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# Study on the regulation of UAS in Hong Kong

Final Report

**CUSTOMER: Civil Aviation Department**

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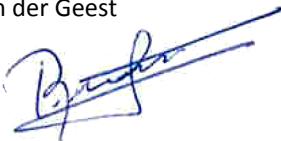
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# 1 Executive summary

- 1.1 The huge advancement in the application of UAS technologies and their rapidly increasing popularity, imply that the associated safety risks are increasing. To ensure aviation safety and the protection of persons and properties on the ground, there is a need for the Hong Kong Special Administrative Region Government (HKSARG) to review and enhance the existing regulation regime of UAS to keep in pace with the developments. Unmanned Aircraft operations involve interested parties familiar with aviation as well as many who are not. It is important to include these parties in the development and adaptation of UAS regulations. Therefore, this study analyses the international regulatory practices for UAS operations and recommends improvement to the current legislative framework and regulations for the safe operation of UAS in Hong Kong, with reference to the local environment and application of UAS, and the development of UAS technology. The following steps are undertaken:
- a) Review of international regulatory practices and policies;
  - b) Survey of UAS design, technologies and applications;
  - c) Assess the local situation and views on the regulation of UAS in Hong Kong;
  - d) Evaluation of practices and effect of regulation in Hong Kong;
  - e) Propose recommendations on UAS classification;
  - f) Propose operations standards and requirements;
  - g) Provide recommendations on implementation strategy and regulatory oversight.
- 1.2 Six key recommendations were made:
- a) Set up a UAS registration system for UAS above 250 g;
  - b) Establish a risk-based classification model for UAS operations, taking into account the weight and type of operations of UAS (e.g. where and how the UAS is operated) and develop the operating standards and requirements for each risk category;
  - c) Establish training and assessment requirements based on the risk category, which should improve operators' safety awareness and knowledge. The duration and complexity of training or assessment should be based on risks of UAS operations;
  - d) Establishment of a UAS (drone) map, primarily to cover no-fly zones and areas suitable for UAS flights;
  - e) Develop insurance requirements for UAS based on the risk category; and
  - f) Indoor operations of UAS to be further studied.
- 1.3 It is recommended to use a three-category model for classification of the different types of UAS operations, which is also suggested by ICAO [3] and EASA [29, 40]. A risk based approach to implement the operations standards and requirements according to the risk category is envisaged, thereby applying the same requirements to both recreational and commercial operation.
- 1.4 When making recommendations on the above risk model and individual operations standards and requirements, the main principles applied are that there will be a gradual evolution of the current rules for the operation of UAS, and that the future rules will be easily enforceable. A strategy for the implementation of new rules in phases is also proposed, in order to cater for appropriate regulatory controls in the near and medium/long term. To support the implementation, key items such as registration database system, guidance material etc. are identified.

- 1.5 The outcomes of this study, and in particular proposed operations standards and requirements, are also subject to further review when new approved standards become available from international bodies such as ICAO.

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## 2 Introduction

### Background

- 2.1 The huge advancement in the application of UAS technologies and their rapidly increasing popularity, imply that the associated safety risks are increasing. For example, some small UAS mainly for recreational purposes, can already reach altitudes at which manned aircraft are flying, and operate at high speeds that both the likelihood and potential consequences of collision with manned aircraft may become unacceptable. In many countries around the world, there is a lack of safety risk awareness with the recreational UAS users, who are often unaware of the consequences of their operations with UAS (or even of the applicable regulations and associated guidelines that may be in place).
- 2.2 It is clear that the general public and their properties as well as other manned aircraft in the vicinity of UAS activities are exposed to higher safety risks as a result. The number of incidents with small UAS is rising, and safety precautions and incident avoidance measures need to be introduced to safeguard aviation and the public.
- 2.3 The Civil Aviation Department (CAD) provides for the safe operation of UAS in order to minimise the safety risks. From a regulatory perspective, e.g. the following currently applies:
- A person shall not recklessly or negligently cause or permit an aircraft to endanger any person or property.
  - If a UAS is to be used for hire or reward, a permit from the CAD is required before operating the UAS and may only be operated under conditions and within the boundaries stipulated in the permit.
  - For flight not for hire or reward, non-recreational UAS operators may submit an application to the CAD for technical assessment on a voluntary basis. Such safety initiative is introduced by CAD to enhance safety.
- 2.4 With UAS as emerging technology and the increasing use of the UAS, by both professionals and hobbyists, the operations of this aircraft type could pose a safety risk to the public and their properties. Higher safety risk could result when the operations of the UAS take place above (densely) populated areas and/or in the vicinity of other manned aircraft. To ensure aviation safety and the protection of persons and properties on the ground, there is a need for the Hong Kong Special Administrative Region Government (HKSARG) to review and enhance the existing regulation regime of UAS so as to keep in pace with the developments.

### Objectives

- 2.5 The overall objective is to conduct a study on international regulatory practices for UAS operations and to recommend improvement to the current legislative framework and regulations for the safe operation of UAS in Hong Kong, with reference to the local environment, the development of UAS technology and an assessment of current practices in Hong Kong. The study aims to produce recommendations that can strike a reasonable balance between facilitating the use of UAS by the public and protecting the safety of the public.

# Approach

2.6 This study on the regulation of UAS in Hong Kong comprises the following Work Packages (WPs):

- WP1 Survey of UAS design, technologies and applications
- WP2 International regulatory practices and policies
- WP3 Assessment of local situation
- WP4 Practices and effect of regulation in Hong Kong
- WP5 Recommendations on UAS classification
- WP6 Operations standards and requirements
- WP7 Implementation strategy and regulatory oversight

## **WP1 Survey of UAS design, technologies and applications**

2.7 As first step, the study starts with a survey with the aim to research into and provide an overview of the design and technological advancement of UAS, and the development of their usage and applications in civilian context in recent years, and their future development direction.

## **WP2 Review of international regulations**

2.8 As a second step, the existing and near future international regulations, guidelines and best practices will be reviewed and evaluated from the viewpoint of potential applicability for Hong Kong. The review will cover non-legislative practice, enforcement measures adopted by other authorities (including the use of technology such as geo-fencing), applicability to specific users (such as search and rescue and law enforcement agencies). The review will cover, in any case, the current regulations, practices and developments of:

- International Civil Aviation Organization (ICAO);
- Joint Aviation Authorities for Rulemaking on Unmanned Systems (JARUS);
- Hong Kong;
- Europe (EASA, United Kingdom, Netherlands, Switzerland, Germany);
- United States (FAA);
- Asia (China (including Macau SAR), Singapore, Japan, South Korea);
- Australia.

## **WP3 Conduct an assessment of the local situation**

2.9 The third step will focus on the actual current situation in Hong Kong. A sampling of views from UAS manufacturers, suppliers, operators and users, as well as relevant personnel in aviation safety, and the use of other information (website, local news etc) will provide a good indication on how UAS regulations may be established.

## **WP4 Evaluate the practices and effect of regulation in Hong Kong**

2.10 This Work Package (WP4) covers an evaluation of the prevailing practices regarding UAS operation and the effect of regulation on this operation in Hong Kong. Through the Work Packages mentioned above, a variety of information is collected and analysed. The results obtained from the Work Packages 1 through 3 will be evaluated and checked against the current regulation to evaluate its effect on the UAS applications in Hong Kong. In the evaluation, the relevant regulations of unmanned and manned aviation of Hong Kong will be considered.

## **WP5 Propose recommendations on UAS classification**

2.11 This Work Package (WP5) will consolidate the results from the Work Packages 1 through 4, as reported in this study, and draw conclusions on the needs and benefits of revising/refining a UAS classification scheme. For establishing an appropriate UAS classification scheme for Hong Kong, the feasibility of introducing a risk based approach will be evaluated. Such approach would distinguish a number of categories, where the regulatory approach used by the civil aviation authorities would depend on the level of safety risk expected to be associated with the category under consideration. For example, a category with a relatively low level of risk would not require specific authorisation for each flight by CAD, in case safety is ensured by defining safety boundaries for the operation (e.g. distance from aerodromes, buildings, people, critical infrastructures). On the other hand, a category with higher level of risk could require a safety risk assessment as basis for operational approval, or may even lead to specific (certification) requirements on the technology, equipment and/or procedures to be used.

## **WP6 Operations standards and requirements**

2.12 This Work Package (WP6) will propose operations standards and requirements for each class of UAS as defined in WP5. Whereas a ‘low level risk category’ may be regulated on the basis of a set of pre-defined operating limitations, for a ‘high level risk category’ more stringent operations standards and requirements would need to be defined.

## **WP7 Implementation strategy and regulatory oversight**

2.13 This Work Package (WP7) will provide recommendations on the way forward for the implementation of:

- The proposed UAS classification scheme resulting from WP5; and
- The proposed operations standards and requirements from WP6.

# **Structure of the document**

2.14 The structure of this document is as follows:

- Chapter 1 Introduction
- Chapter 2 Regulation of UAS in Hong Kong
- Chapter 3 International regulatory developments
- Chapter 4 Regional and national state regulations
- Chapter 5 Developments in UAS and applications
- Chapter 6 Practices and effect of regulation in Hong Kong
- Chapter 7 Recommendations on UAS classification
- Chapter 8 Operations standards and requirements
- Chapter 9 Implementation strategy and regulatory oversight
- Chapter 10 Conclusions and recommendations.

### 3 Regulation of UAS in Hong Kong

- 3.1 UAS, regardless of weight and purpose (recreational, commercial, or other non-recreational purposes), are governed by the Air Navigation (Hong Kong) Order 1995 (Cap 448C, Laws of Hong Kong) (AN(HK)O). Under Article 100 of Cap 448C, small UAS weighing not more than 7 kg (without its fuel) are “Small Aircraft”, which are subject to a few requirements only, such as Article 48, which stipulates that a person shall not recklessly or negligently cause or permit an aircraft to endanger any person or property. Airworthiness or other operational certificates are not required for those small UAS.
- 3.2 For heavier UAS, i.e. those weighing more than 7 kg (without fuel), they are subject to all applicable requirements of Cap 448C, such as Articles 3 and 7 which stipulates that an aircraft shall not fly unless it is issued with a Certificate of Registration and a Certificate of Airworthiness.
- 3.3 Regulation 22 of the Air Transport (Licensing of Air Services) Regulations (Cap 448A, Laws of Hong Kong) states that if a person uses an aircraft for hire and reward, he/she must have CAD’s permit before operating such aircraft and abide by the conditions on the permit. Amongst other considerations, the CAD will consider whether the applicant and his/her UAS can be operated under a safe condition before a permit is granted.
- 3.4 The current law does not require pilot licenses to be issued for the operation of UAS but applicants for non-recreational use of UAS are required to provide evidence of pilot competency. UAS operators envisaging non-recreational use are required to submit the application form(s), operational manuals, flight plans, assess risks involved and propose mitigating measures, and provide copy of an insurance policy that appropriately insures the operator in respect of third party risks. Land managers’ permissions where applicable are needed. The permit for the UAS operator will stipulate relevant conditions and requirements to ensure safe operation.
- 3.5 In addition, the CAD has published UAS safety guidance on website for recreational UAS (including model aircraft). For example, the public are currently advised not to fly a UAS over populated and congested areas, in the vicinity of an airport or aircraft approach and take-off paths. Sites of operations should be clear of buildings, people and away from helicopter landing pads, and clear of any power sources such as power lines, transformer stations, pylons and transmitter towers which might cause radio interference. The site should also be free from visual obstruction, so that the operator can see his UAS in flight only, or referred as “Visual Line of Sight operations” (VLOS). UAS operations shall be conducted in daylight only. As regards recreational use, it is currently not required to obtain a permit from the CAD for the operation of UAS.
- 3.6 While flight safety of UAS is regulated by civil aviation legislation, UAS are also subject to other requirements, such as
  - regulation of radio frequencies by the Office of Communications Authority (OFCA)
  - privacy protection by the Privacy Commissioner for Personal Data (PCPD),
  - property/land managers’ rules where applicable,
  - product safety, etc,
- 3.7 These issues are regulated under relevant guidelines and regulations monitored by different government departments, enforcement agencies or property/land managers as appropriate.
- 3.8 For example, on privacy protection, there exists “Guidance on CCTV Surveillance and Use of UAS” ([https://www.pcpd.org.hk/english/resources\\_centre/publications/files/GN\\_CCTV\\_UAS\\_e.pdf](https://www.pcpd.org.hk/english/resources_centre/publications/files/GN_CCTV_UAS_e.pdf)) to remind users of UAS (i.e. UASs with cameras) of their duty in privacy protection. The guidance note reminds users of UAS that the use of UAS for image recording is also regulated by the Personal Data (Privacy) Ordinance (including

the Data Protection Principles therein). Users of UAS should be particularly aware of the need to respect people's privacy. They should also have due regard to and have understanding of public perception and the reasonable privacy expectations of the individuals affected. Suggestions on the responsible use of UAS in aspects such as recording, retention and encryption of image transmission by UAS are given in the guidance note.

## 4 International regulatory developments

- 4.1 There are currently a number of international and regional platforms where discussions on UAS<sup>1</sup> regulation and operation are being held. These include the ICAO Remotely Piloted Aircraft Systems (RPAS) Panel, the ICAO Small UAS – Advisory Group (SUAS-AG), the Joint Authorities for Rulemaking on Unmanned Systems (JARUS) and ICAO's Asia/Pacific Unmanned Aircraft Systems Task Force (APUAS/TF). The International Organization for Standardization (ISO) is also developing standards for the classification, design, manufacture, operation (including maintenance) and safety management of UAS operations.  
[\(https://www.iso.org/committee/5336224.html\).](https://www.iso.org/committee/5336224.html)

### ICAO

- 4.2 ICAO published the Circular 328 "Unmanned Aircraft Systems" and the "Manual on Remotely Piloted Aircraft Systems" (Doc 10019) (i.e. "RPAS Manual"), which differentiates UAS as:
- RPAS<sup>2</sup> (a subset of UAS) that can be integrated in airspace alongside manned aircraft, and
  - UAS that can only be accommodated in airspace by keeping them away from other aircraft, with appropriate consideration given to the risk they pose to other aircraft, or people and property on ground.
- 4.3 ICAO provides terms and definitions for the UAS domain in its RPAS Manual [1], of which most have an official status within ICAO. Example definitions, important for the establishment of a legal framework, are:
- Operator. Person, organization or enterprise engaged in or offering to engage in an aircraft operation (in the context of remotely piloted aircraft, an aircraft operation includes the remotely piloted aircraft system).
  - Remote pilot A person charged by the operator with duties essential to the operation of a remotely piloted aircraft and who manipulates the flight controls, as appropriate, during flight time.
  - Remote pilot station. The component of the remotely piloted aircraft system containing the equipment used to pilot the remotely piloted aircraft.
  - Remotely piloted aircraft (RPA). An unmanned aircraft which is piloted from a remote pilot station.
  - Remotely piloted aircraft system (RPAS). A remotely piloted aircraft, its associated remote pilot station(s), the required command and control links and any other components as specified in the type design.
  - RPA observer. A trained and competent person designated by the operator who, by visual observation of the remotely piloted aircraft, assists the remote pilot in the safe conduct of the flight.
  - Command and control (C2) link. The data link between the remotely piloted aircraft and the remote pilot station for the purposes of managing the flight.
  - Detect and avoid. The capability to see, sense or detect conflicting traffic or other hazards and take the appropriate action.

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<sup>1</sup> UAS refers to any aircraft that is flown without a pilot on-board. RPAS is a subset of UAS which is piloted from a remote pilot station. ICAO Annex 2 (at Amendment 43) Appendix 4 paragraph 2, requires that RPAS have a Certificate of Airworthiness, the remote pilot be licensed and the operator hold an RPAS operator certificate.

<sup>2</sup> An Unmanned Aircraft refers to an aircraft which is intended to operate with no pilot on board [2]. An Unmanned Aircraft System (UAS) refers to an aircraft and its associated elements which are operated with no pilot on board. Remotely Piloted Aircraft System (RPAS) is a subset of UAS which is piloted from a Remote Pilot Station (RPS). ICAO defines RPAS as *a remotely piloted aircraft, its associated remote pilot station(s), the required command and control links and any other components as specified in the type design*. RPAS are UAS that are able to interact with Air Traffic Control and other aircraft on a real-time basis [1]. ICAO defines RPS as *the component of the RPAS containing the equipment used to pilot the Remotely Piloted Aircraft (RPA)* [1]. The RPS can range from a hand-held device up to a multi-console station. ICAO Annex 2 (Amendment 43) requires that RPAS have a Certificate of Airworthiness, the remote pilot be licensed and the operator hold an RPAS operator certificate.

- 4.4 Furthermore, it is noted that throughout this document the use of the term ‘UAS user’ includes e.g. owners of UAS, operators of UAS and remote pilots, and could refer to all those involved in using the airspace for flights with UAS.
- 4.5 The RPAS Manual envisioned RPAS to be an equal partner in the civil aviation system, able to interact with Air Traffic Control (ATC) and other aircraft on a real-time basis [1]. RPAS are subject to the same equipage and certification requirements as manned aircraft and have the same separation standards. In other words, RPAS act like and are treated like manned aircraft. Further, RPAS are usually large, at present unlikely to be UAS lighter than 25 kg. This could change in the future. Although at present RPAS operations are not common in Hong Kong, recent developments are very important for the establishment of a new legal framework for UAS, and should be taken into consideration.
- 4.6 ICAO has established the following groups to address specific types of UAS. Considering the type of UAS in Hong Kong, the first 2 groups are relevant:
- ICAO Asia/Pacific Unmanned Aircraft Systems Task Force (APUAS/TF/1) in 2017
  - Small UAS – Advisory Group (SUAS-AG) established in 2016
  - Remotely Piloted Aircraft Systems (RPAS) Panel established in 2014.

#### ICAO Asia/Pacific Unmanned Aircraft Systems Task Force (APUAS/TF)

- 4.7 ICAO recently established APUAS/TF with the objective of developing guidance material that supports an Asia/Pacific Seamless ATM Plan element: B1-UAS. This element is expected to incorporate the ICAO Aviation System Block Upgrade (ASBU) B1-RPAS but in addition, to include regional expectations for the regulation and safe operation of small UAS within national airspace from an ATM perspective by November 2019 [4]. The first meeting was held from 3 to 5 April 2017. The APUAS/TF membership is formed by Asia/Pacific States/Administrations and International Organizations. Other non-Asia/Pacific States, and organizations involved in UAS manufacturing, regulation and operations may join the APUAS/TF at the invitation of the ICAO Regional Office.

#### ICAO Small UAS – Advisory Group (SUAS-AG)

- 4.8 The smaller UAS are specifically addressed in SUAS-AG, which was established in 2016. These UAS are typically referred to as ‘drones’, a layman’s term used by the general public. A model aircraft is another example type UAS, operated for recreational purposes, and is usually required to be operated within VLOS.
- 4.9 Considering that most UAS allowed to be operated in Hong Kong are below 7 kg and are segregated from manned aircraft, those UAS are not envisaged for RPAS operations (usually larger UAS that can interact with ATC and other aircraft on a real-time basis). ICAO guidance provided by the SUAS-AG is therefore relevant, and to be considered. The SUAS-AG has recently created the UAS Toolkit [3], a web-based environment that helps States to develop legislation for UAS. It should be noted that ICAO’s UAS Toolkit is under continuous development. The description provided in this document is based on the status of May 2017. The SUAS-AG develops guidance material and provides best practices for routine SUAS operations while aiming to maintain the existing level of safety of manned aircraft operations and people and property on the ground. The regulator should “identify key areas of concern and develop regulations that can be implemented effectively. State regulations should cover all UAS operations in domestic airspace such that the UAS regulatory framework is compatible with existing aviation regulations as well as those of other sectors”.

### ICAO Remotely Piloted Aircraft Systems (RPAS) Panel

- 4.10 The Panel was established by ICAO Air Navigation Commission on 6 May 2014, and serves as the focal point and coordinator of all ICAO RPAS related work, aiming for global interoperability and harmonization. It has seven Working Groups and coordinates the RPASP/SMP Joint Task Force on RPAS Safety Management. The latter was established together with the Safety Management Panel (SMP), to support development of standards and guidance material on RPAS safety management.
- 4.11 Working Groups are:
- WG1 Airworthiness
  - WG2 Communications
  - WG3 Detect and Avoid
  - WG4 Licensing
  - WG5 Operations
  - WG6 Air Traffic Management
  - WG7 Human In The System.
- 4.12 The RPAS Panel develops standards and associated guidance material for the regulatory process, reviews ICAO Standards and Recommended Practices (SARPs), proposes amendments and coordinates the development of RPAS SARPs with other ICAO expert groups. The RPASP also assesses the impacts of proposed provisions on existing manned aviation; and addresses bandwidth and frequency spectrum requirements for command and control of RPAS for the International Telecommunications Union (ITU) World Radio Conference (WRC) negotiations.
- 4.13 The initial focus was on development of SARPs related to airworthiness, operations (including RPAS operator certification) and licensing of remote pilots. The RPAS Panel now also works on SARPs for air traffic management, safety management and detect and avoid requirements for unmanned aircraft, while giving due consideration to human factors aspects.

## JARUS

- 4.14 JARUS (Joint Authorities for Rulemaking on Unmanned Systems) is a group of with regulatory expertise from various countries around the world. JARUS aims to recommend a single set of technical, safety and operational requirements for the certification and the safe integration of Unmanned Aircraft Systems (UAS) in airspace and at aerodrome. The JARUS guidance material aims to facilitate each authority to write its own requirements. Seven Working Groups provide guidance material and recommendations to facilitate national aviation authorities to develop their own requirements. At present, about 50 countries, and EASA and EUROCONTROL, are contributing to development of JARUS work products.
- 4.15 The work is performed by the following seven JARUS Working Groups:
- WG 1 – Flight Crew Licensing
  - WG 2 – Operations
  - WG 3 – Airworthiness
  - WG 4 – Detect and Avoid
  - WG 5 – Command and Control
  - WG 6 – Safety and Risk Management
  - WG 7 – Concepts of Operations

4.16 So far, JARUS has published and made available the following deliverables:

- CS-LURS (Certification Specification for Light Unmanned Rotorcraft Systems) [5]
- RPAS C2 Link (required Communication Performance concept) [6]
- FCL (Flight Crew Licensing) Recommendations [7]
- AMC (Acceptable Means of Compliance) RPAS 1309 [8]
- RPAS “Required C2 Performance (RLP) concept” [9]
- Recommendations on the use of Controller Pilot data Link Communications (CPDLC) [10]
- CS - LUAS (Certification Specification for Light Unmanned Aircraft Systems) [11]

4.17 JARUS promotes a harmonized approach that complements other international efforts. Besides publishing deliverables, JARUS also maintains an overview of current RPAS regulations/rules implemented in some countries around the world. The overview is maintained in an Excel-sheet on the website of JARUS ([www.jarus-rpas.org](http://www.jarus-rpas.org)).

