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Doc 10103

Guidance on the Implementation of ICAO Standards and Recommended Practices for Tilt-rotors

First Edition, 2019



Approved by and published under the authority of the Secretary General

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**Doc 10103, *Guidance on the Implementation of ICAO Standards and
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AMENDMENTS

Amendments are announced in the supplements to the *Products and Services Catalogue*; the Catalogue and its supplements are available on the ICAO website at www.icao.int. The space below is provided to keep a record of such amendments.

RECORD OF AMENDMENTS AND CORRIGENDA

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TABLE OF CONTENTS

	<i>Page</i>
Foreword	(vii)
Glossary	(ix)
Chapter 1. General.....	1-1
1.1 Introduction and scope of guidance.....	1-1
1.2 Structure of this guidance.....	1-1
1.3 Brief history of tilt-rotors.....	1-2
1.4 Tilt-rotor operational characteristics	1-2
1.5 Tilt-rotor concept of operations.....	1-2
1.6 Use of this guidance.....	1-3
Chapter 2. Tilt-rotor guidance for ICAO Annexes.....	2-1
2.1 Annex 1 — <i>Personnel Licensing</i>	2-1
2.2 Annex 2 — <i>Rules of the Air</i>	2-2
2.3 Annex 3 — <i>Meteorological Service for International Air Navigation</i>	2-2
2.4 Annex 4 — <i>Aeronautical Charts</i>	2-2
2.5 Annex 5 — <i>Units of Measurement to be Used in Air and Ground Operations</i>	2-3
2.6 Annex 6 — <i>Operation of Aircraft</i>	2-3
2.7 Annex 7 — <i>Aircraft Nationality and Registration Marks</i>	2-7
2.8 Annex 8 — <i>Airworthiness of Aircraft</i>	2-7
2.9 Annex 9 — <i>Facilitation</i>	2-9
2.10 Annex 10 — <i>Aeronautical Telecommunications</i>	2-9
2.11 Annex 11 — <i>Air Traffic Services</i>	2-9
2.12 Annex 12 — <i>Search and Rescue</i>	2-10
2.13 Annex 13 — <i>Aircraft Accident and Incident Investigation</i>	2-10
2.14 Annex 14 — <i>Aerodromes</i>	2-11
2.15 Annex 15 — <i>Aeronautical Information Services</i>	2-13
2.16 Annex 16 — <i>Environmental Protection</i>	2-13
2.17 Annex 17 — <i>Security — Safeguarding International Civil Aviation against Acts of Unlawful Interference</i>	2-14
2.18 Annex 18 — <i>The Safe Transport of Dangerous Goods by Air</i>	2-14
2.19 Annex 19 — <i>Safety Management</i>	2-14
Appendix A to Chapter 2. Reference Material: Guidance for Annex 6.....	2-App A-1
Appendix B to Chapter 2. Reference Material: Guidance for Annex 8.....	2-App B-1
Appendix C to Chapter 2. Heliport firefighting provisions	2-App C-1

	Page
Chapter 3. Tilt-rotor guidance for ICAO Procedures for Air Navigation Services (PANS) and Regional Supplementary Procedures (SUPPs)	3-1
3.1 <i>Procedures for Air Navigation Services — Air Traffic Management (PANS-ATM, Doc 4444)</i>	3-1
3.2 <i>Procedures for Air Navigation Services — Aircraft Operations (PANS-OPS, Doc 8168).....</i>	3-2
3.3 <i>Regional Supplementary Procedures (Doc 7030)</i>	3-2
 Chapter 4. Tilt-rotor guidance for other ICAO publications.....	 4-1
4.1 <i>Aerodrome Design Manual (Doc 9157)</i>	4-1
4.2 <i>Environmental Technical Manual (Doc 9501), Volume I — Procedures for the Noise Certification of Aircraft</i>	4-1
4.3 <i>Performance-based Navigation (PBN) Manual (Doc 9613)</i>	4-2
4.4 <i>International Aeronautical and Maritime Search and Rescue (IAMSAR) Manual (Doc 9731), Volume II — Mission Co-ordination</i>	4-2
4.5 <i>Advanced Surface Movement Guidance and Control Systems (A-SMGCS) Manual (Doc 9830)...</i>	4-2
 Attachment. Questions and answers related to tilt-rotor operations	 Att-1

FOREWORD

The purpose of this manual is to assist national administrations in planning for the introduction of international civil tilt-rotor operations.

