-off, vertical landing, and low-speed flight, which depend principally on engine-driven lift devices or engine thrust for lift during these flight regimes, and on non-rotating aerofoils for lift during horizontal flight
→ Multicopter → Electric Rotorcraft	**Rotorcraft** A power-driven heavier-than-air aircraft supported in flight by the reactions of the air on one or more rotors

Table 1 — Examples of eVTOL Aircraft Design Configurations and Classification

Design Standards for eVTOL Aircraft

Airworthiness design standards — also known as airworthiness requirements, airworthiness criteria, certification specifications, or airworthiness codes — serve as the basis for aircraft type certification. Existing standards for conventional aircraft typically cover requirements related to flight (e.g., performance, stability and control, and other flight requirements), structural integrity, design and construction, powerplant, system and equipment, operating limitations, and supplementary information. While these categories are relevant to eVTOL aircraft, the specific requirements should be modified where needed to suit their novel design architectures and technologies. Considerations for general design requirements of eVTOL aircraft (manned eVTOL aircraft) are detailed in **Annex D1**, with additional considerations for remotely piloted eVTOL aircraft detailed in **Annex D2**.

A key principle in the development of design standards is to adopt a safety-first approach that adheres to an acceptable level of safety while offering flexibility to accommodate innovation in design and operation. The goal is to ensure that eVTOL aircraft can operate safely in complex and congested airspaces, particularly within urban environments. As technologies continue to evolve, the standards must be refined to maintain an acceptable level of safety while enabling technological advancement.

It will be equally important to strengthen the sharing of information on eVTOL aircraft developments among States. The sharing of insights on legislation, technical standards, and aircraft type certification management processes will promote eVTOL aircraft development and adoption. The collective understanding of requirements and safety targets will be strengthened and unified by enhancing experience sharing of developments and practices in eVTOL aircraft type certification projects.

Both EASA and FAA have developed specific design standards for eVTOL aircraft and continue to refine the standards to address their unique challenges, ensuring safety and reliability while encouraging technological advancement.

EASA has introduced the Special Condition for small category VTOL aircraft (SC-VTOL), which outlines the safety objectives for these aircraft, including eVTOL aircraft. The SC-VTOL framework focuses on airworthiness design standards that address structural integrity, system reliability, environmental compatibility, and safety under failure conditions. Additionally, EASA's framework includes provisions for noise and emissions, addressing public concerns about the environmental and noise impact of these new technologies in urban environments (EASA, 2024).

The FAA has taken an approach to establish certification basis for eVTOL aircraft type certification application as a powered-lift special class aircraft. This is articulated through draft FAA Advisory Circular (AC) No. 21.17-04, which is supported by policy statements (PS) 21.17-01 "Safety Continuum for Powered-lift" and PS 21.17-02 "Special Class Rotorcraft". The FAA's framework incorporates a set of airworthiness criteria drawn from existing regulatory parts, such as 14 Code of Federal Regulations (CFR) Parts 23, 25, 27, 29, 33, and 35, which cover airworthiness standards for aircraft ranging from small general aviation airplanes to large transport-category rotorcraft, engines, and propellers. Where the FAA determines that the criteria outlined in AC No. 21.17-4 are inadequate or not appropriate as a certification basis for a powered-lift aircraft, the FAA may require the applicant to comply with alternate or additional criteria.

Industry standards also play a role in detailing requirements and best practices, which can serve as Means of Compliance (MoC) with regulatory objectives. Significant standards development activities are ongoing for eVTOL aircraft. For example, ASTM International has published standards that address electric propulsion systems, battery performance and safety, and other critical systems for eVTOL aircraft. Similarly, SAE International (Society of Automotive Engineers) has developed a range of aviation standards that apply to electrical systems, avionics, and automation in emerging aircraft technologies. The European Organisation for Civil Aviation Equipment (EUROCAE) provides guidance on battery development, thermal runaway, and the integration of advanced avionics, communication, and navigation systems.

ACTION PLAN

Aircraft Type Certification, Acceptance, or Validation

A key step for SoRs, if not already taken, is to decide upon whether type certification, type acceptance, or type validation would be used for the acceptance of eVTOL aircraft in their respective States. In deciding the approach, SoRs are reminded of ICAO's overarching recommendation that maximum credit be accorded to the type certification work already done by the SoD and to avoid unnecessary duplication or redundant testing, where practical and without prejudice to their unique national requirements.

While not mandatory, some SoRs may choose to enter into bilateral agreements and cooperation with the SoD to facilitate the validation or acceptance of the TC. SoRs that are also SoDs which issue TCs may also consider conducting concurrent type certification (or concurrent validation) with the SoD of the eVTOL aircraft. Early involvement in the certification process allows the SoR to become familiar with the aircraft, thus accelerating the approval process and facilitating an earlier entry into operation.

SoRs that are also SoDs may need to define and officially publish their own design standards and the associated MoC. The information that follows may be used as references to assist SoRs in the development of such definitions:

- → **Definition and Classification of eVTOL Aircraft Types:** See *Key Considerations — eVTOL Aircraft Classification* of this Part for considerations.
- → **Airworthiness Design Standards for eVTOL Aircraft:** See *Design Standards for eVTOL Aircraft* of this part and **Annexes D1 and D2** for specific considerations. CAAs may also wish to review the standards used by other States, such as those described in **Annexes A to C**.
- → **System and Operational Safety Risks and Targets:** Safety targets in terms of probabilities of catastrophic system failures are typically stipulated in the airworthiness design standards, and although the intent is the same, the exact levels of probability may be different between States. States will have to evaluate and decide on establishing a set of safety targets based on their threshold of acceptable risk against the severities of failure. For example, higher-risk activities, such as commercial passenger transport by eVTOL aircraft over urban areas, where continued controlled flight and safe landing at a vertiport must be assured, should be held to a higher safety target compared to lower-risk activities, such as personal use or cargo delivery by eVTOL aircraft over rural areas.

Part 1 References

- → European Union Aviation Safety Agency [EASA]. (2024, June). Special conditions for VTOL-capable aircraft (Issue 2, SC-VTOL-02).
- → International Civil Aviation Organization [ICAO]. (2012, July). Annex 7 to the Convention on International Civil Aviation — Aircraft nationality and registration marks (6th ed.).
- → International Civil Aviation Organization [ICAO]. (2017, July). International standards and recommended practices, Annex 16 — Environmental protection — Volume I: Aircraft noise (8th ed.).
- → International Civil Aviation Organization [ICAO]. (2019). Guidance on the implementation of ICAO Standards and Recommended Practices for tilt-rotors (Doc 10103, 1st ed.).
- → International Civil Aviation Organization [ICAO]. (2020). Airworthiness manual (Doc 9760, 4th ed.).
- → International Civil Aviation Organization [ICAO]. (2022, July). Annex 1 — Personnel licensing (14th ed.).

PART 01 ANNEX A

CIVIL AVIATION ADMINISTRATION OF CHINA (CAAC) EVTOL AIRCRAFT TYPE CERTIFICATION POLICY AND PRACTICE

CAAC eVTOL Aircraft Type Certification Policy and Practice

The Civil Aviation Administration of China (CAAC) has received applications for, and has already issued, TCs for both manned and unmanned eVTOL aircraft. Under CAAC's framework, eVTOL aircraft are considered a configuration of a VTOL aircraft that takes off and lands vertically using electric propulsion. An example is illustrated in Figure A-1.

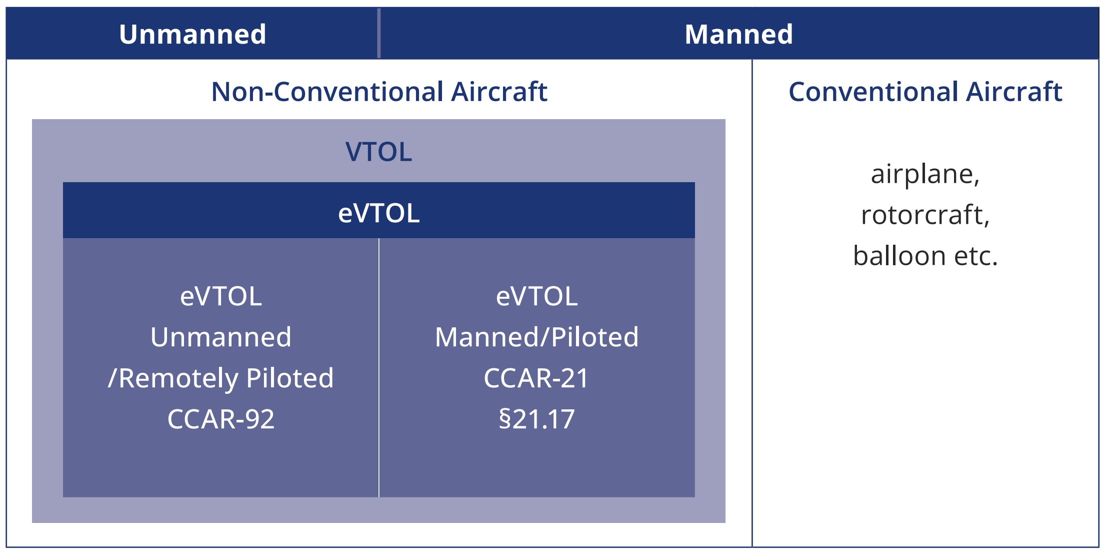


Figure A-1: eVTOL Aircraft in CAAC's Context

Under the CAAC framework, different requirements apply to the type certification of manned and unmanned eVTOL aircraft. Manned eVTOL aircraft are certified as Special Class Aircraft under CCAR-21 §21.17. The certification basis (airworthiness standard) is a Special Condition that is defined on a case-by-case basis for each application.

Special Class Aircraft are types of aircraft for which no airworthiness regulations have been issued. This category includes gliders, airships, very-light-aircraft, and other non-conventional aircraft. eVTOL aircraft being certified under this classification, including their engines and propellers, must comply with the combination of the following requirements as deemed applicable by the CAAC:

- Normal Class, Practical Class, Aerobatic Class and Commuter Class Aircraft Airworthiness Regulations (CCAR-23)
- Transport Class Aircraft Airworthiness Standards (CCAR-25)
- Normal Class Rotorcraft Airworthiness Regulations (CCAR-27)
- Transport Class Rotorcraft Airworthiness Regulations (CCAR-29)
- Manned Free Balloon Airworthiness Regulations (CCAR-31)
- Aero-Engine Airworthiness Regulations (CCAR-33)
- Propeller Airworthiness Standard (CCAR-35)
- Any other airworthiness requirements identified by CAAC as applicable to the specific design and intended use and with an equivalent level of safety.

The CAAC has conducted a public consultation on the Special Condition for the type certification of Aerofugia's E200-100 eVTOL aircraft. Additionally, Autoflight Company's V2000EM manned eVTOL aircraft and Volant Company's VE25-100 manned eVTOL aircraft have both begun their airworthiness certification processes, with Special Conditions currently under development for public consultation.

The type certification of unmanned eVTOL aircraft is governed under CCAR-92, Safety Management Rules for the Operation of Civil Unmanned Aircraft (UA). In accordance with CCAR-92, unmanned eVTOL aircraft are considered large-class or medium-class UA and are required to undergo airworthiness certification. As with manned eVTOL aircraft, the certification basis is specified on a case-by-case basis, through a Special Condition defined specifically for each application. CAAC has issued AC-92-02 for medium-class UA, which provides a commonly accepted airworthiness standard for certification.

To date, the CAAC has issued Special Conditions and TCs for one large-class eVTOL UA: the EH216-S, a remotely piloted multirotor aircraft system designed to carry people. The following milestones reflect this progress:

- The Special Conditions for EHANG's EH216-S Unmanned Aircraft System was published in February 2022.
- A TC was issued for EHANG's EH216-S people onboard Unmanned Aircraft System on October 13, 2023.

The CAAC has since published a public consultation on the Special Condition for Aerofugia's E200-100 eVTOL aircraft for its type certification.

Relevant CAAC Airworthiness Standards for eVTOL Aircraft

CCAR-92 民用无人驾驶航空器运行安全管理规则	Safety Management Rules for the Operation of Civil Unmanned Aircraft, Chapter D Airworthiness Management.
CAAC, EH216-S 型无人驾驶航空器系统专用条件	Special Conditions for EHANG EH216-S Unmanned Aircraft System, SC-21-002, February 9, 2022.
CAAC, V2000CG 型无人驾驶航空器系统专用条件	Special Conditions for V2000CG Unmanned Aircraft System, SC-21-004, November 12, 2023.
CAAC, 民用无人驾驶航空器系统 适航安全评定指南	Civil Unmanned Aircraft Systems Airworthiness Safety Assessment Guide, AC-92-AA-2024-01, February 5, 2024.
CAAC, 中型民用无人驾驶航空器系统适航标准及符合性指导材料（试行）	Airworthiness Standards and Compliance Guidance for Medium-class Civil Unmanned Aircraft Systems (Trial), AC-92-AA-2024-01, July 23, 2024.
CAAC, 民用无人驾驶航空器系统适航审定分级分类和系统安全性分析指南	Civil unmanned aircraft system airworthiness certification guide to classification and System Safety Analysis, AC-21-AA-2022-40, December 21, 2022.
CAAC, 电推进系统专用条件编制指南	Guidelines for preparation of special conditions for electric propulsion systems, AC-21-AA-2024-20.

PART 01 ANNEX B

EUROPEAN UNION AVIATION SAFETY AGENCY (EASA) EVTOL AIRCRAFT TYPE CERTIFICATION POLICY AND PRACTICE

EASA eVTOL Aircaft Type Certification Policy and Practice

The European Union Aviation Safety Agency (EASA) has received several requests for the type certification of eVTOL aircraft for which certification specifications do not yet exist. For EASA, eVTOL aircraft are a subset of a broader class of VTOL-capable aircraft (VCA) as illustrated in **Figure B-1**. EASA's approach to the type certification of VCA has been to develop and apply a complete set of dedicated technical specifications through Special Conditions and associated MoC. The Special Conditions for VTOL (SC-VTOL) was first issued in July 2019, and a second issue was released in June 2024 with some level of harmonisation with the FAA and with participation of Transport Canada and the Agencia Nacional de Aviacao Civil (ANAC) of Brazil. For ease of reference, the second issue of SC-VTOL and MoC 1 to 3 have been compiled and published under a document entitled Easy Access Rules for small category VCA (EAR). This should be read in conjunction with a fourth publication of MoC (MoC-4 SC-VTOL), which has not been incorporated into the EAR. It is expected that the Special Conditions will be replaced by certification specifications once sufficient experience has been gained through type certification projects using SC-VTOL.

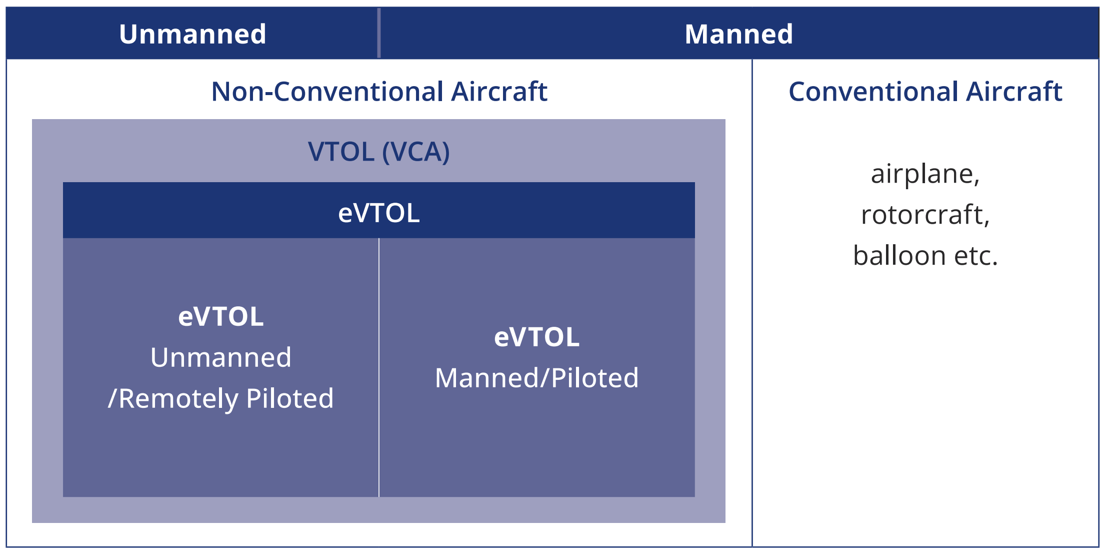


Figure B-1: VTOL Capable Aircraft and eVTOL Aircraft in EASA's Context

The SC-VTOL applies to aircraft with a maximum passenger seating configuration of nine or fewer and a maximum certified take-off mass of 5700 kg or less. Additionally, the SC-VTOL applies to aircraft with a normal operating calibrated airspeed not exceeding 250 knots.

Under SC-VTOL, VCAs are certified under one or both of two categories: Category Enhanced or Category Basic.

Category Enhanced

Category Enhanced aircraft must be capable of continued safe flight and landing and must meet all applicable SC-VTOL requirements. Aircraft intended for operations over congested areas or for commercial air transport operations of passengers must be certified in this category.

Category Basic

Category Basic aircraft must be capable of controlled emergency landing and meet all applicable requirements of SC-VTOL. Category Basic was introduced to provide a level of proportionality in safety objectives depending on the number of occupants and applies to all operations not classified as Category Enhanced (e.g., infrastructure surveys not conducted over congested areas).

The SC-VTOL is complemented by additional specifications such as those for the propulsion system and environmental protection. Requirements for electric propulsion (or hybrid-electric propulsion) are mandated through Special Condition SC E-19, issued in September 2007. Environmental noise considerations are covered by Environmental Protection Technical Specifications (EPTS) and an EPTS has been published in December 2023 for VTOL aircraft with non-tilting rotors. Product Environmental Footprint Category Rules (PEFCR) to assess the environmental performance (i.e. emissions impact) of specific aircraft are currently being developed for eVTOL aircraft.

Relevant EASA Airworthiness Standards for eVTOL Aircraft

- → European Union Aviation Safety Agency [EASA]. (2024, October). Easy access rules for small category VCA (SC-VTOL + MoC) (Revision 0).
- → European Union Aviation Safety Agency [EASA]. (2023, December 12). Environmental protection technical specifications (noise) applicable to VCA powered by non-tilting rotors (Issue 1, Final).
- → European Union Aviation Safety Agency [EASA]. (2023, December 18). Fourth publication of proposed means of compliance with the Special Condition VTOL (MoC-4 SC-VTOL, Issue 1).
- → European Union Aviation Safety Agency [EASA]. (2021, July 4). Special condition: Electric/hybrid propulsion system (SC E-19, Issue 1, Final).

Part 1, Annex B References

- → European Union Aviation Safety Agency [EASA]. (2024, June). Special conditions for VTOL-capable aircraft (Issue 2, SC-VTOL-02).
- → Tauszig, L. (2024, September 10–12). Special condition VTOL: Airworthiness requirements as a first building block for VTOL safety [Conference presentation]. 50th European Rotorcraft Forum, Marseille, France.

PART 01 ANNEX C

U.S. FEDERAL AVIATION ADMINISTRATION (FAA) EVTOL AIRCRAFT TYPE CERTIFICATION POLICY AND PRACTICE

The U.S. FAA eVTOL Aircraft Type Certification Policy and Practice

The FAA has received applications for the type certification of eVTOL aircraft typically configured for six or fewer passengers and with a maximum take-off weight of 12,500 pounds or less, These aircraft are designed as a "powered-lift" special class of aircraft (see *Powered-lift Class of Aircraft* of this Annex for details of the powered-lift class of aircraft).

While the FAA's procedures for type certification and airworthiness certification are stipulated in 14 Code of Federal Regulations (CFR) Part 21, such eVTOL aircraft, while requiring a standard airworthiness certificate, do not fall under an existing airworthiness standard in the form of a dedicated regulatory part. As such, they are considered special class aircraft.

In each of these projects, the FAA had published airworthiness criteria specifically tailored to the project as special class aircraft under §21.17(b). In accordance with §21.17(b), airworthiness criteria for these projects were developed by combining applicable requirements from existing parts, such as Parts 23, 25, 27, 29, 31, 33, and 35, with additional airworthiness criteria stipulated by the FAA to provide an equivalent level of safety. To date, the FAA has issued two final sets of airworthiness criteria for eVTOL aircraft (refer to the section "Relevant FAA Airworthiness Standards for eVTOL Aircraft" in this Annex).

Based on recent eVTOL aircraft type certification projects, the FAA published an AC for the type certification of powered-lift aircraft (Draft AC 21.17-04) to provide a more efficient pathway for certifying certain powered-lift aircraft. The AC provides guidance for the aircraft type, production, and airworthiness certification of powered-lift aircraft and details under §21.17(b) an acceptable means of showing compliance. Specifically, the airworthiness criteria contained in the AC were developed from the airworthiness standards in Parts 23, 27, 33, and 35 and include definitions and performance-based safety objectives specific to powered-lift aircraft, including considerations for installed electric engines and propellers.

The procedures in the AC apply to all powered-lift aircraft certificated as special class under § 21.17(b). The airworthiness criteria are intended for powered-lift aircraft with a maximum gross weight of 12,500 pounds or less, a passenger seating configuration of six or less, battery-powered electric engine(s) for propulsion, and piloted operation.

Powered-lift Class of Aircraft

Powered-lift aircraft are defined in 14 CFR Part 1 as heavier-than-air aircraft capable of vertical take-off, vertical landing, and low-speed flight, which rely principally on engine-driven lift devices or engine thrust for lift during these flight regimes, and on non-rotating airfoil(s) for lift during horizontal flight.

Powered-lift aircraft have characteristics of both an airplane and a rotorcraft. They have the capability to function like a rotorcraft during take-off and landing, and as an airplane during cruise flight.

This combination of lift capabilities creates the potential for increased speeds and flight duration as compared to rotorcraft during the enroute portion of the flight.

As illustrated in **Figure C-1**, some eVTOL aircraft would be classified as powered-lift based on the aircraft's design architecture. eVTOL aircraft that continue to rely on rotating airfoil(s) for lift during horizontal flight (e.g., multicopters) do not fall under the powered-lift category.

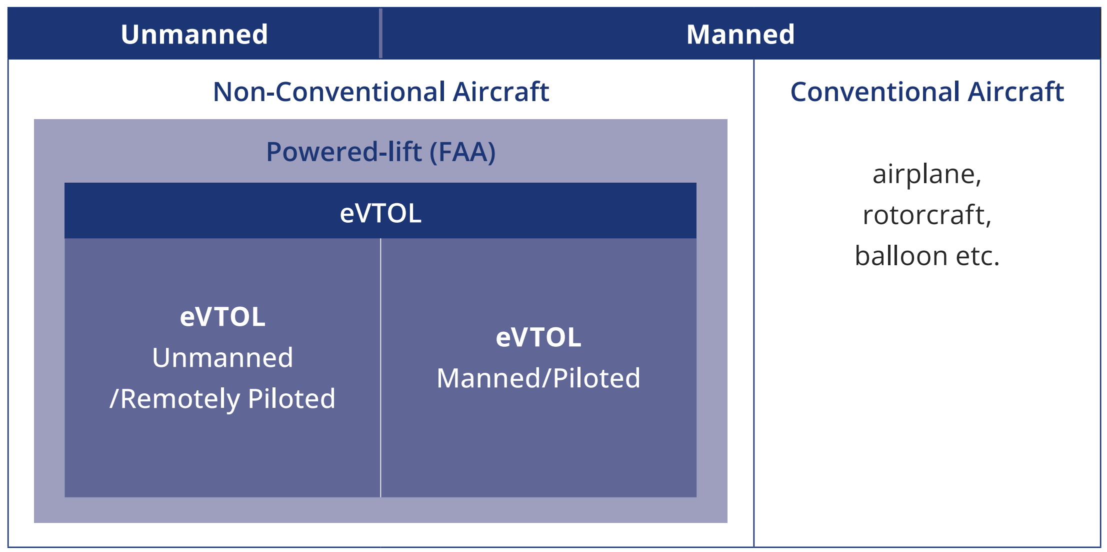


Figure C-1: Powered-lift Class of Aircraft

Tiered Safety Approach for Powered-lift Aircraft

The FAA issued a draft policy PS-AIR-21.17-01 (FAA, 2024a) to develop a regulatory framework for powered-lift aircraft, addressing certification gaps and ensuring safe integration into the national airspace. In the absence of dedicated certification standards, the policy introduces a structured, risk-based approach to safety and operational challenges associated with powered-lift aircraft. It sets airworthiness standards by bridging gaps in fixed-wing and rotorcraft certification frameworks. By defining certification levels and proportionate safety requirements, the policy enhances regulatory clarity and supports the safe integration of powered-lift aircraft into the national airspace. The certification levels, along with an example of safety requirements of probabilities for failures of catastrophic severity, are shown in **Table C-1 and Table C-2**.

System Safety and Performance Requirements

Safety and performance assessments follow established methodologies to ensure compliance with regulatory requirements, as defined in **Tables C-1 and C-2**.

The framework includes:

- → System safety analysis based on SAE (Society of Automotive Engineers) ARP4754B and ARP4761A guidelines
- → Defined probability limits for different failure conditions
- → Performance standards for hover stability, thrust failures, and take-off/landing reliability

Max Passengers & Weight	Commercial (For Hire)	Private (Non-Commercial)
0–1 passengers & ≤12,500 lbs	1A	1B
2–6 passengers & ≤12,500 lbs	2A	2B
7–9 passengers & ≤12,500 lbs	3A	3B
10-19 passengers or >12,500 lbs	4A	4B

Table C-1: Powered-lift Certification Levels

Powered-lift Certification Level	Quantitative Probability for Catastrophic Failures
1B	$<10^{-6}$
1A and 2B	$<10^{-7}$
2A and 3B	$<10^{-8}$
3A, 4A, and 4B	$<10^{-9}$

Table C-2: Examples of Quantitative Safety Level Requirements

Relevant FAA Airworthiness Standards for eVTOL Aircraft

- → Federal Aviation Administration [FAA]. (n.d.). Advisory circular — Subject: Type certification — Powered-lift (AC 21.17-04, Draft).
- → Federal Aviation Administration [FAA]. (2024, April 8). Airworthiness criteria: Special class airworthiness criteria for the Joby Aero, Inc. Model JAS4-1 powered-lift.
- → Federal Aviation Administration [FAA]. (2024, June 24). Airworthiness criteria: Special class airworthiness criteria for the Archer Aviation, Inc. Model M001 powered-lift.
- → Federal Aviation Administration [FAA]. (2024). Policy statement — Safety continuum for powered-lift (PS-AIR-21.17-01, Draft).
- → Federal Aviation Administration [FAA]. (2024). Policy statement — Special class rotorcraft (PS 21.17.02, Draft).

Part 1, Annex C References

- → Federal Aviation Administration [FAA]. (2024). Advisory circular — Subject: Type certification — Powered-lift (21.17-4, Draft, 2024).
- → Federal Aviation Administration [FAA]. (2024a). Policy statement — Safety continuum for powered-lift (PS-AIR-21.17-01, Draft, 2024).

PART 01 ANNEX D1

MANNED EVTOL AIRCRAFT DESIGN REQUIREMENTS

This annex presents design requirements identified by EASA and FAA as examples of the scope and key subject areas relevant to the design of eVTOL aircraft. This annex also describes considerations that may become relevant in future regulatory requirements. The annex is focused on the requirements for manned (piloted) eVTOL aircraft, while differences and additional requirements for unmanned (remotely piloted) eVTOL aircraft are described in **Annex D2.**

General Design Requirements for eVTOL Aircraft (Examples From SoDs)

Aircraft and Equipment	Like manned aircraft certification standards, the special conditions applicable to aircraft such as eVTOL aircraft include requirements organised under common subparts. These typically cover areas such as Flight, Structures, Design and Construction, and Equipment. The topic headings under these subparts are shown in **Tables D1-1 to D1-4.**
Flight Crew Interface and Other Information	Additional requirements for areas such as flight crew interface (i.e., markings and manuals) and instructions for airworthiness are shown in **Table D1-5**. As shown, instrument flight airworthiness criteria have also been specifically identified by the FAA.
Engine, Powerplant, and Propulsion System	The areas where design requirements have been defined in the various special conditions for electric engines (motors) and power generation and distribution are shown in **Table D1-6**. In the case of EASA's approach, the requirements have been detailed in a Special Conditions document separate from the main aircraft requirements.
Propellers	If propellers are used in the eVTOL aircraft design, the various requirements that have previously been detailed are as shown in **Table D1-7**. For EASA, CS-P is an existing certification standard for propellers on VCA, supplemented as necessary by additional criteria from SC-VTOL.

Flight

EASA (SC-VTOL-02)	FAA (AC 21.17-04)
• Mass and Centre of Gravity • Performance Data • Flight Envelopes • Take-off Performance • Climb Requirements • Climb Information • Landing • Controllability • Control Forces • Flying Qualities • Stall Characteristics and Stall Warning • Vibration • Flight in Icing Conditions • Operating Limitations	• Weight and Centre of Gravity • Performance Data • Minimum Safe Speed • Take-off Performance • Climb Requirements • Climb Information • Landing • Controllability • Trim • Stability • Minimum Safe Speed Characteristics and Warning • Ground and Water Handling Characteristics • Vibration, Buffering, and High-Speed Characteristics • Performance and Flight Characteristics Requirements for Flight in Atmospheric Icing Conditions

Table D1-1: eVTOL Aircraft Design Requirements — Flight

Structures

EASA (SC-VTOL-02)	FAA (AC 21.17-04)
• Structural Design Envelope • Interaction of Systems and Structures • Structural Design Loads • Flight Load Conditions • Ground and Water Load Conditions • Component Loading Conditions • Limit and Ultimate Loads • Structural Strength • Structural Durability • Aeroelasticity • Design and Construction Principles • Protection of Structure • Materials and Processes • Special Factors of Safety • Emergency Conditions	• Structural Design Envelope • Interaction Of Systems and Structures • Structural Design Loads • Flight Load Conditions • Ground and Water Load Conditions • Component Loading Conditions • Limit and Ultimate Loads • Structural Strength • Structural Durability • Aeromechanical Stability • Aeroelasticity • Design And Construction Principles • Protection of Structure • Materials and Processes • Special Factors of Safety • Emergency Conditions

Table D1-2: eVTOL Aircraft Design Requirements — Structures

Design and Construction

EASA(SC-VTOL-02)	FAA(AC 21.17-04)
• Flight Control Systems • Landing Gear Systems • Flotation • Means of Egress and Emergency Exits • Occupant Physical Environment • Fire Protection • Fire Protection in Designated Fire Zones • Lightning Protection • Design and Construction Information	• Flight Control Systems • Landing Gear Systems • Flotation • Bird Strike • Means of Egress and Emergency Exits • Fire Protection • Fire Protection In Fire Zones and Adjacent Areas • Lightning and Static Electricity Protection

Table D1-3: eVTOL Aircraft Design Requirements — Design and Construction

Equipment

EASA (SC-VTOL-02)	FAA (AC 21.17-04)
• General Requirements of Systems and Equipment Function • General Requirements on Equipment Installation • Equipment, Systems, and Installations • Electrical and Electronic System Lightning Protection • Electrical Wiring Interconnection System • High-Intensity Radiated Fields (HIRF) Protection • System Power Generation, Energy Storage, and Distribution • External and Cockpit Lighting • Safety Equipment • Pressurised Systems Elements • Installation of Flight Recorders	• Cockpit Voice Recorders (Under Aircraft Level Requirements) • Aircraft Level Systems Requirements • Function and Installation • Equipment, Systems, and Installations • Electrical and Electronic System Lightning Protection • High-Intensity Radiated Fields (HIRF) Protection • System Power Generation, Storage, and Distribution • External and Cockpit Lighting • Safety Equipment • Flight in Icing Conditions • Pressurised Systems Elements • Equipment Containing High-Energy Rotors

Table D1-4: eVTOL Aircraft Design Requirements — Equipment

Flight Crew Interface and Other Information

EASA (SC-VTOL-02)	FAA (AC 21.17-04)
Flight Crew Interface and Other Information • Flight Crew Compartment • Installation and Operation Information • Instrument Markings, Control Markings and Placards • Flight, Navigation, and Lift/Thrust Instruments • Aircraft Flight Manual • Instructions for Continued Airworthiness	**Flight Crew Interface and Other Information** • Flight Crew Interface • Installation and Operation • Instrument Markings, Control Markings, and Placards • Flight, Navigation, and Powerplant Instruments • Aircraft Flight Manual **Instructions for Continued Airworthiness** • Format • Content • Airworthiness Restrictions Chapter **Airworthiness Criteria for Instrument Flight** • IFR Flight Envelope • Trim • Flying and Handling Qualities • Stability Augmentation • Equipment, Systems, and Installation • Aircraft Flight Manual

Table D1-5: eVTOL Aircraft Design Requirements — Flight Crew Interface and Other Information

Engine, Powerplant, and Propulsion System

EASA (SC-VTOL-02 and SC-E-19)	FAA (AC 21.17-04)
Lift/thrust System Installation (SC-VTOL-02) • Lift/Thrust System Installation • Lift/Thrust System Operational Characteristics • Lift/Thrust System Installations, Energy Storage, And Distribution Systems • Lift/Thrust Installation Support Systems • Lift/Thrust System Installation Fire Protection **Electric/hybrid Propulsion System (SC E-19)** • Identification • Instructions for Continued Airworthiness • Instructions for Installation and Operation of the Electric/Hybrid Propulsion Systems (EHPS) • Ratings and Operating Limitations • Materials • Safety Assessment • Ehps Critical Parts • Fire Protection • Static and Fatigue Loads • Strength • Vibration Survey • Overspeed and Rotor Integrity • Rotating Parts Containment • Continued Rotation • Rain Conditions • Icing and Snow Conditions • Bird, Hail Strike and Impact of Foreign Matter • Fuel System • Lubrication System • Cooling System • Equipment • Ignition System • Ehps Control System • Time-Limited Dispatch • Aircraft Instruments • Electrical Power Generation, Distribution and Wirings • Propulsion Battery • General Conduct of Tests • Endurance Demonstration • Durability Demonstration • Calibration Assurance • Teardown Inspection • Operational Demonstration • Rotor Locking Demonstration • EHPS Specific Operation • System, Equipment and Component Tests	**Powerplant** • Powerplant Installation • Power or Thrust Control Systems • Powerplant Installation Hazard Assessment • Powerplant Ice Protection • Powerplant Operational Characteristics • Energy Systems • Powerplant Fire Protection **Electric Engine** • Instruction Manual for Installing, and Operating The Engine • Engine Ratings and Operating Limitations • Selection Of Engine Power and Thrust Ratings • Materials • Fire Protection • Durability • Engine Cooling • Engine Mounting Attachments and Structure • Accessory Attachments • Engine Electrical Systems • Overspeed • Engine Control Systems • Instrument Connection • Stress Analysis • Vibration • Liquid and Gas Systems • Critical and Life-Limited Parts • Lubrication System • Power Response • Continued Rotation • Safety Analysis • Ingestion • Vibration Demonstration • Over Torque • Calibration Assurance • Endurance Demonstration • Temperature Limit • Operation Demonstration • Durability Demonstration • System and Component Tests • Rotor Locking Demonstration • Teardown Inspection • Containment • Operation with Variable-Pitch Propeller • General Conduct of Tests **Instructions For Continued Airworthiness (Electric Engines)** • Format • Content • Airworthiness Limitations Section

Table D1-6: eVTOL Aircraft Design Requirements — Engine, Powerplant and Propulsion System

Propellers

EASA(CS-P)	FAA(AC 21.17-04)
• Instructions for Propeller Configuration and Installation • Instructions for Continued Airworthiness • Propeller Ratings and Operating Limitations • Tests — History • Propeller Safety Analysis • Propeller Critical Parts Integrity • Materials and Manufacturing Methods • Variable and Reversible Pitch Propellers • Feathering Propellers • Propeller Control System • Strength	**Propeller** • Instructions for Propeller Installation and Operation • Propeller Ratings and Operating Limitations • Features and Characteristics • Safety Analysis • Propeller Critical Parts • Materials and Manufacturing Methods • Durability • Variable and Reversible-Pitch Propellers • Feathering Propellers • Propeller Control System • Strength • Inspections, Adjustments, and Repairs • Centrifugal Load Tests • Bird Impact • Fatigue Limits and Evaluation • Lightning Strike • Endurance Test • Functional Test • Overspeed and Overtorque • Components of the Propeller Control System • Propeller Hydraulic Components **Instructions for Continued Airworthiness (Propellers)** • Format • Content • Airworthiness Restrictions Chapter

Table D1-7: eVTOL Aircraft Design Requirements — Engine, Powerplant and Propulsion System

Additional Considerations — Environmental Protection Requirements

To further enhance its value, eVTOL aircraft design should not only prioritise innovation and efficiency, but also be environmental responsible in support of sustainable aviation. This emphasis on mitigating environmental impact is particularly important for eVTOL aircraft operating in UAM contexts, where flights occur in close proximity to the public. Specific design and certification requirements may therefore be expected in areas such as noise emissions, air emissions, and sustainable practices across the entire operational lifecycle. These measures will support public acceptance and the success of eVTOL aircraft operations.

Noise Emissions

Noise pollution is one of the primary concerns in urban eVTOL aircraft operations. Since eVTOL aircraft are expected to operate at low altitudes and near populated areas, the effective management of noise emissions will be critical to gaining public acceptance and achieving regulatory approval for operating such aircraft.

Compliance with Noise Certification Standards (e.g., ICAO Annex 16)

All aircraft conducting international flights are expected to comply with noise standards, such as those outlined in ICAO Annex 16. These standards establish noise certification limits for aircraft and set clear guidelines for maximum permissible noise levels during take-off, landing, and in-flight operations. While States of Designs are already working on methods for noise measurement and standards tailored to eVTOL aircraft, the process remains complex due to the wide variation of structural design possibilities for eVTOL aircraft. As such, noise certification standards for eVTOL aircraft may need to be further tailored to account for urban environments, where noise sensitivity is significantly heightened.

Urban Noise Pollution Limits

Regulatory bodies may consider establishing urban-specific noise limits for eVTOL aircraft operations. These could include limits based on time-of-day, proximity to residential or commercial areas, and acceptable decibel levels during various stages of flight. For example, stricter noise thresholds may be applied during early morning or late evening operations to minimise disturbances in residential areas.

Air Emissions

Reducing greenhouse gas emissions is also a goal for aviation, especially as governments and industries worldwide move toward net-zero emissions targets. The use of electric propulsion systems in eVTOL aircraft offers significant potential for reducing emissions. eVTOL aircraft powered by electric propulsion are expected to produce zero operational emissions, if power is supplied by electrical storage devices such as batteries. eVTOL aircraft may also initially operate using hybrid-electric systems that incorporate combustion engines as a secondary or backup source of power. The design of such hybrid-electric systems should support, and not compromise, the target of reducing emissions levels in aviation.

Sustainable Practices

The goal of net-zero emissions could also apply to the entire lifecycle of an eVTOL aircraft and includes processes such as battery production, aircraft manufacturing, maintenance, and infrastructure development. Notably, sustainability in aviation is still an evolving topic, with much of the current focus on traditional commercial aircraft transport where the carbon footprint is higher. Environmental and Certification Agencies with a strong view towards sustainability could consider imposing requirements to encourage sustainable practices, such as the responsible sourcing of materials, component recycling, and the use of renewable energy for charging and infrastructure.

Battery Recycling and Sustainability

The production and disposal of batteries can have a significant impact on the environment. The manufacturing of batteries can generate hazardous wastes, and batteries that are improperly disposed of can contaminate the environment with chemicals and heavy metals. Design requirements may be introduced to encourage the use of materials in eVTOL aircraft battery systems that can be safely recycled or repurposed to minimise environmental impact.

Additional Considerations — Requirements Driven by the Operating Environment

Environmental Conditions

eVTOL aircraft may operate in a variety of environmental conditions, and the design and certification of such aircraft will need to account for these scenarios to ensure safe and reliable operations. Specifically, the Original Equipment Manufacturer (OEM) of the eVTOL aircraft will need to certify that the aircraft is capable of operating in adverse weather conditions such as rain, fog, snow, wind shear, and extreme heat or humidity. Ice detection and de-icing systems may also be needed for aircraft operating in cold weather environments, as icing may impair rotor or wing performance. Environmental qualification and testing will be key and may be applied wholly or selectively depending on the type of eVTOL aircraft mission and mission environment.

Airspace Requirements

It is ultimately desirable for eVTOL aircraft to be safely integrated into, and routinely operated within, existing airspace systems. It is currently a fundamental principle that all aircraft operating in such airspace systems comply with the rules of the State being flown over, or with the Rules of the Air in accordance with ICAO Annex 2 for international operations. To comply with the Rules of the Air, aircraft must be designed and operated in such a way that mitigates the hazards of collision between aircraft. Specifically, all airborne parties must be able to take complementary action to safely resolve any identified collision risks. eVTOL aircraft seeking to operate in existing airspace will therefore very likely require equipment and systems that enable the aircraft to maintain separation and avoid collisions with other airspace users.

Additional Considerations — Simplified Flight Controls

Most manned eVTOL aircraft designs incorporate pilot controls that are different from those of conventional manned aircraft for several reasons, such as the desire to combine vertical and cruise flight controls into a single piloting interface, reducing the piloting workload compared to traditional aircraft, and minimising piloting interfaces. Various design configurations have emerged, with some designs removing rudder pedals and employing two inceptors (i.e., one for acceleration or speed control and the other for the control of altitude, attitude, and direction), while others incorporate all controls into a single joystick interface. Fly-by-wire is the basic technological enabler for these types of flight controls, with precedent in standards and certification requirements in manned aviation. However, increased simplification of pilot control is typically enabled through an increased reliance on the flight control system (i.e., stability augmentation systems and autopilot flight control systems) to maintain aircraft stability. Flight control system software and hardware, and Ground Control Station (GCS) in such systems will therefore have increased criticality and may require dedicated and more stringent certification requirements, according to the level of criticality.

Part 1, Annex D1 References

- → European Union Aviation Safety Agency [EASA]. (2020, June 24). Certification specifications and acceptable means of compliance for propellers (CS-P) (Amendment 2).
- → European Union Aviation Safety Agency [EASA]. (2021, April 7). CRI consultation paper, special condition: Electric/hybrid propulsion system (Issue 1, SC E-19).
- → European Union Aviation Safety Agency [EASA]. (2024, June). Special conditions for VTOL-capable aircraft (Issue 2, SC-VTOL-02).
- → Federal Aviation Administration [FAA]. (2024). Advisory circular: Type certification — powered-lift (AC 21.17-04, Draft).

PART 01 ANNEX D2

REMOTELY PILOTED EVTOL AIRCRAFT DESIGN REQUIREMENTS

This annex presents additional potential design requirements that may be considered for remotely piloted eVTOL aircraft. These considerations are intended to supplement the primary certification requirements outlined in **Annex D1** for manned eVTOL aircraft.

Design Requirements for Ground Control Stations

Remotely piloted eVTOL aircraft introduce the need for a Ground Control Station (GCS), from which an operator oversees or controls the operations of the aircraft. Some potential design considerations, with reference to a special condition issued by CAAC for a large unmanned eVTOL aircraft, are as shown in **Table D2-1**.

CAAC (SC-21-0004)	
Ground Control Station	• Configuration, Performance, and Reliability • Failure Effects • Physical Operational Environment • Flight Plan Selection and Execution Functions • Ground-Controlled Flight Functions • Switching Between GCSs • Other Features • GCSs Displays • GCSs Alarm Information • GCSs Data Logging and Storage

Table D2-1: Remotely Piloted eVTOL Aircraft — Ground Control Station Requirements

Design Requirements for Datalink

The communications link for data exchange between the GCS and the eVTOL aircraft (i.e., datalink), which is essential for the safe operation of remotely piloted eVTOL aircraft, has been referred to by many names, such as Control and Non-Payload Communications (CNPC) link and Command and Control link. Given its role in ensuring the safe operation of the aircraft, the criticality of the datalink is high. Some example considerations for design requirements of the datalink are shown in **Table D2-2**.

CAAC (SC-21-0004)	
Datalink	• Datalink Performance • Electromagnetic Interference (Immunity) and Compatibility • Link Status • Redundant Link Backups • Datalink Latency • Datalink Loss • Abnormal Datalink • Datalink Switching • Datalink Security

Table D2-2: Remotely Piloted eVTOL Aircraft — Datalink Requirements

Additional Considerations — Automation

Remotely piloted eVTOL aircraft typically incorporate some level of automation in functions such as navigation, maintaining aircraft stability, and emergency handling. The level of automation can vary from one where the aircraft operates under active human monitoring and supervision (and intervention where necessary) to a level where the human does not or is not allowed to intervene in the operation. Some additional design considerations that arise from higher levels of automation are outlined below:

Automation Sensor Hardware

The reliability and performance of automatic functions and system decisions will be highly dependent on the data that the system receives as inputs. Sensors and systems that are used to provide such data (e.g., satellite navigation systems, inertial navigation systems, Light Detection and Ranging (LiDAR) systems, radar altimeters, optical sensors) are considered to have increased criticality. These systems may require more stringent certification requirements to ensure reliability and performance in key areas such as data accuracy, resolution, integrity, traceability, timeliness, and security.

