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**BREAKING NEWS**  
VOL. XI - n. 4356 NCLR INITIATIVE PREPARING FOR THE FUTURE MONTREAL, APRIL 2016

**Plane landing at Heathrow in near miss with drone that didn't show up on radars**



Number of incidents involving unmanned aircraft with the traditional manned aviation are escalating to an alarming stage

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**BREAKING NEWS**  
VOL. XI - n. 4356 NCLR INITIATIVE PREPARING FOR THE FUTURE MONTREAL, APRIL 2016



Purchasers of small drones do not have the information regarding the responsibilities and consequences to fly such drones in the proximity of airports and over populated areas

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**BREAKING NEWS**  
VOL. XI - n. 4356 NCLR INITIATIVE PREPARING FOR THE FUTURE MONTREAL, APRIL 2016



Awareness campaigns to educate the public about the safe operation of small drones are needed. Many States have not yet developed such initiatives

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# BREAKING NEWS

Vol. 21 - n° 4358 NCLB INITIATIVE PREPARING FOR THE FUTURE MONTREAL APRIL 2016



Regulations and guidance for the fast growing unmanned aviation in all its different modalities are necessary

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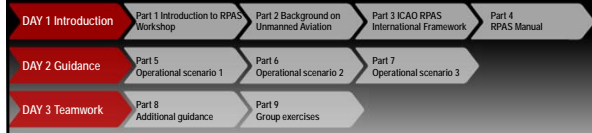
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## STRUCTURE



**DAY 1 Introduction** Part 1 Introduction to RPAS Workshop Part 2 Background on Unmanned Aviation Part 3 ICAO RPAS International Framework Part 4 RPAS Manual

**DAY 2 Guidance** Part 5 Operational scenario 1 Part 6 Operational scenario 2 Part 7 Operational scenario 3

**DAY 3 Teamwork** Part 8 Additional guidance Part 9 Group exercises



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## DAY 1 INTRODUCTION



**DAY 1 Introduction** Part 1 Introduction to RPAS Workshop Part 2 Background on Unmanned Aviation Part 3 ICAO RPAS International Framework Part 4 RPAS Manual



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**OUTLINE**

DAY 1 Introduction **Part 1 Introduction to RPAS Workshop** Part 2 Background on Unmanned Aviation Part 3 ICAO RPAS International Framework Part 4 RPAS Manual

- Introduction of instructors and participants
- House keeping and administrative information
- Objectives
- Structure
- Guidance material



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**MEET RPAS INSTRUCTOR TEAM**



Capt. Miguel Ramos      Prof. Liu Hao      Prof. Filippo Tomasello

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**INTRODUCTION OF THE PARTICIPANTS**



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INTRODUCTION TO RPAS WORKSHOP

Housekeeping and administrative information

- Punctuality
- Participation
- Phones
- No smoking
- Evacuation
- Feedback forms

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INTRODUCTION TO RPAS WORKSHOP

3 Day session

				
Begin 8h30	Pause 10h30	Lunch 12h30	Pause 14h30	End 16h30
Begin 9h	Pause 10h30	Lunch 12h30	Pause 14h30	End 17h
Begin 9h	Pause 10h30	Lunch 12h30	Pause	End 16h

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INTRODUCTION TO RPAS WORKSHOP

At the end of the ICAO RPAS Workshop:

1. Participants will acquire the knowledge regarding the ongoing work by ICAO regarding the development of the international regulatory framework through Standards and Recommended Practices (SARPs), as well as procedures and guidance material contained in Manual on Remotely Piloted Aircraft Systems (RPAS) Doc 10019.



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OBJECTIVES

**At the end of the ICAO RPAS Workshop:**

2. Staff members of Civil Aviation Authorities will be able to identify the role of the State in regulatory development as well as the responsibilities in overseeing RPAS operations



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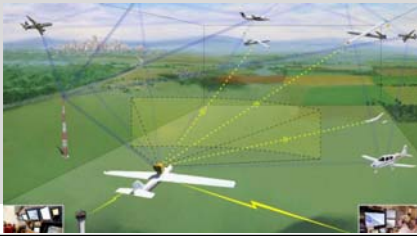
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OBJECTIVES

**At the end of the ICAO RPAS Workshop:**

3. Staff members of Air Navigation Service Providers (ANSPs) will be able to identify the issues to be addressed when integrating RPAS into the ATM system



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OBJECTIVES

**At the end of the ICAO RPAS Workshop:**

4. Specific staff members of RPAS operators and other service providers will obtain the necessary knowledge, regarding certification requirements and the impact of their operation in relation to the well-established manned aviation system



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**OBJECTIVES**

**At the end of the ICAO RPAS Workshop:**

5. Participants will identify different sources of RPAS related information from States and international organizations' webpages dedicated to Unmanned Aviation




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**Guidance material and resources:**



RPAS Manual

GRID RPAS Operations

RPAS website

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**Outline**

DAY 1 Introduction


Part 1 Introduction to RPAS Workshop

**Part 2 Background on Unmanned Aviation**

Part 3 ICAO RPAS International Framework

Part 4 RPAS Manual

- Historical Perspective
- Unmanned Aircraft




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1849 : HISTORICAL PERSPECTIVE

1849

1916 **Austrian War Balloons**

1935 The first flight of a lighter-than-air aircraft took place in 1849 when Austria sent unmanned, bomb-laden balloons to attack Venice


1940

1960

1980

1995

2006




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1916 : HISTORICAL PERSPECTIVE

1849

1916 **Ruston Proctor Aerial Target**

1935 The first 'pilotless' aircraft is believed to be the Ruston Proctor Aerial Target, built in 1916, only 13 years after the first successful controlled manned flight by the Wright brothers on 17 December 1903


1940

1960

1980

1995

2006




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1935 : HISTORICAL PERSPECTIVE

1849

1916 **Converted De Havilland Tiger Moth, known as the Queen Bee**

1935 Following WWI, many conventionally piloted aircraft were converted into radio controlled "pilotless" aircraft for use as targets. One of the most successful was a converted De Havilland Tiger Moth, which became known as the Queen Bee. It is believed that the term 'drone' was adopted in homage to the Queen Bee


1940

1960

1980

1995

2006




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1940 : HISTORICAL PERSPECTIVE

1849

**Reginald Denny and his OQ- 3**

1916

1935

1940


1960

1980

1995

2006

The OQ-2 Radioplane was the first mass-produced RPA (drone) in the US. A follow-on version, the OQ-3, became the most widely used target aircraft in US service, with over 9,400 being built during World War II




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1960 : HISTORICAL PERSPECTIVE

1849

**Lockheed D-21 Mach 3 supersonic**

1916

1935

1940


1960

1980

1995

2006

The Lockheed D-21 was an American reconnaissance drone with maximum speed in excess of Mach 3. The D-21 was initially designed to be launched from the back of a M-21 carrier aircraft. Development began in October 1962. Originally known by the Lockheed designation Q-12, the drone was intended for reconnaissance deep in enemy airspace




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1980 : HISTORICAL PERSPECTIVE

1849

**Sikorsky Cypher**

1916

1935

1940

1960

1980

1995

2006

The Cypher and Cypher II are types of RPA developed by Sikorsky Aircraft.

