Asia-Pacific Reference Materials to facilitate Advanced Air Mobility Operations

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FOREWORD

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ACKNOWLEDGEMENTS

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CONTENTS

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
AML	Aircraft Maintenance Licence
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
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
DGPS	Differential GPS
DO	Design Organisation
DOA	Design Organisation Approvals
EAR	Easy Access Rules for small category VCA
EASA	European Union Aviation Safety Agency
EMC	Electromagnetic Compatibility
EMI	Electromagnetic Interference
EIS	Entry Into Service
EPTS	Environmental Protection Technical Specifications
ERP	Emergency Response Plan

ACRONYM	MEANING
EUROCAE	European Organisation for Civil Aviation Equipment
EV	Electric Vehicle
EWIS	Electrical Wiring Interconnect System
eVTOL	Electrical Vertical Take-off and Landing
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 Rule
INS	Inertial Navigation System
IoT	Internet of Things
ISO	International Organization for Standardization
ITU	International Telecommunications Union
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 Organization
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

ACRONYM	MEANING
RTCA	Radio Technical Commission for Aeronautics
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	Touch 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

EXECUTIVE SUMMARY

The development of the **Asia-Pacific Reference Materials 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) as a descriptive and non-legally binding resource which regulators can consider, adapt, and use to prepare for and facilitate commercial operations of electric vertical take-off and landing (eVTOL) aircraft and UAS operations, in their respective States.

Through the collaboration of representatives of 24 States and Administrations, this publication was developed to guide States of Registry, States of the Operator, and States of the Aerodrome on the following eight topics which were identified as priorities to address for eVTOL aircraft and UAS:

eVTOL Aircraft

1. Certification, Validation, and Acceptance of eVTOL Aircraft
2. Regulations for eVTOL Aircraft Entry into Service
3. Cooperation among National Agencies
4. Economic Policies and Regulations
5. Capability Development
6. Social Acceptance

UAS

7. Technical Guidance for the implementation of BVLOS UAS Operations
8. Capability Building (UAS Personnel Training)

Each of these topics are addressed as individual parts in this publication, and each part consists of five sections: (1) Introduction, providing a brief introduction for the content of the part; (2) Background, that sets the context of the topic with historical precedence or existing practices; (3) Key Considerations that are related to the topic which have been compiled through literature reviews, surveys, workshops, or brainstorming; (4) Action Plan, where the aim is to provide guidance to regulators on steps that may be taken in addressing and being prepared in the respective topic; and (5) References used in the development of the content. Where applicable, each part may be supported by annexes to guide the implementation of the part.

Overall, this is a publication that States may consider, adapt, and use to facilitate the commercial operations of eVTOL aircraft and 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 transportation 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 would need to keep pace to fully reap the benefits of AAM while ensuring public and aviation safety and security. This would be challenging given the speed of development, especially considering the technological novelties and competing priorities from conventional aviation. Collaboration amongst regulators and between regulators and industry is necessary to help overcome these challenges. By pooling expertise and resources, regulators would be able to 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 Unmanned Aircraft Systems (UAS) on November 9, 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 electric vertical take-off and landing (eVTOL) aircraft and complex UAS operations. This development is aligned with the objectives of the ICAO AAM Study Group (AAM SG), given that these reference materials address the key intent of facilitating both eVTOL aircraft and UAS.

On eVTOL aircraft, the scope of this publication focuses primarily on piloted eVTOL aircraft with brief mentions of remotely piloted eVTOL aircraft as a topic for future work. On UAS, the material focuses on Beyond Visual Line of Sight (BVLOS) operations as a start, and other types of complex UAS operations may be covered in the future. This publication is not aimed at being a legally binding document, nor to prescribe requirements and standards for the members of the APAC Regulators' Meeting. Instead, the publication aims to achieve the following:

- Raise awareness of eVTOL aircraft and UAS technologies and regulatory approaches and practices.
- Highlight considerations that need to be assessed when facilitating eVTOL aircraft and complex UAS operations and serve as a reference guide for States to better prepare and build up their capability.

The workstreams were assigned to prepare the contents of this publication through literature review, surveys, workshops, and collective brainstorming and involved representatives from 24 States and Administrations as shown in **Table 1**.

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

Table 1 – Workstreams Members

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

The material is organised into 8 parts, and each part contains an introduction, background, key considerations, and action plan section. A brief outline of the respective parts in these materials is as follows:

eVTOL Aircraft

- **Part 1 – Certification, Validation, and Acceptance:** Technological advancements have allowed the design and manufacturing of new eVTOL aircraft that promise greater efficiency, lower operating and maintenance costs, lower noise, and greater flexibility to operate in confined spaces. Certification of these eVTOL aircraft using existing certification requirements and standards for conventional manned aircraft is challenging due to the novelty of technology and design. Some States of Design (SoDs) have received applications for aircraft type certification, and some have already certified the first few eVTOL aircraft types, but the regulatory frameworks and requirements for aircraft design and manufacturing assurance are different amongst the SoDs. Information on the approach, rationale, and considerations of the SoDs in categorising and certifying an eVTOL aircraft is provided in Part 1 as context for States of Registry (SoR) and States of the Operator (SoO) to consider in their respective means to certify, validate, or accept such aircraft types when the need arises. The action plan in this Part describes the actions expected of a SoR to prepare for eVTOL aircraft, such as establishing clear definitions and classifications of eVTOL aircraft types and airworthiness design standards.
- **Part 2 – Regulations for eVTOL Aircraft Entry into Service (EIS):** Enabling full-scale, safe, efficient, and reliable eVTOL aircraft operations would depend on a holistic but pragmatic regulatory framework and implementation for the EIS of such aircraft and operations. However, existing manned aviation regulations for the typical scope of EIS, such as aircraft registration, air operator certification, and licensing of technical crew (pilots and aircraft maintenance engineers and technicians), have yet to specifically address eVTOL aircraft and operations. In key considerations, this Part reviews each component of EIS, articulating differences and associated gaps of current regulations that do not address the novelty of eVTOL aircraft. This Part's action plan presents processes for CAAs wanting to either create new dedicated regulations to govern eVTOL aircraft EIS and/or to adapt their existing manned aircraft regulations to accommodate specific eVTOL aircraft operations.
- **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 between 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 needed related to eVTOL aircraft and operations, this Part identifies examples of activities involving multiple agencies (i.e., regulating technology safety and development, regulating operational safety, economic policy and governance, and social acceptance), types of national agencies that may be involved, and the possible roles of these agencies in the activities. The action plan in this Part aims to guide CAAs with a process to define their respective scope of activities, stakeholders, and the roles of stakeholders.

- **Part 4 – Economic Policies and Regulations:** Economic policies and regulations are key tools to address market growth, 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 in commercial businesses. eVTOL aircraft commercial operations are still nascent, where economic policy instruments exercised to date are on investments (i.e., test centres and sandboxes) and incentives. Nevertheless, approaches undertaken in existing international air transportation are presented in this Part with a section dedicated to describing considerations related to key topics of market access, consumer protection, and competition. The action plan outlines a process flow that would support the creation of transport strategies, identifying appropriate economic policy instruments, developing and executing, and reviewing the effectiveness of the implementation.

- **Part 5 – Capability Development:** The CAAs of SoRs and SoOs will likely need to further enhance or build their organisation's capabilities to develop policies and regulations, and train personnel for the safety oversight of eVTOL aircraft. This Part details considerations when developing capabilities related to personnel, organisation, and procedures of the CAA. Possible steps and processes are also described in this Part to support SoRs and SoOs in developing an action plan to develop the organisational and personnel capabilities of their CAA.

- **Part 6 – Social Acceptance:** Social acceptance will be a key condition to enable commercial eVTOL aircraft operations to scale and be 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 ensuring social acceptance through a range of initiatives that are 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 used extensively in operations that have a low risk to the public and aviation safety. Although UAS can be used in more complex operations, the risks of such operations are greater and typically involve beyond visual line of sight (BVLOS) UAS operations. This Part reviews the literature on methodologies for managing BVLOS UAS operational approvals and considerations for the evaluation of risk and risk mitigations as part of the approval process, segregated into the areas of airworthiness, crew, organisations, and environment. The action plan describes a process flow which CAAs could consider when adapting existing UAS regulations to regulate BVLOS UAS operations.

- **Part 8 – Capability Building (UAS Personnel Training):** This Part provides guidance on the preparation and training of CAA inspectors involved in evaluating BVLOS UAS operations by describing potential differences between UAS and existing manned aviation that may generate a gap in personnel competencies. The action plan suggests steps that can be taken to address capability building and includes a list of typically expected competencies of UAS safety inspectors. Finally, recording and sharing evaluations of training courses is presented as a useful practice and suggested action related to capability building, including a suggested means to record such evaluations.

The action plans in each part can be considered individually or pursued in parallel.; However, it is recommended that CAAs consider the actions of Part 1 prior to Part 2, as clear design definitions and airworthiness requirements can impact the scope of areas that would need to be adapted for EIS. The actions of Part 3 can be used to support the actions needed in all the other parts, especially when interagency cooperation is expected or required to achieve the necessary outcome.

Ultimately, this publication should be treated as a reference for CAAs and as a guide to their respective efforts in preparing and evolving existing regulations to facilitate commercial eVTOL aircraft and complex UAS operations. The contents of this publication have been developed through the best efforts of the respective States involved and comments from the industry but may have missed out on some considerations or have content that may become invalidated by further eVTOL aircraft or UAS developments. For this reason, it is foreseen that this publication will be updated periodically where possible to keep abreast of the developments, especially in areas such as type certification where an international consensus on standards has yet to be reached. The eVTOL aircraft market is also still an emergent market where technologies and operational requirements are dynamically evolving, and it is envisioned that this publication will help capture these developments to continue fulfilling its aims in supporting States in their regulatory development, raise awareness in eVTOL aircraft technology and regulatory approaches and practices, and facilitate alignment amongst member States. Likewise, for UAS, as States gain experience in approving an increasing frequency of BVLOS UAS operations, new insights and learnings could be further incorporated into this publication along with other more complex UAS operations.

eVTOL aircraft

PART 1

Certification, Validation, and Acceptance

I. INTRODUCTION

For every aircraft engaged in international civil aviation, Article 31 of the ICAO Convention prescribes that the aircraft must have a Certificate of Airworthiness (CoA) issued or rendered valid by the State in which it is registered, and ICAO Annex 8 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). An aircraft type certificate has become the de facto evidence for this purpose while also generally providing an assurance that the design of the aircraft meets stringent safety and performance standards. Some States may also issue type certificates for engines and propellers, and noise certification standards are recommended in ICAO Annex 16 (ICAO, 2017).

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, eVTOL aircraft are expected to leverage new technologies, new aircraft designs, and operations in urban environments that are different from existing mainstream air transportation, and the existing regime for type certification and the standards used in the process will need to evolve to certify these novel features. In view of the emergent nature of eVTOL aircraft, this Part is primarily aimed at providing SoRs an awareness of the developments in eVTOL aircraft type certification and potentially unique considerations for the issuance, acceptance, or validation of type certificates. 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.

II. BACKGROUND

Type certification

In civil aviation, a type certificate 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 type certificates, it has been a formal requirement in ICAO Annex 8 that a SoD issues an aircraft type certificate (TC) as evidence of approval for applications of any new aircraft certification on or after 2 March 2004. In this regard, the TC is a 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), has been subjected to required analysis, ground and flight tests, and has no known or suspected unsafe aircraft characteristics against the standard that it has shown compliance with. The key elements involved in the process leading up to the issuance of a type certificate are thus as follows:

- Identification and establishment of the type certification basis, where the 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 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 airworthiness standards.
- Approval issuance, which is done after all the necessary steps have been taken to demonstrate the compliance of the aircraft design to the airworthiness standards.

Depending on their respective legislative framework, a SoR may accept or validate the original type certificate or issue its own TC based on the original. ICAO recommends that maximum credit should be given to the type certification work already done by the SoD and to avoid unnecessary duplication or redundant testing where practical and without prejudice to a State's own unique national requirements. The overarching aim is to work towards reducing the amount of work needed to accomplish the approval of an aircraft type design and therefore the issuance of a CoA under Annex 8 by the SoR. Issuance, acceptance, or validation of type certifications 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 gave rise to International Standards and Recommended Practices (SARPs) 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 requirements that are at least equal to the standards specified in Annex 16. As of the latest edition of ICAO Annex 16 (8th Edition), SARPs are detailed for subsonic jet aeroplanes, propeller-driven aeroplanes, propeller-driven short take-off and landing (STOL) aeroplanes, helicopters, and supersonic aeroplanes. ICAO Annex 16 also addresses tilt-rotor aircraft by providing guidelines for noise evaluation and certification, but the SARPs 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 would otherwise be a significant setback for the industry. Novel technologies such as electric and distributed propulsion, automated and digitalized systems, and electric and hydrogen battery technology are expected to be introduced in eVTOL aircraft, and the certification process and associated airworthiness standards need to be updated to address new potential hazards introduced by these technologies.

At the ICAO level, there is considerable ongoing effort to study and develop guidance for Advanced Air Mobility (AAM), but SARPs specific to aircraft type certification of eVTOL aircraft have yet to be developed. Guidance material for aircraft with tilt-rotors exists as Doc 10103 (ICAO, 2019), but the material was developed in the past to address gas turbine powered tilt-rotor aircraft.

In the absence of any specific ICAO SARPs, 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 performance, hazards, and the means of design risk mitigation of eVTOL aircraft and proposed airworthiness standards (e.g., airworthiness criteria, special conditions, etc.), mostly on a case-by-case basis according to each aircraft type certification project initiated within their respective State. 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 some of the Civil Aviation Authorities / Agencies that have issued type certificates where considerable progress has been made in the development of the required standards for the type certification of eVTOL aircraft. An overview of their developments is further described in **Annexes A to C**, respectively.

III. KEY CONSIDERATIONS

With individual SoDs devising and implementing different approaches to tackle the aircraft type certification of emergent 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 to appreciate the key aspects of eVTOL aircraft and operations as they develop their regulations, this section aims to provide an awareness of the more commonly and internationally accepted views of 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, from the carriage of passengers and other payloads (e.g., cargo or other mission equipment) in urban areas (Urban Air Mobility) to transportation between cities and across regions (Regional Air Mobility). The characteristics of these missions drive the design requirements for eVTOL aircraft and hence aircraft type certification requirements. The potential types of eVTOL aircraft missions and their key characteristics are as follows:

- **Urban Air Mobility (UAM):** Urban Air Mobility (UAM) involves short-range air transportation within or into and out of cities and metropolitan areas. UAM is aimed at being a more time-efficient alternative to ground-based transportation in urban areas, with the main use cases being in passenger or cargo transportation. In passenger transportation, UAM may serve, for example, VIP transportation, tourism, 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 transportation, with the pilot compartment remaining intact, the rest of the cabin space could be changed out to allow the carriage of more cargo, allowing it to serve as an alternative to traditional delivery truck services, medical supply transport, or the delivery of supplies to areas difficult to reach due to limited or damaged ground transportation infrastructure.
    - **Payload and Range:** UAM is expected to involve the movement of passengers or its equivalent weight in cargo or other mission equipment ranging from 1 to 6 passengers across cities or metropolitan areas. The range is dependent on the size of the city but is expected to be typically less than 100 km.
    - **Airspace:** UAM flights over metropolitan and urban areas will be within low-level airspace and are envisioned to fly within a few hundred meters above cities. Initial eVTOL aircraft UAM operations are expected to follow Visual Flight Rules and subsequently be expanded to Instrument Flight Rule operations. Airspace structures for eVTOL aircraft and associated application of rules of the air are still being studied, and the emerging concepts range from integrating eVTOL aircraft into existing airspace system, flying eVTOL aircraft along prescribed airspace flight routes, or allocating low-altitude airspace or segments of airspace exclusive to eVTOL aircraft.
    - **Infrastructure:** UAM operations may involve dedicated vertiports, rooftop hubs, or

    take-off and landing sites at logistics distribution centres within cities. The infrastructure would ideally facilitate quick turnarounds (e.g., passenger embarkation/disembarkation, cargo loading/unloading, recharging, and through-flight maintenance) to enable frequent and efficient transport in high-demand areas. Operating at low levels and within the urban environment may necessitate additional ground infrastructure to support eVTOL aircraft recharging, communications, navigation, and surveillance functions.

    - **Noise and Aircraft Emission Management:** The management of noise and emissions will be a critical requirement for UAM if operations are conducted close to or over residential and commercial areas. UAM operations in such environments will therefore likely have stringent noise and environmental protection requirements.

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

    - **Payload and Range:** eVTOL aircraft may possibly be used for RAM, and if so, will likely initially have the same number of passengers and equivalent weight in cargo or mission equipment as UAM. These eVTOL aircraft will be optimised for longer flight ranges and could involve covering distances of 400 kilometres or more.

    - **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 have been designed to cruise at altitudes up to 4000 feet altitude. Like UAM, RAM operations are expected to initially follow Visual Flight Rules and ultimately allow Instrument Flight Rule operations. RAM flights will more likely need to integrate into existing airspace and airspace management systems more than UAM due to its operating areas and altitudes.

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

    - **Noise and Aircraft Emission Management:** If required to operate close to or over residential and commercial areas (i.e., for city-to-city operations), RAM will also need to consider the potential requirements of noise and aircraft emissions management as described for UAM.

eVTOL aircraft classification

The classification of aircraft is an essential part of 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 aids in determining requirements for other areas such as crew, maintenance, and infrastructure.

VTOL-capable aircraft do not have their own classification under the ICAO SARPs, which classifies heavier-than-air power-driven aircraft as either aeroplanes, rotorcrafts, or ornithopters under ICAO Annex 7 (ICAO, 2012). A powered-lift aircraft classification, although not identified in Annex 7, is also defined in ICAO Annex 1 (ICAO, 2022). Several different eVTOL aircraft design configurations have emerged to address how vertical and forward flight is achieved. As shown in **Table 1**, these designs 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 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 depends principally on engine-driven lift devices or engine thrust for lift during these flight regimes and on non-rotating aerofoil(s) 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 – Example 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 certification basis for the aircraft. Existing standards for conventional aircraft typically cover requirements for flight (e.g., performance, stability and control, and miscellaneous flight requirements), structure, design and construction, powerplant, system & equipment, operating limitations, and supplementary information. The existing requirements categories are relevant to eVTOL aircraft, although the details of requirements would be modified where needed to suit the novel design architectures and technologies of eVTOL aircraft. Considerations for general design requirements of eVTOL aircraft (manned eVTOL aircraft) are detailed in **Annex D1,** and additional considerations for remotely piloted eVTOL aircraft are in **Annex D2**.

A key principle in the development of design standards is to have a safety-first approach while offering flexibility in design and operations to allow manufacturers to innovate while still adhering to an acceptable level of safety. The goal is to ensure that eVTOL aircraft can operate safely in complex and congested airspaces and urban areas and to continuously refine and evolve the standards as the technologies for eVTOL aircraft mature or new technologies are introduced.

It will be equally important to strengthen the sharing of information on eVTOL aircraft developments among States. Sharing the considerations and implementations of 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 and will continue to refine the standards to address the unique challenges posed by eVTOL aircraft to ensure safety and reliability while encouraging technological advancement.

EASA has introduced the Special Condition for small category VTOL aircraft (SC-VTOL), which sets out 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 through the draft FAA Advisory Circular (AC) No. 21.17-4. The AC is complemented by FAA policy statements (PS) 21.17-01 “Safety Continuum for Powered-lift” and PS 21.17-02 “Special Class Rotorcraft”. In this approach, the FAA had developed a set of airworthiness criteria as contained in draft AC No. 21.17-04 through the incorporation of existing regulatory parts, such as 14 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. In addition, should the FAA find that compliance with airworthiness criteria as outlined in AC No. 21.17-04 is inadequate or inappropriate as a certification basis of a powered-lift aircraft, the FAA may require the applicant to comply with alternate or additional criteria.

Industry standards can also play a role in detailing requirements for essential systems and best practices that would facilitate eVTOL aircraft in meeting design safety and performance expectations as Means of Compliance (MoCs). There are significant standards development activities ongoing for eVTOL aircraft in general. 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. EUROCAE (European Organisation for Civil Aviation Equipment) provides guidance on battery development and thermal runaway and the integration of advanced avionics, communication, and navigation systems.

IV. 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 should be given 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 own unique national requirements.

While not mandatory, some SoRs might choose to enter into bilateral agreements and cooperation with the SoD to facilitate the validation or acceptance of the type certificate. SoRs that are also SoDs which issue type certificates may also consider conducting concurrent type certification (or concurrent validation) with the SoD of the eVTOL aircraft to get involved and become familiar with the aircraft as early as possible, thus accelerating the type design approval process and potentially 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 means of compliance. The information below may be used as references for a SoR to develop their definitions:

- **Definition and classification of eVTOL aircraft types:** See Section II of this part for considerations.
- **Airworthiness design standards for eVTOL aircraft:** See Section II of this part and **Annex 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 safety risk and target, operational safety risk 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 eVTOL aircraft operations performing commercial passenger activities over urban areas, including the need to ensure the aircraft is capable of continued controlled flight to and landing at a vertiport, should be held to a higher safety target as compared to lower-risk activities such as eVTOL aircraft operations for personal operations or performing cargo delivery activities over rural areas.

V. REFERENCES

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ICAO (2012), Annex 7 to the Convention on International Civil Aviation – Aircraft Nationality and Registration Marks, 6th Edition, July 2012.

ICAO (2017), Annex 16 – Environmental Protection – Volume I – Aircraft Noise, 8th Edition, July 2017.

ICAO (2019), Doc 10103, Guidance on the Implementation of ICAO Standards and Recommended Practices for Tilt-rotors, First Edition, 2019

ICAO (2020), Doc 9760, Airworthiness Manual, 4th Edition, 2020.

ICAO (2022), Annex 1 – Personnel Licensing, 14th Edition, July 2022.

ANNEX A TO PART 1

Civil Aviation Administration of China (CAAC) eVTOL Aircraft Type Certification Policy and Practice

I. CAAC EVTOL AIRCRAFT TYPE CERTIFICATION POLICY AND PRACTICE

The Civil Aviation Administration of China (CAAC) has received applications for and has already issued type certificates for both manned and unmanned eVTOL aircraft. For the CAAC, eVTOL aircraft are considered a configuration of a VTOL aircraft that takes off and lands vertically using electric power as propulsion, as illustrated in **Figure A-1**.