## 5 Regional and national state regulations

- 5.1 This Chapter provides an overview of existing UAS regulation and practices, addressing the following topics:
- UAS legislation and regulations in force
  - Non-legislative regulations and enforcement measures adopted
  - Exemptions for different types of users, if any
  - Effectiveness of regulations and enforcement measures in safeguarding aviation safety
- 5.2 For this overview, the following regions / states / administrations are considered Australia, Mainland China, Macau SAR, Europe, Singapore, the United Kingdom, United States, Japan and South Korea. Regarding Europe, the existing regulations and developments at the European Aviation Safety Agency (EASA) as well the Netherlands, Switzerland, and Germany are covered. For the United States, the US Federal Aviation Administration (FAA) approach is considered. Furthermore, an overview of different classifications is provided for the various countries and regions, to distinguish among e.g. the different types of UAS, their weight and functions, and nature and location of the operations. This overview provides a snap-shot of the current situation at the time of writing of this study. It must be realized that the international developments are going at a very rapid pace, i.e. this overview is subject to change.
- 5.3 For each of the above-mentioned regions / states / administration, the UAS legislation and regulations in force, non-legislative regulations and enforcement measures adopted, any exemptions for different types of users, and applied classifications are summarized in Appendix A. All these items, including the 'effectiveness of regulations and enforcement measures in safeguarding aviation safety' are summarized on a global level and with a special consideration to the Asia Pacific region (including Singapore, Macau SAR, Japan and South Korea), in the Chapters hereafter.

### UAS legislation and regulations

- 5.4 The commonly identified principle in all regulations is that the rules have been established with the objective to provide a safe environment in which small UAS can be flown without coming into conflict with manned aircraft and without, or with an acceptable level of, risk to other people or properties. The practical implementation of this differs however from country to country, making it difficult to summarize. Nonetheless, comparable principles in terms of approvals needed and operational privileges are applied.
- 5.5 The permissions granted by the rules (granted privileges) are generally limited to operations:
- in certain areas (uncontrolled, not above densely populated districts or security sensitive areas);
  - to a certain height (generally 400 ft, as manned aviation has generally a minimum flight altitude of 500ft);
  - within VLOS (to ensure pilot can see the UAS and maintain good control to avoid other aircraft);
  - conducted in daytime only;
  - separated from people and/or crowds.
- 5.6 The majority of reviewed regions and national states require some sort of proof of pilot capabilities, predominantly in the form of a pilot license to be obtained after training and examination. Some require additional proof of airworthiness of the UAS and a few require also approved operational procedures and safety management principles to be applied by the organisation operating the UAS.
- 5.7 One outlier in this respect is Switzerland in which UAS up to a weight of 30 kg can basically be operated without permission under the condition that the pilot has at any time eye contact with the UAS and does not fly above

gatherings of people (>2000 persons). In the Asia Pacific region, the operations are limited to daytime, do not allow dropping of objects nor carrying of dangerous goods and limit the operations in certain specific restricted areas. Operations in Japan are limited to a height of 150m and distance of 30m from persons and property and in Macau SAR to a height of 30m and distance of 100m from crowds (defined as 100 persons or more) and 50m from specific buildings. Japan is the only country identified to also explicitly consider population density for its setting of safety standards for UAS operations <sup>3</sup> [30]. Singapore has not published set heights and distances but these can be limited in the operational approvals that are to be obtained for operations other than Recreation or Research and for operations with aircraft exceeding 7kg. In South Korea any person who intends to operate an UA in airspaces around airports within 9.3 km, above no UAS zone (North-Seoul, DMZ and nuclear power facilities) and/or above 150m AGL is required to obtain permission. In other airspace no permission is required.

- 5.8 Furthermore, provisions for additional exemptions (among other aspects night flights) for operations with societal benefits (such as police, fire brigade, R&D and test operations) are catered for in some regulations.

#### Non-legislative regulations

- 5.9 Not all reviewed regions and states have legislation and regulations in force. In case of absence of legislation, guidance material (good practices, recommendations, etc.) is published based on principles similar to the regulations described above.

#### Enforcement measures adopted

- 5.10 With respect to enforcement measures, the majority have such measures in place varying in severity from seizure of the UAS, to fines and even up to criminal prosecution including the possibility for imprisonment. The largest known fine issued to date by the FAA is a \$200,000 fine issued to an operator for conducting 65 illegal UAS flights in congested airspace over Chicago and New York City. The fines however do vary from region to region, for example if the rules are violated in Japan the UA operator is liable for a fine of up to 500,000 yen (about USD 4,500), while violators in Macau SAR will be liable to a fine of MOP 2,000 (about USD 250) to MOP 20,000 (about USD 2,500), in Singapore operators found guilty of flying UAS without a permit will be fined up to \$ 20,000 (Singapore dollars) (about USD 15,000) and/or jailed up to 1 year and in South Korea fines up to 10 million Korean Won (about USD 9,400) or imprisonment up to one year.

#### Differentiation of types of users

- 5.11 The practices regarding whether users are differentiated by types may vary. Some apply the same regulations and principles to all types of users, such as Switzerland, Japan and Macau SAR, while others have different regulations, mainly to differentiate between recreational and professional users, either limited to commercial aerial work (such as United Kingdom) or also including non-commercial use (such as Singapore, Netherlands and Germany). In these cases professional users generally require additional approvals, certificates and/or licenses from their CAAs in order to obtain more operational privileges.

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<sup>3</sup> In Japan, for flights above Densely Inhabited Districts (DID), above a distance of less than 30 m from any persons or properties, or over other event sites where many people gather, the following additional standards apply: the UA shall be structured to reduce any harm (e.g. propeller guard); operator shall have the skills to operate the UAS at his/her discretion; and an assistant shall be positioned to inform the operator of the change of flight or weather condition, and to alert the third party to keep out of the flight area. This implies that in Japan, population density is also taken into account for setting of (additional) standards to improve the safety of third parties [30].

### UAS classifications

- 5.12 The vast majority classifies UAS based on their weight (either empty weight or maximum take-off weight or maximum all up weight) while Mainland China, includes - in addition to weight - also specific types of operation (agricultural use, airship, whether UAS are operated within visual range of the pilots etc). Europe also proposed in EASA NPA 2017-05 to classify UAS based on weight (and/or impact energy in some cases) and how they are operated (e.g. proximity to people, whether UAS are operated within visual range, maximum height above ground etc.).
- 5.13 Speed and/or impact energy is usually not directly considered, but may have been taken into account indirectly for setting of weight limits. The primary classification distinction is always made on the basis of weight.
- 5.14 The graph below provides an overview on the international practice on weight limits. In general, a lower limit of 0 to 250 g delineates UAS which are not regulated. A common national upper limit in Europe is set at 150 kg, and above is governed by EASA. The Mainland China has the highest limit of 5700 kg or above which is not shown below. Number of weight categories may range from 1 (JP) to 6 (China), with incremental weights ranging from 1, 2, 4, 7, 20, 25, 30, 116, 150, 5700 kg. The approval process is usually simplified as weight of UAS decreases. In the Asia Pacific region, Hong Kong, Macau SAR and Singapore use a 7 kg weight limit, while Japan applies a 200 gram limit and South Korea applies 25kg and 150kg limits.

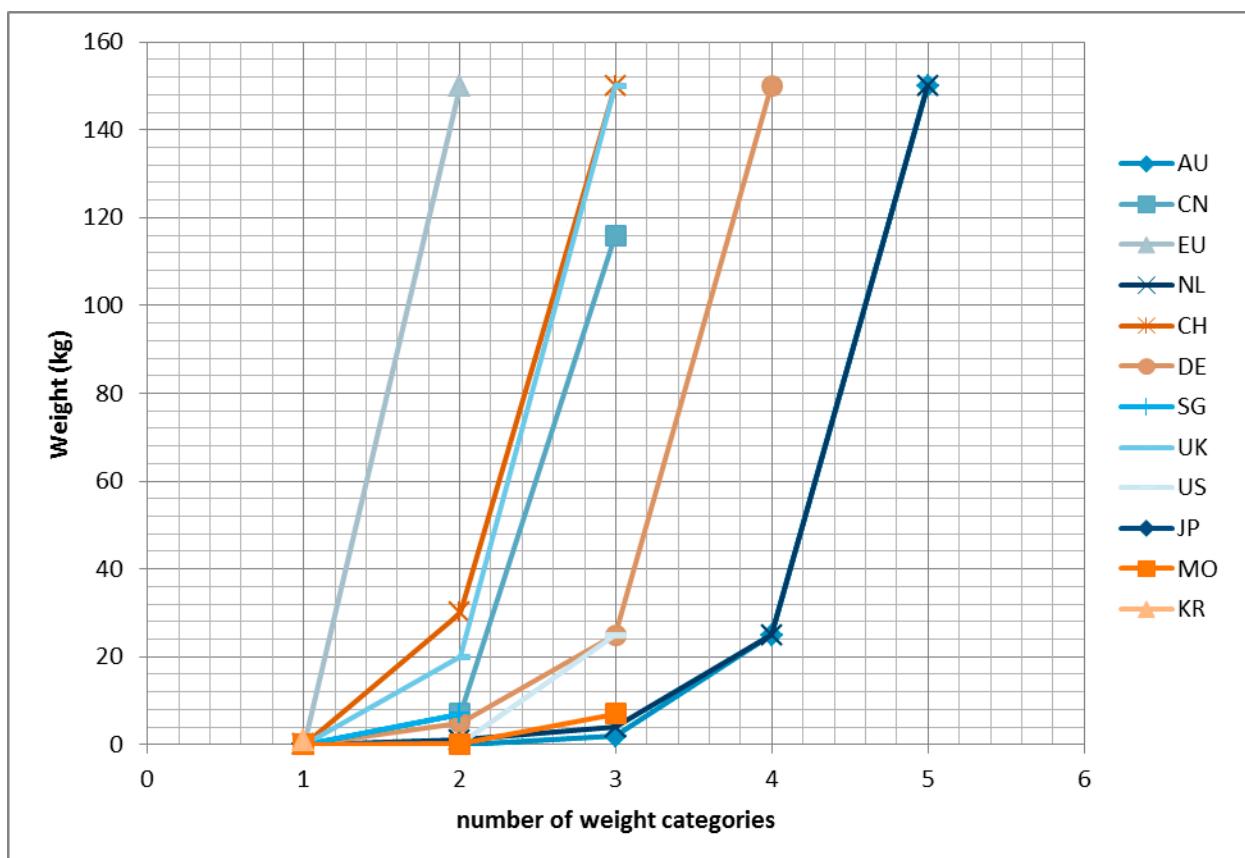


Figure 1 Overview of weight limits used

- 5.15 Based on the wide variance between these incremental limits, it's concluded that there is no consensus on the relation between weight of the UAS and the posed risk to manned aircraft and risk to other people or properties (as mitigated by the different operational limitations).

### Effectiveness of regulations and enforcement measures in safeguarding aviation safety

- 5.16 The objective of UAS regulations is to prescribe conditions for UAS (including UAS) to be flown without conflicts with manned aircraft and without or with an acceptable level of risk to other people or properties. With respect to conflicts with manned aircraft, many sightings of suspected UAS have been reported by pilots worldwide. Collision with manned aircraft is rare<sup>4</sup>.
- 5.17 Regarding the risks to aircraft, EASA's 'UAS collision' task force concluded that a collision with the smallest UAS category (0.25kg) is expected to be harmless for large aeroplane product types but further research is needed to determine the consequences for other aircraft product types. The task force later identified the batteries and the motors of UAS as key critical components. EASA's finding made an analogy between "UAS hit" and "bird strike" false, and the risks of the former is expected to be higher.
- 5.18 Also, in terms of risk to people on the ground, no overarching literature is available. Although UAS have caused injuries and even fatalities<sup>5</sup>, the vast majority were operated without incidents. This may be attributed to the regulations in place.
- 5.19 For assessing the effectiveness of regulations, analysing the occurrences is one, but knowing the number of UAS that are operated in a country or region is also of importance. For this some apply mandatory registration. For the reviewed countries/states with a UAS registration obligation the figures are that some 770,000 UAS are registered in the US (all UAS above 0.55lbs) and 629 in the Netherlands (professionally used UAS only) until March 2017 and 716 in South Korea until July 2015. Although Macau SAR does mandate the labelling of UAS no numbers are available and most other reviewed countries do not mandate a centralised registration. However, China recently introduced a requirement for UAS owners to register UAS above 250 g. Also, EASA in its newly proposed regulatory framework for the operation of UAS envisages the introduction of a requirement for registration [29].
- 5.20 Based on the above, a clear link between effective regulatory system and low safety risks is expected but difficult to substantiate without sufficient incident data. It should however be noted that there is an increasing number of reports and occurrences of airport/airspace intrusion. In fact, in Mainland China there have been a significant number of flight delays in early 2017 due to UAS "incidents":
- January 15. A UAS flew into the Xiaoshan airport in Zhejiang province and recorded a video of a passenger plane in flight. The controller of the UAS then uploaded the video onto the internet attracting widespread public attention. The suspect has since been tracked down and handed to the authorities for further investigation.
  - February 2 night outbound flights were delayed and 3 inbound flights were forced to make emergency landings at other airports in Mianyang airport in Sichuan province, following the appearance of a luminous UAS.
  - February 3 afternoon: 11 flights were affected in Shenzhen airport by UAS. Flights in Shantou airport, Guangdong province were also affected by UAS on the same day.

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<sup>4</sup> A UAS hit a commercial airplane in Canada on 12 October 2017. Also, a British Airways aircraft was allegedly hit by a UAS at Heathrow airport on 17 April 2016, has not been confirmed and might have been a plastic bag. One instance in which a LAM B737-800 suffered a radome structural failure at Tete on 5 January 2017, was first suspected to be hit by a UAS, which was later concluded that the radome most probably failed as result of a structural failure caused by air flow pressure after defective installation.

<sup>5</sup> Injury levels are amongst others studied by the FAA UAS Center of Excellence which produced an UAS Ground Collision Severity Evaluation report, [http://www.assureuas.org/projects/deliverables/a4/ASSURE\\_A4\\_Final\\_Report\\_UAS\\_Ground\\_Collision\\_Severity\\_Evaluation.pdf](http://www.assureuas.org/projects/deliverables/a4/ASSURE_A4_Final_Report_UAS_Ground_Collision_Severity_Evaluation.pdf). Examples of accidents in which a crew member was fatally injured are found in South Korea in which a Schiebel S-100 crash fatally injured an engineer (<https://www.suasnews.com/2012/05/schiebel-s-100-crash-kills-engineer-in-south-korea/>) and a Yamaha RMAX crop spraying helicopter fatally injured the pilot (<https://aviation-safety.net/wikibase/wiki.php?id=169200>). A bystander was fatally injured after being hit by a model plane in the UK (<https://www.theguardian.com/uk/2003/apr/17/jeevanvasagar2>).

- February 3 - February 5. A total of 6 incidents involving UAS intruding into Kunming airport took place.
- March 4. A UAS was found to have flown near the restricted area of Harbin airport.

# 6 Developments in UAS and applications

## Introduction

- 6.1 In this Chapter an overview of the developments in UAS design, relevant technologies, applications and market outlook is given, focusing on the civil operations only with smaller UAS up to about 25 kg.

## UAS design and technology developments

- 6.2 UAS come in various shapes and sizes. Besides multi-rotor UAS, there are other UAS such as model airplane, model helicopter etc. Note that model aeroplane and helicopter are not usually referred to as “drones”.
- 6.3 Multi-rotor UAS can be further classified based on the number of rotors, such as Tricopter (3 rotors), Quadcopter (4 rotors), Hexacopter (6 rotors) and Octocopter (8 rotors). Quadcopters are the most popular and widely used variant.
- 6.4 Although easy to manufacture and relatively cheap, multi-rotor UAS have downsides, including the limited flying time and speed. They are not always suitable for tasks like long distance aerial mapping or surveillance. At present, most of the multi-rotor UAS out there are capable of only a 20 to 30 minutes flying time (often with a minimal payload like a camera). For tasks like long distance aerial mapping or surveillance fixed wing UAS are more commonly used. To illustrate the variety of UAS, Table 1 below gives some characteristics of a selection of UAS. It involves the speed, flight time, operating range and weight. The selection involves a number of popular consumer UAS completed by a number to illustrate the range in terms of speed, weight, size and operating range. Figure 1 shows a mini UAS (Cheerson CX-10) as well as a UAV Factory Penguin B to illustrate the range.

*Table 1 Characteristics of a selection of UAS*

| Name                        | Manufacturer | Speed (km/hr) | Flight time (minutes) | Operating Range (feet) | Weight (kg) |
|-----------------------------|--------------|---------------|-----------------------|------------------------|-------------|
| Spark                       | DJI          | 50            | 16                    | 6300                   | 0.30        |
| Mavic Pro                   | DJI          | 64            | 27                    | 23000                  | 0.73        |
| Phantom 4                   | DJI          | 72            | 28                    | 19700                  | 1.36        |
| Inspire 1                   | DJI          | 79            | 18                    | 18000                  | 3.00        |
| Breeze                      | Yuneec       | 18            | 12                    | 300                    | 0.39        |
| Typhoon H                   | Yuneec       | 70            | 25                    | 5200                   | 1.81        |
| Parrot AR.UAS 2.0           | Parrot       | 24            | 12                    | 165                    | 0.42        |
| Behop                       | Parrot       | 50            | n/a                   | n/a                    | n/a         |
| 3DR IRIS+                   | 3DR          | 64            | 16                    | 3280                   | 1.28        |
| Teal SDK                    | Teal         | 113 + (*)     | 10-20                 | 5000                   | 0.73        |
| Penguin B                   | UAV Factory  | 130           | 1200                  | 16000                  | 10.0        |
| Cheerson CX-10 Mini UAS     | Cheerson     | 13            | 5-8                   | 100                    | 0.01        |
| VXR-190 (FPV racing UAS)    | Quad Star    | 267           | n/a                   | n/a                    | 0.5         |
| Wizard X220(FPV racing UAS) | Eachine      | 109           | n/a                   | n/a                    | 0.5         |

(\*) Stable with winds up to 64 km/hr

(\*\*) Depending on the type of C2 link: WiFi: 300ft, Extended WiFi: 2500ft, 2.4ghz Tx: 5000ft+



*Figure 2 Illustration of the variety of UAS*

- 6.5 Figure 2 illustrates the wide variety of UAS: an image of a mini UAS (Cheerson CX-10 with dimensions 4x4x2.2 cm) and the UAV Factory Penguin B with a wingspan of 3.3 meters. Popular consumer UAS, such as the DJI Phantom 2, which was released in 2013, have already flown as high as 2,000 feet at that time before losing connection with their remotes. Custom-built consumer UAS, without limitations set by manufacturers or other safety features, can fly much higher. A European hobbyist has flown a DJI Phantom 2 to a record 11,000 feet up. To pull off this stunt, the operator had probably disabled software restrictions by the manufacturer that prevent UAS from flying above a certain limit, i.e. 1,500 feet [14]. Technically, some popular UAS are able to reach altitudes of 10,000 feet or above if the manufacturers' restrictions were tampered with by pilots.
- 6.6 While manufacturers' UAS are far more common, there are also privately built UAS, or DIY (UAS It Yourself) kits, consisting of multiple parts that can be assembled and connected with motors and a control unit, without technical know-how needed. These UAS (DIY) kits initially only offered the essentials needed to make something fly, where assembler determines the function by connecting it with an object (e.g. camera). DIY kits are becoming increasingly popular in FPV UAS racing, aiming to attain high speeds and movement flexibility. Without a technical assessment, it is difficult to assess whether DIY UAS are safe. Some CAAs may impose operating restrictions and EASA NPA 2017-05 proposed to restrict where those may be operated, for example, they may only fly far from people, or away from congested areas of cities, towns or settlements, or aerodromes etc.
- 6.7 In FPV UAS racing, participants control the UAS wearing head-mounted displays showing the live stream camera feed from the UAS. The goal is to complete a set course as quickly as possible. UAS racing began as an amateur sport in Australia in late 2014. FPV racing UAS typically can reach very high speeds, and are flown using FPV goggles, meaning that those UAS are operated out of line of sight (or not within visual range of naked eyes). Because of their light weight and electric motors with large amounts of torque, UAS can accelerate and manoeuvre with great speed and agility. This makes for very sensitive controls and requires a pilot with quick reaction times and a steady hand. FPV racing requires high pilot skills, and a hazard analysis with risk mitigation measures may be recommendable. Some countries (e.g. the Netherlands) prohibit outdoor FPV racing, and only allow it indoor in certain dedicated areas.

## Technology developments

- 6.8 In this Chapter some technology developments are highlighted which could be relevant for this study. Not all technologies are readily available. There will be differences in maturity, availability, and local applicability across UAS manufacturers as well as countries.



Obstacle detection



Geofencing



Detect & Avoid



Weather dependent systems



System autonomy



Collaboration / Swarming

*Figure 3 Some technologies relevant for UAS/UAS operations*

### Stability and flight control

- 6.9 Nowadays most consumer UAS are equipped with features that improve the ease of operating and gives the operator more control in case of an emergency situation. These features include flight planning, return-to-home (RTH) functionality and automatic landing. The ease of operating has been greatly improved due to features like First Person View (FPV) flying where the UAS is operated using an iPhone or via FPV goggles. The RTH is also named “one key return” or failsafe. Most medium size UAS use this function along with “headless mode” as a marketing strategy. The RTH can force the UAS return to its takeoff position when activated by pilot, or automatically activated in the event of low battery or loss of signal. The “headless mode” (also known as the Care Free mode (CF mode) can be easily activated, which will enable the UAS to move in the direction aimed by pilot regardless of the position or orientation of UAS. Another mode that enhances the stability of UAS is the “altitude hold” mode, which keeps UAS in current altitude without by pilots’ intervention.
- 6.10 While those features make UAS user friendly, pilot errors (or insufficient knowledge on operating procedures) may lead to accidents.

### Geofencing

- 6.11 Geofencing is the creation of virtual fences around areas or points of interest to keep UAS away: a no-fly zone. The UAS will need a reliable navigation system (i.e. GPS) and autopilot software to create and interact with a fence. When the UAS reaches the vicinity of the fence, the autopilot must respond with a maneuver and/or notify the pilot to do something. If the UAS was already in the no-fly-zone, then the control system may prevent takeoff or flying above a specific altitude.

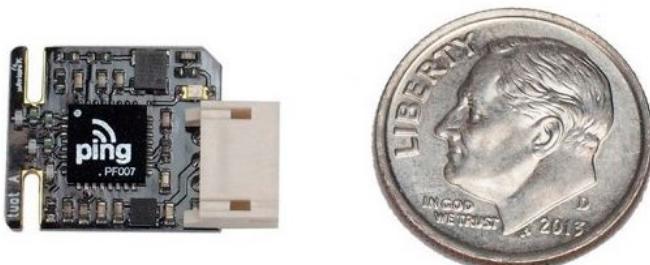


*Figure 4 Artist impression of geofencing*

- 6.12 According to a press release in June 2016 [15], the latest update of the DJI Go app will include the GEO Geofencing System. The Geospatial Environment Online (GEO) software will help pilots avoid flying UAS near airports and other sensitive locations, and automatically updates with temporary flight restrictions around wildfires to help protect authorized firefighting aircraft and help ensure fire crews can operate without disruption.
- 6.13 The geofencing is a promising technology to ensure UAS stay away from sensitive locations, but it requires pilots' cooperation (e.g. not to deactivate or tamper with manufacturers' system).
- 6.14 Mainland China has geofencing requirements for UAS according to weight of UAS or locations of operations. Europe's EASA NPA 2017-05 is proposing geofencing requirements for UAS heavier than 900 g according to zone of operations.

