Law Commission
Reforming the law

Aviation autonomy

Consultation Paper

Consultation Paper 261

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26 February 2024

This publication is available at https://lawcom.gov.uk/project/automated-vehicles/

THE LAW COMMISSION – HOW WE CONSULT

About the Law Commission: The Law Commission was set up by section 1 of the Law Commissions Act 1965 for the purpose of promoting the reform of the law. The Law Commissioners are: The Rt Hon Mr Justice Fraser (Chair), Professor Sarah Green, Professor Nicholas Hopkins, Professor Penney Lewis. Nicholas Paines KC was also a Commissioner when this paper was approved for publication. The Chief Executives are Stephanie Hack and Joanne Otterburn.

Topic of this consultation: The Civil Aviation Authority ("CAA"), and the Department for Transport have asked the Law Commission to review the UK's regulatory framework to prepare the UK for autonomy in aviation. This project forms part of, and has been partly funded by, the UK Research and Innovation Future Flight Challenge.

Our focus in this consultation paper is on reforms that will enable autonomous and remotely piloted flight to take place safely, lawfully, and with appropriate legal mechanisms for attributing criminal and civil liability when things go wrong.

Given the possible extent of the project we have been asked to concentrate on three use cases: drones; advanced air mobility; and air traffic management and air navigation services. This consultation paper focuses on drones and advanced air mobility. We aim to publish second consultation concentrating on air traffic management and air navigation services in the last quarter of 2024.

Geographical scope: This consultation paper considers the law of England and Wales.

Availability of materials: The consultation paper is available on our website at https://lawcom.gov.uk/project/aviation-autonomy/. We are committed to providing accessible publications. If you require this consultation paper to be made available in a different format please email:
aviationautonomy@lawcommission.gov.uk.

Comments may be sent:

Using an online form at https://consult.justice.gov.uk/law-commission/aviation-autonomy.

However, we are happy to accept comments in other formats. If you would like a response form in word format, do email us to request one. Please send your response:

By email to aviationautonomy@lawcommission.gov.uk

OR

By post to Aviation Autonomy Team, Law Commission, 1st Floor, Tower, 52 Queen Anne's Gate, London, SW1H 9AG.

If you send your comments by post, it would be helpful if, whenever possible, you could also send them by email.

Duration of the consultation: We invite responses from 26 February to 27 May 2024.

After the consultation: The responses to this consultation will inform the next stages of this project. We aim to produce a final report with recommendations by the end of 2025.

Consultation Principles: The Law Commission follows the Consultation Principles set out by the Cabinet Office, which provide guidance on type and scale of consultation, duration, timing, accessibility and transparency. The Principles are available on the Cabinet Office website at: https://www.gov.uk/government/publications/consultation-principles-guidance.

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ABBREVIATIONS

AAIB: Air Accidents Investigation Branch

AAM: advanced air mobility

ACAS RA: airborne collision avoidance system resolution advisory

ACAS: airborne collision avoidance system

AI: artificial intelligence

AIG: ICAO Accident Investigation Section

AMC: acceptable means of compliance

ANO: Air Navigation Order 2016

ANS: air navigation services

ANSP: air navigation service provider

ATC: air traffic control

ATFM: air traffic flow management

ATM: air traffic management

ATMUAA: Aircraft Traffic Management and Unmanned Aircraft Act

ATS: air traffic services

BCAR: British Civil Airworthiness Requirements

BEIS: Department for Business, Energy and Industry Strategy

BVLOS: beyond visual line of sight

C2 link: command and control link

CAA: Civil Aviation Authority

CAMO: continuous airworthiness management organisation

CAO: combined airworthiness organisation

CAP: Civil Aviation Publication

CHIRP: Confidential Human Factors Incident Reporting Programme

CMU: command and monitoring unit (EASA)

CS: certification specification

DAA: detect and avoid

DfT: Department for Transport

DL: deep learning

DOA: design organisation approval

EASA: European Union Aviation Safety Authority

EUROCONTROL: European Organisation for the Safety of Air Navigation

EUWA: EU Withdrawal Act 2018

eVTOL: electric vertical take-off and landing aircraft

FAA: Federal Aviation Administration

FIR: flight information region

FIS: flight information service

FISO: flight information service officer

GM: guidance material

HOVTL: human-over-the-loop

ICAO: International Civil Aviation Organisation

IFR: instrument flight rules

JARUS: Joint Authorities for Rulemaking on Unmanned Systems

MAA: Military Aviation Authority

ML: machine learning

MOC: means of compliance

MSO: multiple simultaneous operations

MTOM: maximum take-off mass

MVS: multi-vehicle supervisor

NASA: National Aeronautics and Space Administration

NATS: National Air Traffic Services

NERL: NATS (En Route) plc.