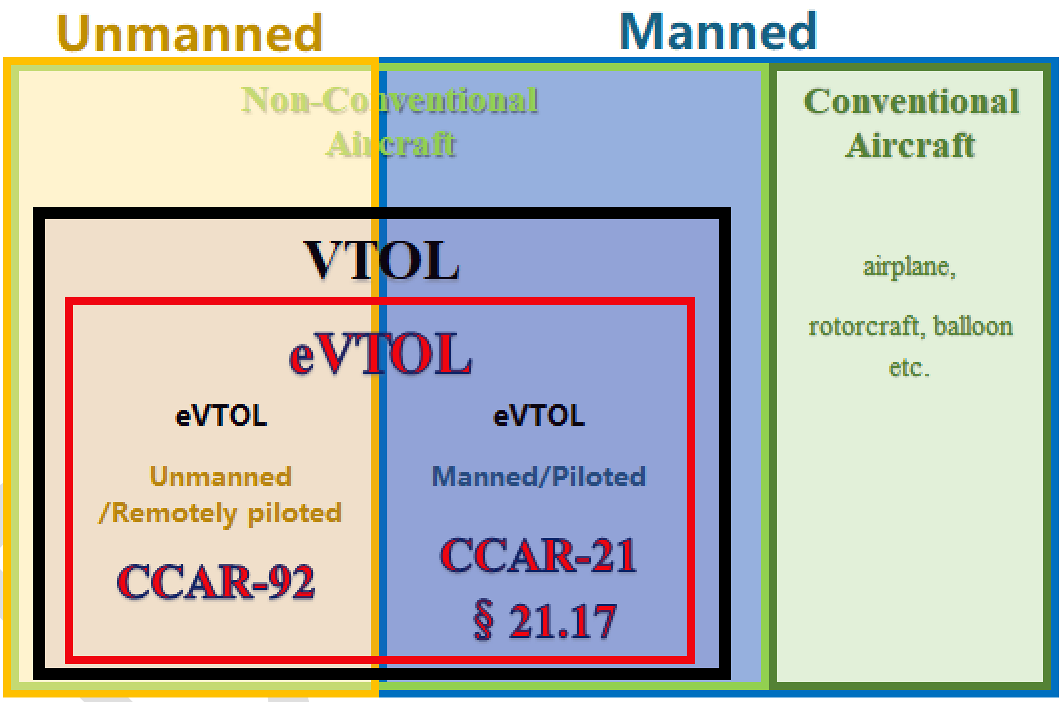

Figure A-1: eVTOL aircraft in CAAC's context

Under the CAAC, different requirements are applied for the type certification of manned and unmanned eVTOL aircraft. Manned versions of 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, such as 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 Regulation (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 since conducted a public consultation on the Special Condition for Aerofugia's E200-100 eVTOL aircraft for its type certification. Additionally, Autoflight Company's V2000EM manned eVTOL aircraft and Volant Company's VE25-100 manned eVTOL aircraft have both begun their airworthiness certification and are in the process of determining Special Conditions for public consultation for their respective aircraft.

The type certification of unmanned eVTOL aircraft is governed by CCAR-92, Safety Management Rules for the Operation of Civil Unmanned Aircraft. In accordance with CCAR-92, such eVTOL aircraft are considered large-class or medium-class unmanned aircraft and must apply for airworthiness certification. Like the process for manned eVTOL aircraft certification, 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 unmanned aircraft providing a common acceptable airworthiness standard for certification.

To date, the CAAC has issued Special Conditions and Type Certificates (TC) for one large-class eVTOL unmanned aircraft as follows:

- EH216-S remotely piloted multirotor aircraft system with people onboard (eVTOL aircraft)
    - Special Condition 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 13th October 13, 2023.

II. 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, 09 Feb 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, 12 Nov 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, 05 Feb 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, 23 Jul. 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, 21 Dec 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.

ANNEX B TO PART 1

European Union Aviation Safety Agency (EASA) eVTOL Aircraft Type Certification Policy and Practice

I. 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 more generic class of VTOL-capable aircraft (VCA) as illustrated in **Figure B-1**. EASA's approach for the type certification of VCA has been to develop and apply a complete set of dedicated technical specifications for the certification of such aircraft through Special Conditions and its associated Means of Compliance (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 the participation of Transport Canada and the Agencia Nacional de Aviacao Civil (ANAC) of Brazil. For easier 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 MoCs (MOC-4 SC-VTOL) that has yet to be 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.

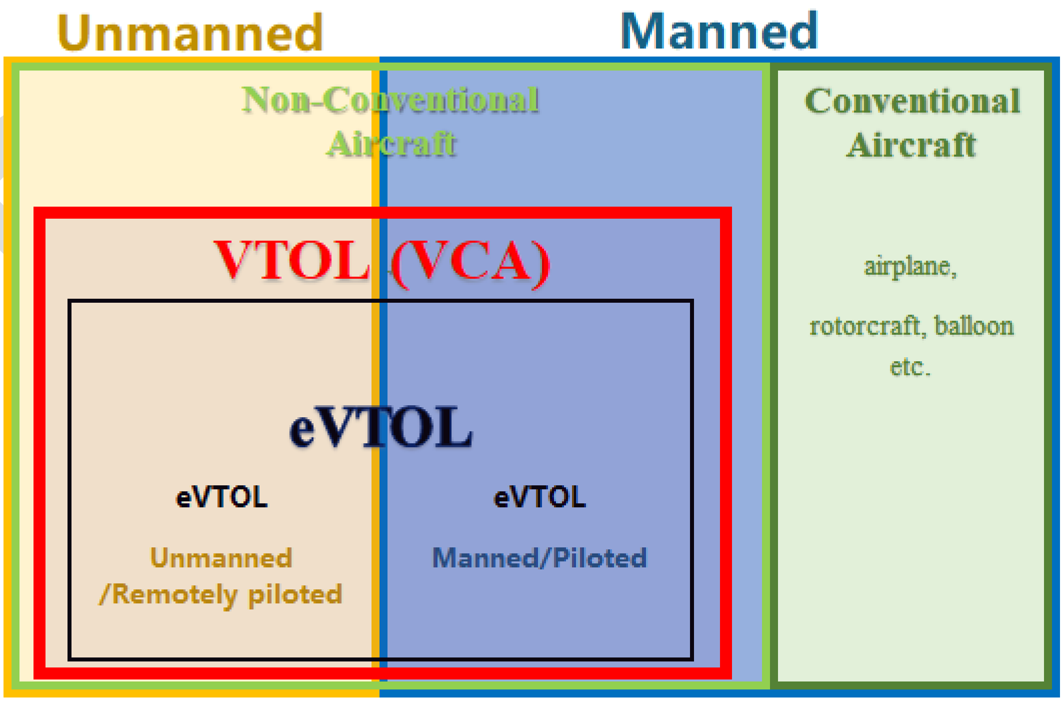

Figure B-1: VTOL capable aircraft and eVTOL aircraft in EASA's context

The SC-VTOL applies to aircraft with a passenger seating configuration of 9 or less 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 limit of less than or equal to 250 knots.

Under SC-VTOL, VCAs are certified in 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 meet all applicable requirements of SC-VTOL. 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 the safety objectives depending on the number of occupants and would apply for all operations that are not 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. The requirements for electric propulsion (or hybrid-electric propulsion) are mandated through Special Condition SC E-19, issued in September 2007. Environmental considerations for noise are covered by Environmental Protection Technical Specifications (EPTS) and an EPTS has been published in December 2023 for VTOLs with non-tilting rotors. Product Environmental Footprint Category Rules (PEFCRs) to assess the environmental performance (i.e., emissions impact) of a particular aircraft are in development for eVTOL aircraft.

II. RELEVANT EASA AIRWORTHINESS STANDARDS FOR EVTOL AIRCRAFT

- EASA, Easy Access Rules for small category VCA (SC-VTOL + MOC) (Revision 0), October 2024.

- EASA, Environmental Protection Technical Specifications (Noise) applicable to VTOL-capable aircraft powered by non-tilting rotors (Final), Issue 1, 12 Dec 2023.

- EASA, Fourth Publication of Proposed Means of Compliance with the Special Condition VTOL, Issue 1, MOC-4 SC-VTOL, 18 Dec 2023.

- EASA, Special Condition: Electric/Hybrid Propulsion System (Final), SC E-19, Issue 1, 04 July 2021.

III. ANNEX REFERENCES

EASA (2024), Special Conditions for VTOL-capable aircraft, Issue 2, SC-VTOL-02, June 2024.

Tauszig, L (2024), Special Condition VTOL: Airworthiness Requirements as a first building block for VTOL Safety, 50th European Rotorcraft Forum, 10-12 September 2024, Marseille, France.

ANNEX C TO PART 1

US Federal Aviation Administration (FAA) eVTOL Aircraft Type Certification Policy and Practice

I. FAA EVTOL AIRCRAFT TYPE CERTIFICATION POLICY AND PRACTICE

The U.S. Federal Aviation Administration (FAA) has received applications for the type certification of eVTOL aircraft with typically six or fewer passengers and a maximum take-off weight of 12,500 lbs or less that are designed as a "powered-lift" special class of aircraft (see Section II of this Annex for details of the powered-lift class of aircraft). The FAA's procedures for type certification and airworthiness certification are stipulated in 14 CFR Part 21, but such eVTOL aircraft, while requiring a standard airworthiness certificate, had no airworthiness standards established as a separate part under the FAA regulations and were therefore considered a special class of 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). Per §21.17(b), airworthiness criteria for these projects were developed as a combination of applicable requirements from other parts such as Parts 23, 25, 27, 29, 31, 33, and additional airworthiness criteria stipulated by the FAA to provide an equivalent level of safety to existing standards. There are to date two final airworthiness criteria issued for eVTOL aircraft (see Section IV of this Annex).

The experiences with recent eVTOL aircraft type certification projects have led the FAA to develop and publish an Advisory Circular (AC) for the type certification of powered-lift aircraft (Draft AC 21.17-4) to provide a more efficient path for the type certification of certain powered-lift aircraft. The AC provides guidance for the aircraft type, production, and airworthiness certification of powered-lift aircraft and details an acceptable means of showing compliance with §21.17(b). 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 and the installed electric engines and propellers.

The procedures in the AC will apply to all powered-lift aircraft certificated as special class under § 21.17(b). The airworthiness criteria of the AC apply to 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 with a pilot on board.

II. 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 that depends 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 as a rotorcraft for 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.

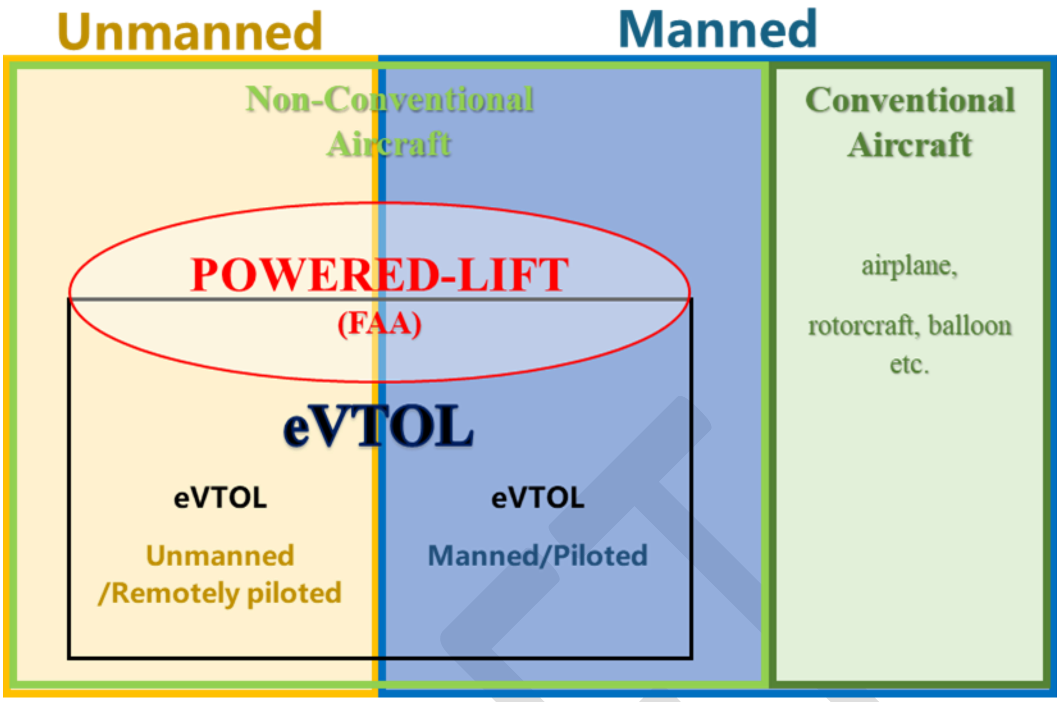

Figure C-1: Powered-lift class of aircraft

III. 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. Lacking dedicated certification standards, the policy introduces a structured, risk-based approach to safety and operational challenges. It sets airworthiness standards, 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, and an example of safety requirements of probabilities for failures of catastrophic severity are shown in **Table C-1 and Table C-2**.

Max Passengers & Weight	Commercial (For Hire)	Private (Non-Commercial)	Catastrophic Failure Probability
0-1 passengers & ≤12,500 lbs	1A	1B	Not explicitly defined
2-6 passengers & ≤12,500 lbs	2A	2B	10^{-7} to 10^{-6} per flight hour
7-9 passengers &≤12,500 lbs	3A	3B	10^{-8} to 10^{-7} per flight hour
10-19 passengers or >12,500 lbs	4A	4B	10^{-9} to 10^{-8} per flight hour

Table C-1: Powered-lift Certification Levels and Safety Requirements

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

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 and the framework incorporates:

- System safety analysis based on SAE ARP4754B and ARP4761A
- Defined probability limits for different failure conditions
- Performance standards for hover stability, thrust failures, and take-off/landing reliability

IV. RELEVANT FAA AIRWORTHINESS STANDARDS FOR EVTOL AIRCRAFT

- FAA, Advisory Circular – Subject: Type Certification – Powered-lift, 21.17-4, Draft.
- FAA, Airworthiness Criteria: Special Class Airworthiness Criteria for the Joby Aero, Inc. Model JAS4-1 Powered-lift, effective April 8, 2024.
- FAA, Airworthiness Criteria: Special Class Airworthiness Criteria for the Archer Aviation, Inc. Model M001 Powered-Lift, effective June 24, 2024.
- FAA, Policy Statement - Safety Continuum for Powered-lift, PS-AIR-21.17-01, Draft, 2024
- FAA, Policy Statement – Special Class Rotorcraft, PS 21.17.02, Draft 2024.

V. ANNEX REFERENCES

FAA (2024), Advisory Circular – Subject: Type Certification – Powered-lift, 21.17-4, Draft, 2024.

FAA (2024a), Policy Statement – Safety Continuum for Powered-lift, PS-AIR-21.17-01, Draft, 2024.

ANNEX D1 TO PART 1

Manned eVTOL aircraft design requirements

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

I. GENERAL DESIGN REQUIREMENTS FOR EVTOL AIRCRAFT (EXAMPLES FROM SODS)

Aircraft and Equipment

Like manned aircraft certification standards, the special conditions for aircraft such as eVTOL aircraft have requirements stipulated in common subparts such as Flight, Structures, Design and Construction, and Equipment. The topic headers under these subparts are shown in **Tables D1-1 to D1-4**.

FLIGHT	
EASA (SC-VTOL-02)	**FAA (AC 21.17-4)**
• Mass and centre of gravity	• Weight and centre of gravity
• Performance data	• Performance data
• Flight Envelopes	• Minimum safe speed
• Take-off performance	• Take-off performance
• Climb requirements	• Climb requirements
• Climb information	• Climb information
• Landing	• Landing
• Controllability	• Controllability
• Control forces	• Trim
• Flying qualities	• Stability
• Stall characteristics and stall warning	• Minimum safe speed characteristics and warning
• Vibration	• Ground and water handling characteristics
• Flight in icing conditions	• Vibration, buffering, and high-speed characteristics
• Operating Limitations	• 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 21.17-4)**
• Structural design envelope	• Structural design envelope
• Interaction of systems and structures	• Interaction of systems and structures
• Structural design loads	• Structural design loads
• Flight load conditions	• Flight load conditions
• Ground and water load conditions	• Ground and water load conditions
• Component loading conditions	• Component loading conditions
• Limit and ultimate loads	• Limit and ultimate loads
• Structural strength	• Structural strength
• Structural Durability	• Structural durability
• Aeroelasticity	• Aeromechanical stability
• Design and construction principles	• Aeroelasticity
• Protection of structure	• Design and construction principles
• Materials and processes	• Protection of structure
• Special factors of safety	• Materials and processes
• Emergency conditions	• Special factors of safety
	• Emergency conditions

Table D1-2: eVTOL aircraft design requirements – Structures

DESIGN AND CONSTRUCTION	
EASA (SC-VTOL-02)	**FAA (AC 21.17-4)**
• Flight control systems	• Flight control systems
• Landing gear systems	• Landing gear systems
• Flotation	• Flotation
• Means of egress and emergency exits	• Bird Strike
• Occupant physical environment	• Means of egress and emergency exits
• Fire Protection	• Fire protection
• Fire Protection in designated fire zones	• Fire protection in fire zones and adjacent areas
• Lightning Protection	• Lightning and static electricity protection
• Design and construction information	

Table D1-3: eVTOL aircraft design requirements – Design and Construction

EQUIPMENT	
EASA (SC-VTOL-02)	**FAA (AC 21.17-4)**
• General requirements of systems and equipment function	• Cockpit voice recorders (under Aircraft Level Requirements)
• General requirements on equipment installation	• Aircraft level systems requirements
• Equipment, systems, and installations	• Function and installation
• Electrical and electronic system lightning protection	• Equipment, systems, and installations
• Electrical wiring interconnection system (EWIS)	• Electrical and electronic system lightning protection
• High-intensity radiated fields (HIRF) protection	• High-intensity Radiated Fields (HIRF) protection
• System power generation, energy storage, and distribution	• System power generation, storage, and distribution
• External and cockpit lighting	• External and cockpit lighting
• Safety equipment	• Safety equipment
• Pressurized systems elements	• Flight in icing conditions
• Installation of flight recorders	• Pressurized systems elements
	• Equipment containing high-energy rotors

Table D1-4: eVTOL aircraft design requirements – Equipment

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.

EASA (SC-VTOL-02)	**FAA (AC 21.17-4)**
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/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.

EASA (SC-VTOL-02 and SC-E-19)	FAA (AC 21.17-4)
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 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/Propulsion System

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 and used as the certification basis for propellers of VTOL capable aircraft if applicable.

EASA (CS-P)	FAA (AC 21.17-4)
• 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/Propulsion System

II. ADDITIONAL CONSIDERATIONS – ENVIRONMENTAL PROTECTION REQUIREMENTS

eVTOL aircraft design must not only be innovative and efficient but should also be environmentally responsible in support of sustainable aviation. The emphasis on mitigating environmental impact may be even greater for eVTOL aircraft used for UAM, as their operations are much closer to the public. Specific design and certification requirements could be expected for eVTOL aircraft in noise emissions, air emissions, and sustainable practices throughout the entire lifecycle of its operations, which could help to ensure public acceptance and 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 close to populated areas, managing noise emissions will be critical to the public acceptance and regulatory approval of operating such aircraft.

- **Compliance with Noise Certification Standards (e.g., ICAO Annex 16):** All aircraft are expected to comply with international 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. For eVTOL aircraft, these standards may need to be further tailored to account for urban environments, where noise sensitivity is higher due to dense populations and frequent operations.
- **Urban Noise Pollution Limits:** Regulatory bodies may wish to specify urban-specific

noise limits for eVTOL aircraft. These limits would consider peak operating hours, proximity to residential and commercial areas, and acceptable decibel levels during various stages of flight. For example, stricter noise controls may be required during early morning or late evening operations to minimise disturbances in residential neighbourhoods.

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, provided that 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 not contribute negatively to 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. Requirements may be considered to encourage sustainable practices in the sourcing of materials, component recycling, and the use of renewable energy for charging or 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 could be considered to encourage the use of materials in eVTOL aircraft battery systems that can be safely recycled or repurposed to minimise environmental impact.

III. 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 OEM of the eVTOL aircraft will need to certify the aircraft such that it is able to operate in adverse weather conditions such as rain, fog, snow, 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 wholly or selectively applied according to the type of eVTOL aircraft mission and mission environment.

Airspace Requirements

It is ultimately desirable for eVTOL aircraft to be able to safely integrate and routinely operate in 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 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 it 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.

IV. ADDITIONAL CONSIDERATIONS – SIMPLIFIED FLIGHT CONTROLS

Most manned eVTOL aircraft designs incorporate pilot controls that are different from existing manned aircraft for several reasons, such as the desire to combine vertical and cruise flight controls into a single piloting interface, lowering the piloting workload compared to traditional aircraft, and reducing piloting interfaces. Several different design configurations have emerged, with some designs removing rudder pedals and using 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 control. Fly-by-wire is the basic technological enabler for these types of flight controls, to which there is precedence 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 in such systems will therefore have increased criticality and may require dedicated and more stringent certification requirements according to the level of criticality.

V. ANNEX REFERENCES

EASA (2020), Certification Specifications and Acceptable Means of Compliance for Propellers (CS-P), Amendment 2, 24 June 2020.

EASA (2021), CRI Consultation paper, Special Condition: Electric/Hybrid Propulsion System, Issue 1, SC E-19, 07 April 2021.

EASA (2024), Special Conditions for VTOL-capable aircraft, Issue 2, SC-VTOL-02, June 2024.

FAA (2024), Advisory Circular – Subject: Type Certification – Powered-lift, 21.17-4, Draft, 2024.

ANNEX D2 TO PART 1

Remotely Piloted eVTOL aircraft design requirements

This annex presents additional potential design requirements that may be considered for eVTOL aircraft that are remotely piloted. These considerations would supplement the main eVTOL aircraft certification requirements described in **Annex D1**.

I. DESIGN REQUIREMENTS FOR GROUND CONTROL STATIONS

Remotely piloted eVTOL aircraft introduce the need for a ground control station 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 ground control stations • Other features • Ground control station displays • Ground control station alarm information • Ground control station data logging and storage

Table D2-1: Remotely piloted eVTOL aircraft - Ground Control Station requirements

II. DESIGN REQUIREMENTS FOR DATALINK

The communications link for data exchange between the ground control station 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 (C2) link. Given its function to ensure 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

III. 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 the incorporation of increased automation are as follows:

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 will have an increased criticality (e.g., satellite navigation systems, inertial navigation systems, lidars, radar altimeters, optical sensors) and may require more stringent requirements prescribed to ensure their reliability and performance in terms of characteristics 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, such as those that employ some degree of artificial intelligence. Conventional aircraft certification focuses on software and algorithms that are fully explainable and with results that are deterministic, whereas software incorporating artificial intelligence may be less deterministic and become incompatible with conventional understanding and requirements for safety assurance. The use and certification of AI in aircraft and related systems is still an area where there is still significant work and discussion at an international level. EASA and FAA roadmaps for AI may be useful as additional 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 lead to a reduction in remote pilot vigilance or situational awareness and therefore reduced or significantly delayed ability to react and intervene where necessary.
- **Loss of proficiency:** Some functions may become so automated that a human is never expected to perform it. This may lead to a decline or loss in the ability for remote pilots to react appropriately 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), remote pilots will need to actively maintain an awareness of which mode the aircraft is in if the aircraft is allowed to automatically switch without human intervention. Else the lack of mode awareness may lead to incorrect human decision-making and inappropriate or erroneous intervention and inputs.