Automation Software

Current regulatory and aircraft certification frameworks are not yet adapted to respond to systems with higher levels of automation, particularly those that employ some degree of artificial intelligence (AI). Conventional aircraft certification focuses on software and algorithms that are fully explainable and with results that are deterministic. However, AI-enabled systems may be less deterministic, posing challenges to existing safety assurance frameworks. As such, the uses and certification of AI in aircraft and related systems remain an active area of significant work and discussion at an international level. EASA and FAA's roadmaps for AI may serve as useful references for consideration in this area (EASA, 2023; FAA, 2024).

Specific Human Factors Design Principles

The use of high levels of automation may present new challenges and hazards related to human factors (i.e., new hazards of remote pilots). Some areas of potential concern include the following:

Complacency	Increased reliance on automation may reduce remote pilot vigilance and situational awareness, potentially delaying timely or adequate intervention when required.
Loss of Proficiency	When certain functions are consistently managed by automation, remote pilots may have fewer opportunities to maintain manual proficiency. Over time, this may lead to a decline or loss in their ability to respond effectively under unforeseen circumstances.
Lack of Mode Awareness	In aircraft that have different operational modes (e.g., different flight control modes in vertical and forward flight), it is important for remote pilots to maintain clear awareness of the current mode, especially if aircraft mode transitions occur automatically. Reduced mode awareness may lead to incorrect human decision-making or unintended intervention and inputs.

Type Certificates Issued

To-date, the CAAC has issued Special Conditions and Type Certificates (TCs) for one large-class eVTOL unmanned aircraft: the V2000CG, an unmanned cargo-carrying aircraft system.

→ Special Conditions for Autoflight Company's V2000CG Unmanned Aircraft System was published in November 2023.

→ A TC was issued for Autoflight V2000CG Unmanned Aircraft System on 21 March 2024.

Part 1, Annex D2 References

→ Civil Aviation Administration of China [CAAC]. (2023, November 12). V2000CG 型无人驾驶航空器系统专用条件 [Special conditions for V2000CG Unmanned Aircraft System] (SC-21-004).

→ European Union Aviation Safety Agency [EASA]. (2023, May). Artificial intelligence roadmap 2.0: Human-centric approach to AI in aviation.

→ Federal Aviation Administration [FAA]. (2024, July). Roadmap for artificial intelligence safety assurance (Version 1).

EVTOL AIRCRAFT: PART 02

Regulations for eVTOL Aircraft Entry into Service

INTRODUCTION

Realistic and pragmatic implementation is important to enable and scale eVTOL aircraft commercial operations in a safe, efficient, and reliable manner. A key part of the pragmatic implementation of eVTOL aircraft operations lies in the actions and requirements of the Entry-into-Service (EIS) phase, where an aircraft is first operationally certified, registered, and approved for commercial operations by a State of Registry (SoR) and a State of the Operator (SoO). As existing regulations related to EIS for commercial air operations may not yet adequately address the novelty of eVTOL aircraft, the aim of this Part is to provide guidelines and considerations that a SoR, a SoO, and a State of the Aerodrome (SoA) may need to address in facilitating the EIS of eVTOL aircraft operations. Specifically, this part focuses on addressing the operation of manned (piloted) eVTOL aircraft, with supplementary considerations for the EIS of remotely piloted eVTOL aircraft contained in **Annex A**.

BACKGROUND

EIS begins with the validation and type acceptance of the aircraft type (see Part 1 for details). This is typically followed by the processes for an operator to apply for and obtain an Air Operator Certificate (AOC), thereby certifying that the operator is competent as an air operator to provide commercial operations for revenue activities such as providing flights for ticketed passengers or freight. In addition, there is an established process for obtaining a Certificate of Airworthiness for the aircraft.

Personnel licensing and maintenance organisation compliance are also fundamental requirements that must be considered as part of EIS. These ensure that the operator can employ adequately trained personnel and engage approved maintenance organisations to ensure the safety of air operations, aircraft airworthiness, and regulatory compliance throughout the period of approval. Personnel licensing ensures that pilots, maintenance engineers, and other relevant operational staff possess the necessary qualifications, certifications, and competency to operate and maintain the aircraft. Maintenance organisation compliance serves to ensure that an aircraft is maintained to a requisite standard for safe and reliable commercial operations (i.e., continued airworthiness).

The novel design and operational characteristics of eVTOL aircraft would likely necessitate a more comprehensive approach to airworthiness involving stringent regulations in initial airworthiness verification, structured procedures for continuing airworthiness, and increased safety oversight efforts on the aircraft's construction and maintenance at the onset. A principle in developing these regulations is to identify and mitigate hazards and risks introduced by novel eVTOL aircraft technology and operations, whereby the greatest risk is the occurrence of failure(s) resulting in the loss of public trust and societal acceptance. Additional hazards could involve, but are not limited to, the ability to maintain the airworthiness of the aircraft, aviation personnel (i.e., pilot and aircraft maintenance licensing, training, and certification), aircraft standards, supporting infrastructure, airspace integration, noise and environmental impact, aviation security, and cybersecurity.

Specific ICAO Standards and Recommended Practices (SARP) for EIS of eVTOL aircraft are still under consideration. However, it is apparent that the process and requirements will be consistent with the principles of SARP for existing manned aircraft.

KEY CONSIDERATIONS

Considerations for the Air Operator Certificate Process

Commercial air transport operations can only be conducted by licensed air carriers, and commercial eVTOL aircraft operations are expected to meet this requirement. The AOC process is where a State's Civil Aviation Authority (CAA) grants approval to an operator to conduct such commercial air transport operations. This certification ensures that the operator has met all necessary regulatory requirements and is assessed to be able to continuously comply with these requirements to carry out approved operations in a safe manner.

The AOC process typically involves a thorough assessment of the operator's organisational structure, appropriateness of persons engaged as key appointment holders, sufficient staffing with competent personnel, airworthiness of aircraft, maintenance procedures, training, and safety protocols. It also includes an evaluation of the operator's ability to comply with relevant State aviation regulations and standards and helps to ensure that the organisation is financially and legally sound, such as having sufficient insurance coverage in case of incidents to third parties. Obtaining an AOC is the first step for any organisation seeking to operate commercial air transport services.

An AOC comes in two parts — the AOC itself, and the associated operations specifications that define the operation. The general process for obtaining an AOC is outlined in ICAO Doc 8335 (ICAO, 2022d).

Under the current AOC certification framework, the operator applicant, who has the responsibility for the safety of the operation, would need to demonstrate eligibility for AOC issuance. This includes, but is not limited to, having the ability and competence to conduct safe and efficient commercial operations and to comply with applicable aviation and safety regulations. If dangerous goods are being transported, the existing AOC processes also provide requirements and stipulate responsibilities to the AOC holder for ensuring that the dangerous goods are transported on an aircraft safely and in compliance with relevant regulations and Technical Instructions (TIs). The CAA would typically be responsible for assessing the ability and competence of the applicant and guiding the applicant in organisational and procedural matters that ensure safe, efficient, and successful operations.

Despite the novel technology and operational use cases, no significant changes are deemed required to the existing AOC process for eVTOL aircraft operations. In situations where an existing conventional AOC holder seeks to expand its commercial operations to include eVTOL aircraft, the process would follow the standard procedure for introducing a new conventional aircraft type to the existing AOC. However, areas pertaining to the novel technology, such as how the electrically propelled aircraft would impact the existing AOC holder's overall operations and safety, would need to be considered and evaluated. In addition, AOC holders will also need to anticipate and plan for operational complexities that may be unique to eVTOL aircraft, such as performance limitations in adverse weather conditions. Emergency response procedures should be developed or updated to address scenarios involving sudden severe weather. See **Annex B** for additional descriptions and guides for the AOC process.

Considerations for Vertically Integrated Original Equipment Manufacturers

Some eVTOL aircraft original equipment manufacturers (OEMs) may be vertically integrated. This may present challenges to SoOs in granting Design Organisation Approvals (DOA), Production Organisation Approvals (POA), Air Operator Certificates (AOC), Aviation Training Organisation (ATO) approvals, and Part 145 approvals to one single entity, as conflicts of interest are likely. While it is commonplace for AOC holders to hold multiple approvals to conduct training or maintenance on their aircraft, it is uncommon for the OEM to hold such approvals. Such integration with the OEM could compromise safety oversight, particularly if the OEM influences multiple facets of the aircraft's lifecycle, from design and production to operations and maintenance. The following measures could be considered to address these concerns:

Segregation of Roles and Responsibilities
Maintaining separation between Design Organisation (DO) and/or Production Organisation (PO) management and staff from operational functions (i.e., air operations, training, and maintenance) may help prevent conflicts of interest in decision-making and ensure impartiality in safety-critical operations.

Independent Quality Audits and Oversight
Ensuring that DO and/or PO quality systems are segregated and remain independent from operational functions (i.e., air operations, training, and maintenance) may contribute to more objective assessments and greater transparency in monitoring compliance and safety performance.

Enhanced CAA Oversight
Vertically integrated OEMs may require enhanced CAA oversight (e.g., through more frequent inspections and audits) to ensure that conflicts of interest do not affect operational safety and standards.

Considerations for Certificate of Registration and Certificate of Airworthiness

Article 20 of the Chicago Convention requires every aircraft engaged in international air navigation to bear its appropriate nationality and registration mark. The registration requirements for eVTOL aircraft are expected to be in accordance with the State's national regulations in compliance with ICAO Annex 7 (ICAO, 2012).

For international operations, Article 31 of the Chicago Convention states that "every aircraft engaged in international navigation shall be provided with a valid Certificate of Airworthiness issued or rendered valid by the State in which the aircraft is registered." A Contracting State is required to issue a Certificate of Airworthiness (CoA) based on satisfactory evidence that the design of the aircraft complies with the appropriate airworthiness requirements.

In general, it is expected that a State's existing rules and regulations for the issuance of CoA will need to be updated for eVTOL aircraft, primarily as the emergent eVTOL aircraft design architectures are not directly addressed by an existing ICAO aircraft classification (see Part 1 for details of eVTOL aircraft classification and configurations).

Some considerations to support the review and updating of rules and regulations concerning CoAs are as follows:

→ Establishing a clear framework for the classification of eVTOL aircraft designs will facilitate the regulatory changes and development of requirements related to the issuance of a CoA (e.g., minimum equipage), specific to the characteristics and limitations of the respective aircraft design architecture (see **Part 1** for details).

→ As a pragmatic approach to phasing in eVTOL aircraft operations, regulations and equipage requirements for non-commercial eVTOL aircraft operations could be differentiated from those for commercial eVTOL aircraft, with the CoA requirements moderated according to the Target Level of Safety (TLOS) applicable to the type of non-commercial operations.

→ Data recorders (e.g.,cockpit voice recorders, flight data recorders, or lightweight data recorders) could serve as a significant tool in enhancing knowledge on the novel technologies and operations of eVTOL aircraft, and could therefore potentially help accelerate the maturity of the technology and requirements for safety governance.

→ In existing SARP, additional instruments and equipment beyond the minimum necessary equipment for the issuance of CoA are prescribed for helicopters in ICAO Annex 6, Part III (ICAO, 2022b) as may be required for various circumstances or kinds of routes. eVTOL aircraft requirements could also take reference from the precedence of helicopters in this regard.

As an additional reference related to the issuance of CoAs, **Annex C** details a typical set of documents that are expected to be submitted by the operator for the initial CoA.

Considerations for Airworthiness of eVTOL Aircraft

The considerations for the airworthiness of eVTOL aircraft are expected to primarily follow the regime of existing regulations. Based on existing regulations, the prospective operator is required to develop a Maintenance Control Manual (MCM) that outlines the procedures and processes to ensure that the aircraft is maintained in accordance with the required airworthiness standards for continued safe operation. This manual includes details of the Aircraft Maintenance Programme, and any contracted maintenance organisations. The MCM is a document that needs to be approved by the SoO.

The Aircraft Maintenance Schedule (AMS), which is a subset of the Aircraft Maintenance Programme, is typically developed from the Maintenance Planning Document or maintenance tasks as outlined in the maintenance manuals. These manuals are provided by the aircraft manufacturer as part of the Instructions for Continuing Airworthiness.

The establishment of robust continuing airworthiness procedures is paramount. This encompasses implementing proactive maintenance schedules that may exceed the minimum requirements specified by manufacturers, and establishing thorough inspection protocols and comprehensive reporting mechanisms. Operators are also expected to produce comprehensive documentation to substantiate the aircraft's airworthiness and its adherence to national standards, thereby demonstrating their commitment to upholding safety and regulatory compliance. Airworthiness Directives (ADs) issued by the State of Design (SoD) address safety concerns related to the aircraft. Operators are required to incorporate these ADs into their maintenance programmes. Compliance with these directives is typically reviewed through regular audits and inspections by a CAA. These oversight activities help to ensure that operators are fulfilling safety requirements and maintaining the continued airworthiness of eVTOL aircraft.

The novelty of eVTOL aircraft presents an opportunity for the industry to leverage advanced methods and technologies for aircraft maintenance. Some of the methods and technologies that may be introduced are as follows:

- → **Usage-Based Maintenance:** Shifting from a conventional time-based method of prescribing maintenance intervals to a usage-based method may help optimise maintenance schedules and component life by focusing on actual performance data. This approach involves recording the component life based on flight data collected through real-time sensors.
- → **Predictive Maintenance:** A more advanced stage to usage-based maintenance involves coupling the real-time sensor data with data analytics methods to predict component failures and enable proactive maintenance. Such predictive maintenance has the potential to better optimise repair schedules and reduce maintenance costs by replacing components only when necessary.
- → **Remote Monitoring and Diagnostics:** Internet of Things sensors and technology can now enable the transmission of real-time flight and system data to ground facilities for better-informed decision-making in the maintenance and repair of aircraft.

Based on existing regulatory regimes, all maintenance on certified aircraft, including work on any associated components, would need to be carried out by a Part 145 Approved Maintenance Organisation (AMO) that is approved by the SoR of the aircraft. If an AOC holder is to contract maintenance work on their aircraft to a Part 145 maintenance organisation, the operator will need to ensure that the contracted Part 145 AMO has trained personnel with the appropriate licence ratings to certify the release of work on the aircraft and that the organisation is approved by the State for work on the eVTOL aircraft and its components. An operator may also perform its own maintenance work if it is approved by the SoR to exercise Part 145 maintenance organisation related activities on its own aircraft.

The organisation maintaining eVTOL aircraft will require equivalent certifying staff that hold appropriate type licences to perform a Release to Service on the maintenance tasks carried out on the aircraft. There are likely to be some unique requirements for certifying staff, especially in consideration of how the eVTOL aircraft and their components have been certified. For example, the propulsion system (i.e. engine/electric motors) may in some cases be part of the aircraft Type Certificate (TC) instead of being issued a separate engine TC, which may affect how personnel ratings are designated for the eVTOL aircraft maintenance tasks.

In eVTOL aircraft that rely on batteries as their primary power source, the replacement or recharging of batteries may constitute a maintenance activity unique to such aircraft. Some eVTOL aircraft may be designed to allow battery assemblies to be swapped between flights, while others may require the batteries to be recharged between flights by plugging the aircraft into a power source.

Under existing maintenance practices, the removal and installation of line replaceable units are carried out by licensed maintenance personnel, and a maintenance release is required after the task is completed. However, it can also be argued that battery swapping could be considered a refuelling task, which in conventional aircraft operations, does not require a maintenance release. As a first principle, a maintenance release may be more appropriate if the task is complex and/or requires further inspection and testing after the replacement of the battery unit.

A summary of considerations for the approval of the organisation and personnel carrying out maintenance of eVTOL aircraft is presented in **Annex D**.

Considerations for Pilot Licences

In accordance with Annex 1 to the Convention on International Civil Aviation (ICAO, 2022a), Contracting States must ensure that flight crew members of aircraft on its registry are authorised to pilot the aircraft by the SoR or by any other Contracting State. The pilots' licences must also be rendered valid by the SoR of the aircraft. A licence means an authorisation issued by a Contracting State that authorises the holder to pilot an aircraft.

While the pilot licence requirements for helicopters and aeroplanes are well established for many CAAs, the uniqueness of eVTOL aircraft may be such that the regimes adopted for helicopters and aeroplanes are not directly applicable. New rules and regulations, or modifications to existing ones, may be necessary to accommodate the granting of pilot licences for various licence types, depending on the design of the eVTOL aircraft — whether classified as rotorcraft, aeroplanes, or powered-lift vehicles. CAAs may also need to work with the SoD of an eVTOL aircraft to develop suitable training requirements that cater to the specific design features of the eVTOL aircraft. ICAO Annex 1 includes a transitional measure that allows using the prior experience of pilots holding aeroplane or helicopter licences for a powered-lift type rating. However, beyond such transitional measures, the development of a dedicated licensing regime specifically tailored to eVTOL aircraft may better account for the unique operational requirements of such aircraft.

The following are some areas to consider in the development of a pilot licensing regime:

- → eVTOL aircraft will very likely operate within existing airspace structure and will need to comply with existing rules that apply to the operation of helicopters and aeroplanes (i.e., existing Rules of the Air).
- → Piloted eVTOL aircraft operations are expected to initially be limited to flights under Visual Flight Rules (VFR), with progressive expansion to flights under Instrument Flight Rules (IFR) and others (such as night VFR, IFR instrument landing system) as eVTOL aircraft operations mature. Commercial eVTOL operations may share several similarities with commercial passenger-carrying operations currently conducted with smaller helicopters under VFR.
- → eVTOL aircraft pilots will need to meet existing medical standards for manned aircraft personnel as per existing regulations.
- → There is precedence in conventional manned aviation for adapting flight crew training in response to the introduction of novel technologies. For example, the introduction of novel flight control systems by Airbus required CAAs to assess and manage new flight crew competencies and procedures. The processes adopted by CAAs in such cases may offer useful reference for the introduction of novel technology in eVTOL aircraft.
- → As a novel aircraft type, pilot training requirements will be informed by the aircraft certification process. The aircraft OEM should define the required training pathway as part of their submission of the Operational Suitability Data (OSD).
- → Training for pilots who hold aeroplane or helicopter licences (Commercial Pilot Licence / Airline Transport Pilot Licence) may vary. Additional theoretical training in operational requirements not previously encountered when operating aircraft in other categories may therefore be required.
- → While conventional aircraft regulations require dual controls for operations such as flight instruction, most eVTOL aircraft are designed or intended to only operate with a single set of controls. The FAA has analysed the safety intent of dual-control requirements and suggests two main alternative Means of Compliance (MoC) use of a functioning throwover control, or the use of Full Flight Simulators. Deciding which alternative is more appropriate will depend on the aircraft design (noting that some aircraft will be designed such that throwover controls cannot be practically used). The principles and treatment

of these two alternatives are extensively described and discussed in FAA's Special Federal Aviation Regulation (SFAR) on the Integration of Powered-lift: Pilot Certification and Operations (FAA, 2024).

- → As flight training operators for type ratings are likely to be located outside the State, the CAA may consider leveraging existing systems used to grant pilot type ratings for other aircraft categories.
- → The ability to simulate non-normal or emergency conditions in eVTOL aircraft may be limited, and the use of a flight simulation training device may be necessary to ensure pilots maintain the required level of competency to conduct flights in the aircraft safely.
- → It is anticipated that aircraft manufacturers will either partner with specialist training providers or develop in-house training capabilities to provide the required pilot training.
- → The CAA may require pilots who hold aeroplane or helicopter licences with an additional powered-lift type rating to demonstrate competency periodically in a powered-lift aircraft. An aircraft operator will need to develop training and assessment programmes to ensure pilot proficiency is maintained.
- → Any changes to existing operating standards or requirements will need to be reflected in the training for the type rating to ensure compliance with any new requirements.
- → CAAs may need to explore strategies for qualifying Aviation Safety Inspectors on eVTOL aircraft, given the unique nature of these aircraft and the limited availability of conventional training resources. One potential approach could involve recognising and leveraging the expertise of aircraft OEMs. Specifically, CAAs could consider provisionally accepting training provided by OEM instructor pilots, even if these instructors are not authorised flight instructors for the eVTOL aircraft.
- → A tailored regime and approach may be necessary for the training and qualification of the initial cohort of eVTOL aircraft pilots, given the lack of approved training organisations and authorised flight instructors for the cohort.

Considerations for Aircraft Maintenance Licences

In accordance with Article 32 of the Chicago Convention, ICAO Contracting States must ensure that maintenance personnel working on aircraft are licensed. The current Aircraft Maintenance Licence (AML) framework has a proven track record of ensuring safety in conventional aircraft maintenance. This success is driven by its comprehensive nature to ensure that licence holders have a solid foundation in aircraft knowledge, alongside adequate practical experience and type-specific certifications.

This well-established system can be effectively applied to certify maintenance personnel for eVTOL aircraft. However, for a smooth transition, there is a need to address some key distinctions between conventional and eVTOL aircraft, such as the following:

Novel Aircraft Architecture
Unlike conventional aircraft with established layouts, eVTOL aircraft may have diverse configurations, such as tilting rotors or ducted fans. Maintenance training should be adapted to address these designs and their unique maintenance requirements.

Electric Propulsion System
eVTOL aircraft will utilise electric propulsion systems. Training modules should therefore cover the intricacies of electric motors, safe battery handling protocols, working with high-voltage systems, and the maintenance of eVTOL aircraft electronic control systems.

Advanced Sensors and Computer Systems
Most eVTOL aircraft designs will leverage advanced computer systems and new sensors. This would necessitate a shift in skill sets from physical inspection towards technical competencies, such as analysing sensor data (e.g., battery health, motor performance) for fault diagnosis and utilising diagnostic software to troubleshoot complex electronic control systems.

Specialised Ground Support Equipment
The unique design of eVTOL aircraft may introduce new types of maintenance Ground Support Equipment (GSE) that create a knowledge gap for maintenance personnel regarding these tools. Examples include GSE for eVTOL aircraft charging and specialised diagnostics equipment for onboard computer systems and sensor data.

The following strategies could be considered to address knowledge gaps in eVTOL aircraft maintenance:

Collaboration with Original Equipment Manufacturers
Collaborating with eVTOL aircraft OEMs can allow for the leveraging of their technical expertise and experience to develop and approve type rating training programmes. These programmes are expected to align closely with the OSD of the respective aircraft.

Enhancing Basic Knowledge Training with Electric Engine Modules
As electric aircraft become more prevalent, the incorporation of dedicated modules on electric engine maintenance into the basic knowledge portion of the AML framework may better equip all aircraft maintenance personnel with a working understanding of electric propulsion systems, thus preparing them for future specialisation in eVTOL aircraft maintenance.

In a typical EIS of an aircraft, AML type training is provided by the OEM to the air operator and its maintenance service providers. Training for a SoR's airworthiness inspectors may be provided by the air operator. Such training can take several weeks, and the planning of AML training and qualification would need to consider that appropriately licensed aircraft maintenance engineers will be required at the time that the aircraft is received from the OEM for its first release-to-service sign-off in a State. In the case of cross-border operations, appropriately licensed aircraft maintenance engineers would be needed at overseas stations to conduct defect rectification if necessary.

Considerations for Supporting Infrastructure

eVTOL aircraft may have lower noise levels that enable them to access and operate in areas that conventional civil aviation does not currently operate within. The novel aircraft designs may require unique ground infrastructure to support their operations, such as take-off and landing areas and terrestrial installations supporting communications, navigation, and surveillance. These new requirements may generate new hazards or considerations that would require changes to existing regulations, guides, or advisories to ensure adequate governance and the safe and efficient operation of these aircraft. The following are some areas for consideration in reviewing the adequacy of governance frameworks and standards for such supporting infrastructure.

- → **Vertiports:** The vertical take-off and landing capabilities of eVTOL aircraft would have to be supported with dedicated infrastructure for passenger or cargo transport. The term vertiport is increasingly used to describe areas designated for the landing, take-off, and movement of eVTOL aircraft. Some considerations may cover the approval process for the establishment of a vertiport, site selection (e.g., integration with existing aerodromes or heliports supporting mixed operations), vertiport design standards, vertiport certification requirements, airspace considerations around the vertiport, and personnel qualifications. See **Annex E** for details of these considerations.

- **Charging and Energy Management:** Given that eVTOL aircraft are powered by electric propulsion systems, charging infrastructure will be a critical component of ground infrastructure to support the continuous operations of such aircraft. The following are some considerations to be taken in setting up charging stations and energy management systems at vertiports:
  - **Standards for Charging Infrastructure:** Establishing and adhering to international standards for the design of charging infrastructure will help ensure that eVTOL aircraft from different manufacturers can be charged safely and efficiently. Standards could cover specifications for elements such as charging connectors, power requirements, and charging speed. Additionally, it would be crucial to integrate appropriate Aerodrome Rescue and Fire Fighting (ARFF) standards that address the unique risks associated with eVTOL charging operations. This includes considerations for specialised fire suppression systems, emergency response protocols for electrical fires, and training for personnel to handle potential incidents during the charging process.
  - **Energy Management Systems:** Effective energy management systems, such as smart grid integration, renewable energy sourcing, and the ability to manage peak loads may be essential to meet the energy demands of eVTOL aircraft while avoiding blackouts or system overloads.
  - **Battery Swapping:** eVTOL aircraft may be designed to replenish their power through on-aircraft charging or battery swapping. Battery swapping may reduce aircraft turnaround times compared to on-aircraft charging but may require dedicated infrastructure and operational procedures to support the safe and efficient swapping of depleted batteries with fully charged ones.
  - **Sustainable Energy Use:** Charging stations powered by renewable energy sources, such as solar or wind, may help reduce the carbon footprint of eVTOL aircraft operations. Integrating energy storage solutions like battery storage systems could be considered to help manage fluctuations in renewable energy generation and to ensure a consistent power supply.
- **Ground Handling and Logistics:** Ground handling and logistics operations that minimise aircraft turnaround times while maintaining safety and compliance with regulatory requirements are essential for smooth operations in high-traffic aerodromes. The following are some considerations for vertiports:
  - **Ground Handling Procedures:** Procedures will need to be developed for eVTOL aircraft recharging, passenger loading and unloading, and maintenance checks. These procedures should be optimised to ensure the rapid turnover of eVTOL aircraft to maximise operational efficiency and optimum vertiport capacity.
  - **Aircraft Towing/Parking and Luggage Transport:** Advanced technologies could be leveraged to facilitate ground handling of eVTOL aircraft and cargo or passenger luggage. Automated systems, such as automated ground vehicles, may be useful for such ground movement, while freeing up human operators for more complex tasks.
  - **Ground Safety Management:** Measures such as Foreign Object Debris (FOD) control, wildlife management, and procedures for safe movement of ground vehicles, personnel, and passengers at the apron and aircraft stands would typically be essential to ensure the safety of operations at the vertiport.
  - **Maintenance and Repair Facilities:** Dedicated on-site maintenance and repair facilities within vertiports would support timely return to service of eVTOL aircraft with defects. These facilities would require suitable tools and equipment, such as diagnostic equipment, tools for quick repairs or battery testing, and replacement stations.

Considerations for Airspace and Flight Rules

While trials of eVTOL aircraft may be conducted in segregated airspace, eVTOL aircraft operations will eventually share airspace with conventional manned aircraft. In such cases, eVTOL aircraft would be expected to comply with the existing Rules of the Air (i.e., ICAO Annex 2 (ICAO, 2024)).

eVTOL aircraft operations will also likely require the provision of Air Traffic Control (ATC) services as specified within Air Traffic Services (ICAO Annex 11 (ICAO, 2018)). Within controlled airspace, ATC is presently the primary source of information and airspace situational awareness. Hence, ATC provide instructions to each aircraft or user in the airspace for every change (e.g., change in altitude, speed, heading). This could also be the primary mode of air traffic management (ATM) for manned (piloted) eVTOL aircraft. However, some modifications may be needed to support the integration of eVTOL aircraft operations into the existing ATM system, particularly regarding communication, navigation, and surveillance systems. As eVTOL aircraft operations are expected to take place within urban airspaces, ATM systems may have to provide real-time data on aircraft locations, low-altitude communications, tracking of flight paths, and vertiport availability to prevent congestion and ensure safe operations.

As eVTOL aircraft technology advances and flight operations scale up, new principles for ATM, airspace construct, navigation standards, or flight rules may need to be developed to address the aircraft's unique flight performance characteristics. For example, reduced noise profiles open the possibilities for routes in areas and heights that are currently not readily accessed by conventional aircraft.

Operations in a low-level airspace in urban environments may introduce meteorological hazards that are unique to the environment and need to be considered in eVTOL aircraft flight routes and airspace. For example, turbulence and wind shear in the vicinity of high-rise infrastructure and buildings may pose challenges to the safe and efficient flight of eVTOL aircraft. Microbursts and downdrafts may also occur in urban canyons. The urban heat island effect, where urban areas are significantly warmer than surrounding rural areas, could also create localised weather patterns that may impact eVTOL aircraft flight operations. Flight routes may also need to consider potential issues of electromagnetic compatibility or electromagnetic interference affecting eVTOL systems in densely populated and built-up areas.

Regulatory frameworks will play a critical role in managing the integration of eVTOL aircraft operations into existing airspace. This includes establishing rules for flight paths, altitude deconflictions or restrictions, and clearly defined communication protocols with ATC. These measures will be critical to ensure the safe coexistence of eVTOL aircraft with traditional aircraft in non-segregated airspace.

Considerations for Noise and Environmental Impact

ICAO Annex 16 Volume 1 (ICAO, 2017) requires that the documents attesting to noise certification be approved by the SoR and that each aircraft be issued with a noise certificate. However, there are presently no published noise standards that apply specifically to eVTOL aircraft. In the absence of standards, SoDs certifying an aircraft would typically develop noise standards as part of the certification process, and SoRs may choose to refer to these criteria when issuing a noise certificate.

Where the SoD has not developed eVTOL-specific noise standards, CAAs may draw reference to the noise standards developed for helicopters as published within ICAO Annex 16 for reference when issuing a noise certificate for eVTOL aircraft. However, the noise standards developed for helicopters do not specifically consider potential eVTOL aircraft operational noise and environmental impact on urban areas. In lieu of a noise standard, alternative means such as restricting flight paths and operating hours may need to be considered when operating eVTOL aircraft in urban areas.

Considerations for Aviation Security and Cybersecurity

Aviation security aims to safeguard civil aviation against acts of unlawful interference that would otherwise pose significant risks to public safety and national security, and incur substantial societal and economic consequences. The foundational principles for international aviation security standards are established in Annex 17 to the Chicago Convention on International Civil Aviation Organization (ICAO, 2022c).

Cybersecurity is a specific element of aviation security. It is defined by ICAO as the body of technologies, controls and measures, and processes and practices designed to ensure confidentiality, integrity, availability, and overall protection of systems, networks, programmes, devices, information, and data from attack, damage, unauthorised access, use, and/or exploitation.

The existing considerations for aviation security in manned aircraft operations, including physical safeguards, personnel and baggage screening, access control systems, aircraft search procedures, and cybersecurity measures such as data encryption, are generally applicable to eVTOL aircraft when conducting cross-border operations. Some CAAs may find it beneficial to apply these considerations to domestic eVTOL operations. Comparatively, eVTOL aircraft operations are expected to be more digitally interconnected with both aeronautical and non-aeronautical data sources, introducing new surfaces for malicious attacks and increasing the need for more robust cybersecurity protection. Furthermore, if eVTOL aircraft operations evolve to be a critical part of national transport infrastructure, it may become a prime target for malicious intents. Some guidelines outlining the expected security requirements from operators, including aviation security and cybersecurity, are provided in **Annexes F and G** to **Part 2**, respectively.

ACTION PLAN

To facilitate the EIS of eVTOL aircraft operations, regulations must be designed to mitigate the new hazards and risks introduced by such operations. States may consider one, or a combination of the two approaches, to accommodate eVTOL aircraft operations within their regulatory framework:

(1) Create new dedicated regulations for eVTOL aircraft operations, and/or

(2) Adapt existing manned aviation regulations.

The development of a mature set of eVTOL aircraft regulations may iterate over time and may include transitional arrangements. The maturity and scale of eVTOL aircraft operations will influence this development process.

The approaches and steps involved are further described as follows:

Creating New Dedicated Regulations for eVTOL Aircraft Operations

The creation and promulgation of new and dedicated regulations may be ideal for some CAAs to address the unique technical, operational, and safety aspects of eVTOL aircraft operations. Creating dedicated aircraft operational standards and requirements that are separate from existing manned aviation standards and requirements could facilitate better clarity and greater flexibility to accommodate ongoing advancements in eVTOL technologies and operations. However, with limited use cases and operational data, establishing a regulatory framework may require an extended timeframe. The timeline will vary depending on each State's regulatory development process and the extent of collaboration and input by relevant stakeholders.

Developing new regulations involves obtaining a consensus on requirements that are practically implementable for initial and continuing airworthiness, as well as for operational certification. The steps involved in the process are illustrated in **Figure 1** and further detailed as follows:

Figure 1 — Action Plan: Creating New Dedicated eVTOL Aircraft Operational Regulations

Build Capabilities

Identifying requirements that ensure public and operational safety, and mitigate the hazards and risks of eVTOL aircraft operations, entails that personnel involved in the regulatory work must have an adequate understanding of relevant eVTOL aircraft technologies and types of operations. This may involve collaboration with the SoDs, training by OEMs, and specific technology training from the local or international industry partners. CAAs may also refer to Part 5 for further details and considerations for capability building.

Establish Working Group(s)

The next steps in the process require the efforts of focused working groups that are dedicated to completing the tasks required. It is important to appoint personnel with the requisite knowledge and experience for the rule-making activity and to clearly specify the Terms of Reference for the working groups (see EASA 2021 for an example). Where necessary, CAAs may convene or leverage official technical specialists to support the working groups. For example, technical bodies supporting the European Union Aviation Safety Agency (EASA) comprise representatives from EASA Member States and the European Commission for technical areas (e.g., aerodromes, ATM/air navigation services, air crew, air operations, production and continuing airworthiness, general aviation, safety management, open and specific category of UAS) (EASA, 2024).

Develop Regulations

Developing regulations would principally follow methods that each respective State currently applies in the development of their manned aircraft regulations. Collaboration with SoDs of eVTOL aircraft and/or with other likeminded States that facilitate eVTOL aircraft operations may serve as useful references and provide varying viewpoints on regulatory requirements and approaches. A key principle in the development of such regulations should be to work towards reducing the amount of effort needed to accomplish the approval of aircraft type design and operations, without compromising safety or the State's own unique national requirements.

Execute Regulations

This step encompasses the issuance and operationalisation of the new regulations. CAAs could continue to leverage existing regulatory processes meant for conventional aviation for both issuance and operationalisation. These may include steps such as consultation with the industry and the public before official promulgation. Additionally, to provide clarity to the industry and companies on the means to comply with the regulations, there is an associated need to develop Acceptable Means of Compliance (AMC) with the regulations. The development of AMC will likely require industry participation and could also involve the creation of industry working groups to develop consensus standards. Following the issuance of the regulations, the CAAs' role would be to provide the relevant approvals, monitor compliance, and enforce regulations.

Review Means of Governance

Continuous review of the promulgated regulations may help ensure their effectiveness and relevance, especially as more operational data and experience with eVTOL aircraft become available. Existing processes may be applied to facilitate the regulatory reviews and updates.

Adapting Existing Manned Aircraft Regulations

As an alternative to creating new regulations, adaptations may be made to a State's existing manned aircraft regulations. This adaptation could take the form of changes or additions to the existing regulations to reflect the needs and expected performance of eVTOL aircraft technologies and operations. It could also involve generating a special set of requirements derived from existing regulations to address a specific approval application. This approach is arguably shorter than promulgating new regulations but may be problematic for complex eVTOL aircraft operations, potentially resulting in extensive changes to existing regulations, such as additions or exemptions. As such, this approach may serve more effectively as an interim measure to rapidly bring initial eVTOL aircraft operations into service or to accommodate a limited set of use cases while a new regulatory framework is developed in parallel.

The steps in the action plan are very similar to the approach used in creating new dedicated eVTOL regulations. This process is illustrated in **Figure 2**, with differences described below:

Figure 2 — Action Plan: Adapting existing manned aircraft regulations for eVTOL aircraft

Build Capabilities

The actions and considerations in this step are the same as those outlined under the capability building phase for the creation of new dedicated eVTOL aircraft operational regulations.

Establish Working Group(s)

The step of appointing working groups and establishing their Terms of Reference also applies to the regulatory adaptation process. However, the requirements that need to be developed would likely be specific to the type of eVTOL aircraft and the nature of operations requested by a few applicants. It may therefore be helpful to involve the applicant (aircraft OEM or operator) in the development of the regulatory adaptations alongside the CAA. Including the aircraft OEM and operator in the working groups can bring technical and operational knowledge and expertise required for the tasks of the working groups.

Develop Adaptations

The regulatory adaptations may take the form of amendments or additions to existing manned aircraft regulations, or a set of requirements derived through the combination of select parts of the existing manned aircraft regulations.

Execute Regulations

The process of issuing and implementing regulatory adaptations will likely be less onerous compared to new regulations, depending on the process of the respective States. Once issued, the expectations to process approvals, monitor compliance, and enforce compliance still apply.

Review Means of Governance

Adaptations made to existing manned aircraft regulatory provisions may need to be further updated for clarity and relevance. Where necessary, such adaptations may be developed into a separate regulatory framework, based on emerging best practices and accumulated data.

Part 2 References

- European Union Aviation Safety Agency [EASA]. (2021, May 12). Terms of reference for rulemaking task RMT.0731 (Subtasks 1, 2, & 3) — New air mobility (Issue 2).
- European Union Aviation Safety Agency [EASA]. (2022, March). Prototype technical specifications for vertiports design (PTS-VPT-DSN).
- European Union Aviation Safety Agency [EASA]. (2024). Advisory bodies. Retrieved September 18, 2024, from https://www.easa.europa.eu/en/the-agency/advisory-bodies
- European Union Aviation Safety Agency [EASA]. (2024, June). Special conditions for VTOL-capable aircraft (Issue 2, SC-VTOL-02).
- Federal Aviation Administration [FAA]. (2024, December 27). Engineering brief no. 105A — Vertiport design.
- Federal Aviation Administration [FAA]. (2024). Integration of powered-lift: Pilot certification and operations; miscellaneous amendments related to rotorcraft and airplanes (RIN 2120-AL72).
- International Civil Aviation Organization [ICAO]. (2012, July). International standards and recommended practices, Annex 7 — Aircraft nationality and registration marks (6th ed.).
- International Civil Aviation Organization [ICAO]. (2017, July). International standards and recommended practices, Annex 16 — Environmental protection — Volume I: Aircraft noise (8th ed.).
- International Civil Aviation Organization [ICAO]. (2018, July). International standards and recommended practices, Annex 11 — Air traffic services: Air traffic control service, flight information service, alerting service (15th ed.).
- International Civil Aviation Organization [ICAO]. (2022, July). International standards and recommended practices, Annex 1 — Personnel licensing (14th ed.).
- International Civil Aviation Organization [ICAO]. (2022, July). International standards and recommended practices, Annex 6 — Part III: International operations — Helicopters (11th ed.).
- International Civil Aviation Organization [ICAO]. (2022, July). International standards and recommended practices, Annex 17 — Aviation security: Safeguarding international civil aviation against acts of unlawful interference (12th ed.).
- International Civil Aviation Organization [ICAO]. (2022). Manual of procedures for operations inspection, certification, and continued surveillance (Doc 8335, 6th ed.).
- International Civil Aviation Organization [ICAO]. (2024, July). International standards and recommended practices, Annex 2 — Rules of the air (11th ed.).

PART 02 ANNEX A

SUPPLEMENTARY CONSIDERATIONS FOR EIS OF REMOTELY PILOTED EVTOLS

Considerations applicable to the EIS of eVTOL aircraft described in Part 2 may also apply to remotely piloted eVTOL aircraft; however, a Remotely Piloted Aircraft (RPA) is a unique configuration with distinctions that introduce additional considerations. ICAO Annex 7 defines any Unmanned Aircraft (UA) piloted from a Remote Pilot Station (RPS) as an RPA (ICAO, 2012), and an RPA, its associated RPS(s), the required Command and Control (C2) link(s), and any other components as specified in its type design are collectively termed as a remotely piloted aircraft system (RPAS) (ICAO, 2024). A remotely piloted eVTOL aircraft with its associated systems is thus an RPAS by this definition.

At the ICAO level, RPAS have been steadily incorporated into the SARP since the early 2010s (e.g., Annex 1 — Personnel Licensing, Annex 2 — Rules of Air, Annex 7 — Aircraft Nationality and Registration Marks, Annex 10 — Aeronautical Telecommunications, and Annex 13 — Aircraft Accident and Incident Investigation).

More significantly, the first edition of ICAO Annex 6 Part IV (ICAO, 2024) has been published in July 2024 as SARP for international operations of RPAS certificated in accordance with Annex 8 — Airworthiness. In its first edition, Annex 6 Part IV only applies to the carriage of cargo, but the transport of passengers will be addressed in the future. Annex 6 Part IV complements Doc 10019, Manual on Remotely Piloted Aircraft Systems (ICAO, 2015), which was released in 2015.

While the provisions of Annex 6 Part IV were developed to apply to international RPAS operations, the approach taken in the SARP may also be applied to domestic RPAS operations, albeit with the requirements scaled down for applicability based on the size and/or operational range of the RPAS. States may thus consider the guidance of Annex 6 Part IV to support their development of regulations for the EIS of remotely piloted eVTOL aircraft.

In summary, the ICAO guidance highlights the following potential differences in considerations between piloted and remotely piloted eVTOL aircraft with respect to the content presented in Part 2:

- **Considerations for AOC process — RPAS Operator Certificate:** ICAO introduces the format and provisions for an RPAS Operator Certificate (ROC) to authorise an operator to conduct RPAS operations. The principles of the provisions and certificate are very similar to those of conventional AOCs, but it is implied that operators would need a ROC that is unique from any existing AOC that they may already hold. ICAO recommends SoOs to issue a single merged certificate, listing the privileges in the operations specification of that certificate, to operators approved to conduct operations under both an AOC and an ROC. However, the operator would still need to complete all requirements to obtain an ROC independently from those required to obtain an AOC.
- **Considerations for Certificate of Registration and Certificate of Airworthiness — RPA and RPS May Not Be in the Same State:** With regards to the general jurisdiction of laws, regulations, and procedures to approve operations, operators of RPAS could be subject to the jurisdiction of multiple States if the RPA is operating in a different State from where the RPS is located. In such cases. RPAS operators are expected to comply with the laws, regulations, and procedures of both States.
- **Considerations for Airworthiness of Aircraft — RPS and C2 Link:** A key distinction in RPAS is the addition of an RPS, which forms an integral part of the type design and therefore an element to be considered in both initial and continuing airworthiness. Additionally, the criticality of the C2 link is significantly higher for RPAS, and ICAO has issued several pieces of guidance outlining requirements for the C2 link. A manual on C2 links for RPAS is expected to be published by ICAO in due course.
- **Considerations for Pilot Licences — Remote Flight Crew Member, Remote Pilot, and Remote Pilot-in-Command:** The RPS may be operated by multiple remote flight crew members, while a remote pilot is a person who manipulates the flight controls of the RPA in flight. A remote pilot-in-command is the remote pilot designated by the operator as being in command and charged with the safe conduct of a flight. Licensing regimes and qualification requirements (i.e., training, experience, and currency) must be considered for all three roles of remote flight crew member, remote pilot, and remote pilot-in-command.
- **Considerations for Airspace and Flight Rules:** It is expected that most RPAS will be operated in accordance with Instrument Flight Rules (IFR) and therefore require considerations in provisions related to operating under such conditions. The existing requirements for flights under IFR would apply to RPAS. Additionally, the ICAO SARP require RPAS operating in accordance with IFR to be equipped with ground proximity warning systems (i.e., with forward-looking terrain avoidance function) or similar capabilities, and Detect and Avoid (DAA) capability that enables the remote pilot to avoid conflicting traffic and other hazards as a minimum equipment.

There are some areas, such as cybersecurity, maintenance of the control station, etc., that are not covered in this edition of the publication and may be better addressed in future editions when more information on remotely piloted eVTOL aircraft becomes available.

Part 2, Annex A References

- International Civil Aviation Organization [ICAO]. (2012, July). International standards and recommended practices, Annex 7 — Aircraft nationality and registration marks (6th ed.).
- International Civil Aviation Organization [ICAO]. (2015). Manual on remotely piloted aircraft systems (RPAS) (Doc 10019, 1st ed.).
- International Civil Aviation Organization [ICAO]. (2024, July). International standards and recommended practices, Annex 6 — Part IV: International operations — remotely piloted aircraft systems (1st ed.).

PART 02 ANNEX B

AIR OPERATOR CERTIFICATION GUIDE

A major milestone in the EIS process is the AOC approval process by the State's CAA to the commercial operator. The purpose of an AOC is to certify that specified commercial air transport operations are authorised by the SoO and are to be conducted in compliance with the State's applicable regulations and rules. An AOC comprises two parts — the AOC itself and the associated operations specifications that define the scope and conditions of the operation. The general process flow for obtaining an AOC can be found in ICAO Doc 8335 (ICAO, 2022).

During the certification process, the CAA will need to be satisfied that the eVTOL aircraft operator applicant, who will have the ultimate responsibility for the safety of the operation, is eligible for the issuance of an AOC and has the ability and competence to conduct safe and efficient eVTOL aircraft operations in compliance with applicable aviation and safety regulations. In addition to assessing the applicant's competence, the CAA is generally expected to provide guidance on organisational and procedural matters that will result in safe, efficient, and successful operations, thereby enhancing public confidence in this novel aircraft operation.

At the commencement of the certification process, CAA inspectors are typically appointed, with one designated as the project manager. A certification team comprising qualified and experienced inspectors with the necessary specialisations, such as operations, licensing, maintenance, and electrical propulsion, would also be assembled.