PDRA: pre-defined risk assessment

POA: production organisation approval

PtF: permit to fly

RMZ: radio mandatory zone (RMZ)

RPA: remotely piloted aircraft

RPAS: remotely piloted aircraft system

SARPs: standards and recommended practices

SDR: special drawing right

SERA: Standardised European Rules of the Air

UAM: urban air mobility

UAS: uncrewed aircraft system

UAV: uncrewed aerial vehicle

UIR: upper information region

UK FIS: UK Flight Information Services

UKAB: UK Airprox Board

UKRI: UK Research and Innovation

UTC: Coordinated Universal Time

UTM: uncrewed aircraft system traffic management

VFR: visual flight rules

VLOS: visual line of sight

VMC: visual meteorological conditions

VTOL: vertical take-off and landing aircraft

Glossary

Advanced air mobility (AAM): a generic term for a collection of new and emerging technologies intended for use for aviation transportation. It includes both crewed and uncrewed aircraft, used both in urban areas and for regional transport. In the context of this project, the term is usually used to refer to VTOL aircraft. **Aircrew:** collective term for cabin crew and flight crew (see below)

Airworthiness: defined in Annex 8 to the Chicago Convention as "the status of an aircraft, engine, propeller or part when it conforms to its approved design and is in a condition for safe operation".

ATM/ANS: air traffic management and air navigation services. For an explanation of the contents of these services, see background material available on our website.

Air Navigation Service Provider (ANSP): provider of air navigation services, including air traffic services.

Assimilated law. From 1 January 2024, this is the term used to refer to what was previously known as "retained EU law". This is domestic law copied from EU law as it stood on the date of the UK's withdrawal from the European Union, 31 January 2020. Since withdrawal, changes to EU law do not impact assimilated law, nor do changes made to assimilated law impact EU Law. (see below).

Autonomous aircraft: aircraft where there is no human pilot (or, if there is, where the pilot is not able to intervene during the normal course of the aircraft's operation).

C2 (command and control) link: data link between a remotely piloted aircraft and ground station.

CAA: Civil Aviation Authority. This is the UK's regulatory body for civil aviation.

CAP: civil aviation publication. Documents published by the CAA, containing guidance, information or instructions relating to civil aviation. Each CAP is assigned a number, such as CAP2530: Airspace Fundamentals and the Future of Flight.

Cabin crew: members of the aircrew who attend to passengers.

Chicago Convention: Convention on International Civil Aviation. Sets out the core principles in relation to civil aviation.

Civil aviation: private, commercial and diplomatic or state flights transporting cargo and passengers.

Commercial air transport: operations conducted for the purpose of transporting passengers, cargo or mail for remuneration or other valuable consideration.

Controlled airspace: airspace classes A-E. In controlled airspace, air traffic services are provided by air traffic controllers and aircraft and its pilot must be of a certain standard.

Permission to enter controlled airspace must be acquired from air traffic control and air traffic control instructions must be followed.

Drone: used generally to describe smaller uncrewed aircraft which are unoccupied and can be remotely piloted or autonomous.

Digital Flight Rules (DFR): a set of flight rules proposed by NASA in 2020 to accommodate and facilitate new advances in aviation.

EASA: European Union Aviation Safety Agency. An agency of the EU responsible for civil aviation safety amongst EU member states.

FAA: Federal Aviation Administration. This is the regulatory body of civil aviation in the United States of America.

Flight crew: any crew member acting as pilot, flight navigator, flight engineer or flight radiotelephony operator. Note that the latter three roles have been made obsolete by technology, with remaining responsibilities falling under the pilot's role.

ICAO: International Civil Aviation Organisation. A UN agency responsible for setting international civil aviation standards. Membership consists of the 193 signatories to the Chicago Convention.

IFR: instrument flight rules. The rules applicable when the pilot flies an aircraft solely by reference to aircraft instruments, rather than by sight.

Joint Authorities for Rulemaking on Unmanned Systems (JARUS): a group of experts with regulatory expertise representing 63 countries, plus EASA and EUROCONTROL. JARUS provides recommendations and guidance material in relation to UAS with the aim of harmonising the regulation of UAS internationally.