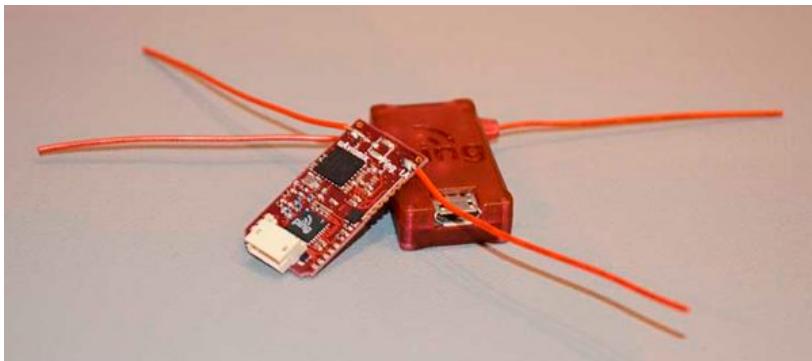
#### Identification of UAS

- 6.15 Mainland China has reporting requirements for UAS according to weight of UAS or locations of operations, for example, operational details may have to be periodically reported in a passive manner by ADS-B, radar etc without the need for pilot involvement to UAS cloud systems (see Appendix A.2). Europe's EASA NPA 2017-05 is proposing requirements for electronic identification (i.e. capability to identify a flying UAS without direct physical access to that aircraft) of UAS according to type of UAS or zone of operations [29, 40].
- 6.16 There are various ways to identify UAS. Several companies are manufacturing ADS-B units that can be placed (and are being placed or tested) on small unmanned aircraft. An important requirement is of course to have such avionics component of low weight. Fortunately, transponders with a variety of capabilities are now becoming available for use on small UAS. As an example, uAvionix Corp, which is also cooperating with DJI, has developed a transponder with the size of a coin which weighs less than 1 gram (see Figure 4 below) [16]. Size and weight typically depends on capabilities offered. Depending on required capability, there are solutions for UAS weighing less than about 20 to 50 g.



*Figure 5 The uAvionix ADS-B transponder*

- 6.17 The ADS-B transponder should allow UAS intruding in restricted areas to be detected, which may enable corrective actions or enforcement actions be taken. The downside is that the broadcasting of the position by the ADS-B transponder consumes a lot of energy. An alternative is to install an ADS-B “in” receiver, which uses less energy (see Figure 5 and 6 below). The ADS-B “in” receiver can warn the UAS pilot when an ADS-B signal is pick-up from an aircraft in the vicinity.
- 6.18 Safety assessments are needed as it is not clear if whether ADS-B transponders may interfere with aircraft and/or ATC systems, thus introducing risks to the aviation community.



*Figure 6 ADS-B “in” receiver*



*Figure 7 ADS-B transceivers and transponders shown to scale with a DJI Matrice 100*

#### Collaboration / swarming

- 6.19 UAS can also be capable of operating together in swarms. A large number of UAS can be operated from a single control unit. In these cases, the UAS collaborate to a certain extent by reacting to each other. This concept has been tested and used by the US military and is currently used by the entertainment industry (see Chapter 5).
- 6.20 In fact, in May 2016, there was a first FAA-approved UAS swarm with a light show by Intel that featured a fleet of 100 tiny aircraft in California, all of those UAS controlled by a single pilot. Intel Shooting Star UAS squad also had a three-week run at Disney World. Approval was provided by the FAA on the basis of an exemption process whereby it grants operators permission to circumvent standard rules, with Intel being one of the beneficiaries. During the 2017 Super Bowl, a fleet of about 300 UAS in a light show seemed to accompany Lady Gaga. However, Intel and NFL had in fact filmed the UAS light show prior to the event, and ‘mixed’ it with live Super Bowl images. This is because the FAA ruled that UAS were not allowed within 34.5 miles of the stadium, with the airspace being a no UAS zone.

### UAS effector techniques

6.21 Currently there are a number of existing and emerging effector (i.e. ‘neutralization’) technologies available. Effectors can be used detect UAS threats, and then disable, capture or destroy the UAS. Table 2 below summarises those techniques based on public literature [26] and [27]. Some were developed by the military and may not be suitable for civilian use. Also, assessments will be needed to assess the safety and effectiveness of these techniques.

*Table 2 Effector Technologies [26, 27]*

| Effectors                   | Technology                  | Typical Effect               | Range     | Collateral Damage                                | Remarks  |
|-----------------------------|-----------------------------|------------------------------|-----------|--|--|
| Guns & Ammunition           | Ammunition                  | Destruction                  | < 1800 m  | Dependent on fall area                           | Low hit probability                                |
| Directed Energy Weapons     | Laser                       | Dazzling optics, Destruction | 10-4000 m | Minimised by focused beam and precision tracking | Swarm, multi shot                                  |
|                             | High-power electromagnetics | IEMI, Electronic Disturbance | < 1000 m  | Reduced, ideal for urban environment             | Swarm, multi shot                                  |
| Electronic Counter Measures | Jamming                     | Communications disturbance   | 100-500 m | Reduced, ideal for urban environment             | Swarm, multi shot                                  |
|                             | GNSS spoofing               | Set false GNSS position      | 100-500 m | Reduced, ideal for urban environment             | Swarm, multi shot                                  |
|                             | RC Takeover                 | Pairing attack               | 100-500 m | Reduced, ideal for urban environment             | Multi shot   |
| Unconventional              | Net launcher                | Catching                     | < 100 m   | Not applicable                                   | Single shot  |
|                             | Trained raptors             | Catching                     | < 100 m   | Not applicable                                   | Single use<br>Lifting limits<br>Unsafe for raptors |
|                             | Water cannon                | Malfunction                  | < 100 m   | Not applicable                                   | Low hit probability                                |
|                             | Sticky foam                 | Malfunction                  | < 100 m   | Not applicable                                   | Low hit probability                                |

### U-space and UAS Traffic Management

6.22 Extensive research is currently being performed regarding UAS traffic management systems. NASA initiated the UAS Traffic Management (UTM) concept for enabling civilian low-altitude airspace and UAS operations (below 500 feet). UTM technologies research and development is taking place in collaboration with the FAA. Results of research in the form of airspace integration requirements are expected to be transferred from NASA to the FAA in 2019 for their further testing. Information is readily available at website: <https://www.utm.arc.nasa.gov/> [10]. The UTM ConOps is focused on safely enabling large-scale small UAS (sUAS) operations in low altitude airspace [11], starting with Class G airspace. The UTM ConOps follows a staged approach. UAS operations first focus on short duration, on-demand flights, and only permitted in areas where interactions with traditional aviation are rare and only limited services and infrastructure are required. Current endurance limits are generally less than one hour at speeds up to 60 knots. Then, UAS operations are expanded to areas of greater numbers of traditional aviation by introducing a growing number of services and infrastructure. Finally, UTM will be scalable to future operational scenarios, with UAS flying for several hours and at much greater speeds. UTM aims to support large-scale VLOS and Beyond Visual Line Of Sight (BVLOS) operations. UTM anticipates to follow a risk-based approach taking onto consideration geographical needs and airspace performance requirements. Two types of UTM systems could be developed:

- Portable -- would move between geographical areas for specific missions or operations;

- Persistent -- would provide continuous coverage for a specific geographical area, and ensuring that only authenticated UAS are allowed to operate in the covered airspace.
- 6.23 As far as known, no safety risk assessment is publicly available, and it is not clear how safety would be ensured. Because airspace integration requirements are planned to be transferred to the FAA in 2019 for testing, UTM is not likely to be brought forward for approval before about 2020 to 2025 or so.
- 6.24 The European Commission (EC) is advancing the “Urban-Space” (U-Space) UAS traffic management system which is comparable to the UTM model in the U.S. According to the EC, the goal is to “make UAS part of the European citizens’ daily lives by 2019” [12]. The precise details of the concept are not clear. In fact, the decision to start with developing the U-Space concept, was taken only recently by the EC and will only materialize in research within the scope of the Single European Sky ATM Research (SESAR) Programme. About 40 million Euros has been allocated to SESAR 2020 to bring the concept and technologies further. New common standards and specific rules/legislation will also have to be developed by EASA to enable U-Space to operate UAS at lower levels, up to 150m high. U-Space aims to enable dense traffic of automated UAS operations over longer distances possible, including over cities. As a first step, in 2017, the EC will present a concept on how UAS operations should be organised after which SESAR demonstration projects to assess the feasibility of the technologies could be started. The U-Space would establish an overall framework for registration, identification and geofencing requirements to ensure safety, security, and privacy. In view of the current status, like UTM, U-Space is not expected to be brought forward for approval by States and full use before about 2020 or so.
- 6.25 UTM/U-Space is foreseen to accommodate the use of UAS at lower flight levels, independent of their purpose (for recreational use or for commercial use). This could include transport of people or goods, or Uber’s flying UAS taxis.
- 6.26 Given that Hong Kong is congested with busy cross boundary as well as local air traffic, it is unclear at this stage if UTM and/or U-Space is feasible in Hong Kong.

#### UAS-Cloud / U-Cloud

- 6.27 The December 2015 Interim Provisions on Light and Small Unmanned Aircraft Operations (UAS Operation Provisions) issued by the Civil Aviation Administration of China (CAAC), regulates the operation of unmanned aircraft systems (UAS) with a maximum empty weight of 116 kg or less, or a maximum take-off gross weight of 150 kg or less, and a calibrated air speed of no greater than 100 km per hour. UAS weighing 1.5 kg or less are generally not required to follow the Provisions.
- 6.28 The UAS Operation Provisions set forth an online, real-time supervision system comprising the electric fence and the UAS Cloud [24]. The electric fence is a system consisting of hardware and software that stops aircraft from entering certain areas. The UAS Cloud is a dynamic database management system that monitors flight data, which has an alarm function for UAS connected to it that is activated when these UAS fly into the electric fence. A UAS Cloud system developed by the Aircraft Owners and Pilots Association of China, “U-Cloud,” has been approved for operation during a two-year period from March 4, 2016, to March 3, 2018 by the CAAC.
- 6.29 UAS under certain specific categories must install and use the electric fence and connect to the UAS Cloud. Operators must report at least every second when in densely populated areas and at least every thirty seconds when in non-densely populated areas. UAS under other categories are required to install and use the electric fence, connect to the UAS Cloud, and report at least every second if they are operated above the airspace of key areas and in airport clear zones. Key areas is defined by the Provisions to include military sites, nuclear plants, administrative centres and their neighbouring areas, and areas temporarily designated as key areas by

local governments. From available information [24], it does not become clear what the system requirements are for those UAS required to report to the UAS cloud.

6.30 Given that Hong Kong is a densely populated city with a lot of high-rise buildings, it is unclear if the Hong Kong environment may benefit from potential application of UAS Cloud.

#### Drone Apps (drone maps, weather information etc)

6.31 These are apps for no-fly zones for UAS or even weather information. These apps (mostly by private developers) allows the user to make flight plans, to get warnings in case the UAS is in the vicinity of a no-fly zone, and may have a flight log capability. After analysing almost 30 available apps [25], the main conclusions are:

- Almost all apps can be downloaded for free or have a free basic version
- None of the apps contains airspace information that is 100% correct
- For many apps it is unclear what the source of the information is
- For many apps it is unclear if the governments or other bodies can influence the representation of the no-fly zones
- For many apps the dynamic update of the no-fly zones is not integrated.

## Developments in UAS applications

6.32 The application of UAS is very broad. This Chapter focuses on consumer and commercial.

#### Recreational use

6.33 Some consumers buy UAS for the sheer joy and challenge of flying an object in the sky, but the biggest thrill for many is capturing spectacular high-quality photographs and video from an aerial vantage point. Another usage is UAS racing.

#### Commercial use

6.34 The commercial use of UAS is very broad. A selection is given below:

- *Aerial filming and photography*: UAS are used by the filming industry to create spectacular shots, or for sport events like skiing/snowboarding, motor cross and surfing etc.
- *Agriculture*: UAS help to enable precision agriculture that will be critical to meet productivity needs and support greener farmer practices
- *Powerline inspections*: UAS can reduce a variety of risks to personnel performing hazardous tasks
- *Public safety and security*: UAS are used by authorities to assist in search and rescue missions, investigations or enforcements etc.
- *E-commerce and delivery*: Urgent packages, including medical supplies, could be completed in a fraction of the time and online retailers could benefit from increased accessibility in both urban and remote areas
- *Mobility and transport*: The infrastructure of today, i.e., railways, may be monitored and kept secure and future forms of passenger aircraft could someday operate safely without the requirement of on-board pilots As such, UAS missions span many more sectors that will also benefit from UAS. These industries – such as mining, construction, telecommunications, insurance and other research by the likes of universities – are also introduced.

- *Entertainment:* UAS are used in sport events to entertain crowd but also for light shows. On YouTube videos are available of Intel's Swarm UAS Create Beautiful Aerial Light Shows 500 UAS [17].
- 6.35 In the United States major applications of commercial small UAS are aerial photography (34%), construction, industrial and utility inspection (26%), real estate (26%) and agriculture (21%). Many of these UAS have multiple uses, and hence, the sum of the percentages exceeds 100% [12].
- 6.36 Dubai's Road and Transport Authority (RTA) has announced a fleet of flying taxis. One-seater passenger UAS made by Chinese company Ehang are anticipated to pick up passengers in July of 2017 this year. The electrically powered driverless UAS -- named Ehang 184 -- have performed some tests flights above sand dunes near Dubai's airport. The RTA strategy is to have self-driving vehicles (of all kinds) account for a quarter of journeys made in Dubai, by 2030.
- 6.37 Uber has announced that plans to deploy flying UAS taxis in Dallas-Fort Worth, Texas and Dubai by 2020. Uber's flying taxis would be a small, electric aircraft for Vertical Take Off and Landing (VTOL). Vertiports - VTOL hubs with multiple takeoff and landing pads, and charging infrastructure – should accommodate the use of flying UAS taxis.
- 6.38 The fast growth of the UAS markets will enable new usages which are currently not foreseen.

## **UAS market outlook**

- 6.39 In this Chapter an outlook of the UAS market is given. There exist many outlooks with various numbers and expectations. In this Chapter an outlook is given for Europe, the United States, Asia-Pacific, and Worldwide.

### Europe

- 6.40 In November 2016, SESAR published an European UAS Outlook Study [13]. In this report they state that overall, growth in the number of UAS in activity is forecasted for each of defence, government & commercial missions and leisure. Overall, in terms of order of magnitude, military defence assets are expected to increase from the aforementioned several hundreds to multiple thousands, leisure units from close to 1 million to approximately 7 million and, finally, government and commercial units from multiple thousands to hundreds of thousands. Leisure unit growth is expected to mature in the near term with defence, government and commercial growth continuing out through 2050. A summary of these forecasts is illustrated below in Figure 7.

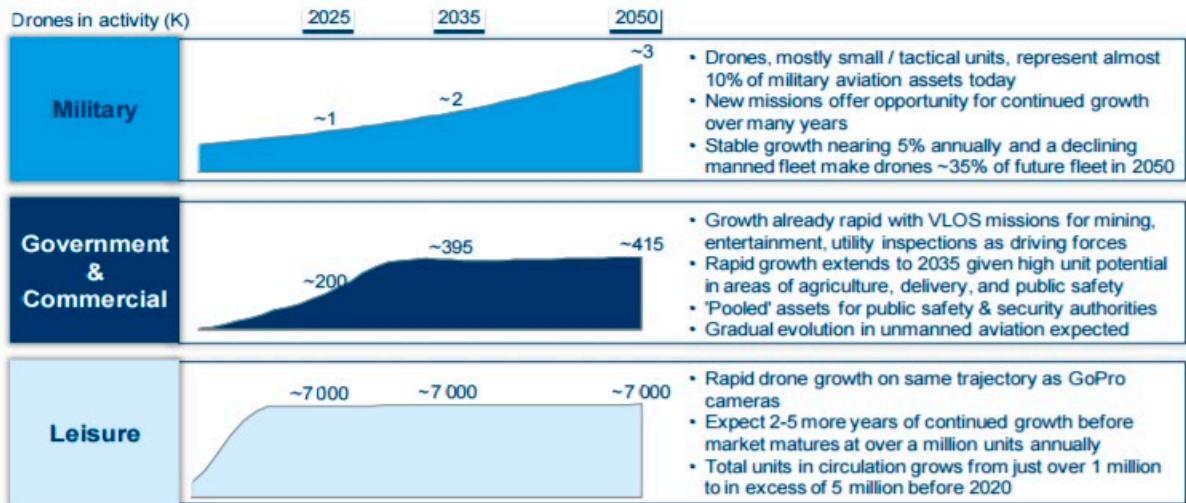


Figure 8 Summary of the forecast on UAS in Europe

#### United States

6.41 For the United States, the FAA annually publishes a 20-year forecast. In the latest forecast FAA Aerospace Forecast 2017-2037 [12], a forecast for UAS is included. This forecast is based on the requirement that UAS users in the US operating UAS between 0.55 pounds (250 g) and less than 55 pounds had to be registered. This resulted in December 31, 2016, 626,245 owner-hobbyists had registered. Registration is per owner and an owner is expected to have one or just a few UAS. Table 3 below gives the forecast for hobbyist (consumers) and non-hobbyist (commercial). The forecast includes a base estimate and a high and low estimate.

Table 3 Forecast Hobbyist and non-hobbyist UAS fleet in the United States

| Year | Total Hobbyist Fleet |      |      | Total Non-Hobbyist (Commercial) Fleet |       |       |
|------|----------------------|------|------|---------------------------------------|-------|-------|
|      | Million sUAS Units   |      |      | Million sUAS Units                    |       |       |
|      | Low                  | Base | High | Low                                   | Base  | High  |
| 2016 | 1.10                 | 1.10 | 1.10 | 0.042                                 | 0.042 | 0.042 |
| 2017 | 1.94                 | 2.15 | 2.31 | 0.095                                 | 0.108 | 0.235 |
| 2018 | 2.37                 | 2.80 | 3.18 | 0.133                                 | 0.167 | 0.445 |
| 2019 | 2.60                 | 3.20 | 3.79 | 0.173                                 | 0.242 | 0.742 |
| 2020 | 2.69                 | 3.40 | 4.15 | 0.207                                 | 0.327 | 1.133 |
| 2021 | 2.75                 | 3.55 | 4.47 | 0.238                                 | 0.422 | 1.616 |

#### Asia-Pacific (APAC) region

6.42 The APAC is expected to be the fastest-growing market for UAV UAS during the forecast period up to 2022 with the highest Compound Annual Growth Rate (CAGR) because the countries in these regions such as China, Australia, Japan, and New Zealand, among others are using UAS for precision agriculture, inspection, and surveying on a large scale [31]. Also, the countries in these regions are considering the use of military UAS for civil type of operations, such as for intelligence, surveillance, and reconnaissance operations. The UAV market in Asia Pacific is growing fast with Frost and Sullivan reporting it the second biggest buyer after the US. In 2011 the region as a whole spent \$ 590 million (USD) on UAVs, Frost and Sullivan estimated that this figure has risen to \$ 1400 million (USD) by 2017. DJI, with its headquarter located in Shenzhen, China, is in fact the current

market leader in the recreational sector, having expanded as well into the commercial market with platforms for professional media production and agricultural crop dusting solutions.

- 6.43 In the Asia Pacific region, the use of small UAS has broadened from the military applications to disaster relief operations, anti-piracy operations, border patrolling, and movie shooting and logistics. The market will witness high growth over the period of 2014-2020, as Asia Pacific has shown a trend to adopt technology more easily compared to other regions [32]. An increased demand for small UAS is expected for protection of the inside and borders of the countries. The region also has a huge coastline and small UAV provide vital intelligence to prevent piracy in the region.

#### Worldwide

- 6.44 It is difficult to get a precise estimate of UAS sales because most manufacturers are private companies. But according to an article in the New York Times [18] a lobbying group, the Consumer Technology Association, says UAS unit sales and revenues are expected to double this year. The group expects 2.8 million consumer UAS will be sold in the United States in 2016 and revenue will reach \$ 953 million (USD). Globally, sales of UAS are projected to reach 9.4 million units in 2016 and revenue is expected to reach \$ 3 billion (USD), the group says.
- 6.45 These estimates are often based on estimated sales figures from the largest UAS manufacturers (DJI, 3DR, and Parrot) and their market share. For example, DJI, which controls over 70 per cent of the world market for commercial UAS, recorded a strong performance in 2015 and 2016. Based on statements like these estimates are made, as a result the estimates vary a lot. Statista [19], for example, predicts that in 2021 68 million UAS are shipped worldwide, see Figure 8 below. Goldman Sachs, however, estimated that "*over the next few years, we expect consumer demand will continue to build. By 2020, we expect 7.8 million consumer UAS shipments and \$3.3 billion in revenue, versus only 450,000 shipments and \$700 million in revenue in 2014.*" [20].

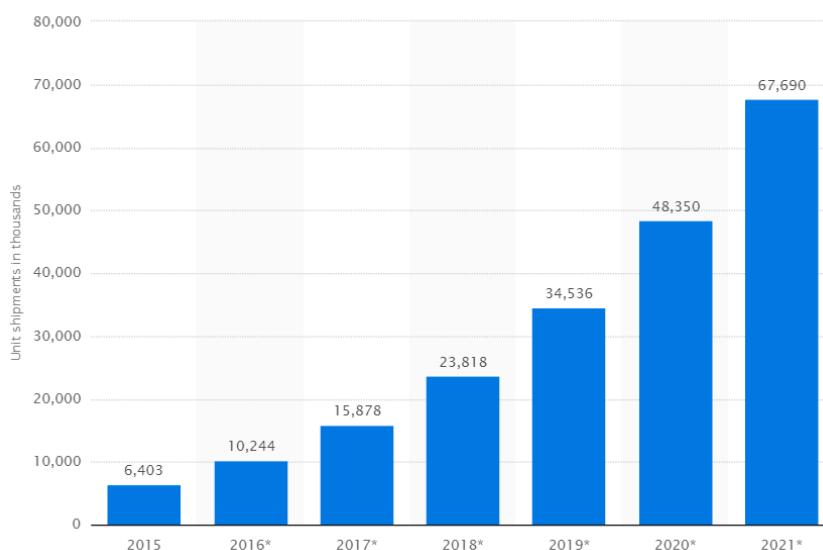


Figure 9 Estimated shipments of UAS

## 7 Prevailing practices and effect of regulation

### Assessment of local situation and views

- 7.1 Views of key UAS manufacturers, operators holding UAS permits issued by the CAD, model aircraft/UAS associations, training institutes, airlines or their representatives, airport / heliport operators, academia, government departments (see Table 4) were gathered through interviews or online questionnaire by NLR in a 5-day period in May 2017. In total, about 30 organisations have been interviewed, and about 60 to 70 representatives of these organisations have completed the online survey. Due to the sampling size, the views gathered are unlikely to represent all individual stakeholders' views. Nevertheless, with other sources of information (e.g. websites, local news), which provide further insights into the prevailing UAS practices in Hong Kong, a good picture of the present situation, as well as expectations regarding possible changes in UAS regulation, is established.

*Table 4 Category of Interviewees*

| Category  |
|---|
| Manufacturers                                       |
| Model aircraft / UAS association                    |
| Local training institutions                         |
| UAS operators holding UAS permits issued by the CAD |
| Airport/heliport operators                          |
| AOC holder / airline representatives                |
| Academia  |
| Government  |
| Others  |

- 7.2 The prevailing practices of UAS operations in Hong Kong based on the collection of information from the above process are discussed and evaluated in the following Chapters.

### Prevailing practices of UAS operation

#### Recreational use

- 7.3 Most UAS used in recreational flights are quadcopters. As they weigh below 7 kg, hobbyists do not need a permit from CAD for their operation.
- 7.4 Recreational use of UAS includes leisure flights or aerial filming. FPV UAS racing is for now also categorised as recreational use, although one may question if someone conducts UAS racing for a prize, being a reward, it may have to be included in the non-recreational category.
- 7.5 Hobbyists purchase their UAS simply from retailers or 'toy-shops'. Operating instructions, safety tips or local regulations are often provided in the UAS package. Sometimes simple flight training is offered by the retailer. However, some UAS associations or flying clubs mentioned that a notable number of pilots attended their

training only after they had crashed or lost their UAS. In other words, most pilots may not recognize the benefits or needs for training until they have experienced an incident.