As each operation may differ significantly in complexity and scope, the project manager and certification team will need to be accorded considerable latitude in decision-making and in formulating recommendations to their Directorate General or approving authority during the certification process. The final recommendation by the project manager, and decision by the approving authority to grant an AOC, are to be based on the determination that the applicant meets the State's regulatory requirements and is in full compliance with all air navigation regulations.

The AOC application and approval process is best organised in phases and will normally take the following sequence:

→ Pre-Application Phase
→ Formal Application Phase
→ Document Evaluation Phase
→ Demonstration and Inspection Phase
→ Award of AOC

Pre-Application Phase

A prospective operator who intends to apply for an AOC would typically enter into preliminary discussions with the CAA. During this phase, the applicant should be provided with complete information concerning the type of operations that may be authorised, the data to be provided by the applicant, and the procedures governing the processing of the application.

Formal Application Phase

Upon completion of the assessment of the financial, economic, and legal aspects of the application, and after any deficiencies have been corrected, a provisional determination may be made regarding the general feasibility of the operation. If the operation is found to be provisionally acceptable, the second phase of the certification process, the formal application phase, may proceed. The applicant must then submit the formal AOC application, accompanied by the required documentation, in accordance with the manner prescribed by the CAA.

Document Evaluation Phase

The document evaluation phase involves a detailed examination of all documentation and manuals provided by the applicant to establish that all regulatory requirements are included and adequately covered. Specific considerations in the context of eVTOL aircraft operations for documents required in the AOC process are shown in **Table B-1**.

Item	Requirements	Considerations
Operations Manuals	• Operations manuals should provide guidelines and procedures for the robust, efficient, and safe operation of eVTOL aircraft and related systems. It is essential that all personnel involved in the operation of the aircraft and its equipment are familiar with the contents of these manuals to ensure safe, efficient, secure, and effective operations, in accordance with the requirements of the OEM, industry standards, and best practices.	• See **Appendix 1 and 2** for sample contents of operations manuals.

Table B-1 — Considerations for AOC Documents

Item	Requirements	Considerations
Maintenance Control Manual (Engineering Exposition Document)	• The Maintenance Control Manual (MCM), approved by the State's authority, details how all maintenance activities are performed in accordance with the State's regulations for aircraft operations. It covers the aircraft maintenance programme, training, quality control, documentation control, monitoring and rectification of defects, limitations, and includes all concessions granted by the Authority.	• The MCM is part of the AOC approval process, and its contents are expected to be similar for the operation of eVTOL aircraft. • For eVTOL aircraft operations, the MCM may need to specifically address the training requirements for service providers, including maintenance contractors at both base and overseas stations. Contracted Maintenance and Repair Organisations will need to be approved by the State to perform maintenance on eVTOL aircraft.
Reliability Manual	• The reliability programme is a subset of the aircraft maintenance programme. The reliability manual, approved by the State, outlines the framework, policies, and procedures for reporting, collecting, analysing, and taking corrective action on aircraft defects. • The reliability manual is approved as part of the AOC approval process.	• Due to the novel design and technology of eVTOL aircraft, it will take considerable time to gather sufficient data for meaningful reliability analysis. • As with all first-of-type aircraft, world fleet data (from the OEM) may be used for reliability monitoring rather than data from just the AOC fleet.
Refuelling Manual	• For standard aircraft, the remaining fuel onboard, the fuel uplifted, and the final fuel onboard are checked before flight by both maintenance personnel and pilots to identify any discrepancies. The fuel onboard can be verified through physical inspection. • New requirements may need to be developed for the following: › Swapping or charging of batteries › Refuelling of hydrogen fuel	• States may need to consider how the aircraft's battery capacity or hydrogen quantity is checked before flight by maintenance personnel or pilots, and the accuracy of these indicators and readings. • As with jet fuel, the capacity of the batteries or quantity of hydrogen fuel uplifted/onboard would need to be recorded in the aircraft logbook prior to flight.
Minimum Equipment List	• The Master MEL (MMEL) is produced by the aircraft manufacturer and approved by the State's certification authority. • Based on the MMEL, the operator develops its MEL for its aircraft fleet type and submits it to the State's authority for approval.	• The MEL for eVTOL aircraft will likely differ from that of standard aircraft due to novel designs and technology. • MEL items related to propulsion units, control systems, batteries/hydrogen fuel systems, and flight control systems may be unique for eVTOL aircraft.

Table B-1 — Considerations for AOC Documents

Demonstration and Inspection Phase

Inspections in this phase typically involve inspections of the main base and station facilities, the operational control and supervision facilities, and the training programmes and associated training facilities. Demonstrations may involve showcasing the operational control system, emergency evacuation procedures, and may also include demonstration flights.

Award of AOC

The certification phase is the final phase of the AOC certification process. It commences when the project manager has determined that all certification requirements, both operational and economic, have been satisfactorily met, and that the eVTOL aircraft operator is capable of complying with the applicable regulations. The operator needs to also demonstrate the ability to conduct safe, efficient, and reliable commercial operations. The culmination of this phase is the issuance of the AOC.

Part 2, Annex B References

→ International Civil Aviation Organization [ICAO]. (2022). Manual of procedures for operations inspection, certification, and continued surveillance (Doc 8335, 6th ed.).

PART 02 ANNEX B APPENDIX 1

OPERATIONS MANUAL EXAMPLE A

** This is a basic template for a typical Operations Manual. It can be further customised by adding specific details to provide a comprehensive guide for employees and stakeholders on the policies, procedures, and guidelines within the organisation.

Table of Contents

01 Introduction

The introduction section provides an overview of the organisation, its mission, and the purpose of the operations manual. It outlines the scope and applicability of the manual and may include a brief history of the organisation.

02 Organisational Structure

This section includes an organisational chart depicting the hierarchy of the organisation. It also outlines the roles and responsibilities of key personnel, including department heads, managers, and other relevant staff.

03 Policies and Procedures

This section details the general operational policies and specific procedures for various tasks or processes within the organisation. It may cover areas such as procurement, inventory management, customer service protocols, and more. Compliance to national regulations and regulatory policies may be included in this section.

04 Safety and Security

This section outlines emergency procedures, which may include eVTOL aircraft related incidents such as battery fires and system failures, along with safety protocols and security measures within the organisation. This may include general fire evacuation plans, first aid procedures, workplace safety guidelines, and security protocols for physical and digital assets.

05 Quality Control

This section focuses on quality assurance processes, standards, and benchmarks for quality. It may include quality control procedures, inspection protocols, and measures for continuous improvement.

06 Human Resources

The human resources section covers recruitment and onboarding processes, employee ethics, code of conduct, performance management, eVTOL aircraft operations, training and development, and policies related to employee benefits and leave.

07 Financial Management

This section outlines the organisation's financial management processes, including budgeting, expense approval procedures, financial reporting requirements, and internal controls related to financial transactions.

08 Information Technology

Here, the organisation's IT infrastructure and support, data security measures, software and hardware usage policies, and disaster recovery plans are detailed.

09 Facilities Management

This section covers maintenance procedures, facility usage guidelines, environmental sustainability initiatives, and any other relevant information related to the management of physical facilities.

10 Appendices

The appendices may include additional reference materials, forms, templates, and any other supplementary documents that support the content of the operations manual.

PART 02 ANNEX B APPENDIX 2

OPERATIONS MANUAL EXAMPLE B

** **This is a basic template for a typical Operations Manual. It can be further customised by adding specific details to provide a comprehensive guide for employees and stakeholders on the policies, procedures, and guidelines within the organisation.**

Table of Contents

01 Introduction

This manual provides high-level guidelines and procedures for the efficient and safe operation of "eVTOL aircraft and related systems." It is essential for all personnel involved in the operation and maintenance of the aircraft and equipment to familiarise themselves with the contents of this manual.

02 Purpose

The purpose of this manual is to ensure the safe and effective operation of the eVTOL aircraft and related systems in accordance with the OEM's requirements, industry standards, and best practices. It aims to minimise the risk of incidents and accidents, ensure equipment longevity, and maintain operational efficiency and safety.

03 Scope

This manual applies to all personnel involved in the operations, maintenance, and troubleshooting of eVTOL aircraft and its related systems. It covers standard operating procedures, safety guidelines, and emergency protocols.

04 Roles and Responsibilities

4.1 Management

Provide necessary resources for the implementation of the procedures and safe practices outlined in this manual.

Ensure that all personnel are trained and competent in the planning, operation, maintenance, and monitoring of the equipment.

4.2 Operators

Adhere to the procedures outlined in this manual.

Account for the safety of single-pilot flight operations, including the management of fatigue arising from the operation of multiple short flights at low altitudes.

Report any malfunctions, deviations, incidents, or safety concerns to the designated authority.

4.3 Maintenance Personnel

Perform regular maintenance according to the maintenance schedule outlined in the aircraft and MCM.

Document all maintenance activities and report any major technical issues to the management and the Director General of Civil Aviation as required in the national regulations.

05 Procedures

5.1 Pre-Flight Planning

Pre-flight planning is a crucial aspect of ensuring safe and efficient flights. It involves several key components, such as:

a. Weather: Check weather conditions along the planned route, including departure, arrival, and alternate destinations.
b. Aircraft Performance: Calculate aircraft performance with particular attention to the limitations associated with the low Maximum Certified Take-off Mass (MCTOM) of eVTOL aircraft. Considerations should include factors such as weights of passengers, luggage or cargo, weight and balance, and the corresponding power requirements for take-off and landing.
c. Navigation: Review the planned flight route, including all terrain profiles, waypoints, and potential airspace restrictions.
d. Battery Energy Planning: Calculate the required battery energy for the flight, considering factors like weather, terrain, alternate airports or vertiports and potential diversions.
e. Notices to Airmen (NOTAMs): Check relevant NOTAMs that could affect the flight.
f. Air Traffic Control (ATC): Review ATC procedures, radio frequencies or requirements for the planned route and destination.
g. Emergency Procedures: Consider all emergency procedures during critical and distinct phases of flight, e.g., take-off, landing, and in-flight.

5.2 Embarkation and Start-Up Procedure

Assist and monitor passenger embarkation, ensuring compliance with cabin safety and security.

Ensure all equipment and safety mechanisms are in place and functional.

Power up the equipment in accordance with the specified sequence outlined in the Aircraft Flight Manual (AFM) or Flight Reference Cards (FRCs).

5.3 In-Flight Operations

Follow the designated operating parameters and guidelines.

Monitor all essential equipment for any anomalies or deviations from normal operation.

Maintain oversight of passenger safety and security throughout the flight.

Record operational data as required.

5.4 Shutdown Procedure

Follow the designated shutdown sequence.

Conduct post-operation checks and ensure all safety measures are in place.

Supervise the safe disembarkation of passengers at the destination.

06 Emergency Procedures

6.1 Equipment Malfunction

In the event of an equipment malfunction, the pilot will follow the designated AFM or FRC procedures.

Immediately cease operation in the event of an equipment malfunction.

Follow the designated emergency shutdown procedure.

Notify the designated authority and maintenance personnel.

6.2 Passenger and Personnel Safety

In the event of a safety hazard, follow emergency response protocols as outlined in the organisation's safety procedures.

Evacuate passengers and personnel from the area using the designated evacuation procedures and routes.

07 Maintenance

7.1 Regular Maintenance

Perform scheduled maintenance tasks as outlined in the maintenance schedule.

** eVTOL aircraft batteries may be subjected to "very harsh conditions," especially requiring short bursts of high-power during take-off and landing, as well as due to fast and frequent charging. Given the aviation sector's focus on safety, it is imperative that enhanced charging does not come at the risk of battery degradation. Batteries must meet rigorous requirements for fire safety, ensuring there is minimal risk of thermal runaway during flight or charging. Therefore, check the batteries for premature and unforeseen damage and corrosion. Document all maintenance activities and observations.

7.2 Unscheduled Maintenance

In the event of unexpected malfunctions, conduct troubleshooting and repairs as per the OEM's guidelines.

Document all unscheduled maintenance activities and report to the management.

08 Conclusion

This Operations Manual serves as a crucial resource for the safe and efficient operation of eVTOL aircraft and related systems. It is the responsibility of all personnel to adhere to the procedures outlined in the manual and to always prioritise safety.

PART 02 ANNEX C

TYPICAL INITIAL CERTIFICATE OF AIRWORTHINESS DOCUMENTS

The following is a typical set of documents to be submitted by the operator for the initial Certificate of Airworthiness (CoA):

- Type Certificate
- Declaration of Compliance with State's Requirements
- Aircraft Flight Manual
- Noise Certificate
- Aircraft Radio Station Licence
- Export Certificate of Airworthiness for Aircraft
- Aircraft Radio Equipment Record
- Aircraft Flight Instrument Record
- Approved Maintenance Schedule
- OEM Aircraft Inspection Report Documents
- List of Service Bulletins Incorporated on Aircraft
- Airworthiness Directive Compliance Report
- List of Aircraft Equipment Installed
- Aircraft Logbook(s)
- Weight and Balance Report
- Customer Acceptance Flight Report or Equivalent
- Aircraft and Engine Performance Report
- Electrical Load Analysis
- Approved Manuals:
  - Maintenance Control Manual
  - Reliability Manual
  - Refuelling Manual
  - Weight and Balance Manual
- Minimum Equipment List

Additionally, during the initial CoA, the owner or operator is typically expected to provide a copy of or access to the following manuals as applicable:

- Aircraft Flight Manual
- Operations Manual
- Minimum Equipment List
- Aircraft Maintenance Manual
- Engine Maintenance Manual
- Propeller Maintenance Manual
- Auxiliary Power Unit Maintenance Manual
- Parts Catalogue
- Standard Practices Manual
- Structural Repair Manual
- Structurally Significant Items
- Loading Procedures Manual
- Weight and Balance Manual
- Non-destructive Testing Manual
- Wiring Diagram Manual

PART 02 ANNEX D

CONSIDERATIONS FOR APPROVED MAINTENANCE ORGANISATIONS

In approving the organisation and personnel for maintenance work on eVTOL aircraft, the State will need to decide on how to classify the eVTOL aircraft, engines, and components. An equivalent of certifying staff would also need to be designated that is appropriate for the aircraft type and task and to perform a release to service of the aircraft. Some considerations in these areas are shown in Table D-1.

Item	Requirements	Considerations
Aircraft Classification and Ratings	• Generally, most existing Part 145 requirements can accommodate the maintenance work for eVTOL aircraft. However, for the scope of work, amendments may be required to include aircraft classification and ratings for aircraft with electric engines powered by batteries/ hydrogen fuel. • Classification of Category A — Aircraft: (Line and Base Maintenance) › Airplane › Rotorcraft/Helicopter › Glider › Airship	• In approving the organisation and personnel for maintenance work on eVTOL aircraft, the State will need to decide on how to classify the eVTOL aircraft, engines, and components (see Part 1). • State should note that amendments to regulations can take several months to a year to be approved and incorporated into legislation. The amendments must be in place before the EIS date of the eVTOL aircraft.
Engines and Components	• Category B — Engines (Engine Overhaul Shop) B1 — Turbine B2 — Piston B3 — Auxiliary Power Unit • Category C — Components (Component Shop) C5 — Electrical C10 — Heli Rotors C16 — Propellers	• When approving engine and component shops for work on eVTOL aircraft propulsion units and components, States will need to decide whether to classify the propulsion unit (electric motor) as an engine or component. › A new classification, “B4 — Electric,” has been suggested by some States. • States will need to determine which component shop can work on rotors removed from eVTOL aircraft — i.e., those with a C10 rating (Heli Rotors) or a C16 rating (Propellers) • New ratings may be required for the servicing of components of eVTOL aircraft that use hydrogen fuel.
Certifying Staff	• Certifying staff must hold the appropriate aircraft type licence issued by the State to perform a release to service on an aircraft. Such personnel undergo foundational training and exams for aeroplanes and helicopters equipped with either turbine or piston engines, including the Theory of Flight. • **EASA System:** Category A: Limited line maintenance tasks and simple rectification. Category B1.1: Aeroplanes with turbine engines Category B1.2: Aeroplanes with piston engines Category B1.3: Helicopters with turbine engines Category B1.4: Helicopters with piston engines Category B2: Avionics Category C: For certification after base maintenance checks. • **FAA System:** Airframe and Powerplant Licence (without type rating) — type training and approval given by the employer.	• With the advent of eVTOL aircraft, the State's licensing department would need to determine the specific examinations and training required to obtain an eVTOL aircraft type rating licence. • The State would need to determine whether to use its current rating system or to introduce a new category. B1.5 Aeroplane with Electric Engines for aircraft type rating has been suggested by some States for endorsement on licences.

Table D-1 — Considerations for Approved Maintenance Organisations

PART 02 ANNEX E

VERTIPORT CONSIDERATIONS

This annex is intended to present some key considerations when developing vertiport specifications, with particular emphasis on the operation of manned eVTOL aircraft, given that the initial phase of eVTOL aircraft operation will primarily involve manned aircraft. It does not contain detailed specifications for vertiport infrastructure or operational requirements. Guidance materials published by civil aviation authorities are primarily based on ICAO Annex 14, Volume II — Heliports, and ICAO Heliport Manual Doc 9261. However, there are differences, especially regarding the unique requirements for vertiports to accommodate the operations of eVTOL aircraft.

Establishment of Vertiport

The regulations governing the establishment of new vertiports or aerodromes differ across States. Nevertheless, the primary objective of the establishment approval requirement for an aerodrome (vertiport) is to ensure that the aerodrome adheres to the national airport policy and other pertinent regulations. This approval process is essential to ensure strategic alignment with national aviation objectives, as well as for the preservation of safety and efficiency.

By obtaining establishment approval, the vertiport demonstrates compliance with national regulatory requirements and industry best practices, while also contributing to the long-term vision for the country's airport network as outlined in the national airport policy.

Site Selection

Selecting an appropriate location for a vertiport requires careful consideration of its proximity to demand centres, the maintenance of safe distances from nearby structures and natural barriers, and an evaluation of environmental implications. These include noise pollution, community effects, urban planning needs, and sustainability considerations. A well-selected site should enable the vertiport to effectively address the needs of urban air mobility.

→ **Integration with Existing Airport**

It may be necessary for certain eVTOL aircraft operations to be conducted from existing aerodromes, and vertiports may become a crucial infrastructure component at aerodromes to support the operations of eVTOL aircraft. Therefore, integrating vertiports into existing aerodromes will likely be an important step for ensuring the compatibility and safety of eVTOL aircraft operations within traditional aviation environments.

ICAO Doc 9981, Procedures for Air Navigation Services — Aerodromes provides guidance for aerodrome operators on conducting compatibility studies to evaluate the potential effects of introducing a new aeroplane type or model (in this instance, eVTOL aircraft) to an aerodrome. These compatibility studies may encompass one or more safety assessments.

Prior to granting approval, it is essential for the CAA to ensure that the physical conditions of the manoeuvring area, apron, and surrounding environment conform to the established standards for aerodromes.

Additionally, a thorough assessment needs to be conducted to determine whether the equipment and facilities are adequate for the intended operations. Furthermore, where specific Touchdown and Liftoff Area (TLOF) and Final Approach and Take-off Area (FATO) requirements apply for eVTOL aircraft operations, considerations must be given to the distance from the runway, departure and approach procedures, to ensure an uninterrupted flow of current air traffic operations. These requirements include the need for the aerodrome operator to demonstrate competence in maintaining the safety of both the aerodrome and its airspace for the safe operation of eVTOL aircraft and other types of aircraft.

→ **Integration with Existing Heliport**

Considering the shared vertical take-off and landing (VTOL) capabilities of helicopters and eVTOL aircraft, existing heliports may potentially be repurposed for dual use. However, challenges may arise due to the unique operational requirements associated with different aircraft types, current designs, and local circumstances.

In contrast to heliports, the international standards for the planning, design and operation of vertiports for eVTOL aircraft have yet to be established, and there is currently no guidance for the integration of eVTOL aircraft elements with existing heliports.

In light of this, modifying an existing heliport to incorporate eVTOL aircraft elements requires considerations such as:

- **Heliport Physical and Load-Bearing Characteristics:** The dimensions and load-bearing capability of landing and safety areas should be assessed and, where necessary, re-configured to meet the requirements of various types of eVTOL aircraft. These requirements may differ from those of traditional helicopters due to their weight design and performance characteristics.
- **Obstacle Environment Requirements:** Height restrictions and airspace constraints should be re-evaluated to ensure that approach and take-off climb surfaces are suitable for both traditional helicopters and modern eVTOL aircraft.
- **Energy and Charging Infrastructure:** Charging or battery swapping stations may be required to support the specific needs of eVTOL aircraft.
- **Rescue and Firefighting (RFF) Services:** Aerodrome RFF (ARFF) services focus on conventional fire and rescue methods tailored to fuel-based fires. In contrast, RFF for eVTOL aircraft will introduce new challenges, primarily in addressing high-voltage battery fires and possibly higher frequency of urban operations. The size of the battery packs, whether small or large, will also impact the quantity of water or other extinguishing agents required to handle these fires effectively. Equipment, training, and procedures will need to be adapted accordingly.
- **Downwash and Outwash Impact:** There may be variations in downwash and outwash between helicopters and eVTOL aircraft, such as their impact on surface erosion, the safety of ground personnel, turbulence, wake vortices, lateral airflow, and noise levels. A study or analysis can be conducted to offer a thorough understanding of how downwash and outwash affect vertiport infrastructure, thereby ensuring safe and efficient operations for eVTOL aircraft.
- **Visual Aids:** The visual aids used in vertiports and heliports may share similarities due to their common purpose of supporting VTOL operations. It is imperative that identification marking is prioritised. The identification marking of a heliport ("H") serves to inform the pilot of the heliport's presence and, through its design, suggests the preferred directions for approach and take-off. For vertiports, the use of the letter "V" is generally recognised as the appropriate identification marking.
- **Passenger and Cargo Facilities and Other Necessary Infrastructure:** An assessment should be conducted to determine whether eVTOL aircraft operations could impact these existing facilities and infrastructure.

Vertiport Design

At present, ICAO has not yet established formal SARP that are specifically tailored to vertiports.

In the absence of specific SARP for vertiports, some CAAs are relying on the established heliport standards outlined in ICAO Annex 14, Volume II — Heliports, along with the ICAO Heliport Manual (Doc 9261), for their guidance. These documents provide essential principles that can be adapted for vertiport design and operation until more specific guidelines for eVTOL aircraft operations are established.

→ **Components of Vertiport Layout:** The vertiport layout includes several essential components, including the FATO, TLOF safety areas, surface strength, taxiway/apron, charging and maintenance infrastructure, and security features. The FATO should be free of obstacles and sufficiently large to accommodate every part of the designated eVTOL aircraft types. A typical requirement is a diameter that is at least twice that of the largest eVTOL's rotor span which differs among aircraft designs. Accordingly, alignment with the eventual operators is recommended to determine the rotor span to avoid any unwanted subsequent redesign.

The TLOF should have a surface free from irregularities that could adversely affect the touchdown or lift-off of eVTOL aircraft, provide sufficient friction to prevent skidding, and feature a level surface capable of enduring the repeated weight and force exerted by eVTOL aircraft, particularly those that are battery-powered. The vertiport should include rapid charging stations, maintenance hangars, secure fencing, surveillance systems, and controlled entry points, particularly in urban environments.

→ **Operational Elements:** These include effective passenger management systems, such as waiting lounges, ticket kiosks, security checkpoints, and efficient access to boarding areas to facilitate rapid eVTOL aircraft turnaround. There must also be adequate space for baggage scanning, loading, and unloading.

→ **Vertiport Capacity and Scalability:** Scalability should be considered in the vertiport design to maintain operational efficiency and positive customer experiences as demand increases. For example, design provisions should allow for the future expansion of aircraft parking areas, passenger processing capacity, and charging station capacity. This would ensure that the vertiport is able to accommodate growing demand over time.

→ **Vertiport Security and Accessibility:** Security will be an important consideration, particularly to prevent unauthorised access to eVTOL aircraft and operational zones. Accessibility features should also be considered to accommodate passengers with disabilities, ensuring a seamless experience for all users.

→ **Vertiport Maintainability:** Ongoing maintenance of the vertiport infrastructure would be necessary to mitigate disruption to operations. Considerations could include, but is not limited to, the repair of pavements, maintenance of navigation and visual aids, and upkeep of other critical infrastructure components.

Certification of Vertiport

Certifying vertiports would be a prudent step, especially considering the evolving nature of advanced air mobility (AAM), including eVTOL aircraft. While the ICAO has not yet established formal SARP for vertiports, similar to those established for heliports, certification is expected to become essential as vertiport infrastructure evolves.

At present, certification of heliports is not mandatory under ICAO, and the decision to require certification lies with individual States or national CAAs. The certification of heliports is often conducted by States that seek to ensure safe and efficient heliport operations in accordance with ICAO's SARP. For domestic eVTOL operations, States should consider leveraging on existing frameworks governing heliports.

States or CAAs may refer to ICAO Doc 9981 (Procedures for Air Navigation Services — Aerodromes) and ICAO Doc 9974 (Manual on Certification of Aerodromes) to produce directives or framework documents for vertiport certification. These documents provide procedural and regulatory guidance for the certification of aerodromes, and can serve as useful references in the absence of dedicated vertiport standards.

→ **Aerodrome Manual**

ICAO Annex 14 stipulates that:

"As part of the certification process, States shall ensure that an aerodrome manual which will include all pertinent information on the aerodrome site, facilities, services, equipment, operating procedures, organization and management including a safety management system, is submitted by the applicant for approval/acceptance prior to granting the aerodrome certificate."

It is essential for the aerodrome operator to obtain the necessary approval or acceptance for any amendments to the aerodrome manual arising from the introduction of a vertiport or the acceptance of eVTOL aircraft at the existing aerodrome.

Airspace Integration

Integration with existing Air Traffic Management (ATM) is crucial for the safe and efficient operation of AAM systems, particularly as eVTOL aircraft become part of the urban transport ecosystem. The integration of airspace requirements around vertiports with the existing ATM framework involves addressing several key factors, such as:

Airspace Design and Structure

The introduction of eVTOL aircraft and vertiports will require a redesign of lower airspace, particularly over urban areas. This includes airspace segmentation, which may involve creating distinct corridors or "highways in the sky" to maintain a safe distance between eVTOL aircraft and traditional aircraft.

Traffic Density and Capacity Management

eVTOL aircraft will significantly increase the volume of air traffic operating in the lower altitudes of urban areas. Therefore, traffic flow management should be considered to optimise the flow of air traffic to ensure safe, orderly and efficient operations.

Integration with Existing ATM Systems

eVTOL aircraft and vertiports should be integrated into current ATM systems to avoid conflicts and ensure interoperability.

Competent Personnel

The operation of a vertiport requires competent personnel with specialised skills to ensure safety, efficiency and compliance with regulatory standards. The types of personnel required may include the following, as an example:

Vertiport Operation Officer	Responsible for overseeing the physical and operational aspects related to maintenance, apron management, safety and compliance, and stakeholder communication to ensure the vertiport is safe for eVTOL aircraft operations.
Vertiport Assistant	Assists the Vertiport Operations Officer in managing vertiport activities, directing passengers to and from eVTOL aircraft, and handling the loading and unloading of freight and baggage.

It will be essential for vertiport operators to establish a comprehensive training programme to ensure that vertiport personnel remain competent and capable of handling the complexities of eVTOL aircraft operations.

Relevant Resources and References for Vertiports

The following is a list of resources and references that may be taken into consideration.
The list is illustrative and not intended to be exhaustive:

Regulatory Frameworks and Guidelines

→ **ICAO SARP**

- Annex 14 — Aerodromes (Volumes I and II)
- Annex 19 — Safety Management
- Doc 9981 — Procedures for Air Navigation Services — Aerodromes
- Doc 9261 — Heliport Manual
- Doc 9774 — Manual on Certification of Aerodromes

→ **National Civil Aviation Authority Documents**

- Civil Aviation Act
- Civil Aviation Regulations (CARs)
- Advisory Circulars (ACs)
- Civil Aviation Directives (CADs)
- Guidance Material
- Certification Manuals

→ **Vertiport Design Manuals**

- **ICAO Annex 14, Volume II — Heliports**
  Even though it is not specifically related to vertiports, this annex is a foundational document for heliport design. It serves as the basis for many of the current design concerns that are being considered for vertiports.

- **FAA Engineering Brief No. 105A — Vertiport Design**
  The document provides initial guidance on the design and planning of vertiports for eVTOL aircraft, covering layout, infrastructure, safety zones, and operational aspects.

- **EASA PTS-VPT-DSN — Prototype Technical Specifications for Vertiports Design**
  This document provides a framework for stakeholders, such as designers, urban planners, and civil aviation authorities, to create vertiport infrastructure that is safe, efficient, and adaptable for the future of eVTOL air mobility services. It ensures that vertiport projects meet essential safety standards, integrate seamlessly into existing urban landscapes, and support efficient operations of eVTOL aircraft.

- **Australia Civil Aviation Safety Agency — Guide to Vertiport Design**
  This guide provides foundational principles for designing safe, functional, and compliant vertiports for the safe and efficient integration of eVTOL aircraft into urban and regional areas, and to assist stakeholders in the development of these aircraft.

- **United Arab Emirates General Civil Aviation Authority CAR-HVD — Civil Aviation Regulations for Heliports and Vertiports Design**
  This document provides guidelines and standards for the design, certification, and operation of heliports and vertiports to support both conventional helicopter operations and the emerging eVTOL aircraft operations as part of AAM.

Part 2, Annex E References

→ Mendonca, N., Murphy, J. R., Patterson, M. D., Patterson, R., Alexander, R., Juárez, G., & Harper, C. (2022). Advanced air mobility vertiport considerations: A list and overview. https://ntrs.nasa.gov/api/citations/20220007100/downloads/Vertiport%20Considerations%20Paper%20Final%20v2.pdf
→ Scott, B. I. (2022). Vertiports: Ready for take-off ... and landing. Journal of Air Law and Commerce, 87(3), 503–510. https://typeset.io/pdf/vertiports-ready-for-take-off-and-landing-g5rylhqz.pdf
→ Civil Aviation Authority. (2023, July). CAP 2538: Considerations for aerodromes and vertiports planning to operate vertical take-off and landing aircraft (VTOL). https://www.caa.co.uk/publication/download/20387
→ Civil Aviation Authority of Malaysia. (2022, May). Civil aviation directives 14 Vol. II — Heliports. https://www.caam.gov.my/wp-content/uploads/2022/05/CAD-14-Vol-II-Heliports-ISS02_REV00.pdf
→ Federal Aviation Administration. (1991, May). Advisory circular 150/5390-3 — Vertiport design. https://www.faa.gov/documentLibrary/media/advisory_circular/150-5390-3/150_5390_3.PDF
→ Peisen, D. J., Berardo, S. V., Dyment, R. J., Ludders, J. R., & Ferguson, S. (1996, January). Vertiport characteristics (DOT/FAA/RD-94/10). Federal Aviation Administration. https://apps.dtic.mil/sti/pdfs/ADA313609.pdf

PART 02 ANNEX F

SECURITY GUIDELINES

Besides aligning with existing State requirements for helicopters, the following are areas that both airline operators transitioning to eVTOL aircraft operations and new commercial operators intending to operate eVTOL aircraft may need to consider incorporating into their security manuals.

Airport Security

- → Include specific security measures for vertiports, such as access control procedures (screening of personnel, passengers, and cargo), perimeter security protocols (to prevent unauthorised ground access into the vertiport and potential drone intrusion), and potential secured storage facilities for batteries or other aircraft spares.
- → Vertiports may have limited space for dedicated passenger screening facilities, and alternative methods or use of technologies may need to be considered.

Aircraft Security

- → Ensure that pre-flight inspection protocols specifically tailored to eVTOL aircraft operations are in place, such as checks for tampering of key components like propulsion systems.
- → Consider the possible risk of passengers attempting to interfere with pilot operations, given the absence of a physical cockpit door separation between the cabin and cockpit. Appropriate measures may need to be included in the response protocols for managing security incidents.

Cargo Security

- → Ensure protocols are in place for secure loading and unloading, and tamper-proofing of cargo operations.
- → Implement a means for real-time tracking of eVTOL aircraft cargo operations.

Passenger and Baggage Screening

- → Passenger and baggage screening procedures may need to be tailored to ensure that eVTOL aircraft are operated safely and within certified limits. These might include, but are not limited to, the weighing of passengers and screening of baggage and passengers where necessary.

Response Protocols for Security Incidents

- → Security incident response protocols would need to address potential eVTOL aircraft- specific scenarios, such as, but not limited to:
  - › Security breaches at vertiports
  - › Disruptive passengers onboard eVTOL aircraft

Security Programme Adaptions

- → Conduct security risk assessments and address threats:
  - › Conduct security risk assessments to address the unique threats and vulnerabilities associated with vertiport operations and consider the specific risk context of the State in which these operations are conducted.
- → Update security management systems:
  - › Security Management Systems may need to be updated to encompass eVTOL aircraft-specific security procedures and incident reporting protocols.

Training Programmes

- → Develop training programmes for security personnel to address:
  - › Security measures specific to eVTOL aircraft operations, including those for vertiports.
  - › Vertiport security protocols.
  - › Potential hazards associated with eVTOL aircraft operations, such as those related to electric or hybrid propulsion systems.

PART 02 **ANNEX G**

CYBERSECURITY GUIDELINES

The following are areas that both airline operators transitioning to eVTOL aircraft operations and new commercial operators intending to operate eVTOL aircraft may need to consider incorporating into their cybersecurity manuals.

System Security

→ Apply defence-in-depth principles to protect critical systems.

→ Define secure communication protocols for ground control systems managing eVTOL aircraft traffic.

→ Define the procedures to ensure control of critical software, such as the prevention of unauthorised loading of software that will affect flight systems/avionics, or ensuring navigation software is up to date.

Network Security

→ Define protocols and standards to prevent network breaches, especially when the systems are transmitting flight information to a ground station.

→ Ensure network segmentation to isolate critical flight systems from non-essential systems.

→ Define processes for access control to limit access to the aircraft network or ground control network to prevent breaches. This will also include the process for regular patching of vulnerabilities in system software and firmware.

→ Implement intrusion detection and prevention systems to monitor network traffic for suspicious activity and prevent cyberattacks.

Data Security

→ Define a data classification and control system to ensure sensitive data is isolated and kept secure.

→ Define specific security measures to protect each data classification level; this can include the need for data backup, data encryption, access control, data loss prevention solutions, and incident response plans.

→ Establish a mechanism for data sharing between OEMs, regulators, and cybersecurity experts to facilitate data sharing, promoting proactive data threat detection and mitigation.

Supply Chain Security

→ Ensure that software and hardware used in critical functions have cybersecurity considered throughout the lifecycle of the systems, from design and development through operations and maintenance, and continuing through to safe and secure disposal.

Staff Training and Awareness

→ Implement ongoing cybersecurity awareness programmes for appropriate staff, emphasising best practices for identifying and mitigating cyber threats.

→ Specify the procedures for cybersecurity assessments and monitoring. This can include the assessment frequency, assessment scope, assessment methods, and the processes for continuous monitoring of system health from malicious attacks or activities.

EVTOL AIRCRAFT: PART 03

Cooperation Among National Agencies

INTRODUCTION

The complexity of eVTOL aircraft operations can impact and be impacted by various domains that may span across the jurisdictions of several different national agencies. For instance, eVTOL aircraft operations in cities can significantly impact urban planning, while concerns for ground safety and security of public and governmental areas and installations directly affect the implementation of eVTOL aircraft operations. In many countries, the regulation and administration of land management (i.e., urban planning) and law enforcement (i.e., ensuring public safety and security) involve multiple national agencies with possibly overlapping delegations of authority (Freeman et.al., 2012). Furthermore, in some countries, this authority may be distributed across jurisdictional territories, adding another layer of complexity. If not managed appropriately, overlapping agency functions may produce inefficiencies and diminish effectiveness and accountability, especially if agencies build their own policy-making and enforcement systems without due coordination with other involved agencies. This potential for fragmentation underscores the critical need for a cooperative multi-agency approach to eVTOL aircraft operational implementation, and cooperation among agencies within nations is a key principle in ensuring the progressive and effective facilitation of eVTOL aircraft operations (NASA, 2018).

This Part aims to provide guidance for CAAs to develop and institute actions that will initiate cooperation between their national agencies to facilitate eVTOL aircraft operations. The Part explores general considerations for some key goals in fostering cooperation between agencies and identifies specific areas where cooperation may be necessary that draw upon lessons learnt from early eVTOL aircraft operational experiences worldwide. Methodologies from literature to facilitate interagency cooperation are subsequently described, followed by a checklist to guide the activities in facilitating interagency cooperation.

BACKGROUND

Goals of Cooperation Between Agencies

Successful cooperation between agencies can be defined by the terms "collaboration" and "coordination" (Soujaa et. al., 2021). Successful interagency collaboration is defined by "any joint activity by two or more organisations that is intended to produce more public value than could be produced when the organisations act alone" (US GAO, 2018).

At a minimum, agencies should aim for interagency coordination, which is simply the alignment of an organisation's actions with those of other organisations to achieve a shared goal (Soujaa et. al., 2021). Numerous problems can arise without interagency coordination, especially when duplicate or conflicting regulations are issued. Additionally, agency time and money can be wasted when decisions and actions are not well coordinated, and public confidence in agency expertise can also be eroded when agencies produce differing decisions on a single topic (NPR, n.d.). When public agencies work together successfully, there are numerous rewards, such as increased safety, greater efficiency through economies of scale, a better public image, increased funding, and more successful recruitment and retention in the respective agencies (Fraley, 2010; Terman et. al., 2019; Harrington et. al., 2021; McQuaid, 2010).

At best, interagency coordination to facilitate the operations of eVTOL aircraft may be optimised through a national level strategic committee, adopting a whole-of-government (WOG) approach to ensure all agencies' objectives are aligned.

For eVTOL aircraft operations, studies of potential roles and responsibilities of stakeholders, along with flight demonstrations and trials, have been and continue to be instrumental in identifying areas where interagency cooperation is needed to develop regulations and requirements. The United States considers that the nation's airworthiness authority has exclusive legal authority over aircraft certification and pilot and mechanic training, whereas other agencies have certain legal authorities related to vertiports, noise, and environmental protection (US GAO, 2024). In some nations, airspace management is also considered exclusively under the jurisdiction of the airworthiness authority (US GAO, 2024), but there are nations where the airspace desired for eVTOL aircraft operations may be under the shared jurisdiction of a nation's military organisation (Gobusiness Singapore, n.d.).

Cooperation is essential to ensure smooth and timely development of regulatory and operational frameworks to ensure safety and security, particularly in areas where jurisdictions overlap (NASA, 2018). From an operational perspective, both the enforcement of these regulations and the coordination of emergency responses will typically involve a multi-agency effort.

KEY CONSIDERATIONS

Subjects Requiring Cooperation to Facilitate eVTOL Aircraft Operations

Adopting eVTOL aircraft operations will involve actions in a wide range of subjects across political, economic, social, technological, environmental, and legal domains, necessitating interagency cooperation to address them effectively. These subjects could be categorised into four main areas as follows:

- → **Technology:** Technology in this context pertains to all aspects related to the research and development, design, testing, and manufacturing of the aircraft, systems, and infrastructure needed in enabling eVTOL aircraft operations. This would involve, for example, the development of regulations, requirements, and standards for aircraft products and infrastructure (e.g., vertiports), as well as support for research and technology (R&T) activities necessary to understand and mature applicable eVTOL aircraft technologies.
- → **Operations:** Operations encompass all subjects related to operation and maintenance of eVTOL aircraft, systems, and infrastructure, as well as the support of R&T to develop and mature operational procedures and requirements. Some of these considerations are presented in **Part 2**. This subject area covers both air and ground operations and hence includes topics such as airspace management, fire safety, emergency response, and law enforcement.
- → **Economic Policies:** This category encompasses all subjects and actions related to market access, consumer protection, and commercial competition, as detailed in **Part 4**. Topics such as organisational requirements for air operators, governmental financial support plans, and consumer protection policy development are examples of subjects under this category.
- → **Social Acceptance:** Subjects of social acceptance comprise all topics that would have a social or environmental impact and thereby influence the acceptance of eVTOL aircraft operations by society. Issues such as the management of noise and visual pollution, and activities related to public engagement and education (as detailed in **Part 6**) are some examples in this category. Topics such as urban zoning and permitting fall into this category as they impact and can also be impacted by social acceptance.

See **Annex A** for examples of the subjects in each of these categories.

Stakeholders Involved

The establishment of policies and governance for eVTOL aircraft will involve multiple national agencies, which may be directly or indirectly involved in aviation, transport, and their related fields. For this publication, these entities are categorised into the following types of agencies according to their areas of jurisdiction or function. It is also important to ensure that the core and auxiliary responsibilities of each agency are clearly identified. The classification below provides a broad segregation, which may differ from State to State:

Aviation and Transport Agencies
Agencies that form the core of eVTOL aircraft regulation and oversight.

Security and Emergency Services Agencies
Agencies that govern civil safety and security, and emergency response protocols.

Legal, Economic, Finance, and Trade Agencies
Agencies that address the legal and economic implications of eVTOL aircraft operations.

Land Use, Utilities, and Environmental Agencies:
Agencies involved in assessing and governing the infrastructure needs and environmental impact of eVTOL aircraft.

Communications and Local Government and Community Agencies:
Agencies involved in local community policy-making and engagement.

Technology and Research Agencies:
Agencies involved in driving eVTOL aircraft technological advancements and research.

See **Annex B** for examples of national agencies in the abovementioned categories.

Methods of Cooperation

There are several methods and approaches suggested in the literature to facilitate interagency cooperation. These methods can be generally categorised into formal or informal methods, as further detailed below:

→ **Formal Methods for Interagency Cooperation:**
Formal methods for interagency coordination comprise concrete contracts or agreements, such as bilateral or multilateral agreements, that clearly define expected roles and responsibilities for parties (Soujaa et. al. 2021; Harrington et. al., 2021). These formal arrangements help minimise or avoid miscommunication, confusion, or mismatched expectations and are enforceable (Harrington et. al., 2021). Examples of formal methods for coordination or collaboration are shown in **Table 1**.

Methods for Coordination	Methods for Collaboration
Interagency Consultation: → **Discretionary Consultation:** While still a formal method, discretionary consultation refers to structured interactions between agencies that are not mandated by law but established through formal agreements or protocols. While not legally required, there is an expectation of engagement and follow-through. Discretionary consultation may be used for emerging issues or when agencies see a need for coordination on non-critical matters. (Freeman et. al., 2012) → **Mandatory Consultation:** This refers to legally required interactions between agencies. Key aspects include a legal basis (required by law, regulation, or executive order), strict procedures, formal documentation, legal accountability, and binding outcomes. Mandatory consultations are used for decisions or processes defined in law. (Freeman et. al., 2012) **Liaison Model:** The liaison model is an approach where personnel from one agency are assigned to another to facilitate interagency communication, support on-site consultation, coordinate joint public communications, and develop both formal and informal relationships, including collaborative strategies and partnerships (Eyerman et. al., 2006). **Strategic Committee to drive Interagency Coordination:** States may consider establishing WOG approach to interagency coordination to facilitate eVTOL aircraft operations. The benefit of establishing such committee(s) is that agencies' concerns can be addressed collectively. There may be competing demands — for example, land use plans may require adjustment depending on the prioritisation at the WOG level. Such committee(s) may address overlapping areas of responsibility between agencies.	**Interagency Agreements and Working Groups:** Formal interagency agreements are written documents (typically non-legally binding) that assign responsibility for specific tasks, establish procedures, and bind the agencies to fulfil mutual commitments (Freeman et. al., 2012; Harrington et. al., 2021). Such agreements can be in the form of Memoranda of Understanding, Memoranda of Agreement, or other similar mechanisms and would typically result in the formation of interagency working groups or committees to achieve the objectives of the agreements. Effective agreements should address the topics of membership, roles, responsibilities, the decision-making process, dispute resolution, agreement termination, and the distribution of the costs of collaboration (Harrington et. al., 2021). **Joint Policymaking:** Joint policymaking is a formal collaboration method where multiple agencies work together to develop policies, regulations, or guidelines that affect their shared areas of responsibility or interest. This approach is particularly relevant for complex, cross-cutting issues such as those that involve various aspects of aviation, urban planning, environmental management, and technology.

Table 1 — Example of Formal Methods for Interagency Cooperation

Formal collaboration on matters is not without risks of failure. The following are several ways in which collaboration may fail, along with measures to mitigate them.

Disagreement

Problems can occur when the actors disagree about the strategies,potential policy solutions, and/or coordination actions. Such problems may bemitigated with sharing and access to heightened knowledge about best practices forsolving particular policy dilemmas (Terman et. al., 2019; McQuaid, 2010).

Division

Division problems arise when joint actions are agreed upon, but the actors have difficulties dividing the benefits and costs of the joint action. Collaborations should consider and establish how responsibilities, benefits, and costs of actions are fairly distributed (Terman et. al., 2019; McQuaid, 2010).

Defection

Defection is a situation where a collaborator does not have the ability to guarantee effective compliance and undertaking of their responsibilities. In a collaborative framework, adequate resources need to be provided for monitoring, detecting, and acting on non-compliances of collaborative partners that "defect" (Terman et. al., 2019). Individually, organisations need to ensure that they have sufficient organisational capacity in the form of adequate infrastructure, finances, workforce, and culture (National Academies, 2022).