Machine learning (ML): a type of AI involving algorithms whose performance can change and improve as they are exposed to data.

Multiple simultaneous operations (MSO): multiple uncrewed aircraft which are under collective control and are in flight simultaneously.

NERL: NATS (En Route) plc. The UK's sole provider of ATM services.

Non-part 21 aircraft: aircraft which falls outside the scope of the UK Basic Regulation and is regulated by the Air Navigation order 2016 and the British Civil Airworthiness Requirements.

Operator: defined for the purposes of the Air Navigation Order 2016 as "in relation to any particular aircraft… the person who at the relevant time has the management of that aircraft."

Part 21 aircraft: aircraft which fall within the scope of the UK Basic Regulation (as set out in Article 2 of that Regulation).

Pilot-in-command: the pilot responsible for the flight and its safe conduct. The pilot-in-command may be the sole pilot or one of several pilots.

Pilot: the person who can manipulate the flight controls of aircraft during flight.

Pre-defined risk assessment (PRDA): template risk assessments which can be used by applicants for repeatable and low risk operations in the specific category.

Remote pilot: the person responsible for operating the flight of an uncrewed aircraft, either manually or, when the uncrewed aircraft flies automatically, by monitoring its course and remaining able to intervene and change its course at any time.

RPA: remotely piloted aircraft. Aircraft where there is a pilot able to intervene during the aircraft's operation, but the pilot is not on board.

RPAS: remotely piloted aircraft system. Remotely piloted aircraft and any associated equipment.

Rules of the air: common rules that aircraft must follow when in flight.

Special Drawing Rights (SDRs): an international currency unit created by the International Monetary Fund and used in international regulations covering mandatory aircraft insurance.

Standards and Recommended Practices (SARPs): technical specifications adopted by ICAO contained within annexes to the Chicago Convention.

UA: uncrewed aircraft. Aircraft with no pilot on board, including remotely piloted and autonomous aircraft systems.

UAS: uncrewed aircraft system. Uncrewed aircraft, together with any associated equipment.

Uncontrolled airspace: Class G airspace. There is no obligation to be in contact with an air traffic controller or flight information service officer and air traffic services may not always be available.

Unoccupied aircraft: aircraft with no people on board at all.

Urban air mobility: used to refer to the transportation of passengers for short distances (less than 100km) in mainly urban environments, using VTOL aircraft.

VFR: visual flight rules. The rules applicable when the pilot relies primarily on sight to fly aircraft.

VTOL: a heavier-than-air aircraft, other than aeroplane or helicopter, capable of performing vertical procedures by means of more than two lift/thrust units and certified for use by one or more occupants.

Assimilated law list

This is a list of the assimilated law referred to in this paper. The full reference adopted is given first, followed by the short form of the title.

LIST OF ASSIMILATED LAW

UK Regulation (EU) 1178/2011 laying down technical requirements and administrative procedures related to civil aviation aircrew.

- UK Regulation (EU) 1178/2011 (the “Aircrew Regulation”).

UK Regulation (EU) 748/2012 laying down implementing rules for the airworthiness and environmental certification of aircraft and related products, parts and appliances, as well as for the certification of design and production organisations.

- UK Regulation (EU) 748/2012 (the “Initial Airworthiness Regulation”).

UK Regulation (EU) 923/2012 laying down the common rules of the air and operational provisions regarding services and procedures in air navigation.

- UK Regulation (EU) 923/2012 on the Standardised European Rules of the Air (“UK SERA”).

UK Regulation (EU) 965/2012 laying down technical requirements and administrative procedures related to air operations.

- UK Regulation (EU) 965/2012 (the “Air Operations Regulation”).

UK Regulation (EU) 376/2014 on the reporting, analysis, and follow-up of occurrences in civil aviation.

- UK Regulation (EU) 376/2014 (the “UK Mandatory Occurrence Reporting Regulation”).

UK Regulation (EU) 1321/2014 on the continuing airworthiness of aircraft and aeronautical products, parts and appliances, and on the approval of organisations and personnel involved in these tasks.

- UK Regulation (EU) 1321/2014 (the “Continuing Airworthiness Regulation”).

UK Regulation (EU) 2015/1018 laying down a list classifying occurrences in civil aviation to be mandatorily reported according to Regulation (EU) No 376/2014.

- UK Regulation (EU) 2015/1018 (the “UK MOR Occurrences Regulation”).