- 7.6 Pilots may practise or use their UAS not only at places where other radio controlled model aircraft or helicopters operate (e.g. Nan Sang Wai) but also at sparsely populated areas, such as areas in the countryside or remote islands.
- 7.7 Although usually, recreational users seem to follow the safety guidance on CAD's website, there have been reports on flights in restricted areas like the Victoria Harbour or in close proximity to persons or buildings, or UAS operated at night. Hobbyists may know those conditions pose safe risks but may not care, or some are unaware of the risks to aviation safety and possible penalties/fines.
- 7.8 Some hobbyists might modify their UAS or allow others to carry out the modification on their behalf. The common reason mentioned for UAS modification is to boost the signal such that the UAS can be "safely" controlled without the chance for a loss of command link. There may be complications when manufacturers' instructions or OFCA's radio frequency requirements are not followed.

#### **FPV UAS**

- 7.9 In recent years, FPV (first person view) UAS may be used in racing both indoor and outdoor. The UAS used in FPV racing are mostly light weight, about 250 -500 g. They can either be bought off-the-shelf or privately built. Although the UAS are small in size and weight, they can travel at high speed. Besides UAS racing, video of FPV UAS flying at great height along a skyscraper has been posted in social media, which shows some FPV UAS may be able to fly at great height.
- 7.10 Outdoor FPV races have been held in open space areas located in the New Territories. Those areas chosen are often sparsely populated. Indoor races were sometimes organised inside abandoned industry buildings or factories and those buildings could be located in the City.
- 7.11 To ensure public safety, risk mitigation measures will be taken by race organisers. For example, for outdoor racing, empty, containers or other obstacles are placed to cordon off the racing area. For indoor racing, safety nets are spanned to protect others from the racing UAS. FPV races were sometimes organised at night in wooded areas for excitement. The organizers of these night races considered these to be "safe for the public" since the chance of other people entering the racing areas would be small.
- 7.12 UAS operations at night would contradict CAD's safety guidance, which advises UAS to be operated within visual range of pilots (not just on mobile phone app screen, FPV goggles or binoculars etc.)

#### **Non-recreational use**

- 7.13 The non-recreational use covers a wide spectrum of operations such as commercial operations, operations by governmental departments, and testing and training flights, and flights for research & development. More common use includes aerial filming operations by media, television or movie companies, or inspection, surveying and mapping for property developers. Some government departments may use UAS for enforcement, search & rescue, aerial photography, engineering or lands survey, 3D terrain modelling for Geographic Information Systems (GIS) and Building Information Modelling (BIM) projects, etc.

- 7.14 The types of UAS used are often the same types used by recreation users, often high-end consumer or (semi) professional products. Such UAS could be equipped with multiple batteries, inertial measurement units, other sensors, or even a parachute for emergency. This redundancy and extra safety feature can ensure a safe continuation of the UAS flight, but at the same time makes the UAS heavier. At present, most operated UAS are below 7 kg.
- 7.15 All UAS operators and remote pilots should follow the safety guidance published on CAD's website. Non-recreational operators may propose variations if they can provide a sound safety case as per Chapter 6. For commercial operation, operators must obtain CAD's permit, and submit a flight plan, operation manual and relevant documents (application forms) to the CAD for evaluation. Based on experience of professional UAS operators, the first time for application may take up to 28 days in total. Such application would be valid for one specific operation. For subsequent applications for the same type of operation, it usually takes a much shorter time to receive the permit.
- 7.16 Where applicable, a letter of consent from land/property manager has to be obtained when the UAS flight has to be made over the land or property. Notwithstanding the fact that this is in respect of safety concerns of those managers or affected persons, the opinion of most professional UAS operators is that consent is often not feasible to be obtained in time and may affect their business.
- 7.17 Professional operators being interviewed appear to be well trained. Most have attended professional training courses and obtain certificates like the UK BNUC and CPD-C. Some have travelled abroad (UK, Australia) to get the required training. Others have taken training courses provided by local companies, who claimed their courses are based on the standards of CAAs with fully developed UAS requirements (e.g. those in UK, Australia). There are operators who hired professional instructors from companies approved by those CAAs. Some local operators or organisations indicated that they have provided training for their customers or members based on the training they have attended. There is no accreditation of these training programmes by the CAD (although they could be accredited by other authorities).
- 7.18 Those trained professional operators being interviewed seem to have good safety awareness. They would conduct risk assessment of their operation, pre-flight checks and assessments of the weather condition, the location, and the air space (flight altitude) prior to their flight operation.
- 7.19 However, some operators mentioned that they have operated modified UAS due to "safety" reasons. Frequently, those UAS were modified with signal boosting such that they may operate in the densely built-up urban areas where signal interference (e.g. from mobile phone, wifi signals, building structures etc) is common. Modifications may include attaching reflectors or other lights to enhance operations. Unauthorised modifications may lead to complications when manufacturers' instructions or OFCA's radio frequency requirements are not followed.

## Exceptions from CAD's Safety Guidance

- 7.20 Professional operators may need to conduct operations outside the limits of CAD's safety guidance (e.g. at the Victoria Harbour, within 5 km from the airport). They may apply to CAD for exceptions (or variations). Such application may be considered if the operator can provide a sound safety case to demonstrate how associated risks may be mitigated.

## Major UAS incidents

- 7.21 Some example of UAS incidents involving safety risk to public and other air space users are presented. Some were from media/news articles or interviewees / respondents to the online survey.

### Incidents in Hong Kong

- 7.22 During the Formula E event in 2016, three men flew separate UAS over the racing circuit. They were eventually charged by the police for endangering public safety. Legal preceding is in progress at the time of writing this report.
- 7.23 From the video-footage and photographs posted on social media, some UAS were flown in restricted areas like Victoria Harbour or above crowd of people. This is not in line with CAD's safety guidance. It is however difficult to locate the perpetrators. Enforcement difficulty may be experienced by the law enforcement agencies worldwide.

### Incidents outside Hong Kong

- 7.24 In Australia, a triathlete was injured by a falling UAS. The sportswoman sustained minor head injuries after the UAS operator, who was making photographs about the triathlon at the moment of accident, had lost control of the device.
- 7.25 In UK, a toddler (about 18 months old) was left blind in one eye after a UAS, which is flown by his family during the horrific accident, hit his face. The UAS propeller sliced his eyeball in half.
- 7.26 Between April and May 2017, a number of international airports in China (Chengdu, Chongqing) experienced disruptions due to UAS intruding into the airport area. This has led to a significant number of aircraft diversions to other airports and flight delays at the airport. UAS not only pose risk to other air space users, but also lead to huge economic loss for the airlines and airports.

### Effect of regulation

- 7.27 In this Chapter the effects of the regulation on the UAS operation in Hong Kong and suggestions for the new rules are discussed and evaluated, taking into consideration the views and opinions gathered.

### Suggestions for future legislation or safety guidance

- 7.28 While the current UAS regulation in Hong Kong (e.g. Article 48 of Cap. 448C) may help deter pilot/operator from recklessly or negligently causing or permitting an aircraft including UAS to endanger person and property, it is not specific for UAS operations. More specificity may make the law more "enforceable".

- 7.29 New rules (law or safety guidance as appropriate) should be practical, simple to follow, and should cater for recreational use as well as non-recreational use. Regulations and law should be enforceable.
- 7.30 Suggestions from interviewees / respondents to the online survey include:
- For UAS above a certain size, owners should be registered. Similar to vehicles, licence plates can help the identification of vehicle owners, and thus drivers in the case of accidents.
  - As for training, similar to driving licenses, operators of UAS over certain size should be licensed to ensure public safety. Some interviewees / respondents to the online survey suggested training may be provided by private firms.
  - “No flying areas” for UAS should be stipulated in the law in the interest of safety for public and aircraft.
  - At present, CAD’s safety guidance advises to restrict UAS operations above or within 50 meters of public (e.g. other people) or property (e.g. building). Some operators suggested UAS be allowed under certain conditions, e.g. if the UAS are essentially small, does not travel at high speed, and operators can mitigate risks to a reasonably low level. Some further suggested a differentiation of areas of operations based on population, density of buildings, country parks or indoor venues (e.g. inside an abandoned factory, industrial building) etc. For each type of operation, specific requirements e.g. UAS size, and safety distance may be established.
  - For operations in urban areas with WIFI/GPS interferences, some suggested that it would be helpful if it is clarified which equipage is needed, for example, redundancy in batteries, additional sensors or measuring units, or signal boosting. Such modifications or enhancements (if not based on instructions or guidance provided by the manufacturer(s)), that may impact the modified UAS’ functionality, safety and reliability should be verified to ensure they are still airworthy and safe. But there has been no suggestion on how to verify those aspects.
  - Some operators wished to use UAS heavier than 7kg or even 20kg. At present, those UAS and operators are required to be certified or licensed like manned aircraft under Cap 448C. Some suggested specific permits for UAS.
  - Some suggested specific rules for other types of UAS operation, for example, VLOS, BVLOS, indoor operations, multiple UAS (e.g. light shows, entertainment, surveys) etc.
  - Pilots reported close encounter with UAS in the Victoria Harbour, e.g. Wanchai Heliport, Skyshuttle Heliport etc, which contravenes safety guidance on CAD website. Strict regulation and enforcement, including heavier penalties, is needed as UAS are increasing in number, and social media may encourage more illegal operations.
  - Some opined that flying UAS above the sports and recreation facilities such as parks, swimming pools during the opening hours may cause injuries in case of UAS failures. In sports grounds, footballs or javelin/disc may hit the UAS. They should be prohibited unless authorized by the venue manager.

## Enforcement measures

- 7.31 Three specific measures to ease law enforcement have been discussed with the interviewees / respondents to the online survey:
- Registration of owners and operators
  - Identification of UAS
  - UAS map for indicating fly – and no-fly zones
- 7.32 Nearly all of the interviewees / respondents to the online survey (about 90 to 95%), is in favour of registration of the owners of UAS and establishing a registration database. Regarding which authority should be tasked to maintain the database, different options were mentioned, including the CAD or the Transport Department (TD). The TD is currently responsible for the registration of vehicles and the licensing of rail and bus operators in Hong Kong. Besides registration of the owners of UAS, registration of remote pilots authorized to fly the respective UAS, was also brought forward. There seems to be a good basis for this as well. Most of the interviewees / respondents to the online survey opined that registration would not be required for UAS below a certain weight limit (e.g. 250 or 500 g), because the risks should be low.
- 7.33 Registration should be done online to facilitate the public to register their UAS. After such registration system is established, it is suggested to introduce an online service for filing flight plans and informing other air space users of UAS flight operation. This could be similar to the Notice to Airmen (NOTAMs).
- 7.34 Regarding identification of UAS, there is a trend for remote identification of UAS through UAS manufacturer or retrofitting airborne electronic identification devices, e.g. in Mainland China, United Kingdom, and the United States. Two options for UAS identification were brought forward by interviewees / respondents to the online survey. The first option is for the manufacturer to stamp a, preferably unique, serial number at the UAS. This serial number is included in the registration database, after the owner registers the UAS. The second option is to use a serial number sticker, issued by the organization responsible for the registration database, and attach this to the UAS and/or the controller unit. This serial number sticker could also include identification of pilots authorized by owners to operate the UAS. It is also, whatever option is used, either one or both simultaneously, it has to be ensured that there is no potential for misuse.
- 7.35 An overwhelming majority is in favour of CAD issuing a UAS map for “no-fly zones” e.g. those for aviation safety (e.g. airspace around aerodromes and flight paths), security/sensitive areas such as prisons and nuclear facilities. Usually UAS maps are promulgated by CAAs on website or by private smartphone app developers. Areas suitable for UAS flying are also suggested to be included in UAS maps but there were no suggestions from interviewees / respondents to the online survey on how this may be achieved given the densely populated environment of Hong Kong.
- 7.36 Some cities such as Seoul have dedicated UAS parks. Such UAS parks may not only be set up for recreational users, but also for testing of UAS, equipment, and operations. Remote areas in the New Territories or areas in country parks for members of UAS clubs/associations are suggested. An alternative suggestion is a dedicated UAS park near the Victoria Harbour (such as West Kowloon Cultural Area). Sparsely populated rural areas, beaches or coastal areas which are away from aerodromes or flight paths could also be used for UAS.

## Safety risk assessments

- 7.37 UAS operators are responsible for the safety of all persons and properties. CAD offers a template to assist non-recreational operators on preparing their operations manual (OM), which include details such as organizational control, operating procedures, pre-flight checks, incident reporting and risk managements (identification of the hazards, risk assessment, and mitigating procedures) etc. CAD evaluates the OM before deciding whether a permit can be issued. UAS operators need to complete a site safety assessment, and make this available to CAD on request.
- 7.38 As regards risk assessment, one interviewee suggested to use the method that is currently being developed in JARUS: the Specific Operations Risk Assessment (SORA) methodology ([http://jarus-rpas.org/sites/jarus-rpas.org/files/jar\\_doc\\_06\\_jarus\\_sora\\_v1.0.pdf](http://jarus-rpas.org/sites/jarus-rpas.org/files/jar_doc_06_jarus_sora_v1.0.pdf)) [36]. The SORA recommends a risk assessment methodology for all size and types of UAS to establish a sufficient level of confidence that a specific operation can be conducted safely.
- 7.39 Internationally or locally, recreational UAS are not normally required to perform a safety risk assessment for approval by CAAs. Most interviewees / respondents to the online survey consider it beneficial if recreational users also conduct risk assessment before flight.
- 7.40 Elements suggested to be taken into account in the risk assessment performed by a professional operator include:
- Site condition, terrain topology and environment, including RF/EMI interference and structures/buildings;
  - Number of vehicles and number of pedestrians nearby;
  - Density of surrounding high-rise buildings, electric cable, railway, expressway, etcetera;
  - Choice of take-off and landing area (open space), emergency location, exposure to water;
  - Gatherings of people and persons nearby, not involved with the UAS operation;
  - Weather (in terms of visibility and wind strength), climate, and geographic conditions;
  - Airspace usage, including potential other airspace users and other objects in the air;
  - Potential flight restrictions, if any;
  - Operations in hazardous areas, such as storages for dangerous goods or chemicals or near nuclear facilities;
  - Contingency plans and emergency procedures
  - Maintenance history;
  - UAS condition (including battery level, GPS signal, propeller, rotary parts, motor);
  - Knowledge of the UAS and manufacturer's instructions;
  - UAS' technical capability and limitations;
  - Operator/pilot capability and competencies;
  - Incident/accident reporting and response;
  - Sensitive areas such as Tamar, Stonecutter, prison premises, firing range, published special use airspace<sup>6</sup>.
- 7.41 Some interviewees / respondents to the online survey suggested that lessons learned from previous UAS incidents be included. Examples mentioned include loss of the signal connection between ground station (controller) and UAS, single engine motor failure, power system failure, control system failure, UAS crash into the water, air proximity between aircraft/helicopter in flight and UAS. Some interviewees / respondents to the online survey suggested new requirements for enhanced redundancy in the UAS flight controls and system components including power system (i.e. duplication of critical components or functions of UAS, with the

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<sup>6</sup> Published special use airspace includes e.g. Prohibited Area, Restricted Area and Danger Area.

intention of increasing reliability) in case of flight at higher altitudes. These would be key elements to be considered in the risk assessment of the proposed operation and pre-flight checks.

- 7.42 In Hong Kong, when UAS are seen, pilots may report to ATC which will warn aircraft in the vicinity immediately and disseminate the sighting report to police. Information may be promulgated by CAD through safety leaflet to increase safety awareness of the aviation community, which could facilitate their risk assessment on UAS hazards.

## Training

- 7.43 Most interviewees / respondents to the online survey consider it important to establish a risk based approach, i.e. training requirements based on the risks associated with the types of operations. Some opined manufacturers should provide training materials, safety guidance, user guide etc. inside the UAS package. For professional pilots, training may be like Private Pilot Licence (PPL) training for recreational manned aircraft. Theory and practical training could be given by some 'UAS flight school' approved by CAD. Most interviewees / respondents to the online survey recommended that recreational users should be certificated also after completing simple training (e.g. watching video or manufacturers' instruction) and simple exam.
- 7.44 Some differentiate between small UAS (under 7 kg) and larger UAS (above 7 kg). The former is suggested to require a recognized course, provided by a CAD approved provider, on flying skills and knowledge of regulations and safety requirements. At least a couple of hours of hands-on practical training and flight assessment would be required, but no specific license would need to be issued. However, the latter would require a more comprehensive course by a professionally qualified instructor to be licensed on a syllabus covering at least flying skills, aviation law, flight planning and flight monitoring, aerodynamics, meteorology, navigation, human performance, electrics and automatic flight, instruments, engine, UAS type technical characteristics, loading, and possibly other topics and issues.
- 7.45 Training courses may include both a theoretical course and a practical course. The theoretical part may include aviation law and guidance, basic aviation and aeronautical knowledge (including aerodynamics), basic meteorology, aviation safety, safety risk assessment, potential risk in operating UAS, human factors, field assessment, theory of GPS and telemetry, electronics, pilot responsibilities, privacy issues, liability issues, awareness on "no-fly zones". The practical part should include UAS operations. Sufficient flight experience (e.g. training hours, simulation of abnormal situations (e.g. low battery, signal loss, engine failure, unexpected encounter with manned aircraft etc.)) may ensure a competent level of flying skills.

## Licensing of remote pilots

- 7.46 Current regulation in Hong Kong does not require pilots operating a small UAS (those below 7 kg) to be licensed. Some interviewees / respondents to the online survey recommend that pilots to be trained and assessed (through examinations) by an institute approved by CAD, comparable to that of a national Qualified Entity<sup>7</sup> in some countries. Other interviewees / respondents to the online survey feel that UAS associations or

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<sup>7</sup> Several Regions and States have implemented an approach in their regulations, which enables the delegation of tasks related to e.g. certification and oversight. E.g. in Europe, the 'Qualified Entity' concept is used by the European Commission and EASA; in the United States, an organization may obtain an Organization Designation Authorization (ODA) from the FAA; and in Australia, certain regulatory powers and functions may be delegated by CASA to 'Industry Delegates and Authorized Persons'.

UAS flying clubs, not necessarily certified to provide training, may provide certificates to pilots who have passed the examination.

- 7.47 Whatever option, if UAS pilot certificates are not required by law, some UAS associations and flying clubs have the idea to, as an alternative, at least offer their own certificates to students who completed their courses.
- 7.48 However, if pilots are required to be licensed, CAD should at least prescribe the syllabus of the theoretical examination and practical tests, and maintain a register of remote pilots. Differentiation between beginner, advanced, and professional levels may be considered. Also, an aeromedical check may be required for pilots performing complex type of operations.
- 7.49 For less complex type of operations, such as those proposed in the EASA NPA 2017-05<sup>8</sup>, no license is proposed to be needed for remote pilots performing operations in the “open” (UAS below 25 kg and operate within certain limits e.g. VLOS, below certain height etc.) and “specific” category [29]. EASA will consider the ICAO’s proposed RPAS licencing requirements as envisaged in the new ICAO Annex 1 for personnel licensing, when developing the NPA on the “certified” category (UAS above 150 kg). It is currently not anticipated that ICAO has plans to develop and publish licensing standards and requirements for the most common type of UAS operations in Hong Kong (Cat A1, A2, B).

## Pre-flight checks

- 7.50 Pre-flight checks are required to be performed by non-recreational operators, as discussed in Chapter 6. In recreational operations, most model aircraft and UAS associations and also local UAS training institutes recommend their remote pilots to use a pre-flight checklist for safety reasons. Often, a template is also provided. The ICAO UAS Toolkit provides a pre-flight checklist for reference [3]. Performing on-site risk assessment using a standard risk assessment form as part of pre-flight check appears to be the prevailing practice with some operators. Different circumstances (e.g. different UAS model or different seasons) may require different checklists, with different steps to go through.
- 7.51 Some interviewees / respondents to the online survey have suggested that the following elements to be included in the pre-flight check:
  - Number of persons/pedestrians within the flying area;
  - Number of moving vehicles within the flying area;
  - Wind speed and weather conditions (within required limitations);
  - Points of attention brought forward by the UAS manufacturer;
  - Motor and propeller test;
  - Manoeuvring test;
  - Safety features test (e.g. Return To Home (RTH) functionality and obstacle avoidance capability);
  - VLOS operations only;
  - Potential hazardous structures nearby (e.g. electric pole, tall building, bird sanctuaries, radio transmitter/antenna, gas venting sites, dangerous goods, power cables, pylons, tall antenna, cranes, etcetera);
  - Potential other aircraft operations nearby (gliding zone, model aircraft clubs, helicopter exit/routes);
  - Potential other transport infrastructures nearby (e.g. highway, railways, etcetera);

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<sup>8</sup> This EASA NPA 2017-05 proposes to create a new regulation defining measures to mitigate the risk of operations in: the open category through limitations, operational rules, requirements for the competence of the remote pilot, and technical requirements for the UAS; and the specific category through a system including a risk assessment conducted by the operator before starting an operation, or the operator complying with a standard scenario, or the operator holding a certificate with privileges.

- Potential prohibited/restricted/danger areas nearby;
- Potential flight restrictions (e.g. maximum altitude, no-fly zones indicated on UAS maps);
- Proximity to aerodromes, MTR protection zones, heliports, helipads;
- Battery condition and level of controller, UAS, ground station and other equipment;
- GPS and radio signals and on-site radio interference;
- Terrain topology;
- Open space for take-off and landing;
- Availability of an emergency landing site (nearby).

## Maintenance

- 7.52 There are currently no specific requirements with respect to maintenance of the UAS. However, CAD requires that commercial operators must conduct a pre-flight check and must not fly the UAS unless they can assure the flight can be conducted safely, including in the event of a failure of or disruption on any control system or loss of radio link. All equipment must have been properly secured, the UAS is in an airworthy condition, UAS assembly is correct and in accordance with manufacturer's instructions etc.
- 7.53 UAS operators indicated during the interview that they will check the condition and serviceability of the UAS immediately after flight. Should repairs or corrections be needed, the UAS will be sent for maintenance.

## Recreational versus commercial applications

- 7.54 At present, UAS regulatory practices are based on types of operations i.e. (a) recreational, (b) non-recreational (commercial) & (c) other non-recreational use. There is a wide spectrum of non-recreational use. Besides commercial operations which require CAD's permit, other uses include government's operations, media use, company's own use (e.g. surveillance or building inspections), UAS manufacturers or retailers' flight demonstration or training for customers, or even school education as some schools teach children to use UAS. In the United States, educational institute's UAS operations may require legal expertise to be classified<sup>9</sup>.
- 7.55 If a UAS operator is going to conduct flight operations e.g. aerial filming in which he/she will receive a reward for this operation, it is evident that the operation is then commercial and require CAD's permit. However, some interviewees / respondents to the online survey mentioned it may be difficult to prove some commercial operations are for 'hire or reward', for example, when a manager requires his staff to conduct aerial filming and treat it as company's own use. The safety risks are essentially the same as those of commercial operations.
- 7.56 In summary, it may not be easy to distinguish the use of UAS (e.g. recreational, commercial or other non-recreational use etc). As some persons may attempt to bypass the requirements to obtain CAD's permits, ambiguity regarding whether a particular operation is for hire or reward should be avoided.