→ **Informal Methods for Interagency Coordination:**
Compared to formal mechanisms, informal mechanisms are not legally binding and comprise activities such as building networks and sharing knowledge so that agencies can exchange ideas and perspectives that ultimately serve to improve the response to a shared concern (Soujaa et. al., 2021). Examples of approaches for such informal methods are as follows:

Network Building

From the experiences of past pandemics, the literature generally concludes that strong relationships between agencies better facilitate coordination during events, emergencies, and decision-making (Soujaa et. al., 2021). Regular engagement also facilitates clearer and more effective means of communication, which is key to fostering collaboration and coordination.

Knowledge Sharing

A feature of effective interagency partnership and cooperation is the sharing of skills, knowledge, and expertise, which helps in maximising the appropriateness, quality, and efficiency of joint decision-making and actions (McQuaid, 2010). Knowledge can be shared through ad-hoc information sharing, through a spokesperson, through third-party communication, centralisation, or joint production of knowledge (Harrington et. al., 2021). Sharing could be at the level of data, methodologies, or consultants as detailed in **Table 2**.

Sharing Foundational Data	Sharing Methodologies	Sharing Consultants
Sharing foundational data involves the exchange of basic, essential information that forms the groundwork for decision-making and policy development across agencies. This could include air traffic patterns and density, urban development plans and zoning information, environmental impact assessments, population demographics and mobility trends, and weather and climate data. Sharing foundational data creates a common understanding of the current situation, reduces duplication of data collection efforts, and enables more comprehensive and accurate analyses. However, challenges include ensuring data compatibility across different agency systems, maintaining data privacy and security, and keeping shared data up to date. It would be useful to establish shared databases, implement regular data-sharing meetings or workshops, and create standardised data formats for easy exchange.	Sharing methodologies entails exchanging the processes, techniques, and approaches used by different agencies to analyse data, assess risks, and make decisions. This could include risk assessment models, urban planning approaches, environmental impact evaluation techniques, and public engagement methods. Sharing methodologies promotes best practices across agencies, enhances consistency in decision-making processes, and facilitates cross-agency learning and improvement. Challenges in sharing methodologies include overcoming resistance to change within established agency practices, adapting methodologies to fit different agency contexts, and ensuring methodologies are understood and applied correctly. To overcome these challenges, agencies may conduct interagency workshops, collaboratively develop new methodologies, or create shared guidebooks.	The approach of sharing consultants involves agencies jointly engaging or sharing access to external experts who can provide specialised knowledge or skills. Examples include eVTOL aircraft technology experts, urban air traffic management specialists, environmental acoustics consultants, and public policy and regulatory experts. This facilitates access to consistent expert advice across agencies and a holistic approach to complex, cross-cutting issues. However, agencies need to be prepared to manage potential conflicts of interest. Agencies may consider setting up joint procurement processes, establishing shared consultant pools, and holding regular interagency meetings with shared consultants.

Table 2 — Example Modes of Knowledge Sharing in Informal Methods for Interagency Cooperation

The tools used for knowledge sharing may need to consider the following to ensure the effectiveness and security of the method:

→ Security and compliance requirements
→ Integration compatibility with existing agency systems
→ User-friendliness and adoption rates
→ Scalability to accommodate expanding requirements
→ Cost-effectiveness and budget considerations

It is important to choose the tools that are aligned with the specific needs of the agencies involved, the nature of the information being shared, and the existing digital infrastructure.

Examples of the types of tools include:

- → **Collaborative document platforms** to allow real-time collaboration on documents.
- → **Project management tools** to coordinate tasks, track progress, and manage shared projects across agencies.
- → **Knowledge management systems** to centralise and organise shared knowledge, policies, and best practices.
- → **Data visualisation tools** to create interactive dashboards to share and analyse complex data sets.
- → **Cloud storage and file sharing platforms** to store and share large files and datasets securely.
- → **Video conferencing platforms** to facilitate virtual meetings, webinars, and training sessions.
- → **Geographic information systems** to share and analyse spatial data relevant to eVTOL aircraft planning.
- → **Secure messaging platforms** to enable secure, real-time communication between agency personnel.

ACTION PLAN

STEP 1 Identify the Scope of Activities

When developing an action plan to facilitate cooperation between agencies for eVTOL aircraft operations, the first step is to identify the scope of work and activities to be coordinated. A list of subjects is provided in **Annex A** as an example and should be reviewed to determine their applicability to the needs of the respective Civil Aviation Authority (CAA). The CAA is also encouraged to develop plans such as a Concept of Operations for their envisaged end-state for eVTOL aircraft operations together with a charted pathway of interim steps that identifies the priority of the subjects listed in **Annex A**.

STEP 2 Identify Stakeholders

Having established the scope of activities, it is crucial to identify all relevant stakeholders that have a role to play in the development and implementation of eVTOL aircraft operations. To ensure a thorough identification process, the following could be considered:

- → Consider agencies with direct and indirect involvement in aviation, transport, and related fields. Refer to **Annex B** for a list of examples.
- → Review existing inter-ministerial committees or working groups related to aviation or emerging technologies.
- → Consider examples of cross-agency cooperation in other technological advancements, such as autonomous vehicles or smart city initiatives.
- → Examine the structure of eVTOL aircraft operations-related bodies in other countries for insights into potential agency involvement.
- → Remain open to including additional agencies as eVTOL aircraft technology and the operational landscape evolve, particularly those dealing with emerging technologies and urban air mobility.

STEP 3

Develop a RACI (Responsible, Accountable, Consulted, and Informed) Matrix of Stakeholders Versus Required Functions

To effectively coordinate the complex web of activities involved in eVTOL aircraft implementation, it is crucial to clearly define the roles and responsibilities of each agency. A RACI matrix is a valuable tool for this purpose, mapping stakeholders to their roles — Responsible, Accountable, Consulted, and Informed — across specific tasks or decisions.

The matrix is defined in **Table 3** below:

Responsible	**A**ccountable
The agency or agencies that are responsible for performing the work or implementing the task. They are the 'doers' who complete the activity. There can be multiple responsible parties for a single task.	The agency that is ultimately answerable for the correct and thorough completion of the task. This agency has the final approving authority and is held accountable for the outcome. There should be only one accountable agency for each task or decision.
Consulted	**I**nformed
The agencies that need to be consulted before a decision or action is taken. This involves two-way communication. These agencies provide input, expertise, or information relevant to the task.	The agencies that need to be kept up to date on progress or decisions, but do not need to be formally consulted. This typically involves one-way communication after a decision or action has been taken.

Table 3 — Definition of RACI

The RACI framework should be developed for the scope of work (subjects and activities) to serve as a clear roadmap for interagency cooperation. Establishing the RACI matrix will minimise confusion and help to ensure that all critical aspects of eVTOL aircraft development are adequately addressed. An example RACI matrix, based on the list of agencies and subjects identified in this publication, is shown in **Annex C**.

Part 3 References

- → European Union. (2022, September 30). AirMOUR: D3.2 ground risk and landing-site management (prepared vs ad hoc).
- → Eyerman, J., & Strom, K. (2006, February). A cross-national comparison of interagency coordination between law enforcement and public health (Report No. 212868). U.S. Department of Justice.
- → Fraley, M. (2020, December 3). 10 things you need to know to increase interagency cooperation and collaboration. EMS1. https://www.ems1.com/ems-products/mobile-data/articles/10-things-you-need-to-know-to-increase-interagency-cooperation-and-collaboration-jX1oftRE5NzOSbS8/
- → Freeman, J., & Rossi, J. (2012). Agency coordination in shared regulatory space. Harvard Law Review, 125(5), 1131–1211.
- → GoBusiness Singapore. (n.d.). Permit for aerial activities. Retrieved from https://www.gobusiness.gov.sg/browse-all-licences/civil-aviation-authority-of-singapore-(caas)/permit-for-aerial-activities
- → Harrington, M., Perides, A., Walsh, A., & Milman, A. (2021). Handbook on interagency coordination. University of Massachusetts Amherst.
- → McQuaid, R. W. (2010). Theory of organisational partnerships: Partnership advantages, disadvantages and success factors. In S. P. Osborne (Ed.), The new public governance: Critical perspectives and future directions (pp. 125–146). Routledge.
- → National Academies of Sciences, Engineering, and Medicine. (2022). Improving the CDC quarantine-station network's response to emerging threats. The National Academies Press. https://doi.org/10.17226/26599
- → NASA. (2018, November). Urban air mobility (UAM) market study.
- → National Performance Review. (n.d.). REG01: Create an interagency regulatory coordinating group. https://govinfo.library.unt.edu/npr/library/reports/reg01.html
- → Soujaa, I., Nukpezah, J., & Benavides, A. (2021). Coordination effectiveness during public-health emergencies: An institutional collective action framework. Administration & Society. Advance online publication. https://doi.org/10.1177/0095399720985440
- → Terman, J., Feiock, R., & Youm, J. (2019). When collaboration is risky business: The influence of collaboration risks on formal and informal collaboration. American Review of Public Administration. https://doi.org/10.1177/0275074019867421
- → U.S. Government Accountability Office. (2018, September). Considerations for maintaining U.S. competitiveness in quantum computing, synthetic biology, and other potentially transformational research areas (GAO-18-656).
- → U.S. Government Accountability Office. (2024, March 14). Advanced air mobility: Legal authorities and issues to consider for operations.

PART 03 ANNEX A

EXAMPLE EVTOL AIRCRAFT OPERATIONS INTERAGENCY COOPERATION SUBJECTS

The following presents a list of subject areas that may be relevant to the development and implementation of eVTOL aircraft operations. While efforts have been made to cover the key subjects that may require interagency cooperation for eVTOL aircraft operations, the list may not be exhaustive. CAAs should review the list for completeness and applicability before its use in their efforts.

Technology

Subjects Pertaining to Research and Development, Design, Testing, and Manufacturing of eVTOL Aircraft, Systems, and Infrastructure

Subject	Description
Airworthiness, Safety and Security	Airworthiness regulations include considerations for the initial and continuing airworthiness of the aviation products that are to be introduced. While this activity is usually led by the nation's civil aviation authority, other agencies, such as those related to accident investigations and defence ministries, may need to be consulted and others informed due to the potential legal and economic impacts of regulatory changes. In the development of standards, technology and research agencies may also need to be consulted to facilitate R&T aimed at ascertaining performance specifications. Additionally, standards and requirements for safety and security may involve other national agencies responsible for critical national infrastructure or data and information management, or other topics such as radio-frequency spectrum allocations to ensure airborne and existing terrestrial communication systems performance.
Infrastructure Safety and Security	Key infrastructure for eVTOL aircraft operations, such as vertiports, would require regulations and standards for the design and construction of such infrastructure that ensure public and national safety and security. Coordination will be necessary to secure take-off and landing areas for eVTOL aircraft and consider the impact on surrounding developments. Coordination could be expected between aviation and transport agencies and agencies responsible for building construction, for example.
Charging Infrastructure Regulations and Standards	Standards for eVTOL aircraft charging impact both aircraft design and public utilities. Developing such standards or regulations will require the coordination of expertise from both the aviation and utilities domains.

Operations

Subjects Pertaining to Operating and Maintaining eVTOL Aircraft, Systems, and Infrastructure

Subject	Description
Operational Certification: Pilot and operator training and licensing	The establishment of regimes for pilot and operator training and licensing is predominantly a task under the civil aviation authority (CAA); however, in some instances, it could be expected that the overall transport ministry and legal, economic, and trade agencies may need to be consulted (or informed) due to their potential implications on market access.
Operational Certification: Air operator certification	The approval of air operators in some nations may require review beyond the Civil Aviation Authority (CAA). The requirements for approving such air operators may also need to consider the requirements and viewpoints of security and emergency services agencies and could also have an impact on ensuring fair market access and appropriate consumer protection.
Air Operations: Airspace approvals	In some countries, the process to grant airspace approvals involves the nation's military organisation (Gobusiness Singapore, n.d.). Coordination is essential to ensure that such approval processes do not delay or deny eVTOL aircraft flight operations. Collaboration would be desirable to develop regulations and processes that will facilitate eVTOL aircraft flight approvals while maintaining the integrity and security of national airspace.
Air Operations: Air traffic management and deconfliction	The real-time deconfliction of air traffic, like the granting of flight approvals, may involve other agencies, such as military organisations, thereby requiring coordination to effectively ensure such functions.
Ground Operations: Infrastructure fire safety requirements	Ensuring adequate fire protection at vertiports will require expertise from agencies that deal with rescue firefighting techniques, operations, materials, and equipment. Collaboration is recommended with such agencies to update and establish minimum fire safety requirements for eVTOL aircraft operations at take-off and landing areas.
Ground Operations: Passenger/cargo screening and security protocols	Although it is in the interest of the CAA to ensure smooth facilitation of passengers and cargo through air terminals, security and emergency services agencies may, in some countries, be responsible for the requirements for passenger and cargo screening and security protocols. The two agencies would need to coordinate to ensure that facilitation is enabled without prejudice to public security.

Law and Regulatory Enforcement	eVTOL aircraft operations may cross multiple jurisdictions, including local, state, and federal levels, each with its own law enforcement agencies. Collaboration between these agencies and the CAA is crucial to establishing clear lines of authority and responsibility for enforcing eVTOL aircraft related regulations. This may involve developing new protocols for handling incidents or violations specific to eVTOL aircraft operations, such as unauthorised flights in restricted areas or non-compliance with vertiport regulations. Coordination is also necessary to ensure that law enforcement agencies are adequately trained and equipped to handle the unique aspects of eVTOL aircraft related incidents, which may differ significantly from traditional aviation or ground-based law enforcement scenarios.
Emergency Response	eVTOL aircraft operations introduce new challenges for emergency response, requiring coordination between aviation authorities, local first responders, and specialised rescue services. Collaboration is essential to developing comprehensive emergency response plans that address the unique characteristics of eVTOL aircraft and operations. This may include establishing protocols for responding to incidents in urban environments, coordinating access to vertiports or other eVTOL aircraft infrastructure during emergencies, and ensuring interoperability of communication systems between different agencies. Additionally, joint training exercises and simulations involving multiple agencies would be beneficial to prepare for potential eVTOL aircraft related emergencies, similar to the collaborative approach needed for fire safety at vertiports.
Operational Cybersecurity	The expertise within the governmental agencies in ensuring and maintaining cybersecurity would typically be beyond the remit of the CAA. The CAAs would need to coordinate requirements to be imposed on operators with the agency responsible for national cybersecurity policy and enforcement.

Economic Policies

Subjects Related to Addressing Issues of Market Access, Consumer Protection, and Commercial Competition

Subject	Description
Market Access: Policies and regulations	The assessment of economic impacts and the need for economic policy instruments for the eVTOL aircraft industry and market would typically be led by legal, economic, and trade agencies. However, this would need to be supported by the Ministry of Transport or CAA to advise on the expected developments and operations of eVTOL aircraft.
Consumer Protection: Policies and regulations	Similar to Market Access considerations, this subject would typically be led by legal, economic, and trade agencies. Consumer protection is a key topic in ICAO, and hence the CAA may be more deeply involved to ensure compliance and harmonisation with any applicable SARP.

Social Acceptance

Subjects That Would Have a Social or Environmental Impact and Thereby Influence the Acceptance of eVTOL Aircraft by the Society

Subject	Description
Noise and Environmental Protection: Noise and visual pollution regulations and standards	eVTOL aircraft operations may be perceived as public nuisances due to noise or visual disruption, often referred to as “visual noise” (Gobusiness Singapore, n.d.). While incorporation of noise abatement procedures, such as optimised flight paths and quieter propulsion systems, will help mitigate these concerns, there remains a need to align these measures with community expectations. It is also necessary to establish noise guidelines and requirements in collaboration with relevant agencies involved in addressing public noise concerns.
Noise and Environmental Protection: Evaluation of environmental protection	The methods and metrics for environmental reviews of eVTOL aircraft operations will require agencies with expertise in assessing environmental quality. Such evaluations will impact the decision-making for other areas of regulatory development (e.g., aircraft certification, vertiport construction, and airspace management) and collaboration.
Public Engagement and Education	The engagement and education of the public will be a multi-agency effort that could be led by communications, local government, and community agencies, in consultation with agencies such as the CAA.
Industry Engagement	Establishing and maintaining two-way interaction between the regulators and the industry would be important in ensuring that requirements are developed to support industries without compromising public safety and security and national legislative requirements. This could include ensuring that the regulatory framework and processes are effectively communicated to applicants such that they are readily adhered to by the industry. Industry engagement may involve the civil aviation authority and other agencies such as communications and local government and community agencies, and technology and research agencies.
Urban Zoning and Permitting	Zoning refers to considerations regarding where infrastructure for eVTOL aircraft can be constructed, while permitting refers to the granting of permission to undertake certain activities (US GAO, 2024). Agencies other than the airworthiness authority are likely to be responsible for zoning and permitting processes for vertiports and infrastructure. Zoning and permitting may place constraints on eVTOL aircraft operations or, conversely, affect building permits for taller structures (European Union, 2022). Traditional zoning and permitting processes and requirements may not be suitable for the novel characteristics of infrastructure and may require updating through cooperation between the airworthiness authority and relevant authorities governing such urban planning considerations.

PART 03 ANNEX B

EXAMPLE STAKEHOLDERS

The following lists examples of governmental agencies for the respective categories of stakeholders that may be involved in eVTOL aircraft operations as described in Part 3. CAAs are encouraged to adapt this illustrative list with their own governmental agencies according to the categories presented.

Aviation and Transport Agencies	→ Agency Responsible for Civil Transport Accident Investigations → Civil Aviation Authority	→ Land Transport Authority → Ministry of Transport → Ministry of Defence
Security and Emergency Services Agencies	→ Border Control Agency → Cybersecurity Agency → Infocomm Media Development Authority	→ Ministry of Home Affairs → National Disaster Management Authority
Legal, Economic, and Trade Agencies	→ Competition Commission → Economic Development Agency → Ministry of Finance	→ Ministry of Law → Ministry of Tourism → Ministry of Trade and Industry
Land Use, Utilities, and Environmental Agencies	→ Building Construction Authority → Electricity Regulation Agency → Land Planning Authority	→ Ministry of Energy → Ministry of Environment → Public Utilities Board → Urban Planning Department
Communications, Local Government, and Community Agencies	→ Ministry of Communications and Information	
Technology and Research Agencies	→ Ministry of Science and Technology → National Research Agency	→ Standards Development Agencies

PART 03 ANNEX C

EXAMPLE RACI MATRIX FOR EVTOL AIRCRAFT DEVELOPMENT AND IMPLEMENTATION

**** This annex presents a suggested, non-exhaustive RACI matrix for cooperation among national agencies that may be required in the development and implementation of eVTOL aircraft technologies, operations, economic policies, and social acceptance initiatives.**

Technology

	Responsible	Accountable	Consulted	Informed
Airworthiness, Safety, and Security	• Civil Aviation Authority	• Ministry of Transport	• Agency responsible for Civil Transport Accident Investigations • Ministry of Defence • Security and Emergency Services Agencies • Technology and Research Agencies	• Legal, Economic, and Trade Agencies
Infrastructure Safety and Security	• Civil Aviation Authority	• Ministry of Transport	• Agency responsible for Civil Transport Accident Investigations • Security and Emergency Services Agencies • Land Use, Utilities, and Environmental Agencies • Technology and Research Agencies	• Legal, Economic, and Trade Agencies
Charging Infrastructure Regulations and Standards	• Civil Aviation Authority	• Ministry of Transport • Electricity Regulator Agency	• Land Use, Utilities, and Environmental Agencies • Legal, Economic, and Trade Agencies	• Legal, Economic, and Trade Agencies

Operations

	Responsible	Accountable	Consulted	Informed
Operational Certification: Pilot and operator training and licensing	• Civil Aviation Authority	• Ministry of Transport	• Legal, Economic, and Trade Agencies	• Agency responsible for Civil Transport Accident Investigations
Operational Certification: Air operator certification	• Civil Aviation Authority	• Ministry of Transport	• Legal, Economic, and Trade Agencies	• Agency responsible for Civil Transport Accident Investigations
Air Operations: Airspace approvals	• Civil Aviation Authority • Ministry of Defence	• Ministry of Transport	• Security and Emergency Services Agencies • Land Use, Utilities, and Environmental Agencies	-
Air Operations: Air traffic management and deconfliction	• Civil Aviation Authority • Ministry of Defence	• Ministry of Transport	-	-
Ground Operations: Infrastructure fire safety requirements	• Land Use, Utilities, and Environmental Agencies	• Land Use, Utilities, and Environmental Agencies	• Security and Emergency Services Agencies	-
Ground Operations: Passenger/cargo screening and security protocols	• Civil Aviation Authority	• Ministry of Transport	• Security and Emergency Services Agencies	-
Law and Regulatory Enforcement	• Security and Emergency Services Agencies	• Ministry in Security and Emergency Services Agencies	• Civil Aviation Authority	-
Emergency Response	• Security and Emergency Services Agencies	• Ministry overseeing Security and Emergency Services Agencies	• Civil Aviation Authority • Agency responsible for Civil Transport Accident Investigations • Land Use, Utilities, and Environmental Agencies	-
Operational Cybersecurity	• Security and Emergency Services Agencies	• Ministry overseeing Security and Emergency Services Agencies	• Civil Aviation Authority	-

Economic Policies

	Responsible	Accountable	Consulted	Informed
Market Access: Policies and regulations	• Legal, Economic, and Trade Agencies	• Ministry overseeing Legal, Economic, and Trade Agencies	• Civil Aviation Authority • Ministry of Transport	-
Consumer Protection: Policies and regulations	• Legal, Economic, and Trade Agencies • Civil Aviation Authority	• Ministry overseeing Legal, Economic, and Trade Agencies	-	• Ministry of Transport

Social Acceptance

	Responsible	Accountable	Consulted	Informed
Noise and Environmental Protection: Noise and visual pollution regulations and standards	• Civil Aviation Authority • Land Use, Utilities, and Environmental Agencies	• Ministry of Transport	• Legal, Economic, and Trade Agencies • Communications, Local Government, and Community Agencies	-
Noise and Environmental Protection: Evaluation of environmental protection	• Civil Aviation Authority • Land Use, Utilities, and Environmental Agencies	• Ministry of Transport	• Technology and Research Agencies	-
Public Engagement and Education	• Communications, Local Government, and Community Agencies	• Ministry overseeing Communications, Local Government, and Community Agencies	• Civil Aviation Authority • Land Use, Utilities, and Environmental Agencies • Security and Emergency Services Agencies	-
Industry Engagement	• Civil Aviation Authority	• Ministry of Transport	• Communications, Local Government, and Community Agencies	-
Urban Zoning and Permitting	• Land Use, Utilities, and Environmental Agencies	• Ministry overseeing Land Use, Utilities, and Environmental Agencies	• Civil Aviation Authority • Security and Emergency Services Agencies • Communications, Local Government, and Community Agencies	-

EVTOL AIRCRAFT: PART 04

Economic Policies and Regulations

INTRODUCTION

Amongst various mechanisms, economic policies and regulations are key tools that governments can use to enable and ensure the safe, sustainable, and equitable introduction of modes of transport such as eVTOL aircraft operations to society.

Economic policies comprise principles or guidelines supporting decision-making and actions, while economic regulations enforce and ensure that policies are adhered to by specifying technology, service, or organisational requirements and standards. In general, economic policies and regulations serve to address market development, investment, innovation, and market openness, and in so doing, underpin markets, protect the rights of citizens, and ensure the delivery of public goods and services (OECD, 2011).

Although commercial eVTOL aircraft operations are still emergent and the market is nascent, it can be expected that the economic policies and regulations would be adopted from principles and experiences of conventional air transport. Economic policies may also need to be considered to shift transport behaviour towards the use of eVTOL aircraft as such operations are introduced into communities. This Part therefore provides an overview of the existing frameworks governing economic policies and regulations in the transport domain and highlights considerations for extending these frameworks to encompass commercial eVTOL aircraft operations. An action plan is also presented, providing a series of steps to assist States in identifying and developing economic policies or regulations necessary to support such operations.

BACKGROUND

International air transport presents unique challenges with multinational trade and political considerations. The policy work of ICAO in this area is primarily aimed at stimulating market growth by pursuing "continuous liberation of international air transport to the benefit of all stakeholders and the economy at large" (ICAO, 2024). This is further guided by the principle to "ensure respect for the highest levels of safety and security and the principle of fair and equal opportunity for all States and their stakeholders" (ICAO, 2024). Within this overarching principle, the ICAO's recommended economic policies seek to reduce the regulatory burden on States, increasing consumers' benefits and choices, improving air connectivity, creating more competitive business opportunities in the marketplace, and supporting sustainable economic development, including through the expansion of trade and tourism.

In line with these objectives, several guidance materials are available from ICAO, contained in documents such as ICAO Doc 9587, Policy Guidance on the Economic Regulation of International Air Transport, ICAO Doc 9626, Manual on the Regulation of International Air Transport, and ICAO Doc 8632, ICAO's Policies on Taxation in the Field of International Air Transport. The key topics and challenges addressed by ICAO are market access, air carrier ownership and control, consumer protection, market competition, the assurance of essential services, and trade in services (ICAO, 2024). To achieve these economic policy objectives, there are generally three governmental policy instruments that can be leveraged:

- → **Regulations:** Regulations are instruments that enforce and ensure that policies are adhered to by mandating requirements and standards on aspects such as technology, services, and organisations.
- → **Investments:** Public transport has been traditionally supported through investments in the construction or upgrading of transport infrastructure (e.g., roads, highways, railways, and airports), and in supporting technologies that enhance transport services (e.g., improved access, increased capacity, and enhanced connectivity, security, safety).
- → **Incentives and Disincentives:** Incentives or disincentives (i.e., grants, subsidies, or taxes) can be leveraged to influence the pricing dynamics of transport supply and demand and used as tools to uphold service quality. These instruments may also be used to steer transport behaviours in desired directions (e.g., fare concessions, tolls, fuel and emission taxes, or environmental subsidies).

Commercial eVTOL aircraft operations are still nascent, and current economic policy examples are primarily centred around incentives and investments in test centres or sandboxes to nurture the emerging industry. Examples of such investments have been observed in Australia (Australian Government, 2021), Europe (EASA, 2024), and the United States (US Congress, 2021), where grants and sponsored projects are used to incentivise the development of eVTOL aircraft operations. These incentives support the development and testing of technologies and use cases, as well as studies for supporting elements of eVTOL aircraft operations, such as vertiports, other infrastructure, and traffic management.

China's "low-altitude economy" policy introduced at the end of 2023 is a strong example of a step towards supporting the development of eVTOL aircraft operations through facilitating use cases and enabling technologies, such as smart device technologies for drones and eVTOL aircraft, new energy technologies related to batteries, and artificial intelligence technologies for autonomous flight (Ke, 2024).

Further policies for investments in eVTOL aircraft operations, as well as related incentives, disincentives, and economic regulations, remain largely academic. Nevertheless, it may be possible to draw lessons and considerations from the ongoing studies and from international air transport, and these considerations are further explored in the Key Considerations section.

KEY CONSIDERATIONS

General Principles and Objectives of Economic Policies and Regulations for Commercial eVTOL Aircraft Operations

Developing overarching principles for economic policies and regulations to support commercial eVTOL aircraft operations would largely depend on the objectives of the State and whether the operations are intended to be domestic or international. For international operations, it may be useful to refer directly to the principles established in the domain of international air transport. Although cross-border commercial eVTOL aircraft operations may emerge in the future, the market will most likely begin with domestic air transport (i.e., predominantly urban and regional air transport). Issues such as multinational market access and trade in services are less critical in domestic contexts, but the vision of a safe, secure, equitable, and liberal market remains equally applicable to eVTOL aircraft operations.

The objectives for economic policies in support of commercial eVTOL aircraft operations could therefore be to:

- → Enhance consumer benefits and increase choices (and affordability in certain instances)
- → Improve connectivity
- → Create more competitive business opportunities
- → Support sustainable economic development

The following further explores considerations in areas such as market access, consumer protection, and competition in the context of eVTOL aircraft operations to achieve the four policy objectives mentioned above.

Market Access

Regulations: Market access would primarily involve topics related to regulations specifying requirements of a company that wishes to operate eVTOL aircraft. As with conventional air transport, an eVTOL aircraft operator would be expected to obtain a licence to conduct air transport services. The licensing regime should require the operator to have an appropriate business plan, financing plan, and insurance coverage (to address liability in the event of an accident), to ensure that operations are conducted safely and in compliance with national business, environmental protection, and consumer protection requirements (European Parliament, 2024). Most States require, for national security, industrial, or economic reasons, that air transport operators be either nationals or companies established within the State. Commercial eVTOL aircraft operations are not expected to deviate from this existing framework.

A specific recommendation drawn from the current practice is to rely generally and initially on voluntary commitments undertaken by the operators and service providers (non-legally binding self-regulation). Regulatory measures should only be introduced if such voluntary commitments are insufficient to ensure or improve service quality.

- → **Investment:** Air transport operators may comprise a mix of privately-owned companies, State-owned enterprises, and State-owned firms. In conventional aviation, concerns have been raised about the market-distorting effect of State aid in the existing aviation industry. While State aids may ease and accelerate the entry of an operator into the market, it may discourage competition from unsubsidised operators (Balasubramaniam, 2007). These perspectives are equally applicable to commercial eVTOL aircraft operations. The degree of governmental financial intervention should therefore be carefully considered to mitigate competitive imbalance.

- **Essential Air Services:** In some cases, governmental intervention through investments or financial support may be justified and necessary. Essential air services are defined as air services of a public or social nature that a State may consider as needing support since the market may not have sufficient incentive to do so (ICAO, 2005). In domestic terms, these may encompass critical public services, such as emergency medical transport or other types of services where strong reasons warrant enhanced domestic oversight. Support may also be warranted on economic grounds, such as the strategic economic development of remote or peripheral destinations by linking underserved areas to urban centres. In such cases, State subsidies may be required, particularly if there is insufficient incentive for the market to do so through private operations. Provision of air services to remote areas, for example, may have a very low initial traffic volume, which may not be commercially viable without government intervention. The potential for improved social welfare (social and economic benefits) must be demonstrably evident to justify State intervention over the principle of a liberalised market. ICAO's study on essential air services and route support for tourism development may be a useful resource for developing frameworks for eVTOL aircraft operations (ICAO, 2005).
- **Modes of Investment (OECD, 2008; WBCSD, 2009):** Building, maintenance, finance, and operating companies often contract with governments to build and operate long-term transport projects, after which the project is typically transferred back to the government. In this mode of development, the responsibilities for both upstream activities, such as design and building, and downstream activities, such as operations and maintenance, can be transferred to a private company, which may be more motivated to accomplish the project efficiently (i.e., reducing costs and thereby increasing profits). The Organisation for Economic Co-operation and Development (OECD) discusses the options for efficient transport investment in further detail, and its relevant publication may be used as a resource for consideration (OECD, 2008).

→ **Incentives and Disincentives:** Incentives and disincentives in the form of subsidies, taxes, or charges are typically used to decrease or increase the price per unit of transport or the value of transport use. A tax is a levy designed to raise government revenues not necessarily applied on a cost-specific basis, whereas a charge is a levy intended to recover the costs of providing facilities and services (ICAO, 2012). These impacts of incentives and disincentives can also have other outcomes related to capacity and technology management. Various potential uses of subsidies, taxes, and charges are as follows:

- **Market Behaviour Management:** Incentives and disincentives could be used as instruments to influence market behaviour, by making one mode of transport more attractive than another. For example, incentives or disincentives could influence the price of using a particular mode of transport. Tax relief for companies in emerging industries, and tax exemptions for the import of aircraft and parts, are common practices to encourage industry and market development. Such incentives could be used to encourage the uptake of commercial eVTOL aircraft services; however, it should be considered whether such incentives are sustainable for the State in the long run.
- **Operations Capacity and Flow Management:** Taxes, charges, and subsidies could be leveraged to discourage or encourage aspects such as the locations of operations (i.e., routes), times of operation, and the total volume of operations (i.e., number of aircraft in the market). Preventing congestion helps to ensure positive social welfare and better operational efficiencies. The management of operational flow can also be a means to manage noise and visual pollution to facilitate social acceptance.
- **Technology and Sustainable Development Prioritisation:** The direction and focus of technology development could be pushed towards more sustainable development by incentivising or disincentivising the use of certain types of technologies (e.g., emission taxes).
- **Service Standard Assurance:** It may be possible to tie incentives and disincentives to service standards. For example, operators that are supported through governmental incentive schemes could have support withdrawn should they not meet reliability targets.

Annex A lists examples of incentives and disincentives from both land and air transport sectors, as well as some potential adaptations for eVTOL aircraft operations.

Consumer Protection

The protection and improvement of passenger rights is a considerable area of importance for air transport, and there is significant work on regulatory measures, as well as voluntary and non-legally binding self-regulation within the industry. Regulatory measures cover considerations for access to air travel for passengers with reduced mobility, fare transparency, and obligations of operators towards passengers in case of flight disruption (e.g., flight cancellations, flight delays, or denied boarding due to overbooking) (ICAO, 2024).

Operators could consider establishing comprehensive consumer protection systems, such as mechanisms for complaint and feedback, and measures for consumer data protection (i.e., to protect the consumer's privacy).

Furthermore, a long-term mechanism for continuously improving service quality could be implemented, potentially through the establishment of operational service standards.

The key principle is to develop consumer protection regimes that balance the protection of consumers and industry competitiveness without prejudice to the safety and security of aviation (ICAO, n.d.). Such regimes for consumer protection should reflect the principle of proportionality, allow for consideration of the impact of widespread disruptions, and be consistent with international treaty regimes on air carrier liability, such as the Warsaw Convention 1929 and Montreal Convention 1999. Refer to the brochure and full text of the ICAO Core Principles on Consumer Protection for further details (ICAO, n.d.a; ICAO, n.d.b).

Competition Management

In the spirit of liberalisation of the market, competition regulations serve the overall welfare and sustainable economic growth of the market by promoting market conditions in which the nature, quality, and price of goods and services are naturally determined by market forces (ICAO, 2024). Measures to ensure competition must also include appropriate safeguards to promote fairness and effective, sustained participation. This includes considerations for State investment and subsidies that may distort the competitive landscape, as briefly discussed above. ICAO has developed and published a Competition Compendium (ICAO, 2024b) that provides access to competition laws, regulations, practices, and forms of cooperation collected from its Member States. The compendium is available online and is recommended as a resource for consideration in the institution of regulations related to competition in the commercial eVTOL aircraft operations market.

Market Measurement and Review

The economic policy instruments (i.e., regulations, investments, and incentives and disincentives) could be fine-tuned by monitoring the market and its growth. Doing so would involve commercial eVTOL aircraft operators agreeing to share their commercial data with a governmental agency through some established means. Sufficient market data may facilitate a better understanding of the effectiveness of the economic policies, enabling timely adjustments to more readily support market growth and success.

ACTION PLAN

Implementing economic policies and regulations for commercial eVTOL aircraft operations requires strategic decisions and actions centred around a clear social, environmental, and economic objective for the State. A notional process outlining the decisions and actions for the development of economic policies and regulations is illustrated in Figure 1 and described in further detail below.

Figure 1 — Action Plan for Commercial eVTOL Aircraft Operations Economic Policies and Regulations Development

Create Transport Strategy

To develop economic policies and regulations for commercial eVTOL aircraft operations, the nation's Aviation and Transport Agencies (as defined in **Part 3** of this publication) should be clear on how eVTOL aircraft services fit within the nation's existing transport strategy. To determine this, it would be useful to list all eVTOL aircraft operational use cases envisioned for the nation (such as commercial transport, emergency services, and tourism) and to determine the strategic significance of the services rendered for the social, economic, and environmental benefit of the nation. This step would enable governments to distinguish between use cases that should be fully market-driven and those that may warrant or require governmental support. Existing modes of transport that potentially overlap with commercial eVTOL aircraft operations are highlighted in this exercise, supporting strategic decisions on which transport modes to prioritise or de-emphasise using economic policy instruments.

Establish Working Group(s)

The development of economic policies and regulations for transport is an interagency activity that would be more effectively carried out by having a focused working group dedicated to completing the exercise. Considerations and mechanisms for interagency cooperation are detailed in **Part 3** of this publication. The working group would be more likely to employ formal methods for interagency coordination, and the topic of economic policies and regulations is expected to involve the following governmental stakeholders as defined in **Part 3** of this publication: Aviation and Transport Agencies; Legal, Economic, and Trade Agencies; Land Use, Utilities, and Environmental Agencies; Communications and Local Government and Community Agencies.

Identify Economic Instruments

Upon establishment of the interagency working group, the next step is to expand on the transport strategy for eVTOL aircraft by determining specific policy objectives and desired outcomes. As outlined in **Part 4**, the broad objectives should include increasing consumers' benefits and choices, improving connectivity, enabling competitive business opportunities, and supporting sustainable economic development. An example is shown in **Annex B.**

Develop Regulations and Other Economic Instruments

Once the potential economic instruments have been identified, the associated regulatory and policy mechanisms required to implement them can be developed. At this stage, it may be necessary to determine the financial impact and feasibility of certain measures, such as taxes and subsidies. The process for regulatory development, approval, and promulgation may be different for each individual State.

Execute Regulations and Other Economic Instruments

The process of executing regulations is not unique to commercial eVTOL aircraft operations, and existing local governmental processes would be applicable. This phase includes the issuance, monitoring, and enforcement of regulations. For investments, appropriate funding and financing would need to be determined and acted upon.

Review Economic Policies and Regulations

The economic policies and regulations may need to be updated upon gaining more experience in the technologies introduced by commercial eVTOL aircraft operations. Periodic reviews, with the actors involved in the development of the policies and regulations, help ensure that policies remain aligned with strategic objectives. Where necessary, these objectives should also be reviewed to ensure their continued relevance. Existing processes for policy and regulation review would apply in this stage.

Part 4 References

→ Australian Government. (2021, September 30). Emerging aviation technology partnerships program. Australian Department of Infrastructure, Transport, Regional Development, Communications and the Arts. https://www.drones.gov.au/policies-and-programs/emerging-aviation-technology-partnerships-program
→ Balasubramaniam, U. (2007). Market access and the GATS air transport annexure: Possible approaches for India. Journal of Air Law and Commerce, 72(1), 45–77.
→ European Union Aviation Safety Agency [EASA]. (2024). Financing innovative air mobility and services. https://www.easa.europa.eu/en/domains/drones-air-mobility/drones-air-mobility-landscape/financing-innovative-air-mobility-and-services
→ European Parliament. (2024). Fact sheets on the European Union — 2024: Air transport — market rules. https://www.europarl.europa.eu/erpl-app-public/factsheets/pdf/en/FTU_3.4.6.pdf
→ International Civil Aviation Organization [ICAO]. (n.d.a). ICAO core principles on consumer protection. Retrieved June 9, 2025, from https://www.icao.int/sustainability/SiteAssets/pages/eap_ep_consumerinterests/ICAO_CorePrinciples.pdf
→ International Civil Aviation Organization [ICAO]. (n.d.b). ICAO core principles on consumer protection [Brochure]. Retrieved June 9, 2025, from https://www.icao.int/sustainability/Documents/ConsumerProtection/CorePrinciplesBrochure.pdf
→ International Civil Aviation Organization [ICAO]. (2005). A study of an essential service and tourism development route scheme. https://www.icao.int/sustainability/Documents/EssentialAirService/TourismRouteStudy.pdf
→ International Civil Aviation Organization [ICAO]. (2012). ICAO's policies on charges for airports and air navigation services (Doc 9082). https://www.icao.int/publications/Documents/9082_8ed_en.pdf
→ International Civil Aviation Organization [ICAO]. (2024). Air transport policy and regulation. https://www.icao.int/sustainability/Pages/economic-policy.aspx
→ International Civil Aviation Organization [ICAO]. (2024). ICAO competition compendium. https://www.icao.int/sustainability/Compendium/Pages/0-default.aspx
→ Ke, D. (2024, September 2). China's push for the low-altitude economy: What's behind it? Think China. https://www.thinkchina.sg/chinas-push-low-altitude-economy-whats-behind-it
→ Organisation for Economic Co-operation and Development [OECD]. (2008). Transport infrastructure investment: Options for efficiency. OECD Publishing. https://doi.org/10.1787/9789282101551-en
→ Organisation for Economic Co-operation and Development [OECD]. (2011). Regulatory policy and governance: Supporting economic growth and serving the public interest. OECD Publishing. https://doi.org/10.1787/9789264116573-en
→ U.S. Congress. (2021). Advanced Aviation Infrastructure Modernization Act. https://www.congress.gov/bill/117th-congress/house-bill/6270
→ World Business Council for Sustainable Development [WBCSD]. (2009). Mobility for development. https://docs.wbcsd.org/2009/03/Mobility_for_Development.pdf

PART 04 ANNEX A

EXAMPLE INCENTIVES AND DISINCENTIVES

The following presents some examples of existing taxes, charges, or subsidy regimes from both land and air transport. Notably, many of the existing economic instruments for land and air transport may be applicable for commercial eVTOL aircraft operations. Some of the economic instruments would also extend to unique elements that could be introduced by eVTOL aircraft, such as more electrification, dynamic airspace usage, and vertiports or other ground infrastructure.

Aim	Conventional Transport (Land/Air) Charges/Taxes/Subsidies	Notional Additional eVTOL Aircraft Charges/Taxes/Subsidies
Market Behaviour Management	• Vehicle Tax/Subsidy • Registration Tax/Charge/Subsidy • (Re)Sales Tax/Charge/Subsidy • Scrappage Tax/Charge/Subsidy • Licensing Charges • Taxes/Subsidies on Aircraft-Supporting Services • Taxes/Subsidies on Aircraft Consumable Technical Supplies	• Ground Infrastructure Licensing (e.g., Vertiports and Other Infrastructure) Charges/Subsidies.
Operations Capacity and Flow Management	• Fuel Tax/(Sur)Charges • Tax on Vehicle Miles Travelled • Parking Charges • Tolls • Road Use Charges (Road Pricing) • Congestion Pricing • Public Transport Subsidies	• Electricity Tax/(Sur)Charges • Dynamic Airspace Usage Charges (e.g., Time of Day, Traffic Density, Routes) • Ground Infrastructure Use (e.g., Vertiports and Other Infrastructure) Taxes/Subsidies.
Technology and Sustainable Development Prioritisation	• Tax Differentiations Based on Emissions • Carbon/Energy Taxes • Emission Fees • Emissions-Based Surcharges • Subsidies, Tax Rebates for Low-Emission Vehicles/Technologies • Green Building Subsidies	-

References: (Schwaab et. al., 2001) ; (ICAO, 1994)

Part 4, Annex A References

→ International Civil Aviation Organization [ICAO]. (2004). ICAO's policies on taxation in the field of international air transportation (Doc 8632-C/968).
→ Schwaab, S., & Thielmann, S. (2001). Economic instruments for sustainable road transport. Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ) GmbH.

PART 04 ANNEX B

IDENTIFYING ECONOMIC INSTRUMENTS

The following is a demonstration of the process of moving through the transport strategy and policy objectives, to the required results, and ultimately to identifying potential economic instruments to consider as options to implement. The required results and economic instruments could be determined by the designated working group through brainstorming methods.

Transport Strategy	Policy Objective	Required Results	Regulatory Measures	Incentives /Disincentives	Investments
eVTOL Aircraft to be Primary Emergency Medical Services (EMS) Transport Means	Increase consumer's benefits and choices	Air ambulance to be on-site X minutes or less XX% of the time	Air ambulance operator licence requirements Right-of-way for EMS flights	Performance charges or subsidies on operators	Infrastructure (vertiport) network development for closer response
	Improve connectivity	Patients to be receiving medical care in the hospital by X minutes or less XX% of the time upon embarkation on-site	Hospital licence requirements Patient transfer standards and regulations		Development of eVTOL aircraft handling infrastructure at key national hospitals
	Create more competitive business opportunities	Not initially applicable as a critical public service			
	Support sustainable economic development	Reduction of CO_2/NO_x particle emissions from transport by X% by 20XX	Emission certification regulations	Emission fees and surcharges to discourage heliborne operations Reduced carbon/ energy taxes for eVTOL aircraft operations	-

Note: Contents of this table are meant to demonstrate the process and do not represent an existing or notional implementation for commercial eVTOL aircraft operations.

EVTOL AIRCRAFT: PART 05

Capability Development

INTRODUCTION

The core responsibility of a State of Registry (SoR) and State of the Operator (SoO) is to establish and administer the regulatory regime within their respective jurisdictions to ensure that aircraft are operated safely. To undertake this responsibility, the SoR and SoO must implement comprehensive safety oversight regimes comprising legislation, regulations, organisational set-up, and staffing with sufficient technically competent personnel. These elements must support the development and execution of procedures for the issuance of aviation safety authorisations and the resolution of safety concerns.

eVTOL aircraft, by virtue of their novel designs, technologies, and operational use cases, may pose new challenges to an SoR or SoO's organisational and personnel capabilities. This Part aims to describe these potential challenges and suggest considerations to assist fulfilling any gaps in capabilities.

BACKGROUND

SoRs and SoOs are expected to promulgate legislation and regulations that provide adequate safety oversight of civil aviation and its activities within their respective territories and airspace.

The key functions of the SoR and SoO are thus to identify aviation safety risks, develop and implement mitigation measures to address those risks through regulatory response, advice, or guidance, draft rules where a regulatory response is required, issue approvals, monitor compliance, and take actions to enforce or resolve safety concerns.