UK Regulation (EU) 2015/640 on additional airworthiness specifications for a given type of operations and amending Regulation (EU) No 965/2012.

- UK Regulation (EU) 2015/640 (the “Additional Airworthiness Specifications Regulation”).

UK Regulation (EU) 2017/373 laying down common requirements for providers of air traffic management/air navigation services and other air traffic management network functions and their oversight.

- UK Regulation (EU) 2017/373 (the “ATM/ANS Implementing Regulation”).

UK Regulation (EU) 2018/1139 on common rules in the field of civil aviation and establishing a European Union Safety Agency.

- UK Regulation (EU) 2018/1139 (the “Basic Regulation”).

UK Regulation (EU) 2019/945 on unmanned aircraft systems and on third-country operators of unmanned aircraft systems.

- UK Regulation (EU) 2019/945 (“UAS Delegated Regulation”).

UK Regulation (EU) 2019/947 on the rules and procedures for the operation of unmanned aircraft.

- UK Regulation (EU) 2019/947 (“UAS Implementing Regulation”).

Chapter 1: Introduction

1.1 The Civil Aviation Authority ("CAA"), and the Department for Transport have asked the Law Commission to review the UK's regulatory framework to prepare the UK for autonomy in aviation. This project forms part of, and has been partly funded by, the UK Research and Innovation Future Flight Challenge.[1]

1.2 This is our second project concerned with automated transport. In 2022 we concluded a four year review into automated vehicles with the Scottish Law Commission.[2] The UK Government has now accepted many of the Law Commissions' recommendations for law reform in that area, and at the time of writing, a Bill which would implement these recommendations is under consideration by the UK Parliament.

1.3 Some of the challenges we faced in that project are similar for aviation. We have been asked to recommend how the law should change to adapt to circumstances that (for the most part) do not yet exist. This means we have had to predict what might happen next. Knowing when to regulate is difficult. Aviation law is currently extensive and very prescriptive. Failing to update these prescriptive standards and regulating too late could therefore prevent innovation and disincentivise investment. Regulating too early risks introducing reforms that do not fit neatly with how the industry will look in decades to come.

1.4 Our focus in this Consultation Paper is on reforms that will enable autonomous and remotely piloted flight to take place safely, lawfully, and with appropriate legal mechanisms for attributing criminal and civil liability when things go wrong.

1.5 We are keen to receive a wide range of responses, from all those who may be affected by highly automated and autonomous flight. We are committed to facilitating open consultation and rely on responses to form our conclusions. Open consultation is particularly important in this area, where fast-moving technology is raising issues that have no direct precedent. The recommendations that we make to the UK Government in our final report will reflect what we have heard in the consultation.

1.6 In some areas, we ask open questions to seek views. In other areas, we make tentative proposals for reform, or say that in our initial view the law is adequate to deal with possible issues. We then ask stakeholders if they agree with our conclusions, so that we can generate focused and critical feedback.

1.7 **We seek responses by 27 May 2024.** For details of how to respond, see page i above.

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1 https://www.ukri.org/what-we-offer/browse-our-areas-of-investment-and-support/future-flight/. All links were last checked in February 2024.

2 Automated Vehicles (2022) Law Com No 404; Scot Law Com No 258.

THE FUTURE FLIGHT CHALLENGE

1.8 The Future Flight Challenge is a collaborative research and development programme funded by industry and the UK Government, delivered by Innovate UK and the Economic and Social Research Council in particular (a part of UK Research and Innovation).The programme aims to build the aviation ecosystem required for the introduction of "electric sub-regional aircraft, advanced air mobility vehicles and drones into the UK".[3] Advanced air mobility is an umbrella term for a collection of new and emerging technologies intended for aviation transportation. The programme has involved working with industry, academia, government and regulators. Our review is therefore part of a package of measures, including industry trials, designed to support the introduction of remotely piloted and autonomous aircraft in the UK, such as vertical take-off and landing aircraft ("VTOLs")[4] and drones.

TERMS OF REFERENCE

1.9 The Law Commission is an independent law reform agency. We work closely with Government departments and other governmental bodies, but conduct our work independently under terms of reference agreed in advance.