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<sup>9</sup> In the United States, educational institutions are commercial entities for the FAA and must therefore apply for an exemption to fly UAS, which then allows research, training, and flight demonstrations. It requires extensive paperwork and, in most cases, the involvement of legal counsel with expertise in UAS and FAA regulations.

## Property/land manager permission

- 7.57 When applying for CAD's permits, permission from property/land manager or Marine Department is needed before UAS can be flown above the land, property or waters. The requirement to obtain such permission is perceived by many operators being interviewed as impractical.
- 7.58 Notwithstanding the fact that many understand the safety concerns of property/land managers or affected persons, it often appears to be very time consuming or even impossible to obtain permission. A significant number of interviewees / respondents to the online survey (notably from model aircraft and UAS associations and also from UAS operators) have suggested reconsideration of this requirement.

## Insurance

- 7.59 Commercial UAS operators in Hong Kong are required to secure an insurance policy for third party risks for the proposed operation. For recreational users, such insurance policy is not required.
- 7.60 Interviewees / respondents to the online survey mentioned it is difficult to obtain such insurance policy in respect of third party risks as there are few insurers in Hong Kong. Those that provide insurance, usually do so at high costs. Therefore, some UAS operators may obtain a policy through overseas insurance providers from Australia, the United Kingdom etc.
- 7.61 The view on the necessity of an insurance policy is mixed. In Hong Kong, it appears to be quite common for most activities not to have third party insurance. Interviewees explained that the persons liable for incidents will usually pay for the damage and consequences.
- 7.62 It should be noted that in other parts of the world e.g. Europe, it is common practice and very easy to obtain affordable insurance for the commercial use of UAS. In fact, in Europe, UAS insurance with respect to third party risks is required by law according to Article 7 "Insurance in respect of liability for third parties" of the EC Regulation 785/2004 [38]. Although this Regulation does not explicitly mention UAS, it is applicable to UAS as well, as backed up by a study that addressed the question *Are Unmanned Aircraft in scope of EC Regulation 785/2004* [28]. Also, with increasing UAS activities, more insurers are offering affordable insurance schemes for commercial or recreational users (e.g. <http://flockcover.com/>, <https://verifly.com/>, <https://www.idra.co/insurance>)
- 7.63 In view of the above, and also considering the fact that there are UAS operations that may pose a potential risk to aircraft, other persons or properties, it is not recommendable to completely remove insurance requirements. For very small UAS (toys), it is not practicable and probably also not necessary to require insurance against third party risks. However, for operations with somewhat larger UAS that may pose risks, insurance requirements are beneficial and needed. In Europe, there are serious concerns about the possibility of UAS colliding with helicopters [37]. This concern also exists in Hong Kong. Without insurance, who will pay for the costs?

## Use of radio spectrum under telecommunication ordinance

- 7.64 The CAD has published UAS safety guidance on website. Basic safety rules included that sites of operations should be clear of buildings, people and away from helicopter landing pads, and clear of any power sources such as power lines, transformer stations, pylons and transmitter towers which might cause radio interference. While the flight safety of UAS is regulated by civil aviation legislation, UAS are also subject to other regulatory or administrative requirements, such as the regulation of radio frequencies set by the Hong Kong Office of Communications Authority (OFCA) [35].
- 7.65 Some stakeholders expressed the need for frequency spectrum and Radio Frequency Interference (RFI) considerations to stay included in future regulations. In particular, some interviewees / respondents to the online survey noted that there are sometimes RFI problems with 5.8 GHz in the Hong Kong city environment. Those that mentioned RFI problems suspected that it could be caused by the fact that Hong Kong's city environment is relatively congested, with a lot of high-rise buildings and possibly insufficient exterior space to allow radio signals to be transferred well. Radio interference problem do not seem to occur with 2.4GHz, since there is no or little overlap with frequencies used by UAS. However, problems with 5.8 GHz could be due to the fact the bandwidth is used by mobile phone as well.
- 7.66 Apart from regulation of frequency band, transmission power and modulation of the radio control equipment are also under the control of OFCA [34]. Modification of transmission power, directivity, use of inline amplifier or modification of circuitry without consent of the manufacturer could violate license (or exemption from licensing) of the original equipment. Any such modifications should be verified and checked by the UAS operator.

## Indoor flight

- 7.67 In Hong Kong, Article 48 of Cap 448C applies to UAS whether it operates indoor or outdoor. There is a misconception with some interviewees/respondents to the online survey that the current aviation law is not applicable for indoor, when discussing a widely reported case of a small UAS operated by a foreign retailer in a shopping mall.
- 7.68 It will be of interest to UAS racing organisations that hold indoor races or operators that use UAS for indoor maintenance to know how new regulations may apply to their activities. In the Netherlands, indoor racing is allowed, whereas outdoor racing is prohibited. In Mainland China, indoor flight is allowed, whereas simple rules seem to apply to outdoor racing. EASA also excludes indoor UAS operations from its proposed regulatory framework. In summary, international regulatory practices vary.

## Model aircraft

- 7.69 ICAO states that 'model aircraft, generally recognized as intended for recreational purposes only, fall outside the provisions of the Chicago Convention, being exclusively the subject of relevant national regulations, if any' [2]. For this reason, it is not expected that ICAO will develop guidance for model aircraft soon.

- 7.70 Notwithstanding the fact that a model aircraft is a subset of unmanned aircraft, most countries have specific rules for model aircraft, which may be different from UAS rules. For example, FAA has a specific rule for model aircraft, whereas EASA proposes to regulate model aircraft and UAS through the same rules [29]
- 7.71 Considering the fact that model aircraft are a subset of unmanned aircraft but there is no clear definition by ICAO, it will be difficult to differentiate between model aircraft and UAS legally. Therefore, model aircraft should be regulated by the new UAS regulations in Hong Kong, which is in line with the EASA NPA 2017-05, which proposes options: be member of a model aircraft flying club, operate in dedicated areas, or follow the operational limitations set by CAAs.

## Promotion of responsible and safe flying of UAS

### Safety promotion campaign

- 7.72 To educate the public on UAS safety, since 2016, the Hong Kong CAD has distributed over 30,000 safety leaflets to UAS manufacturers, distributors and public. New initiatives were launched by the CAD in 2017 to reach out to a wider audience. A 30-second UAS safety commercial was aired in TV and radio since May, and safety messages were posted in social media. UAS operators and UAS associations also felt there are benefits of having the government promote safety awareness and responsible flying, through TV announcements, or support associations' safety campaigns on social media.
- 7.73 Some manufacturers (e.g. DJI) will include CAD's safety leaflet in UAS package. Most model aircraft and UAS associations and also UAS training institutes provide guidelines for the safe operation of UAS to their members and promote the use of pre-flight checklists. Safety leaflets may be distributed to members.
- 7.74 Others also suggested promoting UAS safety through schools and clubs, retailers, manufacturers, or supported the responsible use of UAS through new registration requirements etc.

### Promote cooperation within the UAS industry

- 7.75 It has been suggested for the government to take a leading role and promote the establishment of a working group with UAS stakeholders in Hong Kong discussing different UAS operations and the associated safety issues. Such group could jointly organize workshops or conferences with the aim to promote safe and responsible UAS flight. This could support the application of safety standards and encourage private sectors to invest in proper and good UAS practices.

### Promote voluntary safety management practices

- 7.76 None of the operators mentioned in interview about the use of Safety Management Systems (SMS), which is required for by ICAO for certain aviation service providers such as airlines, airports etc. Whereas some

countries (e.g. the Netherlands) may promote voluntary implementation of a simple version of SMS by UAS operators and provide a template [33], Hong Kong does not have such scheme.

## Incident/accident reporting

- 7.77 It becomes clear from interviews that commercial operators are required to report UAS accidents or incidents within three calendar days to CAD. These UAS operators are asked to use the CAD's Incident Reporting Form (DCA 234) for reporting of UAS accidents and incidents (<http://www.cad.gov.hk/application/DCA%20234.pdf>).
- 7.78 This is in line with the ICAO UAS Toolkit as the ICAO encourages the reporting of incidents/accidents to CAAs. A non-punitive and de-identified mechanism can encourage incident reporting, which enables CAAs to have safety data for further analysis [3].
- 7.79 Definitions for serious incidents and accidents with unmanned aircraft are included in ICAO Annex 13 [43] but the type of UAS to be subject to the scope of Annex 13 has yet to be defined by the ICAO. The accident investigation authorities overseas are not normally expected to investigate into incidents of UAS being used in Hong Kong, which are small.

## 8 Recommendations on UAS classification

- 8.1 In developing a new framework for the future regulation of UAS in Hong Kong, the following principles are applied:
- The different types of operation are categorized in accordance with the risk associated with these operations.
  - The categories of operation shall be objective and unambiguous.
  - Future regulations shall be easily enforceable.
  - There shall be a gradual evolution of the current rules for the operation of UAS.
- 8.2 The current UAS classification in Hong Kong differentiates on the basis of weight and purpose of the operation (recreational or for hire and reward). A weight limit of 7 kg is currently in use. The situation is as follows:
- For UAS weighing more than 7 kg, all legal requirements under Cap 448C that are applicable to manned aircraft (pilot licence, airworthiness certificate, operator's certificate etc.) will also be applicable to UAS.
  - When flying UAS lighter than 7 kg recreationally, CAD's permit is not required.
  - Regardless of weight, if UAS are used for hire and reward, CAD's permit is required under Cap 448A.
- 8.3 This leads to the following key research questions concerning the regulations and guidelines for UAS:
- Is the weight limit of 7 kg (to be certificated or licenced by CAD) still appropriate? Is it necessary, given the technological advancements over the last years, to lower the weight limit?
  - Is it beneficial to also require persons operating UAS of lesser weight (i.e. also less than 7 kg) and/or for recreational purposes, to register their UAS and possibly even obtain a permit from the CAD?
  - Is it beneficial, or maybe even needed from a safety risk perspective, to also require persons to obtain CAD's permit for non-recreational operations despite those UAS were flown without hire or reward?
- 8.4 Several countries worldwide are dealing with similar issues, and are gradually adapting their regulations and guidelines to cope with rapid technological changes. Clearly there is a large variety of options and alternatives for UAS classification. Once standards are developed by ICAO, JARUS or ISO, it is expected that regulatory practices become more harmonised.
- 8.5 The vast majority of countries classify UAS based on weight of UAS or types of operations. From Chapter 4, it can be concluded that regulatory requirements vary. The current weight limit of 7 kg in Hong Kong is in line with that of Mainland China, Singapore, and Macau SAR. In view of this, for now, it is probably reasonable if Hong Kong maintains its current 7 kg weight limits, subject to review when new standards become available from the international bodies.
- 8.6 With reference to the international practice for UAS registration system, a new weight limit of 250 g is recommended. Normally, at low speed, UAS below such weight should not cause serious injury.
- 8.7 Regarding whether to differentiate the type of users, the international practices also vary. Some apply the same regulations to all, and some differentiate between recreational and professional users irrespective of their operational risks.
- 8.8 On a worldwide level, a risk based approach to the regulation of UAS is promoted by the ICAO, JARUS, FAA, EASA, UK, the Mainland China etc. A risk based approach defines categories of operations based on local risks, such as environmental conditions, weight or types of operations of UAS (e.g. where or how UAS are operated). The regulatory approach would depend on the level of safety risk of those categories, not those UAS were used for. Both ICAO and EASA propose the use of three risk categories.

- 8.9 For example, a category with a relatively low level of risk would not require authorization by CAA before flight, as safety is assured by pilots' adherence to CAA's operational limitations (e.g. distance from aerodromes and/or controlled airspace, buildings, people, critical infrastructures). On the other hand, a category with medium level of risk would e.g. require a safety risk assessment as basis for operational approval. In case of more complex operations, specific (certification) requirements on technology, equipment and/or procedures would apply.
- 8.10 In view of this, it is recommended to move towards a risk based categorization scheme with at least three categories, and remove the differentiation between recreational and commercial operations. Examples can be found in the ICAO UAS Toolkit [3] or EASA's new proposal to regulate UAS below 150 kg [5, 40]. Although terminology and naming of categories differs slightly, the concepts are more or less the same as follows:
- *Category A* should not require an authorization by the CAA before flight but must stay within specified conditions and operational limitations for the operation as promulgated by the CAA.
  - *Category B* will require an authorization by the CAA with specific limitations adapted to the type of operation, complexity of the UAS and qualifications and experience of operating personnel. As soon as an operation begins posing a significant aviation risk to other persons or aircraft, the operation should fall within this category. For these activities, each specific aviation risk would be analyzed and mitigation would be agreed by the authorities before the operation can start, based on a safety risk assessment. This would be materialized by the issuance of an authorization for the specific operation.
  - *Category C*. Operator certification will be required for operations with a higher associated risk due to the kind of operation or might be requested on a voluntary basis by organizations providing services such as remote piloting or equipment such as detect and avoid. When the aviation risks rise to a level akin to normal manned aviation, the operation would be positioned in category C. These operations and the aircraft involved therein would be treated in the classic manned aviation manner. Multiple certificates would need to be issued as for manned aviation plus some more specific to unmanned aircraft. SMS would be required for this category.
- 8.11 Light UAS, below 250 g, would not normally cause any serious injury<sup>10</sup> when bound by operational limitations. At present, all UAS must maintain at least 50 m distance to persons and buildings. This implies that UAS flights can only be feasible in country parks or other sparsely populated areas. By splitting Category A into sub-categories being Cat A1 ( $\leq 250$  g) and Cat A2 ( $250\text{g} < \text{UAS} \leq 7$  kg), each with its own operational limitations, Cat A1 UAS may be able to operate in areas where they are not currently allowed. When flying at low speed (e.g. below China's proposed speed limit for "micro" UAS (weighing  $< 250\text{g}$ ), below 40 km/h, a smaller distance of e.g. 10 m distance should be sufficiently safe.
- 8.12 Category C are mainly RPAS operations. Relevant SARPs will be prescribed under the new Annex 6 Part IV, which should be published by ICAO in 2022. For this reason, it is recommended to wait for ICAO to publish the proposed SARPs first. These shall then become applicable to Hong Kong and will need to be implemented in the law.
- 8.13 In summary, the following UAS categories are recommended for Hong Kong:
- Category A1 - low risk UAS operations with very small UAS ( $\leq 250$  g) that do not require CAD's authorisations before operations nor registration. Pilots must adhere to CAD's operational limitations;
  - Category A2 - low risk UAS operations with small UAS ( $250\text{g} < \text{UAS} \leq 7$  kg) that do not require CAD's authorisations before operations but do require owners' registration. Pilots must adhere to CAD's operational limitations;

<sup>10</sup> There may be a few exceptions, depending e.g. on the area of operation, batteries and the motors of UAS that are being used.

- Category B - UAS operations with UAS below 25 kg that may pose risk to e.g. other persons, properties or aircraft and for which safety risk assessment and operations authorization by the CAD are required.
- Category C - it is recommended to wait for ICAO's developments on RPAS SARPs in 2020.

## 9 Operations standards and requirements

- 9.1 This Chapter will propose a set of operations standards and requirements for each category of UAS as defined in Chapter 8. An overview of these proposed requirements and comparison with the existing practice is given in Appendices D and E.

### Category A

- 9.2 *Category A* should not require an authorization by CAD when pilots adhere to CAD's operational limitations, which may be similar to examples suggested in the ICAO UAS Toolkit:
- Day time, Visual Meteorological Conditions (VMC), VLOS operations only;
  - In uncontrolled, non-restricted airspace
  - Fly at a specified distance away from people, buildings and aerodromes;
  - Fly at a specified maximum height Above Ground Level (AGL)\*;
  - The unmanned aircraft operates within specific performance limitations.
- \* Note that Above Ground Level (AGL) should be measured in terms of vertical height of the (flying) Unmanned Aircraft from the underlying ground surface, as an indication of where the 'zero level' is located (and not from where the operator is standing).
- 9.3 It is recommended in Chapter 8 to distinguish two sub-categories. Cat A1 covering operations with very small UAS ( $\leq 250$  g), which are less visible, and relatively sensitive to wind/weather influences. UAS in this category would normally have very low speed and mass, so that in case of impact, the kinetic energy is low enough to pose only negligible safety risk. A recent study from the Aalborg University in Denmark suggests that a mass threshold of 250 g is reasonable to classify UAS as 'harmless' [39]. From a regulatory point of view such easily measurable threshold should be easier to enforce. Some authorities, including Denmark and EASA, are considering the 250 g limit as an appropriate value. In a technical opinion from EASA [40] a 'harmless' subcategory is proposed, to accommodate 'toy aircraft or nano UAS that cannot cause serious injuries or significant damage', and 250 g is listed as a suitable limit. The 'UAS Collision' Task Force [41] adapts a 250 g threshold for their smallest category, stating that "A [mid-air] collision with the smallest UAS category [harmless] is expected to be harmless, at least for large aeroplane product types." In this context, 250 g may be perceived as a 'cut off weight' below which no UAS rules should apply to small UAS and the example operational limitations for Cat A1 may be used as recommendations and guidance without the need for strict enforcement. It should however, be kept in mind that UAS technology develops very rapidly. A 'cut off weight' of 250 g alone may not necessarily constitute a 'harmless' threshold [42]. It is thus recommended to introduce additional safety guidance, or even requirements, such that high speed UAS will not be operated directly over people.
- 9.4 The recommendation for Cat A1 UAS not required to be registered is in line with international practices in the United States, the Mainland China and also the EASA proposal.
- 9.5 The Cat A2 covers relatively low risk operations with UAS below 7 kg (the current weight limit in Hong Kong). The command and control link of these UAS would typically be more reliable<sup>11</sup>, enabling flight at further

<sup>11</sup> However, known radiating sources (high voltage lines and radio/telephone antenna's need to be considered as these might interfere with the flight controls.

distance from the remote pilot than for the small UAS. This Category A2 would need strict requirements that are based on the principle of a high degree of consistency with, and a gradual evolution of, the current rules for the operation of UAS. This will apply to all UAS as it is not always easy to distinguish recreational UAS use from commercial applications (see Chapter 6). Table 5 provides an example of potential operating limitations for Category A operations in Hong Kong.

*Table 5 Example of operating limitations*

|  | Category A1  | Category A2   |
|--|--|---|
| Registration   | No   | Yes   |
| Weight of UA ( <i>max. all up weight, ready to fly, including batteries, fuel, and all other parts</i> ) | $\leq 250 \text{ g}$   | $250 \text{ g} < \text{UAS} \leq 7 \text{ kg}$  |
| Distance from people and buildings   | $> 10 \text{ m}$   | $> 50 \text{ m}$ (with an exception at most $> 30 \text{ m}$ during take-off and landing) |
| Distance from aerodromes <sup>12</sup>   | More than 5 km   | More than 5 km  |
| Distance from operator   | Less than 50 m or within visual range #, whichever is more restrictive | Less than 500 m or within visual range #, whichever is more restrictive                   |
| Altitude of operations (maximum height AGL)  | 100 feet   | 300 feet  |
| Performance limitations  | Less than 40 km/h  | Less than 80 km/h   |
| Surface wind limits  | As set by the manufacturer   |   |
| Visibility   | More than 1 km   | More than 5 km  |

Notes:

1. More examples based on international practice, safety guidance on CAD website or prevailing practices in Hong Kong are discussed below.
2. Should an operator wish to operate his/her UAS outside the predefined operating parameter, the operator will be required to apply to CAD.
3. # within visual range (or VLOS) means the pilot can see the UAS with the naked eye (not just on mobile phone app screen, FPV goggles or binoculars etc.)
4. Most operating limits, e.g. distance from aerodromes (5 km), are based on CAD's safety guidance and/or similar to requirements of other CAAs.

- 9.6 Regarding maximum distance from the operator, some countries have prescribed a distance that is largely consistent with the maximum visual range at which UAS can be seen with the unaided eye (VLOS). In the Netherlands and Mainland China, 500 m distance from the operator is felt consistent with VLOS operations. It is felt that at larger distances, it may not be possible to keep the smaller UAS within visual range, i.e. UAS enter BVLOS.
- 9.7 It should however be noted that the Mainland China's operational regulations caters for larger UAS (e.g. above 150 kg), which may explain the use of "500 m distance".
- 9.8 In Hong Kong, current guidance requires all UAS to be operated within visual range. For Cat A2 ( $250 \text{ g} < \text{UAS} \leq 7 \text{ kg}$ ), the visual range are normally between 100 and 200 m. However, some UAS may be unusually large (e.g. tethered balloon/UAS of 2 m), which can be seen at 500 m. Therefore, a limit of 500 m or VLOS, whichever is more restrictive is recommended for Cat A2. As Cat A1 UAS ( $\leq 250 \text{ g}$ ) are typically very small and sensitive for wind influences. It is recommended to keep those UAS within a closer range (50 m or VLOS, whichever is more restrictive).
- 9.9 Note that operational regulations for UAS up to 150 kg in China (AC-91-FS-2015-31) can be downloaded from <https://uas.caac.gov.cn/login/download/file/1>. Appendix A.2 provides a summary of regulations in Mainland China.
- 9.10 Regarding height limit, it is international practice that CAA's authorisations are not needed for small UAS flying below 300 or 400 feet. The current limit of 300 feet may be maintained for Cat A2. A lower limit of 100 feet is recommended for Cat A1 due to its sensitivity to wind.

<sup>12</sup> It is an option to also specify a minimum distance from controlled airspace as an operating limitation.

- 9.11 Some countries have introduced a speed limit for regular operation of UAS e.g. in Mainland China, a speed limit of 100 to 120 km/hour applies, where in the United States a speed limit of 100 miles/hour is used. In NPA 2017-05 (A), EU proposed a UAS Class C1 (a subcategory under EU's proposed "OPEN" Category) to be "made of materials and have performance and physical characteristics such as to ensure that in the event of an impact with a human body, the energy transmitted to the human body is less than 80 J, or, as an alternative, have an MTOM, including payload, of less than 900 g and a maximum cruising speed of 18 m/s" (i.e. 64.8 km/hour). It is possible that this is in consideration of the fact that UAS usually 'drops down from the sky' vertically in case of a system failure (e.g. loss of C2 link, serious battery failure), it. Considering that Category A2 requires at least 50 m to people/buildings, the risk may still be perceived as relatively low. In view of the rapid technological developments in UAS, it is recommended to introduce a more conservative speed limit for Category A2 (e.g. 80 km/h).
- 9.12 It should be noted that Category A type of operations would not need authorisation from the CAD. However, requirements on the owners and/or pilots may be coupled with the registration of owners. This could, for example, include a statement that registration is only accepted after owners confirm that they understand CAD's operational limitations and will be adhered to them, or registration may be revoked if UAS were operated recklessly or negligently and endangered the safety of others.
- 9.13 Choice of flying sites is determined through CAD's UAS-map, or restrictions and guidance on CAD's website, such as:
- The site shall be flat enough to enable safe take-off and landing at all times
  - The UAS operator must maintain direct, unaided visual contact with the UAS sufficient to monitor its flight path in relation to other aircraft, persons, vehicles and structures for the purpose of avoiding collision.
  - The site shall be clear of persons, vessels, vehicles or structures
  - UAS shall be flown away from helicopter landing pads
  - UAS shall be flown away from correctional facilities
  - UAS shall not be flown in the vicinity of an airport and aircraft approach and take-off paths. This includes:
    - Hong Kong International Airport;
    - North Lantau coastal area;
    - Coastal areas from Tai Lam Chung to Tsuen Wan and Tsing Yi Island;
    - Victoria Harbour and its coastal areas; and
    - Shek Kong area
  - UAS shall not be flown over, or close to, any object, installation or facility that would present a risk to safety in the event of damage due to any impact by the UAS,
  - UAS shall not be flown such that no person and property would be endangered by the UAS, and shall not fly the UAS unless the person in charge has reasonably satisfied himself that the flight can be safely made.
  - UAS shall not be flown in such a manner that the control thereof may be or may likely be jeopardised
  - UAS shall not be flown in case of (expected) meteorological adverse conditions e.g. Rain Storm Warning, Tropical Cyclone Warning or Strong Monsoon Warning.
- 9.14 As regards Category A2, the UAS operator is additionally required to ensure the following:
- The UAS operator shall not fly the UAS unless before the flight he has satisfied himself that the mechanism and systems that control the UAS, including the radio link, is in working order.
  - The UAS operator shall maintain vigilance so as to see and avoid aircraft and shall yield right of way to all aircraft, and shall respect right of way rules to other UAS. The UAS operator shall not operate the UAS in such a manner that the aircraft creates a collision hazard with respect to any other aircraft, including other UAS.