They are vertical take-off and landing aircraft which use two opposing rotors enclosed in a circular shroud for propulsion




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1995 : HISTORICAL PERSPECTIVE

1849

**General Atomics MQ-1 Predator**

1916

1935

1940


1960

1980

1995

2006

The MQ-1 Predator is an RPA built by General Atomics and used primarily by the United States Air Force (USAF) and Central Intelligence Agency (CIA). The aircraft has been in use since 1995, initially conceived in the early 1990s for aerial reconnaissance and forward observation roles




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1995 : HISTORICAL PERSPECTIVE

1849

**DJI Phantom**

1916

1935

1940


1960

1980

1995

2006

DJI manufactures a range of small UAS (a.k.a. drones) for industrial, professional and amateur purposes. This manufacturer among many others are expecting to get the global drone market to reach USD 5.59 Billion by 2020




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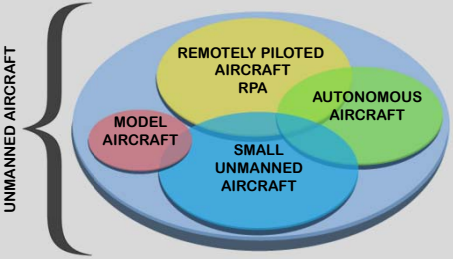
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Unmanned aircraft (UA)

*Unmanned aircraft (UA) :*  
*Any powered or unpowered aircraft that is flown without a pilot onboard. These aircraft may operate autonomously or with a remote pilot. UA include:*




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Unmanned aircraft (UA)

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**Model aircraft**

- for recreational (hobby) purposes
- non commercial
- flown visual line of sight (VLOS) in visual meteorological conditions (VMC)
- low altitude – normally below 120 meters
- normally conducted away from aerodromes and populated areas




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Unmanned aircraft (UA)


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**Small Unmanned Aircraft**

- for recreational or commercial purposes
- most popular category of UA
- usually flown visual line of sight (VLOS) in VMC
- may require special authorization and coordination from the competent authority to operate in the vicinity of an aerodrome
- commonly referred to as Drones
- A majority of people operating in this category have no aviation background or particular interest on it

**Operations will generally be conducted under the following conditions:**

- < 120 meters/400 feet
- daytime VMC
- > 30meters from people
- > 5.5 km from an aerodrome
- outside of controlled airspace
- Generally < 25 kg




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Unmanned aircraft (UA)


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**REMOTELY PILOTED AIRCRAFT RPA**

**RPA definition (ANNEX 2)**

An Unmanned aircraft which is piloted from a Remote Pilot Station:

- expected to be integrated into the Air Traffic Management System equally as manned aircraft
- real time piloting control is provided by a licensed remote pilot




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Unmanned aircraft (UA)

**Autonomous aircraft**

- an unmanned aircraft that does not allow pilot intervention in the management of the flight
- not a specific type of unmanned aircraft but a characteristic in its operation



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Outline

DAY 1 Introduction    Part 1 Introduction to RPAS Workshop    Part 2 Background on Unmanned Aviation    **Part 3 ICAO RPAS International Framework**    Part 4 RPAS Manual

- Overview of ICAO
- History of the Legal Framework
- Foundations of the Legal Framework
- The development of the Legal Framework
- UASSG and RPASP
- Focus of ICAO and States
- Guidance principles for RPAS Operations



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Overview of ICAO

- ICAO is a specialized agency of the United Nations established in 1944 to manage the administration and governance of the Convention on International Civil Aviation (Chicago Convention)
- ICAO's headquarters are located in Montreal with 7 Regional Offices around the world
- The ICAO Council is a permanent body that gives continuing direction to the work of ICAO



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Overview of ICAO

- The Secretary General is responsible for general direction of the work of the Secretariat
- The Air Navigation Commission (ANC) considers and recommends Standards and Recommended Practices (SARPs) and Procedures for Air Navigation Services (PANS) for adoption or approval by the ICAO Council
- Standards and Recommended Practices (SARPs) once adopted by Council are translated into national regulations by States

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Do you know ?

- Panels and Study Groups are technical groups of qualified experts.
- The ANC works through established panels of experts in various disciplines who are assigned specific tasks from the overall work programme.
- RPAS Panel is one of those groups of experts

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History of the legal framework

- The legal framework for ICAO started with the Paris Convention on 13 October 1919
- The Protocol of 15 June 1929 amending the Paris Convention first refers to "pilotless aircraft"
- The Chicago Convention of 7 December 1944 replaced the Paris Convention which included Article 8 entitled "Pilotless aircraft"
- All unmanned aircraft, whether remotely piloted, fully autonomous or combinations thereof, are subject to the provisions of Article 8 of the *Convention on International Civil Aviation*

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Article 8

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*Article 8*  
*"Pilotless aircraft"*

No aircraft capable of being flown without a pilot shall be flown without a pilot over the territory of a contracting State without special authorization by that State and in accordance with the terms of such authorization. Each contracting State undertakes to insure that the flight of such aircraft without a pilot in regions open to civil aircraft shall be so controlled as to obviate danger to civil aircraft."

Note: Article 8 of the Chicago Convention assures each Contracting State of the absolute sovereignty over the authorization for RPA operations over its territory  
- ICAO Assembly Resolution A38-12 – Oct, 2013

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Foundations of the Legal Framework

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**International civil aviation:**

- Developed in a safe and orderly manner
- On basis of equality of opportunity
- Applies equally to manned and unmanned

*Art 3 bis – Civil and state aircraft*  
*Art 12 – Rules of the air*  
*Art 15 – Airport and similar charges*  
*Art 29 – Documents carried in aircraft*  
*Art 31 – Certificates of airworthiness*  
*Art 32 – Licenses of personnel*  
*Art 33 – Recognition of certificates of licenses*

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Development of the legal framework for Unmanned Aircraft

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- need *special authorization* to fly a UA over another contracting State
- UA must be controlled to *obviate danger* to civil aircraft
- remotely piloted aircraft are one type of unmanned aircraft
- ICAO serves as the focal point for global interoperability and harmonization

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Annexes affected by SARPs related to RPAS
Annex 1 - Personnel Licensing
Annex 2 - Rules of the Air
Annex 3 - Meteorological Services
Annex 4 - Aeronautical Charts
Annex 5 - Units of Measurement
Annex 6 - Operation of Aircraft
Annex 7 - Aircraft Nationality and Registration Marks
Annex 8 - Airworthiness of Aircraft
Annex 9 - Facilitation
Annex 10 - Aeronautical Telecommunications
Annex 11 - Air Traffic Services
Annex 12 - Search and Rescue
Annex 13 - Aircraft Accident and Incident Investigation
Annex 14 - Aerodromes
Annex 15 - Aeronautical Information Services
Annex 16 - Environmental Protection
Annex 17 - Security
Annex 18 - The Safe Transportation of Dangerous Goods by Air
Annex 19 - Safety management