1.10 Our terms of reference are set out in full in Appendix 2 and described below.

Autonomous and highly automated flight and remote piloting

1.11 Many functions of a modern aircraft already have many sophisticated automated functions. This review considers further developments, when automation will change or make redundant existing human roles, such as that of the pilot. In this paper when we discuss autonomous flight, we use the existing legal definition: an "autonomous operation" is one during which an uncrewed aircraft operates without a remote pilot being able to intervene.[5] There is no legal definition of "highly automated". We use it to refer to automation of functions beyond what is currently common in aviation, and in particular where this affects roles of humans involved in the system. Examples include drone flight beyond the visual line of sight of a remote pilot, or multiple simultaneous operations, where one remote pilot is in charge of many drones flying at the same time.

1.12 Greater levels of automation will also enable remote piloting which requires less human input. While drones are already remotely piloted, reform of the law is required to allow remotely piloted aircraft to carry passengers (discussed in Chapter 6, VTOLs).

A regulatory framework that is fit for purpose

1.13 We have not been asked whether introducing greater autonomy in aviation is a desirable policy. Instead our focus is on the regulatory framework. We have been asked to review the existing law and identify where there are gaps, uncertainties, or provisions which could prevent the safe deployment of highly automated and

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3 https://www.ukri.org/what-we-do/browse-our-areas-of-investment-and-support/future-flight/.

4 For further discussion of what is meant by "VTOL" in this paper, see the glossary and ch 2, paras 2.36 to 2.40.

5 UK Regulation (EU) 2019/947 on the rules and procedures for the operation of unmanned aircraft, art 2(17).

autonomous systems. Our overall aim is to propose law reform measures which will ensure the legislative and regulatory framework is prepared for future advances in automation and, ultimately, autonomous flight.

1.14 In particular, we have been asked to consider:

(1) where the law allocates responsibilities to a human (for example, a pilot or remote pilot) and the issues that arise where functions are performed by autonomous systems; and

(2) how to allocate civil and criminal responsibility where functions are performed by a system, or shared between a human and a system.

Our use cases

1.15 Given the possible extent of this project, we have been asked to focus on three use cases. These are:

(1) drones (defined for these purposes as remotely piloted, non-passenger carrying vehicles);

(2) advanced air mobility (and in particular VTOLs providing short journeys for up to ten people); and

(3) air traffic management and air navigation services (including communications, navigation and surveillance and aeronautical information services).

1.16 This consultation paper focuses on the first two use cases. The third will be the subject of a second consultation paper, to be published towards the end of 2024.

Areas outside the scope of this review

1.17 Our project is confined to civil aviation. The following topics are out of scope of the review:

(1) defence;

(2) land-use;

(3) labour relations; and

(4) cybersecurity and terrorism.

1.18 We do however touch on some aspects of cybersecurity where they intersect with our examination of existing aviation criminal offences in Chapter 9.

1.19 While it is not the focus of our review, we have had in mind the extent to which the law in this area could benefit from emerging approaches in other transport sectors, for example, the Law Commissions' work on automated vehicles.

A THREE-YEAR REVIEW

1.20 This is a three-year project, which started in September 2022. Our aim is to publish a final report with recommendations for legislation by November 2025.

DEVOLUTION

1.21 Our current assumption is that any new legislation would be enacted at Westminster. However, in accordance with the Sewell Convention, the UK Parliament will not normally legislate for devolved matters without the agreement of the devolved legislatures. Devolved competence in Wales will therefore need to be taken into account.

1.22 The Welsh Parliament, or Senedd Cymru, may pass legislation so long as it does not relate to a matter reserved to the UK Parliament. Aviation, air transport, airports and aerodromes are areas that are reserved. However, there are three exceptions to these reservations, in relation to which the Senedd can legislate.

(1) Financial assistance to providers or proposed providers of air transport services or airport facilities or services.

(2) Strategies by the Welsh Ministers or local or other public authorities about provision of air services.

(3) Regulation of the carriage of animals on aircraft for the purposes of protecting human, animal or plant heath, animal welfare or the environment.[6]

1.23 Our remit does not extend to Scotland or Northern Ireland: we can only make recommendations in respect of England and Wales. However, we acknowledge that the issues relating to autonomy in aviation apply across the UK. We welcome feedback from stakeholders in Scotland and Northern Ireland.

STRUCTURE OF THIS PAPER

1.24 In this chapter, we set out the background to the paper. This includes an overview of aviation law as it exists today, both for uncrewed aircraft and for more traditional forms of aviation. We consider briefly how aviation law has been shaped (and is still being shaped) by international treaties. Finally, we set out key principles that are embodied in the existing law and which inform our review.