Tilt-rotors are part of the powered-lift category of aircraft. This manual does not address other aircraft within the powered-lift category such as vectored-thrust or ducted-fan. It is, however, anticipated that this manual will be used as a basis for other civil-powered lift aircraft as they approach design maturity.

The guidance material herein was developed by the ICAO Flight Operations Panel (FLTOSP) and is based on the best knowledge available to the panel up to the end of its fourth meeting (FLTOSP/4) (Montréal, 4 to 8 December 2017).

Comments concerning the manual should be addressed to:

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GLOSSARY

ACRONYMS

ACAS	Airborne collision avoidance system
AGL	Above ground level
AOC	Air operator certificate
CVS	Combined vision system
DIFFS	Deck-integrated firefighting system
EVS	Enhanced vision system
FDR	Flight data recorders
HUD	Head-up display
IFR	Instrument flight rules
IMC	Instrument meteorological conditions
KIAS	Knots indicated air speed
MNPS	Minimum navigation performance specifications
OEI	One engine inoperative
PANS	Procedures for Air Navigation Services
RFFS	Rescue and firefighting services
RPM	Revolutions per minute
RVSM	Reduced vertical separation minimum
SARPs	Standards and Recommended Practices
STOL	Short take-off and landing
SUPPs	Supplementary procedures
SVS	Synthetic vision system
TLOF	Touchdown and lift-off area
VFR	Visual flight rules
VTOL	Vertical take-off and landing

DEFINITIONS

Aeroplane mode. When the proprotor conversion angle is locked on the down-stop.

Configuration. A particular combination of the positions of the moveable elements (such as wing flaps, conversion angle and landing gear) that alter the aerodynamic and mass characteristics.

Conversion angle. The angle the proprotor assembly is set to.

Note.— The conversion angle is measured from 0° when the proprotor drive shaft is parallel to the longitudinal axis of the aircraft (defined as X axis) to 90° when the proprotor drive shaft is perpendicular to the X axis. Angles greater than 90° (for low speed and hover manoeuvres) and less than 0° may be anticipated. See Figures 1 and 2.

Engine. A unit used or intended to be used for aircraft propulsion. It consists of at least those components and equipment necessary for functioning and control, but excludes the propeller/rotors (if applicable).

Final approach and take-off area (FATO). A defined area over which the final phase of the approach manoeuvre to hover or landing is completed and from which the take-off manoeuvre is commenced. Where the FATO is to be used by helicopters operating in performance Class 1, the defined area includes the rejected take-off area available.

Maximum dimension. The largest overall dimension of the tilt-rotor (rotors turning), equivalent to D-value for a conventional helicopter.

Note.— Figure 3 depicts the maximum dimension of a tilt-rotor.

Proprotor. A set (two or more) of rotating aerofoil shaped structures that can be used as a propulsion propeller and/or a lift-rotor during the same flight.

Tilt-rotor. A powered-lift aircraft capable of vertical take-off, vertical landing and sustained low-speed flight which depends, principally, on engine-driven rotors mounted on tiltable nacelles for the lift during these flight regimes and on nonrotating aerofoil(s) for lift during high-speed flight.

VTOL/conversion mode. All approved conversion angles and flight modes where the proprotor conversion angle is not locked on the down-stop.