IV. TYPE CERTIFICATES ISSUED

To-date, the CAAC has issued Special Conditions and Type Certificates (TC) one large-class eVTOL unmanned aircraft as follow:

- V2000CG unmanned cargo-carrying aircraft system (eVTOL aircraft)
    - 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 22nd March, 2024.

V. ANNEX REFERENCES

CAAC (2023), 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, 12 Nov 2023.

EASA (2023), Artificial Intelligence Roadmap 2.0, Human-centric approach to AI in aviation, May 2023.

FAA (2024), Roadmap for Artificial Intelligence Safety Assurance, Version 1, July 2024.

eVTOL aircraft

PART 2

Regulations for eVTOL Aircraft Entry Into Service

I. INTRODUCTION

Realistic and pragmatic implementation is important to realise 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 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, and supplementary considerations for the EIS of remotely piloted eVTOL aircraft are contained in **Annex A**.

II. 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 a process to obtain a Certificate of Airworthiness for the aircraft.

Personnel licensing and maintenance organisation compliance is also a fundamental requirement that is necessary to be considered as part of EIS. This is to ensure that the operator can employ adequately trained personnel and engage 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 (SARPs) for EIS of eVTOL aircraft are still under consideration, but it is apparent that the process and requirements will be consistent with the principles of SARPs for existing manned aircraft.

III. 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 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 flow for obtaining an AOC can be found in ICAO document 8335 (ICAO, 2022d).

Based on the existing AOC certification process, the operator applicant, who has the responsibility for the safety of the operation, would need to demonstrate their eligibility for an AOC. 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 would like to expand their commercial operations to include eVTOL aircraft, the process would be similar to the introduction of 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. See **Annex B** for additional descriptions and guides for the AOC process.

Considerations for vertically integrated Original Equipment Manufacturers (OEMs)

Some eVTOL aircraft OEMs may be vertically integrated, and this can pose a challenge 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, as the OEM might influence 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:** Keeping design organisation (DO) and/or production organisation (PO) management and staff independent from operations (i.e., air operations, training, and maintenance) may help avoid conflicts of interest in the decision-making processes and ensure impartiality in safety-critical operations.

- **Independent Quality Audits and Oversight:** Keeping DO and/or PO quality systems segregated and independent from operations (i.e., air operations, training, and maintenance) could help ensure objective assessment and 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 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 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 commercial eVTOL aircraft operations, and the CoA requirements moderated according to the target level of safety of the type of non-commercial operations.

- Data recorders (e.g., CVR/FDR, or lightweight data recorders) could be a significant tool in enhancing knowledge on the novel technologies and operations of eVTOL aircraft and therefore, potentially help accelerate the maturity of the technology and requirements for safety governance.

- In existing SARPs, 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 according to the required airworthiness standards for continued safe operation. This manual includes details of the Aircraft Maintenance Programme and any contracted maintenance organisations, and 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 (ICA).

The establishment of robust continuing airworthiness procedures is paramount, encompassing proactive maintenance schedules above what are required by the manufacturers, 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, and operators are required to incorporate the ADs into their maintenance programs. 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 (IoT) 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 (Part 145 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 their own maintenance work if they are approved by the SoR to exercise Part 145 maintenance organisation related activities on their 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 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 instead of issuing a separate engine type certificate, which would affect how personnel ratings are designated for the eVTOL aircraft maintenance tasks.

In eVTOL aircraft relying on batteries as their primary power source, the replacement or recharging of batteries may be a maintenance activity unique to such aircraft. Some eVTOL aircraft may be designed to swap battery assemblies between flights, while others require the batteries to be recharged between flights by plugging the aircraft into a power source. In existing maintenance practices, the removal and installation of line replaceable units (LRUs) are carried out by licensed maintenance personnel, and a maintenance release is required after the task is completed. It can also be argued that battery swapping could be considered a refuelling task, which in conventional aircraft operations is a task that 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 inspections 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 rules and regulations, may be necessary to accommodate the granting of pilot licences for various licenses depending on eVTOL aircraft designs under rotorcraft, aeroplane, or powered-lift categories. CAAs may need to work with the SoD of an eVTOL aircraft to develop suitable training requirements that cater to the unique design of the specific 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. Beyond these transitional measures, the development of a new licensing regime specifically tailored to eVTOL aircraft may more adequately address potentially unique operational requirements of such aircraft.

The following are some areas to consider for the development of a pilot's licensing regime:

- eVTOL aircraft will very likely operate within existing airspace structure and would need to comply with existing rules that apply to the operation of helicopters and aeroplanes (i.e., existing Rules of the Air).
- It is expected that piloted eVTOL aircraft operations may initially be limited to flights under VFR and progressively expanded to flights under Instrument Flight Rules (IFR) as eVTOL aircraft operations matures. Commercial eVTOL aircraft operations may have several similarities with commercial passenger-carrying operations currently conducted with smaller helicopters under Visual Flight Rules (VFR).
- eVTOL aircraft pilots would need to meet existing manned aircraft personnel medical standards as per existing regulations.
- There is precedence in conventional manned aviation where flight crew training pathways had to be adapted with the introduction of novel technologies. For example, novel flight

control systems introduced by Airbus in the past had required CAAs to assess and manage new flight crew skills and procedures introduced by such technology. The processes adopted by CAAs in these past examples for the introduction of novel technology may be applicable to the introduction of eVTOL aircraft and could be consulted as references.

- As a novel aircraft type, the CAA will be reliant on the aircraft certification process to identify the appropriate pilot training requirements. The required training pathway should be developed by the aircraft OEM as part of their submission of the Operational Suitability Data (OSD).
- Training for pilots who hold aeroplane (CPL/ATPL) or helicopter (CPL/ATPL) licences may vary, and thus additional theory training in operational requirements that they have not previously been exposed to when operating aircraft of other categories may be required.
- Conventional aircraft regulations require an aircraft to have dual controls for operations such as flight instruction, whereas manufacturers of eVTOL aircraft mostly have or intend to only have a single set of controls. The FAA has analysed the safety intent of this requirement and suggests two main alternative means to fulfil the intent: requiring the use of a functioning throwover control and the use of Full Flight Simulators. Deciding which alternative is more appropriate will depend on the design of the aircraft (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 will likely be located outside of the State, the CAA may consider utilising their existing systems or processes it uses 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 are maintaining a level of competency to conduct flights in the aircraft safely.
- It is anticipated that aircraft manufacturers will partner with specialist training providers or develop their own training capability to provide the required pilot training.
- The CAA may require pilots who hold aeroplane or helicopter licences with a powered-lift type rating to demonstrate competency periodically in a powered-lift aircraft. An aircraft operator will need to develop a training and assessment program to ensure that their pilots maintain competency to conduct flights in the aircraft.
- Any changes to existing operating standards and requirements will need to be considered in the training for the type rating to ensure flight operations comply with any new requirements.
- CAAs may need to explore strategies for qualifying Aviation Safety Inspectors (ASI) on eVTOL aircraft given the unique nature of these aircraft and the initial scarcity of traditional training resources. One potential approach is to recognise and leverage 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 needed 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 and adequate 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 needs to address these designs and their unique maintenance requirements.
- **Electric Propulsion System:** eVTOL aircraft will utilise electric propulsion. Training modules should 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 from primarily physical inspection to proficiency in technical skills 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 (GSE):** The unique design of eVTOL aircraft may introduce new types of maintenance GSE that create a knowledge gap for maintenance personnel regarding these tools. Examples include GSEs 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 (OEMs):** Collaborating with eVTOL aircraft OEMs can help leverage their technical expertise and experience to develop and approve type rating training programs. These programs 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 typically 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 the overseas station for possible rectification of defects.

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 (CNS). 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 the means of governance and standards for such supporting infrastructure.

- **Vertiports:** The vertical take-off and landing capabilities of eVTOL aircraft would have to be accommodated with dedicated infrastructure in support of passenger or cargo transportation. The term vertiport is becoming more commonly used to refer to any such area used for the landing, take-off, and movement of eVTOL aircraft. Some considerations may cover areas such as obtaining approvals for the establishment of a vertiport, site selection (e.g., integration with existing aerodromes if applicable), vertiport design, vertiport certification, airspace considerations around the vertiport, and personnel. 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. Below are some of the considerations when it comes to setting up charging stations and energy management of a vertiport:

    - **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 specifically tailored to 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 to prevent blackouts or system overloads, may be needed to better facilitate the energy demands of eVTOL aircraft operations.

    - **Battery Swapping:** eVTOL aircraft may be designed to replenish their power through on-aircraft charging or by swapping batteries. Battery swapping may reduce aircraft turnaround times as compared to on-aircraft charging but may require dedicated infrastructure where operations of swapping depleted batteries with fully charged ones are carried out.

    - **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 FOD and wildlife management and procedures for safe movement of ground vehicles, personnel, and passengers at the apron/aircraft stands would typically be essential to ensure the safety of operations at the vertiport.

- **Maintenance and Repair Facilities:** Dedicated facilities within vertiports for on-site maintenance and repair of eVTOL aircraft would ensure that aircraft with defects can be returned to service quickly. 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 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 and hence gives 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 for manned (piloted) eVTOL aircraft. However, some modifications may be needed to support eVTOL aircraft operations including the communication, navigation and surveillance systems that are integral to the ATM system. As eVTOL aircraft operations are expected to be operated within urban airspaces, ATM systems may have to provide real-time data on aircraft locations, communications with the aircraft at very low altitudes, 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 of air traffic management, airspace construct, navigation standards, or flight rules due to their unique flight performance characteristics may need to be considered. For example, potentially 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, and microbursts or downdrafts may also occur in urban canyons. Urban heat island effects, where an urban area is significantly warmer than its surroundings, could also create localised weather patterns that could affect eVTOL aircraft flight operations. Flight routes may also need to consider potential issues of electromagnetic compatibility or electromagnetic interference on eVTOL systems in densely populated and built-up areas.

Regulations will be crucial to address the integration of eVTOL aircraft operations into existing airspace, including rules for flight paths, altitude deconflictions/restrictions, and communication protocols with ATC. This 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 shall be approved by the SoR and that each aircraft needs to be issued with a noise certificate; however, there are presently no published noise standards specifically for 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 them when issuing the noise certificate.

Where the SoD has not developed 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 costs. 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, 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, programs, devices, information, and data from attack, damage, unauthorised access, use, and/or exploitation.

The existing considerations for aviation security measures in manned aircraft operations, including physical safeguards, person and baggage screening, access control systems, aircraft search, and cybersecurity measures such as data encryption, are generally applicable for eVTOL aircraft. Comparatively, eVTOL aircraft operations are expected to be more digitally interconnected with both aeronautical and non-aeronautical data sources, leading to new surfaces for malicious attacks and may require more specific emphasis in cybersecurity. Furthermore, if operations with eVTOL aircraft evolve to be a critical part of national transport infrastructure, it may become a prime target for malicious intents. Some guidelines for expected security from operators and cybersecurity are provided in **Annexes F and G to Part 2**, respectively.

IV. ACTION PLAN

To facilitate the EIS of eVTOL aircraft operations, regulations would need to mitigate any potentially new hazards and risks introduced by such operations. Either one, or a combination of the two approaches, could be considered to update a State's regulations for eVTOL aircraft operations: create new dedicated regulations for eVTOL aircraft operations or adapt existing manned aviation regulations. The development of a matured set of eVTOL aircraft regulations may iterate over time and use transitional arrangements, and 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 and operational standards and requirements that are separate from existing manned aviation standards and requirements could facilitate better clarity and flexibility to change as the technologies and operations mature. However, with limited use cases and operational data, the time frame to arrive at such a regulatory framework may be long, depending on the processes of the respective State and the speed at which involved stakeholders contribute to the regulatory development tasks.

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

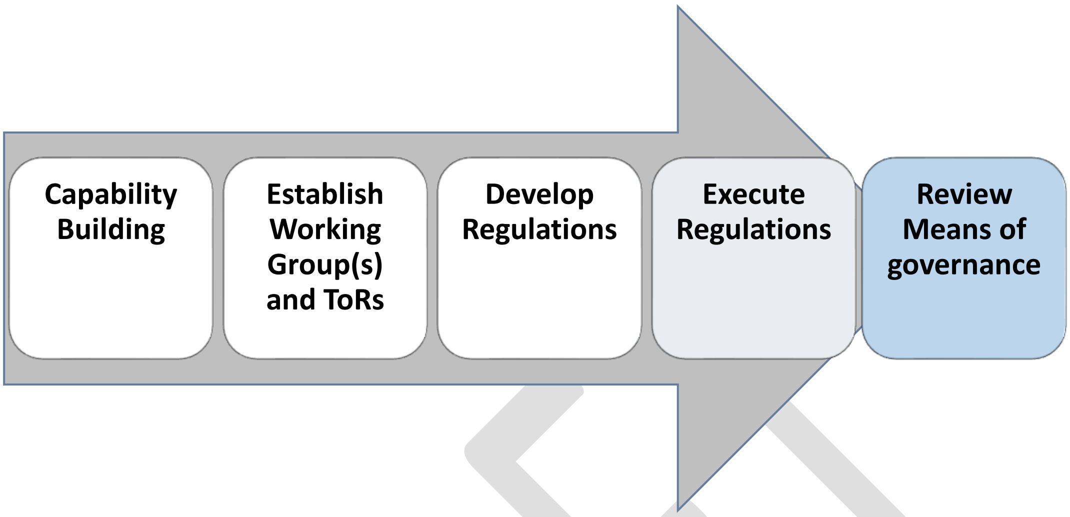

Figure 1– Action Plan: Creating new dedicated eVTOL aircraft operational regulations

- **Capability Building:** Identifying requirements that ensure public and operational safety and mitigating the hazards and risks of eVTOL aircraft operations implies that the personnel involved in the regulatory work must have an adequate understanding of the eVTOL aircraft technologies and types of operations involved. This may involve collaboration with the SoDs, training by OEMs, and specific technology training from the local industry or international community. CAAs may also refer to Part 5 for further details and consideration 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 that have 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 could convene or leverage official technical specialists to support the working groups. For example, Technical Bodies supporting the European Union Aviation Safety Agency are composed of representatives of the EASA Member States and European Commission for technical areas (e.g., Aerodromes, Air Traffic Management/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 the respective State uses in developing their manned aircraft regulations. Collaborations with SoDs of eVTOL aircraft and/or other likeminded States that facilitate eVTOL aircraft operations may help as references and provide varying viewpoints on regulatory requirements and approaches. A key principle in the development of regulations should be to work towards reducing the amount of effort needed to accomplish the approval of aircraft type design and operations without prejudice to safety and its own unique national requirements.

- **Execute Regulations:** This step encompasses the issuance and operationalisation of the new regulations. CAAs could continue to leverage the existing processes meant for conventional aviation for the issuance and operationalisation, which could involve processes such as industry and public consultation 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 the acceptable means of compliance with the regulations. Developing the means of compliance 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, compliance monitoring, and enforcement of regulations.

- **Review Means of Governance:** Continuous review of the promulgated regulations may help ensure its effectiveness and relevance, especially as more operational data and experience with eVTOL aircraft become available. Existing processes may be applicable for the regulatory review and updates.

Adapting existing manned aircraft regulations

As an alternative to creating new regulations, adaptations could be made to a State's existing manned aircraft regulations. This adaptation could be in the form of changes or additions to the existing regulations to reflect the needs and expected performance of eVTOL aircraft technologies and operations or generating a special set of requirements derived from existing regulatory requirements to address a specific approval application. This approach would arguably be shorter than trying to promulgate new regulations but may be problematic for complex eVTOL aircraft operations that may result in lengthy changes and additions to or exemptions from existing regulations. This approach could therefore be more of an interim measure to rapidly bring initial eVTOL aircraft operations into service or on a limited basis for a few use cases while a new regulatory framework is developed in parallel.

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

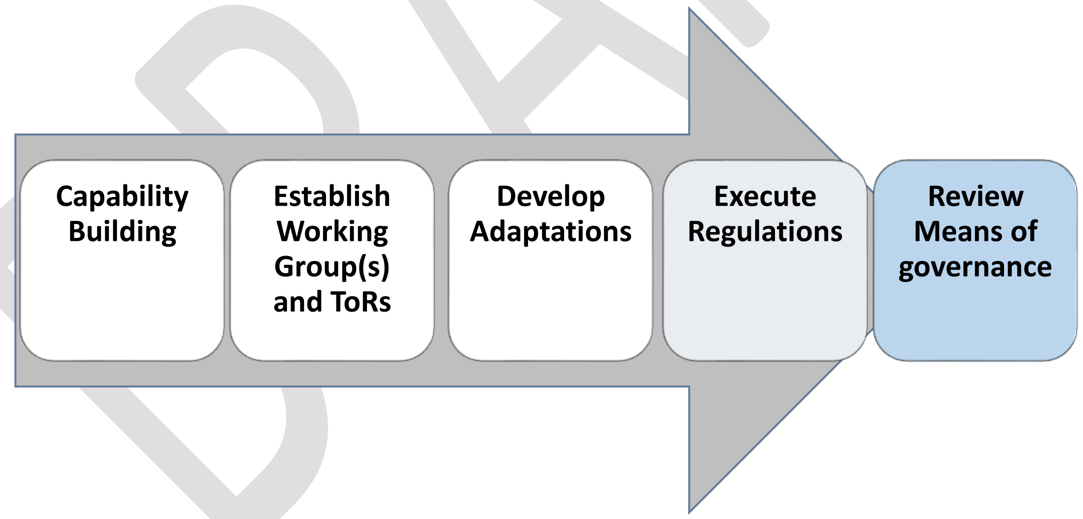

Figure 2 – Action Plan: Adapting existing manned aircraft regulations for eVTOL aircraft

- **Capability Building:** The actions and considerations in this step are the same as with the step of capability building for creating 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 operations requested by a few applicants, and it may be helpful if the applicant (aircraft OEM or operator) is involved in developing the regulatory adaptations with the CAA. Having the aircraft OEM and operator in the working groups could help bring technical and operational knowledge and expertise required for the tasks of the working groups.

- **Develop Adaptations:** The regulatory adaptations may be 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 involved in issuing and executing 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 that have been made to manned aircraft regulatory provisions may need to be further updated for clarity and relevance or, where necessary, developed into a separate regulatory framework, especially once more knowledge and experience in eVTOL aircraft operations is available.

V. REFERENCES

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ICAO (2022d), Manual of Procedures for Operations Inspection, Certification, and Continued Surveillance, Doc 8335 Sixth Edition, 2022

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ANNEX A TO PART 2

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 is a unique configuration with distinctions that introduce additional considerations. ICAO Annex 7 defines any unmanned aircraft piloted from a remote pilot station (RPS) as a remotely piloted aircraft (RPA) (ICAO, 2012), and an RPA, its associated RPS(s), the required 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 such definition.

At the ICAO level, RPAS have been steadily incorporated into the SARPs since 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 SARPs 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 transportation of passengers will be addressed in the future. Annex 6 Part IV complements Doc 10019, Manual on Remotely Piloted Aircraft Systems (ICAO, 2015), that 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 SARPs may also be applied for 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.

Summarily, 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 unique from any existing AOC that they might already hold. ICAO recommends SoOs to issue a single merged certificate, listing the privileges in the operations specification in the single certificate, to operators that are approved to conduct operations under an AOC and an ROC, but the operator would need to complete all requirements to obtain an ROC independently from the requirements 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 as the RPA may be operating in a different State from where the RPS is located. RPAS operators are expected to comply with the laws, regulations, and procedures of both States if that is the case.

- **Considerations for Airworthiness of Aircraft – RPS and C2 Link:** A key distinction in RPAS is the addition of an RPS that is an integral part of the type design and therefore an element to be considered in airworthiness and continuing airworthiness. Additionally, the criticality of the C2 Link is significantly higher for RPAS, and there is several guidance on requirements for the C2 Link by ICAO. A manual on C2 Links for RPAS should be forthcoming from ICAO.
- **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) would need to 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 SARPs require RPAS operating in accordance with IFR to have 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 minimum equipment.

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

I. ANNEX REFERENCES

ICAO (2012), International Standards and Recommended Practices, Annex 7 – Aircraft Nationality and Registration marks, 6th edition, July 2012.

ICAO (2015), Manual on Remotely Piloted Aircraft Systems (RPAS), Doc 10019, 1st edition, 2015.

ICAO (2024), International Standards and Recommended Practices, Annex 6 Part IV – International Operations – Remotely Piloted Aircraft Systems, 1st edition, July 2024.

ANNEX B TO PART 2

AOC 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 comes in two parts: the AOC itself and the associated operations specifications that define the operation. The general process flow for obtaining an AOC can be found in ICAO document 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 and comply with applicable aviation and safety regulations. The CAA, in addition to assessing the ability and competence of the eVTOL aircraft operator applicant, is generally expected to guide the applicant in 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 would typically be appointed as the project manager, and a certification team consisting of qualified and experienced inspectors with the necessary specialisations, such as operations, licensing, maintenance, and electrical propulsion, would be appointed.

Since each operation may differ significantly in complexity and scope, the project manager and the certification team will need considerable latitude in taking decisions and making recommendations to their Directorate General or approving authority during the certification process. The ultimate recommendation by the project manager and decision by the approving authority regarding certification and awarding an AOC is to be based on the determination of whether the applicant meets the regulatory requirements established by the State in its compliance with all the air navigation regulations.

The procedure for the application and granting of an AOC 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; and
- 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 and should be provided with complete information concerning the type of operations that may be authorized, the data to be provided by the applicant, and the procedures that will be followed in the processing of the application.

Formal Application Phase

Upon completion of the assessment concerning the financial, economic, and legal aspects of the application and after any deficiencies have been corrected, a provisional determination would 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, can be undertaken. The formal application for an AOC accompanied by the required documentation should be submitted in the manner prescribed by the CAA.

Document Evaluation Phase

The document evaluation phase involves the detailed examination of all documentation and manuals provided by the applicant to establish that every aspect required by the regulations is 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 for all personnel involved in the operations of the aircraft and equipment to familiarise themselves with the contents of these manuals to ensure the safe, efficient, secure, and effective operation of the eVTOL aircraft and the associated system in accordance with the Original Equipment Manufacturer (OEM) requirements, industry standards, and best practices.	• See **Appendix 1 and 2** for sample contents of operations manuals.
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 program, training, quality control, documentation control, monitoring and rectification of defects, limitations, etc., 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 Maintenance Control Manual may need to specifically address training requirements for service providers, including maintenance contractors both at base and overseas. Contracted MROs will need to be approved by the State to perform maintenance on eVTOL aircraft.
Reliability Manual	• The reliability program is a subset of the aircraft maintenance program. 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) could 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 inspections. • New requirements may need to be developed for the following: ➢ Swapping/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/pilots and the accuracy of these indications and readings. • As with jet fuel, the capacity of the batteries or quantity of hydrogen fuel uplifted/onboard would need to be entered into the aircraft logbook before flight.
Minimum Equipment List (MEL)	• The Master MEL (MMEL) is produced by the aircraft manufacturer and approved by the State's certification authorities. • The operator, based on the MMEL, 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 the common MEL items for standard aircraft due to novel designs and technology. • MEL items related to the propulsion units and 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 main base and station facility inspections, inspection of the operational control and supervision facilities, and inspection of training programs and training facilities. Demonstrations involve showing the operational control system and emergency evacuation procedures and may involve demonstration flights.