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UASSG and RPASP
<b>UASSG</b>
<ul style="list-style-type: none"><li>• First meeting Apr, 2008</li><li>• Scope - three task groups</li><li>• Develop accident and incident investigation requirements for UAS</li><li>• Develop a coordination and cooperation framework for interaction with other standards-making organizations</li><li>• Develop an outline of a regulatory guidance document relating to unmanned aircraft systems</li></ul>

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UASSG and RPASP
<b>Outcomes 2008-2014</b>
Amendments to:
<ul style="list-style-type: none"><li>• Annex 13 - Definition of accident</li><li>• Annex 2 - Certification and special authorizations</li><li>• Annex 7 - Registration</li><li>• Circular - 328 UAS</li><li>• Draft RPAS Manual (Doc 10019)</li></ul>

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UASSG and RPASP

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**RPASP**

- First meeting of RPAS Panel (Nov 2014)
- Approved by ANC during the 196th Session in May 2014
- Continue the work from the former UASSG
- Manage the work program as assigned by the ANC
- Focal point of ICAO RPAS related work

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Focus of ICAO and States

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- ICAO main focus:
  - international IFR operations
  - global interoperability
  - fundamentals to initiate international operations:
    - Certificate of airworthiness
    - RPAS operator certificate
    - Remote pilot license
- State (National Authority) Focus:
  - domestic operations, which may differ significantly from international operations




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Focus of ICAO and States

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**To support States in their development of national regulations**

- ICAO formed an advisory group in March 2016 to share best practices and to assist States in the development of guidance material regarding small UAS operations (SUAS-AG)
- 15 SUAS-AG members:
  - 8 States from diverse geographic regions
  - 5 international organizations
  - 1 manufacturer (DJI), and
  - 1 international operator
- The group has held 6 meetings and will produce a virtual SUAS-AG Toolkit by September 2016




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Guiding Principles for RPAS Operations

- RPA shall be operated in such a manner as to minimize hazards to persons, property or other aircraft
- RPAS regulations should address the protection of society from mid-air collisions with aircraft and crashes into the ground
- No distinction is made between commercial air transport and general aviation operations conducted by RPA
- Ultimately, RPAS are to be integrated into the existing aviation system without negatively affecting manned aviation
- Until RPA can meet all the requirements for integration, they may be accommodated by being restricted to specific conditions or areas
- In order for RPA to be integrated into non-segregated airspace and at aerodromes, a remote pilot may only control one RPA at any given time

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Outline

- Scope and purpose of the Manual (Chapter 1)
- Introduction to RPAS (Chapter 2)
- Special authorization (Chapter 3)
- Type certification and airworthiness approvals for RPA, RPS and RPAS (Chapter 4)
- RPA registration (Chapter 5)
- Responsibilities of the RPAS operator (Chapter 6)
- Safety management (Chapter 7)
- Remote pilot licensing and RPA observer competencies (Chapter 8)
- RPAS operations (Chapter 9)
- Detect and avoid (Chapter 10)
- Command and control (C2) link (Chapter 11)
- ATC communications (Chapter 12)
- Remote pilot station (RPS) (Chapter 13)
- Integration of RPAS operations into ATM and ATM procedures (Chapter 14)
- Use of aerodromes (Chapter 15)

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Chapter 1 - Purpose and scope of the RPAS Manual

Purpose of the RPAS Manual :

- provide guidance on the technical and operational issues applicable to the integration of RPA into non-segregated airspace and at aerodromes
- material in the Manual consistent with the standards already adopted for RPAS
- manual will be updated and expanded as additional provisions are developed

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Chapter 1 - Purpose and scope of the RPAS Manual

Scope of the RPAS Manual:

- RPAS addressed as one subset of UAS
- RPAS envisioned to be an equal partner in the civil aviation system
- guidance is consistent with the existing aviation regulatory framework and will assist in the development of future RPAS-specific SARPs
- material recommended for the benefit of the entire UAS community (e.g. regulators, manufacturers, operators, pilots, and air navigation service providers)

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Chapter 1 - Purpose and scope of the RPAS Manual

**Manual does not address:**

- State Aircraft
- autonomous unmanned aircraft (e.g. unmanned free balloons)
- operations in which more than one RPA is being managed by a single remote pilot
- unmanned aircraft used for recreational purposes only
- VLOS operations

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Chapter 2 – Introduction to RPAS

- Unmanned aircraft are aircraft but they have many styles and different capabilities. Regulators need to be able to distinguish the different categories. Whereas the ICAO SARPs will only address the remotely piloted *subset*



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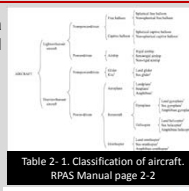

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**Remotely Piloted Aircraft System (RPAS) Components:**

An unmanned aircraft which is piloted from a remote pilot station is an RPA. All aircraft classified in [Table 2-1](#) could be remotely piloted

An RPAS consists of the following:

- remotely piloted aircraft
- remote pilot station (s)
- command and control (C2) link
- other components as specified in the type design


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**Criteria for RPA Categorization**

- **Maximum take-off mass MTOM**
- **Kinetic energy**
- **Performance criteria:**
  - speed
  - range
  - endurance

Factors affecting Performance:

- barometric pressure
- pressure-altitude
- temperature
- humidity
- wind
- runway slope, and
- surface conditions of the runway

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**Criteria for RPA Categorization**

- **Type/area of operations:**
  - Policing
  - Firefighting
  - Aerial photography
  - Aerial surveying
  - Powerline inspection
  - Aerial spraying
  - Search and rescue
  - Cargo delivery

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RPAS Operations

The operation of RPAS will be determined by:

- **Type of operation**
- **Flight rules**
- VLOS operations are normally limited to visual meteorological conditions (VMC)
- IFR flight depends upon flying by reference to instruments in the flight deck, and navigation is accomplished by reference to electronic signals
- While VFR and IFR apply, as they do for manned aircraft (e.g. requirements for equipment, operations and responsibility); they can be more difficult to address for RPA

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RPAS Operations

The operation of RPAS will be determined by:

- **Areas of operation:**
  - **INTERNATIONAL OPERATIONS.** In manned aviation, international operations are considered to be those in which the aircraft crosses an international border or operates in high seas airspace
  - RPAS present additional scenarios for consideration:
    - the RPA only, the RPS only or both the RPA and RPS are operated in other than the territory of the State of the Operator
- **Functional levels of the C2 links.**