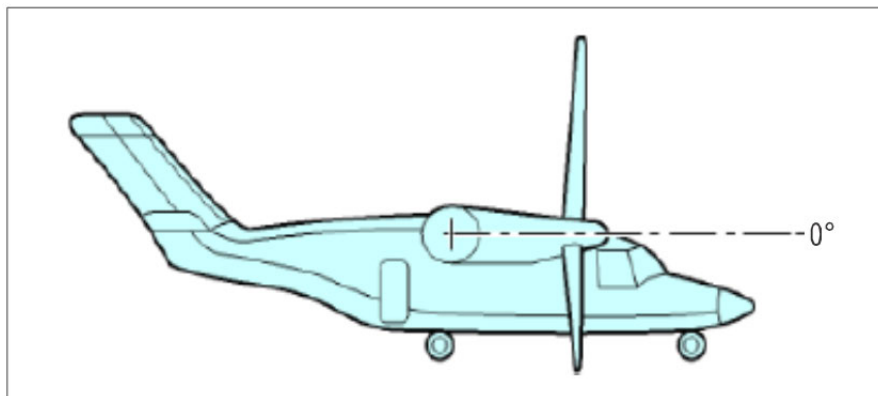


Figure 1. Aeroplane mode

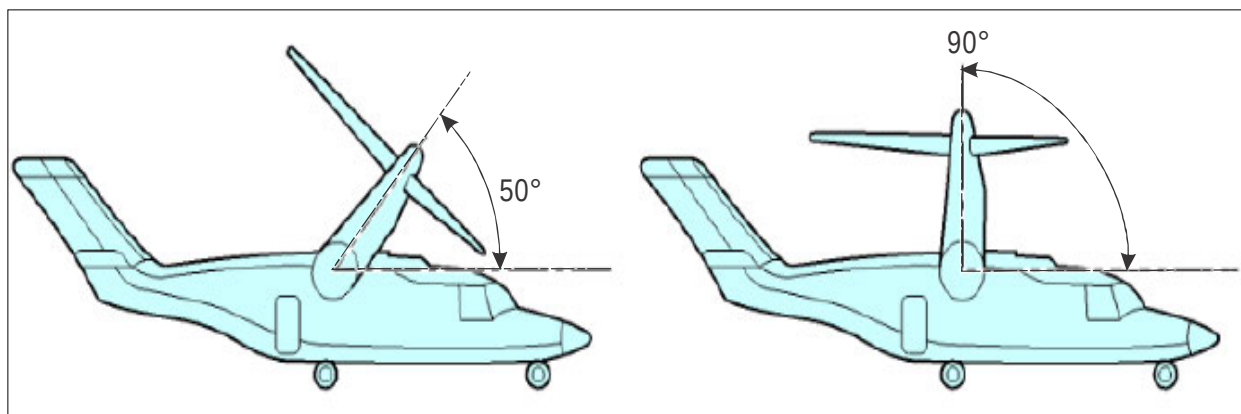


Figure 2. Examples of VTOL/conversion mode

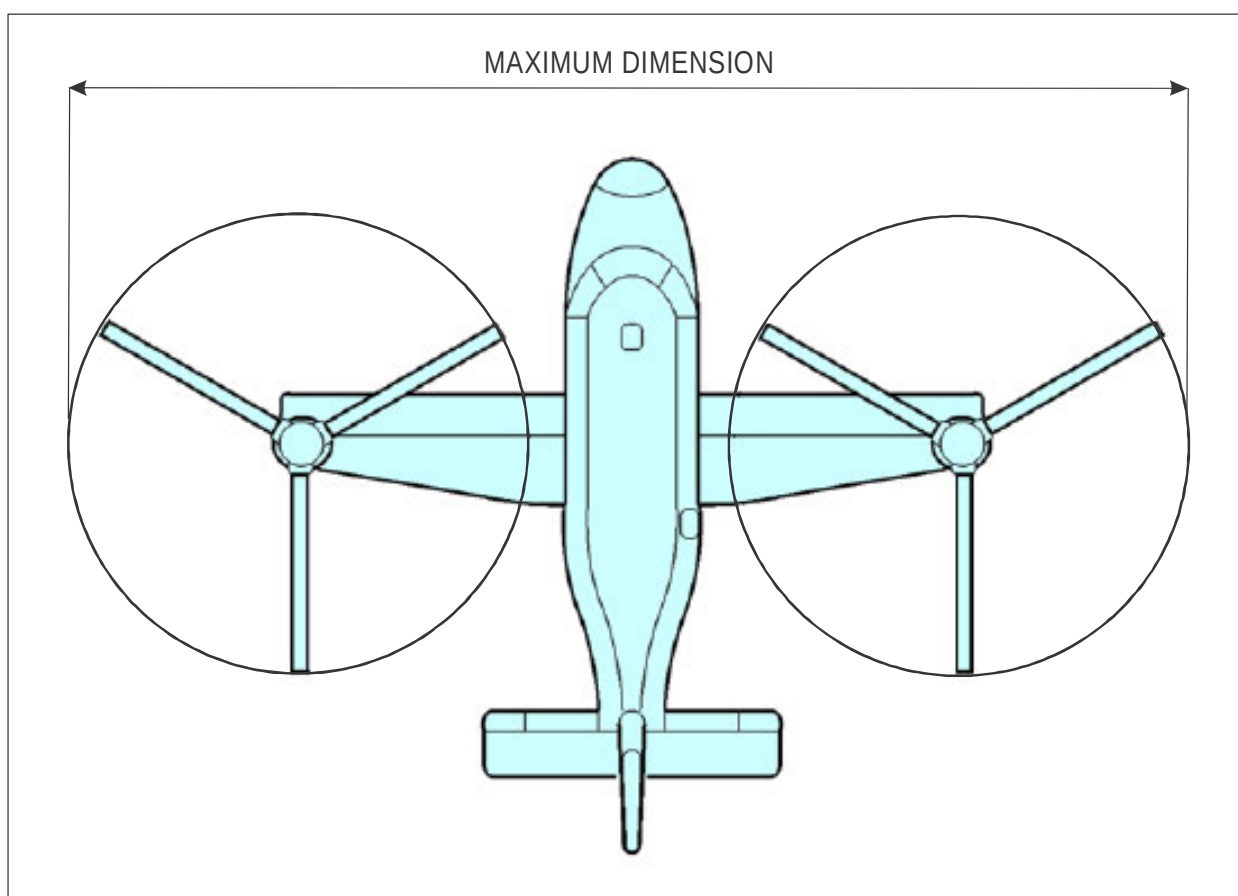


Figure 3. Maximum dimension

Chapter 1

GENERAL

1.1 INTRODUCTION AND SCOPE OF GUIDANCE

1.1.1 The purpose of this document is to provide a basis for States to accommodate tilt-rotors within their existing regulatory and procedural framework, where this is required.

1.1.2 It is anticipated that civil-certified tilt-rotors will begin operating in 2019.

1.1.3 Tilt-rotor technology is a new concept in civil aviation that combines the attributes of helicopters and aeroplanes. Currently, ICAO Standards and Recommended Practices (SARPs) do not specifically address the operating features and technology of tilt-rotors.

1.1.4 A combination of existing helicopter and aeroplane SARPs can enable the safe introduction of the tilt-rotor technology without the need for new provisions.

1.1.5 While sharing aeroplane characteristics, tilt-rotors are most closely aligned with helicopters due to their ability to sustain flight at low speed, as well as to take-off and land vertically. Therefore, helicopter SARPs should be used as the basis for tilt-rotor operations. Where deviation is required from helicopter SARPs to cover other aspects of flight, this manual provides guidance and reference to relevant aeroplane SARPs.

1.1.6 As tilt-rotors become more common and their capabilities expand, this document may require revision or the issue of tilt-rotor-specific SARPs may be considered.

1.1.7 At the issue of this document, Annex 1 — *Personnel Licensing* and Annex 16 — *Environmental Protection* contain SARPs relating to tilt-rotors or the powered-lift category.