The SoR and SoO will need to ensure that they possess adequate capabilities in terms of organisational set-up, and sufficiency in competent technical and safety inspectors to carry out these functions effectively.

eVTOL aircraft and their operations may differ significantly from conventional aircraft operations, and the capabilities of the SoR and SoO may require further development to address the following challenges:

- → **Novel Technologies:** Being technologically novel, there is limited or no safety data on eVTOL aircraft and systems. This makes it challenging to develop new safety standards and to design the appropriate inspection and certification procedures. Additionally, existing legacy regulations may not be directly applicable, requiring adaptation or the creation of entirely new standards and requirements.
- → **Pace of Industry Development:** The eVTOL aircraft industry is innovative and developing very rapidly, and regulators will need to keep pace with industry demands while maintaining aviation safety and security. Therefore, training needs for safety inspectors may need to be very dynamic and time-critical, necessitating continuous investment in upskilling to maintain effective safety oversight.
- → **Lack of Internationally Harmonised Standards for eVTOL Aircraft:** Standards for eVTOL aircraft are still emerging and not yet internationally harmonised, leading to potential regulatory gaps and inconsistent interpretation of requirements and safety standards. SoRs and SoOs may need to actively seek to stay informed of the latest developments (i.e., through participation in international forums and engagement of eVTOL aircraft industry actors) and remain flexible in adapting to emerging standards or changes in standards, until further guidance is provided via ICAO or through the ICAO Advanced Air Mobility Study Group (AAMSG).

KEY CONSIDERATIONS

Organisational Capabilities

The governance and regulation of eVTOL aircraft operations may require a Civil Aviation Authority (CAA) to adapt its organisation's existing principles, procedures, and structure to better suit the dynamic nature of emerging technologies. Managing emergent technologies may require a regulatory mindset that is less prescriptive but more adaptive and collaborative.

Being adaptive involves actively co-designing regulation and standards with the industry with rapid feedback loops, prototyping, and testing. This could involve creating and managing regulatory and operational sandboxes, policy labs, and being more involved in industry self-regulatory standards-setting activities and/or the development of non-regulatory guidance material. Additionally, while CAAs are traditionally industry-driven, there may be a need to consider an organisation that more actively drives the industry in developing capabilities, policies, and standards for eVTOL aircraft operations. Focusing on developing regulations that are not prescriptive but rather performance- or outcome-based could also be more effective in adapting to emergent developments in the industry. CAAs could also benefit from strengthening internal capabilities related to safety risk management. This includes establishing systems for safety data collection, analysis and feedback, and trending reviews which will then support a risk-informed and evidence-based approach.

Equally important in regulating emergent technologies would be the adoption of a nationally and internationally collaborative approach to regulatory development. Engaging across a broader ecosystem for regulatory development can help ensure that regulations are better aligned globally, stay up to date, and benefit from a more holistic set of experience and best practices.

For some CAAs, the mandate, procedures, or capacity of the existing organisation supporting the governance and safety oversight of conventional manned aviation may be insufficient or may constrain the ability of the CAA to adjust to managing emergent technologies and operations such as eVTOL aircraft. Most CAAs have established dedicated team(s), allocated independent resources to eVTOL aircraft operations, and adjusted regulatory frameworks towards performance- or outcome-based approaches.

Personnel Capabilities

The overall role of the SoR or SoO in ensuring safe integration and operations of eVTOL aircraft will likely remain unchanged. As such, existing guidance material such as those contained in ICAO Doc 8335 (ICAO, 2022) and ICAO Doc 10070 (ICAO, 2016) on the qualifications and competencies of safety inspectors should be applicable as an initial basis. Existing training resources available to the SoRs and SoOs (e.g., through Memoranda of Understanding with educational institutes, through other approved training organisations, or through ICAO training (ICAO, n.d.)) may also provide a variety of content to help build an aviation professional's capabilities.

Fundamentally, it would be expected that the staff of SoRs or SoOs be equipped with adequate capabilities minimally covering the following areas:

- Certification, Validation, and Acceptance of Aircraft Type
- The Air Operator Certificate Approval Process
- Certificates of Registration and Airworthiness
- Airworthiness of Aircraft
- Personnel Licences
  - Pilot Training Certification and Licences
  - Aircraft Maintenance Personnel Licences
- Supporting Infrastructure
- Airspace and Flight Rules
- Noise and Environmental Impact
- Aviation Security and Cybersecurity

Parts 1 and 2 of this publication outline the relevant considerations and recommended actions pertaining to areas listed in the context of eVTOL aircraft operations. The following section sets out additional considerations to support the training and capability development of SoR and SoO personnel in these areas:

- **Certification, Validation, and Acceptance of Aircraft Type:** Depending on their respective legislative framework, SoRs may accept or validate the original aircraft Type Certificate (TC) or issue its own TC based on the original. SoR personnel involved in this process are expected to possess the necessary technical capability to understand the hazards associated with the new technology or aircraft design being introduced.

  There are several ways that this capability may be developed:

  - **Collaboration with States of Design and Manufacturing:** Where opportunities arise, it may be mutually beneficial for a State of Design (SoD) and a SoR to establish a formal agreement (i.e., a bilateral agreement or memorandum of understanding) enabling the SoR to participate in or observe the aircraft certification process (e.g., shadow certification). Through such arrangements and exercises, SoR personnel will gain a better understanding of the design and certification decisions, potential new hazards, and hazard mitigations associated with the new aircraft type.
  - **Training by Original Equipment Manufacturers:** Aircraft-type training for SoRs conducted by Original Equipment Manufacturers (OEM) is already a standard practice for type validation. This mechanism is expected to be effective for eVTOL aircraft operations and may be essential where the OEM has incorporated a novel technology or aircraft design.
  - **Specific Technology Training:** SoRs may deem it necessary to develop deeper technical expertise to govern and provide safety oversight of specific technologies. Some areas relevant to eVTOL aircraft may include:
    - Lithium-ion battery design, production, and maintenance safety standards (including thermal runaway effects) and practices (e.g., DO-311 compliance)
    - Electric propulsion systems (e.g., electric motors, high-voltage direct current (HVDC) safety)
    - Digital data and information management (e.g., data security and cybersecurity)
    - Automation, autonomy, and artificial intelligence (i.e., analytical and operational AI, advanced sensors, and computer systems)
    - Specialised ground support equipment (e.g., charging infrastructure)
  - **International Collaboration — Participation in International Standards Making or Working Groups:** Involvement as members or observers in international and regional study groups (e.g., ICAO AAM SG), Meeting of Asia-Pacific Regulators on Advanced Air Mobility) or in standards development organisations focused on eVTOL aircraft will allow SoR personnel to stay informed of emergent technologies being considered or used in eVTOL aircraft operations. In addition, CAA safety inspectors may benefit from participating in technology training courses organised by research institutes or participating in eVTOL aircraft technical forums, which facilitate the sharing of latest technology developments and also serve as platforms for information exchange with safety inspectors from other CAAs.
- **Air Operations:** eVTOL aircraft may have unique functions and features that may introduce operational hazards not typically encountered in conventional aviation. When evaluating the air operator submission, the capabilities that are developed for the certification, validation, or acceptance of the aircraft TC would be valuable in assessing the severity and risks of these potentially novel operational hazards.

  The safety inspectors of SoRs or SoOs may also need to assess the impact of novel technologies in eVTOL aircraft on key aspects of operational planning, such as the planning of air routes and determination of alternative landing sites, as well as on flight crew management. eVTOL aircraft type training conducted by the OEM would typically detail the operating characteristics of the aircraft and its operating procedures (i.e., normal and emergency procedures), which will help safety inspectors in understanding how the novel technologies affect operational planning and flight crew management. This knowledge is essential for evaluating new hazards and operational procedures, and for conducting safety investigations.
- **Certificate of Registration and Certificate of Airworthiness:** Existing training frameworks for conventional manned aviation are expected to provide sufficient preparation for safety inspectors involved in the issuance of a Certificate of Registration for an eVTOL aircraft. For the issuance of the Certificate of Airworthiness, the safety inspector may need additional guidance on how to classify the eVTOL aircraft (i.e., powered-lift or rotorcraft).
- **Airworthiness of Aircraft:** eVTOL aircraft designs typically adopt novel technologies in propulsion systems, battery and energy systems, rotors, avionics and software, and structures and airframes. These designs place greater emphasis on electronic systems, software, and energy system maintenance, where specialised training in topics such as battery management and software diagnostics becomes essential for the licensed aircraft engineer that is performing the maintenance. Accordingly, the SoR or SoO safety inspector responsible for oversight of aircraft airworthiness may require training to be equipped with the necessary knowledge to approve the corresponding OEM maintenance schedule.
- **Personnel Licences:** The existing principles for developing oversight capabilities for crew, such as pilots, flight dispatchers, and maintenance engineers, are generally applicable to eVTOL aircraft. As detailed in Part 2 of this publication, greater emphasis may be required on the use of simulators for eVTOL aircraft pilot training and licensing due to the unique design of such aircraft. Officers tasked with qualifying these simulators should be adequately trained and technically competent.

  Standardisation of pilot licensing requirements remains an emerging topic within ICAO; thus, participating in international working groups on pilot licensing and training procedures could serve as effective means for SoRs or SoOs to stay informed of the latest global consensus

Personnel Capabilities

and evolving standards in this area. SoRs and SoOs may also reference regulations and materials published by other CAAs. For example, the Federal Aviation Administration (FAA) has proposed eVTOL aircraft pilot training and operating standards, including processes for obtaining ratings specific to each type of powered-lift aircraft which could be considered as a reference (FAA, 2023).

- **Supporting Infrastructure:** eVTOL aircraft may operate from existing aerodromes (e.g., airfields, airports, heliports), or from dedicated vertiports. Aerodrome regulators may require training to verify that the landing sites are suitable for accommodating both the ground as well as performance characteristics of the eVTOL aircraft that would operate from these sites. As the standards for certifying eVTOL aircraft are still in development and are expected to evolve, collaboration between States, sharing by OEMs on operational norms and limitations (including specific technology training, electrical grids, charging facilities, etc.), and participation in international standards-making or working groups are recommended. However, it should be noted that urban planning does not fall within the remit of the SoR or SoO inspector, as this role is typically undertaken by other experts within the State.
- **Airspace and Flight Rules:** eVTOL aircraft may have unique flight performance and capabilities that allow for more optimised flight rules and operations in areas not currently flown by conventional aviation. The development of new flight rules are an emergent topic for eVTOL aircraft, and involvement in ongoing studies and efforts may be beneficial. Notable examples are NASA's study on digital flight rules (NASA, 2022) and the efforts of the ICAO AAM SG.
- **Noise and Environmental Impact:** Some States may require the development of noise standards and specifications, especially if eVTOL aircraft are expected to operate in residential areas after dark. For such States, it would be necessary to develop the capability to evaluate aircraft noise and establish public noise level limits in collaboration with the State's primary authority responsible for ambient noise governance.
- **Aviation Security and Cybersecurity:** Existing training regime and content are deemed applicable and may be sufficient for the integration of eVTOL aircraft operations. In the area of cybersecurity, recent models of manned aircraft (e.g., the Airbus A350 and Boeing 787) already incorporate cybersecurity protection. SoRs and SoOs with oversight experience of such aircraft are likely to have built up the necessary capability to monitor compliance with aviation security and cybersecurity requirements. For CAAs without this prior experience, OEMs may serve as a resource for developing an understanding of the risks and mitigation measures specific to their eVTOL aircraft.

ACTION PLAN

Organisational Capability Building

The key step that could help in ensuring that a CAA is capable and effective in managing and regulating eVTOL aircraft operations is a retrospective review centred around whether existing legislation, regulations, organisational procedures, organisational culture, or organisational structure (and capacity) may pose constraints to innovation. This process would involve deciding on the regulatory approach (as described in Key Considerations) that would be most effective for eVTOL aircraft developments, particularly if the approach needs to be adaptive and collaborative.

Questions such as when and how to implement organisational changes should also be addressed to ensure that if changes are necessary, they are adequately supported (e.g., financially) and implemented in a timely manner to keep pace with the developments of eVTOL aircraft. The CAA may reference the readiness study provided in **Annex A** as a guide to help identify the existing gaps and to develop a phased implementation schedule.

Personnel Capability Building

The approach to developing training programmes for SoR and SoO personnel involved in overseeing eVTOL aircraft operations should be generally aligned with the existing ICAO framework for inspector training. In this, there are four key steps as follows:

Evaluation of Capability and Competency	In this step, a State would evaluate the capabilities and competencies of their regulatory, technical, and safety personnel to ensure that they are equipped to oversee aspects of eVTOL aircraft operations. This includes considerations in understanding new technologies, operational challenges, and regulatory requirements specific to eVTOL aircraft, with some considerations described in the Key Considerations Section of this Part.
Sourcing Infrastructure and Resources	In this step, the action is to identify and source the necessary infrastructure and resources, such as partnering with industry experts to provide hands-on training opportunities to support the training.
Development of Training Programmes	Following the above two steps, a systematic and comprehensive process should be used to develop the necessary training programmes. These programmes should address the requirements determined in Step One (Evaluation of Capability and Competency) and, where possible, be aligned with competency-based learning as well as scenario-based training. SoRs and SoOs may also consider requesting support from other States that have experience in certifying and operating eVTOL aircraft to benefit from their experiential insights. With these programmes in place, the SoR personnel and inspectors can embark on their respective training paths.
Continuous Education and Development	Continuous education and development are essential investments as new concepts and technologies continue to emerge in eVTOL aircraft. Mechanisms for ongoing training, refresher courses, and professional development should be established to ensure that the State's personnel remain current with industry advancements and regulatory updates.

Personnel Capability Building

The time required for the initial training of SoR and SoO staff would generally depend on the existing experience and knowledge level of the staff. There are several different views as to how early such training should commence. Just-in-time training is one approach; however, this approach may not be suitable for eVTOL aircraft operations given the novelty, depth, and breadth of the specialised knowledge potentially required.

Starting the training at least one to two years in advance of any anticipated entry-into-service of eVTOL aircraft operations may be more effective and allow for a more comprehensive and holistic build-up of technical and safety competencies in specific technical areas for the CAAs. Planning for at least two years may be more desirable for some CAAs, as completing an effective training regime within one year may be difficult due to various factors such as competing priorities and the existing level of knowledge and experience in eVTOL aircraft operations.

Part 5 References

→ Federal Aviation Administration [FAA]. (2023, June 14). Integration of powered-lift: Pilot certification and operations; miscellaneous amendments related to rotorcraft and airplanes (Docket No. 2023-11497).

→ International Civil Aviation Organization [ICAO]. (n.d.). Training. Retrieved June 9, 2025, from https://www.icao.int/training/Pages/default.aspx

→ International Civil Aviation Organization [ICAO]. (2016). Manual on the competencies of civil aviation safety inspectors (Doc 10070, 1st ed., advance unedited).

→ International Civil Aviation Organization [ICAO]. (2022). Manual of procedures for operations inspection, certification, and continued surveillance (Doc 8335, 6th ed.).

→ National Aeronautics and Space Administration [NASA]. (2022, September). Digital flight: A new cooperative operating mode to complement VFR and IFR (NASA/TM-20220013225).

PART 05 ANNEX A

READINESS CHECK

The respective eight Parts of these Reference Materials outline the various areas in detail that a CAA could consider in relation to facilitating commercial eVTOL aircraft and complex UAS operations. CAAs may utilise the following self-assessment checklist to conduct a readiness check and identify broad areas where further development(s) may be needed.

Readiness Checklist

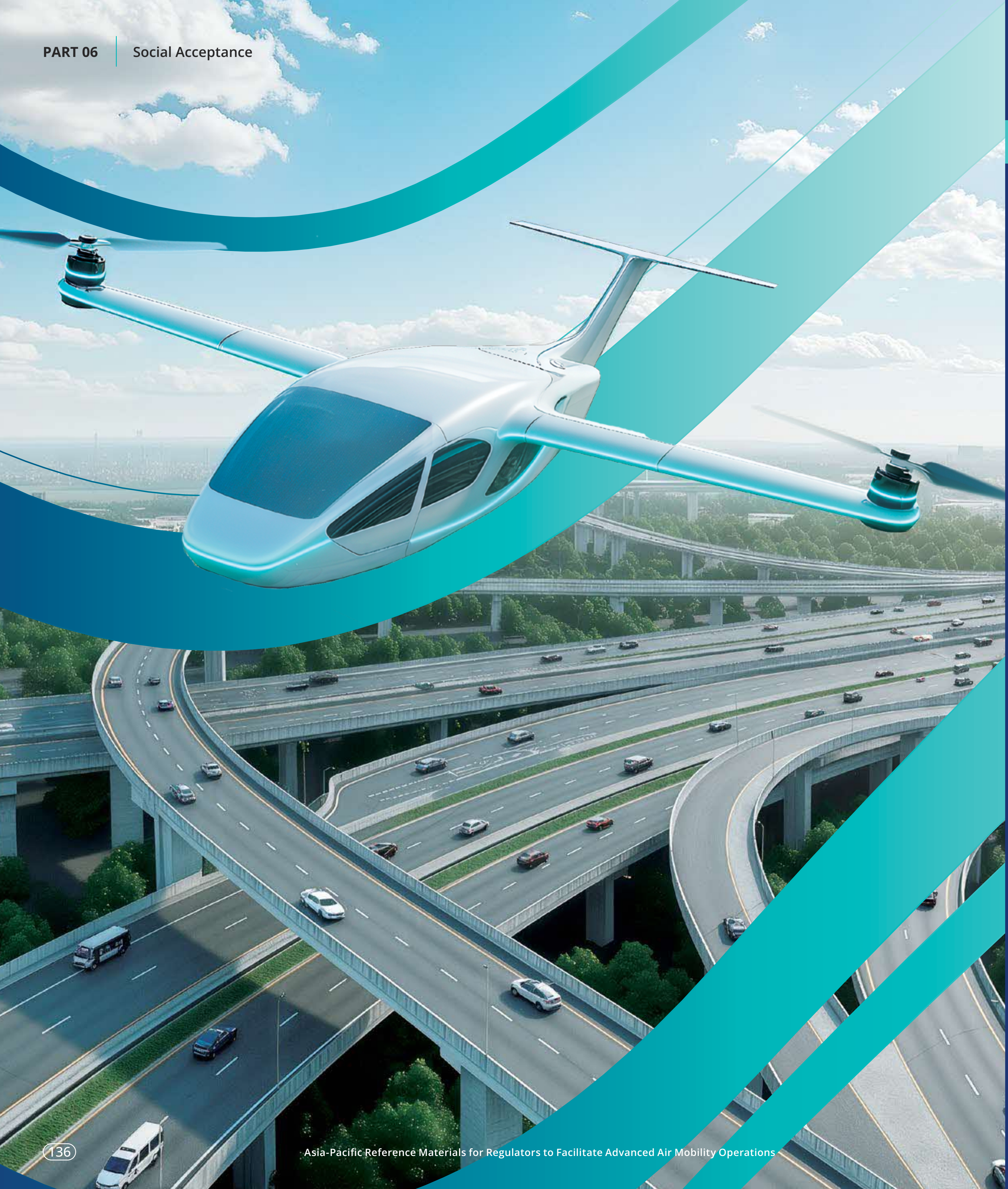
Review the Considerations and Action Plans outlined in each Part of this publication and indicate accordingly in the table below.

Commercial eVTOL Operations	Status
Part 1: Certification, Validation and Acceptance	☐ Have previously evaluated all the Key Considerations articulated in this Part and developed the necessary CAA Action Plans to facilitate eVTOL aircraft operations.
	☐ To review previously made assumptions based on the Key Considerations and Action Plans provided in this Part and update the CAA's Action Plan.
	☐ The Key Considerations and Action Plans contained in this Part are valid and will be referenced to develop the CAA Action Plans for the necessary framework, policies, regulations, or procedures
Part 2: Regulations for eVTOL Aircraft Entry into Service	☐ Have previously evaluated all the Key Considerations articulated in this Part and developed the necessary CAA Action Plans to facilitate eVTOL aircraft operations.
	☐ To review previously made assumptions based on the Key Considerations and Action Plans provided in this Part and update the CAA's Action Plan.
	☐ The Key Considerations and Action Plans contained in this Part are valid and will be referenced to develop the CAA Action Plans for the necessary framework, policies, regulations, or procedures
Part 3: Cooperation Among National Agencies	☐ Have previously evaluated all the Key Considerations articulated in this Part and developed the necessary CAA Action Plans to facilitate eVTOL aircraft operations.
	☐ To review previously made assumptions based on the Key Considerations and Action Plans provided in this Part and update the CAA's Action Plan.
	☐ The Key Considerations and Action Plans contained in this Part are valid and will be referenced to develop the CAA Action Plans for the necessary framework, policies, regulations, or procedures
Part 4: Economic Policies and Regulations	☐ Have previously evaluated all the Key Considerations articulated in this Part and developed the necessary CAA Action Plans to facilitate eVTOL aircraft operations.
	☐ To review previously made assumptions based on the Key Considerations and Action Plans provided in this Part and update the CAA's Action Plan.
	☐ The Key Considerations and Action Plans contained in this Part are valid and will be referenced to develop the CAA Action Plans for the necessary framework, policies, regulations, or procedures.
Part 5: Capability Development	☐ Have previously evaluated all the Key Considerations articulated in this Part and developed the necessary CAA Action Plans to facilitate eVTOL operations.
	☐ To review previously made assumptions based on the Key Considerations and Action Plans provided in this Part and update the CAA's Action Plan.
	☐ The Key Considerations and Action Plans contained in this Part are valid and will be referenced to develop the CAA Action Plans for the necessary framework, policies, regulations, or procedures.
Part 6: Social Acceptance	☐ Have previously evaluated all the Key Considerations articulated in this Part and developed the necessary CAA Action Plans to facilitate eVTOL aircraft operations.
	☐ To review previously made assumptions based on the Key Considerations and Action Plans provided in this Part and update the CAA's Action Plan.
	☐ The Key Considerations and Action Plans contained in this Part are valid and will be referenced to develop the CAA Action Plans for the necessary framework, policies, regulations, or procedures.

Complex UAS Operations	Status
Part 7: Technical Guidance for the Implementation of BVLOS UAS Operations	☐ Have previously evaluated all the Key Considerations articulated in this Part and developed the necessary CAA Action Plans to facilitate complex UAS operations.
	☐ To review previously made assumptions based on the Key Considerations and Action Plans provided in this Part and update the CAA's Action Plan.
	☐ The Key Considerations and Action Plans contained in this Part are valid and will be referenced to develop the CAA Action Plans for the necessary framework, policies, regulations, or procedures.
Part 8: Capability Building (UAS Personnel Training)	☐ Have previously evaluated all the Key Considerations articulated in this Part and developed the necessary CAA Action Plans to facilitate complex UAS operations.
	☐ To review previously made assumptions based on the Key Considerations and Action Plans provided in this Part and update the CAA's Action Plan.
	☐ The Key Considerations and Action Plans contained in this Part are valid and will be referenced to develop the CAA Action Plans for the necessary framework, policies, regulations, or procedures.

Prioritisation of Resources and Efforts

Based on the results of the readiness checklist, each CAA can then develop a gap analysis to determine the areas where greater focus and efforts need to be invested. This would, in turn, contribute to the development of an overall master schedule for facilitating commercial eVTOL aircraft and complex UAS operations, tailored to the specific concept of operations for each use case.



EVTOL AIRCRAFT: PART 06

Social Acceptance

INTRODUCTION

Among other factors, the successful integration of eVTOL aircraft operations will be dependent on securing the trust and support of society for the new products and services that eVTOL aircraft operations will introduce. Dedicated efforts are therefore needed to educate the community about the safety regulations and potential benefits of eVTOL aircraft operations and to effectively address the public's concerns. Building trust and support for this emerging technology will help pave the way for a smooth rollout of eVTOL aircraft operations, which can benefit both the public and the industry.

The aim of this Part is to provide material and guidance for Civil Aviation Authorities (i.e., SoR and SoO) to develop their actions toward social acceptance in their respective States. This Part begins by presenting a broad view of the aims and importance of social acceptance and the results of relevant past studies of public opinion on eVTOL aircraft operations. As considerations for social acceptance efforts, a definition of target audiences, a description of potential means to achieve social acceptance, and a description of expected roles of stakeholders are also presented. Finally, an action plan is presented as a stepwise checklist to support CAAs in their social acceptance efforts.

BACKGROUND

The Aim of Social Acceptance Efforts

Transport planning in the past has typically been based on a top-down approach where governments made decisions mainly driven by traffic flow capacity. However, it has become apparent that in modern society, the involvement of local decision-makers and the resident population in shaping the decisions that affect their daily lives is critical (Agarwal, et. al., 2019).

Land transport offers several historical examples, such as the Lower Manhattan Expressway project, where public opinion galvanised against its development, resulting in the project being halted (Aurbach, 1976). Such projects displaced large communities to make way for the development, and while eVTOL aircraft operations may not impact the communities at such scales, changes in airport or vertiport operations, airspace procedures, aviation infrastructure, and technology could still have effects on communities (FAA, 2023).

Although communities will be affected by eVTOL aircraft operations, it is argued that public opinion is not a barrier to the EIS of eVTOL aircraft, but rather a condition for eVTOL aircraft operations to become a viable market (National Academies, 2020). Governments could introduce new technologies and enforce their use; however, a technology and its market can only scale up if it is positively adopted by the public (NASA, 2018). The Concorde (JSTOR, 2017) and helicopter transport services by New York Airways in the 1970s (Beresnevicius, 2019) illustrate the role that eroded public opinion and loss of trust in the safety of the mode of transport, played in the demise of these businesses. More recently, negative public perceptions of noise and pollution from helicopters in New York City have led lawmakers in the United States to seek to ban non-essential helicopter flights in the city (New York Post, 2024). It has been asserted that public participation, especially in the initial planning and implementation of such technologies and operations, may have prevented these negative outcomes for the respective businesses.

The means to social acceptance and the formation of positive public opinion should therefore involve public participation, especially in the decision-making of the planning and implementation of eVTOL aircraft operations. While the public does not necessarily need to take part in purely technical decisions, which are better addressed by experts, many decisions that appear technical are in fact not. For example, decisions made about what level of health and safety risk is acceptable are not purely technical; they can also reflect societal values and philosophy (Creighton, 2005). Decisions can also require choosing between multiple values and deciding which are more important (e.g., human health concerns vs. economic benefits vs. costs). In this regard, public participation can provide decision-makers with insights into the relative importance and value the public assigns to the available choices. It also allows decision-makers to anticipate what the acceptable limits for such values will be. The benefits, and thus the aims, of social acceptance efforts can be summarised as follows:

- → Incorporating Public Values into eVTOL Aircraft Planning Decisions
- → Improving the Substantive Quality of eVTOL Aircraft Planning Decisions
- → Resolving Conflicts Among Competing Community Interests
- → Building Trust in Institutions
- → Educating and Informing the Public

A key premise of the above aims is that decision-making authority shall remain with the governmental agency, although some of that authority may be shared. It must be recognised that while the collective input can be considered the voice of the public, participants represent their individual interests and do not speak for the public as a whole. Additionally, governmental agencies are better positioned to consider and act on legal, economic, or political constraints affecting particular decisions.

Key Public Opinions and Concerns Regarding eVTOL Aircraft

Studies on public opinion of unmanned aircraft (UA) technologies are said to have begun in 2015, initially focusing on the acceptance of unmanned aircraft systems (UAS) for aerial work. Studies involving public perception of passenger and cargo-carrying UA emerged more recently from 2019 onwards. Sixteen sample studies and reports spanning a the period from 2015 to 2022, covering general public opinion across Australia, Europe (including Finland, Germany, Luxembourg, Netherlands, Norway, Sweden and Switzerland), New Zealand, Mexico, Singapore, and the United States of America (see references) indicate that while the general public and local communities in these countries did not express categorical rejection of UA and eVTOL aircraft operations, there are nonetheless concerns in the following areas:

Privacy

In terms of privacy, some studies indicate that the public may be mainly concerned about the potential infringement of private space. It is suggested that privacy is the most significant concern and that these concerns are associated with the limited knowledge regarding who is operating the UA and for what purpose. Addressing operator anonymity and enhancing operational traceability may assist in mitigating these concerns.

Safety

Studies commonly identify the safety of people both in the air and on the ground as a concern, and a high level of such safety would be essential for the acceptability of eVTOL aircraft use cases, such as urban and regional air mobility. Concerns about mid-air collisions with other aircraft and crash landings are the next significant area of concern after privacy.

Security

Security concerns typically relate to the possibility for malicious misuse of UA (e.g., for terrorism, by criminals, for other malicious intents). A key area relates to the security vulnerabilities that new technologies may introduce, which may lead to hijacking or spoofing of UA for criminal use.

Noise

Noise from aircraft and other transport modes is a complex topic spanning acoustics, physiological human response, the psychological perceptions listeners have of the sound source and what it represents to them (National Academies, 2020). Some studies suggest that the concerns around noise are less about physiological impact and more related to the perceived intrusion of personal space, which ties closely to privacy concerns.

Key Public Opinions and Concerns Regarding eVTOL Aircraft

Visual Pollution	Visual pollution and the concern against "crowded skies" are often highlighted in the studies. Another associated concern is visual disruption, where the sight of UA may be perceived as an unwelcome physical presence in personal space, thereby compounding privacy concerns.
Jobs	In some countries, concerns have been highlighted that existing jobs may be displaced by the introduction of eVTOL aircraft operations. Industries such as logistics and taxi services have been specifically noted in this context.
Environmental Impact	Concerns about the environmental impact of eVTOL aircraft operations tend to focus less on direct emissions from aircraft (which are minimal in battery-electric models) and more on perceptions of the overall environmental impact, and indirect impact on climate change from supporting processes such as the manufacturing and generation of electricity to charge the aircraft. Other concerns also include potential impact of flight operations on bird life and insects and disruptions in biodiversity.
Equity	Some members of the public are concerned that eVTOL aircraft operations may exclusively benefit parts of society that are able to afford the new services, leading to inequities in access. This could result in resentment among those exposed to the disadvantages of eVTOL aircraft operations (e.g., privacy, safety, and noise concerns) but who are excluded from benefiting from the new services.

KEY CONSIDERATIONS

In preparing to take actions towards social acceptance, it is useful to understand three key elements: the target audiences, the means to assure social acceptance, and the roles of stakeholders. These considerations are detailed as follows:

Target Audiences for Building Social Acceptance

The successful implementation of eVTOL aircraft operations hinges on understanding and engaging with diverse target audiences beyond the public and local communities. The target audiences can be broadly classified into the following groups, each with their own unique concerns, interests, and potential impacts that must be addressed to build broad social acceptance:

General Public	This group includes urban and suburban residents, commuters, and environmental advocates. They are concerned about how eVTOL aircraft operations will affect their daily lives, from noise levels to privacy issues. Outreach efforts may focus on the benefits of reduced traffic congestion, improved air quality, and enhanced mobility options.
Local Communities	Residents in potential eVTOL aircraft operational areas and neighbourhood associations are crucial stakeholders. They may have concerns about noise, safety, and property values. Engagement strategies should involve town halls, local forums, and direct community outreach to address specific concerns at the local level and highlight potential community benefits.
Business Sector	This includes potential users of eVTOL aircraft operations such as logistics companies and emergency services, as well as local businesses that might be affected. Economic opportunities, improved efficiency, and potential for new business models should be communicated. Case studies and economic impact assessments can be powerful tools for engaging this audience.
Media	Local and national news outlets, technology journalists, and relevant social media play a key role in shaping public perception. Providing the media with accurate and timely information and maintaining open lines of communication is crucial.
Special Interest Groups	Environmental organisations, accessibility advocates, and privacy rights groups may have specific concerns about eVTOL aircraft operations. It is essential to proactively address these issues through targeted outreach, including in planning processes, and demonstrating how eVTOL aircraft operations align with or address their interests.

Social Acceptance Assurance Means

The means to achieve the aims of social acceptance assurance can be classified into public participation, acceptance-focused policy-making, and public acceptance measurement. The details of these methods are as follows:

→ **Public Participation:** Public participation includes, for example, activities for public engagement, public communication, and public education.

› **Public Engagement:** Even the most well-conceived public policies and plans will likely fail without sufficient public involvement and acceptance. Engaging the public facilitates a better understanding of the social interests, goals, and concerns that must be considered during key decision-making and planning processes (UIC2, 2021; NASA, 2023). Some means that could be used to engage the public for such purposes include the following:

- **Focus Groups and Surveys:** Focus groups and surveys are generally convenient for participants and allow targeted feedback from specific community groups. A guide to developing surveys, along with an example, is provided in **Annex A**.
- **Public Participation Programmes:** It is argued that there is no universal or one-size-fits-all approach to public participation. Public engagement plans should be carefully developed. States may refer to handbooks and resources, such as those listed in **Part 6 References**, to guide the development of a robust public participation programme.

› **Public Communication and Messaging:** Increased communications to the public will ensure that they are better informed of the development of eVTOL aircraft operations, thereby aiding in acceptance and community outreach. Communication campaigns could highlight the social and economic benefits of eVTOL aircraft operations while also providing information on the risks and how public concerns are being addressed. Dissemination of information could be accomplished via both conventional and modern communication channels (e.g., traditional media, social media, public events) in various forms, such as social media posts, articles, flyers, or posters.

- **Communicate Social and Economic Benefits Using the UN Sustainable Development Goals Framework:** Environmental protection and sustainability are the commonly cited potential benefits of eVTOL aircraft operations. However, while carbon emissions and noise are quantifiable, the goals for sustainability are often less clearly defined. The United Nations Sustainable Development Goals (UN SDGs) comprise a set of 17 interconnected global goals under the 2030 Agenda for Sustainable Development, adopted by all United Nations Member States in 2015 (United Nations, 2024). The SDGs aim to end poverty and other forms of deprivation, while promoting strategies to improve health and education, reduce inequality, and spur economic growth, all while tackling climate change and preserving natural resources such as oceans and forests. For civil aviation, ICAO has mapped their strategic objectives to the UN SDGs to help define its contribution to sustainability (ICAO, 2024). Articulating the social and economic benefits of eVTOL aircraft operations based on the UN SDGs can provide a strong and coherent framework to communicate with the public.

› **Public Education:** A challenge with innovations such as eVTOL aircraft is that the enabling technologies and potential new services are not yet experienced by the public in real situations, which may hinder the accurate formulation of public opinion. Public education is a step beyond one-way communication campaigns that will help provide more knowledge and experience to the public. It involves the development and publication of educational materials, accompanied by active briefings, training sessions, or demonstrations to the public. Educational material could be developed in the form of FAQs, brochures, and explanatory videos, among other formats.

→ **Acceptance Focused Policy Making:** eVTOL aircraft products and operations may be more acceptable to the public if policies and plans for eVTOL aircraft operations are aligned with the values and concerns of the public. This may involve principles during eVTOL aircraft policy-making such as creating community-first policies and prioritising specific types of eVTOL aircraft missions. Details of these principles are as follows:

› **Creating Community-First eVTOL Aircraft Operations Policies:** Creating community-first policies involves placing the interests and concerns of the community at the forefront of eVTOL aircraft operational planning. The following guiding principles may be adopted to reflect public interests:

- Ensure that the eVTOL aircraft services promote equitable mobility across all segments of society, including low-income communities, persons with disabilities, and the ageing population.
- Develop flight routes and schedules that are community-friendly with the aim to reduce the visual and acoustic signatures of eVTOL aircraft operations and reduce overflight of the populace.
- Encourage the co-location and integration of eVTOL aircraft infrastructure with existing transport networks to maximise benefits. For example, vertiport siting should not exacerbate existing transport disparities but rather provide affordable and accessible options for all communities.
- Focus on encouraging eVTOL aircraft services that clearly foster positive social benefits and economic growth.
- Ensure that eVTOL aircraft service providers meet or exceed existing safety criteria established by the airworthiness authority.
- Ensure that the development of eVTOL aircraft products and services is aligned with the objectives of the UN SDGs.

› **Prioritisation of Missions:** A strategy to gain trust and social acceptance is to progressively implement eVTOL aircraft operations, starting with use cases and missions that are either least disruptive or most meaningful to society, and complement existing transport operation. Considerations in these two approaches are as follows:

- Prioritise the lowest community impact missions: Early operations could start with missions that present minimal acoustic and visual impact to the general public (i.e., operations conducted away from densely built-up urban areas). It is thought that logistics and enterprise applications may encounter fewer risks and achieve widespread adoption more rapidly than eVTOL aircraft passenger services due to a lower exposure to the public (Orbit, 2023).
- Prioritise meaningful use cases: It is suggested that social acceptance is more likely for applications in health and safety domains, especially those perceived as highly meaningful to society (Aviation Studies Institute, 2024). Prioritising eVTOL aircraft operations for emergency medical services, search and rescue, disaster relief, or missions aligned with the UN SDGs, may facilitate social acceptance.

→ **Public Acceptance Measurement:** Measurements to assess public sentiments and key metrics affecting social acceptance (e.g., noise) may be required to review and help ensure that policies and decisions affecting eVTOL aircraft operations have a positive effect on social acceptance. There are several metrics that could be measured, such as the following:

› **Economic Benefits and Impact:** Measuring economic benefits and impact may help communicate the benefits and opportunities of eVTOL aircraft operations. However, it could be difficult to accurately measure the economic benefits and impact in the early stages, as use cases will be new, and

Social Acceptance Assurance Means

outcomes may not become evident until operations have matured and users have adapted to the new services. As such, studies on economic benefits and impact may need to rely on using scenario-based analyses and simulations.

- **Social Values and Opinions:** Understanding social values and opinions can provide insight into social sentiments towards eVTOL aircraft operations. This measurement of public values and opinions is typically conducted through public engagement (refer to **Table 5** on "Public Engagement"). Key considerations include:
  - **Demographics of studies:** In designing of social value and opinion measurement activities, care should be taken to consider the target demographics. Surveys should avoid limiting responses to only favourable categories of participants, such as targeting only those in higher income brackets. Results should also consider potential biases due to participant backgrounds. For example, answers from surveys through aeronautical industry associations may have a biased perspective due to the knowledge and experiences of a predominantly engineering-biased audience.
  - **Measuring acceptance of autonomy:** To obtain meaningful results, assessments of the potential reaction to increasing "autonomy" should clearly explain the specific automated functions, the rationale for automation, its limitations, and the respective roles of humans and automation in potentially critical or uncertain situations.
  - **Measuring trust:** Trust is an essential component for gaining public support in any emerging technology; however, it is a psychological construct and difficult to measure directly. When trust is given, it can be said that it is assumed by one person that a situation is being executed safely and well.

    On this basis, the measurement of trust can use alternative metrics such as perception of reliability. The support and trust of technology could potentially be evaluated by asking questions related to perceptions of the level of reliability, predictability, quality of engineering, technical capabilities, severity of system failures, and potential risks.
  - **Developing surveys:** The literature offers extensive guidance on the systematic design of public opinion surveys. Some useful resources, such as handbooks and guides, are listed in **Part 6 References** (e.g., Ducharme, 2020; Creighton, 2005).
- **Noise:** There is no international consensus on a noise metric specifically suited to eVTOL aircraft. It is suggested that helicopter noise measurement methods could be used. Alternatively, EASA has also published a guideline on noise measurement of UAS under 600kg, which could be used as a reference (EASA, 2023).
- **Visual Pollution:** There are no standard definitions for visual pollution, and conversely, the definitions are said to be becoming more diverse. It is suggested that visual pollution, being tied to privacy concerns, should be measured through public engagement (i.e., surveys and focus groups).

Stakeholders and Their Roles in Social Acceptance of eVTOL Aircraft Operations

Effective implementation of eVTOL aircraft operations requires a collaborative effort from various stakeholders including actors from academia, associations, industry, and national agencies. Each stakeholder plays a crucial role in building social acceptance. Examples of the stakeholders and their potential roles in social acceptance of eVTOL aircraft operations are described in **Tables 1 to 4**, respectively.

Type of Stakeholder	Stakeholder	Roles in Social Acceptance of eVTOL Aircraft Operations
Academia	Universities and Research Institutions	→ Conduct and publish independent studies on societal impacts of eVTOL aircraft operations. → Host public lectures and workshops on eVTOL aircraft technology and implications. → Develop educational programmes to prepare the public for eVTOL aircraft integration.

Table 1 — Stakeholders and Their Roles in Social Acceptance of eVTOL Aircraft Operations: Academia

Type of Stakeholder	Stakeholder	Roles in Social Acceptance of eVTOL Aircraft Operations
Associations	Industry Associations	→ Coordinate industry-wide social acceptance campaigns. → Develop and promote ethical guidelines for eVTOL aircraft implementation. → Organise public events and forums to facilitate industry-community dialogue. → Assess and communicate potential impact of eVTOL aircraft operations on industries and jobs.
	Community Associations	→ Organise public outreach programmes and events to facilitate public dialogue.
	Workers Unions	→ Organise and communicate developments, benefits, and impacts of eVTOL aircraft operations to potentially impacted workforces. → Engage with potentially impacted workforces to obtain feedback on new eVTOL aircraft technologies and services.
	Insurance Companies	→ Publish reports on safety assessments of eVTOL aircraft operations to build public confidence. → Develop consumer-friendly insurance products to address public concerns about risks on eVTOL aircraft operations. → Participate in public forums to explain risk management for eVTOL aircraft operations.

Table 2 — Stakeholders and Their Roles in Social Acceptance of eVTOL Aircraft Operations: Associations

Type of Stakeholder	Stakeholder	Roles in Social Acceptance of eVTOL Aircraft Operations
Industry	Aircraft Original Equipment Manufacturers	→ Engage in transparent communication about development progress and safety measures. → Collaborate with local communities to address concerns in vehicle design (e.g., noise reduction). → Conduct public demonstrations to showcase safety features and low acoustic impact. → Develop and share easy-to-understand materials on eVTOL aircraft technology, highlighting its social and economic benefits and alignment with sustainable development goals.
	Operators	→ Implement community outreach programmes to raise public awareness and understanding of eVTOL aircraft services. → Establish transparent communication channels for addressing public concerns. → Develop and publish clear safety protocols and passenger experience information. → Offer trial flights or virtual experiences to build public comfort. → Develop services that aim to ensure social equity and support global sustainability goals. → Introduce eVTOL aircraft and services incrementally to build public awareness, trust, and confidence. → Public education about how eVTOL aircraft are serviced/maintained to ensure peace of mind about the serviceability and safety of the eVTOL aircraft.
	Infrastructure Providers	→ Engage in early community consultation for infrastructure placement. → Demonstrate how eVTOL aircraft infrastructure can be integrated into and enhance existing urban environments and transport modes. → Develop visually appealing and community-friendly vertiport designs. → Host community open houses at vertiport sites to familiarise the public with eVTOL aircraft infrastructure, its potential social and economic benefits, and its alignment with sustainable development goals.
	Insurance Companies	→ Publish reports on eVTOL aircraft safety assessments to build public confidence. → Develop consumer-friendly insurance products to address public concerns on risk associated with eVTOL aircraft operations. → Participate in public forums to explain the risk management approach for eVTOL aircraft.
	System Original Equipment Manufacturers and Technology Providers	→ Develop, demonstrate, and promote technologies that mitigate social acceptance concerns (e.g., safety, noise, security).

Table 3 — Stakeholders and Their Roles in Social Acceptance of eVTOL Aircraft Operations: Industry

Type of Stakeholder	Stakeholder	Roles in Social Acceptance of eVTOL Aircraft Operations
National Agencies	Aviation and Transport Agencies	→ Develop and communicate clear and accessible safety standards for eVTOL aircraft operations. → Conduct public consultations on proposed policies and regulations governing eVTOL aircraft operations. → Provide regular updates on safety oversight to build and maintain public trust. → Demonstrate how eVTOL aircraft operations integrate with and improve existing transport systems. → Conduct and publish studies on potential of eVTOL aircraft operations to reduce traffic congestion. → Engage the public in visioning exercises for the future of urban mobility. → Facilitate and support eVTOL aircraft trials and demonstrations by the industry to generate public awareness and build public confidence.
	Security and Emergency Services Agencies	→ Demonstrate potential of eVTOL aircraft operations in improving emergency response. → Conduct public safety drills incorporating operations of eVTOL aircraft to build confidence. → Communicate safety protocols and emergency procedures related to eVTOL aircraft operations.
	Legal, Economic, and Trade Agencies	→ Communicate potential job creation and economic benefits of eVTOL aircraft deployment. → Organise job fairs and training programmes for eVTOL aircraft-operations related opportunities. → Showcase how eVTOL aircraft operations can enhance local businesses and tourism.
	Land Use, Utilities, and Environmental Agencies	→ Conduct visual impact assessments and develop mitigation strategies. → Engage the public in participatory planning processes, including community design workshops, for eVTOL integration. → Develop guidelines for vertiport placement that balance operational requirements with community concerns. → Develop and communicate a vision of how eVTOL aircraft operations fit into future urban landscapes. → Publish transparent environmental impact assessments of eVTOL aircraft operations. → Engage the public in discussions about environmental concerns and mitigation strategies.
	Communications and Local Government and Community Agencies	→ Establish citizen advisory boards to represent community interests in eVTOL aircraft operations planning processes. → Conduct town halls and public forums to facilitate community feedback and disseminate accurate information about eVTOL aircraft. → Develop and communicate local benefits of eVTOL aircraft services.
	Technology and Research Agencies	→ Develop and communicate national technology strategies highlighting their potential social and economic benefits. → Support academic and Industry-led studies on the social and economic benefits and impact of eVTOL aircraft operations.