- The UAS operator shall take every precaution not to endanger any person or property and keep a watch for any aircraft, model aircraft, paraglider, etc. flying in the vicinity.
- The UAS operator must not cause or permit any article or animal to be dropped from the UAS so as to endanger persons or property.
- The UAS operator shall have received basic training, including e.g. the watching of video(s) for instruction, demonstration of sufficient operating skills, and pass a simple exam for a certificate. This exam shall be based on measurable learning objectives, which are to be agreed upon with the CAD<sup>13</sup>.
- The UAS shall not be operated in prohibited or restricted areas and/or private properties, unless permission from the controlling agency and/or property owner is obtained.
- The UAS operator shall report any accidents and serious incidents<sup>14</sup> regarding their UAS operations within three calendar days by email to the CAD, using an appropriate Incident/Accident Reporting Form.
- The UAS operator shall use a pre-flight checklist for safety items.
- The UAS operator shall read and consider the operational limitations, safety guidance and tips provided by the UAS manufacturer.
- Low age users (e.g. below 14 or 16 years of age) shall only be allowed to operate UAS with supervisor nearby.
- CAD may consider providing a simple online training with test to check if the owners/operators are aware of relevant aviation law and CAD's safety guidance. Training needs should be based on risks and complexity of operations. CAD may also consider allowing manufacturers, model aircraft or UAS associations etc. to deliver similar training and/or test. For higher risk operations, CAD may approve qualified instructors or organisations to provide advanced training, examination or certification according to learning objectives or other requirements to be agreed with the CAD.

## Category B

- 9.15 Category B type of operations should require an authorization by CAA with specific limitations adapted to the type of operation, complexity of the UAS and qualifications and experience of operating personnel. In case the operating limitations for Category A are exceeded, the operation may begin to pose a risk to persons overflown and/or other airspace users. For these type of operations, each specific aviation risk would need to be analyzed and mitigation would be agreed by the authorities before the operation can start, based on a safety risk assessment. This would be materialized by the issuance of an authorization for the specific proposed operation.
- 9.16 For Category B, the additional requirements and responsibilities as detailed in the following shall be complied with.

### A) Registration, identification and geo-fencing

- UAS operators shall register their unmanned aircraft and the remote pilots allowed to operate their UAS.

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<sup>13</sup> Basic training could address UAS General knowledge, Electrical system, Data link, Mass and center of Gravity, Air Law, Meteorology, Fit to Fly and Operational Procedures, aimed at practical relevance to operations of type Category A. Examination could include a few multiple choice questions, possibly complemented with practical flight training and examination verifying a proper control over the aircraft and appropriate airmanship and asking how to respond to emergencies.

<sup>14</sup> Definitions for accidents and serious incidents with unmanned aircraft are contained in ICAO Annex 13 'Aircraft Accident and Incident Investigation' [43].

- Depending on the zone of operation<sup>15</sup>, geo-fencing functionality<sup>16</sup> shall be required in order to reduce the risk of entering ‘no-fly zones’ (e.g. for the protection of aerodromes and/or helicopters or manned aircraft nearby).
- Depending on the zone of operation<sup>15</sup>, UAS shall be equipped with an electronic capability<sup>17</sup> (e.g. small transponder), which enabled those UAS to be identified and tracked without direct physical access to that UAS.
- UAS operators shall attach ‘sticker identification’ to their UAS<sup>18</sup>, indicating that these are approved for a certain period of time – by CAD – for performing Category B type of operations.

#### **B) Operating Limitations**

- The maximum all up weight of the Unmanned Aircraft shall not exceed 25 kg, including fuel and possible detachable parts.
- No flight shall be flown outside the approved hours and at a distance beyond visual range of the UAS operator.
- The UAS shall not be flown when the ground visibility is less than 5 km or the cloud base is lower than the maximum altitude of operation or the surface wind is more than the operational wind limitation (i.e. 20 knots). Neither shall it be flown in (expected) meteorological adverse conditions, e.g. when any Rain Storm Warning, Tropical Cyclone Warning or Strong Monsoon Warning is in force.
- The surface wind speed on site shall be monitored with a hand-held anemometer or other wind meter.

#### **C) Responsibilities of the Operator**

- The UAS operator is responsible to ensure that no person and property would be endangered by the UAS and shall not fly UAS unless person in charge has reasonably satisfied himself that the flight can be safely made.
- The UAS operator shall not fly the UAS unless before the flight he has satisfied himself that the mechanism that causes the UAS to home or land in the event of a failure of or disruption on any control systems, including the radio link is in working order and correctly programmed.
- The UAS operator shall maintain vigilance so as to see and avoid aircraft and shall yield right of way to all aircraft. The UAS operator shall take every precaution not to endanger any person or property and keep a watch for any aircraft, model aircraft, paraglider, etc. flying in the vicinity.
- The UAS operator shall not operate the UAS in such a manner that the aircraft creates a collision hazard with respect to any other airspace user.
- The UAS operator is required to secure an insurance policy that appropriately insures the company operating the UAS in respect of third party risks for the proposed operation<sup>19</sup>.

<sup>15</sup> Only UAS operated in restricted areas are required to have geo-fencing capability and/or an electronic capability, which enabled UAS to be identified and tracked without direct physical access to UAS.

<sup>16</sup> The EASA NPA 2017-05 [29] specifies product requirements for a geofencing component as follows. A geofencing system should include the following functionalities and performance characteristics so as to provide: (a) an interface to update data containing information on airspace limitations and requirements, as well as to ensure the integrity and validity of this data; (b) information about the airspace limitations and requirements where the UA operates, as well as the position and movement of the UA relative to those limitations; and (c) information on the status of the system as well as on the validity of its position or navigation data.

<sup>17</sup> The EASA NPA 2017-05 [29] specifies product requirements as follows. The electronic identification system shall provide in real time the following information through electronic data, which is compliant with standards acceptable to EASA: (a) the UAS operator and UA registration; (b) the UAS class; (c) the type of the UAS operation; (d) the status of the UAS geofencing function; and (e) the geographical position of the UA and its altitude above ground level.

<sup>18</sup> The sticker should only contain the minimum required information enabling to check the granted approval, such as registration number, date of approval, time period of validity, issuing entity (could e.g. be CAD or qualified entity), type of operation. Together with an operational registration system, this is sufficient to trace the owner.

<sup>19</sup> As an example, the Regulation (EC) No 785/2004 of the European Parliament and of the Council of 21 April 2004 on insurance requirements for air carriers and aircraft operators as baseline for insurance requirements for Category B. In Europe, this regulation is also applicable to Unmanned

- The UAS operator must not cause or permit any article or animal to be dropped from the UAS so as to endanger persons or property.
- The UAS operator must maintain direct, unaided visual contact with the UAS sufficient to monitor its flight path in relation to other aircraft, persons, vehicles and structures for the purpose of avoiding collision.
- The UAS operator shall operate the UAS within the limits of the manufacturer's technical specifications.

#### **D) Operations Manual (OM)**

- The UAS operator shall have a CAD approved OM that:
  - includes at least the following: organization structure and responsibilities, operational control, operating procedures, flight/planning preparation, on site procedures, pre-flight checks, flight procedures, emergency procedures, training program, and incident/accident reporting procedures.
  - includes a safety risk assessment and safety plan process, to ensure the operator shall not recklessly or negligently cause or permit the UAS to endanger any person or property.
  - includes a maintenance plan, including procedures to ensure that equipment is properly secured, the UAS is in an airworthy condition, the assembly of the UAS is correct and in accordance with manufacturer's instructions. Should the UAS not be serviceable, then maintenance and repair is needed.
  - Includes adjustments and modifications require UAS manufacturer(s) and/or third party's safety and airworthiness certification.

#### **E) Safety Assurance**

- The operator shall perform safety risk assessment(s) of the proposed operation(s), and demonstrate those are sufficiently safe to operate.
- The operator shall collect operational and safety data, enabling assessment of safety performance indicators.
- The operator shall share safety information on a regular basis (e.g. once every 6 months) with the CAD<sup>20</sup>.
- The operator shall be active in safety promotion towards all involved remote pilots and maintenance staff.
- The operator shall report any accidents and serious incidents regarding their UAS operations within three calendar days by email to the CAD, using an appropriate Incident/Accident Reporting Form.

#### **F) Training**

- Remote pilots shall be competent and trained according to CAD's requirements.

- 9.17 In general, modification of UAS is not recommendable unless specified in the manufacturer's guide or instructions. UAS owners and operators should not make modifications that breach compliance with the requirements specified by the manufacturer and/or the Hong Kong Office of Communications Authority (OFCA) for the envisaged type of UAS operations. Such modifications typically imply that the approvals for specific type of operations will be revoked.
- 9.18 It should be noted that operations not explicitly covered, for example BVLOS or night operations, would require CAD's authorization if the operator can mitigate risks specific to those operations.

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Aircraft Systems of any size and weight. Article 7 prescribes that 'in respect of liability for third parties, minimum insurance cover per accident, for each and every aircraft, shall be 750000 Special Drawing Right (SDR) – as defined by the International Monetary Fund – for aircraft with MTOM of less than 500 kg. This is equal to about 890000 Euro, by early September 2017.

<sup>20</sup> Safety information to be shared should at least provide the means to verify the safety performance of the UAS operator, in reference to its safety policy and safety objectives (safety performance targets) using dedicated safety performance indicators. Trends should be analysed and, consequently, corrective actions should be identified after detecting any deterioration of specified safety levels. There should be a systematic collation of the safety information for safety monitoring in place.

## Category C

- 9.19 ICAO suggests that this category of operations could, for example, consist of B-VLOS operations utilizing a larger and/or heavier aircraft with more payload capacity and with the potential to cause fatality or injury to persons on the ground or other airspace users [3]. As described in Chapter 3 and 7, it is recommended to await publication of Annex 6, Part IV on RPAS, which will be around 2022. Until then, it is anticipated that Category C type of RPAS operations with heavier UAS will not be requested and approved in Hong Kong.

## 10 Implementation strategy and regulatory oversight

- 10.1 This Chapter provides recommendations on the way forward for implementation of:
- The proposed UAS classification scheme resulting from Chapter 8; and
  - The proposed operations standards and requirements from Chapter 9.

### Implementation strategy

- 10.2 Previous Chapters have laid the foundations for the improvements to the legislative framework and regulations for the safe operation of UAS in Hong Kong. One of the main recommended conditions is a gradual evolution of the current rules for the operation of UAS. Implementing new rules and regulations may be in phases to cater for appropriate regulatory controls in the near, medium/long term.

*Table 6 Goals and objectives of the implementation strategy*

| Time Frame                      | Goals and objectives   |
|---------------------------------|--|
| Near term<br>(2017 – 2020)      | Implement new rules and regulations for safe operation of UAS performing Category A and B types of operations. Key elements are: UAS classification, operations standards and requirements for Categories A/B, registration system, insurance for higher risk operations, identification of UAS, geo-fencing, operations manual template, remote pilot competency requirements, theoretical and practical education/training requirements, practical skills test and exam requirements, method for safety risk assessment, occurrence reporting form, safety promotion, promulgation of voluntary SMS implementation, UAS map with UAS parks & no-fly zones, possibility for ‘qualified entities’ to undertake certain safety oversight tasks and responsibilities from the CAD, enforcement measures. |
| Medium/long term<br>(from 2020) | When ICAO has published the new SARPs for RPAS, extend new rules and regulations to also cover UAS performing Category C operations, including BVLOS operations. Key elements to be included are: operations standards and requirements for Category C, RPAS Operator Certificate requirements, special airworthiness certificate requirements, training requirements comparable to manned aviation, remote pilot licensing, SMS requirement for RPAS operators and maintenance organizations, standards and specific rules* to enable operations/traffic of UAS at lower altitudes (outside no-fly zones).  |

\* Rules for managing UAS traffic may need to be supported by a UAS traffic management system (see UTM [21, 22] or U-Space [23]). Given that Hong Kong is congested, and densely populated with a lot of high-rise buildings, it is not yet clear if Hong Kong's environment may benefit sufficiently from UTM or U-Space.

*Table 7 Material that may support the implementation strategy in near Term*

| Description                              | Remark   |
|--|--|
| Operations Manual (OM) Template          | Existing OM Template may be updated  |
| Remote Pilot Competency Requirements     | Develop requirements for Cat A2 and B  |
| Category B Operations Authorization Form | Example from UAS Toolkit [3] is an option  |
| Category B Airspace Coordination Form    | Example from UAS Toolkit [3] is an option  |
| Category B Operators SMS Template        | Could be included in the OM template   |
| Category B Safety Risk Assessment Method | JARUS WG6 SORA [36] is a possible option   |
| Incident/Accident Reporting Form         | Existing form to be updated when ICAO Annex 13 has clarified the type of unmanned aircraft to be subject to the investigation scope. |
| Registration system                      | Online system to be developed  |
| UAS Map (no-fly zones & UAS parks)       | New activity/study should be initiated   |

- 10.4 As technological developments in the field of UAS seem to outpace rulemaking activities, it is also recommended to establish UAS R&D facilities in HK with segregated airspace structures. These ‘UAS test parks’, preferably also indicated on a UAS map, provide several benefits to the UAS community and the authorities, including e.g.:
- Support to academic aerospace and engineering programmes;
  - Testing of new UAS and new technologies by manufacturers;
  - Testing of UAS in various operational conditions by UAS operators;
  - Demonstrating UAS capabilities to the authorities;
  - Testing the integration of UAS payload in order to validate its application;
  - Testing and training for remote pilots;
  - Reducing the requests from UAS operators for access to other airspace.
- 10.5 The CAD may keep in view the international community’s development on harmonising UAS standards (e.g. those by JARUS, ICAO or ISO) and have the discretion of recognizing or validating authorizations or certifications issued by States with more advanced and developed UAS regulatory systems, or their approved persons or organisations.
- 10.6 The CAD should provide training for its personnel on the new rules. Also, stakeholders should be informed about the changes in a timely manner. This could be done through workshops, flyers and/or brochures.

## Regulatory oversight

- 10.7 Next step is to provide recommendations for implementation of a regulatory oversight mechanism to enable control, enforcement, and the monitoring of compliance of the standards and requirements for the respective classes of UAS. It is important to develop good and enforceable UAS rules and regulations that are well embedded in the law.
- 10.8 Similar to other parts of the world, enforcement on UAS operations can be difficult. Measures to facilitate or support enforcements are recapitulated below:
- Registration of owners and/or operators to enable UAS to be identifiable. The owner must acknowledge responsibility and accountability for its operation.
  - Identification of UAS
  - UAS map for indicating fly – and no-fly zones

- 10.9 Moving towards registration of owners and remote pilots of UAS above 250 g is an unavoidable step to ensure and maintain safe UAS operations. After establishing a registration system, operators performing Cat B operations may be required to file flight plans, which should further enhance safety oversight on UAS operations.
- 10.10 It should be realized that there may be a large number of UAS in Hong Kong (especially UAS above 250 g) subject to the new registration requirements. For this reason, it may be wise to put in place transitional arrangements to minimize the initial impact (e.g. voluntary scheme before commencement of legislation to encourage early registration, 6-month grace period). Furthermore, the introduction of new rules for UAS may also have a noticeable impact on the efforts needed from the CAD. In view of this, the establishment and set-up of a separate UAS regulatory office or increase in manpower for UAS tasks in the CAD and/or approving persons to certify pilots etc., is strongly recommended.
- 10.11 Regarding the identification of UAS, two options were discussed. It is recommended that the manufacturer may stamp a unique serial number on the UAS as input to registration system, and/or the owner may print a sticker with registration number issued by CAD after the UAS is registered, and attach the sticker to the UAS or the controller unit. Such stamps or stickers allow owners and pilots to be traced using information provided by owners and/or pilots in CAD's registration systems.
- 10.12 It is recommended to make available a UAS map which indicates no-fly zones. Such map will enable enforcement officers (e.g. police) to quickly identify UAS that operate in restricted areas. Further actions may be taken, such as seeking confirmation from CAD or property owners/managers whether those operations were permitted.
- 10.13 Enforcement methods may have various forms such as the issuance of warning, fines or revoke of permits etc. depending on the severity of the transgression. Similar to international practice, the responsibility for enforcement may continue to rest with the local law enforcement agencies, mainly the Hong Kong Police and CAD, the former acts upon the aviation expertise and requirements of the latter. For scenarios unrelated to aviation safety or other situations, other government authorities may be the enforcement agencies.

## 11 Conclusions and recommendations

- 11.1 The huge advancement in UAS technologies and their rapidly increasing popularity, imply that the associated safety risks are increasing. To ensure aviation safety and the protection of persons and properties on the ground, there is a need for the Hong Kong Government to review and enhance the existing regulation regime of UAS to keep in pace with the developments.
- 11.2 Therefore, this study has analyzed international regulatory practices for UAS operations and recommends improvement to the current legislative framework and regulations for the safe operation of UAS in Hong Kong, with reference to the local environment, the development of UAS technology, and the views of UAS operators/users.
- 11.3 The following steps have been undertaken:
1. Review of international regulatory practices and policies;
  2. Survey of UAS design, technologies and applications;
  3. Conduct an assessment of the local situation;
  4. Evaluation of practices and effect of regulation in Hong Kong;
  5. Propose recommendations on UAS classification;
  6. Propose operations standards and requirements;
  7. Provide recommendations on implementation strategy and regulatory oversight.
- 11.4 **Review of international regulations.** The existing and near future international regulations, guidelines and best practices have been reviewed and evaluated from the viewpoint of potential applicability for Hong Kong. The review covered non-legislative practice, enforcement measures adopted by other authorities (including the use of technology such as geo-fencing), any exemption for specific users (such as press, law enforcement agencies). The review has covered the current regulations, practices and developments of ICAO, JARUS, Hong Kong, Europe (EASA, United Kingdom, Netherlands, Switzerland, Germany), United States (FAA), Asia (China (including Macau SAR), Singapore, Japan, South Korea), Australia.
- 11.5 **Survey of UAS design, technologies and applications.** The study has surveyed design and technological advancement of UAS, and the development of their usage and applications in civilian context in recent years, and their future development direction. The overview provides a flavour of the state-of-the-art. Completeness is not possible due to the rapid developments that are going on world-wide. The focus is on the smaller UAS, i.e. up to 25 kg (55 pounds), being UAS for the consumer market as well as commercial use, as these are most relevant for Hong Kong. A market outlook summary is also provided.
- 11.6 **Conduct an assessment of the local situation.** Through sampling the views of key UAS manufacturers, suppliers, operators holding UAS permits issued by the CAD, and model aircraft/UAS associations, training institutes, airlines or their representatives, airport / heliport operators, academia, government bureaux and departments etc, and use of other information (e.g. website, local news etc.), a good picture of views of the interviewees / respondents to the online survey on the present situation and regulation of UAS, as well as their expectations regarding possible changes, is established. This has provided insight into the effectiveness of introducing rule changes, will have a positive impact on safety culture, and will increase confidence in the efficacy of safety precaution measures to be taken as part of the regulatory process, including for safety oversight.

- 11.7 **Evaluation of Practices and effect of regulation in Hong Kong.** The prevailing practices regarding UAS operation and the effect of regulation on this operation in Hong Kong have been evaluated. In the evaluation, the relevant regulations of unmanned and manned aviation of Hong Kong have been considered. As regards the prevailing practices of UAS operation, recreational use and non-recreational use has been considered. Some exceptions (or variations) from CAD's safety guidance have also been identified. As regards the effect of the regulation, the following aspects have been considered: aim of the legislation, enforcement measures, safety risk assessments, training, licensing of remote pilots, pre-flight checks, maintenance, recreational versus commercial applications, property/land manager permission, insurance, use of radio spectrum under telecommunication ordinance, indoor flight. For each aspect, recommendations on the way forward have been proposed. Additionally, recommendations to promote responsible and safe flying of UAS have been identified. This concerns safety promotion campaign, promote cooperation within the UAS industry and voluntary safety management practices by UAS operators.
- 11.8 **Recommendations on UAS classification.** Conclusions on the needs and benefits of revising/refining the UAS classification scheme, which is currently in use in Hong Kong, have been drawn. It is recommended to use a three-category model for classification of the different types of UAS operations. Such model is also advocated by ICAO [3] and EASA [29]. A risk based approach to implement the operations standards and requirements for the classes of UAS is envisaged, thereby removing differentiation between recreational and commercial/professional (for hire or reward). In general, such risk based categorization schemes for UAS are based on the concept that the operation of UAS should be regulated in a manner proportionate to the risk of the specific operation. It is recommended to implement the following three categories of operation and establish requirements for owners and/or operators to register their UAS through a UAS registration system maintained by CAD:
- *Category A* ( $\leq 7$  kg) will not require an authorization by CAD before flight but must stay within specified conditions and operational limitations for the operation as promulgated by CAD. It has two sub-categories:
    - *Category A1.* Low risk operations with very small UAS ( $\leq 250$ g), for which registration is not required
    - *Category A2.* Low risk operations with small UAS ( $250$  g  $<$  UAS  $\leq 7$ kg), for which registration is required
  - *Category B* ( $\leq 25$  kg) will require an authorization by CAD with specific limitations adapted to the type of operation, complexity of the UAS and qualifications and experience of operating personnel. Operations that may pose a significant risk to other persons, properties or aircraft will require safety risk assessment and authorization by CAD. Registration of UAS owners and remote pilots is required. There are further requirements with respect to e.g. operations manual, safety assurance, risk assessment and pilot training and certification by CAD's certified instructors. Operations in certain zones and above certain altitudes of operation would require geo-fencing functionality, an electronic capability (such as a small transponder) and airspace coordination. Other operating limitations may be set by CAD as appropriate.
  - *Category C* requires operator certification due to the higher risk associated with the complexity of the operations involved. Multiple certificates, including special airworthiness certificates, need to be issued as for manned aviation plus some specific to unmanned aircraft. As Category C are mainly RPAS operations, it is recommended to await the developments of new SARPs for RPAS by ICAO which is anticipated to be in 2020. Until then, it is anticipated that Category C RPAS operations with heavier UAS will not be requested and approved in Hong Kong.