1.1.8 The information herein is based on the results of extensive flight simulation and other studies, including data obtained from actual tilt-rotor flight trials.

1.2 STRUCTURE OF THIS GUIDANCE

1.2.1 For ease of use, this manual details how each ICAO Annex should be applied to tilt-rotors. Further chapters are dedicated to relevant ICAO Procedures for Air Navigation Services (PANS) and guidance materials.

1.2.2 There are four appendices to this document that contain additional information on individual ICAO Annexes and tilt-rotor operation.

1.3 BRIEF HISTORY OF TILT-ROTORS

The goal of achieving the vertical lift capability of a helicopter combined with the speed and range of an aeroplane has been long held by the aviation industry. The first patent representing a tilt-rotor was filed in the 1930s and the late 1940s saw the first experimental tilt-rotor flight. However, progress was stalled by aeroelastic instability issues encountered in aeroplane mode and in proprotor conversion that exceeded pilot workload capacity. Development of the technology was initially driven by military aviation and, with the increasing capability of avionics, the first mass production tilt-rotor entered into military service in the early 2000s. Since then, there has been a growing demand for tilt-rotor technology in civil aviation and private companies have begun to develop their own designs. The first civil tilt-rotor is anticipated to enter operation in 2019.

1.4 TILT-ROTOR OPERATIONAL CHARACTERISTICS

1.4.1 Tilt-rotors possess a combination of turboprop aeroplane and helicopter attributes. Tilt-rotors can take off and land vertically or, at low speeds, climb to a mid-level altitude and cruise, similar to an aeroplane at turboprop-like airspeeds and ranges. Tilt-rotors are capable of conducting instrument approach operations using instrument approach procedures designated Category A and Category H as defined in Doc 8168, *Procedures for Air Navigation Services — Aircraft Operations*, Volume I — *Flight Procedures*.

Note 1.— Instrument approach aircraft category terminology should not be confused with helicopter certification and performance terminology (see 1.4.2).

Note 2.— For guidance on other approaches, see Chapter 3, 3.2 of this manual.

1.4.2 Due to their design and certification basis, tilt-rotors are potentially capable of Category A or Category B operations as defined by Annex 8 — *Airworthiness of Aircraft*.

Note.— The terminology conversion stated in 1.6.4 should be applied.

1.4.3 Tilt-rotors are potentially capable of performance Class 1 helicopter, performance Class 2 helicopter or performance Class 3 helicopter performance as defined by Annex 8.

Note.— The terminology conversion stated in 1.6.4 should be applied.

1.4.4 Tilt-rotor aircraft are potentially capable of flight into known icing conditions.

1.5 TILT-ROTOR CONCEPT OF OPERATIONS

1.5.1 There are many opportunities for civil tilt-rotors to operate. The capability of point-to-point travel at speeds and ranges normally reserved for multi-engine aeroplanes will likely progress towards operations around the world.

1.5.2 As with any new technology, future users will find new and creative ways to maximize the benefits of tilt-rotors. Below are examples of anticipated early utilization.

1.5.3 Offshore oil and gas

A flight would depart from an aerodrome or a heliport on an instrument flight rules (IFR) flight plan in most weather conditions. Shortly after take-off, a tilt-rotor would transition to aeroplane mode and climb to a cruising altitude greater than 6 096 m (20 000 ft). After levelling off, the tilt-rotor would cruise at over 200 kts true airspeed, typically above low-level weather or icing. The crew would descend in aeroplane mode and convert back to vertical take-off and landing (VTOL)/conversion mode. On short final, the proprotors would be positioned at the angle used for hovering, and the tilt-rotor would be flown similarly to a helicopter.

1.5.4 Search and rescue

A tilt-rotor would perform a search in aeroplane mode at low altitude. Once the survivors are spotted, it would convert to VTOL mode and execute the rescue portion of the mission before reconverting to aeroplane mode and returning to base or a medical centre where it could land vertically.