Table 4 — Stakeholders and Their Roles in Social Acceptance of eVTOL Aircraft Operations: National Agencies

ACTION PLAN

This suggested action plan outlines a strategic approach to fostering social acceptance of eVTOL aircraft operations and proposes a range of initiatives focusing on public participation, acceptance-focused policy-making, and measurement of public acceptance, as detailed in **Tables 5 to 7**. By combining proactive engagement, clear communication, and data-driven decision-making, the plan aims to address potential concerns, highlight benefits and impacts, and foster a collaborative vision for the future of eVTOL aircraft operations. These suggestions are designed to be flexible and adaptable and may be refined based on community feedback and technological advancements, with the goal of aligning eVTOL aircraft operations development with societal needs and values.

Public Participation

Description	Stakeholders
Public Engagement • Implement a comprehensive public participation programme. • Organise focus groups with diverse community representatives. • Host town halls and online forums for direct citizen input. • Create groups to address specific concerns (e.g., safety mitigations, urban planning, wildlife impact, integration with existing transport). • Regularly update public engagement efforts in response to new developments and findings from public acceptance measurements.	• Industry • Industry Associations • Community Associations • National Agencies
Public Communication and Messaging • Develop a multi-channel communication strategy (social media, traditional media, community events). • Create targeted messaging highlighting social and economic benefits and impacts. Leverage the UN SDGs as a framework for messaging. • Use storytelling to illustrate real-world eVTOL aircraft applications. • Regularly update communication strategies and materials based on new developments and findings from public acceptance measurements.	• Industry • Associations • National Agencies
Public Education • Publish accessible materials explaining eVTOL aircraft technology and safety measures. • Publish accessible materials explaining social and economic benefits and impact. • Develop school programmes to educate youth. • Regularly update public education strategies and materials based on new developments and findings from public acceptance measurements.	• Aircraft OEMs • Insurance Companies • Academia • Aviation and Transport Agencies • Technology and Research Agencies

Table 5 — Potential Actions by Stakeholders Supporting Public Participation

Acceptance Focused Policy Making

Description	Stakeholders
Creating Community-First eVTOL Aircraft Operations Policies • Establish local advisory boards to inform policy decisions. • Implement feedback mechanisms for continuous policy refinement. • Ensure policies address community concerns. • Establish a feedback loop between public acceptance measurements and policies/policy decisions.	• Aviation and Transport Agencies • Land Use, Utilities, and Environmental Agencies • Communications and Local Government and Community Agencies
Prioritisation of Missions • Identify and prioritise eVTOL aircraft missions with clear public benefits. • Design pilot programmes based on prioritised missions. • Facilitate tests and trials for incremental introduction of eVTOL aircraft operations. • Ensure transparent reporting of all pilot programme outcomes. • Use pilot data to inform policy adjustments and public communication. • Create a roadmap for gradual expansion of eVTOL aircraft services.	• Aviation and Transport Agencies • Local Government and Community Associations • Legal, Economic, and Trade Agencies • Operators

Table 6 — Potential Actions by Stakeholders Supporting Acceptance-Focused Policy-Making

Public Acceptance Measurement

Description	Stakeholders
Measuring Economic Benefits and Impact • Conduct regular economic impact studies. • Track job creation and skills development in the eVTOL aircraft sector. • Analyse effects on local businesses and property values.	• Industry Associations • Academia • Legal, Economic, and Trade Agencies
Measuring Social Values and Opinion • Implement periodic public opinion surveys. • Use sentiment analysis on social media and news coverage. • Conduct in-depth interviews with community leaders.	• Industry Associations • Academia • Communications and Local Government and Community Agencies
Measuring Noise • Establish baseline noise levels in target areas. • Conduct regular noise impact assessments. • Publish comparative studies with existing transport noise levels.	• Aircraft OEMs • Operators • Academia • Aviation and Transport Agencies • Land Use, Utilities, and Environmental Agencies
Measuring Visual Pollution • Assess visual impact through simulations and pilot programmes. • Conduct surveys on perceived visual disturbance. • Develop guidelines for minimising visual impact.	• Operators • Infrastructure Providers • Community Associations • Land Use, Utilities, and Environmental Agencies • Communications and Local Government and Community Agencies

Table 7 — Potential Actions by Stakeholders Supporting Public Acceptance Measurement

Part 6 References

- (**) Denotes references used in the study of key public opinion and concerns of eVTOL.
- Agarwal, O. P., Kumar, A., & Zimmerman, S. (2019). Transport planning and decision making in the age of social media: From exclusivity to inclusivity (Chap. 9, pp. 169–197). Elsevier.
- AiRMOUR. (2022, June 30). Guidebook for UAM integration process management [Draft version].
- AiRMOUR. (2022, October 5). Public and stakeholder acceptance of urban air mobility and its application for emergency medical services. (**)
- AiRMOUR. (2022, June 29). Public and stakeholder acceptance: Interim report (Rev. 2.0). (**)
- Andrade, A., Vieira, D., Marques, J., & Babadopoulos, M. (2022, October). Operational feasibility to introduce eVTOL in São Paulo using the existing infrastructure of helipads and heliports [Research report]. Embry-Riddle Aeronautical University.
- Aurbach, J. (1976). The power broker, Robert Moses and the fall of New York. The Urban Lawyer, 8(2), 406–412.
- Aviation Studies Institute. (2024, March). A future with autonomous urban air mobility: Preparing cities and citizens.
- Beresnevičius, R. (2019). Defining urban travel in the 1950s: The story of New York Airways. Aerotime. https://www.aerotime.aero/articles/22811-new-york-airways-story
- Booz Allen Hamilton. (2018, November 21). Urban air mobility (UAM) market study. (**)
- Clothier, R., Greer, D. A., Greer, D., & Mehta, A. (2015). Risk perception and the public acceptance of drones. Risk Analysis, 35(6), 1160–1186. **
- Creighton, J. L. (2005). The public participation handbook: Making better decisions through citizen involvement. John Wiley & Sons.
- Ducharme, D. (2020, November). Handbook for survey development (War Gaming Department Working Paper WGD_20202). U.S. Naval War College.
- European Commission. (2022, November 29). A drone strategy 2.0 for a smart and sustainable unmanned aircraft eco-system in Europe. (**)
- European Union Aviation Safety Agency [EASA]. (2021, May 19). Study on the societal acceptance of urban air mobility in Europe. (**)
- European Union Aviation Safety Agency [EASA]. (2023, September 11). Guidelines on noise measurement of unmanned aircraft systems lighter than 600 kg operating in the specific category (low and medium risk) (Rev. 1).
- Eißfeldt, H., Vogelpohl, V., Stol, M., Papenfuß, A., Biella, M., Belz, J., & Kügler, D. (2020). Acceptance of civil drones in Germany. CEAS Aeronautical Journal, 11(2), 665–678. (**)
- Federal Aviation Administration [FAA]. (2023, July). Advanced air mobility (AAM) implementation plan (Version 1.0).
- Hochschule für Technik Stuttgart. (2019, December 5). Acceptance of air taxis: A field study during the first flight of an air taxi in a European city. (**)
- Institution of Mechanical Engineers. (2019). Public perceptions: Drones — Survey results. (**)
- International Civil Aviation Organization [ICAO]. (2024). ICAO and the United Nations Sustainable Development Goals. https://www.icao.int/about-icao/aviation-development/Pages/SDG.aspx
- JSTOR Daily. (2017). The rise and fall of the supersonic Concorde. https://daily.jstor.org/the-rise-and-fall-of-the-supersonic-concorde/
- Lidynia, C., Philipsen, R., & Ziefle, M. (2017). Droning on about drones: Acceptance of and perceived barriers to drones in civil usage contexts. In Proceedings of the International Conference on Human—Computer Interaction (pp. 317–329). Springer. (**)
- NASA. (2018, November). Urban air mobility (UAM) market study. (**)
- NASA. (2023, May). Advanced air mobility community integration considerations playbook.
- National Academies of Sciences, Engineering, and Medicine. (2020). Advancing aerial mobility: A national blueprint. The National Academies Press. (**)
- New York Post. (2024). NYC residents fume at ‘hellish helicopter highway’ as lawmakers seek to ban ‘non-essential’ choppers. New York Post. https://nypost.com/2024/04/16/us-news/nyc-residents-hellish-helicopter-highway-lawmakers-seek-ban-on-non-essential-choppers/
- Orbit Management Services. (2023). Advanced air mobility risk report.
- Smith, A., Dickinson, J., Marsden, G., Cherrett, T., Oakey, A., & Grote, M. (2022). Exploring public perceptions of drone use in the United Kingdom. Technology in Society, 68, 101914. (**)
- Tan, L., Lim, B., Park, G., Low, K., & Yeo, V. (2020). Public acceptance of drone applications in a highly urbanised environment. Technology in Society, 64, 101454. (**)
- UIC2. (2021, December). Urban air mobility and sustainable urban mobility planning: Practitioners briefing.
- United Nations Department of Economic and Social Affairs. (2024). The 17 goals: Sustainable development. https://sdgs.un.org/goals
- Virginia Tech. (n.d.). Perspectives on drone delivery. (**)
- Yedvavalli, P., & Moobery, J. (n.d.). An assessment of public perception of UAM. Airbus. (**)

PART 06 ANNEX A

GUIDE TO DEVELOPING SURVEYS FOR PUBLIC ENGAGEMENT IN EVTOL AIRCRAFT POLICY MAKING

This annex serves as a guide for CAAs and stakeholders in designing surveys that effectively capture community perspectives. The insights gained from these surveys can support the development of informed and responsive policies for eVTOL aircraft and operations.

One approach to public engagement includes assessing perceptions — how people feel and think about eVTOL aircraft operations — and expectations — what they hope for or anticipate regarding eVTOL aircraft. Understanding perceptions enables stakeholders to address potential concerns early on, while exploring expectations helps guide service offerings and community outreach in ways that align with public aspirations.

The annex is organised into three key sections:

- Developing Effective Survey Questions for Public Engagement
- Sample Questions
- Sample Survey

These materials are adaptable for use across various public engagement methods, such as focus groups and large-scale surveys, offering flexible and effective means to gather feedback from diverse community groups.

Developing Effective Survey Questions for Public Engagement

Crafting survey questions effectively is essential to gathering reliable, accurate, and actionable data. This section provides techniques, question types, and best practices for crafting and creating survey questions that capture relevant data to support policy development and target public outreach.

- **Techniques for Crafting Effective Survey Questions:** Well-designed questions ensure that respondents understand exactly what is being asked and provide responses that reflect their true perceptions and expectations. The following techniques focus on clarity, neutrality, and precision, which contribute to the effectiveness of survey questions and the overall validity findings:
  - **Define Clear Objectives:** Begin with a clear understanding of the survey's purpose. For instance, the survey may aim to assess public perceptions and expectations. Defining these goals clearly would help in formulating questions that yield relevant data.
  - **Use Simple and Direct Language:** Avoid technical jargon or complex wording that may confuse respondents.
  - **Focus on Neutral Wording:** Keep questions unbiased to avoid influencing responses. Avoid terms that carry emotional weight or imply a 'correct" answer, as these may skew results.
  - **Be Specific and Precise:** Questions should clearly identify the topic and scope. Vague questions can lead to ambiguous responses.
  - **Limit the Scope of Each Question:** Avoid double-barrelled questions that address more than one subject at a time, as they may confuse respondents or yield ambiguous results.
  - **Pilot Test the Survey:** Conduct a pilot test with a small group to identify and resolve any issues related to question clarity or interpretation.
- **Types of Questions to Include in Surveys on eVTOL Aircraft Operations:** Including a variety of question types in surveys is essential to gathering both quantitative and qualitative data that reflect public sentiment, knowledge, and expectations. The following are some recommended question types:
  - **Close-Ended Questions:** These provide respondents with specific answer choices, allowing for easier analysis and quantitative insights.
  - **Multiple-Choice Questions:** Useful for gathering specific information or perceptions. For example: "What concerns do you have about eVTOL aircraft? (Select all that apply: Safety, Security, Privacy, Noise Impact, Visual Impact, Environmental Impact, Job Impact, Equity, Affordability, and Accessibility, or None)."
  - **Yes/No Questions:** Useful for obtaining clear, binary responses, often to assess basic awareness or interest. For example: "Would you personally be interested in participating in community engagement activities related to eVTOL aircraft?"
  - **Rating Scale Questions:** Allow respondents to rate their level of concern, interest, or agreement on a numerical or descriptive scale. The Likert scale, which measures agreement or frequency (e.g., "Strongly Agree" to "Strongly Disagree"), could be used as an option for rating scale questions. For example: "How concerned are you about eVTOL's impact on privacy? (Not at all concerned, slightly concerned, very concerned, extremely concerned)."
  - **Ranking Questions:** Useful for prioritising preferences or concerns, such as ranking potential benefits of eVTOL aircraft. For example: "Please rank the following benefits of eVTOL aircraft operations in order of importance to you."
  - **Open-Ended Questions:** These questions allow respondents to provide detailed answers, giving insight into motivations, concerns, and expectations. For example: "What safety measures would you expect to see implemented for eVTOL aircraft?"
  - **Demographic Questions:** These questions gather background information on respondents (age, gender, location, etc.), allowing for analysis based on demographics.
  - **Contingency or Follow-Up Questions:** Triggered based on previous responses, these provide further insight into specific areas. For instance, if a respondent selects "Noise impact" as a concern, a follow-up might ask, "What measures would you like to see to minimise noise impact?"

  These question types, when used strategically, provide a comprehensive view of public perceptions and expectations, enabling stakeholders to make data-driven decisions for eVTOL aircraft initiatives.
- **Best Practices:** The following are some best practices for designing surveys and formulating survey questions:
  - **Survey Question Structure:** Begin with broad questions, such as general knowledge or familiarity with eVTOL aircraft, before progressing to more complex or thematic questions. Group questions by themes (e.g., Safety, Security, Privacy, Environmental Impact, etc.) to help respondents stay focused on specific aspects of eVTOL aircraft operations.
  - **Balance of Question Types:** Incorporate a mix of question types, such as close-ended and open-ended questions (as listed in the section above), to capture both quantitative and qualitative data. This allows for more specific and measurable responses while also giving respondents space to express unique perspectives.

Sample Questions

This section provides a selection of sample questions that may be used or adapted to assess public perceptions and expectations around eVTOL aircraft, as shown in **Tables A-1 and A-2**, respectively. The questions are organised across themes such as general perceptions, safety, security, privacy, noise and visual impact, environmental impact, job impact, equity, and other relevant social factors. By capturing a range of community perspectives, CAAs and stakeholders will be better positioned to develop policies that are attuned to public sentiment.

CAAs are encouraged to review these questions for relevance to their specific contexts, adapting them as needed to address unique local considerations and engagement goals.

Questions Related to Understanding Perceptions of eVTOL Aircraft Operations
General Perceptions 1. How would you rate your current understanding of eVTOL aircraft technology? 2. What comes to mind when you think about eVTOL aircraft technology? 3. How informed do you feel about eVTOL aircraft's potential impact on society? 4. Which sources have informed your knowledge about eVTOL aircraft? 5. How would you describe your general impression of eVTOL aircraft? 6. How interested are you in learning more about eVTOL aircraft operations? 7. What specific topics would you like more information about regarding eVTOL aircraft operations? 8. How beneficial do you believe eVTOL aircraft operations could be for society? 9. Which potential benefits of eVTOL aircraft operations do you find most compelling? 10. What are your main concerns regarding eVTOL aircraft operations in your community? 11. What specific information would make you feel more confident about eVTOL aircraft operations? 12. Which of the following would increase your trust in eVTOL aircraft technologies and operations? 13. Which methods of public engagement would you find most effective for eVTOL-related decisions? 14. How would you like to see your community engaged in decisions about eVTOL aircraft operations? 15. How confident are you that public input will be meaningfully integrated into eVTOL aircraft operations planning? 16. Would you personally be interested in participating in community engagement activities related to eVTOL aircraft operations? 17. How would you like to be engaged in eVTOL aircraft operations? 18. How would you prefer to receive information about eVTOL aircraft developments?
Safety 19. How confident are you in the safety of eVTOL aircraft for both passengers and people on the ground? 20. What do you perceive is the greatest safety risk associated with eVTOL aircraft operations? 21. How concerned are you about the safety of eVTOL aircraft operations for both passengers and people on the ground?
Security 22. How vulnerable do you think eVTOL aircraft operations might be to security risks (e.g., hacking, unauthorised use, or malicious activities)? 23. How concerned are you that eVTOL aircraft systems might be vulnerable to hacking or unauthorised use?
Privacy 24. To what extent do you believe eVTOL aircraft operations could impact personal privacy (i.e., visibility into private spaces)? 25. How confident are you that privacy protections will be in place as eVTOL aircraft are developed? 26. How concerned are you that eVTOL aircraft operations might infringe on personal privacy?
Noise Impact 27. How do you anticipate eVTOL aircraft operations could impact noise levels in your area? 28. How concerned are you that eVTOL aircraft operations will increase noise pollution in your area?
Trust 29. How reliable do you think eVTOL aircraft are in terms of maintaining consistent performance and avoiding system failures? 30. How predictable do you believe eVTOL aircraft operations are, especially in emergency situations? 31. How much trust do you have in the flight systems and technologies of eVTOL aircraft when they are operated under human control during the initial stages of deployment? 32. How much trust do you have in the automation and control systems of eVTOL aircraft to make safe and accurate decisions under human oversight and occasional intervention during more mature stages of operation?
Visual Impact 33. How do you perceive the potential visual impact of eVTOL aircraft operations (e.g., crowded skies)? 34. How concerned are you about the visual impact of eVTOL aircraft operations?
Environmental Impact 35. To what extent do you believe eVTOL aircraft operations could positively or negatively impact the environment? 36. How concerned are you that eVTOL aircraft operations could negatively impact the environment?
Job Impact 37. How do you perceive eVTOL aircraft and their operational impact on employment overall? 38. How do you perceive eVTOL aircraft and their operational impact on employment in traditional industries like transport and logistics? 39. How concerned are you that eVTOL aircraft operations will negatively impact jobs in traditional industries like transport and logistics?
Equity, Affordability, and Accessibility 40. Do you think eVTOL aircraft services will be accessible and affordable to most community members? 41. How affordable do you think eVTOL aircraft services will be compared to existing transport options (e.g., taxis)? 42. How concerned are you about fair access to eVTOL aircraft services for all socioeconomic groups?

Table A-1 — Example Survey Questions — Understanding Perceptions of eVTOL Aircraft

Questions Related to Understanding Expectations of eVTOL Aircraft Operations
General Expectations
43. What benefits do you expect eVTOL aircraft to provide for your community?
44. How important is it to you that eVTOL aircraft services are introduced gradually, with comprehensive testing and regulatory oversight?
45. What information would make you feel more confident about eVTOL aircraft?
46. How important is it to you that the public is consulted in the development of eVTOL aircraft policies and regulations?
47. How often would you expect the public to be updated on eVTOL aircraft developments?
Safety
48. What safety measures would you expect to see implemented for eVTOL aircraft?
Security
49. What security measures do you expect to be in place for eVTOL aircraft operations?
Privacy
50. What privacy protections would you like to see in place for eVTOL aircraft operations?
Noise Impact
51. What steps would you like to see taken to minimise eVTOL aircraft-related noise?
Visual Impact
52. How important is it to you that eVTOL aircraft operations avoid disrupting residential areas visually?
53. How important is it to you that eVTOL aircraft operations avoid disrupting natural areas visually?
Environmental Impact
54. What environmental impacts do you hope eVTOL aircraft operations may bring?
55. What environmental standards or initiatives would you expect eVTOL aircraft operations to follow to reduce their environmental impact?
Job Impact
56. What role would you like to see eVTOL aircraft operations play in supporting local job growth?
Equity, Affordability, and Accessibility
57. How should eVTOL aircraft services address equity in service access?
58. What measures would you expect to ensure that eVTOL aircraft services are affordable and accessible to all community members?
59. How much would you be willing to pay for a short eVTOL aircraft trip within your city (e.g., a 10–15-minute ride)?
60. If eVTOL aircraft services were priced similarly to other private services (e.g., private hire cars), would you consider using them?
61. Would you be interested in subscription or membership plans offering discounted eVTOL aircraft service rates?
Community Engagement and Preferred Communication Channels
62. How would you prefer to receive information about eVTOL aircraft developments and regulations?
63. How would you like to see your community engaged in decisions about eVTOL aircraft operations?
64. Would you be interested in participating in public consultations or focus groups on eVTOL aircraft operations?

Table A-2 — Example Survey Questions — Understanding Expectations of eVTOL Aircraft Operations

Sample Survey

This sample survey is designed to assess public perceptions and expectations surrounding eVTOL aircraft operations. The survey includes questions that explore respondents' understanding of eVTOL aircraft operations, their general attitudes toward the technology, and their specific concerns or expectations — including safety, security, privacy, noise impact, visual impact, environmental impact, job impact, equity, affordability, and accessibility) — with the goal of informing policies that address community needs and priorities. Additionally, questions about community engagement and preferred communication channels will inform effective outreach strategies.

Public Engagement Survey for eVTOL Aircraft Operations
Introduction Thank you for participating in this survey. Your feedback will guide the development of policies to support the safe and effective integration of electric Vertical Take-off and Landing (eVTOL) aircraft operations in your community. This survey will help us understand your perspectives, priorities, and concerns regarding eVTOL aircraft operations.
Section 1: Understanding of eVTOL Aircraft
1. How would you rate your current understanding of eVTOL aircraft technology? ☐ Very good ☐ Good ☐ Limited ☐ None
2. What comes to mind when you think about eVTOL aircraft technology? (Open-ended response)
3. Which sources have informed your knowledge about eVTOL aircraft operations? (Select all that apply) ☐ News media ☐ Social media ☐ Government publications ☐ Industry websites ☐ Academic papers ☐ Personal research ☐ I have not received any information about eVTOL aircraft
4. How interested are you in learning more about eVTOL aircraft operations? ☐ Very interested ☐ Somewhat interested ☐ Not interested
5. What specific topics would you like more information about regarding eVTOL aircraft operations? (Select all that apply) ☐ Safety regulations and protocols (e.g., collision avoidance, emergency procedures) ☐ Security measures (e.g., protections against misuse or malicious activities) ☐ Privacy (e.g., surveillance concerns) ☐ Noise impact (e.g., noise levels, mitigation strategies) ☐ Visual impact (e.g., crowded skies, aircraft visibility) ☐ Environmental sustainability (e.g., emissions, impact on biodiversity) ☐ Job impacts and economic changes (e.g., effects on existing jobs, job creation) ☐ Equity, accessibility, and affordability (e.g., fair access to services across communities) ☐ Benefits of eVTOL aircraft operations ☐ Other (please specify): _________

6. How beneficial do you believe eVTOL aircraft operations could be for society?
- ☐ Very beneficial
- ☐ Somewhat beneficial
- ☐ Neutral
- ☐ Not beneficial

7. Which potential benefits of eVTOL aircraft do you find most compelling? (Select up to 3)
- ☐ Improved local transport options
- ☐ Faster delivery of goods (e.g., drones for local delivery)
- ☐ Faster emergency response times (e.g., medical drones)
- ☐ Economic growth and job creation
- ☐ Environmental sustainability
- ☐ Other (please specify): _________

8. What are your main concerns regarding eVTOL aircraft operations in your community? (Select up to 3)
- ☐ Safety
- ☐ Security (e.g., misuse or malicious activities)
- ☐ Privacy (e.g., surveillance concerns)
- ☐ Noise impact
- ☐ Visual impact (e.g., crowded skies, aircraft visibility)
- ☐ Environmental impact (e.g., emissions, impact on biodiversity)
- ☐ Job impact (e.g., effects on existing jobs, job creation)
- ☐ Equity, accessibility, and affordability (e.g., fair access to services across communities)

9. What specific information would make you feel more confident about eVTOL aircraft operations?
(Open-ended response)

10. Which of the following would increase your trust in eVTOL aircraft technologies and operations?
(Select all that apply)
- ☐ Transparent safety records
- ☐ Clear communication about regulations
- ☐ Demonstrations of eVTOL aircraft and services
- ☐ Gradual introduction of services
- ☐ Involvement of trusted institutions (e.g., universities, research centres)
- ☐ Other (please specify): _________

Section 2: Safety and Security

11. How confident are you in the safety of eVTOL aircraft operations for both passengers and people on the ground?
- ☐ Very confident
- ☐ Somewhat confident
- ☐ Not very confident
- ☐ Not at all confident

12. What safety measures would you expect to see implemented for eVTOL aircraft?
(Open-ended response)

13. How concerned are you about the safety of eVTOL aircraft operations for both passengers and people on the ground?
- ☐ Not at all concerned
- ☐ Slightly concerned
- ☐ Very concerned
- ☐ Extremely concerned

14. How vulnerable do you think eVTOL aircraft operations might be to security risks (e.g., hacking, unauthorised use, or malicious activities)?
- ☐ Highly vulnerable
- ☐ Somewhat vulnerable
- ☐ Minimally vulnerable
- ☐ Not vulnerable

15. What security measures do you expect to be in place for eVTOL aircraft operations?
(Open-ended response)

16. How concerned are you that eVTOL aircraft systems might be vulnerable to hacking or unauthorised use?
- ☐ Not at all concerned
- ☐ Slightly concerned
- ☐ Very concerned
- ☐ Extremely concerned

Section 3: Privacy

17. To what extent do you believe eVTOL aircraft operations could impact personal privacy (e.g., visibility into private spaces)?
- ☐ High impact
- ☐ Moderate impact
- ☐ Low impact
- ☐ No impact

18. What privacy protections would you like to see in place for eVTOL aircraft operations?
(Open-ended response)

19. How concerned are you that eVTOL aircraft operations might infringe upon personal privacy?
- ☐ Not at all concerned
- ☐ Slightly concerned
- ☐ Very concerned
- ☐ Extremely concerned

Section 4: Noise and Visual Impact

20. How do you anticipate eVTOL aircraft operations could impact noise levels in your area?
- ☐ High impact
- ☐ Moderate impact
- ☐ Low impact
- ☐ No impact

21. What steps would you like to see taken to minimise noise-related to eVTOL aircraft operations?
(Open-ended response)

22. How concerned are you that eVTOL aircraft operations will increase noise pollution in your area?

- ☐ Not at all concerned
- ☐ Slightly concerned
- ☐ Very concerned
- ☐ Extremely concerned

23. How do you perceive the potential visual impact of eVTOL aircraft operations (e.g., crowded skies)?

- ☐ High impact
- ☐ Moderate impact
- ☐ Low impact
- ☐ No impact

24. How important is it to you that eVTOL aircraft operations avoid disrupting residential and natural areas visually?

- ☐ Not important at all
- ☐ Slightly important
- ☐ Very important
- ☐ Extremely important

Section 5: Environmental Impact

25. To what extent do you believe eVTOL aircraft operations could positively or negatively impact the environment?

- ☐ Very positive impact
- ☐ Somewhat positive impact
- ☐ Somewhat negative impact
- ☐ Very negative impact

26. How concerned are you that eVTOL aircraft operations could negatively impact the environment?

- ☐ Not at all concerned
- ☐ Slightly concerned
- ☐ Very concerned
- ☐ Extremely concerned

Section 6: Job Impact

27. How do you perceive the impact of eVTOL aircraft operations on employment in traditional industries like transport and logistics?

- ☐ High impact
- ☐ Moderate impact
- ☐ Low impact
- ☐ No impact

28. How concerned are you that eVTOL aircraft operations will negatively impact jobs in traditional industries such as transport and logistics?

- ☐ Not at all concerned
- ☐ Slightly concerned
- ☐ Very concerned
- ☐ Extremely concerned

29. What role would you like to see eVTOL aircraft operations play in supporting local job growth? (Open-ended response)

Section 7: Equity, Affordability, and Accessibility

30. Do you think eVTOL aircraft services will be accessible and affordable to most community members?

- ☐ Yes
- ☐ Maybe
- ☐ No

31. If eVTOL aircraft services were priced similarly to other private services (e.g., private hire cars), would you consider using them?

- ☐ Yes
- ☐ Maybe
- ☐ No

32. How concerned are you about fair access to eVTOL aircraft services for all socioeconomic groups?

- ☐ Not at all concerned
- ☐ Slightly concerned
- ☐ Somewhat concerned
- ☐ Very concerned
- ☐ Extremely concerned

33. How much would you be willing to pay for a short eVTOL aircraft trip within your city (e.g., a 10–15-minute ride)? (Open-ended response)

Section 8: Community Engagement and Preferred Communication Channels

34. How important is it to you that the public is consulted in the development of policies and regulations for eVTOL aircraft operations?

- ☐ Not important at all
- ☐ Slightly important
- ☐ Very important
- ☐ Extremely important

35. How would you like to see your community engaged in decisions about eVTOL aircraft operations? (Select all that apply)

- ☐ Community meetings with industry representatives and regulators
- ☐ Online surveys and forums to share opinions
- ☐ Public access to detailed reports on the impacts of eVTOL aircraft operation
- ☐ Educational campaigns on eVTOL aircraft safety and operational benefits
- ☐ Other (please specify): _________

36. How confident are you that public input will be meaningfully integrated into the planning of eVTOL aircraft operations?

- ☐ Very confident
- ☐ Somewhat confident
- ☐ Not very confident
- ☐ Not at all confident

37. Would you personally be interested in participating in community engagement activities related to eVTOL aircraft operations?

- ☐ Yes, definitely
- ☐ Probably
- ☐ Probably not
- ☐ No, definitely not

38. How would you like to be engaged in discussions about eVTOL aircraft and operations?

- ☐ Community meetings with industry representatives and regulators
- ☐ Online surveys and forums to share opinions
- ☐ Public access to detailed reports on eVTOL aircraft operations impacts
- ☐ Educational campaigns on eVTOL operational safety and benefits
- ☐ Other (please specify): _________

39. How would you prefer to receive information about eVTOL aircraft developments?
(Select all that apply)

- ☐ Public meetings/town halls
- ☐ Government websites
- ☐ Social media
- ☐ Traditional media (TV, radio, newspapers)
- ☐ Email newsletters
- ☐ Mobile apps
- ☐ Other (please specify): _________

Section 9: Additional Feedback

40. Any additional feedback? (Open-ended response)

Section 10: Demographics

41. Age

- ☐ Under 18
- ☐ 18 – 24
- ☐ 25 – 34
- ☐ 35 – 44
- ☐ 45 – 54
- ☐ 55 – 64
- ☐ 65 and above

42. Gender

- ☐ Male
- ☐ Female
- ☐ Other
- ☐ Prefer not to say

43. Highest level of education attained

- ☐ High school diploma or equivalent
- ☐ College or university degree
- ☐ Graduate or professional degree
- ☐ Other (please specify): _______
- ☐ Prefer not to say

44. Employment status

- ☐ Employed full-time
- ☐ Employed part-time
- ☐ Self-employed
- ☐ Unemployed
- ☐ Student
- ☐ Retired
- ☐ Other (please specify): _______

45. Household income

- ☐ Under $25,000
- ☐ $25,000 – $49,999
- ☐ $50,000 – $74,999
- ☐ $75,000 – $99,999
- ☐ $100,000 – $149,999
- ☐ $150,000 – $199,999
- ☐ $200,000 or more
- ☐ Prefer not to say

46. Primary mode of transport

- ☐ Personal vehicle
- ☐ Public transit (bus, subway, etc.)
- ☐ Taxi or rideshare
- ☐ Bicycle
- ☐ Walking
- ☐ Other (please specify): _______

Conclusion

Thank you for your participation. Your responses will help us better understand public views, ensuring that eVTOL aircraft services are developed in a manner that meets community needs and addresses your concerns.

Unmanned Aircraft Systems

UAS: PART 07

Technical Guidance for the Implementation of Beyond Visual Line of Sight Unmanned Aircraft Systems Operations

INTRODUCTION

Unmanned Aircraft Systems (UAS) have evolved from remote-controlled hobby craft and consumer drones in the early 2010s, when the aircraft was flown by an operator on the ground. The developments in technology have enabled such UAS to become extensively deployed in a wide range of commercial and recreational applications, such as infrastructure inspection, surveillance, delivery and logistics, sports, and aerial photography and videography.

While operating the UAS within the visual range of the remote pilot may be sufficient in some cases, being able to operate the UAS beyond the visual range of the person controlling the aircraft offers opportunities for greater operational efficiencies, productivity, and economic value. As the technology and operational experiences continue to mature, these types of UAS operations Beyond Visual Line of Sight (BVLOS) of the operator are becoming increasingly desirable.

Since the mid-2010s, various States have conducted trials and studies of BVLOS UAS operations. Many States have introduced frameworks to govern low risk BVLOS UAS activities (i.e., operations BVLOS but over an area sanitised and free of uninvolved persons) and have selectively approved operations involving increasing levels of risk and complexity.

To support CAAs in the development and harmonisation of their governance policies and regulations for advanced (i.e., more complex and higher risk) BVLOS UAS operations, this part aims to provide an overview of key considerations, and the regulatory approaches developed through global experience. Particular focus is placed on the governance of more advanced (i.e., higher risk and complexity) type of operations.

BACKGROUND

Definition of BVLOS

Although BVLOS is a commonly used term in the UAS industry, there are notable variations in its definition globally. The main differences between definitions pertain to two elements: the individual responsible for maintaining visual contact, and the definition of visibility.

For the individual responsible for visual contact, some definitions include both the operator and observers, while others restrict responsibility solely to the person operating the flight controls of the UA.

With respect to visibility, some definitions focus on the visibility of the UA, whereas some others define visibility to also include the visibility of other aircraft, persons, vessels, vehicles, terrain, adverse weather, or obstacles that may pose a threat to the aircraft in operation. A few organisations have also included the distance between the UA and the visual observer as a proxy to visibility. In such cases, BVLOS UAS operations are typically defined as any UAS operation conducted outside a prescribed Visual Line of Sight (VLOS) distance. The VLOS distance varies between States but is said to average around 500 metres. However, VLOS distance is potentially subjective, as it may vary due to several factors such as the drone size, exterior colour, environmental conditions (e.g., weather or time of day), the visual acuity of the person maintaining visual contact, and obstacles or terrain that may obstruct a clear view of the aircraft.

Amidst the variations in definition, there is a basic consensus that BVLOS UAS operations involve a type of operation in which the aircraft is not within continuous visual contact and hence extends the operating range of UAS.

Challenges of BVLOS UAS Operations

Flying BVLOS significantly increases the operational range, and the extended range thereby provides greater coverage for UAS services. It may also enhance operational flexibility and efficiency by removing the need for a ground control station or remote pilot on-site or near the operating area.

BVLOS UAS operations also typically involve a leap in operational complexity by pushing the boundaries of UAS capabilities with longer-range missions, more complex flight paths, and flights across diverse environments. Such complex operations come with increased challenges that demand a higher level of regulatory oversight and operator competency, such as:

- → **Limited Visual Awareness:** At BVLOS distances, the UA no longer has the benefit of the on-site remote pilot (or observer) providing situational awareness to avoid terrain, obstacles, or other aircraft. Onboard and ground systems and telemetry used to provide situational awareness therefore become increasingly critical.
- → **Communication Range:** The performance of typical line-of-sight-based aviation communication systems degrades with increasing distance between transceivers, thereby limiting bandwidth, impacting data integrity and reliability, or introducing technical challenges that may necessitate increased transmission power. BVLOS UAS operations may also be conducted beyond radio horizon distances that require the use of supplementary or additional communication systems, such as satellite-based communications. This introduces additional challenges in ensuring data integrity, availability, and timeliness for critical communications.
- → **Challenges to Emergency Management:** With a much wider area of operation, operators may be challenged to provide reactive and timely emergency responses to incidents and accidents.
- → **Diversity of Operational Environments:** BVLOS UAS operations may traverse different airspace classes, atmospheric conditions, highly populated areas, or areas in proximity to manned aircraft. This necessitates advanced knowledge of airspace structures, high aircraft reliability, and effective traffic management capabilities.
- → **UAS Technical Complexity:** BVLOS UAS operations often involve more sophisticated UAS equipped with autopilot systems, detect-and-avoid capabilities, and redundant communication links.

It may ultimately be desirable to conduct BVLOS UAS operations within existing airspace systems without the need for special provisions or segregation from other airspace users. In such cases, the UAS operations would be expected to comply with ICAO Annex 2 — Rules of the Air (ICAO, 2024), and would require a level of design, production, and operational assurance sufficient to ensure that the UAS is capable of: (1) avoiding collisions with other aircraft, and (2) maintaining separation so as not to create a collision hazard.

As with VLOS UAS operations, BVLOS UAS operations are expected to mitigate hazards to other UA, as well as persons and property when flying over populous areas.

These challenges may be compounded by the commercial UAS industry's limited experience or knowledge in conventional aviation safety practices. The commercial UAS industry is generally dominated by start-ups, and most UAS have been developed by adapting or adopting consumer electronic components for rapid and low-cost development. Given these traits, the assumptions underlying conventional aviation industry expectations of design, production, and operational safety assurance may not hold. Conversely, rigid application of existing aviation standards may increase costs, hinder business growth, and thus prove inappropriate for the industry.

Existing Means of Governance for BVLOS UAS Operations

Significant efforts have been made at the ICAO level to develop guidance material for UAS regulations. An Unmanned Aircraft Systems Advisory Group (UAS-AG) was established in 2015 and tasked with developing a global baseline of provisions and guidance material to support harmonisation of UAS regulations that fall outside the scope of the International Instrument Flight Rules (IFR) framework (ICAO, n.d.). An Asia/Pacific Unmanned Aircraft System Task Force (APUAS/TF) was also formed in 2016 and had promulgated an initial set of basic guidance for the safe operation of UAS within national airspace in 2019. These initiatives have since evolved into the promulgation of Model UAS Regulations (Parts 101, 102, and 149) and a set of ACs (ICAO, n.d.b). While the ICAO Model UAS Regulations can serve as useful starting points for CAAs developing or supplementing their national UAS regulations; they address BVLOS operations only briefly.

The development of detailed regulations for BVLOS UAS operations remains an evolving landscape worldwide. Several nations have permitted BVLOS operations, but typically under limited conditions through special approvals, exemptions, or waivers. As presented in **Annex A**, the standards and means of governing BVLOS UAS operations worldwide share a common aim to ensure the safety of existing airspace users and the safety of people and property on the ground or waters, though international harmonisation has yet to be achieved.

KEY CONSIDERATIONS

Advanced BVLOS UAS Approvals Management Methodology

The majority of UAS currently in operation are small or lightweight UAS, and in most States, UA less than 25 kg do not require airworthiness certification for VLOS operations if public and aviation safety risks are low. It is generally thought that imposing aircraft airworthiness standards on such operations would lead to a significant increase in regulatory compliance effort, in terms of time and cost for UAS operators, without significant added benefits to risk mitigation.

At the other end of the risk spectrum, the conventional principles of aircraft certification, including aircraft airworthiness design standards and certification requirements, are expected to be applied for UAS operations that present very high public and aviation safety risks. Some States have granted type certification to aircraft for specific operations. CAAs intending to facilitate advanced BVLOS operations may consider accepting/validating these type-certificated UA after evaluation of the certification basis.

BVLOS UAS operations are typically considered to have a higher risk than standard VLOS operations, but they are not always within the high-risk category. The level of risk is dependent on the combination of air and ground risks associated with the challenges of BVLOS UAS operations, such as those mentioned in the previous section.

There can be a few different approaches to determining the risk level of BVLOS UAS operations. One approach involves predefining risk categories (e.g., Category A, B, C, or Category Low, Medium, High Risk) based on prescriptive conditions that determine how an operation is classified. These conditions may include but are not limited to: type of airspace, time of day, distance from aerodromes, distance from the public, purpose of flight, population density, size and/or weight of aircraft, maximum speed of aircraft, and kinetic energy or energy potential of the aircraft.

Another approach involves the use of a risk assessment methodology to calculate an overall risk level as a combination of air and ground risk levels. The Specific Operations Risk Assessment (SORA) methodology developed by the Joint Authorities for Rulemaking on Unmanned Systems (JARUS). JARUS is one example (JARUS, 2024). Similarly, the FAA's Section 44807 provides a risk-based methodology that evaluates UAS operations on a case-by-case basis, requiring detailed documentation including the concept of operations, safety risk analysis, and emergency procedures to determine if the operation can be conducted safely within the national airspace system. Other existing aviation risk assessment methodologies may also be applied, according to the needs of the respective State and the operational use case under consideration.

The approval of BVLOS UAS operations that fall between low and very high-risk levels is more commonly addressed through a risk-based approach. This approach involves comprehensively identifying the risks associated with the intended operations, establishing alignment between the Civil Aviation Authority (CAA) and the operator regarding the risk level of the operation and corresponding mitigations, and assessing and ensuring that those mitigations are sufficient and met by the operator. In this approach, the approval requirements are proportionate according to the level of risk potentially introduced by the operation.

In a risk-based approach, the role of the CAA as the regulator would be to evaluate the risks and assess whether the mitigations proposed by the UAS operator are sufficient to reduce this risk to an acceptable level. It is generally desired that risks are mitigated through design, operational procedures, and operational limitations, in that order of priority. To support this process, the regulator should determine and publish target levels of safety (TLOS), which will shape the type and depth of risk mitigations. A key principle is that the TLOS for ground and air risks should be commensurate with the established levels of safety in manned aviation. See **Annex B** for further details of UAS TLOS.

Operators are expected to provide detailed information on their UAS and planned operations to facilitate risk assessment and determination of risk mitigation measures. This information is typically presented in the form of a system design document detailing the system architecture of the UAS, a design specifications document clearly indicating the operating envelope of the UAS, typical design missions, operational modes, launch, landing, and recovery conditions.

A typical methodology that may be applied for approving advanced BVLOS UAS operations not requiring conventional certification processes for approval is summarily illustrated in **Figure 1.**

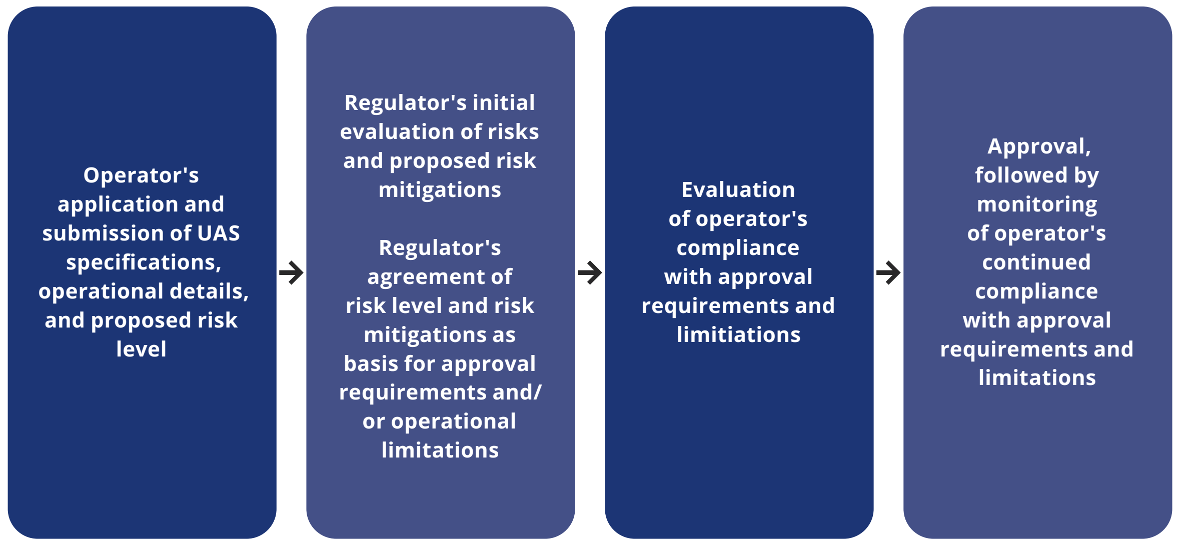


Figure 1 — Typical Approvals Management Methodology (BVLOS UAS Operations Not Requiring Conventional Certification Processes)

Conventional Certification Processes
Considerations for Evaluation of Risks and Risk Mitigations

Several considerations have been identified that could guide regulators in evaluating the risks and risk mitigations of BVLOS UAS operations. These considerations have been categorised into four areas as shown in **Figure 2** and further detailed below:

Airworthiness Considerations linked to the principles of initial and continuing airworthiness and specifically the safety level of the UAS design and its production.	→ Considerations for Aircraft design, Production, Maintenance, and Specifications of Critical Systems
Crew Considerations related to the licensing and standards of UAS pilots and operators.	→ Considerations for UAS Operator Licenses
Organisation Considerations related to the organisation that operates the unmanned aircraft and is responsible for ensuring safe flight operations.	→ Safety Management Systems → Flight Planning → Emergency Preparedness
Environment Considerations related to the operating environment, such as atmospheric conditions, airspace structures and standards, surrounding infrastructure, and proximity to populous.	→ Airspace Environment → Population Density and Infrastructure Concentration → Radio Frequency Spectrum

Figure 2 — Overview of Key Considerations

- **Airworthiness:** The scope of risks related to airworthiness may encompass several areas, including aircraft design, production, and maintenance, and specifications for certain critical systems. Some examples and areas of consideration are presented in **Annex C**.
- **Crew:** The qualification or certification of UAS crew (operators and/or pilots) can help ensure that they are able to reliably execute actions required to mitigate certain risks (e.g., aircraft maintenance and emergency procedures). It is crucial that the UAS crew possess the skills, knowledge, and sound judgement to execute complex operations safely and efficiently. Licensing is a common way to attest to and uphold these standards.