Award of AOC

The certification phase is the final phase of an AOC certification process when the project manager has determined that all certification requirements, both operational and economic, have been completed in a satisfactory manner and that the eVTOL aircraft operator is deemed able to comply with the applicable regulations and fully capable of fulfilling its responsibilities for conducting safe, efficient, and reliable commercial operations. The culmination of this phase is the issuance of the AOC.

I. ANNEX REFERENCES

ICAO (2022), Manual of Procedures for Operations Inspection, Certification, and Continued Surveillance, Doc 8335 Sixth Edition, 2022

APPENDIX 1

ANNEX B TO PART 2

OPERATIONS MANUAL EXAMPLE A:

**This is a basic template for a typical Operations Manual. It can be further customized 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

1. 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.

2. 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.

3. Policies and Procedures

This section details the general operational policies and specific procedures for various tasks or processes within the organization. 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.

4. Safety and Security

Here, emergency procedures that may include eVTOL aircraft incidents on specific battery fires and system failures, safety protocols, and security measures within the organisation are outlined. This may include general fire evacuation plans, first aid procedures, workplace safety guidelines, and security protocols for physical and digital assets.

5. 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.

6. 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.

7. 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.

8. Information Technology

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

9. 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.

APPENDIX 2

ANNEX B TO PART 2

OPERATIONS MANUAL EXAMPLE B:

**This is a basic template for a typical Operations Manual. It can be further customized 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:

1. 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 familiarize themselves with the contents of this manual.

2. 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 Original Equipment Manufacturer (OEM) requirements, industry standards, and best practices. It aims to minimise the risk of incidents/accidents, ensure equipment longevity, and maintain operational efficiency and safety.

3. 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.

4. 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.

Safety considerations for single-pilot flight operations and fatigue management measures due to the likelihood of operating multiple short flights and at low altitudes.

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

4.3 Maintenance Personnel

Perform regular maintenance as per the maintenance schedule outlined in the aircraft and maintenance control manual (MCM).

Document all maintenance activities and report any major technical issues to the management and DGCA as required in the national regulations.

5. 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, departure, arrival, and alternate destinations.

b. Aircraft Performance: Calculate the eVTOL aircraft performance, especially considering the low Maximum Certified Take-off Mass (MCTOM). Considerations should include factors such as weights of passengers/luggage/cargo, weight and balance, and take-off/landing power requirements.

c. Navigation: Review the planned flight route, terrain, including waypoints, and any potential airspace restrictions.

d. Battery Energy Planning: Calculate the required battery energy for the flight, considering factors like weather, terrain, alternate airports/vertiports and potential diversions.

e. NOTAMs: Check relevant Notices to Airmen (NOTAMs) that could affect the flight.

f. Air Traffic Control: Review air traffic control 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/monitor passengers embarkation and cabin safety/security.

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

Power on the equipment following the specified sequence in the Aircraft Flight Manual (AFM)/Flight Reference Cards (FRCs).

5.3 In-Flight Operations

Follow the designated operating parameters and guidelines.

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

Monitor passengers onboard and their safety/security in-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.

Monitor passengers' safe disembarkation at destination.

6. Emergency Procedures

6.1 Equipment Malfunction

In the event of an equipment malfunction, the pilot will follow the designated AFM/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 organization's safety procedures.

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

7. 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.

8. 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.

ANNEX C TO PART 2

Typical initial CoA Documents

The following is a typical set of documents to be submitted by the operator for the initial 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 SBs incorporated on aircraft
- AD compliance report
- List of aircraft equipment installed
- Aircraft Logbook(s)
- Weight and balance report
- Customer acceptance flight report, or equivalent
- Aircraft & Engine Performance Report
- Electrical Load Analysis
- Approved Manuals:
  - Maintenance Control Manual
  - Reliability Manual
  - Refuelling Manual
  - Weight & 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

1	Engine Maintenance Manual
2	Propeller Maintenance Manual
3	APU Maintenance Manual
4	Parts Catalogue
5	Standard Practices Manual
6	Structural Repair Manual
7	Structurally Significant Items
8	Loading Procedures Manual
9	Weight and Balance Manual
10	Non-destructive Testing Manual
11	Wiring Diagram Manual

ANNEX D TO PART 2

AMO Considerations

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 organization 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) • The State needs to 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 – APU • 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 (CS)	• 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:** A&P 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 ratings has been suggested by some States to be endorsed on licences.

Table D-1 – Considerations for AMO

ANNEX E TO PART 2
Vertiport Considerations

This annex is intended to present some aspects to consider 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. Other civil aviation authorities have published guidance materials for vertiports that are primarily based on ICAO Annex 14, Volume II – Heliports and ICAO Heliport Manual Doc 9261. However, there are differences, especially on the unique requirements for vertiports to accommodate the operations of eVTOL aircraft.

Establishment of vertiport

The regulations that govern the establishment of new vertiports or aerodromes differ from one State to another. 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 for the aerodrome's strategic alignment with national aviation objectives, as well as for the preservation of safety and efficiency.

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

Site selection

Choosing a vertiport location requires careful consideration of its closeness to demand centers, maintaining safe distances from nearby structures and natural barriers, and evaluating the environmental implications, including noise pollution, community effects, urban planning needs, and sustainability, 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 – PANS Aerodromes provides aerodrome operators with guidance on conducting compatibility studies to evaluate the potential effects of introducing a new aeroplane type or model (in this instance, eVTOL aircraft) to the aerodrome. In which case, a compatibility study 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, the adequacy of the equipment and facilities provided for the anticipated flying activities must be thoroughly assessed. Furthermore, should there be specific Touchdown and Liftoff Area (TLOF) and Final Approach and Take-off Area (FATO) requirements for eVTOL aircraft operations, considerations must be given to the distance from the runway, as well as departure and approach procedures to ensure an uninterrupted flow of current air traffic operations. These requirements will encompass the necessity for the aerodrome operator to demonstrate their competence in ensuring that both the aerodrome and its airspace are safe for the operation of eVTOL aircraft and other types of aircraft.

- **Integration with existing heliport**

  Considering the shared vertical take-off and landing capabilities of helicopters and eVTOL aircraft, it is possible that existing heliports could be repurposed for dual use. However, challenges may arise due to the unique operational requirements of different types of aircraft with 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 re-configured, as needed, to meet the requirements of various types of eVTOL aircraft, which may differ from those of traditional helicopters due to their design and performance characteristics.
  - **Obstacle environment requirements:** Height restrictions and airspace constraints should be re-evaluated for each heliport 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. Meanwhile, RFF for eVTOL aircraft will introduce new challenges, primarily dealing with 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 the vertiport infrastructure, thereby ensuring safe and efficient operations for eVTOL aircraft.
  - **Visual aids:** The visual aids used in vertiports and heliports may share some similarities due to their common purpose of supporting vertical take-off and landing (VTOL) operations. It is imperative that identification marking be given priority. The identification marking of a heliport (H) serves to inform the pilot of the heliport's existence and, through its design, suggests the preferred directions for helicopter approach and take-off. Regarding vertiports, the use of the letter "V" is generally recognized as the appropriate identification marking.
  - **Passenger and cargo facilities and other necessary infrastructure:** To assess if the operations of eVTOL aircraft could impact these existing facilities and infrastructure.

Vertiport design

At present, the International Civil Aviation Organization (ICAO) has not yet established formal standards and recommended practices (SARPs) that are specifically tailored to vertiports.

In the absence of specific SARPs for vertiports, some CAAs are relying on the established heliport standards outlined in ICAO's Annex 14, Volume II – Heliports, along with the 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 final approach and take-off area (FATO), touchdown and lift-off area (TLOF), safety areas, surface strength, taxiway/apron, charging and maintenance infrastructure and security. The FATO should be free of obstacles and sufficiently large to accommodate every part of the designated eVTOL aircraft types, with a diameter that is at least twice that of the largest eVTOL's rotor span.

  The TLOF surface should be free of irregularities that would adversely affect the touchdown or lift-off of eVTOL aircraft, has sufficient friction to avoid skidding of eVTOL aircraft, 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:** the operational components of a terminal encompass effective passenger management, which includes waiting lounges, ticket kiosks, and security checkpoints as well as prompt access to boarding areas to facilitate rapid eVTOL aircraft turnaround times, alongside adequate space for baggage scanning, loading, and unloading.

- **Vertiport Capacity and Scalability:** The scalability of the capacity of vertiports would be important to consider in the design of a vertiport to ensure smooth operations and positive customer experiences are maintained as operational demands increase. For example, provisions that allow for the future expansion of aircraft parking areas, passenger processing capacity, and number of charging stations would help ensure that the vertiport is able to accommodate growing demand over time.

- **Vertiport Security and Accessibility:** Security will be an important consideration in the design of vertiports in preventing unauthorised access to eVTOL aircraft. Accessibility features should also be considered to accommodate passengers with disabilities, ensuring a seamless experience for all users.

- **Vertiport Maintainability:** Maintenance of the vertiport infrastructure would be necessary to mitigate disruption to operations. Aspects of maintainability to take into consideration could include, but is not limited to, the repair of pavements and navigation and visual aids.

Certification of vertiport

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

For now, the certification of heliports is not mandatory under ICAO, however, the decision to require certification is the discretion of individual states or national CAAs. The certification of heliports is often conducted by states that want to ensure safe and efficient heliport operations in accordance with ICAO's SARPs.

States or CAAs may refer to ICAO documents Doc 9981 (PANS-Aerodromes) and Doc 9774 (Manual on Certification of Aerodromes) to produce directives or framework documents for vertiport certification. These documents provide procedural and regulatory guidance related to the certification of aerodromes and they 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 changes to the aerodrome manual in light of 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 transportation ecosystem. The integration of airspace requirements around vertiport 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 in urban areas. This includes airspace segmentation, which involves creating distinct corridors or "highways in the sky" for eVTOL aircraft traffic to maintain a safe distance from traditional aircraft.
- **Traffic density and capacity management:** eVTOL aircraft will significantly increase the number 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 specialized skills to ensure safety, efficiency and compliance with regulatory standards. The types of personnel required could be as follows (as an example):

- **Vertiport operation officer (VOO):** 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 assistance (VPA):** Responsible for assisting the VOO in operation of vertiport, directing passenger to and from the eVTOL aircraft, loading and unloading freight and baggage from eVTOL aircraft.

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

I. RELEVANT RESOURCES AND REFERENCES FOR VERTIPORTS

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

Regulatory Frameworks and Guidelines

- **ICAO SARPs (Standards and Recommended Practices)**
  - Annex 14 – Aerodromes (Volumes I and II)
  - Annex 19 – Safety Management

- Doc 9981 – Procedures for Air Navigation Services (PANS-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
  - 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 taken into account for vertiports.

  - **FAA Engineering Brief No. 105 – 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**

    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. This document ensures that vertiport projects meet essential safety standards, integrate seamlessly into existing urban landscapes, and support efficient operations of eVTOL aircraft.

  - **Australia CASA's – 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 in urban and regional areas, aiming to assist stakeholders in the development of these aircraft.

  - **GCAA CAR-HVD – Civil Aviation Regulations for Heliports and Vertiports Design**

    Provide guidelines and standards for the design, certification, and operation of heliports and vertiports to support both conventional helicopter operations and the emerging electric vertical take-off and landing (eVTOL) aircraft operations as part of AAM.

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ANNEX F TO PART 2
Security 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 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 pre-flight inspection protocols specifically tailored to eVTOL aircraft operations, such as checking for tampering of key components like propulsion systems, or battery systems are in place.
- Consider the possible risk of passengers trying to interfere with pilot operation given that there is no cockpit door separation between the cabin and cockpit. Appropriate measures may need to be included in the response protocols for security incident management.

Cargo Security

- Ensure protocols for secure loading and unloading and tamper-proofing of cargo operations.
- Have 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 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 Program Adaptions

- Security Risk Assessments:
  - Review 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.

- Security Management Systems:
    - Security Management Systems may need to be updated to encompass eVTOL aircraft specific security procedures and incident reporting protocols.

Training Programs

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

ANNEX G TO PART 2

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 nonessential 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 life cycle 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 programs 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.

PART 3

Cooperation among National Agencies

I. INTRODUCTION

The complex nature 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 eVTOL aircraft operational implementation. 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 disbursed by jurisdictional territories, adding another layer of complexity. If not managed appropriately, overlapping agency functions may produce inefficiencies and diluted effectiveness and accountability, especially if agencies build their own policymaking 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.

II. 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 “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 the 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 operations of eVTOL aircraft may be optimised through a national level strategic committee leading through a whole of government approach to ensure all agencies' objectives are aligned.

For eVTOL aircraft operations, the studies into potential roles and responsibilities of stakeholders, flight demonstrations, and trials have been and are instrumental in identifying areas where interagency cooperation could be required 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 faster development of regulatory and operational rules to ensure safety and security in such topics where jurisdictions overlap (NASA, 2018). Operationally, both the enforcement of such regulations and operational rules as well as emergency responses will typically involve a multi-agency effort.

III. 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 that would require interagency cooperation to address. 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), and support for research and technology (R&T) activities that may be needed to understand and mature applicable eVTOL aircraft technologies.

- **Operations:** Operations encompass all subjects related to operating and maintaining 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 have been presented in Part 2 – Regulations For eVTOL Aircraft Entry Into Service. 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 or actions related to addressing issues of market access, consumer protection, and commercial competition as detailed in Part 4 – Economic Policies and Regulations. 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 – Social Acceptance) 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 the respective subject categories.

Stakeholders Involved

The establishment of policies and governance for eVTOL aircraft will involve multiple different national agencies that may be directly or indirectly involved in aviation, transportation, and its related fields. For this publication, these entities are categorised into the following types of agencies according to their areas of jurisdiction or function:

- **Aviation and Transportation Agencies:** Agencies that form the core of eVTOL aircraft regulation and oversight.
- **Security and Emergency Services Agencies:** Agencies that govern civil safety and security.
- **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 eVTOL aircraft's potential infrastructure needs and environmental impact.
- **Communications and Local Government and Community Agencies:** Agencies involved in local community policies 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 either 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). Formal arrangements can help to reduce 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 are 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 having a legal basis (required by law, regulation, or executive order), strict procedures, formal documentation, legal accountability, and binding outcomes. Mandatory consultations are used for critical 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 agency to facilitate communication and on-site consultation, joint release of public communications, development of formal and informal relationships, and development of strategies and partnerships (Eyerman et. al., 2006). **Strategic Committee to drive Interagency Coordination:** States can consider establishing a whole-of-government (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 may require adjustment of plans 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 Memorandum of Understandings, Memorandum of Agreements, or other similar mechanisms and would typically result in forming 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 formal methods for interagency cooperation

Formal collaboration on matters is not without risks of failure. It is said that there are potentially three ways in which collaboration may fail, as follows:

- **Disagreement:** Problems can occur when the actors disagree about the strategies, potential policy solutions, and/or coordination actions. Such problems may be mitigated with sharing and access to heightened knowledge about best practices for solving 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, workforces, 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 clear and 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 in 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 having 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 capabilities with existing agency systems.
- User-friendliness and adoption rates.

- Scalability to accommodate growing needs.
- Cost-effectiveness and budget considerations.

It would be 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 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.

IV. 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 that should be reviewed to determine its applicability to the needs of the respective CAA. The CAA is also encouraged to develop plans such as a concept of operations for their envisaged end-state for eVTOL operations together with a charted pathway of interim steps identifying the priority of the subjects that are as 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, transportation, 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 the eVTOL aircraft technological and

operational landscape evolves, particularly those dealing with emerging technologies and urban air mobility.

Step 3: Develop a Responsible, Accountable, Consulted, and Informed (RACI) 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. The RACI matrix serves as a powerful tool for this purpose. RACI stands for Responsible, Accountable, Consulted, and Informed, representing the four key types of involvement an agency may have in any given task or decision. The RACI is defined in **Table 3** below:

Responsible 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.	**A**ccountable 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 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 for the task.	**I**nformed 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 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**.

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ANNEX A TO PART 3

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 effort has 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 effort.

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 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 to surrounding developments Coordination could be expected between aviation and transportation agencies and agencies in 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.

1 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; however, in some instances, it could be expected that the overall transportation ministry and legal, economic, and trade agencies may need to be consulted (or informed) due to its 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. The requirements for approving such air operators may also need to take into account 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 civil aviation authority 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.

Subjects pertaining to operating and maintaining eVTOL aircraft, systems, and infrastructure.

Subject	Description
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 civil aviation authority. The CAAs would need to coordinate requirements to be imposed on operators with the agency responsible for national cybersecurity requirements 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 transportation or civil aviation authority directly to advise on the expected developments and operations of eVTOL aircraft.

Subjects related to addressing issues of market access, consumer protection, and commercial competition.

Subject	**Description**
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 civil aviation authority may be more deeply involved in order to ensure compliance and harmonisation with any applicable SARPs.

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 by noise or visually as "visual noise" (Gobusiness Singapore, n.d.). Setting noise guidelines and requirements will require 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 the evaluation of 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 general public will be a multi-agency effort that could be led by communications, local government, and community agencies with the consultation of agencies such as the civil aviation authority.
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. The process of 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.

Subjects that would have a social or environmental impact and thereby influence the acceptance of eVTOL aircraft by the society.	
Subject	**Description**
Urban Zoning and Permitting	Zoning refers to issues such as 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 higher constructions (European Union, 2022). Traditional zoning and permitting processes and requirements may not be suitable for the novel characteristics of infrastructure for eVTOL aircraft and need to be updated through cooperation between the airworthiness authority and relevant authorities governing such urban planning considerations.

ANNEX B TO PART 3

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 Section III. CAAs are encouraged to adapt this example list with their own governmental agencies according to the categories presented.

Aviation and Transportation Agencies

- Agency responsible for Civil Transportation 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

ANNEX C TO PART 3

Example RACI for eVTOL Aircraft Development and Implementation

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

	Responsible	Accountable	Consulted	Informed
TECHNOLOGY				
Airworthiness, Safety, and Security	● Civil Aviation Authority	● Ministry of Transport	● Agency responsible for Civil Transportation 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 Transportation Accident Investigations ● Security and Emergency Services Agencies ● Land Use, Utilities, and Environmental Agencies ● Technology and Research Agencies	● Legal, Economic, and Trade Agencies

	Responsible	Accountable	Consulted	Informed
Charging infrastructure regulations and standards	● Civil Aviation Authority	● Ministry of Transport ● Electricity Regulatory Agency	● Land Use, Utilities, and Environmental Agencies ● Legal, Economic, and Trade Agencies	● Legal, Economic, and Trade Agencies
		OPERATIONS		
Operational Certification: Pilot and operator training and licensing	● Civil Aviation Authority	● Ministry of Transport	● Legal, Economic, and Trade Agencies	● Agency responsible for Civil Transportation Accident Investigations
Operational Certification: Air operator certification	● Civil Aviation Authority	● Ministry of Transport	● Legal, Economic, and Trade Agencies	● Agency responsible for Civil Transportation 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	-

	Responsible	Accountable	Consulted	Informed
Emergency Response	• Security and Emergency Services Agencies	• Ministry overseeing Security and Emergency Services Agencies	• Civil Aviation Authority • Agency responsible for Civil Transportation 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		
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		
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	-

	Responsible	Accountable	Consulted	Informed
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	-

PART 4

Economic Policies and Regulations

I. 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 transportation 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 growth, 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 transportation. 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 regime for economic policies and regulations in transportation and highlights considerations for the introduction of commercial eVTOL aircraft operations. An action plan is also presented to provide a series of steps that are aimed at helping States identify economic policies or regulations that may need to be developed to address commercial eVTOL aircraft operations.

II. BACKGROUND

International air transportation presents unique challenges with multinational trade and political considerations, and the efforts at ICAO are focused on 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). With this overarching principle, the economic policies in international air transportation recommended by ICAO are aimed at reducing a State's costs in performing its economic regulatory function, increasing consumers' benefits and choices, improving air connectivity, creating more competitive business opportunities in the marketplace, and supporting sustainable economic development and the expansion of trade and tourism.

Along the lines of 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, competition, assurance of essential services, and trade in services (ICAO, 2024). To achieve the 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 transportation has been traditionally supported through investments in the building of or upgrading of transport infrastructure (e.g., roads, highways, railways, and airports) and supporting technologies to improve the transport services (e.g., better access, better capacity, facilitation of passenger connectivity, security, safety, etc.).
- **Incentives and Disincentives:** Incentives or disincentives (i.e., grants, subsidies, or taxes) can be leveraged to affect the price of transport supply and demand and used as tools to assure service qualities. These instruments can also influence and shift transport behaviour in desired directions (e.g., fare concessions, tolls, fuel and emission taxes, or environmental subsidies).

Commercial eVTOL aircraft operations are still nascent, and the examples of economic policies are mostly centred around incentives and investments in test centres or sandboxes to nurture the emerging industry. There are several examples of such investments from countries such as Australia (Australian Government, 2021), Europe (EASA, 2024), and the United States (US Congress, 2021) of governmental grants and sponsored projects aimed at incentivising 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, incentives, disincentives, and economic regulations are mostly still academic. Nevertheless, it may be possible to draw lessons and considerations from the ongoing studies and from international air transportation, and these considerations are further explored in **Section III**.

III. KEY CONSIDERATIONS

General principles and objectives of commercial eVTOL aircraft operations economic policies and regulations

Developing overarching principles for economic policies and regulations to support commercial eVTOL aircraft operations would largely be dependent on the State's objectives and whether the operations will be domestic or international. For international operations, it may be useful to refer directly to the principles found in international air transportation. Although there may be cross-border commercial eVTOL aircraft operations in the future, the market will mostly likely begin as domestic air transportation (i.e., mostly urban and regional air transportation). Issues such as multinational market access and trade in services are not as pertinent in domestic air transportation, but there can be no doubt that the vision of a safe, secure, equitable, and liberal market is also applicable to eVTOL aircraft operations. The objectives for economic policies in commercial eVTOL aircraft operations could thus be to:

- Increase consumers' benefits and choices (and affordability in certain instances),
- Improve connectivity,
- Create more competitive business opportunities, and
- 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. Like conventional air transportation, an eVTOL aircraft operator would be expected to obtain a licence to conduct air transport service, and the licensing regime should require the operator to have an appropriate business plan, financing plan, and insurance (to cover liability in the event of an accident) that ensures that the operator is able to safely conduct the operations and is in compliance with national business, environmental protection, and consumer protection requirements (European Parliament, 2024). Most nations mandate, for national security, industrial, and economic reasons, that only a person of the nation or a company established in the nation is eligible as an air transport operator of the nation. Commercial eVTOL aircraft operations are not expected to deviate from the existing regime.