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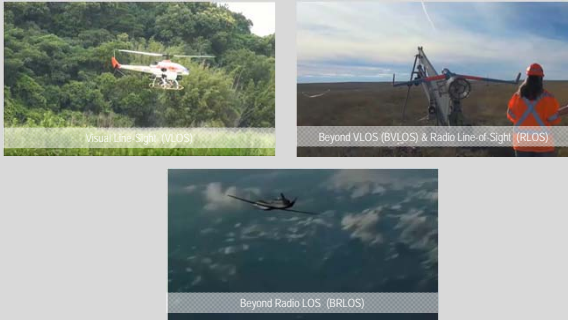
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VLOS/BVLOS Operations

The capability of an RPA will usually be determined by the type of on-board technology. Some examples include:



Visual Line Sight (VLOS)

Beyond VLOS (BVLOS) & Radio Line-of-Sight (RLOS)

Beyond Radio LOS (BRLOS)

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**Chapter 6 – Responsibilities of the RPAS Operator**

**RPAS**

- role and responsibilities of an RPAS operator, based upon provisions in Annex 6, Part I
- responsibilities may include among others:
  - RPAS Operator Certificate (ROC)
  - personnel management
  - document requirements
  - oversight of service providers
  - operating facilities




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**Chapter 7 – Safety Management**

**RPAS operator's SMS**

- all RPAS operators must be certified by the State
- the RPAS operator is responsible for the safe conduct of all operations
- RPAS operator must implement an SMS relevant to the size and complexity of the operation.
- the introduction of RPA into non-segregated airspace requires a thorough assessment of the safety performance of the RPAS operations.


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**Chapter 7 – Safety Management**

**Safety responsibilities**

- responsible for work by contractors, unless contractor is certified
- coordination of emergency response planning


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Chapter 8 – Licensing and Competencies

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**Guidance on rules for remote pilot licence and RPA observer competency**

- human performance
- language proficiency
- issue of remote pilot licences
- training standards




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Chapter 8 – Licensing and Competencies

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**Guidance on rules for remote pilot licence and RPA observer competency**

- remote pilots have the same basic responsibilities as pilots of manned aircraft for the operation of the aircraft in accordance with the rules of the air, and the laws, regulations and procedures of those States in which operations are conducted
- a person must not act either as remote pilot in command (PIC) or as a remote co-pilot of an RPA unless that person is the holder of a remote pilot licence, containing the ratings suitable for the purpose of executing the operation
- proof of language proficiency in either English or the language used for communications involved in the remotely piloted flight should be endorsed on the remote pilot licence

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Chapter 8 – Licensing and Competencies

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**Remotely Pilot licence (RPL) subjects of knowledge**

Applicants for a RPL should demonstrate knowledge among others on:

- air law
- RPAS general knowledge
- human performance
- meteorology
- navigation
- operational procedures
- radiotelephony




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Chapter 8 – Licensing and Competencies



**Practical skill test may include :**

- management of threat and errors
- operation of RPA within its limitations
- complete manoeuvres with accuracy
- apply aeronautical knowledge

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Chapter 8 – Licensing and Competencies

**RPA observer competency**

- the RPAS operator is responsible for ensuring the competency of RPA observers
- a person should not act as an RPA observer unless that person has undergone a competency-based training on visual observer duties concerning RPA VLOS operations
- there is no intent to license RPA observers

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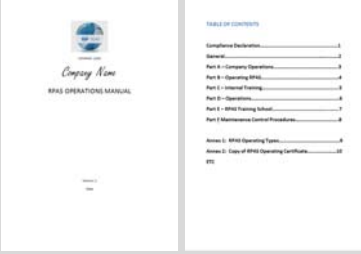
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Chapter 9 – RPAS Operations

**Manuals**

- Operations Manual

An RPAS operator must provide an Operations Manual for the use and guidance of the RPAS operations personnel concerned




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Chapter 9 – RPAS Operations

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**RPAS operations considerations**

RPAS operations may include, but not be limited to, the following:

- VLOS operations
- night VLOS operations
- beyond VLOS operations
- populated areas
- take-off/launch/landing/recovery
- launch/recovery equipment preparation/set-up/inspection
- special operations



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Chapter 9 – RPAS Operations

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**Emergencies and contingencies**

RPAS flight planning should include provisions for any emergencies and contingencies for:

- emergency landing/ditching locations
- loss of C2 link
- interception operations



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Chapter 9 – RPAS Operations

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**Other requirements for consideration**

- RPA performance and operating limitations
- accident and incident investigation
- security
- cargo safety



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Chapter 10 – Detect and Avoid (DAA)

**Fundamental requirements**

- Detect and avoid (DAA) – "the capability to see, sense or detect conflicting traffic or other hazards and take the appropriate action"
- remain well clear (RWC) to avoid potentially conflicting traffic
- to be as safe as, or safer than, present manned operations
- DAA capabilities are required for RPA to limit the risk of integration into non-segregated airspace
- must comply with airspace rules and procedures
- safety analysis/mitigation strategies may be required.

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Chapter 10 – Detect and Avoid (DAA)

**Protection layers**

**1 Strategic conflict management**  
• Airspace organization and management  
• Demand and capacity balancing  
• Traffic synchronization components

**2 Separation provision (by ATC) and/or remain-well-clear by RPAS**  
Tactical process of keeping aircraft away from hazards by at least the appropriate separation minima or distance

**3 Collision avoidance**  
Must activate when the separation mode has been compromised  
1. Separation mode is an approved set of rules, procedures and conditions of application associated with separation minima.

RPAS Manual, Fig 10-1 Protection layers

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Chapter 11- Command and Control (C2) Link

RPA are piloted from an RPS utilizing a command and control (C2) link.

- a C2 link allows full manipulation of the RPA controls
- all non payload information to and from remote pilot and the RPA is via the C2 link
- commands from the remote pilot to the RPA are real time minus latency

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Chapter 11- Command and Control (C2) Link

**Spectrum for the C2 link**

- spectrum for international operations is being worked jointly by ICAO and the ITU
- for domestic operations, local solutions may be available if they do not impact other spectrum dependent uses
- different spectrums are utilized by video, voice and C2 that may be subject to licensing by the State




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Chapter 11- Command and Control (C2) Link

**Required communication performance (RCP) of the C2 link**

- The RCP type parameters for the specific type of operation may include:
  - transaction time
  - integrity
  - continuity
  - availability
- RCP will be a part of the system performance

\* Discussions are underway on required link performance (RLP) to include existing communication, surveillance and navigation (RCP, RSP, RNP)

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Chapter 11- Command and Control (C2) Link


**C2 link architecture**

C2 link architecture to support RPAS operations are usually classified as RLOS or BRLOS

- RLOS refers to the situation in which the transmitter(s) and receiver(s) are within mutual radio link coverage
- BRLOS refers to any configuration in which the transmitters and receivers are not in RLOS. BRLOS includes all satellite systems