- 11.9 It should be noted that specific operations, not explicitly covered, for example BVLOS or night operations, would require authorisation from the CAD. Such authorisation would normally require the operator to mitigate risks specific to those operations.
- 11.10 Furthermore, the proposed Categorization no longer differentiates between recreational and non-recreational operations, because it is not always easy to distinguish those operations despite their risks may be similar. By the same token, it is not recommended to exempt specific type of UAS users (e.g. press, law enforcement, etc.) The UAS community and public are also more likely to accept and comply with rules if these are uniformly enforced.
- 11.11 **Operations standards and requirements.** A set of operations standards and requirements for each class of UAS as defined has been proposed. This concerns standards and requirements with respect to e.g. registration, identification and geo-fencing; operating limitations, responsibilities of the operator, the operations manual, safety assurance, and training, assessment and licensing of remote pilots, insurance etc. The key operations standards and requirements for each of the Categories are listed above. Main principles applied are that there will be a gradual evolution of the current rules for the operation of UAS, and that the future rules and regulations will be easily enforceable. The development of UAS maps by the CAD, mainly for “no flying zones”, to facilitate compliance and enforcement was also recommended.
- 11.12 **Implementation strategy and regulatory oversight.** Recommendations on the implementation of the proposed UAS classification scheme and operations standards and requirements have been provided. A strategy for the implementation of new rules and regulations has been proposed. The strategy for phased implementation will cater for appropriate regulatory controls in the near and medium/long term. To support the implementation, the availability of manpower, registration system and other software tools, guidance material will be required. Key items recommended for the near term have been identified. Recommendations on enforcement measures are elaborated in Chapter 9. Also, recommendations for ‘UAS test parks’, to be located in segregated airspace, for uses such as UAS training and testing were made.
- 11.13 From a regulatory perspective, indoor UAS operations such as those for building inspection or UAS racing are new and emerging activities. Most countries do not yet have a clear view on how to establish regulations for these activities. Further study on these UAS activities and associated safety aspects is needed.
- 11.14 In summary, six key recommendations were made:
1. Set up a UAS registration system for UAS above 250 g;
  2. Establish a risk-based classification model for UAS operations, taking into account the weight and type of operations of UAS (e.g. where and how the UAS is operated) and develop the operating standards and requirements by each risk category;
  3. Establish training and assessment requirements based on the risk category, which should improve operators’ safety awareness and knowledge. The duration and complexity of training or assessment should be based on risks of UAS operations;
  4. Establishment of a UAS (drone) map, primarily to cover no-fly zones;
  5. Develop insurance requirements for UAS based on the risk category; and
  6. Indoor operations of UAS to be further studied.
- 11.15 To conclude, while this study has provided recommendations for future UAS regulations, a concrete proposal for enactment of legislation and guidance that are clear, reasonable and easy to enforce is envisaged as a follow-up of this study. The outcomes of this study, and in particular proposed operations standards and requirements, are also subject to further review when new approved standards become available from international bodies such as ICAO.

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## Appendix A Regional and national state regulations

## Appendix A.1 Australia

| Country / region  | Australia   |
|---|---|
| <b>Summary of UAS legislation and regulations in force</b>  | The Regulation establishes a set of standard operating conditions for RPA, categorisations for RPA according to weight or, in the case of airships, envelope capacity, and introduces the concept of 'excluded RPA' to represent RPA operations considered to be lower risk, as determined by RPA category and operational use. Excluded RPA have reduced regulatory requirements, such as not needing an operator's certificate or a remote pilot licence (RePL). The Regulation permits private landowners to carry out some commercial-like operations on their own land under the 'standard RPA operating conditions' without requiring them to hold an Unmanned Aircraft Operator's Certificate (UOC) or RePL, if using an RPA weighing up to 25 kg provided that none of the parties involved receive remuneration. For RPA weighing between 25 kg to 150 kg, the operator needs to hold a remote pilot licence in the category of aircraft being flown. The Regulation requires a person operating, or conducting operations using, a very small RPA for hire or reward to notify CASA rather than being required to obtain a UOC and RePL. The Regulation makes it an offence for a person to operate a very small RPA for hire or reward without notifying CASA and also allows CASA to establish and maintain a database of information that relates to these notifications. Autonomous flight is prohibited until such time as suitable regulations can be developed by CASA. There is scope for autonomous flight to be approved by CASA on a case-by-case basis in the meantime. |
| <b>Non-legislative regulations and enforcement measures</b> | <p>There are 11 strict liability offence provisions in the Regulation. The offences fall at the lower end of the scale being set at 50 penalty units (around \$9000):</p> <ul style="list-style-type: none"> <li>• operating an unmanned aircraft in controlled airspace and does not comply with the requirements in the MOS.</li> <li>• operating an unmanned aircraft beyond their visual line of sight.</li> <li>• causing an autonomous aircraft to be launched or released</li> <li>• operating an RPA in a prescribed area not in accordance with a requirement in the MOS.</li> <li>• operating an RPA without a remote pilot licence that authorises the person to operate that RPA.</li> <li>• conducting non-excluded operations using RPA without holding a certificate as an RPA operator.</li> <li>• not complying with a requirement under subregulation 101.272(1) to keep records and give information to CASA as set out in the Part 101 MOS.</li> <li>• failure to comply with conditions of a remote pilot licence.</li> <li>• not complying with the operator's documented practices and procedures.</li> <li>• operating a very small RPA for hire or reward without notifying CASA at least 5 business days before the first operation, unless they hold an UOC.</li> <li>• failing to notify CASA of a change, event or matter of a kind set out in the Part 101 Manual of Standards within 21 business days.</li> </ul>  |
| <b>Exemptions for different types of users</b>              | There is a concept of 'excluded RPA' to represent RPA operations considered to be lower risk, as determined by RPA category and operational use. Excluded RPA have reduced regulatory requirements, such as not needing an operator's certificate or a remote pilot licence (RePL). This exemption targets private landowners, using RPAS < 25 kg. Autonomous flight may be approved on case-by-case basis.   |
| <b>Applied (weight) categories</b>                          | <100g<br>100g-2kg<br>>2-25kg<br>>25-150kg<br>>150kg   |
| <b>Main source(s)</b>                                       | Civil Aviation Legislation Amendment (Part 101) Regulation 2016. Authorised Version F2016L00400 registered 29/03/2016   |

## Appendix A.2 China

| Country / region                                    | Mainland China   |
|---|--|
| Summary of UAS legislation and regulations in force | <p>There are (interim) regulations and requirements for operation with civil UAS in China. These regulations cover the pilot/observer (license, training, exam), the information regarding the UAS and its operation or activity, the requirement for the UAS Cloud (U-Cloud) data service, and the operation of UAS in its (separated) air space specified within the civil air space. AC-91-FS-2015-31 is an advisory document which applies to the operation of light and small UAS, in low air space and with low speed. Radio control model aircraft and indoor UAS operation are not applicable. The UAS operation conditions and situations in which UAS pilot must concern are specified. This include clear language used in the communication between pilot, operator and observer, flight preparation, congested area for operation, data link and storage of relevant flight data. MD-TM-2016-004 document, management directive "Civil UAS ATM method", applies to UAS operation within civil air space with the following conditions:</p> <ul style="list-style-type: none"> <li>1) outside airport clearance area</li> <li>2) UAS with TOW less than or equal to 7 kg</li> <li>3) within VLOS (120m height, 500m distance)</li> <li>4) daylight condition</li> <li>5) speed not more than 120 km/h</li> <li>6) compliance with civil UAS air worthiness requirements</li> <li>7) pilot relevant certification requirement</li> <li>8) completion of pre-flight check</li> <li>9) ground crew, facility, environment safety and society must not be affected adversely</li> <li>10) operator must comply with the conditions mentioned above for assurance of a sustained flight activity.</li> </ul> <p>Such operations need to be assessed. The assessment includes, but is not limited to: UAS system information, Information and certificate/license for pilot and observer, operator basic info, UAS flying capabilities, UAS flight plan, air space protection measure, UAS subsystems, emergency planning and risk management measures.</p> <p>Pilots of UAS heavier than 250 g have to register e.g. weight, maximum altitude, and place of manufacture with the authorities, before being allowed to fly.</p> <p>A new airworthiness regulation for UAS above 250 g is under consideration. For the UAS in this weight category (above 250 gr), they are divided into 3 groups and for each group, limitations in flight operation and conditions are set:</p> <ul style="list-style-type: none"> <li>1) special/specific - 1a) entertainment/recreational use; 1b) professional</li> <li>2) limited</li> <li>3) standard</li> </ul> <p><i>Provisions on Administration of the Real-name Registration of Civil Unmanned Aircraft</i></p> <p>The present Provisions on the Administration are formulated for the administration of the civil unmanned aircrafts (hereinafter referred to as "civil UAVs") and implementing real-name registration of the owners of civil UAVs. These Provisions on the Administration shall be applicable to the civil UAVs with the maximum weight of 250 g or more within the territory of the People's Republic of China. The owners of the civil UAVs are required to conduct real-name registration. If, after August 31, 2017, the owner of a civil UAV does not conduct real-name registration or use the registration label under these Provisions, it shall be deemed illegal as in violation of the laws and regulations, the owner's use of a UAV shall be affected, and the competent supervision department shall impose penalties under relevant provisions. In the document (AP-45-AA-2017-03), responsibilities are stated for the following parties:</p> <ul style="list-style-type: none"> <li>• CAAC – (1) set up the real-name registration of civil UAS; and (2) manage the real-name registration system</li> <li>• UAS manufacturer – (1) specify the UAS name, type, model, weight, type of product,</li> </ul> |

|   |   |
|---|---|
|   | <p>UAS buyer and mobile phone information etc; (2) make notice to buyer about the real-name registration and warn of the danger of no real-name registration; (3) and provide (special) printer paper in the package for the UAS owner to print out UAS registration sticker.</p> <ul style="list-style-type: none"> <li>• UAS owner – (1) registrate, according the rule no. 3.2 in the provisions; (2) put sticker on the UAS according to rule 3.4 ; and (3) renew the the UAS information when (one or more) situations mentioned in 3.5 (in the provisions) occur.</li> </ul> <p>The real-name registration takes place in the webpage: <a href="https://uas.caac.gov.cn">https://uas.caac.gov.cn</a><br/> Relevant information of the manufacturer and owner must be provided, as specified.<br/> Registration of UAS must be renewed when:</p> <ul style="list-style-type: none"> <li>• UAS is sold, changed from owner, damaged, written-off, lost or stolen etc. The UAS owner must timely cancel the UAS information in the ‘real-name registration system’</li> <li>• If the ownership of UAS is changed, the new owner must (re-)register in the system in compliance with this provision.</li> </ul> |
| <b>Non-legislative regulations and enforcement measures</b> | None found  |
| <b>Exemptions for different types of users</b>              | None found  |
| <b>Applied (weight) categories</b>                          | 1) micro/mini UAS - empty aircraft weight no more than 7 kg<br>2) light UAS - 7kg < empty aircraft weight < or = 116 kg, cruise speed no more than 100 km/h, climb limit 3000m<br>3) small UAS - empty aircraft weight < or = 5700 kg, with the exemption of micro/mini and light UAS types<br>4) large UAS - empty aircraft weight larger than 5700 kg.  |
| <b>Main source(s)</b>                                       | <a href="https://uas.caac.gov.cn/login/download/file/1">https://uas.caac.gov.cn/login/download/file/1</a><br>MD-TM-2016-004, issue date 21 Sep 2016<br>AC-91-FS-2015-31, issue date 29 Dec 2015<br>AC-61-FS-2013-20, issue date 18 Nov 2013<br>AP-45-AA-2017-03, date of issue: 16 May 2017   |

## Appendix A.3 Europe

| Country / region  | Europe  |
|---|---|
| <b>Summary of UAS legislation and regulations in force</b>  | <p>Regulation (EC) No 216/2008 mandates EASA to regulate Unmanned Aircraft Systems (UAS) and in particular Remotely Piloted Aircraft Systems (RPAS), when used for civil applications and with an operating mass of 150 Kg or more. For these types of UAS no specific regulation is published. Although UAS under 150 kg are currently NOT a mandate for EASA, the Agency published a Technical Opinion (Opinion of a technical nature) in December 2015. This includes 27 concrete proposals for a regulatory framework for all unmanned aircraft (UA) which is operation centric, proportionate, risk- and performance-based. It establishes three categories with different safety requirements, proportionate to the risk: 'Open' category, 'Specific' category, and 'Certified' category.</p> <p>EASA then issued a follow-up Notice of Proposed Amendment in 2017 (NPA 2017-05) to create a new regulation, defining the measures to mitigate the risk of operations in:</p> <ul style="list-style-type: none"> <li>- the open category through a combination of limitations, operational rules, requirements for the competence of the remote pilot, as well as technical requirements for the UAS;</li> <li>- the specific category through a system including a risk assessment conducted by the operator before starting an operation, or the operator complying with a standard scenario, or the operator holding a certificate with privileges.</li> </ul> <p>Sub-NPA 2017-05 (A) contains the explanatory note and the proposed draft rules, which were made available for consultation until 15/09/2017.</p> <p>These draft rules are subject to potential further change and decision making, before the actual Regulation's publication in the Official Journal of the European Union takes place.</p> |
| <b>Non-legislative regulations and enforcement measures</b> | to be applied in accordance with COMMISSION IMPLEMENTING REGULATION (EU) No 646/2012 of 16 July 2012 laying down detailed rules on fines and periodic penalty payments pursuant to Regulation (EC) No 216/2008 of the European Parliament and of the Council  |
| <b>Exemptions for different types of users</b>              | No, the rules are applied irrespectively of the purposes (commercial or recreational) of the flights.   |
| <b>Applied (weight) categories</b>                          | <p>Current:</p> <ul style="list-style-type: none"> <li>&lt;150kg</li> <li>&gt;150kg</li> </ul> <p>Envisioned:</p> <ul style="list-style-type: none"> <li>&lt;250g</li> <li>&lt;25kg</li> <li>&gt;25kg</li> </ul>  |
| <b>Main source(s)</b>                                       | <a href="https://www.easa.europa.eu/easa-and-you/civil-UAS-rpas">https://www.easa.europa.eu/easa-and-you/civil-UAS-rpas</a>   |

## Appendix A.4 The Netherlands

| Country / region  | The Netherlands  |
|---|--|
| <b>Summary of UAS legislation and regulations in force</b>  | <p>Professional UAS operations are regulated in the Netherlands under the 'regeling op afstand bestuurde luchtvaartuigen'. These operations require for the organisation operating the UAS an RPAS Operator Certificate (ROC), for the pilot a Remotely Piloted Aircraft License (RPA-L), and the RPAS needs to be registered in the national civil aviation registry, obtain a Special certificate of airworthiness (S-COA), and shall be insured for legal liability. Once this is assured, operations may be performed:</p> <ul style="list-style-type: none"> <li>• In uncontrolled airspace</li> <li>• Within the Uniform Daylight period only</li> <li>• Within Visual Line of Sight (VLOS) up to a maximum of 500m</li> <li>• Not above 120m (400ft)</li> <li>• At least 150m horizontally separated from crowds and populated areas (note that this distance will be reduced significantly (to 20-50m) in the near future).</li> <li>• At least 50m horizontally separated from all other objects except those that are subject to the UAS operation (such as a crane to be inspected).</li> <li>• Flights within an aerodrome control zone are (limited) possible after obtaining special approvals from the aviation authority and local air traffic control.</li> </ul> <p>For professional operations with a UAS of maximum 4kg only an ROC-light can be applied for requiring only a pilot theoretical examination or equivalent manned pilot or ATC license. Under an ROC light operating approval a UAS may be operated up to a distance of 100m, height of 50m and maintaining 50m separation from objects and people.</p> |
| <b>Non-legislative regulations and enforcement measures</b> | If the rules are violated, the UA operator or pilot is liable for a fine (amounts vary based on involved hazards and repeatability) or seizure of the UAS. Repeated offences may be penalized with jail time.  |
| <b>Exemptions for different types of users</b>              | Yes, professional (including non-commercial) and recreational. Professional operators can obtain waivers to operate above 120m, within 50m of an object part of the aerial work and/or within a CTR.   |
| <b>Applied (weight) categories</b>                          | 0-1 kg<br>0-4 Kg<br>0-25 kg<br>>25-150kg   |
| <b>Main source(s)</b>                                       | <a href="https://www.ilent.nl/onderwerpen/transport/luchtvaart/UASvliegers/">https://www.ilent.nl/onderwerpen/transport/luchtvaart/UASvliegers/</a> (in Dutch)   |

## Appendix A.5 Switzerland

| Country / region  | Switzerland  |
|---|--|
| <b>Summary of UAS legislation and regulations in force</b>  | <p>Up to a weight of 30 kg the UAS can basically be operated without a special permission under the condition that the pilot has at anytime eye contact with the flying object. Furthermore UAS are not allowed to fly above gatherings of people (&gt;2000 persons). In certain exceptional cases permits may be granted for such operations. In order to be able to grant a permit for the operation of a UAS above a gathering of people or without direct eye contact, it first has to carry out a comprehensive safety assessment of the system. The UAS's degree of reliability has to be tested in accordance with the applicable civil aviation directives and standards. The most important safety precautions that have to be taken are as follows:</p> <ul style="list-style-type: none"> <li>- In the event of a technical defect, the system must be able to prevent the UAS from falling out of control and injuring or killing people.</li> <li>- In the event of loss of contact with the remote control device (data link or control link), functions must be activated automatically that ensure that the UAS cannot endanger third parties either on the ground or in the air.</li> </ul> |
| <b>Non-legislative regulations and enforcement measures</b> | None found   |
| <b>Exemptions for different types of users</b>              | No   |
| <b>Applied (weight) categories</b>                          | < 30 kg<br>> 30 kg   |
| <b>Main source(s)</b>                                       | <a href="https://www.bazl.admin.ch/bazl/en/home/good-to-know/UAS-and-aircraft-models.html">https://www.bazl.admin.ch/bazl/en/home/good-to-know/UAS-and-aircraft-models.html</a>  |

## Appendix A.6 Germany

| Country / region  | Germany  |
|---|--|
| <b>Summary of UAS legislation and regulations in force</b>  | <p>In Germany, the civil operation of Remotely Piloted Aircraft Systems (RPAS) in principle requires permission of the authorities. RPAS may be operated in Germany if the maximum weight does not exceed 25kg and the RPAS is operated in the visual line of sight of the operator. To qualify as the visual line of sight, the operator must have an unaided view of the unmanned aircraft. Optical instruments (e.g. binoculars) are not allowed. The individual civil aviation authorities of the German Federal States are responsible for granting permission for the operation of RPAS in the visual line of sight. It is the responsibility of these authorities to define additional requirements (e.g. not flying over populated areas) for the permission to operate. For example there are two types of permissions: a) General permission to fly unmanned aerial systems without an internal combustion engine and with a total mass not exceeding 5 kg. This permission shall be granted for a maximum period of two years. b) Granting specific permission to fly unmanned aerial systems: on a case-by-case basis limited to time and place.</p> <p>Additionally, RPAS weighing more than 25kg, or those operated outside the visual line of sight may be operated in segregated airspace and in an aerodrome traffic circuit if the following requirements are met. These flights require an additional permit from the responsible Federal State authorities. Additionally, permission must be granted by the aerodrome operators and/or the authority responsible for the segregated airspace (e.g. military authorities). As RPAS flights are generally prohibited in Germany, it has not yet been necessary to develop regulations for certification and type design. The Ministry of Transport in Germany and the individual Federal States will coordinate further procedures with the aim to assure that common rules for operating RPAS apply throughout German airspace.</p> |
| <b>Non-legislative regulations and enforcement measures</b> | None found   |
| <b>Exemptions for different types of users</b>              | <p>Yes, Sport or recreational and others.</p> <p>The German law defines RPAS as unmanned aircraft, which are not operated for the purpose of sport or recreational activity.</p>   |
| <b>Applied (weight) categories</b>                          | <p>&lt; 5 kg (without internal combustion engine)</p> <p>&lt;25 kg</p> <p>&gt;25kg</p>   |
| <b>Main source(s)</b>                                       | legal conditions in germany.pdf  |

## Appendix A.7 Singapore

| Country / region  | Singapore   |
|---|---|
| <b>Summary of UAS legislation and regulations in force</b>  | <p>The main features of the framework are as follows:</p> <ul style="list-style-type: none"> <li>(a) Permit system: While flying UAS for hobby does not need permit under normal circumstances, business usage and UAS with weight over 7 kg require two separate permits (an operator permit and an activity permit).</li> <li>(b) No-UAS zone: UAS are not allowed in some 70 security sensitive areas (e.g. military camps, prisons and power stations) which are clearly marked in a multi-purpose online map accessible to the public. UAS are also banned over special event areas declared by the Ministry of Home Affairs under the Public Order Act.</li> <li>(c) Enforcement power: Under the amended Public Order Act, it is a criminal offence for a UAS to interfere with or disrupt the conduct of an activity associated with a special event, whether in or outside the event area.</li> <li>(d) Extra permit requirement if: <ul style="list-style-type: none"> <li>(a) There is discharging or dropping of substances/items from the unmanned aircraft.</li> <li>(b) The radio frequencies and power limits used for operating the unmanned aircraft do not comply with IDA's guidelines on radio frequencies and power limits for short range devices.</li> </ul> </li> </ul> <p>Civil UAVs shall not weigh more than 7kg and are prohibited from carrying dangerous materials including weapons, bio-chemical or radioactive material. A list of protected areas is in the Air Navigation (Protected Areas) Order 2015. The list of restricted areas and danger areas is in the Aeronautical Information Publication Singapore.</p> |
| <b>Non-legislative regulations and enforcement measures</b> | persons found guilty of operating their UAS within 5 km of aerodromes or at heights greater than 200 ft without a permit will be fined up to \$10,000 and up to \$20,000 for subsequent convictions. UAS operators found guilty of flying UAS within protected areas without a permit will be fined up to \$20,000 and/or jailed up to 1 year. If found guilty of taking photos or videos of protected areas without a permit, the UAS operator – and the camera operator, if the UAS operator is not the one operating the camera – will be fined up to \$20,000 and/or jailed for up to 1 year. Persons found guilty of flying their UAS in restricted areas and danger areas without a permit will be fined up to \$10,000 and up to \$20,000 for subsequent convictions.  |
| <b>Exemptions for different types of users</b>              | An extra permit requirement may allow: discharging or dropping of substances/items from the unmanned aircraft. (b) Use of radio frequencies and power limits for operating the unmanned aircraft, which do not comply with IDA's guidelines on radio frequencies and power limits for short range devices.  |
| <b>Applied (weight) categories</b>                          | A weight limit of 7 kg is used.   |
| <b>Main source(s)</b>                                       | Unmanned Aircraft (Public Safety and Security) Act 2015 (to amend the Air Navigation Act (Chapter 6 of the 2014 Revised Edition) and the Public Order Act (Chapter 257A of the 2012 Revised Edition) to regulate the operation of unmanned aircraft in Singapore in the interests of public safety and security).   |

## Appendix A.8 United Kingdom

| Country / region  | United Kingdom  |
|---|---|
| <b>Summary of UAS legislation and regulations in force</b>  | <p>Small unmanned aircraft are subject to safety rules, which are underpinned by UK law. These apply to both recreational and professional (aerial work) use. There are some specific additional steps that must be taken if a UAS is being flown for ‘aerial work’. These rules have been established to provide a safe environment in which small UAS can be flown without coming into conflict with manned aircraft and without risk to other people or properties. Operational limitations are summarized in the UAS code:</p> <ol style="list-style-type: none"> <li>1. Always keep your UAS in sight (a General Exemption E 4457 (dated 28 April 2017) to Air Navigation Order (ANO) 2016 provides an alleviation if certain criteria are met);</li> <li>2. Stay below 400ft;</li> <li>3. Follow the manufacturer’s instructions;</li> <li>4. Keep the right distances from people and property (people and properties 50m, crowds and built up areas 150m);</li> <li>5. Legal responsibility lies with the pilot, failure to fly responsibly could result in criminal prosecution;</li> <li>6. Stay well away from aircraft, airports and airfields.</li> </ol> <p>One must be in possession of a Permission issued by the CAA before conducting any aerial work. To get this Permission, one will need to be at least 18 years of age, demonstrate a sufficient understanding of aviation theory (airmanship, airspace, aviation law and good flying practice), pass a practical flight assessment (flight test), develop basic procedures for conducting the type of flights and set these out in an Operations Manual.</p> <p>If small unmanned aircraft or UAS are to be used outside of the operating limits set out in the Air Navigation Order (including flying over congested areas or within 50m of a building), a permission from the CAA is needed, even for non-commercial activities.</p> <p>Small Unmanned Aircraft – First Person View (FPV) Flying: the Civil Aviation Authority, in exercise of its powers under article 266 of the Air Navigation Order 2016 ('the Order'), exempts any person in charge of a Small Unmanned Aircraft (SUA) from the requirement at article 94(3) of the Order to ensure that direct unaided visual contact is maintained with the aircraft sufficient to monitor its flight path in relation to other aircraft, persons, vehicles, vessels and structures for the purpose of avoiding collisions.</p> <p>Article 95 of the Order states that, if you wish to fly your camera fitted UAS within 150m of either a congested area<sup>21</sup> or an organised open air crowd or more than 1000 persons (such as a sporting event or concert) and/or within 50m of people or properties/objects that are not under your control (e.g. a person, vehicle, building or structure) then you will need to obtain a Permission from the CAA in order to do so legally.</p> |
| <b>Non-legislative regulations and enforcement measures</b> | When a UAS endangers the safety of an aircraft it is a criminal offence with a maximum of 5 years in prison   |
| <b>Exemptions for different types of users</b>              | Yes, aerial work and recreational. For aerial work, special permissions need to be obtained   |
| <b>Applied (weight) categories</b>                          | 0-20 kg<br>>20-150 kg<br>>150kg   |
| <b>Main source(s)</b>                                       | <a href="https://www.caa.co.uk/Consumers/Model-aircraft-and-UAS/Flying-UAS/">https://www.caa.co.uk/Consumers/Model-aircraft-and-UAS/Flying-UAS/</a><br><a href="https://publicapps.caa.co.uk/docs/33/1226.pdf">https://publicapps.caa.co.uk/docs/33/1226.pdf</a>  |

<sup>21</sup> The definition of a congested area in relation to a city, town or settlement means: any area which is substantially used for residential, industrial, commercial or recreational purposes. As a general rule, unless the UAS pilot has permission from the CAA, he or she should not be flying a camera equipped within 150 m of a ‘congested area’ (e.g. town or city) or at a public event. To obtain such permission, the UAS pilot has to e.g. demonstrate certain competences and capabilities.