  A specific recommendation from the existing regime is to rely generally and initially on voluntary commitments undertaken by the operators and service providers (non-legally binding self-regulation) and to consider regulatory measures only when such voluntary commitments are not sufficient to ensure or improve the service quality.

- **Investment:** Air transport operators could comprise a mix of privately owned companies, state-owned enterprises, and state-owned firms, and concerns have been raised about the effect of state aid in the existing aviation industry. While state aids could ease and hasten the entry of an operator into the market, such programs may have distorting effects on the market by discouraging competition from unsubsidised operators (Balasubramaniam, 2007). These perspectives can be drawn across to commercial eVTOL aircraft operations, where the degree of governmental intervention in the financing of certain operators should be carefully considered to avoid any such distortive effects.

  - **Essential air services:** In some cases, governmental intervention through investments or financial support may be needed and justified. 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, it may encompass critical public services such as emergency medical transportation or other types of services where there could be strong reasons to have tight domestic control over the services. Services could also be tied to economic reasons, such as the strategic economic development of remote or peripheral destinations by providing transport services to and from these areas. States may consider providing financial assistance 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) would need to be sufficiently evident for State intervention to be justified over the principle for a liberal market. ICAO’s study on essential service and tourism development route support may be a useful resource to consider and adapt for the development of eVTOL aircraft operations (ICAO, 2005).

  - **Modes of investment (OECD, 2008; WBCSD, 2009):** Building, maintenance, finance, and operating companies often contracts 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 their 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 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 the market behaviour by making one mode of transportation more attractive than another. For example, incentives or disincentives could influence the price of using a particular mode of transportation. Tax reliefs for companies in emergent 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 locations of operations (i.e., routes), times of operation, and 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 operations 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 payments withdrawn should they not meet reliability targets.

  Annex A lists example incentives and disincentives from land and air transportation, 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 transportation, 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, price 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 complaint and feedback mechanisms and the means 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.). Regimes for consumer protection should reflect the principle of proportionality, allow for consideration of the impact of massive 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.; 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). The measures to ensure competition must also include safeguard measures to ensure fair competition and effective and sustained participation. Part of this relates to 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 such that they can be adjusted if needed to more readily support market growth and success.

IV. 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 nation. A notional process for the decisions and actions for the development of economic policy and regulations is illustrated in **Figure 1** and described in further detail below.

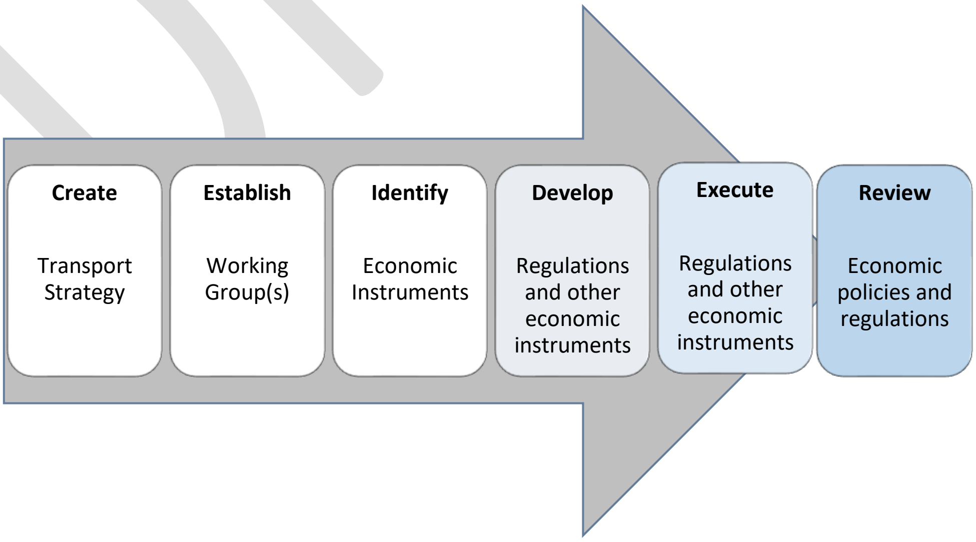

Figure 1 – Action plan for commercial eVTOL aircraft operations economic policy and regulation development

- **Create Transport Strategy:** To develop economic policies and regulations for commercial eVTOL aircraft operations, the nation's Aviation and Transportation 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 the eVTOL aircraft operational use cases envisioned for the nation and to determine the criticality 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 use cases that could be or require governmental support. Existing modes of transport that potentially overlap with commercial eVTOL aircraft operations are highlighted in this exercise, supporting a strategic decision as to which transport mode to emphasise or de-emphasise through 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 Transportation Agencies; Legal, Economic, and Trade Agencies; Land Use, Utilities, and Environmental Agencies; Communications and Local Government and Community Agencies.

- **Identify Economic Instruments:** With the designation or appointment 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 results. Referring to Section III, the broad objectives should be to increase consumers' benefits and choices, improve connectivity, create more competitive business opportunities, and support sustainable economic development. An example is shown in **Annex B**.

- **Develop regulations and other economic instruments:** Having identified the potential economic instruments to pursue, the regulations and actions to implement these instruments can be developed. In 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 the regulations is not unique to commercial eVTOL aircraft operations, and existing local governmental processes would be applicable. This phase generally involves the issuance of and the monitoring and enforcement of regulations. For investments, the 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. A periodic review with the actors involved in the development of the policies and regulations would help ensure that they are on track in achieving the strategic objectives. Where necessary, the strategic objectives should also be reviewed to ensure their continued relevance. Existing processes for policy and regulation review would apply in this stage.

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ANNEX A TO PART 4

Example Incentives and Disincentives

The following presents some examples of existing taxes, charges, or subsidy regimes from both land and air transportation. Notably, many of the existing economic instruments for land and air transportation 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 transportation (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)		

I. ANNEX REFERENCES

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ANNEX B TO PART 4

Identifying Economic Instruments

The following is a demonstration of the process of moving through the transport strategy and policy objectives, required results, and ultimately 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 EMS transportation 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 transportation 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 does not represent an existing or notional implementation for commercial eVTOL aircraft operations.

PART 5

Capability Development

I. INTRODUCTION

The core responsibility of a State of Registry (SoR) and State of the Operator (SoO) is to determine and administer the regulatory regime in their respective State to ensure that aircraft can be operated safely. To undertake this responsibility, an SoR and SoO must establish a safety oversight regime that includes legislation, regulations, organisational set-up, and staffing with sufficient and competent personnel that create and implement processes and procedures to grant aviation safety instruments and to resolve any safety concerns.

eVTOL aircraft, with its 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 new challenges and suggests considerations that could be used to assist to fulfil any gaps in capabilities.

II. BACKGROUND

SoRs and SoOs are expected to bring into force legislation and regulations that provide adequate safety oversight of civil aviation and its activities within their country and airspace. The key functions of the SoR and SoO are thus to identify aviation safety risks, develop mitigation measures to address the 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 have adequate capability in terms of organisational set-up and sufficiency in competent technical and safety inspectors to carry out these functions effectively.

eVTOL aircraft and operations can be unique from conventional aircraft and operations, and the capabilities of the SoR and SoO may need to be further developed to tackle 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 developing very rapidly, and regulators will need to keep pace with industry demands while maintaining aviation safety and security. Training needs for safety inspectors can therefore be very dynamic and time-critical to maintain necessary capabilities to provide appropriate safety oversight of the industry.

- **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 differing interpretations of requirements and safety standards. SoRs and SoOs may need to actively seek to stay informed of the latest developments (i.e., through international engagements and forums and engagement of eVTOL aircraft industry actors) and remain flexible in adapting to the introduction of new standards or changes in standards until international consensus can be achieved through ICAO.

III. KEY CONSIDERATIONS

Organisational Capabilities

The governance and regulation of eVTOL aircraft operations may require a CAA to adapt their existing organisation's 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 and 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.

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 experiences 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 constrain the ability of the CAA to adjust to managing emergent technologies and operations such as eVTOL aircraft. Most CAAs have stood up dedicated team(s) or allocated independent resources to eVTOL aircraft operations and adjusted regulatory frameworks more towards performance- or outcome-based approaches.

Personnel Capabilities

The overall role of the SoR or SoO in ensuring safe integration and operations will not likely change for eVTOL aircraft operations. As such, existing guidance material such as those contained in ICAO Doc 8335 (ICAO, 2022) and ICAO Doc 10070 (ICAO, 2016) for 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 Memorandum of Understandings with educational institutions, through other approved training organisations, or 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

Part 1 and Part 2 of this publication provide considerations and actions for the above list of areas in the context of eVTOL aircraft operations, and the following are additional considerations for the training and capability building of SoR and SoO staff in these areas:

- **Certification, Validation, and Acceptance of aircraft type:** Depending on their respective legislative framework, a SoR may accept or validate the original aircraft type certificate or issue its own type certificate based on the original. The SoR personnel involved in this process would be expected to have the necessary technical capability to understand the hazards of the new technology or aircraft design that is being introduced. There are several ways that this capability could be built up, as follows:
    - **Collaboration with States of Design and Manufacturing (SoD):** Where opportunities arise, it may be mutually beneficial for a SoD and a SoR to have a formal agreement (i.e., bilateral agreement or memorandum of understanding) enabling the SoR to be a part of or observer to an aircraft's certification process (e.g., shadow certification). The SoR personnel will be able to better understand the design and certification decisions, potential new hazards, and hazard mitigations of the new aircraft type through such exercises.
    - **Training by OEMs:** Aircraft-type training for SoRs conducted by the OEM is already a standard practice for type validation. This mechanism is expected to be effective for eVTOL aircraft operations and perhaps essential if the OEM has incorporated a novel technology or aircraft design.
    - **Specific technology training:** SoRs may deem it necessary to have a 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 and practices (e.g., DO-311 compliance).
        - Electric Propulsion Systems (e.g., electric motors, 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 of or observers to international and regional study groups (e.g., ICAO AAM Study Group, Asia-Pacific Regulators' meeting on AAM and UAS) or in standards development organisations on eVTOL aircraft will allow the SoR personnel to be better aware of the state-of-the-art in technologies being considered or used in eVTOL aircraft operations.
- **Air operations:** eVTOL aircraft may have unique functions and features that introduce new operational hazards as compared to conventional aviation. When evaluating the air operator submission, the capabilities that are developed for certification, validation, or acceptance of the aircraft type certificate would be useful in assessing the severity and risks of potentially new operational hazards.

  The safety inspectors of a SoR or SoO may also need to be able to assess the impacts of the novel technologies in eVTOL aircraft on operational planning (such as planning of air routes and determination of alternative landing sites) and flight crew management. eVTOL aircraft type training conducted by the OEM would typically detail the operating characteristics of the aircraft and operating procedures (i.e., normal and emergency procedures), which will help safety inspectors better understand how the novel technologies in the eVTOL aircraft impact operational planning and flight crew management, evaluate new hazards and operational procedures, and conduct safety investigations.

- **Certificate of Registration and Certificate of Airworthiness:** Training from existing conventional manned aviation regimes is expected to be sufficient 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. The designs have a greater emphasis on electronic, 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 on the aircraft. Accordingly, the SoR or SoO safety inspector conducting oversight on the airworthiness of the aircraft may need to be trained to be equipped with the necessary knowledge to approve the corresponding OEM maintenance schedule.

- **Personnel Licences:** The existing principles for developing capabilities to provide oversight for crew, such as pilots, flight dispatchers, and maintenance engineers, may be generally applicable to eVTOL aircraft. As detailed in Part 2 of this publication, there may be a need for a greater emphasis 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 would need to be suitably trained and competent.

  Standardisation of pilot licensing requirements is still an emerging topic within ICAO; thus, participating in international working groups on pilot licensing and training procedures could be a means for SoRs or SoOs to be aware of the latest global consensus and evolving standards in this area. SoRs and SoOs could also draw reference to regulations and materials published by other CAAs. For example, the FAA has proposed eVTOL pilot training and operating standards, including the process to obtain ratings specific to each type of powered-lift aircraft that could be considered as a reference (FAA, 2023).

- **Supporting Infrastructure:** eVTOL aircraft may potentially operate out of existing aerodromes (e.g., airfields, airports, heliports), or from dedicated vertiports. Aerodrome regulators may need to be trained to verify that the landing sites are suitable to handle 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 would likely undergo further changes, collaboration between States, sharing by OEMs to understand the operational norms and limitations (including specific technology training, electrical grids, and charging facilities, etc.), and participation in international standards-making or working groups could be useful. However, it should be noted that it is not the role of the SoR or SoO inspector to be trained in urban planning, 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. New flight rules are an emergent topic for eVTOL aircraft, and being involved with or in ongoing studies and efforts may be beneficial. Some examples are NASA’s study on digital flight rules (NASA, 2022) and the efforts of the

ICAO AAM Study Group.

- **Noise and Environmental Impact**: Some States may desire or need to develop 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 consider developing the capability to evaluate aircraft noise and establish public noise level limits in conjunction with the respective State’s primary agency responsible for governing the State’s ambient noise standards.

- **Aviation Security and Cybersecurity:** In this area, the existing training regime and contents are deemed applicable and may be sufficient for eVTOL aircraft operations. In cybersecurity, some of the newer manned aircraft (such as the Airbus A350 and Boeing 787) have already incorporated elements of cybersecurity protection, and the SoRs and SoOs that have facilitated the operations of such aircraft would have built up the necessary capability in conducting oversight of compliance to security and cybersecurity requirements. For CAAs that have not done so, OEMs could be leveraged to develop an understanding of the risks and risk mitigation measures specific to their eVTOL aircraft.

IV. ACTION PLAN

Organisational capability building

The key step that could help in ensuring that a CAA organisation is capable and effective in managing and governing eVTOL aircraft operations is a retrospective review centred around whether existing legislation, regulations, organisational procedures, organisational culture, or organisational structure (and capacity) could be a hindrance to innovation. This would involve deciding on the regulatory approach (as described in Section III) that may be more effective for eVTOL aircraft developments if it is adaptive and collaborative. Questions of when and how to adjust the organisation would also need to be addressed such that changes, if needed, are adequately supported (e.g., financially) and timely to keep pace with the developments of eVTOL aircraft. CAA may utilise the readiness study as provided in **Annex A** as a reference to help identify the existing gaps and work towards an overall schedule.

Personnel capability building

The approach to developing training programs 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 Section III.

- **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 would be used to develop the necessary training programmes. The programmes would address the requirements determined from Step 1 (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 learn from their experiential insights. With these programmes, the SoR personnel and inspectors can embarked on their respective training paths.

- **Continuous education and development:** Continuous education and development are essential investments as new concepts and technologies will emerge in eVTOL aircraft. Mechanisms for ongoing training, refresher courses, and professional development would help ensure that the State's personnel remain abreast of industry advancements and regulatory updates.

The time required for the initial training of SoR and SoO staff would generally depend on the 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 considering the novelty, depth, and breadth of the specialised knowledge potentially required.

Starting the training at least 1 to 2 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 2 years may be more desirable for some CAAs, as completing an effective training regime within 1 year may be difficult due to various factors such as competing priorities and the existing level of knowledge and experience in eVTOL aircraft operations.

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ANNEX A TO PART 5

Readiness Check

The respective eight Parts of this reference material outlines the various areas in detail that a CAA could consider in relation to facilitating commercial eVTOL aircraft and complex UAS operations. CAAs could utilise the below self-assessment checklist to conduct a readiness check and identify broad areas where further development is needed.

Readiness Checklist

Review the Considerations and Action Plans as provided in each Part of this publication and indicate accordingly per 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 worked out 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 CAA's Action Plan.
	☐	The Key Considerations and Action Plans contained in this Part is valid and will take reference to develop the CAA Action Plans for the necessary framework / policies / regulations / procedures
PART 2: REGULATIONS FOR EVTOL AIRCRAFT ENTRY INTO SERVICE	☐	Have previously evaluated all the Key Considerations articulated in this Part and worked out 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 CAA's Action Plan.
	☐	The Key Considerations and Action Plans contained in this Part is valid and will take reference to develop the CAA Action Plans for the necessary framework / policies / regulations / procedures
PART 3: COOPERATION AMONG NATIONAL AGENCIES	☐	Have previously evaluated all the Key Considerations articulated in this Part and worked out 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 CAA's Action Plan.
	☐	The Key Considerations and Action Plans contained in this Part is valid and will take reference to develop the CAA Action Plans for the necessary framework / policies / regulations / procedures

PART 4: ECONOMIC POLICIES AND REGULATIONS	◻	Have previously evaluated all the Key Considerations articulated in this Part and worked out 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 CAA's Action Plan.
	◻	The Key Considerations and Action Plans contained in this Part is valid and will take reference to develop the CAA Action Plans for the necessary framework / policies / regulations / procedures
PART 5: CAPABILITY DEVELOPMENT	◻	Have previously evaluated all the Key Considerations articulated in this Part and worked out 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 CAA's Action Plan.
	◻	The Key Considerations and Action Plans contained in this Part is valid and will take reference to develop the CAA Action Plans for the necessary framework / policies / regulations / procedures
PART 6: SOCIAL ACCEPTANCE	◻	Have previously evaluated all the Key Considerations articulated in this Part and worked out 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 CAA's Action Plan.
	◻	The Key Considerations and Action Plans contained in this Part is valid and will take reference to develop the CAA Action Plans for the necessary framework / policies / regulations / 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 worked out 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 CAA's Action Plan.
	◻	The Key Considerations and Action Plans contained in this Part is valid and will take reference to develop the CAA Action Plans for the necessary framework / policies / regulations / procedures
PART 8: CAPABILITY BUILDING (UAS	◻	Have previously evaluated all the Key Considerations articulated in this Part and worked out the necessary CAA Action Plans to facilitate complex UAS operations.

PERSONNEL TRAINING)	□	To review previously made assumptions based on the Key Considerations and Action Plans provided in this Part and update CAA's Action Plan.
	□	The Key Considerations and Action Plans contained in this Part is valid and will take reference to develop the CAA Action Plans for the necessary framework / policies / regulations / 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 more focus and efforts needs to be invested in. This will then contribute to the development of an overall master schedule for the facilitation of commercial eVTOL aircraft and complex UAS operations, for the specific concept of operations for each use case.

PART 6

Social Acceptance

I. INTRODUCTION

Among other factors, the successful integration of eVTOL aircraft operations will be dependent on gaining 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 effectively address the public's concerns. Building trust and support for this emerging technology would 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. The 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.

II. 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, whereas it has become apparent that in modern society, the involvement of local decision-makers and the resident population in shaping the decisions that matter to them in their day-to-day lives is critical (Agarwal, et. al., 2019). Land transportation has 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 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 that the public use these technologies; however, a technology and its market can only scale if it is positively adopted by the public (NASA, 2018). The Concorde (JSTOR, 2017) and helicopter transportation services by New York Airways in the 1970s (Beresnevicius, 2019) are lessons in the role that eroded public opinion and loss of trust in the safety of the mode of transportation have 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 was asserted that public participation, especially in the initial planning and implementation of the above-mentioned 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 seem purely technical are in fact not. For example, decisions made about what level of health and safety risk is acceptable are not purely technical decisions and can be decisions about values or philosophy (Creighton, 2005). Decisions can also require choosing between multiple values and deciding what is more important (e.g., human health concerns vs. economic benefits vs. costs). In this regard, public participation can provide decision-makers with information about the relative importance and value the public assigns to the choices of a particular decision. It also allows decision-makers to anticipate what the acceptable limits for such values will be. The benefits and thus 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 in the above aims is that the 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 inputs can be considered the voice of the public, the participants represent their self-interest and do not speak for the public individually. Additionally, governmental agencies are better able to consider and act on legal, economic, or political constraints affecting particular decisions.

Key Public Opinion and Concerns of eVTOL aircraft

Studies on public opinion of unmanned aircraft technology are said to have begun in 2015, starting with an emphasis on the acceptance of unmanned aircraft systems (UAS) for aerial work. Studies involving public opinion on passenger and cargo-carrying unmanned aircraft are more recent from 2019. 16 sample studies and reports spanning a period from 2015 to 2022 covering general public opinion across Australia, Europe (Finland, Germany, Luxembourg, Netherlands, Norway, Sweden, 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 reject unmanned aircraft and eVTOL aircraft operations, there could be concerns in the following areas:

- **Privacy:** In terms of privacy, some studies indicate that the general public may be mainly concerned about visual information privacy (i.e., peeking and stalking) and the potential infringement of private space. It is suggested that privacy is the greatest concern and that the concerns are associated with the limited knowledge of who or why the unmanned aircraft is being used. Addressing anonymity and traceability of operators and operations may assist in mitigating these concerns.
- **Safety:** Studies commonly identify the safety of people 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 like urban and regional air mobility. Studies suggest that concerns about mid-air collisions with other aircraft and crash landings are the next significant area of concern after privacy.
- **Security:** Concerns of security typically involve an association with the possibility for malicious misuse of unmanned aircraft (e.g., for terrorism, by criminals, for other malicious intents). A key area relates to the potential use of new information technologies

and the security vulnerabilities that such new technologies may present and lead to hijacking or spoofing unmanned aircraft with an aim for use for criminal purposes.

- **Noise:** Noise from aircraft and other transportation modes is a complex topic spanning acoustics, the physiological way humans experience noise, and the psychological perceptions listeners have of the source of the noise and what it represents to them (National Academies, 2020). Some studies suggest that the concern of noise is less on physiological effects but more linked to a perception of unwanted presence around personal space and hence to privacy.

- **Visual Pollution:** Visual pollution and the concern against "crowded skies" are often highlighted in the studies. Another associated concern is visual disruption, where the appearance of an unmanned aircraft can be perceived as a physical intrusion of personal space and thus an invasion of privacy.

- **Jobs:** In some countries, concerns have been highlighted that existing jobs may become obsolete with the introduction of eVTOL aircraft operations. Some specific industries where this concern has been noted are in logistics and taxi services.

- **Environmental Impact:** Concerns of air pollution from eVTOL aircraft operations involve less of the emissions from the vehicles (which should be almost zero in a battery-electric aircraft) but are more on perceptions of the overall environmental impact and impact on climate change from supporting processes such as the manufacturing and generation of electricity to charge the aircraft. Environmental impact also includes concerns for the impact of flight operations on bird life and insects and their potential impact on decreasing biodiversity.

- **Equity:** Some members of the public are concerned that eVTOL aircraft operations will be confined to or will only benefit parts of society that are able to afford the new services. There may be resentment against eVTOL aircraft operations by those who are subjected to the disadvantages (e.g., privacy, safety, and noise) but are unable to benefit from the new services.

III. KEY CONSIDERATIONS

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

Target Audiences for Social Acceptance

The successful implementation of eVTOL aircraft operations hinges on understanding and engaging with diverse target audiences beyond the general 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. Messaging 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 local concerns and highlight community benefits.