  Developing a comprehensive licensing regime may be a complex but essential undertaking for CAAs. To keep pace with a rapidly evolving UAS sector, such a licensing regime should consider flexibility and scalability to allow the incorporation of new technologies, operational concepts, and airspace integration strategies as they emerge. Enabling regular reviews and updating of the licensing requirements in consultation with industry stakeholders may also help to ensure that the regime stays relevant and effective.

  The regime for licensing could be analogous to the approach in manned aviation, where different ratings and endorsements reflect varying levels of complexity and risk. BVLOS UAS operations may be sufficiently unique to warrant a BVLOS-specific pilot licence or endorsement. Some States have implemented BVLOS-specific categories within their licensing ratings. Further considerations for UAS operator licensing, such as the types of operations, licence categories, basic knowledge, and practical skill requirements, are detailed in **Annex D**.
- **Organisation:** In conventional air transport, certification, validation, or acceptance of the aircraft type is followed by assessment of the operator's competency to conduct the intended operations. While these principles also apply to UAS operations, a risk-based and iterative approach is more commonly used to assess the organisational capability, instead of requiring an Air Operator Certificate. In BVLOS UAS operations that carry a higher level of risk, it is essential to ensure that the organisation has adequate personnel, methods, organisational structures, tools and equipment, and suitable working environment to conduct their operations reliably and safely. The following outlines specific considerations across the five organisational domains most relevant to BVLOS UAS operations:
  - **Safety Management Systems:** As BVLOS UAS operations are potentially more complex and higher risk in nature, operators must adopt an aviation safety mindset. A Safety Management System (SMS) is a systematic approach to managing safety, and encompasses the necessary organisational structures, accountabilities, policies, and procedures (Skybrary, 2024). A SMS is required for various commercial aviation service providers (e.g., training organisations, operators, maintenance organisations, design and production organisations). Implementation guidelines for establishing and maintaining a SMS is provided in Doc 9859, Safety Management Manual. For operators of BVLOS UAS operations, the SMS principles may be leveraged and proportionately applied by considering the scale, scope, and complexity of the operation.
  - **Flight Planning:** An operator's flight planning procedures for BVLOS UAS operations should ensure comprehensive operational risk identification and mitigation procedures. This includes pre-flight risk assessments addressing elements such as route hazards, weather, airspace restrictions, and population density. Flight planning procedures that consider geofencing, coordination with authorities, and periodic assessment of route hazards can help prevent unintended incursions and ensure compliance with any limits, such as altitude, speed, and visibility — whether due to environmental conditions, UAS capabilities, or regulatory requirements.
  - **Emergency Preparedness:** An Emergency Response Plan (ERP) would establish a structured framework for handling emergencies during BVLOS UAS operations. In an ERP covering BVLOS UAS operations, operators should designate clear roles and procedures for immediate response, including steps for transitioning between normal and emergency operations, and coordination with other airspace users. Such an ERP should also incorporate training, periodic drills, and specific protocols for various scenarios, including lost communication links and automated responses to lost links.

  A comprehensive means of governance would typically involve ongoing assessment of an operator's compliance with organisational requirements throughout their operations. Oversight by the regulatory authority, such as through audits, robust surveillance programmes, and mandatory reporting, would help ensure that safety standards are maintained and improved over time.

→ **Environment:** The operating environment influences the risks and requirements of UAS operations, where some risks are determined by the nature and location of the operation and may not fall within an operator's control. Thorough analyses and surveys of the operational area are therefore needed to ensure a comprehensive understanding of the environment and its risks. The following are some specific considerations for air and ground risk mitigation during BVLOS UAS operations:

- **Airspace Environment:** Globally, countries are reviewing airspace management policies, particularly at low altitudes. This is a continually evolving area that includes the implementation of various airspace management strategies. In this context, CAAs play a crucial role in engaging the air navigation service provider to organise the airspace environment for UAS operations.

  Most States currently employ the strategy of airspace segregation and adopt a tiered approach in determining permissible airspace for UAS operations. Recognising that UAS operators may lack familiarity with airspace classifications and their complexities, zones are typically clearly marked to establish no-fly zones, restricted areas, and other airspace boundaries. These demarcations assist in maintaining separation between manned and unmanned flight operations and allow appropriate airspace risk mitigation.

  Some States have also introduced operational conditions, such as maximum flight altitudes, which are geographically constrained. Additional requirements may also be imposed on UAS operations conducted in certain areas. This approach facilitates the safe integration of UA while preserving the integrity of existing air traffic systems.

  To implement airspace segregation strategies or explore the transition toward integrated airspace, some States have deployed specific technologies. These include surveillance and traffic management systems to identify, track, and manage UAS within defined airspaces. For instance, surveillance systems may use a range of sensors, from radar to remote sensors, to provide comprehensive monitoring in high-population-density areas. Many States are also exploring traffic management systems designed to support flight plan submission, airspace capacity management, and real-time flight monitoring. These tools help automate and digitalise processes and coordination, allowing for improved airspace utilisation and safety.

- **Population Density and Infrastructure Concentration:** Unlike manned aircraft which carry persons onboard, the fatality risk associated with non-passenger-carrying UAS incident depends on the proximity of operations to populated areas. If UAS operations are conducted far from people, the fatality risk approaches zero. Therefore, when assessing operational risk, population density would be a crucial factor to consider, as it determines the number of people potentially at risk in the event of a UAS failure or crash.

  Infrastructure considerations include the presence of essential facilities or security-sensitive buildings within the operational area, where the consequences of damage from a UAS incident may be critical. Conversely, buildings may also serve as shelters and potentially reduce the ground risk of a UAS operation. Whether buildings serve to increase or reduce risk can significantly influence the risk assessment of an operation, therefore requiring a clear position on this matter by the regulator.

  In developed areas, advanced infrastructure can enhance or support UAS operations and provide support in mitigating some risks. For example, mobile telecommunication networks (i.e., 3G, 4G LTE, and 5G) may be leveraged as a redundant means for UAS datalinks, and Differential GPS (DGPS) ground stations may be used to enhance UAS Global Navigation Satellite Systems-based navigation accuracy.

- **Radio Frequency Spectrum:** The radio frequency spectrum is critical but limited resource required by multiple sectors. High integrity and availability of the Command and Control datalink, also referred to as Control and Non-Payload Communications (CNPC), would be critical for BVLOS UAS operations. However, dense urban environments pose significant challenges due to heavy utilisation of the radiofrequency spectrum. A study by the International Telecommunications Union (ITU) estimated that UAS may require up to 34 MHz and 56 MHz of radio frequency spectrum for terrestrial and satellite systems, respectively, by 2030 (ITU, 2009).

  Internationally, the 5030-5091 MHz band has been allocated for aeronautical use at the 2012 World Radiocommunication Conference (WRC-12). Some States, such as the United States, have designated a portion of this band specifically for UAS C2/CNPC links (FCC, 2024). Radiofrequency planning will be essential for States that have not yet assessed their UAS operational needs, as it underpins the effectiveness and reliability of UAS C2/CNPC links. Planning should also consider that international spectrum allocations are the result of years of negotiation and coordination undertaken by the ITU, and processes with local telecommunication authorities may also require some time. UAS frequency requirements should also consider that the end-to-end availability of a single communication link is unlikely to meet expected safety levels (e.g., 99.999%), and that multiple links may be required to satisfy a particular data stream, leading to greater spectrum needs.

  Some analyses have considered the feasibility of new radiofrequency bands for UAS C2/CNPC links. To date, analyses have identified that 13.25-13.40 GHz, 15.4-15.7 GHz, 22.5-22.55 GHz, and 23.55-23.6 GHz are not considered suitable for supporting UAS C2/CNPC links in non-segregated airspace (ITU-R, 2011).

Example BVLOS UAS Operations Use Cases

Assessments and experiences from precedent BVLOS UAS operations could be leveraged and adapted. Predefined Risk Assessments (PDRAs), where risk assessments have already been carried out for specific operational scenarios, may therefore serve as useful references. These scenarios are typically defined by the nature of the mission (e.g., agricultural works, short-range cargo operations, surveillance) and by conditions on the type of airspace and ground environment in which the UAS is operated. JARUS has developed several PDRAs (JARUS, 2024b), and EASA has adopted a few as an acceptable Means of Compliance (MoC) with their regulatory requirements (EASA, 2024). Additionally, as further examples and references of regulatory precedent, some States have shared their experiences in BVLOS UAS approvals for this publication. These examples use cases are detailed in **Annex E**.

ACTION PLAN

It is assumed in this section that CAAs seeing to manage higher-risk BVLOS UAS operations have already established regulations for basic UAS operations. Where such operations are not yet in place, CAAs may wish to refer to ICAO Model UAS Regulations and Advisory Circulars (ICAO, n.d.b.) as a foundation for developing their baseline regulatory framework.

An effective means of governing higher-risk BVLOS operations would address and mitigate any potential hazards introduced by such operations. The overarching objective is therefore to determine and implement requirements that are specifically designed to mitigate these new hazards. These new requirements may be implemented as adaptations or additions to the existing UAS regulations, or alternatively, some CAAs have promulgated the requirements through supplementary documents such as ACs.

A stepwise approach to identifying and implementing these new requirements is shown in **Figure 3** and further detailed below:

Figure 3 — Action Plan: Adapting Existing Manned Aircraft Regulations

Build Capability

The identification of requirements to ensure public and operational safety, and to mitigate the hazards and risks of higher-risk BVLOS UAS operations, will be more effective if CAA personnel assigned to this task possess an adequate level of understanding of the technologies and operations involved. While such personnel may already have some level of experience in providing safety oversight of basic UAS operations, additional training specific to advanced technologies and operational scenarios supporting BVLOS flights may be desirable. CAAs may refer to **Part 8** of this publication for further details and consideration for capability building.

Define Scope

A clear definition of the conditions under which a UAS operation is considered higher-risk BVLOS will greatly facilitate the development of new regulations to govern such operations. These conditions and risk thresholds may differ according to unique national requirements, and hence it would be important to review and have a clear definition if they have not yet been established. These conditions will form the basis for determining the applicability of any new requirements incorporated into the set of UAS regulations. Some methods to determine risk categories are discussed in previous section.

Establish Working Group(s) and Term of Reference(s)

The next step involves establishing a working group to undertake the ensuing steps in the process. CAA personnel appointed to this working group would be expected to possess requisite knowledge and experience for the rule-making activity. Some States may also consider having UAS OEMs, operators, or technical experts from the industry in the working group to supplement technical and operational knowledge and expertise. A clear Terms of Reference would help guide and ensure the effectiveness of the working group (see EASA, 2021, for an example).

Develop New Requirements

The aim of this step is for the working group to develop a list of mitigations to the new hazards and risks of higher-risk BVLOS operations. These mitigations would then be formed as new requirements. There are several methods for developing such a list, including brainstorming or a function-based analysis. Key areas that may require new requirements are detailed in previous section and recapped as follows:

- → Airworthiness (UAS design and production — See **Annex C**)
- → Crew (Licensing of standards of UAS pilots and operators — See **Annex D**)
- → Organisation (Addressing SMS, Flight planning, emergency preparedness)
- → Environment (Addressing hazards from airspace environment and population density and infrastructure concentration)

The new requirements may be implemented as amendments or additions to the existing set of UAS regulations.

Execute Regulations

This step involves the CAA issuing and executing the regulatory adaptations or additions in accordance with the processes of their respective State. This may include developing acceptable MoC with the new requirements and supporting the development or adoption of industry standards. The CAA will also be responsible for processing approvals, monitoring compliance, and enforcing compliance to new regulations.

Review Means of Governance

Some decisions and requirements may need to be updated as UAS technologies and higher-risk BVLOS UAS operations mature. A regular review and updating of the means of governance will help ensure that the regulations remain effective in mitigating the hazards and risks of such operations.

Part 7 References

- → European Union Aviation Safety Agency [EASA]. (2021, May 12). Terms of reference for rulemaking task RMT.0731 (Subtasks 1, 2, & 3) — New air mobility (Issue 2).
- → European Union Aviation Safety Agency [EASA]. (2024). Predefined risk assessment (PDRA). https://www.easa.europa.eu/en/domains/drones-air-mobility/operating-drone/specific-category-civil-drones/predefined-risk-assessment-pdra
- → Federal Aviation Administration [FAA]. (2024). Section 44807 special authority for certain unmanned aircraft systems. https://www.faa.gov/uas/advanced_operations/certification/section_44807
- → Federal Communications Commission [FCC]. (2024, August 29). In the matter of spectrum rules and policies for the operation of unmanned aircraft systems (WT Docket No. 22-323).
- → International Civil Aviation Organization [ICAO]. (n.d.). Unmanned Aircraft Systems Advisory Group (UAS-AG). https://www.icao.int/safety/UA/Pages/Unmanned-Aircraft-Systems-Advisory-Group-(UAS-AG).aspx
- → International Civil Aviation Organization [ICAO]. (n.d.). ICAO model UAS regulations: Introduction to ICAO model UAS regulations and advisory circulars. https://www.icao.int/safety/UA/Pages/ICAO-Model-UAS-Regulations.aspx
- → International Civil Aviation Organization [ICAO]. (2024, July). International standards and recommended practices, Annex 2 — Rules of the air (11th ed.).
- → International Telecommunication Union [ITU]. (2009, December). Characteristics of unmanned aircraft systems and spectrum requirements to support their safe operations in non-segregated airspace (Report ITU-R M.2171).
- → International Telecommunication Union — Radiocommunication Sector [ITU-R]. (2011, November). Frequency sharing between unmanned aircraft systems for beyond line-of-sight control and non-payload communications links and other existing and planned services in the frequency bands 13.25–13.40 GHz, 15.4–15.7 GHz, 22.5–22.55 GHz and 23.55–23.60 GHz (Report ITU-R M.2230).
- → Joint Authorities for Rulemaking on Unmanned Systems [JARUS]. (2024, May 13). JARUS guidelines on specific operations risk assessment (SORA) (Ed. 2.5).
- → Joint Authorities for Rulemaking on Unmanned Systems [JARUS]. (2024). JARUS publications. http://jarus-rpas.org/publications/
- → Skybrary. (2024). Safety management system. https://skybrary.aero/articles/safety-management-system

PART 07 ANNEX A

WORLDWIDE MEANS OF BVLOS UAS OPERATIONS GOVERNANCE

The following is a compilation of selected governance approaches adopted by CAAs for BVLOS UAS operations. As shown, the means of implementation are varied and tailored according to the needs and regulatory structure of individual States. They all generally share a common aim to ensure the safety of existing airspace users and the safety of people and property on the ground or waters; however, some States have tailored their BVLOS regulations specifically to address risks to air navigation

Regulator (Reference)	BVLOS Unmanned Aircraft Operations Governance Approach
CAA China (CAAC, 2023)	→ In accordance with the Interim Regulations on the Flight Management of Unmanned Air Vehicles National Decree No. 761, effective as of 1 January 2024, BVLOS flights are generally allowed, except for micro- UA (empty weight less than 0.25 kg, maximum altitude of 50 m, flight speed less than 40 km/h), which may only be flown within VLOS. A BVLOS flight is subject to an application and approval process according to Article 26 by the air traffic management agency.
CAA Malaysia (CAAM, 2022)	→ Allowed in accordance with Civil Aviation Directive — 6011 part (V), subject to approval under Special UAS Project (SUP). Applications for approval are based on a risk assessment conducted using SORA methodology from JARUS.
CAA NZ (CAA NZ, 2015)	→ Allowed for an operator that holds an UA Operator Certificate according to Part 102. In accordance with AC102-1, operators must identify the airspace class to be used and the associated requirements, explain how these requirements will be met, demonstrate ability to provide separation from other traffic (e.g., through segregated airspace or a technological solution), and mitigate risks to persons, property, and terrain.
CAA Singapore (CAAS, 2019)	→ BVLOS UAS operations are allowed with requirements detailed in AC 101-2-2(0). The CAA assesses the compliance of an applicant's UAS and proposed BVLOS operations against a set of requirements categorised into the following areas: General, Operational, Software, Communication, Navigation, Detect and Avoid, Structural, Propulsion, Failure Management, and Others. These requirements are progressively detailed according to the level of risk (low to high) and are aimed at addressing ground and air risks, as well as ensuring containment of UA within designated flying areas.
EASA (EASA, 2022)	→ Allowed for UAS operations in the 'Specific' category, below 120 m above ground level, and over sparsely populated areas and controlled ground areas, with a low probability of encountering manned aircraft. → Permitted as a privilege granted to holders of a Light UAS Operator Certificate (LUC) in accordance with the Annex to Implementing Regulations (EU) 2019/947, Part C. UAS operating at Specific Assurance and Integrity Level (SAIL) V and VI must hold an EASA TC, while operations at SAIL III and IV may be subject to EASA TC requirements.
FAA (FAA, 2023)	→ Allowed for Part 107 (Commercial UAS) operations with a waiver (7711-2 form) upon demonstration of an equivalent and acceptable level of safety for the applicable paragraphs (e.g., 107.25, 107.29(a)(2) and (b), 107.31, 107.33, 107.35, 103.37(a), 107.39, 107.41, 107.51, 107.145). This waiver does not apply to the carriage of property of by another aircraft for compensation or hire. → Allowed with an Air Carrier and Operator's Certificate in compliance with 14 CFR Part 135 (with exemptions where Part 135 is not applicable for UAS Operations). → Special authority under 49 U.S.C. §44807 allows for case-by-case approval for UAS operations using a risk-based approach. → Type certification pathway is available through the "special class" category under §21.17(b), using a durability and reliability (D&R) process to establish the certification criteria.
JCAB (JCAB, 2022)	→ Flight permissions are granted according to Japan Civil Aeronautics Act Article 132-86 if measures are taken to ensure the safety of aircraft navigation and safety of people and property on the ground or water; or → Allowed with UAS that obtain a UAS certification, and where operators comply with a pilot qualification system.
TCCA (TCCA, 2024)	→ Allowed with Special Flight Operations Certificate for Remotely Piloted Aircraft System (SFOC-RPAS) in accordance with CAR 903.01, for operations in isolated areas or sparsely populated areas (i.e., fewer than 5 persons per square kilometre), and in atypical airspace or controlled airspace. Applicants must submit several details, including details of the company, the UAS, and the intended operations, and demonstrate the ability to perform the operation without adversely affecting aviation safety or endangering persons. Submission of a Remotely Piloted Aircraft Systems Operational Risk Assessment (with reference to AC 903-001, Advisory Circular: Remotely Piloted Aircraft Systems Operational Risk Assessment).
UK CAA (UK CAA, 2024)	→ Allowable as 'Specific' category and 'Certified' category operations, or as a privilege to light UAS operator certificate LUC, in accordance with UK Regulation (EU) 2019/947, Article 5 and Part C of the Annex. In accordance with CAP 722, BVLOS operations require either a technical capability that has been accepted as providing at least an equivalent level of safety to that of the ability of a pilot to 'see and avoid' potential conflicts — i.e., a Detect and Avoid (DAA) capability — or an operational mitigation that reduces the likelihood of encountering another aircraft to an acceptable level (e.g., using airspace segregation or another suitable method for ensuring such segregation).

Part 7, Annex A References

- Civil Aviation Administration of China [CAAC]. (2023, June 28). 无人驾驶航空器飞行管理暂行条例 [Interim regulations on the flight management of unmanned air vehicles] (National Decree No. 761). State Council & Central Military Commission. https://www.gov.cn/zhengce/content/202306/content_6888799.htm
- Civil Aviation Authority of Malaysia [CAAM]. (2022, November 15). Civil aviation directive 6011 Part (V): Unmanned aircraft system — Special UAS project (Issue 01, Revision 01).
- Civil Aviation Authority of New Zealand [CAA NZ]. (2015, July 27). Advisory circular: Unmanned aircraft — Operator certification (AC102-1).
- Civil Aviation Authority of Singapore [CAAS]. (2019, December 30). Advisory circular: Beyond visual line-of-sight operations for unmanned aircraft (AC101-2-2(0)).
- European Union Aviation Safety Agency [EASA]. (2022, September). Easy access rules for unmanned aircraft systems.
- Federal Aviation Administration [FAA]. (2023, June 23). Part 107 waiver safety explanation guidelines and guiding questions (Version 06-23-2023).
- Federal Aviation Administration [FAA]. (2024). Section 44807 special authority for certain unmanned aircraft systems. https://www.faa.gov/uas/advanced_operations/certification/section_44807
- Japan Civil Aviation Bureau [JCAB]. (2024, December 5 [effective]). Civil Aeronautics Act (Act No. 231 of 15 July 1952), Article 132-86. https://laws.e-gov.go.jp/law/327AC0000000231
- Transport Canada Civil Aviation [TCCA]. (2024, June 3). Advisory circular: Remotely piloted aircraft systems operational risk assessment (AC 903-001, Issue 02).
- United Kingdom Civil Aviation Authority [UK CAA]. (2024, April). Unmanned aircraft system operations in UK airspace: Policy and guidance (CAP 722, 9th ed., Amendment 2).

PART 07 ANNEX B

UAS TARGET LEVEL OF SAFETY

To satisfy the requirements for safety levels, the general practice in the aviation industry, and in commercial aircraft certification, is to complete a safety analysis of all aircraft systems to determine the effects of any failure conditions or malfunction on the aircraft. To establish rational probability values representing an acceptable level of risk, target levels of safety were developed based on historical data concerning serious accidents resulting from operational and airframe-related causes.

In general, it was determined that such accidents occur at a rate of approximately one per million hours of flight, of which 10 percent were attributed to failure conditions caused by system malfunctions. Therefore, it was generally considered that the probability of a serious accident from all such failure conditions should not exceed one in ten million flight hours (probability of less than 1 x 10-7). For system-level targets, it was arbitrarily assumed that in any one aircraft, there could be 100 potential failure conditions (i.e., systems or system functions) that would prevent continued safe flight and landing. Therefore, by equally apportioning the risk, each failure condition should have a risk that is no greater than 1 x 10-9, which was considered the acceptable probability of an individual system failure condition per hour of flight (ICAO, 2014).

A key principle in establishing target levels of safety for UAS is that the level of safety should be commensurate with existing levels of safety in manned aviation. Thus, it common to observe safety targets such as 1x10-6 for overall accident rates, 1x10-7 for accidents due to aircraft failure or malfunction, and 1x10-9 for individual aircraft system level failure probabilities. However, the operational and hazard conditions for UAS often differ from those of manned aircraft — UAS typically do not carry passengers and may operate in areas where their presence do not pose a significant hazard to the ground or users of the air. These factors support adaptations in target levels of safety to be commensurate with the level of UAS operational hazard conditions. **Table B-1** is an example from JARUS, which defines target levels of safety according to the UAS operational conditions.

Risk Definition		Target Level of Safety
Ground Risk		Less than one fatality per million hours (1x10-6 fatalities per hour)
Air Risk	For operations that primarily occur under self-separation and see-and-avoid (primarily uncontrolled airspace)	Less than one mid-air collision per 10 million flight hours (1x10-7 mid-air collisions per flight hour)
	For operations that occur with separation provided by an air navigation service provider (primarily controlled airspace)	Less than one mid-air collision per billion flight hours (1x10-9 mid-air collisions per flight hour)

Table B-1 — JARUS Target Level of Safety (JARUS, 2024)

Part 7, Annex A References

- International Civil Aviation Organization [ICAO]. (2014). Airworthiness manual (Doc 9760 AN/967, 3rd ed.).
- Joint Authorities for Rulemaking on Unmanned Systems [JARUS]. (2024, May 13). JARUS guidelines on specific operations risk assessment (SORA) (Ed. 2.5).

PART 07 ANNEX C

AIRWORTHINESS CONSIDERATIONS FOR UAS RISK ASSESSMENT

Assessing Airworthiness Related Risk Elements

The scope of UAS airworthiness risks can be broadly categorised into the following 3 areas: UAS design, manufacturing, and maintenance. These areas are detailed as follows:

UAS Design

Determining the key risks in UAS design involves identifying those systems in its design that are critical for the safety of operations. Flight-critical systems are defined as systems or components whose failure would directly impact the aircraft's ability to maintain safe flight and landing, potentially leading to loss of aircraft control. Typical flight-critical systems in a UAS include navigation and flight control systems, propulsion systems, electrical systems, and flight management systems.

The CAA typically retains the final authority in defining the flight-critical systems of the UAS design. Establishing a common understanding between the CAA and the UAS operator is always desirable for enabling a more effective and holistic approach to risk assessment and mitigation.

Standards may be used as an acceptable MoC to support risk mitigation measures in UAS design and operations. There are various types of standards, such as interface standards, test method standards, or standard practices.

Interface standards specify physical, functional, or operational interface characteristics of systems, subsystems, equipment, assemblies, components, items, or parts to permit interchangeability, interconnection, interoperability, compatibility, or communication. Test method standards specify the procedure or criteria for measuring, identifying, or evaluating the qualities, characteristics, performance, and properties of a product or process. Finally, practice standards define recommended procedures for conducting operations. Several standards development organisations have published standards for UAS systems and operations, such as:

- ASTM International
- Eurocontrol
- European Organisation for Civil Aviation Equipment (EUROCAE)
- International Organization for Standardization (ISO)
- Radio Technical Commission for Aeronautics (RTCA)
- SAE International

One of two approaches could be used in adopting standards into airworthiness-related requirements for BVLOS UAS operations. In addition, these two approaches may also be combined to create a hybrid methodology:

- **Design-Based Approach — Demonstrating Compliance with Requirements:** This approach involves defining design requirements and the corresponding MoC and necessitates a detailed review of the UAS design and system architecture. It is more commonly used in airworthiness design assessment and may leverage the combination of interface standards, test method standards, and standard practices as the MoC.

- **Outcome-Based Approach — Prescribing Specified Tests:** This approach utilises standardised tests as the means to demonstrate that a UAS is safe and reliable. In this approach, demonstration plans would be developed for a specific UAS and would require revalidation if the UAS is modified.

  The demonstration plans would typically focus on flight-critical systems and design features and may include areas such as airframe design, structural integrity, whole vehicle crash resilience, energy source reliability, and data link security. Other subsystems of importance for BVLOS UAS operations would include DAA and communication systems. Tests may also be prescribed to demonstrate operational performances such as wind resistance, noise control, and lighting. Human factors related features of the Ground Control Station (GCS) may also require demonstration and evaluation to ensure adequate interface error protection, and to confirm that the remote pilot can easily maintain situational awareness and exercise effective control of the UAS throughout all phases of operation.

  Examples of standards adopted for this approach include ASTM F3478, Standard Practice for Development of a Durability and Reliability Flight Demonstration Program for low-risk UAS under FAA Oversight (ASTM, 2020) and GB42590-2023, Safety Requirements for Civil Unmanned Aircraft Systems (SAPRC, 2023).

Manufacturing

Current manufacturing standards primarily outline manufacturing procedures and responsibilities applicable to both UAS operators and manufacturers. In some States, particularly those that certify UAS, dedicated manufacturing standards have been developed to ensure quality control in UA production.

For instance, China has adopted an outcome-based approach, requiring all UAS to undergo specified test cases prior to release from the manufacturing facility (SAPRC, 2023). In Japan, uniformity standards have been implemented, mandating UAS operators or manufacturers to demonstrate compliance with requirements related to manufacturing and storage facility procedures, personnel training and competency, management of materials and equipment, and inspection and acceptance processes and criteria (JCAB, 2022). In the case of UAS operating at SAIL III and above, EASA requires demonstration of compliance with UAS manufacturing requirements described in JARUS SORA Annex E, OSO #02 (JARUS, 2024).

These examples may be used as reference models for the development of UAS manufacturing standards. Stringent manufacturing controls help assure that each produced UA conforms to the initially assessed UA design. Therefore, the level of manufacturing control directly impacts the consistency, reliability, and safety performance of the final product.

Maintenance

Current standards primarily outline maintenance responsibilities for UAS operators or manufacturers. However, regulatory and industry development in this area is still maturing, and further effort is needed to establish clear maintenance requirements. It is worth noting that, unlike manned aircraft, typical UAS have considerably shorter life cycles, typically spanning only a few years, suggesting that maintenance requirements may not need to be as extensive.

Comprehensive maintenance instructions for UAS checks would form part of the baseline maintenance requirements. These checks would typically be conducted after a certain number of flight hours and periodically even when the UAS is not flown. Additionally, maintenance logs should also be kept as a record of all maintenance performed.

For higher-risk operations, a more stringent and detailed maintenance programme would help to ensure that system safety levels established during the initial airworthiness assessment are maintained throughout the operational life of the UAS. Such a programme would typically entail structured maintenance activities with clearly defined maintenance instructions for subsystems, tailored to the intended UAS, its operation, and operating environment.

Assessing Risk Elements Related to Specific Aircraft Systems

The following are additional specific considerations in the assessment of UAS airworthiness:

Assessing UAS to Meet Safety Objectives

A System Safety Assessment (SSA)is a typical approach used to assess whether a UAS meets safety objectives at the system level. This assessment c analyses the fault modes and impact of flight-critical systems. Fault tree analysis or event tree analysis are commonly used methods to break down the fault modes into their contributory subsystems.

UAS may be designed using several off-the-shelf systems and components where the failure rates are not known or assessed. In the absence of proven reliability through robust manufacturing processes and quality control, a common practice is to assume that these components have a failure rate of 1 failure in 1000 hours of operation (1x10-3) or higher.

Navigation and Flight Control System

In BVLOS UAS operations, the navigation and flight control are fundamental to ensuring safe flight. Navigation is typically achieved through a combination of Global Navigation Satellite Systems (GNSS) and Inertial Navigation Systems (INSs), while flight stability and control rely primarily on autopilot systems.

Most performance-based requirements for navigation and flight control systems generally focus on two key aspects: the ability of the UAS to stay within its defined area of operation, and its positioning accuracy. The most commonly used MoC to meet the first aspect is through geo-fencing. Positioning accuracy requirements are typically determined based on a function of the operational needs, the risk profile of the intended operation, and the capabilities of the navigation and flight control systems. Additional considerations may include the nature of the mission, the operating environment, and the potential consequences of positioning errors.

To meet the higher safety objectives of high-risk operations, UAS designs may employ system redundancies to improve both positioning accuracy and fault tolerance. For instance, INS navigational accuracy could be improved by correcting drift and supplementing positional information from GNSS. Additionally, GNSS systems may use a combination of different satellite systems, such as the Global Positioning System (GPS) and BeiDou Navigation Satellite System (BDS), for redundant signal coverage. The key aspect of assessing navigation and flight control adequacy is to identify the layers of mitigations in the event of a fault in the system and whether there are any single points of failure.

Flight control systems typically provide both autopilot and attitude control. The flight control system, including the software, firmware, and hardware of the flight control computer, is highly complex, as a result, many UAS operators rely on commercial off-the-shelf flight control systems, which are widely available and cost-effective. However, these systems use open-source firmware and software, such as PX4 or ArduPilot, where configuration control would be crucial. Demonstration tests, or showing of compliance, are typically conducted on a fixed configuration, and any subsequent configuration changes may require reassessment and requalification.

Command and Control/Control and Non-payload Communications Link

The communication system providing UAS health data and/or for the command of the UAS becomes critical in BVLOS UAS operations, where safe flight is dependent on remote pilot intervention, especially in emergency situations. Several communication technologies are typically leveraged in UAS design, such as conventional HF/VHF/UHF radio, cellular communications, and satellite communications. Using multiple dissimilar communication technologies can be an effective means of providing redundancy and reducing the occurrence of link loss.

Accuracy, resolution, integrity, traceability, format, and timeliness (i.e., latency) are typical attributes used to assess the suitability of Command and Control (C2) /Control and Non-payload Communications Link (CNPC) datalinks for a given operation. Local restrictions on C2/CNPC datalink frequency and output power would have to be considered during system planning. It is important to note that link performance is influenced by its operating environment; therefore, if there is a change in the operating environment, link performance may have to be reviewed.

Air-to-ground, ground-to-ground, and air-to-air communications may be vulnerable to cyberattacks such as data spoofing, modification, or jamming, which could lead to unauthorised access to, use of, and/or exploitation of the UAS. Security/cybersecurity risks are therefore critical considerations, and appropriate controls, measures, processes, and practices should be in place to ensure the confidentiality, integrity, and availability of the UAS's critical functions.

Detect and Avoid Systems

Detect-and-Avoid (DAA) systems may be considered critical if they serve as the primary means to mitigate the risk of collisions with other aircraft and/or terrain. A DAA system allows UAS to detect aircraft or obstacles in the vicinity and take appropriate manoeuvres or provide advice to a remote pilot to take evasive action.

DAA system designs may incorporate several different types of detection sensors, such as optical cameras, infrared cameras, radar, ultrasonic sensors, and Light Detection and Ranging (LiDAR). These sensors monitor environmental changes around the aircraft and calculate obstacle position, speed, and direction in real-time, enabling the system to compute avoidance strategies. Optical and infrared sensors are commonly used on small UAS. However, their performance may be degraded in adverse visual environments such as low visibility, high humidity or low temperature contrast.

AI technologies may also be applied to optimise DAA detection algorithms. For example, machine-learning-based pattern recognition algorithms can be used to identify different types of obstacles and predict their flight paths to determine if evasive action is needed.

While significant progress has been made in detection technologies and algorithms, further work is required to mature these capabilities and to achieve international consensus on avoidance actions and algorithms for UAS operations. The capability of DAA systems would have to be carefully assessed and duly demonstrated if they are used as the primary means to mitigate the risk of collisions in a BVLOS UAS operation.

Ground Control Station

UAS, especially those that operate Beyond Visual Line of Sight of the remote pilot, may be designed to operate via a GCS. A GCS typically contains a Remote Pilot Station (RPS), where the UA can be controlled by a human, along with other systems and functions to manage the UAS flight operation such as mission planning. Depending on the design of the UAS, the RPS may perform a critical role in ensuring flight safety. It would therefore be necessary to identify and mitigate risks arising from operating the RPS/GCS.

Key considerations include ensuring that there is satisfactory human-machine interface such that the remote pilot can perform his/her duty without undue concentration, skill, vigilance, or fatigue. The timely provision of key information needed for safe operation or emergency recovery of the UA (i.e., UA health, UA status, or alerts) to the remote pilot would also need to be assured, especially after the occurrence of a failure or combination of failures.

The GCS may also leverage digital services such as Unmanned Aircraft Systems Traffic Management UTM, cloud storage services, or Application Programming Interfaces for data such as weather and geographical data, which could make it vulnerable to cyberattacks. The risks and cybersecurity measures would have to be considered depending on the criticality of the functions that the GCS provides for the safe operation of the UAS.

Automation and Software

UAS are highly automated systems, typically designed to minimise direct human/pilot input. Aside from the computing hardware, the software and firmware design, along with the logic of automated functions, are critical to ensuring operational safety. Conventional aviation practices would refer to RTCA/DO-178 (RTCA, 2011) for software design assurance and certification. However, demonstrating compliance with this standard can entail significant lead time.

Software Design Assurance Levels (DALs) should be practically applied to UAS and be appropriate for the risk level of the UAS operation. In lower-risk UAS operations, it may be sufficient to use system-level verification of the aircraft systems and equipment containing the software/firmware. This approach serves as a MoC to demonstrate that its functionality and any mitigations to potential failure conditions are implemented as intended.

ASTM F3153-22 (ASTM, 2022) is a standard that is accepted by some CAAs that provides a process for performing such system-level verification of aircraft systems and equipment.

Part 7, Annex C References

- ASTM International [ASTM]. (2020, October 1). Standard practice for development of a durability and reliability flight demonstration program for low-risk unmanned aircraft systems (UAS) under FAA oversight (ASTM Standard F3478-20).
- ASTM International [ASTM]. (2022, April 7). Standard specification for verification of aircraft systems and equipment (ASTM Standard F3153-22).
- Joint Authorities for Rulemaking on Unmanned Systems [JARUS]. (2024, May 13). JARUS guidelines on SORA: Annex E — Integrity and assurance levels for the operational safety objectives (JAR-DEL-SRM-SORA-E-2.5).
- Japan Civil Aviation Bureau [JCAB]. (2022, December 2). UAS airworthiness inspection manual for inspections of unmanned aircraft systems against safety and uniformity standards for UAS type certification (Circular No. 8-001).
- RTCA. (2011, December 13). Software considerations in airborne systems and equipment certification (RTCA DO-178C).
- Standardization Administration of the People's Republic of China [SAPRC]. (2023, May 23). Safety requirements for civil unmanned aircraft system (GB 42590-2023).

PART 07 ANNEX D

CREW LICENSING CONSIDERATIONS

The increased complexity of BVLOS UAS operations necessitates a more comprehensive approach to crew licensing to ensure the safety and efficiency of these advanced missions. Furthermore, the absence of direct visual contact with the aircraft may require a higher level of technical knowledge and operational skill from the remote pilot in emergency management.

Given these unique aspects, it could be beneficial to qualify or certify the crew operating the UAS in BVLOS conditions through a specialised crew licensing regime. Establishing a thorough and appropriate licensing standard for BVLOS UAS operations would help ensure that remote pilots are adequately prepared for the challenges of these advanced missions. This, in turn, would support the safe integration of BVLOS UAS flights into national airspace systems and foster the continued growth and innovation in the UAS industry.

A licensing regime for BVLOS UAS operations would go beyond the requirements for VLOS operations and address additional competencies and knowledge required for safe and effective BVLOS flights. Some areas of consideration in establishing such a regime are as follows:

Special Operations Ratings

BVLOS UAS operations can encompass a wide range of specialised missions, each with unique challenges and risks. These may be organised into special endorsements or ratings that are added to a basic BVLOS licence. Areas for such special endorsements may include:

- Night Operations
- Overflight of Populated Areas
- Operations in Low Altitude, Controlled Airspace
- Non-Segregated Flight (Sharing Airspace with Manned Aircraft)
- Multiple UAS Operations
- Swarming Operations
- Cargo Operations (Including Underslung Operations)
- Discharge/Dropping of Items

For each of these special operations, requirements would need to be established for the following:

- Additional Theoretical Knowledge
- Specific Practical Skills to be Demonstrated
- Any Operational Limitations or Restrictions
- Currency to Maintain the Endorsement
- Highlighted Possible Risks of the Activity

Special operations rating and requirements for the ratings would need to be regularly reviewed and updated to account for emerging UAS applications and evolving operational concepts.

Theory Requirements

A comprehensive theoretical knowledge curriculum would be essential for BVLOS UAS operations. Key areas may include:

- UAS Regulations and Air Law
- Airspace Structure and Management
- Aviation Safety and Risk Management
- Human Factors and Crew Resource Management (e.g., use of IMSAFE checklists)
- Navigation and Flight Planning
- Meteorology
- UAS Systems and Operations
- Emergency Procedures (including contingencies for abnormal situations)
- Communications (including emergency scenarios)

For BVLOS UAS operations, these topics should be covered in greater depth than for VLOS licences. Emphasis should be placed on:

- Advanced Navigation Techniques
- Airspace Integration and Traffic Management
- Automated Flight Systems and Their Limitations
- Long-Range Communication Systems
- Extended Emergency Procedures

The depth of knowledge required for each topic, based on the complexity of permitted operations, would need to be determined. A system for regular updates to the curriculum should be established to ensure that the content keeps pace with technological and regulatory changes.

Practical Requirements

Practical skills assessment for BVLOS UAS pilots should be comprehensive and scenario based. Key areas to assess may include:

- Pre-Flight Planning and Risk Assessment
- UAS Assembly and Pre-Flight Checks
- Normal Flight Operations
- Advanced Flight Manoeuvres (e.g., Manual Control for Figure-8 Flights and Precision Take-off and Landing).
- Emergency Procedures and Decision-Making
- Post-Flight Procedures and Debriefing

For BVLOS UAS operations, additional focus should be placed on:

- Management of Automated Flight Systems
- Long-Range Navigation and Flight Path Management
- Handling of Communication Failures and Link Losses
- Interaction with Air Traffic Control or Unmanned Aircraft Systems Traffic Management Systems
- Execution of Emergency Procedures Without Visual Reference

A minimum number of supervised BVLOS flight hours before licensing may be beneficial to ensure remote pilot standards.

Additionally, simulators may have the potential to support practical training and assessment depending on the fidelity of the simulator.

Medical Requirements

While UAS remote pilots may not be subjected to the same physical stresses as manned aircraft pilots, BVLOS UAS operations still require a high level of mental acuity and sensory perception. Basic medical requirements of UAS remote pilots may comprise of the following:

- Vision (including colour vision and depth perception)
- Hearing
- Mental Health and Cognitive Function
- Substance Use

The level of medical requirements may vary based on the scale and risk profile of permitted operations. Furthermore, the frequency of medical assessments, or the appropriateness of self-declaration, may be tailored according to the level of risk of the UAS operation.

Compliance with ICAO Class 3 medical requirements, as prescribed in ICAO Annex 1 (ICAO, 2022) may be a means to assure the fitness of BVLOS UAS pilots, especially for higher-risk operations.

Age and Experience Requirements

Age and experience requirements for BVLOS UAS remote pilots may need to balance the need for maturity and sound judgement with the objective of fostering innovation and career development in the UAS industry. It may therefore be appropriate to define a clear minimum age for solo BVLOS UAS operations, as well as to consider whether upper age limits or additional requirements for older remote pilots are necessary. In many States, the minimum age for commercial UAS operations is set at 18 years old. However, some States allow younger pilots to operate under supervision.

Experience level may be an alternative to age requirements. However, the manner in which prior experience is credited, such as experience gained through VLOS operations or manned aviation would need to be clearly defined. If experience is used as a qualification criterion, the following are some considerations:

- Minimum Number of VLOS Flight Hours for BVLOS UAS Qualification
- Minimum Supervised BVLOS UAS Flight Hours
- Recency Requirements to Maintain BVLOS UAS Operations Currency

Examination and Assessment

A robust examination and assessment regime would help ensure that BVLOS UAS remote pilots meet the required standards of proficiency and knowledge. The assessment framework would typically include theoretical examinations and practical assessments.

Theoretical examinations comprise comprehensive written tests that cover all required knowledge areas. Scenario-based questions may be included to assess decision-making. Computer-based testing for theoretical exams may be an efficient and effective means to conduct these examinations.

Practical assessments involve in-person flight tests conducted by a qualified examiner. These may include scenario-based assessments to test a remote pilot's proficiency in both normal and emergency procedures. In practical assessments, clear and systematic assessment criteria (i.e., standardised checklists, test tolerances, and passing standards) may help promote consistency in evaluation across different examiners.

A common practice for examinations and assessments is to establish an approval regime for training organisations, authorising them to conduct the assessments on behalf of the regulator. This approach helps meet industry demands while ensuring that assessment standards are upheld.

Instructor and Examiner Qualifications

As with standard practices for a licensing regime for aviation, qualifications and requirements would need to be established for instructors and examiners involved in BVLOS UAS licensing or rating. Instructors and examiners would be expected to hold appropriate UAS instructor and examiner licenses and possess the requisite qualifications and experience in BVLOS UAS operations. As such, requirements for qualification would cover areas such as minimum BVLOS UAS experience, additional BVLOS UAS theoretical knowledge, and defined standards to check for proficiency.

However, until a qualified cohort of instructors and examiners is established, transitional measures may be necessary. These could allow current UAS instructors and examiners to leverage prior relevant experience as a basis for obtaining a BVLOS UAS instructor or examiner rating or qualification.

Licence Issuance and Renewal

Establishing clear processes for BVLOS UAS licence issuance, validity, and renewal would help ensure an effective licensing regime. In these processes, the following conditions are typically considered:

- Initial Licence Validity Period (e.g., 1–5 Years)
- Renewal Requirements (e.g., Recent Experience, Refresher Training, Re-Examination)
- Processes for Adding Ratings or Endorsements to Existing Licences.

Given the diversity and specialised nature of BVLOS UAS operations, a graduated licensing system may be more suited for BVLOS UAS remote pilot licences and qualifications. Under such a system, UAS remote pilots would progressively obtain privileges as they accumulate experience and additional qualifications.

Enforcement and Oversight

As with existing UAS pilot licensing regimes, mechanisms for enforcing the BVLOS UAS licensing requirements and oversight of such operations would be required. The licensing regime would typically include a process for licence suspension or revocation, requirements for remote pilots to log BVLOS UAS flights, and periodic audits or inspections of BVLOS UAS licensed pilots. Incident reporting and investigation procedures would also be key in ensuring the adequacy and effectiveness of licensing requirements, standards, and execution.

Part 7, Annex D References

- International Civil Aviation Organization [ICAO]. (2022, July). International standards and recommended practices, Annex 1 — Personnel licensing (14th ed.).

PART 07 ANNEX E

BVLOS UAS USE CASES

The following use cases illustrate examples of the risk assessment and mitigation measures for BVLOS UAS operations that were approved through a risk-based approach. Seven use cases are presented below, each summarising the general operational context. The risks identified in the use cases and corresponding mitigations are detailed in Tables E-1 to E-7:

Food Delivery Within an Offshore Island (Japan)

A BVLOS UAS operation was conducted to deliver food approximately 2.3 km from a supermarket in the central area of a town to a square near a resident's house in the offshore island of Okinawa Prefecture. The food delivery involved using a "PF2-CAT3" medium-sized UAS (<25 kg) monitored from the GCS at the parking lot of the supermarket. The UAS operated at an altitude not exceeding 45 metres above ground level (AGL), and within uncontrolled Class G airspace.

Island logistics with Drones (South Korea)

A BVLOS UAS operation was conducted to demonstrate a goods delivery service for island residents in the coastal and island regions of Gyeongsangnam-do, South Korea. The operation involved both daytime and night-time BVLOS UAS flights using a medium-sized UAS with a maximum take-off weight (MTOW) of less than 25 kg. The UAS operated within an 8 km radius from the take-off point at altitudes below 150 meters. Equipped with a video recording camera and RTK-GPS for precise navigation, it also featured an automated Return-to-Home (RTH) function to ensure safe recovery in case of communication loss or emergencies. The GCS provided real-time monitoring, issuing alerts for anomalies, which were transmitted to external operators. Flight routes were carefully planned, with take-off and landing areas selected to minimise obstacles and public interference, ensuring safe and efficient operations.