## Appendix A.9 United States

| Country / region  | United States  |
|---|--|
| <b>Summary of UAS legislation and regulations in force</b>  | <p>A UA may be operated by a pilot of at least 16 years old that have passed an initial aeronautical knowledge test at an FAA-approved knowledge testing center, is vetted by the Transportation Safety Administration (TSA), with a registered aircraft weighing less than 55lbs and obeying the following Operating Rules:</p> <ul style="list-style-type: none"> <li>•Class G airspace*</li> <li>•Must keep the aircraft in sight (visual line-of-sight)*</li> <li>•Must fly under 400 feet*</li> <li>•Must fly during the day*</li> <li>•Must fly at or below 100 mph*</li> <li>•Must yield right of way to manned aircraft*</li> <li>•Must NOT fly over people*</li> <li>•Must NOT fly from a moving vehicle*</li> </ul> <p>* All of these rules are subject to waiver</p> <p>The small UAS rule (14 CFR part 107) includes the option to apply for a certificate of waiver, which allows for a small UAS operation to deviate from certain operating rules if the FAA finds that the proposed operation can be performed safely.</p> <p>For recreational use of UAS, FAA requires registration and marking requirements for small unmanned aircraft weighing more than 0.55 pounds (250 g) and less than 55 pounds (approximately 25 kg) including payloads such as on-board cameras<sup>22</sup>. This requirement applies to all (unmanned) aircraft, including model aircraft. Owners may register through a web-based system at <a href="http://www.faa.gov/uas/registration">www.faa.gov/uas/registration</a>. Upon completion of the registration, a Certificate of Aircraft Registration/Proof of Ownership with a unique identification number for the UAS owner, which must be marked on the UA, is provided.</p> |
| <b>Non-legislative regulations and enforcement measures</b> | <p>Failure to register an unmanned aircraft may result in regulatory and criminal penalties. The FAA may assess civil penalties up to \$27,500. Criminal penalties include fines of up to \$250,000 and/or imprisonment for up to three years.</p> <p>There is no one-size-fits-all enforcement action for violations. All aspects of a violation will be considered, along with mitigating and aggravating circumstances surrounding the violation. In general, the FAA will attempt to educate operators who fail to comply with registration requirements. However, fines will remain an option when egregious circumstances are present.</p>   |
| <b>Exemptions for different types of users</b>              | <p>Yes, professional (including non-commercial) and recreational.</p> <p>For recreational purposes the operating rules apply as guideline with Public Law 112-95, Chapter 336 – Special Rule for Model Aircraft FAA Interpretation of the Special Rule for Model Aircraft as regulatory basis</p>  |
| <b>Applied (weight) categories</b>                          | <p>&lt; 0.55 lbs (no registration required)</p> <p>&lt; 55 lbs (regulated under 14 CFR part 107)</p> <p>&gt; 55 lbs (operators will need to use the existing Chapter 333 exemption process.)</p>   |
| <b>Main source(s)</b>                                       | <a href="https://www.faa.gov/uas/">https://www.faa.gov/uas/</a>  |

<sup>22</sup> In May 2017, the federal court in Washington D.C. ruled that the FAA's UAS registration rules were in violation of FAA's Modernization and Reform Act. The latter prohibited the FAA from passing any rules on the operation of model aircraft ( rules that restrict how non-commercial hobbyist UAS operators fly). Now, if a person buys a new UAS to fly for fun, they no longer have to register that aircraft with the FAA. But if flying for commercial purposes, UAS buyers still need to register.

## Appendix A.10 Japan

| Country / region  | Japan   |
|---|---|
| <b>Summary of UAS legislation and regulations in force</b>  | <p>Any person who intends to operate an UA in airspaces around airports, above densely inhabited districts and/or above 150m AGL is required to obtain permission. In other airspace no permission is required. In general the following operational conditions apply:</p> <ul style="list-style-type: none"> <li>(i) Operation of UAs in the daytime.</li> <li>(ii) Operation of UAs within Visual Line of Sight (VLOS).</li> <li>(iii) Maintenance of 30m operating distance between UAs and persons or properties on the ground/ water surface.</li> <li>(iv) Do not operate UAs over event sites where many people gather.</li> <li>(v) Do not transport hazardous materials such as explosives by UA.</li> <li>(vi) Do not drop any objects from UAs.</li> </ul> <p>These limitations are not applied to flights for search and rescue operations by public organizations in case of accidents and disasters.</p> <p>Additional standards for Flights above Densely Inhabited Districts, night time and BVLOS apply.</p> |
| <b>Non-legislative regulations and enforcement measures</b> | If the rules are violated, the UA operator is liable for a fine of up to 500,000 yen.   |
| <b>Exemptions for different types of users</b>              | No, the rules are applied irrespectively of the purposes (commercial or recreational) of the flights.   |
| <b>Applied (weight) categories</b>                          | <200 gram (unregulated)<br>>200gram   |
| <b>Main source(s)</b>                                       | "Civil Aeronautics Act", as amended by Act No. 67 of 2015 in effect from December 10.   |

## Appendix A.11 Macau SAR

| Country / region  | Macau SAR   |
|---|---|
| <b>Summary of UAS legislation and regulations in force</b>  | <p>In accordance with the relevant Macau SAR's legislation, namely Article 6 of Portaria No. 233/95/M of 14 August which has been revised by Chief Executive's Despacho No. 295/2010, a resident or an organization who wishes to carry out a flying activity in Macau SAR must get the written permission from the Civil Aviation Authority.</p> <p>The flying activities include performing an organized release of latex balloons; flying a captive balloon, a kite, a hot air balloon, a lantern, a model aircraft or an unmanned aerial vehicle which is over 7 kg.</p> <p>Restrictions on UAS operations in Macau SAR air traffic control zone is regulated in accordance with the Air Navigation Regulation of Macau SAR (Chapter 67).</p> <p>1. A person shall not operate an UA to fly, at any height, within the Macau SAR air traffic control zone, unless the operation is performed indoors or the operation is performed with the authorisation in writing of the CAA.</p> <p>2. All UA weighing more than 250 g must be labelled with the owner's name and phone number</p> <p>3. A person may operate an UA under the following conditions:</p> <ul style="list-style-type: none"> <li>a) UA weighs 7 kg or less;</li> <li>b) UA flies no more than 30m (or 100ft) height above the surface;</li> <li>c) During day time;</li> <li>d) UA is not carrying dangerous substances, weapons, fireworks, chemical or biological agent or toxin and any radioactive material or substance;</li> <li>e) UA is not discharging any gas, liquid or solid (substance);</li> <li>f) UA is not towing other object;</li> <li>g) UA is not flying within 100 m of a gathering of 100 persons or more;</li> <li>h) operator on-site is within 100 m and with direct control of the UA;</li> <li>i) UA operation under VLOS;</li> <li>j) operator is reasonably satisfied that the flight can safely be made.</li> </ul> <p>4. UA operation is prohibited at any height over any part of a protected area, including:</p> <ul style="list-style-type: none"> <li>a) The airspace within 1000 m of any aerodrome or landing location, and the aircraft flight path area</li> <li>b) The airspace within 50 m of a number of specific buildings or locations, including the Macau SAR Government HQR, Legislative Assembly Building, the Court of Final Appeal Building, etc.</li> <li>c) Area over which CAA has restricted or prohibited flying in accordance with Chapter 66 of the Air Navigation Regulation of Macau SAR.</li> </ul> |
| <b>Non-legislative regulations and enforcement measures</b> | In accordance with Provision 16 of Decree Law No. 52/94/M of 7 November, anyone who performs a flying activity in the protection area as set forth in the aeronautical restrictions and does not comply with the above requirements will be liable to a fine of MOP2,000 to MOP20,000 imposed by AACM.  |
| <b>Exemptions for different types of users</b>              | No, the rules are applied irrespectively of the purposes (commercial or recreational) of the flights.   |
| <b>Applied (weight) categories</b>                          | > 250g<br>≤ 7kg   |
| <b>Main source(s)</b>                                       | <a href="https://www.aacm.gov.mo/fly_activity.php?id=103">https://www.aacm.gov.mo/fly_activity.php?id=103</a>   |

## Appendix A.12 South Korea

| Country / region  | South Korea  |
|---|--|
| <b>Summary of UAS legislation and regulations in force</b>  | <p>According to the “Aviation Safety Act”, nr. 14551, the following operational conditions apply:</p> <ul style="list-style-type: none"> <li>(1) Report to Ministry of Land, Infrastructure and Transport (MOLIT) 7 days prior to the operation (art. 122).</li> <li>(2) UAS operator has to be accredited by the MOLIT (art. 125).</li> <li>(3) Any person who intends to operate an UA in airspaces around airports within 9.3 km, above no UAS zone (North-Seoul, DMZ and nuclear power facilities) and/or above 150m AGL is required to obtain permission. In other airspace no permission is required.</li> <li>(4) Do not drop any objects from UAs which may harm human life or properties.</li> <li>(5) Do not operate UAs over event sites where many people gather.</li> <li>(6) Operation of UAs within Visual Line of Sight (VLOS).</li> <li>(7) Operation of UAs in the daytime.</li> <li>(8) Aerial photography only allowed after registration to the MOLIT.</li> <li>(9) Operation of UAS's allowed around the clouds according to the following classification:<br/>Above 10000 ft: Airspace class B,C,D,E,F,G, keep distance of the clouds 1500m horizontally and 300m vertically,<br/>Between 3000 ft 10000 ft or 1000 ft above an obstacle: Airspace class B,C,D,E,F,G, keep distance of the clouds 1500m horizontally and 300m vertically,<br/>Below 3000 ft or below 1000 ft above an obstacle: Airspace class B,C,D,E, keep distance of the clouds 1500m horizontally and 300m vertically,<br/>Below 3000 ft or below 1000 ft above an obstacle: Airspace class F,G, keep the aircraft out of the vicinity of the clouds</li> </ul> |
| <b>Non-legislative regulations and enforcement measures</b> | <p>Failure to register an unmanned aircraft may result in regulatory and criminal penalties. The MOLIT may assess civil penalties up to 10 million Korean Won or imprisonment up to one year.</p> <p>Operating UAV without proper clearance may result in penalty of max. 5 mil korean Won.</p> <p>Violation of Airspace may result in penalty of max. 2 mil Korean Won</p>  |
| <b>Exemptions for different types of users</b>              | <p>Military UAS's are exempted.</p> <p>UAS's for R&amp;D and test purpose may be exempted for limitations</p>  |
| <b>Applied (weight) categories</b>                          | <p>&lt; 25 kg take-off weight (no registration required),<br/>&lt; 150 kg aircraft weight excl. fuel and payload (registration and certification required)</p>   |
| <b>Main source(s)</b>                                       | <a href="http://www.law.go.kr/lsc.do?menuId=0&amp;p1=&amp;subMenu=1&amp;nwYn=1&amp;chapter=&amp;tabNo=&amp;query=%ED%95%AD%EA%B3%B5%EC%95%88%EC%A0%84%EB%B2%95#undefined">http://www.law.go.kr/lsc.do?menuId=0&amp;p1=&amp;subMenu=1&amp;nwYn=1&amp;chapter=&amp;tabNo=&amp;query=%ED%95%AD%EA%B3%B5%EC%95%88%EC%A0%84%EB%B2%95#undefined</a>  |

## Appendix B Overview operations standards and requirements

|   |   | <b>UAS Category:</b>   | <b>A1</b>   | <b>A2</b>  | <b>B</b>  |
|---|---|--|---|--|---|
| <b>(A) Characteristics</b>                              |   |  |   |  |   |
| i)  | Weight (Max. all up weight)   |  | ≤ 250 g   | 250 g < UAS ≤ 7 kg   | ≤ 25 kg   |
| <b>(B) Registration, identification and geo-fencing</b> |   |  |   |  |   |
| i)  | Registration of UAS and owners  | No   | Yes   | Yes  |   |
| ii)   | Registration of operators (or pilots)   | No   | No  | Yes  |   |
| iii)  | Application to CAD (and “sticker approval”)   | No   | No  | Yes  |   |
| iv)   | Safety risk assessment / safety case  | No   | No  | Yes  |   |
| v)  | Operation Manual (OM) to be approved by CAD (including e.g. organizational structure & responsibilities, operating procedures, flight/planning preparation, pre-flight checks, emergency procedures, training program, incident/ accident reporting procedures, safety risk assessment, maintenance plan, etc.) | No   | No  | No   | Yes   |
| vi)   | Geo-fencing functionality   | No   | No  | No   | Yes (depending on the zone and altitude of operation) |
| vii)  | Electronic capability (e.g. small transponder)  | No   | No  | No   | Yes (depending on the zone and altitude of operation) |
| <b>(C) Operating limitations</b>                        |   |  |   |  |   |
| i)  | Height above ground (AGL)   | < 100 ft   | < 300 ft  | As approved by CAD   |   |
| ii)   | Distance from people / buildings  | > 10 m   | > 50 m (> 30 m during take-off/landing)                                 | As approved by CAD   |   |
| iii)  | Distance from aerodrome   | > 5km  | > 5km   | As approved by CAD   |   |
| iv)   | Distance from operator  | within visual range (VLOS)<br>or < 50 m, whichever is more restrictive | within visual range (VLOS)<br>or < 500 m, whichever is more restrictive | As approved by CAD   |   |
| v)  | Visibility  | > 1 km   | ground visibility > 5 km<br>cloud base > 300 ft                         | ground visibility > 5 km<br>cloud base > maximum altitude of operation |   |
| vi)   | Performance limitation e.g. Speed limit   | 40 km/h  | 80 km/h   | As approved by CAD   |   |
| vii)  | Surface wind limit  | As set by the manufacturer   | As set by the manufacturer  | < 20 knots   |   |

|  | <b>UAS Category:</b>  | <b>A1</b>   | <b>A2</b>  | <b>B</b>   |
|--|---|---|--|--|
| viii)  | Suitable flying site  | In accordance with guidelines and no-fly areas published by CAD       | In accordance with guidelines and no-fly areas published by CAD  | As approved by CAD   |
| ix)  | Other requirement   | CAD's existing operational parameters (e.g. day-time & VLOS ops etc.) | CAD's existing operational parameters (e.g. day-time & VLOS ops etc.)  | As required by CAD   |
| x)   | Additional requirements   | N/A   | <ul style="list-style-type: none"> <li>• Basic training &amp; exam</li> <li>• Pre-flight checklist</li> <li>• Accident/Incident reporting</li> </ul> | <ul style="list-style-type: none"> <li>• Insurance</li> <li>• Sticker indicating period of approval</li> <li>• Operations Manual</li> <li>• Sharing of safety data</li> <li>• Training and exam (similar to PPL) certified by CAD</li> <li>• Airspace Coordination (if necessary)</li> </ul> |
| <b>(D) Safety assurance</b>                        |   |   |  |  |
| i)   | Safety risk assessments of the proposed operations  | No  | No   | Yes  |
| ii)  | Collect safety data, conduct assessment of Safety Performance Indicators (SPIs) and compare with Safety Performance Targets   | No  | No   | Yes  |
| iii)   | Sharing of safety info with CAD regularly (e.g. once every 6 months)  | No  | No   | Yes  |
| iv)  | In-house safety promotion (to enhance operators/pilots' safety awareness)   | No  | No   | Yes  |
| v)   | Report any accidents and serious incidents within 3 calendar days by email to the CAD, using a standard Reporting Form  | No  | Yes  | Yes  |
| <b>(E) Training and licensing of remote pilots</b> |   |   |  |  |
| i)   | Basic training including e.g. the watching of video(s) for instruction, demonstration of sufficient operating skills, and pass a simple exam for a certificate. This exam may e.g. be handled by UAS association(s) and shall be based on learning objectives, which are to be agreed upon with the CAD | No  | Yes  | N/A  |
| ii)  | Advanced training - PPL like training (both theory & practical) and/or examinations for remote pilots through instructors, course organisers and/or examiners approved by CAD.  | No  | No   | Yes  |

Note : Should an operator wish to operate his/her UAS outside the predefined operating parameter, the operator will be required to apply to CAD.

## Appendix C Comparison of Cat A2 operations with existing requirements

|   |  | Existing baseline in HK  | UAS Cat A2   | Justification/reference   |
|---|--|--|--|---|
| <b>(A) Characteristics</b>                              |  |  |  |   |
| ii)   | Weight (Max. all up weight)  | ≤7 kg  | 250 g < UAS ≤ 7 kg   | Upper limit i.e. 7kg is in line with existing practice, and is also used in Singapore, Macau SAR.   |
| <b>(B) Registration, identification and geo-fencing</b> |  |  |  |   |
| viii)   | Registration of UAS owner  | No   | Yes  | USA, UK and China have introduced a registration requirement. ICAO supports registration. Threshold 250g is motivated in Chapter 8  |
| ix)   | Application to CAD (and “sticker approval”)  | Yes (commercial use)<br>No (recreational use)<br>No sticker approval | No   | Existing distinction between recreational and commercial is proposed to be removed.   |
| x)  | Individual risk assessment / safety case   | No (recreational use)<br>Yes (commercial use)                        | No   | Since Cat. A operations have low risk, application to CAD, risk assessments/safety case and Operations Manual are not felt to be necessary.   |
| xi)   | OM to be approved by CAD (including e.g. organizational structure & responsibilities, operating procedures, flight/planning preparation, pre-flight checks, emergency procedures, training program, incident/ accident reporting procedures, safety risk assessment, maintenance plan, etc.) | Yes (commercial use)   | No   |   |
| xii)  | Geo-fencing functionality  | No   | No   | In line with existing practice  |
| xiii)   | Electronic capability (e.g. small transponder)   | No   | No   | In line with existing practice  |
| <b>(C) Operating limitations</b>                        |  |  |  |   |
| xi)   | Altitude (AGL)   | 300 ft   | 300 ft   | In line with existing practice  |
| xii)  | Distance from people / buildings   | > 50 m (> 30 m during take-off/landing)                              | > 50 m (> 30 m during take-off/landing)                              | In line with existing practice  |
| xiii)   | Distance from operator   | within visual range (VLOS)   | < 500 m or within visual range (VLOS), whichever is more restrictive | A distance of 500 m is used in e.g. China and the Netherlands (see Chapter 8). In China, it should be noted that their operational regulations are catered for larger UAS (e.g. those up to |

|  |   | Existing baseline in HK   | UAS Cat A2   | Justification/reference   |
|--|---|---|--|---|
| xiv)   | Visibility  | ground visibility > 5 km<br>cloud base > 300 ft                       | ground visibility > 5 km<br>cloud base > 300 ft  | 150 kg), which are larger than UAS in Hong Kong, which are below 7kg.   |
| xv)  | Speed limit   | N/A   | 80 km/h  | A speed limit is used in e.g. China, USA (see Chapter 8).   |
| xvi)   | Surface wind limit  | 20 knots, unless otherwise specified by manufacturer                  | As set by the manufacturer   | In line with existing practice  |
| xvii)  | Suitable flying site  | As permitted by CAD   | As permitted by CAD  | In line with existing practice  |
| xviii)   | Other requirement   | CAD's existing operational parameters (e.g. day-time & VLOS ops etc.) | CAD's existing operational parameters (e.g. day-time & VLOS ops etc.)                          | In line with existing practice  |
| xix)   | Additional requirements   |   | a) Basic training & exam<br>b) Pre-flight checklist<br>c) Accident/incident reporting by owner | a) and b) for safety reasons. Incidents/accident reporting is already required for non-recreational UAS use in HK.                            |
| <b>(D) Safety assurance</b>                        |   |   |  |   |
| vi)  | Safety risk assessments of the proposed operations  | No (recreational use)<br>Yes (commercial use)                         | No   | Cat A inherently has low risk   |
| vii)   | Collect safety data, conduct assessment of Safety Performance Indicators (SPIs) and compare with Safety Performance Targets   | No  | No   | Cat A inherently has low risk   |
| viii)  | Sharing of safety info with CAD regularly (e.g. once every 6 months)  | No  | No   | Cat A inherently has low risk   |
| ix)  | In-house safety promotion   | No  | No   | Cat A inherently has low risk   |
| x)   | Report any accidents and serious incidents within 3 calendar days by email to the CAD, using a standard Reporting Form  | No (recreational use)<br>Yes (commercial use)                         | Yes  | In line with existing practice for commercial use of UAS  |
| <b>(E) Training and licensing of remote pilots</b> |   |   |  |   |
| iii)   | Basic training e.g. the watching of video(s) for instruction, demonstration of sufficient operating skills, and pass a simple exam for a certificate. This exam may e.g. be handled by UAS association(s) and shall be based on learning objectives, which are to be agreed upon with the CAD | No  | Yes  | This is to ensure that the remote pilots have the basic skills and safety awareness to maintain their UAS within operating limits for Cat. A. |



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