- **Business Sector:** This includes potential eVTOL aircraft operations users like 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, and case studies and economic impact assessments can be powerful tools for this audience.

- **Media:** Local and national news outlets, technology journalists, and relevant social media influencers shape public perception. Providing the media with accurate and timely information and maintaining open lines of communication would be crucial.

- **Special Interest Groups:** Environmental organisations, accessibility advocates, and privacy rights groups may have specific concerns about eVTOL aircraft operations. It would be essential to proactively address their issues through targeted outreach, inviting them to participate in planning processes, and demonstrating how eVTOL aircraft operations aligns 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 best thought-out public policies and plans will most likely fail without sufficient public involvement and acceptance. Engaging the public will facilitate a better understanding of the social interests, goals, and concerns that need to be considered during key decision-making and planning (UIC2, 2021; NASA, 2023). Some means that could be used to engage the public for such purposes are as follows:

        - **Focus groups and surveys:** Focus groups and surveys are generally studies that are convenient for participants, and can target and obtain feedback from specific community groups. A guide to developing surveys, together with an example, is in **Annex A**.

        - **Public participation programmes:** It is argued that there is no such thing as a one-size-fits-all means of public participation and that public engagement plans need to be carefully developed. States can refer to handbooks and resources such as those listed in Section V in guiding the development of a public participation programme.

    - **Public Communication and Messaging:** Increased communications to the public will ensure that they are more informed of the development of eVTOL aircraft operations and aid in acceptance and community outreach. Communication campaigns could be used to highlight the social and economic benefits of eVTOL aircraft operations while also providing information on the risks and how public concerns are addressed. The dissemination of information could be accomplished via 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 UN Sustainable Development Goals framework:** Environmental protection and sustainability are the commonly cited potential benefits of eVTOL aircraft operations, but while carbon emissions and noise are tangibly defined, the goals for sustainability are rarely well defined. The United Nations Sustainable Development Goals (UN SDGs) are a set of 17 interconnected global goals from the 2030 Agenda for Sustainable Development that was adopted by all United Nations Member States in 2015 (United Nations, 2024). The SDGs aim to end poverty and other deprivations in conjunction with strategies that improve health and education, reduce inequality, and spur economic growth while tackling climate change and preserving our oceans and forests. For civil aviation, the International Civil Aviation Organization (ICAO) has mapped their strategic objectives to the UN SDGs to help define their contributions to sustainability (ICAO, 2024). Articulating the social and economic benefits of eVTOL aircraft operations based on the UN SDGs can be a strong and clear way 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 could cloud or prevent 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 and involves the development and publication of educational materials with active briefing, training, or demonstrations to the public. Educational material could be developed in the form of FAQs, brochures, and explanatory videos as examples.

- **Acceptance Focused Policy Making:** eVTOL aircraft products and operations may be more acceptable to the public by ensuring that policies and plans for eVTOL aircraft operations align 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 eVTOL aircraft policies involves ensuring that the policies are created to serve the interests and concerns of the community as a priority. Some guiding principles that may be aligned with general public interests and could be adopted are as follows:
    - Ensure that the eVTOL aircraft services promote equitable mobility for all segments of society, such as considerations for low-income communities, persons with disabilities, and the ageing population.
    - Develop flight routes and operation times that are community-friendly with the aim to reduce the signature (noise and visual) of eVTOL aircraft operations and reduce overflight of the populace.
    - Encourage the co-location and integration of eVTOL aircraft with existing transport network options to maximise benefits. For example, the location of vertiports should not exacerbate existing transportation 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 from the airworthiness authority.
    - Ensure that the development of eVTOL aircraft products and services is aligned with and helps achieve 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 the least negatively impacting or most meaningful to society. Considerations in these two approaches are as follows:
    - **Prioritise the lowest community impact missions:** Early operations could start with missions that have a less intense acoustical and visual impact on the general public (i.e., away from densely built-up urban areas). It is thought that logistics

        and enterprise applications will face fewer risks and achieve widespread adoption sooner than eVTOL aircraft passenger applications due to a lower exposure to the general public (Orbit, 2023).

        - **Prioritise meaningful use cases:** It is suggested that social acceptance would be higher for applications in health and safety domains and especially use cases that are highly meaningful to society (Aviation Studies Institute, 2024). Prioritising the introduction of eVTOL aircraft through operations such as emergency medical services, search and rescue, and disaster relief, or such as those clearly aligned with helping to achieve 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 in the communication of the benefits and opportunities of eVTOL aircraft operations. However, it could be difficult to accurately measure the economic benefits and impact of eVTOL aircraft services as they will be new, and measures will not be evident until the use cases are matured, and users have adapted to the new services. As such, studies on economic benefits and impact may need to rely more on using scenario-based analyses and simulations.

    - **Social Values and Opinions:** Social values and opinions may be used to understand social sentiments towards eVTOL aircraft operations. The measurement of public values and opinions is typically conducted through some means of public engagement (see section on “Public Engagement”). The following are some specific considerations when conducting the measurement of social values and opinions:

        - **Demographics of Studies:** In the design of social value and opinion measurement activities, methods such as surveys should be aware of the target demographics. Surveys should be careful not to be limited to favourable categories of participants, such as targeting only those in higher income brackets. Results should also consider if there are any biases due to the background of the participants. 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 have more meaningful results, the assessments of the potential reaction and/or acceptance of increasing “autonomy” should clearly present which functions are actually automated, reasons why the automation is expected to be beneficial, relevant limitations, and descriptions of human and automation authorities 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 is rich in materials available to support the systematic development of surveys to collect information from the general public. Some resources, such as handbooks and guides, are listed in Section V (e.g., Ducharme, 2020; Creighton, 2005).

- **Noise:** There are many different metrics and measurement methods for noise, and there is yet to be an international consensus on a specific metric suited for eVTOL aircraft. It is suggested that helicopter noise measurement methods could be used. Alternatively, EASA has a guideline on noise measurement of UAS lighter than 600kg that could be used as a reference (EASA, 2023).
- **Visual Pollution:** There are no standard definitions of 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 that can be categorised as being a part of academia, associations, industry, and national agencies. Each stakeholder plays a crucial role in building social acceptance, and 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 on the potential impact of eVTOL aircraft operations on industries and jobs.
	Community Associations	• Organise general public outreach programs and events to facilitate general public dialogue.
	Workers Unions	• Organise and communicate on the 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 (OEMs)**	• 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 quiet operation. • Develop and share easy-to-understand materials on eVTOL aircraft technology and its social and economic benefits and alignment with sustainable development goals.
	Operators	• Implement community outreach programmes to educate about eVTOL aircraft services. • Establish transparent communication channels for addressing public concerns. • Develop and publicise clear safety protocols and passenger experience information. • Offer trial flights or virtual experiences to build public comfort with eVTOL aircraft. • Develop services that aim to ensure social equity and achievement of global sustainable development goals. • Introduce eVTOL aircraft and services in an incremental approach to build public awareness, trust, and confidence.
	Infrastructure Providers	• Engage in early community consultation for infrastructure placement. • Demonstrate how eVTOL aircraft infrastructure can be integrated with and enhances 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 and its potential social and economic benefits and 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 risk management of eVTOL aircraft.
	System OEMs 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 Transportation Agencies**	• Develop and communicate clear, accessible safety standards for eVTOL aircraft operations. • Conduct public consultations on policies and regulations for eVTOL aircraft operations. • Provide regular updates on safety oversight of eVTOL aircraft operations to build public trust. • Demonstrate how eVTOL aircraft operations would integrate with and improves existing transport systems. • Conduct and publish studies on potential of eVTOL aircraft operations to reduce traffic congestion. • Engage the public in visioning exercises for future 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 for eVTOL aircraft operations integration, including by organising community design workshops. • Develop guidelines for vertiport placement that balance operational needs 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 on eVTOL aircraft integration to facilitate community feedback and dissemination of accurate information about eVTOL aircraft. • Develop and communicate local benefits of eVTOL aircraft.
	Technology and Research Agencies	• Develop and communicate national technology strategies and their potential social and economic benefits. • Support studies by the Academia and Industry 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

IV. ACTION PLAN

This suggested action plan outlines a strategic approach to building social acceptance for eVTOL aircraft operations and proposes a range of initiatives focusing on public participation, acceptance-focused policy-making, and public acceptance measurement in **Tables 5 to 7**, respectively. 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 based on new developments and results of public acceptance measurement.	• 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 results of public acceptance measurement.	• 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 results of public acceptance measurement.	• Aircraft OEMs • Insurance companies • Academia • Aviation and Transportation 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 Transportation 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 Transportation 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 transportation noise levels.	• Aircraft OEMs • Operators • Academia • Aviation and Transportation 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

V. REFERENCES

(**) Denotes references used in the study of key public opinion and concerns of EVTOL

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ANNEX A to PART 6

Guide to Developing Surveys for Public Engagement in eVTOL Aircraft Policy Making

This annex serves as a guide for CAAs and stakeholders to design 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 to 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, all of which contribute to the effectiveness of survey questions and the validity of the survey's findings:
    - **Define clear objectives:** Begin with a clear understanding of the purpose of gathering the information. For instance, the survey could seek to assess the public's perceptions or expectations. Defining these goals would help craft 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 words that may carry emotional weight or imply a 'correct" answer, which can skew results.
    - **Be specific and precise:** Questions should be clear about the topic and scope. Vague questions can lead to ambiguous responses.
    - **Limit the scope of each question:** Avoid questions that ask about two subjects at once, as they may confuse respondents or yield ambiguous results.

- **Pilot test the survey:** Conduct a pilot test with a small group to identify any confusing questions and ensure question clarity.

- **Types of questions to include in surveys on eVTOL aircraft operations**: Including a variety of question types in surveys is essential to gather both quantitative and qualitative data that reflects public sentiment, knowledge, and expectations. The following are some types of questions that could be asked:
  - **Close-Ended Questions:** These questions 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, measuring agreement or frequency on a scale (e.g., "Strongly Agree" to "Strongly Disagree"), could be used as options 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 more 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 questions allow further insight into specific areas. For instance, if someone expresses concern over noise, 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, helping stakeholders make data-driven decisions for eVTOL aircraft initiatives.

- **Best Practices:** The following are some best practices in the crafting of surveys and survey questions:
  - **Survey Question Structure:** Begin with broad questions such as general knowledge or familiarity with eVTOL aircraft before moving 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 can 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 miscellaneous factors. By capturing a range of community perspectives, CAAs and stakeholders may 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 on 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?

Questions related to understanding perceptions of eVTOL aircraft operations
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?
Visual Impact 29) How do you perceive the potential visual impact of eVTOL aircraft operations (e.g., crowded skies)? 30) How concerned are you about the visual impact of eVTOL aircraft operations?
Environmental Impact 31) To what extent do you believe eVTOL aircraft operations could positively or negatively impact the environment? 32) How concerned are you that eVTOL aircraft operations could negatively impact the environment?
Job Impact 33) How do you perceive eVTOL aircraft and operational impact on employment on the whole? 34) How do you perceive eVTOL aircraft and operational impact on employment in traditional industries like transportation and logistics? 35) How concerned are you that eVTOL aircraft operations will negatively impact jobs in traditional industries like transportation and logistics?
Equity, Affordability, and Accessibility 36) Do you think eVTOL aircraft services will be accessible and affordable to most community members? 37) How affordable do you think eVTOL aircraft services will be compared to existing transport options (e.g., taxis)? 38) 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

39) What benefits do you expect eVTOL aircraft to provide for your community?

40) How important is it to you that eVTOL aircraft services are introduced gradually, with comprehensive testing and regulatory oversight?

41) What information would make you feel more confident about eVTOL aircraft?

42) How important is it to you that the public is consulted in the development of eVTOL aircraft policies and regulations?

43) How often would you expect the public to be updated on eVTOL aircraft developments?

Safety

44) What safety measures would you expect to see implemented for eVTOL aircraft?

Security

45) What security measures do you expect to be in place for eVTOL aircraft operations?

Privacy

46) What privacy protections would you like to see in place for eVTOL aircraft operations?

Noise Impact

47) What steps would you like to see taken to minimise eVTOL aircraft-related noise?

Visual Impact

48) How important is it to you that eVTOL aircraft operations avoid disrupting residential areas visually?

49) How important is it to you that eVTOL aircraft operations avoid disrupting natural areas visually?

Environmental Impact

50) What environmental impacts do you hope eVTOL aircraft operations may bring?

51) What environmental standards or initiatives would you expect eVTOL aircraft operations to follow to reduce its environmental impact?

Job Impact

52) What role would you like to see eVTOL aircraft operations play in supporting local job growth?

Equity, Affordability, and Accessibility

53) How should eVTOL aircraft services address equity in service access?

54) What measures would you expect to ensure that eVTOL aircraft services are affordable and accessible to all community members?

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

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

57) Would you be interested in subscription or membership plans offering discounted eVTOL aircraft service rates?

Community Engagement and Preferred Communication Channels

58) How would you prefer to receive information about eVTOL aircraft developments and regulations?

59) How would you like to see your community engaged in decisions about eVTOL aircraft operations?

60) Would you be interested in participating in public consultations or focus groups about 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 (related to safety, security, privacy, noise impact, visual impact, environmental impact, job impact, and 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 about 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

Public Engagement Survey for eVTOL aircraft operations

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 to 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 transportation 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

Public Engagement Survey for eVTOL aircraft operations

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 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 on personal privacy?**
 ☐ Not at all concerned
 ☐ Slightly concerned
 ☐ Very concerned
 ☐ Extremely concerned

Section 4: Noise and Visual Impact

Public Engagement Survey for eVTOL aircraft operations

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 eVTOL aircraft operations-related noise? *(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 or 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 eVTOL aircraft operation's impact on employment in traditional industries like transportation 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 like transportation 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 eVTOL aircraft operation policies and regulations?

☐ 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 eVTOL aircraft operation impacts
☐ Educational campaigns on eVTOL aircraft safety and operational benefits
☐ Other (Please specify): ___________

Public Engagement Survey for eVTOL aircraft operations

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

☐ 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 on 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

Public Engagement Survey for eVTOL aircraft operations

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 understand the public's views, ensuring that eVTOL aircraft services are developed in a way that meets community needs and addresses your concerns.

1

UAS

PART 7

Technical guidance for the implementation of BVLOS UAS operations

I. INTRODUCTION

Unmanned Aircraft Systems (UAS) have evolved from remote-controlled hobby craft and consumer drones in the early 2010s, where the aircraft was flown by a person 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, sport activities, and aerial photography and videography. While operating the UAS within the visual range of the person flying the aircraft is sufficient in some cases, being able to operate the UAS beyond the visual range of the person controlling the aircraft can open opportunities for greater operational efficiencies, productivity, and economic value. As the technology and operational experiences continue to mature, these types of UAS operations beyond the visual line of sight of the operator (BVLOS) are becoming increasingly desirable.

Trials and studies of BVLOS UAS operations have been ongoing for several years since the mid-2010s, and many States already have some means to govern low risk BVLOS UAS operations (i.e., operations beyond visual line of sight but over an area sanitised and free of uninvolved persons) and have selectively approved operations with increasing levels of risk and complexity. To support CAAs in evolving and harmonising 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 regulations and procedures developed from global experiences, with a particular focus on the more advanced (i.e., higher risk and complexity) type of operations.

II. BACKGROUND

Definition of BVLOS

Although BVLOS is a relatively well-used term in the UAS industry, there are some variations in its definition globally. The main differences between definitions pertain to two elements: the type of person responsible for maintaining visual contact and the definition of visibility. For the type of person responsible for visual contact, some definitions include operators and observers, while others only consider the person behind the flight controls of the unmanned aircraft.

Regarding visibility, some definitions focus on the visibility of the unmanned aircraft, whereas some others define visibility to also include other aircraft, persons, vessels, vehicles, terrain, adverse weather, or obstacles that could be threats to the operating aircraft. A few organisations have also included the distance between the unmanned aircraft and the visual observer as a proxy to visibility. It is typical in those cases to find that BVLOS UAS operation is defined as any UAS operation that is not within a prescribed Visual Line of Sight (VLOS) distance. The VLOS distance varies between States but is said to average around 500 meters. However, VLOS distance is potentially subjective as it can vary due to several factors such as the size of the drone, the exterior colour, environmental conditions (e.g., weather or time of day), visual acuity of the person maintaining visual contact, and obstacles or terrain that 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 operating distance, and the extended range provides greater coverage for UAS services. Operational flexibility and efficiency is also potentially enhanced 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 competencies, such as:

- **Limited visual awareness:** At BVLOS distances, the unmanned aircraft no longer have the benefit of the on-site remote pilot (or observer) having or providing the situational awareness to avoid terrain, obstacles, or other aircraft. Onboard and ground systems and telemetry used to provide situational awareness will increase in criticality.
- **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 with a need to increase transmission power. BVLOS UAS operations may also be conducted beyond radio horizon distances that require the use of alternative communications means such as satellite-based communications. This can add 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 be able to provide reactive and timely emergency response to incidents and accidents.
- **Diversity of operational environments:** BVLOS UAS operations may more readily occur in and through different airspace classes, atmospheric conditions, highly populated areas, or in proximity to manned aircraft, necessitating advanced knowledge of airspace structure, reliability of the aircraft, and traffic management.
- **UAS technical complexity:** BVLOS UAS operations often involve more sophisticated UAS with advanced autopilot systems, detect-and-avoid capabilities, and redundant communication links.

It may ultimately be desirable to conduct BVLOS UAS operations in 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 require a level of design, production, and operational assurance that the UAS is able to (1) avoid collisions between aircraft and (2) maintain separation so as not to create a collision hazard.

As with VLOS UAS operations, BVLOS UAS operations will also be expected to mitigate hazards to other unmanned aircraft and persons and property when flying over populous areas.

The challenges can be further compounded by the commercial UAS industry potentially having less experience or knowledge in conventional aviation safety. The commercial UAS industry is generally dominated by start-ups, and most UAS have been developed by adapting or adopting consumer electronic parts for rapid and low-cost development. Given these traits, the conventional aviation industry's expectations of design, production, and operational safety assurance cannot be assumed. Conversely, rigidly applying existing aviation standards may drive up costs, hindering business growth and thus proving inappropriate for the industry.

Existing means of governance for BVLOS UAS Operations

There has been much effort 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 to develop a global baseline of provisions and guidance material for the proper harmonization of regulations on UAS that remain outside 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, which had promulgated an initial set of basic guidance for the safe operation of UAS within national airspace in 2019. These efforts have evolved further into the promulgation of Model UAS Regulations (Part 101, 102, and 149) and a set of advisory circulars (ICAO, n.d.b). The ICAO Model UAS Regulations can serve as useful starting points for a CAA to develop or supplement their regulations for UAS operations; however, BVLOS is only very briefly addressed in these documents.

The development of detailed regulations for BVLOS UAS operations is still an evolving landscape worldwide, with several nations having already allowed such operations, but mostly on a limited basis with special approvals or waivers and exemptions from specific requirements of existing regulations. 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 but are not yet internationally harmonised.

III. KEY CONSIDERATIONS

Advanced BVLOS UAS Approvals Management Methodology

The majority of UAS currently in operation are small or lightweight UAS, and in most States, unmanned aircraft 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.

On the other end of the risk spectrum, the conventional principles of aircraft certification, such as aircraft airworthiness design standards and certification requirements, are expected to be applied for UAS operations that have very high public and aviation safety risks. Some States have granted type certification to aircraft for specific operations. CAAs intending to faciliate advance BVLOS 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 ordinary VLOS operations but are not necessarily at the very high-risk end of the spectrum all the time. The level of risk is dependent on the combination of air risks and ground risks that can be associated with the challenges of BVLOS UAS operations such as those mentioned in Section II.

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) with prescriptive conditions that would warrant the operation to be in the category. These conditions could include, but are not limited to, the 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 is 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 JARUS is one example of such a methodology (JARUS, 2024). Similarly, the FAA's Section 44807 provides another risk-based methodology that evaluates UAS operations on a case-by-case basis, requiring detailed documentation including concept of operations, safety risk analysis, and emergency procedures to determine if the UAS can operate safely in the national airspace system. Other existing methodologies for aviation risk assessment may also be applicable according to the needs of the respective State and the operational use case that is being evaluated.

The approval of BVLOS UAS operations that are between low- and very high-risk is more commonly addressed through a *risk-based approach*. The risk-based approach involves comprehensively identifying the risks of the intended operations, establishing an alignment between the CAA and the operator regarding the risk level of the operation and necessary mitigations, and assessing and ensuring that the mitigations are sufficient and met by the operator. In this approach, the approval requirements are thus scoped 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 sufficiently 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 would need to 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 existing level 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 would typically be 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**.

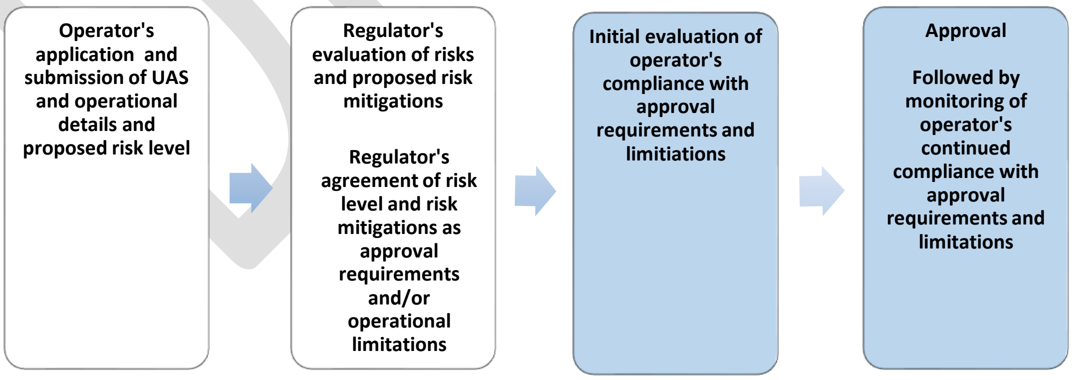

Figure 1 – Typical approvals management methodology (BVLOS UAS operations not requiring conventional certification processes)

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:

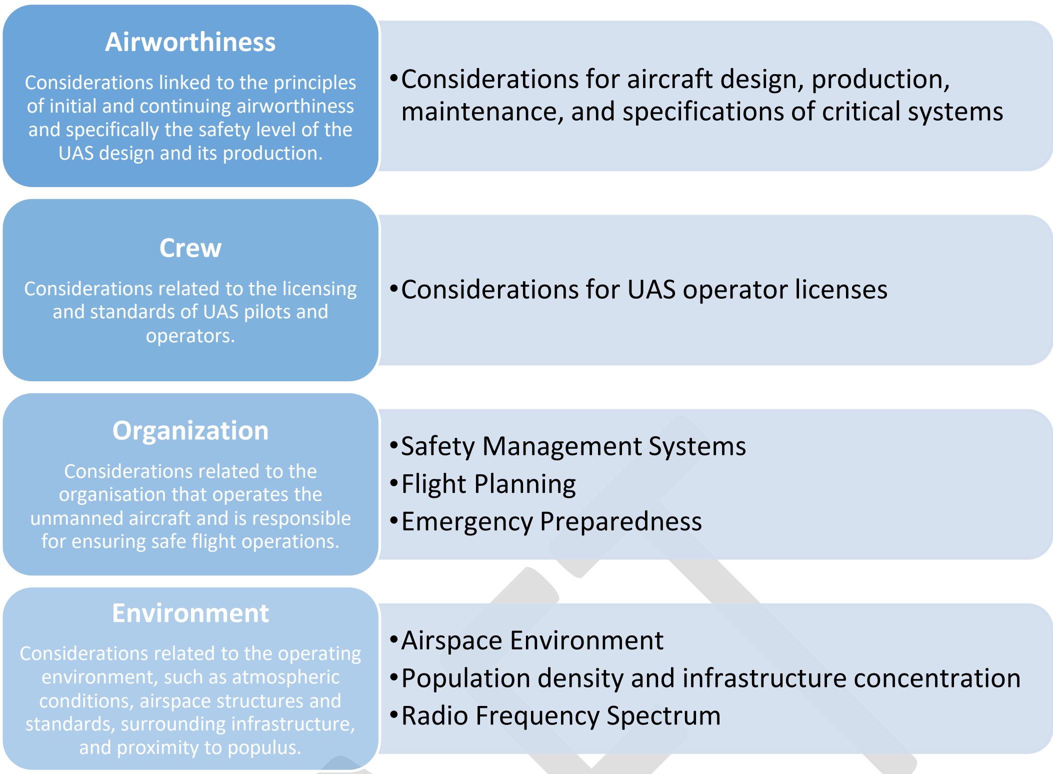

Figure 2 – Overview of Key Considerations

- **Airworthiness:** The scope of risks related to airworthiness may cover several areas, such as aircraft design, production, and maintenance, and specifications for certain critical systems. Some examples and details of areas to consider 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 that are used to mitigate certain risks (e.g., maintenance of aircraft, emergency procedures). It is crucial that the UAS crew possess the skills, knowledge, and sound judgement to execute complex operations safely and efficiently, and licensing is a common way to attest to and ensure the standards of the persons operating the UAS.