1.5.5 Medical evacuation

Use of tilt-rotors would grant a greater service area and quicker transfers to hospitals and medical centres. A tilt-rotor would utilize instrument approaches to heliports and landing pads.

1.5.6 Law enforcement

A tilt-rotor would allow a police force to deploy resources (surveillance or personnel) to a specific location when required. In addition, it would extend the radius of a patrol where surface action could be taken if necessary, i.e. boarder/coastal patrol.

1.5.7 Corporate/private individuals

International point-to-point travel to and from major city centres, sporting events and rural locations would be possible with tilt-rotors.

1.6 USE OF THIS GUIDANCE

1.6.1 For ease of reference, guidance for each Annex is provided in Chapter 2. Chapter 3 presents guidance for the relevant PANS documents, along with the supplementary procedures (SUPPs), and Chapter 4 provides information on specific ICAO guidance material.

1.6.2 As noted in the introduction, tilt-rotors are most closely aligned in concept and operation with helicopters. Helicopter SARPs are, therefore, used as the basis for tilt-rotors.

1.6.3 This material provides guidance on where tilt-rotor flight modes or characteristics require the use of aeroplane SARPs instead of, in addition to, or in conjunction with helicopter SARPs.

1.6.4 Where this guidance states that existing SARPs should be applied to tilt-rotors, a conversion of aeroplane/helicopter terminology to tilt-rotor terminology may be required. This guidance will specify when the conversion should be applied. The conversion is as follows:

- for aeroplane, read tilt-rotor;
 - for helicopter, read tilt-rotor; and
 - for rotor, read proprotor.
-

Chapter 2

TILT-ROTOR GUIDANCE FOR ICAO ANNEXES

2.1 ANNEX 1 — PERSONNEL LICENSING

Introduction

2.1.1 Annex 1 — *Personnel Licensing* has provisions for powered-lift category aircraft which includes tilt-rotors. The guidance below is, therefore, provided to emphasize sections of particular importance.

Guidance

2.1.2 Annex 1, Chapter 1, 1.2.2.1, *Method of rendering a licence valid* provides an alternative for a State, which has yet to implement licensing regulations and procedures for a powered-lift licence, to render valid a powered-lift licence from another Contracting State issued in compliance with the specifications of Annex 1.

2.1.3 The SARPs contained in Annex 1, Chapter 2, *Licences and Ratings for Pilots*¹ apply to tilt-rotor aircraft as a class of powered-lift aircraft. Particular attention is drawn to the following SARPs:

- a) Annex 1, Chapter 2, 2.1.1.4, *Transitional measures related to the powered-lift category*.

Note.— States are advised to monitor the approach taken by the authorities certifying the first tilt-rotor designs.

- b) Annex 1, Chapter 2, 2.3.5, Specific requirements for the issue of the powered-lift category rating.
- c) Annex 1, Chapter 2, 2.4.5, Specific requirements for the issue of the powered-lift category rating.
- d) Annex 1, Chapter 2, 2.6.1, General requirements for the issue of the licence appropriate to the aeroplane, helicopter and powered-lift categories.
- e) Annex 1, Chapter 2, 2.6.5, Specific requirements for the issue of the powered-lift category rating.

Note 1.— The Recommendation in 2.6.5.1.1 will likely be unrealistic with the initial entry-into-service of this new category of aircraft. States should closely observe the licensing of the States where initial pilot ratings are obtained.

Note 2.— The SARPs contained in Annex 1, Chapter 4, Licences and Ratings for Personnel other than Flight Crew Members, 4.1 and 4.2 apply to tilt-rotors. The remaining paragraphs (air traffic control and meteorological personnel) have no direct impact on tilt-rotors.

1. As of 3 November 2022, Chapter 2, *Licences and Ratings for Pilots* will be titled *Licences and Ratings for Pilots and Remote Pilots*.

2.2 ANNEX 2 — RULES OF THE AIR

Guidance

2.2.1 Annex 2 — *Rules of the Air* is applicable to tilt-rotors. The terminology conversion stated in Chapter 1, 1.6.4 of this manual should be applied, in addition to the guidance below.