RPAS Manual, Fig 11-1 RLOS - RPS and RPA direct access



RPAS Manual, Fig 11-2 BRLOS - RPS and RPA via satellite access

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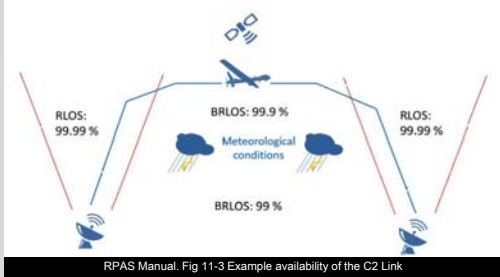
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Chapter 11- Command and Control (C2) Link

C2 links are not 100% reliable, they are subject to interference (intentional or unintentional, e.g atmospheric conditions) equipment failure etc. Procedures for handling lost C2 link will be addressed




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Chapter 12 – ATC Communications

- general requirements for ATC communications, to and from the remote pilot, are the same as for manned aviation
- because the remote pilot is not on board the aircraft, a range of alternative communication architectures are possible

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Chapter 12 – ATC Communications

- ATC voice and data link communications architecture options:

ATC voice and data TO/FROM the RPS, relayed via the RPA




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Chapter 12 – ATC Communications

- ATC voice and data link communications architecture options:

ATC voice and data TO/FROM the RPS without a relay via the RPA

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Chapter 13 – Remote Pilot Station - RPS

*RPS : "the component of the remotely piloted aircraft system containing the equipment used to pilot the remotely piloted aircraft."*

- the specific shape, size, contents and layout of any RPS may vary due to aspects such as:
  - a) the type of operation conducted (VLOS or BVLOS)
  - b) the complexity of the RPAS
  - c) the type of control interface used
  - d) the number of remote pilots required to operate the RPA
  - e) the location of the RPS — fixed position on the ground or within another vehicle/platform (e.g. ship or aircraft)

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Chapter 13 – Remote Pilot Station - RPS

The design of an RPS must consider the following:

- layout and identification of controls and instruments
- rapid identification of emergency situations
- remote pilot input on flight controls
- ventilation, heating and noise

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Chapter 13 – Remote Pilot Station - RPS

Human performance implications:

- visual sensory information (e.g. light and flash)
- auditory sensory information (noise environment including engine and airframe noise)
- proprioceptive sensory information (e.g. vibration and acceleration)
- tactile sensory information (e.g. heat and vibration)



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Chapter 14 Integration of RPAS Operations into ATM and ATM Procedures

- contains best practices and procedures that can be used for the safe integration of RPAS, taking into consideration the current technological limitations. Operations in segregated airspace are not within the scope of this chapter
- identification of current best practices for consideration by States and aviation standards organizations (e.g. RSOs, RTCA, EUROCAE)
- operations in non-segregated airspace, controlled and uncontrolled

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Chapter 14 Integration of RPAS Operations into ATM and ATM Procedures

- operational and equipage requirements of RPA will be governed by the class of airspace in which they will be operating. Airspace class definitions are defined in Annex 11 — Air Traffic Services



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Chapter 14 Integration of RPAS Operations into ATM and ATM Procedures

- right-of-way: RPA are obliged to comply with the Annex 2 right-of-way rules of other aircraft (manned or unmanned)
- RPAS operators will need to file flight plans in accordance with Annex 2 (until aircraft type designators are defined, "ZZZZ" should be entered in item 9 of the flight plan & the RPA type specified in item 18)
- RPAS operator should define lost C2 link procedures that are acceptable to the ANSP and regulator
- it may be difficult for ATCOs, pilots of manned aircraft and other remote pilots to acquire visual contact with the RPA due to low conspicuity



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Chapter 15 – Use of Aerodromes

- RPAS integration will require technology to allow the remote pilot to safely operate the RPA and identify, in real-time, the physical layout of the aerodrome and associated equipment, such as aerodrome lighting and markings during operations at aerodromes open to public use
- The RPAS needs to have the ability to communicate and manoeuvre in a manner that will not disrupt routine airport operations
- States may consider establishing aerodromes to serve RPAS operations only



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Outline


DAY 2 Guidance

Part 5 Operational scenario 1

Part 6 Operational scenario 2

Part 7 Operational scenario 3

- Case study – three operational scenarios
  - Share different regulatory approaches and best practices
  - Propose limitations for the operation



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DAY 2 Guidance    Part 5 Operational scenario 1    Part 6 Operational scenario 2    Part 7 Operational scenario 3

Remotely Piloted Aircraft Systems (RPAS)  
Cross FIR Wildfire Reconnaissance  
Operation



Scenario

Operator

Request

Aircraft Specifications

CAA Considerations

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DAY 2 Guidance    Part 5 Operational scenario 1    Part 6 Operational scenario 2    Part 7 Operational scenario 3

Remotely Piloted Aircraft Systems (RPAS)  
Cross FIR Wildfire Reconnaissance  
Operation

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DAY 2 Guidance    Part 5 Operational scenario 1    Part 6 Operational scenario 2    Part 7 Operational scenario 3

Remotely Piloted Aircraft Systems (RPAS)  
Cross FIR Wildfire Reconnaissance  
Operation

**Scenario**

In the summer of 2015, several large wildfires raged across the borders of two small countries requiring that they share support and emergency equipment to maximize their efforts and minimize property loss. A two year local drought, extremely dry weather conditions and high winds pushed the wildfires across mountain ranges and through valleys destroying small towns and valuable crops across both nations.

Fire officials stated the 100,000 acres consumed were the largest fire destruction in their States' history and unless they joined forces, the fires would rage uncontained for weeks. The wildfires caused a total of 87 injuries and 2 fatalities primarily from smoke inhalation, in addition to causing at least 67 million (2015 Euros) in damage.

Due to budget constraints and lack of availability of accurate satellite surveillance due to heavy smoke, the States' officials passed an emergency resolution to open their sky's borders to emergency operators and to recognize RPAS operations for surveillance in hopes of containing the fires. They also jointly created a Danger Area limiting other civil operations in the airspace.