  Developing a comprehensive licensing regime can be a complex but essential task for CAAs. To keep pace with a rapidly evolving UAS sector, a licensing regime should consider flexibility and scalability to allow for 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, and some States have chosen to implement BVLOS-specific categories within their licensing ratings. Further considerations for UAS operator licences, such as the types of operations, licence categories, basic knowledge, and practical skill requirements, are detailed in **Annex D**.

- **Organisation:** In conventional air transportation, certification, validation, or acceptance of the aircraft type is followed by processes involved in ensuring that the operator is competent as an air operator to provide the type of operations they intend to engage in. These principles generally apply to UAS operations, but 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 have a higher risk, it would be important to ensure that the organisation has the adequate personnel, methods, management (i.e., organisational structure), tools and equipment, and working environment to conduct their operations reliably and safely. The following are some specific considerations related to some of the five areas of the organisation that may be more relevant for BVLOS UAS operations:

  - **Safety Management Systems:** With BVLOS UAS operations being potentially a more complex and higher-risk type of operation, the operator must have an aviation safety mindset. A Safety Management System (SMS) is a systematic approach to managing safety, including the necessary organizational 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) with guidelines on the implementation contained in Doc 9859, Safety Management Manual. For operators of BVLOS UAS operations, the SMS principles could be leveraged and proportionately applied by considering the scale, scope, and complexity of the operation.

  - **Flight planning:** An operator's procedures for flight planning of BVLOS UAS operations would need to ensure comprehensive operational risk identification and mitigation procedures, including pre-flight risk assessments addressing elements such as route hazards, weather, airspace restrictions, and population density. Flight planning procedures that consider geofencing and coordination with authorities would also help prevent unintended incursions and ensure compliance with any limits, such as altitude, speed, and visibility that may be required due to environmental conditions and UAS capabilities or as prescribed by the authorities.

  - **Emergency Preparedness:** An Emergency Response Plan (ERP) would ensure that there is a comprehensive framework for handling emergencies during BVLOS UAS operations. In an ERP covering BVLOS UAS operations, operators would designate specific roles and procedures for immediate response, including steps for transitioning between normal and emergency operations while coordinating with other airspace users. Such an ERP would 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 typically would involve assessing an operator's compliance with organisational requirements continuously throughout their operations. Governance oversight by the regulatory authority, such as audits, robust surveillance programs, 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 of these risks are determined by the nature and location of the operation and may not be 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, particularly at low altitudes. This area is continually evolving and includes the implementation of various airspace management strategies. In this, CAAs play a crucial role in engaging the ANSP 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 not be familiar with airspace classes and their complexities, zones are typically clearly marked to establish no-fly zones, restricted areas, and other airspace boundaries. These demarcations help maintain separation between manned and unmanned flight operations and allow appropriate airspace risk mitigation.

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

To implement the airspace segregation strategies, some States have deployed segregation technologies. These include surveillance systems 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 primarily 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 where there are humans on board the aircraft, the risk of fatality from a 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 for which the severity, if damaged due to a UAS incident, may be critical. However, buildings may also serve as shelters and potentially reduce the ground risk of a UAS operation. Whether buildings are considered 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.

  Developed areas often have advanced infrastructure that can enhance or support UAS operations that could help mitigate some risks. For example, mobile telecommunication networks (i.e., 3G, 4G LTE, and 5G) could be leveraged as a redundant means for UAS datalinks, and Differential GPS (DGPS) ground stations could enhance UAS GNSS-based navigation system precision.

- **Radio Frequency Spectrum:** The radiofrequency spectrum is a resource required by many industries and hence a scarce resource. High integrity and availability of Command and Control (C2) datalink (a.k.a. CNPC - Control and Non-Payload Communications) would be critical for BVLOS UAS operations but can be severely challenged in dense urban environments where the radiofrequency spectrum is heavily utilised. A study by ITU (International Telecommunications Union) had estimated that UAS could require up to 34 MHz and 56 MHz of radiofrequency spectrum for terrestrial and satellite systems, respectively, by 2030 (ITU, 2009).

  Internationally, 5030-5091 MHz has been allocated for aeronautical use at the 2012 World Radiocommunication Conference (WRC-12), and some States, such as the United States, have specifically allocated a portion of the band for UAS C2/CNPC links (FCC, 2024). Radiofrequency planning will be key for States that have yet to study the needs for their UAS operations in ensuring the effectiveness of UAS C2/CNPC links. The planning should consider that allocations at the international level 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 link availability of a single communication link would likely be insufficient to achieve expected safety levels (e.g., 99.999%), and multiple links may be required to satisfy a particular data stream, leading to greater spectrum needs.

Some analyses have considered whether new radiofrequency bands could be used for UAS C2/CNPC link requirements. So far, some studies 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 able to adequately support 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 a risk assessment has already been carried out for a particular operational scenario, could therefore be potential references. The operational scenarios are typically defined according to the type of mission (e.g., agricultural works, short-range cargo operations, surveillance) with conditions on the type of airspace and ground environment that the UAS is operated in. JARUS has been working on several PDRAs (JARUS, 2024b), and EASA has adopted a few as an acceptable means of compliance with their regulatory requirements (EASA, 2024). As additional examples and references of precedence, some States have contributed their past experiences in BVLOS UAS approvals for this publication. The example use cases are detailed in **Annex E**.

IV. ACTION PLAN

It is assumed in this section that in wanting to manage higher-risk BVLOS UAS operations, CAAs already have UAS regulations to manage basic operations. Else, CAAs may wish to consider referring to ICAO Model UAS Regulations and Advisory Circulars (ICAO, n.d.b.) to establish their basic regulations first.

An effective means of governing higher-risk BVLOS operations would address and mitigate any new potential hazards of such operations, and the overarching goal is therefore to determine and implement requirements unique in mitigating these new hazards. These new requirements could be implemented as adaptations or additions to the existing UAS regulations or, as an alternative, some CAAs have promulgated the requirements through supplementary documents such as advisory circulars.

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

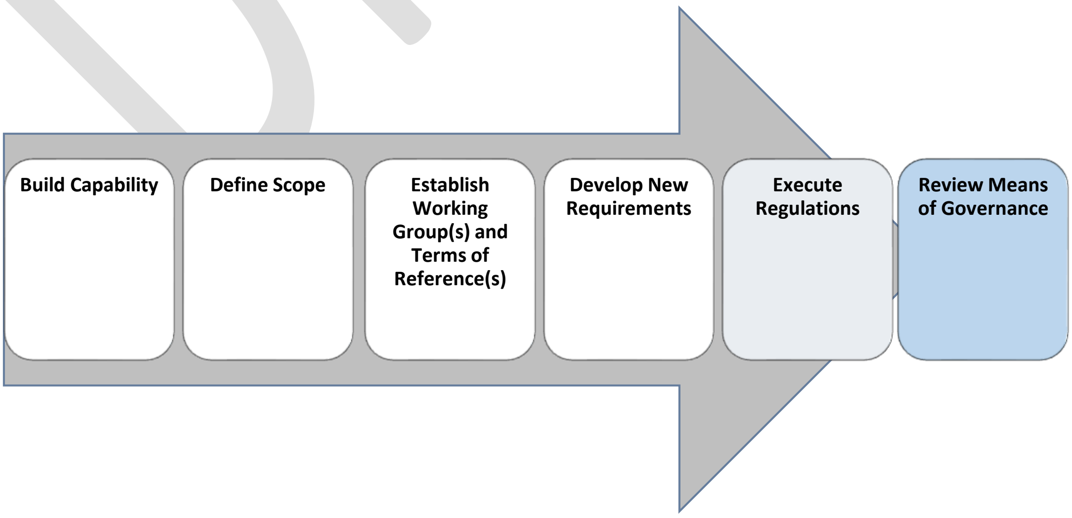

Figure 3 – Action Plan: Adapting existing manned aircraft regulations

- **Build Capability:** The identification of requirements that ensure public and operational safety and mitigate the hazards and risks of higher-risk BVLOS UAS operations will be more effective if the CAA personnel assigned to this task have 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 supporting BVLOS UAS flights and operating scenarios 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 that would lead a UAS operation to be considered as higher-risk BVLOS will greatly facilitate the steps in developing new regulations to govern such operations. The set of 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 it has not yet been established. These conditions will form the basis of the applicability of the new requirements that are introduced to the set of UAS regulations. Some methods to determine risk categories are discussed in Section III.

- **Establish Working Group(s) and Term of Reference(s):** The next step involves establishing a working group dedicated to completing the ensuing set of steps in the process. CAA personnel appointed to this working group would be expected to have 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 which would then be formed as new requirements. There are multiple methods that could be used to develop such a list, including, for example, brainstorming or a function-based analysis. Some key areas that may require new requirements are detailed in Section III and recapped as follows:

  - Airworthiness (UAS design and production – **See Annex C**)
  - Crew (Licensing of standards of UAS pilots and operators – **See Annex D**)
  - Organization (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 according to the process of their respective State. This may include activities to detail acceptable means of compliance with the new requirements and supporting the development or adoption of industry standards that could be used as a means of compliance. The CAA will also be expected to undertake the responsibilities for processing approvals, monitoring compliance, and enforcing compliance in this step.

- **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 continue to adequately mitigate the hazards and risks of such operations.

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ANNEX A to PART 7

Worldwide means of BVLOS UAS operations governance

The following is a compilation of a select few means of governance by CAAs for BVLOS UAS operations. As shown, the means of implementation are varied and tailored according to the individual States' needs and regulatory structure. 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 have tailored their BVLOS regulations specifically to address the risks to air navigation.

Regulator (Reference)	**BVLOS Unmanned Aircraft Operations Governance Approach**
CAA China (CAAC, 2023)	• In accordance with "Interim Regulations on the Flight Management of Unmanned Air Vehicles" National Decree No. 761, effective as of 01 January 2024, BVLOS flights are generally allowed except for micro-unmanned aircraft (empty weight less than 0.25 kg, maximum altitude of 50 m, flight speed less than 40 km/h) which may only be flown 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 a Special UAS Project (SUP) approval. Applications for an approval are based on a risk assessment adopting the methods of SORA from JARUS.
CAA NZ (CAA NZ, 2015)	• Allowed for an operator that has an Unmanned Aircraft Operator Certificate according to Part 102. In accordance with AC102-1, operators must identify the airspace class to be used and associated requirements and how they will be met, have the 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 to a set of requirements categorized into the areas of General, Operational, Software, Communication, Navigation, Detect and Avoid, Structural, Propulsion, Failure Management, and Others. The requirements are progressively detailed according to the level of risk (low to high) and are aimed at addressing ground risks, air risks, and 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 over controlled ground areas with a low probability of encountering manned aircraft. • Allowed as a privilege to a Light UAS Operator Certificate (LUC) holder in accordance with Annex to Implementing Regulations EU 2019/947, Part C. UAS for operations at SAIL V and VI must have an EASA TC and operations at SAIL III and IV may be subject to an EASA TC.

Regulator (Reference)	BVLOS Unmanned Aircraft Operations Governance Approach
FAA (FAA, 2023)	• Allowed for Part 107 (Commercial UAS) operations with a waiver (7711-2 form) by showing an equivalent and acceptable level of safety required for various 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). Not for the carriage of property of another by 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 case-by-case approval for certain UAS operations using a risk-based approach. • Type certification pathway available through "special class" category under §21.17(b), using a "durability and reliability" (D&R) process to establish certification criteria.
JCAB (JCAB, 2022)	• Flight permissions 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 operators must 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 in isolated areas or populated areas that are dispersed at a density of less than 5 persons per square kilometre and in atypical airspace or controlled airspace. Applicants must submit several details (e.g., of the company, of the UAS, of the desired operations) and demonstrate the ability to perform the operation without adversely affecting aviation safety or the safety of any person, as well as complete and submit 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 being at least equivalent to the ability of a pilot to 'see and avoid' potential conflictions (i.e., 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).

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ANNEX B to PART 7

UAS Target Level of Safety

To satisfy the requirements for safety levels, the general existing practice in the aviation industry and for commercial aircraft certification is to complete a safety analysis of all aircraft systems to determine the effect on the aircraft of a failure condition or malfunction. To establish the rational probability values representing an acceptable level of risk, the target levels of safety were developed based on historical evidence of the rate of serious accidents due to operational and airframe-related causes. In general, it was determined that such accidents occur at a rate of one per million hours of flight, of which 10 percent were attributed to failure conditions caused by system problems. Therefore, it was generally considered that the probability of a serious accident from all such failure conditions should be no greater than one in ten million flight hours (probability of less than 1×10^{-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 1×10^{-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 is not uncommon to see target levels of safety such as $1\text{x}10^{-6}$ for an overall accident rate, $1\text{x}10^{-7}$ rate of accidents due to aircraft failure or malfunction, and $1\text{x}10^{-9}$ for individual aircraft system level failure probabilities. However, the operational and hazard conditions for UAS may be different from manned aviation - there are typically no passengers carried onboard UAS, and the UAS may be operating in areas where it is not a significant hazard to the ground or users of the air. These result in adaptations in the 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 condition.

Risk Definition		**Target level of Safety**
Ground Risk		Less than one fatality per million hours ($1\text{x}10^{-6}$ 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 ($1\text{x}10^{-7}$ mid-air collisions per flight hour)
Air Risk	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 ($1\text{x}10^{-9}$ mid-air collisions per flight hour)

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

I. ANNEX REFERENCES

ICAO (2014), Airworthiness Manual, Doc 9760, AN/967, Third Edition, International Civil Aviation Organization, 2014.

JARUS (2024), JARUS Guidelines on Specific Operations Risk Assessment (SORA), Edition 2.5, 13 May 2024.

ANNEX C to PART 7

Airworthiness Considerations for UAS Risk Assessment

I. 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 the systems in its design that are critical for the safety of operations. Flight-critical systems are 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 of 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, and a common understanding between the CAA and the UAS operator is always desirable for more effective and holistic risk assessment and mitigation.

Standards could be leveraged as an acceptable means of complying with UAS design risk mitigation measures. 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 communications. 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, standard practice standards specify procedures on the conduct of operations. There are several standards development organisations that have developed standards for UAS systems and operating procedures, 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:

- **Design-based approach - Demonstrating compliance with requirements:** This approach involves defining design requirements and means of compliance and requires a close review of the UAS design and system architecture. It is a more common approach in UAS airworthiness design assessment and could leverage the combination of interface standards, test method standards, and standard practices as the means of compliance.
- **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 could 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 may also need to be demonstrated to ensure interface error protection and that maintaining situational awareness and control of the UAS is easy for a remote pilot.

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 for operators and UAS manufacturers. Some States, particularly those that certify UAS, have developed manufacturing standards to ensure quality control in UA production.

For instance, China has adopted an outcome-based approach that requires all UAS to undergo specified test cases before leaving the manufacturing facility (SAPRC, 2023). Japan has developed uniformity standards, mandating UAS operators or manufacturers to demonstrate compliance with requirements covering manufacturing and storage facility procedures, personnel training and competency, management of materials and equipment, and inspection and acceptance processes and criteria (JCAB, 2022). For UAS operating at SAIL III and above, EASA has prescribed the need to demonstrate compliance with UAS manufacturing requirements as described in JARUS SORA Annex E, OSO #02 (JARUS, 2024).

These examples may be used as guidance for UAS manufacturing standards. Stringent control on manufacturing will help assure that each produced UA conforms to the initially assessed UA design. Therefore, the level of manufacturing control directly impacts the consistency and reliability 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, necessitating more effort to establish clear maintenance requirements. It's important to note that unlike manned aircraft, typical UAS have a much shorter life cycle of a few years, suggesting that maintenance requirements may not need to be as extensive.

Comprehensive maintenance instructions for UAS checks would be part of 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 would be kept as a record of all conducted maintenance.

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

II. 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 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. Unless proven reliable through good 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, navigation and flight control are fundamental to ensuring safe flight. Most UAS navigate using Global Navigation Satellite Systems (GNSS) and Inertial Navigation Systems (INS), while flight stability and control rely primarily on autopilot systems.

Most performance-based requirements for navigation and flight control systems consider two aspects: the ability of the UAS to stay within its defined area of operation and its positioning accuracy. The most common means of compliance 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. Factors such as the nature of the mission, the operating environment, and the potential consequences of positioning errors would also need to be considered.

To meet the higher safety objectives of high-risk operations, UAS designs may employ system redundancies to improve 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 to assessing the adequacy of the navigation and flight control system is to identify the layers of mitigations should there be 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 and not many UAS operators develop their own flight control systems. Instead, commercial off-the-shelf flight control systems can be commonly found in UAS due to their availability and low cost. 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 configuration changes may require reassessment and requalification.

Command and Control (C2)/Control and Non-payload Communications (CNPC) Link

The communication system providing UAS health data and/or for the command of the UAS could also be 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 of C2/CNPC datalinks to assess and ensure that it is suited for the operation. There will typically be local restrictions on C2/CNPC datalink frequency and output power that would have to be considered. It is important to note that link performance can be a function of its operating environment, and as such, 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 can be vulnerable to cyberattacks such as data spoofing, modification, or jamming that lead to unauthorised access, use, and/or exploitation of the UAS. Security/cybersecurity risks are therefore important elements to consider such that adequate controls, measures, processes, and practices are in place to ensure confidentiality, integrity, and availability of critical functions of the UAS.

Detect and Avoid (DAA) System

Detect-and-Avoid (DAA) systems can be critical systems if they are used as the primary means to mitigate the risk of collisions with aircraft and/or terrain. A DAA system allows UAS to detect aircraft or obstacles in the vicinity and take or advise a remote pilot to take evasive actions.

DAA system designs could use several different types of detection sensors, such as optical cameras, infrared cameras, radar, ultrasonic sensors, and LiDAR. These sensors monitor environmental changes around the aircraft and calculate obstacle position, speed, and direction in real-time, enabling the computation of avoidance strategies. Optical and infrared sensors are commonly used on small UAS but may perform poorly in degraded visual environments (e.g., low visibility, high humidity, 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.

There is significant progress in detection technologies and algorithms, but there is still much work required to mature and have an 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 from the remote pilot, may be designed to operate via a Ground Control Station (GCS). A GCS typically contains a remote pilot station (RPS), where the unmanned aircraft can be controlled by a human, along with other systems and functions to manage the UAS flight operation (e.g., mission planning). Depending on the design of the UAS, the RPS may have a critical role in ensuring the safety of flight, and it would be necessary to identify and mitigate risks arising from operating the RPS/GCS.

Some 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 unmanned aircraft (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 UTM, cloud storage services, or APIs 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 human/pilot inputs. Aside from the computing hardware, the software and firmware design and logic of automated functions are critical to ensuring the safety of operations. Conventional aviation practices would refer to RTCA/DO-178 (RTCA, 2011) for software design assurance and certification; however, the lead time required to demonstrate compliance with this standard can be long. Software Design Assurance Levels (DALs) should be practically applied to UAS and be appropriate for the level of risk 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 as a means of compliance 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.

III. ANNEX REFERENCES

ASTM (2020), Standard Practice for Development of a Durability and Reliability Flight Demonstration Program for Low-Risk Unmanned Aircraft Systems (UAS) under FAA Oversight, F3478-20, 01 Oct 2020, DOI 10.1520/F3478-20.

ASTM (2022), Standard Specification for Verification of Aircraft Systems and Equipment, F3153-22, 07 Apr 2022, DOI 10.1520/F3153-22.

JARUS (2024), JARUS guidelines on SORA: Annex E – Integrity and assurance levels for the Operational Safety Objectives, JAR-Del-SRM-SORA-E-2.5, 13 May 2024.

JCAB (2022), UAS Airworthiness Inspection Manual for inspections of unmanned aircraft systems against Safety and Uniformity Standards for UAS Type Certification, Circular No. 8-001, 02 Dec 2022.

RTCA (2011), Software Considerations in Airborne Systems and Equipment Certification, DO-178C, 13 Dec 2011.

SAPRC (2023), The Standardization Administration of the People’s Republic of China, Industry Standard for the People’s Republic of China, Safety requirements for civil unmanned aircraft system, GB 42590-2023, 23 May 2023.

ANNEX D to PART 7

Crew Licensing Considerations

The increased complexity of BVLOS UAS operations would necessitate 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 specialized 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, will 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 specialized missions, each with unique challenges and risks. These may be formed 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 (including swarming)
- 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. Particular 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, and a system for regular updates to the curriculum would 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 flight 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 UTM 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 of permitted operations. Furthermore, the frequency of medical assessments or whether self-declaration is sufficient could be tailored according to the level of risk of the UAS operation.

Fulfilling 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 judgement with the desire to foster innovation and career development in the UAS industry. A clear definition of the minimum age for solo BVLOS UAS operations as well as any upper age limits or additional requirements for older remote pilots may therefore be desirable. For many States, 18 years is the minimum age for commercial UAS operations; however, some States allow younger pilots to operate under supervision.