Signals for use in the event of interception

2.2.2 Refer to Annex 2, Appendix 1, paragraph 2. Due to the ability to fly at low speeds and hover, tilt-rotors should be treated as helicopters.

Marshalling signals

2.2.3 Refer to Annex 2, Appendix 1, paragraph 5. Due to the ability to fly at low speeds and hover, tilt-rotors should be treated as helicopters.

VMC visibility and distance from cloud minima

2.2.4 Refer to Annex 2, Chapter 3, 3.9. Tilt-rotors should be permitted to operate in low visibility if manoeuvred at a speed that will give adequate opportunity to observe other traffic or any obstacles in time to avoid collision, as specified by Annex 2, Table 3-1 (consistent with helicopters).

2.2.5 For further guidance on operations refer to Chapter 3, *Tilt-rotor guidance for ICAO Procedures for Air Navigation Services (PANS) and Supplementary Procedures (SUPPs)*, of this manual.

2.3 ANNEX 3 — METEOROLOGICAL SERVICE FOR INTERNATIONAL AIR NAVIGATION

Annex 3 is applicable to all aircraft. Guidance is, therefore, not required.

2.4 ANNEX 4 — AERONAUTICAL CHARTS

Guidance

2.4.1 Tilt-rotors should utilize existing routes, navigational aids and infrastructure as stated in this manual.

2.4.2 Tilt-rotor aircraft will be capable of operating at speeds that well exceed today's helicopter performance limitations. Therefore, if a maximum design speed is used in the development of the procedure, it should be noted on the relevant aeronautical chart.

Note.— This is to avoid pilot confusion when operating across States that designate different maximum speeds on low altitude helicopter routes.

2.5 ANNEX 5 — UNITS OF MEASUREMENT TO BE USED IN AIR AND GROUND OPERATIONS

Annex 5 is applicable to all aircraft. Guidance is, therefore, not required.

2.6 ANNEX 6 — OPERATION OF AIRCRAFT

Annex 6, Part I — International Commercial Air Transport — Aeroplanes

Introduction

2.6.1 For international commercial air transport operations, Annex 6, Part I has specific provisions for aeroplanes while Annex 6, Part III, Section II has specific provisions for helicopters. The operation of tilt-rotors is closely aligned with that of helicopters. Therefore, Annex 6, Part III, Section II should be applied to tilt-rotors.

2.6.2 The guidance below states when the SARPs in Annex 6, Part I should be used in conjunction with or instead of the SARPs in Annex 6, Part III, Section II. When referring the relevant SARPs of Annex 6, Part III or Annex 6, Part I in this section, the terminology conversion stated in Chapter 1, 1.6.4 of this manual should be applied. For example, where the word “airplane” is used in the Standard, this should be read as “tilt-rotor”.

2.6.3 For a detailed breakdown of Annex 6, see Appendix A to Chapter 2 — *Reference Material: Guidance for Annex 6 of this manual*.

Guidance

2.6.4 Air operator certificates (AOCs)

Reference: Annex 6, Part III, Section II, Chapter 2, 2.2 — *Operational certification and supervision*

Guidance: SARPs should be applied to tilt-rotors. As such, the air operator certificate (AOC) and associated operations specifications should be used as a template for an air operator that will incorporate tilt-rotor aircraft to its fleet.

Where elements of a tilt-rotor's planned operations involve aeroplane-specific operations (such as reduced vertical separation minimum (RVSM)), these should be incorporated into the AOC operations specifications, in accordance with the template found in Annex 6, Part I, Appendix 6.

2.6.5 Oxygen supply

Reference: Annex 6, Part III, Section II, Chapter 2, 2.3 — *Flight preparation*

Guidance: Due to the high cruising altitude of tilt-rotors, the Standards apply to tilt-rotors in conjunction with Annex 6, Part I, Chapter 4, 4.3.9, 4.4.5 and 4.4.6.