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DAY 2 Guidance    Part 5 Operational scenario 1    Part 6 Operational scenario 2    Part 7 Operational scenario 3

Remotely Piloted Aircraft Systems (RPAS)  
Cross FIR Wildfire Reconnaissance  
Operation

**Scenario (cont.)**

**Emergency Mission:**

The Insitu ScanEagle provided reconnaissance of wildfires in the rugged mountains and valleys of the two nations. After initial flights were flown by a fleet of four ScanEagles providing accurate GIS information to the joint command center, allowed real time mapping of the fires

When coupled with wind information, fire officials were able to deploy bomber and helicopters and to position hotshot firefighters in the most effective manner. Night IFR operations were approved and the ScanEagles were able to utilize infrared sensors to map hotspots

At dawn each day the feedback to the Incident Management team allows relocation and pinpoint bombing of the fire on multiple fronts. The effectiveness of the night operations stops the advancing fire after five days and on the sixth day thunderstorms move into the area soaking the dry terrain and containing the wildfires

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DAY 2 Guidance    Part 5 Operational scenario 1    Part 6 Operational scenario 2    Part 7 Operational scenario 3

Remotely Piloted Aircraft Systems (RPAS)  
Cross FIR Wildfire Reconnaissance  
Operation

**Operator**

Operator is a service provider to government agencies worldwide for emergency response and monitoring. Aircraft has 900 hours of flight time in this type of operation, all pilots hold RPL certificates with third class medical certificates

**Request**

To provide its services under the oversight of the Minister or Department of Public Services and the CAA with the necessary requirements to operate according to the national regulations especially in regard to the licensing and competency requirements

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DAY 2 Guidance    Part 5 Operational scenario 1    Part 6 Operational scenario 2    Part 7 Operational scenario 3

Remotely Piloted Aircraft Systems (RPAS)  
Cross FIR Wildfire Reconnaissance  
Operation

**Aircraft specifications – Insitu ScanEagle**

- can fly at altitudes up to 15,000 feet
- can feed imagery and other data obtained by the aircraft by satellite into the command center
- provides a broad overview and systematic surveillance using high-resolution synthetic aperture radar (SAR) and long-range electro-optical/infrared (EO/IR) sensors
- has long loiter times over target areas - for more than 20 hours
- the Scan Eagle RPAS configured for fire fighting operations consists of:
  - the remotely piloted aircraft, ScanEagle payload: EO and IR turret and camera;
  - a launcher and Skyhook for recovery.
  - remote pilot station




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DAY 2 Guidance    Part 3 Operational scenario 1    Part 6 Operational scenario 2    Part 7 Operational scenario 3

**CAA considerations**      Remotely Piloted Aircraft Systems (RPAS)  
Cross FIR Wildfire Reconnaissance  
Operation

- what is the role of the CAA?
- in a designated danger area, what approval does a civil aircraft require to operate in the area?
- does the ScanEagle requires a type certificate and certificate of airworthiness?
- how will the remote pilots communicate with air traffic control and other aircraft fire bombing in the area?
- will the radio frequencies be over congested?
- what is the nature of the communications links in use?
- what does air traffic control need for the operation?
- if civilian regular public transport (RPT) operations are active in the area of operation, what would need to be done?
- will smoke or temperature be a hazard?

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DAY 2 Guidance    Part 3 Operational scenario 1    Part 6 Operational scenario 2    Part 7 Operational scenario 3

**Proposed limitations for the operation:**      Remotely Piloted Aircraft Systems (RPAS)  
Cross FIR Wildfire Reconnaissance  
Operation

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DAY 2 Guidance    Part 5 Operational scenario 1    Part 6 Operational scenario 2    Part 7 Operational scenario 3

Scenario

Operator

Request

Aircraft Specifications

CAA Considerations

Remotely Piloted Aircraft Systems (RPAS)  
Commercial agricultural operation




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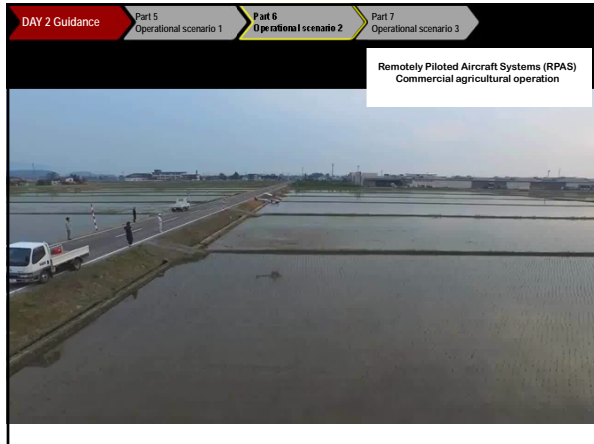
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DAY 2 Guidance Part 5 Operational scenario 1 Part 6 Operational scenario 2 Part 7 Operational scenario 3

Remotely Piloted Aircraft Systems (RPAS)  
Commercial agricultural operation

**Scenario**

A consortium of local farmers approached the competent authority to obtain an authorization for its Helicopter RMAX to perform commercial agricultural aircraft operations for several large farms.

**Operator**

- private funded company
- has previous experience in crop dusting operations with manned aircraft
- their operational staff include licensed remote pilots and observers that have been properly trained on the aircraft specifications and perform aerial photography

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DAY 2 Guidance Part 5 Operational scenario 1 Part 6 Operational scenario 2 Part 7 Operational scenario 3

Remotely Piloted Aircraft Systems (RPAS)  
Commercial agricultural operation

**Request**

The operator proposes to fly the RMAX RPA to conduct precision agricultural related services in rural areas at altitudes of less than 10 meters above ground level (AGL).

The petitioner intends to conduct agricultural services of spraying, seeding, remote sensing, frost mitigation and variable rate dispersal.

The RMAX can also be equipped with sensors and equipment to detect and monitor agricultural areas that require irrigation, fertilization, or other treatments. Yamaha provides the CAA with following documents as part of their proposal:

- RMAX training program
- Yamaha RMAX Ground Theory Manual
- Yamaha RMAX Operations Manual
- Yamaha RMAX Agricultural Guidebook

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DAY 2 Guidance Part 5 Operational scenario 1 Part 6 Operational scenario 2 Part 7 Operational scenario 3

Remotely Piloted Aircraft Systems (RPAS)  
Commercial agricultural operation

**Aircraft specifications – RMax Helicopter**


**PERFORMANCE**  
Load capacity, 28 kg  
Practical range, (Visual range) Up to 400 m  
Control System, YACS-G (RMAX Type II G) / YMCS (RMAX Type II)

**DIMENSIONS**  
Overall Length, 2,750 mm / 3,630 mm (with rotor)  
Overall Width, 720 mm  
Overall Height, 1,080 mm

**ENGINE**  
Type, 2-cycle, horizontally opposed 2-cylinder  
Starting System, Electric starter  
Fuel, Regular gasoline mixed with 2-cycle engine oil

**OTHER FEATURES**  
High performance GPS  
In case of Radio interference, the helicopter decelerates quickly  
In case of GPS Signal interruption, indicator flashes and helicopter goes into preselected flight mode.