Medicine Delivery in the Suburbs (Japan)

The BVLOS UAS operation involved the delivery of medicine about 2.4 km from a clinic to a nursing home in the suburbs of Tokyo. The medicine delivery involved using a "PF2-CAT3" medium-size UAS (<25 kg) monitored from the GCS at a remote operating base in central Tokyo. The UAS operated no higher than 70 meters AGL and within a US Air Force Warning Area.

Offshore Oil Rig Sub-Platform Inspection (Thailand)

A BVLOS UAS operation was conducted to inspect the structural integrity and condition of an offshore oil and gas sub-drilling platform located within 10 km of a main platform. The inspections involved using an in-house developed "drone-in-the-box" medium-sized UAS (<25 kg) monitored from the main platform. The UAS operated no higher than 90 meters AGL and within uncontrolled Class G airspace.

Package Delivery in Suburban Environment (Australia)

The BVLOS UAS operation involved package delivery operations in a populated suburban environment of a city. Operational flights were conducted below 400 ft AGL and were not permitted near aerodromes or helicopter landing sites (SORA Air Risk Class B). A 7 kg small drone, custom designed for the mission, was used. The UAS design included frangible components, fault detection, and redundancy to reduce ground risk. The organisation employed a high level of automation, crew training, and documented risk management systems.

Package Delivery in the Suburbs (Japan)

A BVLOS UAS operation was conducted for package delivery about 4.5 km from a post office in the central area of the town to a resident's house in a mountainous area in the suburbs of Tokyo. The package delivery involved using a "PF2-CAT3" medium-sized UAS (<25 kg) monitored from the GCS on the rooftop of the post office. The UAS operated no higher than 145 meters AGL and within uncontrolled Class G airspace.

Pipeline Gas Inspection Using Nested Drone (Malaysia)

A BVLOS UAS operation was conducted for gas pipeline inspection using nested drones launched from mobile docking stations. Operations were carried out in accordance with the Specific Operations Risk Assessment (SORA) framework and Civil Aviation Directive (CAD) 6011 Part V. These drones autonomously inspected pipelines for structural defects using advanced sensor technology. Operations were conducted at a maximum altitude of 400 ft AGL across all locations within Class G airspace. This approach minimised human risk, reduced downtime, and improved data accuracy, offering a more effective inspection solution.

Food Delivery Within Offshore Island (Japan)	
Risks	**Risk Mitigations**
• **Airworthiness:** › Medium-sized drone (<25 kg). › The "PF2-CAT3" drone was designed to be operated BVLOS and over sparsely populated areas. › A malfunction of the aircraft was discovered during preliminary checks of the flight permit/approval application. • **Crew** › This was the first Category III flight (Level 4 flight, flight over people) for this crew. • **Organisation** › This was the first Category III flight (Level 4 flight, flight over people) for this organisation. • **Environment:** › Air Risk Class ARC-b in accordance with SORA 2.0 (Ops < 500 ft AGL, operations in uncontrolled airspace over rural areas). › Conducted over a sparsely populated area with low risk to human life; local residents constitute the primary ground risk. › Operations took place within the U.S. Air Force's restricted airspace.	**General:** • The UAS must obtain a Class 1 UAS certification, and the operator must obtain a Class 1 Pilot license. The operator is required to obtain flight permission from JCAB after conducting a risk assessment, and they need to conduct appropriate risk mitigation measures derived from the prior risk assessment for operations over sparsely populated areas. • The risk assessment was conducted in accordance with SORA (Safety Operational Risk Assessment) 2.0. • Following the issuance of Service News (five cases) by the manufacturer, it was verified that operational procedures were reflected in the necessary manuals to ensure flight safety. **Supplementary Risk Mitigations:** • **Airworthiness:** › The UAS is required to show compliance with airworthiness criteria (durability and reliability requirements). • **Crew:** › Crew members are to effectively utilise the company's (manned aircraft airline's) training policy, including Crew Resource Management (CRM) training. • **Organisation:** › The organisation shall effectively utilise the company's (manned aircraft airline's) policy and know-how, including the creation and compliance of regulations. • **Environment:** › Issue NOTAMs specifying operation time, location, and operator contact information. › Provide advance notification of flight plans to relevant manned aircraft organisations. › Obtain airspace use permission from the U.S. Navy via Okinawa Defense Bureau to reduce air risk. • **Others:** › The UAS must be equipped with Remote ID. Information such as the Registration ID, Serial Number, Location/Vector, Timestamp, and Authentication Data shall be transmitted once every second by communication protocol of Bluetooth 5.x Long Range, Wi-Fi Aware, Wi-Fi Beacon. These specifications comply with ASTM F3411-19 standard.

Table E-1: BVLOS UAS Use Case — Food Delivery to Offshore Island

Island Logistics with Drones (South Korea)	
Risks	**Risk Mitigations**
• **Airworthiness:** › Medium-sized drone (<25 kg). › Classified as a Category 2 UAS (7 kg < MTOW < 25 kg) under Aviation Safety Act Implementation Regulations Article 306. › An in-house developed UAS intended for package delivery operations. • **Crew:** › Lack of specific qualifications for the flight environment and operation type. • **Organisation:** › Lacks familiarity with aviation Safety Management Systems (SMS) for drone operations. • **Environment:** › Flight crew demonstrated limited situational awareness. › Potential risks identified due to shared airspace with other operations (e.g., helicopters, UAS, etc.). › Operations involved flight over people on the island when delivering to and from islands.	**General:** • The BVLOS operation was approved based on safety standards and approval procedures for special flights of unmanned aerial vehicles [Enforcement 2021. 11. 18.] [Ministry of Land, Infrastructure and Transport Notification No. 2021-1264, 2021. 11. 18., partially revised], Act on Promotion and Foundation Creation of Drone Utilization (abbreviated name: Drone Act) [Enforcement 2022. 6. 8.] [Law No. 18556, 2021. 12. 7., partially revised]. **Supplementary Risk Mitigations:** • **Airworthiness:** › UAS operators must submit specification sheets including UAS specifications and capabilities, operating limits, visual aids, and other relevant information. › The UAS must be equipped with fail-safe features (e.g., return-to-home), collision avoidance systems, and location transmission functions to determine the UAV's position in the event of a crash. › The UAS must enable real-time location tracking through precise navigation performance and visual assistance devices (First Person View) connected to the GCS. › The GCS must be equipped with features to display the aircraft's status and to generate alerts in the event of equipment malfunction. • **Crew:** › Flight Crew must possess the appropriate license based on the UAS's MTOW (Category 1–4). › Pre-flight checks were required, including verification of the flight path, operational environment, and presence of obstacles. • **Organisation:** › An emergency response manual was established, that includes the following: › Emergency response procedures; • Reporting procedures; • Contact information of emergency response agencies (e.g., local fire stations, medical centres, police stations, and so on). • **Environment:** › An observer was positioned along the planned flight path to visually monitor the UAS during its operation. › The allowable altitude was limited to 500 ft. • Operations above this altitude require notification to Air Traffic Control and issuance of NOTAM. › Flight routes were subject to approval, considering potential conflicts with other airspace users. › A specific flight path was allocated. › Located take-off and landing spots in wide, obstacle-free areas and safeguarded against any access by the public. › Flight routes were subject to approval, considering potential conflicts with other airspace users. › A specific flight path was allocated. › Located take-off and landing spots in wide, obstacle-free areas and safeguarded against any access by the public.

Table E-2: BVLOS UAS Use Case — Island Logistics with Drones

Medicine Delivery in the Suburbs (Japan)	
Risks	**Risk Mitigations**
• **Airworthiness:** › Medium sized drone (< 25kg) › The "PF2-CAT3" is designed to be operated BVLOS and over sparsely populated areas. • **Crew:** › Human error occurred during the crew's second Category III flight (Level 4 flight, flight over people). • **Organisation:** › Lacks familiarity with the basic concepts of aviation safety, including aviation SMS. • **Environment:** › Air Risk Class ARC-b, in accordance with SORA 2.0 (Ops < 500 ft AGL, operations in uncontrolled airspace over rural areas). › The flight was conducted over a sparsely populated area with low risk to human life; local residents constitute the primary ground risk. › The purpose of the flight was to deliver medicines. › Operations were conducted from a remote operating base.	**General:** • The UAS must obtain Class 1 UAS certification, and the operator must obtain a Class 1 Pilot license. The operator is required to obtain flight permission from JCAB after conducting a risk assessment, and they need to conduct appropriate risk mitigation measures determined by the prior risk assessment for a flight over a sparsely populated area. • The risk assessment method was conducted in accordance with SORA (Safety Operational Risk Assessment) 2.0. **Supplementary Risk Mitigations:** • **Airworthiness:** › The UAS is required to show compliance with airworthiness criteria (durability and reliability requirements). • **Crew:** › Pilots and other related parties are required to take CRM training provided by manned aircraft airlines, to ensure safety and reduce human error. • **Organisation:** › Pilots and other related parties are required to take CRM training provided by manned aircraft airlines, to ensure safety and reduce human error. • **Environment:** › Issued NOTAMs specifying operation time, location, and operator contact information. › The operator complied with the requirements of guidelines for the transporting of medical items issued by the Ministry of Health, Labour and Welfare (MHLW). › The previous operational system was revised by clarifying the division of roles between local personnel and personnel at the remote operation base, and by simulating flight operations in advance to ensure safety. • **Others:** › The UAS must be equipped with Remote ID. Information such as Registration ID, Serial Number, Location/Vector, Timestamp, and Authentication Data shall be transmitted once every second by communication protocol of Bluetooth 5.x Long Range, Wi-Fi Aware, Wi-Fi Beacon. These specifications comply with ASTM F3411-19 standard.

Table E-3: BVLOS UAS Use Case — Medicine Delivery in the Suburbs

Offshore Oil Rig Sub-Platform Inspection (Thailand)	
Risks	**Risk Mitigations**
• **Airworthiness:** › Medium-sized drone (<25 kg). › An in-house developed "drone-in-the-box" UAS designed for BVLOS operations. • **Crew:** › Inadequate handling of environmental challenges such as high-speed wind. › Failure to manage offshore-specific hazards due to insufficient emergency response training. • **Organisation:** › Lack familiarity with aviation Safety Management Systems (SMS). › Lack of clear communication protocols between stakeholders in this operation. • **Environment:** › Airspace is shared with offshore helicopter services — potential increase in encounter risk due to helicopters regularly operating at low altitudes in offshore environments. › Air Risk Class ARC-b in accordance with SORA 2.0 (Ops < 500 ft AGL, operations in uncontrolled airspace over rural areas). › Sparsely populated operational area with low risk to human life. Maritime workers (on vessels or oil rigs) constitute the primary ground risk. › Oil rig infrastructure may overlap with UAS flight paths due to its height and range of motion, pose a risk of electromagnetic compatibility to UAS communications and navigation systems, and endanger the UAS due to flare radiation and gas dispersion.	**General:** • The requirements of JARUS Pre Defined Risk Assessment, PDRA-05 for Aerial Work operations were applied. See (JARUS, 2022). **Supplementary Risk Mitigations:** • **Airworthiness:** › The UAS is required to show compliance with design and testing standards, incorporate redundancy in critical systems, include fail-safe features (e.g., return-to-Home), and be resilient to environmental factors (e.g., corrosion and high winds). • **Crew:** › Specialised training for offshore UAS operations was conducted, including manufacturer-provided training and instruction tailored to the offshore environment. › Regular evaluation and continuous learning programmes were implemented to reinforce safety and operational effectiveness. › Training was conducted to handle emergencies and operational complexities specific to oil rig environments. • **Organisation:** › A robust SMS was tailored to offshore UAS operations. › Conducted proactive risk assessments specific to oil and gas environments. › Established clear communication protocols with offshore helicopter operators and platform personnel. • **Environment:** › Maintained a 50-meter buffer around any structure (e.g., oil rigs, vessels, or platforms) where individuals may be present, and 112-meter buffer around the tips of vent flares required. › Procedures — UAS operator to have direct communication with offshore helicopter operators to coordinate schedules and avoid overlapping operations. › Procedures — UAS operator to establish procedures for oil rig platform crane operator during UAS flight operations. › NOTAMs were issued specifying operation time, location, and operator contact information (taken from PDRA-05). › Implemented geofencing around sensitive zones (e.g., oil rigs, vent flares). • **Others:** › Use ADS-B dual-band receivers for detection of air traffic in the area (taken from PDRA-05).

Table E-4: BVLOS UAS Use Case — Offshore Oil Rig Sub-Platform Inspection

Package Delivery in a Suburban Environment (Australia)	
Risks	**Risk Mitigations**
• **Airworthiness:** › Small-size drone (<3 m / 7 kg). › The UAS was customised for the mission (e.g., C2 link and GNSS are not safety critical) and designed to be operated BVLOS. • **Environment:** › Air Risk Class ARC-B in accordance with SORA 2.0, • Flights ≤ 400 ft AGL. • No flights within the 'no fly' zone of a controlled aerodrome as defined by CASR Part 101 Manual of Standards. • No flights within 3 nautical miles of the movement area of a non-controlled aerodrome that is published by Airservices Australia unless that aerodrome is a Helicopter Landing Site (HLS). • No flights within 465 m of an HLS. • No flights within 1389 m of an HLS at a height (AGL) greater than 250 ft; and • No flights within active restricted airspace. › Populated operational area.	**General:** • The requirements of JARUS SORA V2.0 were applied. **Supplementary Risk Mitigations:** • **Airworthiness:** › The UAS featured a small, lightweight, foam airframe with frangible components to significantly reduce energy transfer dynamics in the event of an impact, dramatically reducing the risk of serious injury and fatality (JARUS SORA v2.0 M2 high level of robustness). › The UAS was designed to enter a spin manoeuvre in the event of critical failure to reduce impact airspeed and impact area. › The UAS was designed with redundancy for most components and can demonstrate a loss of control rate meeting or exceeding JARUS SORA SAIL value. › The UAS was designed to meet the high level of containment (JARUS SORA v2.0). › The UAS was designed to be resilient to environmental factors (e.g. wind and rain). › The UAS performed a set of automated health checks and will not take off if it detects a fault. • **Crew:** › Training was adapted to the level of automation. Remote Pilot Licence required as a minimum. • **Organisation:** › Implementation of a risk management system. › Operator is certified through an assessment of the head of operations (Chief Remote Pilot) and the documented practices and procedures. • **Environment:** › The UAS operated in an underutilised and low-risk airspace. › No flights in areas where historical ADS-B survey or stakeholder engagement shows high traffic density. › Active VHF monitoring in controlled airspaces as mandated by the Civil Aviation Safety Regulations and, in certain uncontrolled airspaces when no other alternative exists to achieve a level of safety that is as low as reasonably practicable. › Local conventional aviation operators were notified of UAS operations through outreach and Notice to Airmen. › DAA capability relying on ground-based sensors for detection and pilot-initiated actions for avoidance was used. • **Others:** › **Automation:** High level of automation was used to reduce the risk of human errors, in particular, the UAS automatically planned a safe route from the launch facility to the pickup and delivery locations. The route considers airspace restrictions, known obstacles, aircraft performance and other UAS (through strategic conflict detection via a UTM system). The pilot cannot take direct control of the aircraft and only command a land now.

Table E-5: BVLOS UAS Use Case — Package Delivery in a Suburban Environment

Package Delivery in the Suburbs (Japan)	
Risks	**Risk Mitigations**
• **Airworthiness:** › Medium-sized drone (< 25kg) › A "PF2-CAT3" was designed for BVLOS operations and over sparsely populated areas. • **Crew:** › Because this was the first Category III flight (Level 4 flight, flight over people) in Japan, and the application for flight permission and approval was made shortly after obtaining type certification and UAS certification, there were not enough opportunities for training using the UAS after the certification. • **Organisation:** › Demonstrated lack of familiarity with the basic concepts of aviation safety, including aviation SMS › Unclear whether the operational arrangements in place, including emergency response plans (ERPs), were sufficient. • **Environment:** › Air Risk Class ARC-b in accordance with SORA 2.0 (Ops < 500 ft AGL, operations in uncontrolled airspace over rural areas). › Over sparsely populated area operation with low risk to human life. Local residents constitute the primary ground risk.	**General:** • The UAS must obtain a Class 1 UAS certification, and the operator must obtain a Class 1 Pilot license. The operator must obtain flight permission from JCAB after conducting a risk assessment, and they need to conduct appropriate risk mitigation measures determined by the prior risk assessment for a flight over a sparsely populated area. • The risk assessment method was conducted in accordance with SORA (Safety Operational Risk Assessment) 2.0. **Supplementary Risk Mitigations:** • **Airworthiness:** › The UAS was required to show compliance with airworthiness criteria (durability and reliability requirements). • **Crew:** › The manufacturers provided training programmes that can be implemented prior to obtaining type certification and UAS certification. • **Organisation:** › ERPs and associated measures were thoroughly discussed, and the plan was established with due consideration for safety. • **Environment:** › Issued NOTAMs specifying operation time, location, and operator contact information. › Provided advance notification of flight plans to manned aircraft organisations. • **Others:** › The UAS must be equipped with Remote ID. Information such as Registration ID, Serial Number, Location/Vector, Timestamp, and Authentication Data shall be transmitted once every second by communication protocol of Bluetooth 5.x Long Range, Wi-Fi Aware, Wi-Fi Beacon. These specifications comply with ASTM F3411-19 standard.

Table E-6: BVLOS UAS Use Case — Package Delivery in the Suburbs

Pipeline Gas Inspection Using Nested Drone (Malaysia)	
Risks	**Risk Mitigations**
• **Airworthiness:** › Equipment failure due to the malfunctions of the critical systems such as propulsion, navigation, and communication. • **Crew:** › Inadequate training that caused the mishandling of the UAS › Crew-related issues including fatigue, human error, and health issues. • **Organisation:** › Lack of Standard Operating Procedures › Insufficient information related to the operations, maintenance, and safety in the manuals › Insufficient risk management framework in the organisation • **Environment:** › Presence of geographical obstacles › Airspace height limitations	**General:** • The Specific Operation Risk Assessment (SORA) 2.0 methodology was adopted for the Special UAS Project (SUP) operation. • The operation for SUP refers to the Civil Aviation Directives (CAD) 6011 Part V, published by the Civil Aviation Authority of Malaysia. **Supplementary Risk Mitigations:** • **Airworthiness:** › Compliance was ensured with design and testing standards approved by the Standards and Industrial Research of Malaysia (SIRIM), a recognised conformity assessment body responsible for certifying the safety of electronics equipment. › The Malaysian Communications and Multimedia Commission (MCMC) reviewed and approved the operating frequency of the UAS, to ensure compliance with national spectrum policies. • **Crew:** › The remote pilot held a Remote Pilot Certificate of Competency Basic (RCOC - B), along with Module 1 — Extended Visual Line of Sight (EVLOS), as required under CAD 6011 Part V. › Training was conducted by the UAS manufacturer for both the remote pilot and support personnel. This included instruction on operations, maintenance, and systems for the UAS. In addition, personnel completed the Oil and Gas Training Passport (OGSP) and other related training for the operation. › A schedule was established to mitigate fatigue experienced by the remote pilot while operating the UAS. › Health monitoring protocols were in place to ensure operators were fit for duty. • **Organisation:** › Standard Operating Procedures for UAS operations were standardised and reviewed by the Authority and relevant stakeholders. › All related documents for the operation, such as Concept of Operations, Specific Operation Risk Assessment, and related manuals for the operations, were prepared in accordance with regulatory guidelines. › Aviation standards for the SMSs were implemented for the operation. › The flight operations manual adhered to the requirements set by the Authority. › The aircraft maintenance manual adhered to the requirements set by the Authority, along with maintenance guidelines set by the manufacturer. › Comprehensive incident action plan and emergency response plan for the operation were developed. • **Environment:** › The remote pilot conducted site survey to be familiarised with the environment and potential obstacles prior to the start of each operation. › The operator performed an evaluation of the Ground Risk Class (GRC), which included: • Assessment of ground population; • Application of the 1:1 rule for ground risk buffering; • Definition of the operational volume, including flight geography and contingency volume; • Implementation of geofencing at the area of operation; • The operator evaluated the Air Risk Class (ARC), indicating that the UAS would operate in uncontrolled airspace below 400 ft AGL, and thus classified the operation under ARC C. • A NOTAM was issued for the UAS operation. › The Specific Assurance Integrity Level (SAIL) was derived based on the final GRC and ARC value.

Table E-7: BVLOS UAS Use Case — Pipeline Gas Inspection Using Nested Drone

UAS: PART 08

Capability Building (UAS Personnel Training)

INTRODUCTION

Commercial Unmannaed Aircraft Systems (UAS) are employed across a growing range of new airborne services beyond commercial air transport, leveraging leading-edge technologies in aircraft electrification and automation. UAS operators are also characterised by a predominance of start-ups, many of which do not necessarily have conventional aviation backgrounds. These unique traits of the UAS industry require that CAAs adapt their existing capabilities to effectively carry out their regulatory responsibilities. This section aims to specifically highlight potentially new qualifications and training for Civil Aviation Authority (CAA) personnel that may enhance their ability to oversee and ensure the safety and security of UAS operations.

BACKGROUND

The CAA is a statutory body responsible for regulating civil aviation activities within its national jurisdiction and airspace, in compliance with ICAO SARP. The key functions of the CAA include identifying aviation safety risks, developing mitigations to address aviation safety risks through regulatory response, advice, or guidance, drafting rules where regulatory response is required, issuing approvals, monitoring compliance; and enforcing regulatory requirements. A CAA may also be involved in aircraft accident investigations or the development and operation of airports, although in many countries these responsibilities are undertaken by a separate institution.

To fulfill these responsibilities, the CAA must therefore be staffed with competent personnel capable of overseeing airworthiness and environmental protection, crew standards, air operations, aerodrome operations, air traffic management, and air navigation services.

The design, industry, and operations of UAS are different from those of conventional manned aviation. UAS aircraft designs have evolved from radio-controlled hobby aircraft, and the industry is largely dominated by start-ups seeking to rapidly adapt or adopt consumer, prosumer, or general industrial hardware and systems for low-cost solutions. The types of operations and flying environments of a UAS often require propulsion, navigation, communication, and situational awareness technologies that are not commonly applicable or used for commercial aircraft. In pursuit of size, weight, power, and cost (SWaP-C) optimisation, UAS developers frequently incorporate new technologies that may not yet be fully understood or matured to a point where there is sufficient knowledge and standards in the aviation industry. These technologies may lack established standards or sufficient operational history. As a result, the existing explicit or tacit knowledge of CAA personnel, based on manned aviation experiences, may be insufficient to adequately carry out their responsibilities for safety governance of UAS operations.

KEY CONSIDERATIONS

Recognising the fundamental differences between UAS and existing manned aviation, this section provides considerations and identifies potential gaps in the competencies of existing trained CAA safety inspectors. It is assumed that these personnel already possess foundational knowledge and experience in aviation regulations, airworthiness, Safety Management Systems (SMSs), and flight instruction for conventional aviation. Accordingly, the focus here is on how the type of UAS operations and technologies may impact the knowledge and skillsets required of the CAA personnel. The expected core competencies are thus also presented in this section.

Effect of UAS Operational Profile

UAS have evolved from remote-controlled hobby craft and the popularisation of consumer drones in the early 2010s. Initially used predominantly for personal and then commercial aerial photography and videography, advancements in UAS technology have since enabled their integration into a wide range of other commercial applications. Some examples of commercial UAS applications include:

- → Infrastructure Inspection
- → Recreational and Sports Activities
- → Surveillance and Security
- → Delivery and Logistics
- → Aerial Photography and Videography

Unlike traditional manned aircraft, UAS do not necessarily require dedicated aerodromes and can be operated from almost any location that is sufficiently clear and large enough for take-off and landing. This versatility allows UAS to serve a wide range of applications in diverse environments. Moreover, most UAS missions are conducted close to the ground or near buildings, which are areas not typically served by conventional aviation. This unique capability enables UAS to fill operational niches that were previously impractical or impossible for manned aircraft. However, this operational freedom remains subject to certain limitations. UAS operations require local approval and may be constrained by various site-specific requirements such as noise levels in urban areas. Other considerations may include privacy concerns, wildlife protection, and local airspace restrictions.

UAS currently fly mostly during daylight hours but may fly at night if equipped with suitable aircraft systems such as aircraft lighting and approved to do so by the authorities. UAS may also be operated without direct manual control of an operator (pilot), and it may not need to remain within the visual range of the operator (i.e., Beyond Visual Line of Sight operations). However, most UAS are still limited to flying under fair weather (tolerating up to moderate winds and light rain), although more weatherproof systems are being developed.

The unique operational profiles of UAS missions create an expectation that the operators and regulators possess a broadened range of knowledge related to the operating environment and technologies used at low altitudes. These include, for example, local and micro-weather, the performance and coverage of navigational and communication systems at low altitudes, and civil rights (i.e., privacy and property rights).

Effect of UAS Technologies

On one end of commercial UAS design, the majority of UAS are small or lightweight systems that have principally evolved from radio-controlled hobby aircraft, while the other extreme includes larger UAS that may be equivalent to unmanned versions of existing conventional aircraft. Although the principles and design of UAS and their flight controls may be similar to those of conventional aircraft and helicopters, the flight performance characteristics in terms of endurance, speed, manoeuvrability, and noise profiles can be very different. Existing knowledge or experience of conventional aircraft may have some relevance, but it may not be sufficient to understand how to safely and effectively operate UAS for the various types of operations they are designated to undertake.

The specific systems that are used in commercial UAS are also typically distinct from conventional aircraft systems. Low cost and weight are often key design goals for commercial UAS and are critical for their diverse applications and operational flexibility. This leads to a preference for SWaP-C-optimised systems that are not qualified under conventional airborne equipment and hardware standards. While this approach enables the versatility of UAS, it potentially conflicts with requirements for high-risk category operations, which demand rigorous design assurance. For instance, a consumer-grade GNSS module might be used for critical navigation functions. Ensuring the safety of aircraft designs that use consumer, prosumer, or general-industry-grade systems for critical functions presents a unique challenge for CAA safety inspectors. They must balance innovation with safety, often in the absence of established standards for these novel technologies.

CAA safety inspectors may require additional training to expand their technical knowledge and experience in technologies used in UAS design that are unique from manned aviation, such as the following:

- **High-Power-Density Rechargeable Batteries:** While using batteries on aircraft is not new, high power density batteries (e.g., lithium-ion batteries), typically developed to support consumer devices and electric vehicles, are significantly different in composition and construction. These pose new hazards (i.e., battery fires) that must be well understood to ensure a proper means of safety governance.
- **Navigation and Automation:** Most UAS use GNSS and inertial navigation systems for navigation, which is not necessarily novel. New methods such as optical-based navigation and non-GNSS navigation (e.g., laser-based or radio frequency-based positioning) may also be employed on UAS. It is also expected that UAS employ automation technologies that are more advanced than conventional aircraft. The means for qualification or certification for advanced automation, especially if artificial intelligence is employed, remain an emergent topic in the aviation industry that may require additional knowledge and training.
- **Communication:** Flying aircraft close to buildings and the ground makes conventional line-of-sight-based airborne communication technologies less suitable for UAS operations. Most UAS leverage terrestrial mobile network technologies, which have better coverage in low-level airspace, especially around urban areas. Satellite-based communications systems are also being leveraged for UAS operations that are beyond radio line of sight. These types of communication systems, and issues such as signal coverage, datalink requirements (i.e., accuracy, resolution, integrity, traceability, format, timeliness/latency, and security), and the means to achieve the datalink requirements are areas that may require additional specialised training and knowledge.
- **Situational Awareness:** The low-level flying of UAS requires the use of technologies for situational awareness and obstacle avoidance. Obstacle avoidance technologies are also more critical for UAS, as there is no pilot onboard to ensure safe separation or collision avoidance. As part of situational awareness, means of conspicuity other than conventional Mode-S type transponders may be employed, while sensors like LiDARs, optical detection, or acoustic detectors may be used to detect potential threats. These are some of the potentially unique technologies where additional technical knowledge and experience may be needed to provide safe and adequate governance and standards.
- **Digital Services:** Many of the functions of UAS ground control systems and services, such as Unmanned Aircraft Systems Traffic Management (UTM), leverage digital platforms such as cloud storage and Application Programming Interfaces for weather, map, or terrain data. The reliance on digital services for essential functions raises expectations regarding knowledge in digital information and data management and information security, which may not be familiar to some CAA safety inspectors. Additional training may be required to ensure adequate knowledge and experience in developing, implementing, and executing adequate safety governance and oversight of digital services supporting UAS operations.
- **Additive Manufacturing:** Many UAS companies, with an aim to optimise manufacturing or leverage the ability to produce more complex and material-efficient geometries, have explored the incorporation of additive manufacturing technologies into their production process. Additive manufacturing has been studied and is used in commercial aircraft within a limited scope, such as for non-critical parts (e.g., for interior trims and non-structural parts), whereas UAS designs seek to apply additive manufacturing for more critical parts. There will be much to understand about the capabilities of additive manufacturing and the reliability, quality, and tolerance of parts produced.

In many cases, the rigid application of existing aviation standards and certification practices to UAS design and technologies employed may be inappropriate and may not provide additional value in ensuring the safety of UAS operations, especially when the operational risks are low. As a result, approaches to airworthiness governance may differ for UAS operations compared to manned aviation, for example, through the adoption of a risk-based approach instead of a certification approach. Some airworthiness considerations for complex and higher-risk UAS operations (i.e., higher-risk Beyond Visual Line of Sight (BVLOS) UAS operations) are detailed in **Part 7** of this publication. Supplementary training and knowledge may therefore be required for some CAA safety inspectors who have not yet been introduced to the alternative approaches to providing airworthiness qualification for UAS.

Summary of Expected Competencies for UAS Safety Inspectors:

As a guide, a summary of expected competencies for UAS safety inspectors has been compiled that also takes into account the abovementioned considerations of the impact of UAS operations and technology into account. The list is contained in **Annex A** and focuses on competencies that are expected in areas such as assessing UAS pilots, training organisations, air and ground risks, the command-and-control link environment, weather-related issues, UTM integration and Detect and Avoid (DAA) capabilities, geographical and topographical considerations, and infrastructure.

ACTION PLAN

Developing and Implementing Individual Training Plans

The responsibilities of CAA personnel may involve activities in one or more areas of UAS airworthiness and environmental protection, crew standards, UAS air operations, air traffic management, and air navigation services. Some of the specific activities within the areas of responsibility may comprise the following:

- → Identifying and/or evaluating UAS aviation safety risks and associated risk mitigation measures.
- → Developing UAS safety risk mitigations through regulatory response, advice, or guidance.
- → Assessing and issuing approvals.
- → Overseeing UAS operator compliance and taking enforcement actions where necessary ensure regulatory compliance.
- → Safety investigation or support thereof for serious incidents and accidents.

The competencies that could support the above activities have been discussed in previous section and detailed in **Annex A**; however, it is not necessary nor expected for an individual to have all the competencies listed. Instead, an individual should aim to have the specific competencies required to fulfil their specific objectives within their scope of responsibilities. To this end, CAAs may consider using the process as shown in **Figure 1** to help develop and implement a tailored training programme for individual CAA personnel.

Figure 1 — Action Plan: Adapting Existing Manned Aircraft Regulations

The four-step process is detailed as follows:

Clarifying Mission and Outcomes

A high-performing staff member is one who successfully achieves objective outcomes specific to their role consistently and effectively. This is difficult to do if their role or objectives are unclear. If not already defined, the first step is to formulate a short statement of one to five sentences describing why the role exists in order to help set the context for outcomes and competencies. This should then be followed by a list of specific desired objective outcomes that the staff member must accomplish to be considered a high performer over a set period (i.e., within a work year).

Evaluating Capability and Competency

In this step, the aim is to identify competencies that are needed to fulfil the objective outcomes. **Annex A** can be used as a guide for a list of topics. The current capability of the staff is then evaluated (i.e., whether they have been trained and their level of proficiency on a particular topic) to determine further training needs and priorities. The results can then be used to formulate a training plan that can be implemented for the staff.

Sourcing or Developing Training Resources

The steps for clarifying missions and outcomes and evaluating capabilities and competencies should be repeated for all staff as necessary. Once the exercise has been completed, the collated results provide an overview of training programmes to be fulfilled either through external or internal training courses. The compilation of courses and course catalogues is outside the scope of this publication; however, CAAs may be able to find some of their training needs addressed through ICAO training (see ICAO, 2024). CAAs may also consider asking other States for training programs or activities, if available, to help fulfil the training plans for their staff.

Continuous Education and Development

Continuous education and development may be necessary as new concepts, technologies, and complex operational scenarios emerge for UAS. Additionally, the target objective outcomes of the individual are likely to change periodically (e.g., on an annual basis), which would change training needs and require adjustments to training plans. Mechanisms should be established for the periodic re-evaluation of capabilities and competencies and the adjustment of an individual's training pathway to ensure that CAA personnel are able to perform their roles effectively and remain current with industry advancements and regulatory updates.

Sharing and Supporting Community Awareness

CAAs may find that they have a limited awareness of available training courses or that there are too many similar courses available, which makes the sourcing and selection of training difficult. It may therefore be useful if CAAs record and share their evaluation of the training courses that their staff have attended, especially if the course is highly commendable or if there are valid reasons to not recommend it. The means and channels to share such feedback have yet to be determined; however, to standardise the record of such evaluations, a template is suggested as shown in **Annex B**.

Part 8 References

→ International Civil Aviation Organization [ICAO]. (n.d.). Training. https://www.icao.int/training/Pages/default.aspx

PART 08 ANNEX A

EXPECTED COMPETENCIES OF UAS SAFETY INSPECTORS

The following is a list of competencies that could be expected of UAS safety inspectors that have been compiled by the workstream members. The list covers the following areas:

- → Basic competencies
- → Competencies for airworthiness assessment
- → Competencies for UAS remote pilot assessment
- → Competencies for organisational assessment
- → Competencies to assess environmental factors

Basic Competencies

This list is aimed at providing UAS safety inspectors with the fundamental competencies required to assess UAS operations and provide safety oversight of UAS operators. The list may not be exhaustive, and continuous learning and adaptability are essential to ensure that the UAS safety inspectors stay updated on the latest developments, methodologies, and tools.

UAS Technology Knowledge:

- → Different types of UAS platforms and their capabilities
- → UAS technology and systems, including sensors, payloads, and control systems
- → Communication links and data transmission in UAS operations
- → Autonomous flight systems and their limitations

Regulatory Knowledge:

- → National and international UAS regulations
- → BVLOS-specific rules and requirements
- → Airspace classifications and restrictions
- → UAS registration and identification requirements

Knowledge in Risk Assessment and Management:

- → Understanding and applying risk assessment methodologies for UAS operations
- → Identifying potential hazards in mission scenarios
- → Evaluating risk mitigation strategies proposed by operators
- → Familiarity with risk assessment methodologies such as Specific Operations Risk Assessment (SORA)

Knowledge in Human Factors in UAS Operations:

- → The impact of human factors on UAS operations
- → Crew Resource Management in a UAS operations context
- → Fatigue management for UAS remote pilots
- → Decision-making processes in UAS remote piloting
- → Human-machine interfaces in UAS systems

UAS Flight Operations Practical Knowledge:

- → Flight planning for missions
- → Weather interpretation and its impact on UAS operations
- → Emergency procedures and contingency planning
- → UAS maintenance and pre-flight inspection requirements

Communication and Interpersonal Skills:

- → Clear and effective communication with UAS manufacturers, operators (e.g., operational crew, remote pilots, and management), and UAS pilot training organisations
- → Providing constructive feedback during assessments
- → Conflict resolution and problem-solving in a regulatory context
- → Writing detailed and accurate reports

Competencies for Airworthiness Assessment

Personnel assessing UAS airworthiness would need to possess an even deeper understanding of the technical systems and components that are critical to the safe operation of UA. They may need to be well-versed in a wide range of engineering disciplines, including structural design, propulsion systems, flight controls, avionics, and software systems. The ability to evaluate these complex and interconnected systems and their potential failure modes is essential.

It would also be important to be able to interpret test data, analyse performance metrics, and assess the compliance of UAS designs with relevant technical standards. Given the rapid pace of technological advancement in the UAS field, knowledge on the technologies would need to be continuously updated to be able to evolve the assessment techniques to new and emerging technologies. The expected technical knowledge and competencies for airworthiness assessment are as follows:

Structural Design and Materials:

- → Airframe structural analysis and load distribution
- → Material selection and fatigue characteristics
- → Structural testing methods and acceptance criteria

Propulsion Systems:

- → Engine/motor and control systems performance and efficiency
- → Propeller/rotor design and stress analysis

Flight Control Systems:

- → Control surface design and actuator mechanisms
- → Flight control laws and stability augmentation
- → Redundancy in critical control systems

Avionics and Navigation:

- → Sensor integration and data fusion techniques
- → Navigation system accuracy and reliability
- → Autopilot functionality and failure modes
- → Electrical wiring interconnect system principles

Communication Systems:

- → Datalink performance and reliability metrics
- → Frequency management and interference mitigation
- → Lost link procedures and failsafe mechanisms

Electrical Systems:

- → Power generation and distribution
- → Electrical system redundancy and backup power
- → Fuel/battery systems, safety, and energy management

Software Systems:

- → Software architecture and modularity
- → Real-time operating systems for UAS
- → Software testing and validation procedures

Environmental Qualification:

- → Temperature and altitude operating envelopes
- → Vibration and shock resistance
- → Ingress protection (IP) ratings for various components
- → Electromagnetic compatibility, electromagnetic interference, and testing

Detect and Avoid Systems:

- → Sensor technologies (e.g., radar, LiDAR, cameras)
- → Collision avoidance algorithms
- → Integration with air traffic management systems

Payload Integration:

- → Payload mounting and quick-release mechanisms
- → Centre of gravity calculations and limits
- → Electromagnetic interference between payload and UAS systems

Performance Testing:

- → Flight envelope determination
- → Endurance and range testing
- → Stability and control characteristics assessment

Competencies for UAS Remote Pilot Assessment

In general, personnel involved in developing the framework and requirements for UAS remote pilot assessment and qualification would be expected to have a comprehensive understanding of UAS operations, regulations, and technologies and be experienced and qualified UAS remote pilots themselves. Additional training or competencies may be required to carry out specific tasks in developing an assessment regime. Some of these tasks could include:

Developing Requirements for UAS Remote Pilot Theoretical Knowledge Assessment:

- → Developing comprehensive question banks covering all required subjects
- → Creating standardised exam formats with secure administration procedures
- → Establishing appropriate pass/fail criteria and retake policies

Developing Requirements for UAS Remote Pilot Practical Skill Assessment:

- → Creating detailed checklists for required manoeuvres and procedures
- → Identifying specific special operations rating skills (e.g., BVLOS ratings if applicable).
- → Developing scenarios to test specific special operations rating skills
- → Establishing performance metrics and clear pass/fail criteria

Developing Requirements for Human Factors:

- → Identifying decision-making and situational awareness skills and requirements for UAS operations

Data Management and Analysis:

- → Tracking and analysing pilot performance data

Standardisation and Quality Assurance:

- → Ensuring consistency in assessment across regions or organisations

Competencies for Organisational Assessment

Assessing UAS organisations may require a diverse set of skills that encompass an understanding of SMS principles and methods for evaluating procedural and regulatory compliance. It would also be more effective if safety inspectors were able to support organisations in adapting to regulatory requirements, recognising that UAS organisations may have their own unique constraints. The following lists the competencies that may support a safety inspector in assessing a UAS organisation and helping these organisations comply with regulatory requirements:

Basic SMS Knowledge:

- → Comprehensive understanding of SMS principles and their application to UAS operations
- → Ability to evaluate the effectiveness of an operator's safety policy and objectives
- → Competence in assessing safety risk management processes
- → Skills to evaluate safety assurance mechanisms and safety promotion activities

Competencies in Methods to Assess Organisational Structure:

- → Ability to evaluate the clarity of roles, responsibilities, and accountabilities within the operator's organisation
- → Competence in assessing the appointment and qualifications of key personnel (e.g., Accountable Executive, Safety Manager)
- → Skills to assess management commitment to safety

Competencies in Process and Procedure Evaluation:

- → Ability to review and assess the adequacy of operational procedures, including normal, abnormal, and emergency procedures
- → Skills to evaluate the robustness of change management processes
- → Competence in assessing training programmes and records

Competencies for Organisational Assessment (cont.)

Competencies in Documentation Review:

- → Proficiency in reviewing operations manuals, safety management manuals, and other relevant documentation
- → Ability to verify the completeness and adequacy of record-keeping systems
- → Skills to assess emergency response plans

Competencies in Safety Culture Assessment:

- → Ability to evaluate operator safety culture and commitment to continuous improvement
- → Skills to assess the effectiveness of safety communication within the organisation

Competencies in Assessing Means of Compliance Verification:

- → Knowledge of local and international regulations applicable to UAS operations
- → Ability to verify compliance with applicable requirements and identify gaps
- → Understanding of how operators demonstrate compliance with regulations

Competencies in Audit and Inspection:

- → Competence in conducting thorough audits and inspections of UAS operations
- → Ability to identify systemic issues and root causes of non-conformities

Competencies to Assess Environmental Factors

Competencies in assessing factors of the operating environment influencing operational safety would assist in ensuring that operational risks are adequately identified and mitigated. The list below covers some competencies in the following areas:

- → Airspace
- → Ground and Infrastructure
- → Electromagnetic Environment Affecting Communications
- → Atmospheric Factors

Airspace

- → Airspace Classification Analysis:
  - › Thorough understanding of different airspace classes and their implications for UAS operations
  - › Skills to assess compliance with specific regulations for each airspace class
- → Air Traffic Management Integration:
  - › Ability to assess the adequacy of communication and surveillance equipment for airspace integration
  - › Skills to review conflict detection and resolution strategies in shared airspace
- → Separation and Deconfliction Evaluation:
  - › Skills to assess proposed separation standards for UAS operations
  - › Ability to evaluate deconfliction procedures with manned aircraft and other UAS
- → Emergency Procedures and Contingency Planning:
  - › Competence in reviewing emergency procedures for airspace-related incidents
  - › Ability to assess contingency plans for loss of separation incidents or communication failures
- → UTM System Assessment:
  - › Understanding of UTM concepts and technologies
  - › Ability to evaluate the integration of UAS operations with existing and planned UTM systems
  - › Skills to assess the adequacy of data exchange and interoperability with air traffic management systems

Competencies to Assess Environmental Factors (cont.)

→ **Airspace Design and Procedure Development:**
- Knowledge of airspace design principles and their application to UAS operations
- Ability to evaluate proposed changes to airspace structure or procedures to accommodate special operations (e.g., BVLOS UAS operations)
- Competence in assessing the impact of new UAS corridors or zones on existing airspace users

Ground and Infrastructure

→ **Environmental Impact Analysis:**
- Competence in reviewing environmental impact assessments and mitigation strategies
- Ability to identify potential navigation and sensor challenges in different landscapes

→ **Critical Infrastructure Assessment:**
- Knowledge of various types of critical infrastructure and their vulnerabilities
- Skills to assess UAS capabilities in detecting and avoiding infrastructure-related obstacles
- Competence in reviewing procedures for updating navigation data and communicating temporary obstacles
- Ability to evaluate procedures and risk mitigations for close-proximity flights

→ **Emergency Response Evaluation:**
- Ability to assess the suitability of emergency landing sites in various environments
- Skills to evaluate emergency response plans in the context of specific operating environments
- Competence in reviewing coordination plans with local emergency services

Electromagnetic Environment Affecting Communications

→ **Electromagnetic Environment Expertise:**
- Proficiency in identifying potential interference sources in various operating areas
- Ability to assess C2 link frequency bands and their susceptibility to interference
- Skills to evaluate signal quality monitoring and management plans
- Comprehensive understanding of radio propagation principles

→ **Multi-layer Redundancy Assessment:**
- Competence in analysing various C2 link technologies and their redundancies
- Ability to assess transition procedures between different link types
- Skills to evaluate geographical coverage and reliability of communication systems

→ **Testing and Verification Competence:**
- Ability to determine the necessity and scope of on-site testing and signal surveys
- Skills to evaluate proposed signal strength testing methodologies
- Competence in assessing the integration of test results into operational plans
- Ability to analyse and interpret C2 link performance data

Atmospheric Factors

→ **Weather and Seasonal Variation Analysis:**
- Competence in assessing the impact of weather patterns on operational frequency and reliability
- Proficiency in understanding manufacturer-defined weather-related limitations for UAS
- Skills to assess the safety margins built into operational weather limits
- Skills to assess the appropriateness of weather-related decision-making processes
- Ability to identify potential microclimates within operating areas
- Skills to review contingency plans for adverse weather scenarios

PART 08 ANNEX B

TRAINING COURSE EVALUATION TEMPLATE

Training Evaluation Form		
Date of evaluation:		
Evaluated by (Name of CAA):		
Type of evaluation:	☐ Recommendation	☐ Non-recommendation
Course title:	**Course date(s):**	
Training provider:	**Instructor (if relevant to the quality of course):**	
Training provider contact/website address:	**Training location:**	
Course synopsis:		
Competencies addressed:		
Reason for recommendation/non-recommendation:		

Version 1.0