Experience level may be an alternative to age requirements; however, how prior experience is credited (e.g., VLOS operations, manned aviation) would need to be determined. The following are some considerations if using experience level as a criterion:

- Minimum hours of VLOS operations 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 the standard of BVLOS UAS remote pilot proficiency and knowledge. The scope of examination and assessment would typically include theoretical examination and practical assessment.

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

Practical assessments are in-person flight tests with a qualified examiner and could likewise include scenario-based assessments to test proficiency in normal and emergency procedures. In practical assessments, clear and systematic assessment criteria (i.e., standardised checklists, test tolerances, and passing standards) may help ensure that there is the same level of assessment standard between examiners.

A common practice for examinations and assessments is to have a regime to approve training organisations that could then conduct the assessments on behalf of the regulators to help cope with industry demands.

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 for BVLOS UAS licences or ratings. Instructors and examiners would be expected to be licensed UAS instructors and examiners that have a requisite qualification 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 standards to check for proficiency. However, until an initial cohort of instructors and examiners is qualified, transitional measures would need to be considered to allow the use of prior experience of existing UAS instructors and examiners as the means to obtain a BVLOS UAS instructor or examiner rating or qualification.

Licence Issuance and Renewal

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.

Having several different and special types of BVLOS UAS operations, a graduated licensing system may be more suited for BVLOS UAS remote pilot licences and qualifications. In a graduated licensing system, UAS remote pilots would progressively gain 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.

I. ANNEX REFERENCES

ICAO (2022), International Standards and Recommended Practices, Annex 1 - Personnel Licensing, Fourteenth edition, July 2022.

ANNEX E to PART 7

BVLOS UAS use cases

The following are several use cases that have been compiled as examples of the risk assessment and risk mitigation measures for BVLOS UAS operations that were approved through a risk-based approach. Seven use cases are presented with the general synopsis of the use cases as shown below. The risks that were identified in the use cases and risk mitigations are summarised in **Tables E-1 to E-7**:

- **Food delivery to offshore island (Japan):** A BVLOS UAS operation was conducted for food delivery about 2.3 km from a supermarket in the central area of a town to a square near the 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 no higher than 45 meters above ground level 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 ground control station (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 above ground level and within a US Air Force Warning Area.
- **Offshore oil rig sub-platform inspection (Thailand):** A BVLOS UAS operation was carried out to conduct inspections of the structural integrity and condition of an offshore oil and gas sub-drilling platform located within 10 km of the 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 above ground level 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 below 400 ft AGL and were not permitted near aerodromes or helicopter landing sites (SORA Air Risk Class B). The UAS was a small, 7 kg drone, custom designed for the mission. 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 mountain 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 above ground level and within uncontrolled Class G airspace.

- **Pipeline gas inspection using nested drone (Malaysia):** The deployment of nested drones for pipeline gas inspection in Malaysia enhances efficiency, safety, and accuracy while ensuring compliance with the Specific Operations Risk Assessment (SORA) framework and Civil Aviation Directive (CAD) 6011 Part V. Launched from mobile docking stations, these drones autonomously inspect pipelines for patrolling and structural defects using advanced sensor technology. By minimising human risk, reducing downtime, and improving data collection, they offer a more effective inspection solution. Operations will be conducted at a maximum altitude of 400 ft AGL across all locations within Class G airspace.

Food delivery to offshore island (Japan)	
Risks	**Risk mitigations**
• **Airworthiness:** ○ Medium sized drone (<25 kg). ○ "PF2-CAT3" drone designed to be operated BVLOS and over sparsely populated areas. ○ A malfunction of the aircraft was discovered during preliminary checks of the contents of the flight permit/approval application. • **Crew:** ○ The first Category III flight (Level 4 flight, flight over people) for this crew. • **Organisation:** ○ 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). ○ Over sparsely populated area operation with low risk to human life. Local residents represent the primary ground risk. ○ 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 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 based on SORA (Safety Operational Risk Assessment) 2.0. • Following the issuance of Service News (five cases) by the manufacturer, we verified that operational procedures were reflected in the necessary manuals to ensure flight safety. **Supplementary Risk Mitigations:** • **Airworthiness:** ○ UAS required to show compliance with airworthiness criteria (durability and reliability requirements). • **Crew:** ○ Effectively utilise the company's (manned aircraft airline's) training policy, including CRM training. • **Organisation:** ○ Effectively utilise the company's (manned aircraft airline's) policy and know-how, including the creation and compliance of regulations. • **Environment:** ○ Issuing of NOTAMs specifying operation time, location, and operator contact information. ○ Advance notification of flight plans to manned aircraft organisations. ○ Obtained airspace use permission from the U.S. Navy via Okinawa Defense Bureau to reduce air risk. • **Others:** ○ 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-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). ○ Category 2 UAS (7 kg < MTOW < 25 kg) in Aviation Safety Act Implementation Regulations Article 306. ○ In-house developed UAS to operate for package delivery. • **Crew:** ○ Lack of specific qualifications for the flight environment and operation type. • **Organisation:** ○ Not familiar with Aviation Safety Management Systems (SMS) for drone operations. • **Environment:** ○ Flight crew's lack of situational awareness. ○ Potential risk associated with sharing airspace with operations (e.g., helicopters, UAS, etc.). ○ Flying over people on the island when delivering to and from islands.	**General:** • Approved BVLOS operation 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, etc. ○ UAS must be equipped with fail-safe features (e.g., return-to-home), collision avoidance, and location transmission functions to determine the UAV's position in the event of a crash. ○ 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 alert information of equipment malfunction. • **Crew:** ○ Required Flight Crew License based on the UAS's MTOW (Category 1-4). ○ Required to pre-flight check, including flight path, operation environment, obstacle conditions, etc. • **Organisation:** ○ Establish an emergency response manual that includes the following: ▪ Emergency response procedure. ▪ Reporting procedure. ▪ Agency information related to emergency response (e.g., local fire stations, medical centres, police stations, and so on). • **Environment:** ○ Mandating an observer on the planned flight path who can visually monitor the UAS during its operation. ○ Allowable altitude was 500 ft. ▪ Required reporting to ATC and issuing NOTAM if higher operations. ○ Considering potential conflicts with other operators, the flight route is approved. ○ Designating a specific flight path. ○ Restricting take-off and landing spots to wide, obstacle-free areas and ensuring they are not accessed by the general 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) ○ "PF2-CAT3" designed to be operated BVLOS and over sparsely populated areas. • **Crew:** ○ Human error by the crew for the second Category III flight (Level 4 flight, flight over people). • **Organisation:** ○ Not familiar with the basic concepts of aviation safety, including Aviation Safety Management Systems (SMS). • **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 represent the primary ground risk. ○ The purpose of the flight is to deliver medicines. ○ Operation from a remote operating base.	**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 based on SORA (Safety Operational Risk Assessment) 2.0. **Supplementary Risk Mitigations:** • **Airworthiness:** ○ UAS required to show compliance with airworthiness criteria (durability and reliability requirements). • **Crew:** • By having pilots and other related parties take CRM training provided by manned aircraft airlines, safety was ensured as an effort to reduce human error. • **Organisation:** ○ By having pilots and other related parties take CRM training provided by manned aircraft airlines, safety was ensured as an effort to reduce human error. • **Environment:** ○ Issuing of NOTAMs specifying operation time, location, and operator contact information. ○ Operator must comply with the requirements of guidelines for the transporting of medical items issued by the Ministry of Health, Labour and Welfare (MHLW). ○ Changed the previous operational system. By clarifying the division of roles between local personnel and personnel at the remote operation base and simulating flight operations in advance to ensure safety. • **Others:** ○ 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). ○ In-house developed “drone-in-the-box” UAS designed to be operated BVLOS. • **Crew:** ○ Inadequate Handling of Environmental Challenges such as high-speed wind. ○ Failure to Manage Offshore-Specific Hazards due to Insufficient Emergency Response training. • **Organisation:** ○ Not familiar 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 encounter risk due to helicopters regularly operating at low altitudes in offshore environments. ○ Air Risk Class ARC-b iaw 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) represent the primary ground risk. ○ Oil rig infrastructure may overlap with UAS flight paths due to height and range of motion, cause EMI to UAS communications and navigation systems, or be a risk to 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:** ○ UAS required to show compliance with design and testing standards, have redundancy in critical systems, have 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, including manufacturer-provided training and instruction tailored to the offshore environment. ○ Regular evaluation and continuous learning programs to reinforce safety and operational effectiveness. ○ Training on handling emergencies and operational complexities specific to oil rig environments. • **Organisation:** ○ Implementation of robust safety management systems tailored to offshore UAS operations. ○ Proactive risk assessments specific to oil and gas environments. ○ Establishment of clear communication protocols with offshore helicopter operators and platform personnel. • **Environment:** ○ 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 was required to have direct communication with offshore helicopter operators to coordinate schedules and avoid overlapping operations. ○ Procedures – UAS operator required to establish procedures for oil rig platform crane operator during UAS flight operations. ○ Issuing of NOTAMs specifying operation time, location, and operator contact information (taken from PDRA-05). ○ Implementation of geofencing around sensitive zones (e.g., oil rigs, vent flares). • **Others:** ○ Use of 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 suburban environment (Australia)	
Risks	**Risk mitigations**
• **Airworthiness:** ○ Small size drone (<3 m / 7 kg). ○ UAS custom designed 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 a HLS. ▪ No flights within 1389 m of a 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 adapted to the level of automation. Remote Pilot Licence required as a minimum. • **Organization:** ○ 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:** ○ UAS operated in an underutilized 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 are notified of UAS operations through outreach, 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 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 takes into account airspace restrictions, known obstacles, aircraft performance and other UAS (through strategic conflict detection via a UTM system). Pilot cannot take direct control of the aircraft and only command a land now.

Table E-5: BVLOS UAS Use Case – Package delivery in suburban environment

Package delivery in the suburbs (Japan)	
Risks	**Risk mitigations**
• **Airworthiness:** ○ Medium sized drone (< 25kg) ○ "PF2-CAT3" designed to be operated BVLOS 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:** ○ Not familiar with the basic concepts of aviation safety, including Aviation Safety Management Systems (SMS). ○ Unclear whether the operational arrangements in place, including emergency response plans, 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 represent 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 is based on SORA (Safety Operational Risk Assessment) 2.0. **Supplementary Risk Mitigations:** • **Airworthiness:** ○ UAS required to show compliance with airworthiness criteria (durability and reliability requirements). • **Crew:** ○ The manufacturers provided training programs that can be implemented prior to obtaining type certification and UAS certification. • **Organisation:** ○ Concerning emergency response plans, etc., the necessary items were thoroughly discussed, and the plan was made, including considerations for safety. • **Environment:** ○ Issuing of NOTAMs specifying operation time, location, and operator contact information. ○ Advance notification of flight plans to manned aircraft organisations. • **Others:** ○ 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
  ○ 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:**
  ○ Geographical obstacles
  ○ Airspace height limitation
	General:
	• Adoption of Specific Operation Risk Assessment (SORA) 2.0 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 required with design and testing standard approved by Standard and Industrial Research of Malaysia (SIRIM) which a conformity body on testing the safety standard requirement for the electronics equipment, and Malaysian Communications and Multimedia Commission (MCMC) as the frequency of the drones need to adhere the allowable frequency to operate the drones in Malaysia.
	• **Crew:**
	  ○ Required Remote Pilot Certificate of Competency Basic (RCOC - B) with Module 1 - Extended Visual Line of Sight (EVLOS) which is highlighted in the CAD 6011 Part V as a requirement for the operator to conduct the operation.
	  ○ The remote pilot and personnel for the operation needed to have training from the UAS manufacturer on the operation, maintenance, and system for the UAS. Also, Oil and Gas Training Passport (OGSP) and other related training for the operation were required.
	  ○ Schedule for the remote pilot to operate the UAS to prevent fatigue or mishandled of UAS during the operation
	  ○ Health monitoring protocols to ensure operators are fit for duty
	• **Organisation:**
	  ○ Standardised Standard Operating Procedures for the operation of UAS, which have been reviewed by the Authority and the stakeholder for the operations
	  ○ Preparing related documents for the operation, such as Concept of Operations, Specific Operation Risk Assessment, and related manuals for the operations
	  ○ Implementation of aviation standards for the Safety Management Systems for the operation.
	  ○ The flight operation manual needed to adhere to the requirements that had been set by the Authority
	  ○ The aircraft maintenance manual needed to adhere to the requirements that have been set by the Authority and the maintenance guidelines that have been set by the manufacturer
	  ○ Preparing adequate incident action plan and emergency response plan for the operation
	• **Environment:**
	  ○ The familiarisation with the environment and obstacles needed to be conducted by the remote pilot before the start of any operation
	  ○ Evaluation of Ground Risk Class (GRC) from the operator with indication of the ground population
	    - Ground risk buffer to adhere to the 1:1 rule
	    - Operational volume, which is composed of the flight geography and the contingency volume
	    - Geofencing at the area of operation
	  ○ Evaluation of Air Risk Class (ARC) from the operator with indication of the UAS operating height (e.g., operation for UAS will be in the uncontrolled airspace below 400 ft AGL, thus the ARC will fall under ARC c
	    - Issuance of NOTAM for the UAS operation
	  ○ Determining the Specific Assurance Integrity Level (SAIL) based on the final GRC and ARC value

Table E-7: BVLOS UAS Use Case – Pipeline gas inspection using nested drone

PART 8

Capability building (UAS Personnel Training)

I. INTRODUCTION

Commercial UAS have become quite extensively used in a wide range of new airborne services beyond commercial air transport and employ leading-edge technologies in aircraft electrification and automation. UAS operators are also unique, being dominated by start-ups that do not necessarily have conventional aviation backgrounds. These unique traits of the UAS industry require CAAs to adapt their existing capabilities to be able to effectively carry out their responsibilities as a regulatory body. This part aims to specifically highlight potentially new qualifications and training for CAA personnel that may help the regulator in overseeing and ensuring the safety and security of UAS operations.

II. BACKGROUND

The CAA is a statutory authority that is responsible for overseeing the regulation of civil aviation within its country and aviation activities that occur within its airspace in compliance with ICAO SARPs. The key functions of the CAA are thus to identify aviation safety risks, develop mitigations to the aviation safety risks through regulatory response, advice, or guidance; draft rules where a regulatory response is required; issue approvals; monitor compliance; and take actions to enforce the regulatory requirements. A CAA may also be involved in the safety investigation of aircraft accidents or build and operate airports, although in many countries these responsibilities are undertaken by a separate institution. To enable the CAA to carry out these functions, the CAA must therefore have personnel that is able to oversee airworthiness and environmental protection, crew standards, air operations, aerodrome operations, air traffic management, and air navigation services.

UAS design, industry, and operations are different from conventional manned aviation. UAS aircraft designs evolved from radio-controlled hobby aircraft, and with an industry that is dominated by start-ups seeking to rapidly adapt or adopt consumer, prosumer, or general industrial hardware and systems for low-cost solutions. The type of operations and flying environment of a UAS are also such that technologies in aircraft propulsion, navigation, communication, and situational awareness that are not commonly applicable or used for commercial aircraft are employed. The desire for size, weight, power, and cost (SWaP-C) optimisation can also lead to the use of new technologies not yet fully understood or matured to a point where there is sufficient knowledge and standards in the aviation industry. These differences are such that 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.

III. KEY CONSIDERATIONS

Understanding that there is a difference between UAS and existing manned aviation, this section provides considerations and details of where the gaps may be for existing trained CAA safety inspectors. It is assumed that such personnel already have basic knowledge or experience in aviation regulations, airworthiness, safety management systems, and flight instruction for conventional aviation, and thus it focuses on describing how the type of UAS operations and technology can affect the expectations of knowledge and skills 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. While initially used predominantly for personal and then commercial aerial photography and videography, the developments in UAS technology have enabled such aircraft systems to become quite extensively used in a wide range of other commercial applications. Some examples of commercial UASapplications 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 need dedicated aerodromes and could be operated from almost any location that is clear and big enough for take-off and landing. This versatility allows UAS to serve a wide range of applications in diverse environments. Moreover, most UAS missions fly close to the ground or 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 is still subject to some limitations. UAS operations are subject to local approval and may be limited 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), nor does it need to be in 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 have a broadened range of knowledge related to the operating environment and technologies used at low altitudes. These could include, for example, local and micro-weather, navigational and communication systems performance and coverage 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 UAS principally evolved from radio-controlled hobby aircraft, while the other extreme could comprise larger UAS that could go all the way up to unmanned versions of existing conventional aircraft. Although the principles and design of UAS and its flight controls may be like conventional aircraft and helicopters, the performance flight 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 that it is designated to undertake.

The specific systems that are used in commercial UAS are also typically unique from conventional aircraft systems. Low cost and weight are often key design goals for commercial UAS and crucial for their diverse applications and operational flexibility. This leads to a preference for size, weight, power, and cost-optimised systems that are not qualified per 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 (EVs), are significantly different in composition and construction. These present 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) could also be used on UAS. It can also be expected that UAS employ automation technologies that are well in advance of conventional aircraft. The means for qualification or certification for advanced automation, especially if artificial intelligence is employed, is still an emergent topic in the aviation industry that may require more 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 also means that it would need to employ 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 services such as cloud storage and APIs for weather, map, or terrain data. The reliance on digital services for essential functions of the UAS raises expectations of 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, are looking at incorporating 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 hope to use 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 for the UAS design and technologies employed may be inappropriate and does not add additional value to ensuring the safety of UAS operations, especially when the operational risks are low. The approaches to airworthiness governance may therefore be different for UAS operations as compared to manned aviation, such as the use of a risk-based approach instead of a certification approach. Some airworthiness considerations for complex and higher-risk UAS operations (i.e., higher-risk 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 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 would be 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 DAA capabilities, geographical and topographical considerations, and infrastructure.

IV. ACTION PLAN

Developing and implementing individual training plans

The responsibilities of a 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 risk mitigation measures.
- Developing UAS safety risk mitigations through regulatory response, advice, or guidance.
- Assessing and issuing approvals.
- Overseeing UAS operator compliance and taking actions to enforce regulatory compliance where required.
- Safety investigation or support thereof for serious incidences and accidents.

The competencies that could support the above activities have been discussed in Section III 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 these ends, CAAs may consider using the process as shown in **Figure 1** to help develop and implement a tailored training program for individual CAA personnel.

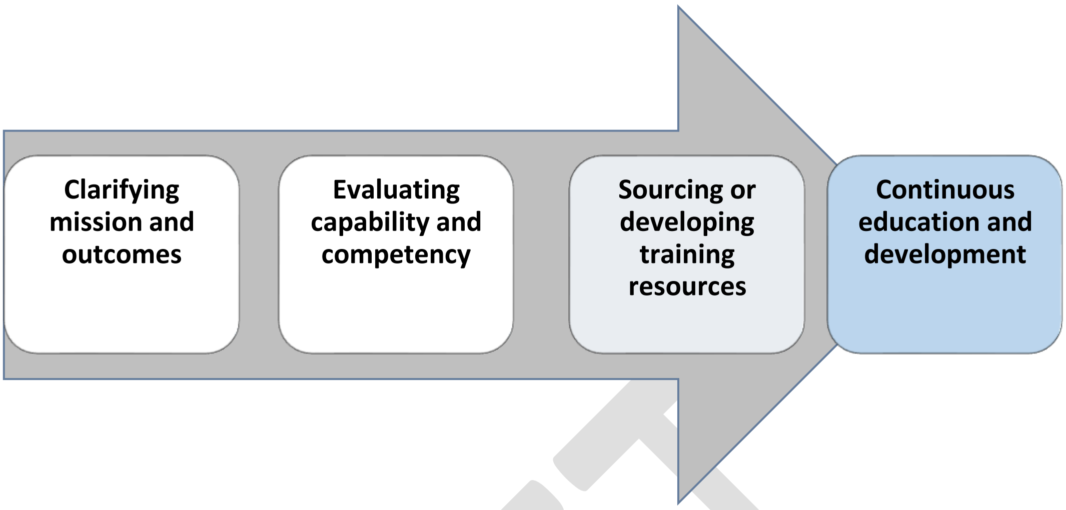

Figure 1 – Action Plan: Adapting existing manned aircraft regulations

The four-step process is detailed as follows:

- **Clarifying mission and outcomes:** A high-performing staff is one that successfully achieves objective outcomes specific to their role 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 their role exists to help set the context of outcomes and competencies. This should then be followed by a list of specific desired objective outcomes that the staff 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 for the staff. The results can then be formed into a training plan that can be implemented for the staff.

- **Sourcing or developing training resources:** The steps of clarifying missions and outcomes and evaluating capability and competencies should be repeated for all staff as necessary. Once the exercise has been completed, the collated results provide an overview of training programs 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 an adjustment of 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 reasons to not recommend the course. 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**.

V. REFERENCES

ICAO (2024), Training, https://www.icao.int/training/Pages/default.aspx

ANNEX A to PART 8

Expected competencies of UAS Safety Inspectors

The following are lists 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

I. BASIC COMPETENCIES

This list is aimed at providing UAS safety inspectors with a fundamental competency to assess UAS operations and provide safety oversight of UAS operators. The list may not be exhaustive, and continuous learning and adaptability would be important 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
- How to identify potential hazards in mission scenarios
- How to evaluate 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 UA pilot training organisations
- Providing constructive feedback during assessments
- Conflict resolution and problem-solving in a regulatory context
- Writing detailed and accurate reports

II. 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 unmanned aircraft. 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 would be important.

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 (EWIS) 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 (EMC), electromagnetic interference (EMI), 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

III. COMPETENCIES FOR UAS REMOTE PILOT ASSESSMENT

In general, personnel that may be 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

IV. COMPETENCIES FOR ORGANISATIONAL ASSESSMENT

Assessing UAS organisations may require a diverse set of skills that encompass understanding SMS principles and methods of procedural and regulatory compliance evaluation. It would also be more effective if safety inspectors are able to help organisations adapt to regulatory requirements, recognising that UAS organisations may have their own unique constraints. The following lists competencies that may support a safety inspector in assessing a UAS organisation and helping these organisations to 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 organizational 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 programs and records

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 organization

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

V. 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 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 ATM systems
- **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
  - Ability to analyse and interpret C2 link performance data

Atmospheric factors

- **Climate 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

ANNEX B to PART 8

Training Course Evaluation Template

<table>
<tr><th colspan="4">TRAINING EVALUATION FORM</th></tr>
<tr><td colspan="4">Date of evaluation:</td></tr>
<tr><td colspan="4">Evaluated by (Name of CAA):</td></tr>
<tr><td>Type of evaluation:</td><td colspan="2">Recommendation</td><td>Non-recommendation</td></tr>
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<tr><td colspan="2">Training provider contact/website address:</td><td colspan="2">Training location:</td></tr>
<tr><td colspan="4">Course synopsis:</td></tr>
<tr><td colspan="4">Competencies addressed:</td></tr>
<tr><td colspan="4">Reason for recommendation/non-recommendation:</td></tr>
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