**CAMERAS**  
Fitted with FLIR, and Zenmuse X5 with Lens and focus system, with remote controls.



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DAY 2 Guidance Part 5 Operational scenario 1 Part 6 Operational scenario 2 Part 7 Operational scenario 3

Remotely Piloted Aircraft Systems (RPAS)  
Commercial agricultural operation

**CAA considerations**

- what risks need to be mitigated for an authorization?
- CAA application process through to authorization?
- licensed pilot required?
- insurance requirements?
- privacy issues?
- CAA review and acceptance of manuals and procedures
- location, planning, airspace, weather communication, deconfliction
- need to consider maintenance and reliability

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DAY 2 Guidance Part 5 Operational scenario 1 Part 6 Operational scenario 2 Part 7 Operational scenario 3

Remotely Piloted Aircraft Systems (RPAS)  
Commercial agricultural operation

**Proposed limitations for the operation:**

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DAY 2 Guidance    Part 5 Operational scenario 1    Part 6 Operational scenario 2    Part 7 Operational scenario 3

Scenario


Operator

Request

Aircraft Specifications

CAA Considerations

Small Unmanned Aircraft System (SUAS) Bridge Inspection



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DAY 2 Guidance    Part 5 Operational scenario 1    Part 6 Operational scenario 2    Part 7 Operational scenario 3

Small Unmanned Aircraft System (SUAS) Bridge Inspection



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DAY 2 Guidance    Part 5 Operational scenario 1    Part 6 Operational scenario 2    Part 7 Operational scenario 3

Small Unmanned Aircraft System (SUAS) Bridge Inspection

**Scenario**

A local SUAS operator has contacted the State Civil Aviation Authority (CAA) regarding requirements for an authorization to perform bridge inspections. A bridge of 200 feet long (61 m) and 80 feet tall (24.3 m) has been struck by a ship requiring detailed inspections by civil engineers in order to determine the extent of the damage and the integrity of the structure. The operator is also initiating a trial of continuous inspection and monitoring for the condition of bridge welds, bolts and steel beams to be analyzed by civil engineers and Transportation Department inspectors.

**Operator**

- The operator works in a division of a large civil engineering company who also design, inspect and construct steel infrastructures including bridges and powerline towers for over 5 years. The remote pilots and observers will be employees of the operator.

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DAY 2 Guidance Part 5 Operational scenario 1 Part 6 Operational scenario 2 Part 7 Operational scenario 3

Small Unmanned Aircraft System (SUAS) Bridge Inspection

**Request**

- guidance from the CAA for the use of SUAS in visual line of sight (VLOS) operations
- all bridge inspection work will be flown under the bridge structure or at least 30 meters horizontal distance from bridge
- environment limited to day only visual meteorological conditions (VMC)
- SUAS aircraft utilized: Walkera Scout X4 with 25 minute endurance and G3 3.8 Pro 1
- flown by licensed remote pilots with valid medical certificates

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DAY 2 Guidance Part 5 Operational scenario 1 Part 6 Operational scenario 2 Part 7 Operational scenario 3

Small Unmanned Aircraft System (SUAS) Bridge Inspection

**Aircraft specifications - Walkera Scout X4**

- Remote control: DEVO F12E FPV Transmitter 2.4 Ghz and Video at 5.8 Ghz
- Support both Apple IOS and Android based devices
- Waypoint mission planning / Designated flight
- Follow Me Mode / Record Track Back To Home
- Hybrid, can be changed from 4 for to 8 motors
- 2.4 Bluetooth datalink ground station (BT-2401A/B FCC / BT-2402A/B CE)
- Flight time: Up to 25 minutes
- Flight range: up to 1500 m
- Receiver: DEVO-RX707(CE) / RX709(FCC)
- Real time flight data (telemetry) monitoring
- Auto return to home (RTH)
- Motors: Brushless WK-WS-34-002
- Battery: 6cell 22.2V 5400 mAh Li-Po
- iPad holder with backup power
- Size: 335x335x275 mm
- Rotor Blades Length: 233 mm
- Weight with battery: 1770 g
- Flying Weight: <2.27 Kg
- Larger Payload with the ability to carry a wider selection of cameras to be announced




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DAY 2 Guidance Part 5 Operational scenario 1 Part 6 Operational scenario 2 Part 7 Operational scenario 3

Small Unmanned Aircraft System (SUAS) Bridge Inspection

**CAA considerations**

- evaluation of SUAS operations in the transportation infrastructure environment
- authorization for bridge inspection would advance the public interest by providing the CAA with valuable user experience on SUAS command and control in VLOS operations
- initial research efforts are integral to the use of SUAS well beyond those operations that will be conducted by the operator
- if operating directly over travel lanes, the operator will coordinate with the local transportation authority for traffic control and lane closures
- CAA is monitoring the operation
- Transportation Department inspection methods performed in a safe manner without danger to workers in lifts or scaffolding
- analysis of structures performed with greater detail and accuracy in laboratories with SUAS high resolution sensors

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DAY 2 Guidance

Part 5 Operational scenario 1

Part 6 Operational scenario 2

Part 7 Operational scenario 3

Small Unmanned Aircraft System (SUAS) Bridge Inspection

Sample limitations for the operation

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Outline

DAY 3 Teamwork

Part 8 Additional guidance

Part 9 Group exercises

- ICAO UAS regulation portal
- Responsibilities of regulators
- Best practices

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ICAO UAS Regulation Portal

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**Narrative**  
The goal of ICAO is to secure the airway operations and to prevent UAS from operations, issues beyond and regulations for your consideration.

**Fly Safe-Fly Legal**  
In order to ensure that safe operations, to encourage business and to provide societal benefits, all aircraft must share airspace in a safe, predictable and regulated manner.

**UAS Toolkit**  
UAS operators, remote pilots and recreational pilots will benefit from the information contained in the toolkit as UAS operations grow in airspace traditionally occupied by manned aircraft.

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Additional Guidance

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**Responsibilities of regulators**  
**State of Registry**

- certificate of airworthiness
- radio station licence
- issue remote pilot licences\*
- assess international safety developments
- encourage high safety standards
- promote consultation and communication with industry/public

\* licence may or may not be issued by the State of Registry of the RPA

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Additional Guidance

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**Responsibilities of regulators**  
**State of the Operator**

- issue RPAS operator certificates (ROC)
- safety standards development
- conduct surveillance
- identify safety trends and risks
- issue remote pilot licences \*
- assess international safety developments
- encourage high safety standards
- promote consultation and communication with industry/public

\* licence may or may not be issued by the State of Registry of the RPA

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Best practices

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**Other regulators approach**

- FAA proposed framework of regulations would allow routine use of small UAS (under 55 pounds) into the NAS
- EASA ANPA 2015-10 – Introduction of a regulatory framework for the operation of drones
- UK CAP722 - provides guidance to enable UAS operations to be conducted within the relevant regulations
- CASA (Australia) CASR Part 101 - consolidates the rules governing all unmanned aeronautical activities into one body of legislation

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Best practices

**International Organizations**

- EUROCAE WG-73; tasked to deliver standards and guidance that will ensure the safety and regularity of UAS missions WG-73 works in coordination with RTCA SC-228 MOPS for Unmanned Aircraft Systems
- EUROCAE WG-93 is tasked to develop standards and recommendations for guidance material for the safe operation of Light RPAS
- RTCA SC 228 is developing MOPS for UAS

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Best practices

**International Organizations**

- ISO – ISO is developing UAS design, production, and maintenance standards for power, propulsion, and avionics, as well as for terminology and operations
- Joint Authorities for Rulemaking on Unmanned Systems (JARUS)
  - recommends a single set of technical, safety and operational requirements for the certification and safe integration of UAS into airspace and at aerodromes
  - provides guidance material aiming to facilitate each authority to write their own requirements and to avoid duplicate efforts

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Outline

DAY 3 Teamwork    Part 8 Additional guidance    Part 9 Group exercises

**Group Exercise**

- Case study – three scenarios
- Groups assignment
- Group discussion
- Proposed limitations for the operation




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DAY 3 Teamwork    Part 8 Additional guidance    Part 9 Group exercises

### Group Exercise

- Case study – first scenario

Flare stacks are structures that serve as safety devices in refineries, oil rigs and at other petrochemical facilities. They burn off excess hydrocarbon gases which cannot be recovered or recycled. Excess hydrocarbon gases are burnt in the flare systems as an alternative to releasing gas directly into the atmosphere. Historically, flare stacks have been inspected by cranes, helicopters or sometimes with scaffolding requiring an expensive shut down of the operation and a dangerous environment for the inspector.

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DAY 3 Teamwork    Part 8 Additional guidance    Part 9 Group exercises

### Request

A local UAS operator has contacted the State Civil Aviation Authority (CAA) along with a large petroleum company regarding necessary requirements for an authorization to perform flare stack inspections on their privately owned property. The request includes inspection of 10 flare stacks at their refining plant and at remote drilling operation sites.

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DAY 3 Teamwork    Part 8 Additional guidance    Part 9 Group exercises

### CAA considerations

- Evaluation of UAS operations for flare stack inspections in a remote, low altitude, VMC, VLOS environment.
- Approval and authorization of UAS flare stack inspections

*Note: more details on handout*

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DAY 3 Teamwork    Part 8 Additional guidance    Part 9 Group exercises

**Your task**

- a) complete the application for authorization
- b) propose the appropriate limitations for the operation and
- c) fill in the Grid for Unmanned Aircraft Operations according to each scenario

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DAY 3 Teamwork    Part 8 Additional guidance    Part 9 Group exercises

**Group Exercise**

- Case study – second scenario

Oil and gas producers must perform pipeline inspections at regular intervals that are expensive, not 100% reliable and sometimes dangerous when performed using manned aviation assets. UAS technology proposes to revolutionize pipeline inspection methods utilizing high definition and thermal imaging to detect faults, corrosion and other signs of deterioration, while posing almost no risk to humans and without interrupting operations. Results from infrared (IR) sensors and imaging can be interpreted immediately, allowing for the prompt reporting and handling of maintenance and spills in accordance with the operator's safety management systems. UAS's can be used to measure and quantify pipeline leaks before they become oil spills. They can also be used as a tool where a spill has already occurred to determine how the oil is moving in water and provide information and imagery to the company's command center.

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DAY 3 Teamwork    Part 8 Additional guidance    Part 9 Group exercises

**Request**

A UAS manufacturer has approached a CAA for an authorization to perform pipeline patrols to detect leaks, breaks and provide imagery for maintenance and also to provide imagery of adjacent road infrastructure on an oil company's private property. The request includes inspection of 200 miles for pipeline in remote areas below 120 meters above ground level in VMC VLOS conditions.

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DAY 3 Teamwork    Part 8 Additional guidance    Part 9 Group exercises

### CAA considerations

- Evaluation of UAS operations for pipeline patrols in a remote, low altitude, VMC, VLOS environment
- The CAA and State legislative bodies have determined that pipeline patrols are in the public interest and are interested in advancing the use of UAS technology as a measure to prevent oil spills and the resulting potential damage to the environment

*Note: more details on handout*

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DAY 3 Teamwork    Part 8 Additional guidance    Part 9 Group exercises

### Your task

- a) complete the application for authorization
- b) propose the appropriate limitations for the operation and
- c) fill in the Grid for Unmanned Aircraft Operations according to each scenario

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DAY 3 Teamwork    Part 8 Additional guidance    Part 9 Group exercises

### Group Exercise

- Case study – third scenario

Oil and gas pipelines deliver the earth's natural resources without consideration of flight information regions (FIR) or international boundaries. Many of these pipelines cover thousands of kilometers and multiple States; the use of RPAS for pipeline inspection across international boundaries requires coordination between multiple State authorities

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DAY 3 Teamwork    Part 8 Additional guidance    Part 9 Group exercises

### Request

The RPAS operator proposes a monitoring and inspection program to three adjoining States who share an oil pipeline. The operator proposes to fly operations beyond visual line of sight (BVLOS) but within radio line of sight (RLOS) in VMC conditions, flying at or below 300 meters AGL utilizing a transponder equipped Insitu ScanEagle that has been issued a type certificate and certificate of airworthiness (CofA) recognized by all three States

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DAY 3 Teamwork    Part 8 Additional guidance    Part 9 Group exercises

### CAA considerations

- How will the CAAs join together to approve this operation?
- Do all CAAs use the same authorization form or what differences will be imposed to allow for the crossing of their State boundaries?
- Do the adjoining CAAs utilize compatible spectrum bands for civilian operations (C2)?

Note: more details on handout

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DAY 3 Teamwork    Part 8 Additional guidance    Part 9 Group exercises

### Your task

- a) complete the application for authorization
- b) propose the appropriate limitations for the operation and
- c) fill in the Grid for Unmanned Aircraft Operations according to each scenario

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Group Exercise

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**Groups assignment**

- each group will be assigned to one of the variables of the case study
- template to be used, cross-reference grid and the RPAS Manual is included in the memory stick that has been distributed to the participants on the first day of the workshop
- results of the exercise will be presented in plenary by a rapporteur elected in each of the groups for general discussion.

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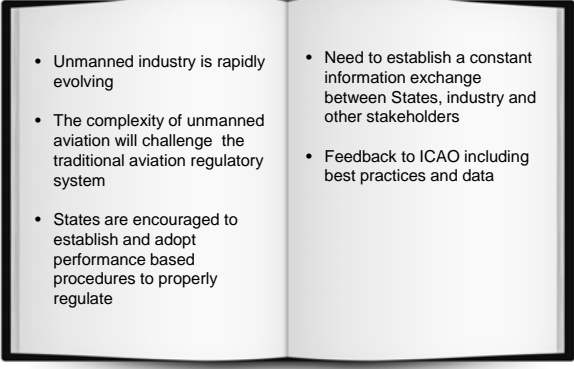
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Take aways

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• Unmanned industry is rapidly evolving

• The complexity of unmanned aviation will challenge the traditional aviation regulatory system

• States are encouraged to establish and adopt performance based procedures to properly regulate

• Need to establish a constant information exchange between States, industry and other stakeholders

• Feedback to ICAO including best practices and data

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ICAO

REMOTELY PILOTTED AIRCRAFT SYSTEMS

**ICAO RPAS WORKSHOP**  
Thank you

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