1.25 In Chapter 2, we introduce some key concepts and terminology. We consider what definitions are already in the law of automated and autonomous flight, and aircraft that are remotely piloted, and explain our preferred terminology. We also consider other frameworks which have been developed to describe levels of automation within aviation. We have also included a glossary and list of abbreviations at the beginning of the paper.

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6 Government of Wales Act 2006, sch 7A(125).

1.26 Chapter 3 sets out the existing regulatory regime relating to uncrewed aircraft systems (referred to as "unmanned aircraft systems", or "UAS" in the current law).

1.27 Chapter 4 gives an overview of airworthiness and certification in relation to both drones and VTOLs. We consider the existing ways in which regulation ensures that aircraft are safe, and the challenges that new technology poses to those methods.

1.28 Chapter 5 considers the "rules of the air" that currently apply to aircraft. We explore problems in translating these to autonomous operations.

1.29 Chapters 6 and 7 relate specifically to VTOLS (Chapter 6) and drones (Chapter 7), identifying particular legal challenges posed by these use cases. Chapter 6 contains an in-depth analysis of the current role of the pilot of an aircraft, and in particular the duties that a pilot owes to passengers.

1.30 Chapters 8 and 9 are focused on what happens when things go wrong. Chapter 8 gives a broad overview of the various bases of civil liability in relation to our use cases and insurance requirements. We consider here topics such as negligence, but also trespass and various statutory routes for those who suffer damage caused by aircraft (including injury to passengers and damage to people or property on the ground) to claim against those responsible. Chapter 9 considers existing criminal offences in aviation and their application to UAS.

1.31 In Chapter 10, we give some initial consideration to the impact of our proposals, including their equality impact, and seek views on these points from consultees.

1.32 The paper concludes with two Appendices. Appendix 1 gives an overview of air accident investigation and the role of the Air Accident Investigation Branch. The terms of reference of this project can be found at Appendix 2. Some initial work on our third use case, air traffic management and air navigation services, may be found on our website as background material to the project.

PRINCIPLES OF REGULATION

1.33 Aviation is a highly regulated field. When considering how regulation should evolve to respond to highly automated and autonomous forms of aviation, there are a number of principles relevant to its development. These include the CAA's existing regulatory principles, as well as its consumer principles; the current approach taken to allocation of airspace; and aviation safety (including the attitude to investigation of accidents). These are summarised briefly below.

Aviation safety

1.34 Safety in civil aviation is extremely important. Whilst accidents are comparatively rare, they can incur large losses of life. The International Civil Aviation Organisation ("ICAO") reported that in 2021 there were just four fatal accidents worldwide for scheduled commercial air transport. However, these four fatal accidents resulted in 104 fatalities.[7] Accidents are clearly a risk for both passengers and those on the

[7] International Civil Aviation Organisation ("ICAO"), *Safety Report* (2022), table 1, p 14.

ground. Safety is therefore the primary duty of lawmakers, regulators and stakeholders in the aviation system.

1.35 The CAA is generally required to maintain a "high standard of safety".[8] UK Regulation (EU) 2018/1139 (the "Basic Regulation") also cites as its principal objective to "establish and maintain a high uniform level of civil aviation safety in the United Kingdom".[9] To help fulfil this objective, the Secretary of State is required to establish and maintain a State safety programme.[10] This is done in consultation with the CAA and other stakeholders. Annex 19 to the Chicago Convention 1944 (the "Chicago Convention") requires states to establish an "acceptable level of safety performance", which is included with the safety programme.[11]

1.36 The UK's acceptable level of safety performance is:

> No accidents involving commercial air transport that result in serious injuries or fatalities. No serious injuries or fatalities to third parties as a result of aviation activities.[12]

1.37 This applies to novel forms of aviation. The CAA's guidance on unmanned aircraft system operations in UK airspace explains that:

> Civil UAS operating in the UK must meet at least the same safety and operational standards as manned aircraft when conducting the same type of operation in the same airspace.
>
> As a result, when compared to the operations of manned aircraft of an equivalent class or category, UAS operations must not present or create a greater hazard to persons, property, vehicles or vessels, either in the air or on the ground.[13]

1.38 The CAA notes however that with uncrewed aircraft with no one on board, the CAA's focus will be on the risk the UAS operation presents to third parties.

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8 Transport Act 2000, s 2 in relation to air traffic services and s 70 in relation to air navigation functions; see also Civil Aviation Act 1982, s 4(1)(a).

9 UK Regulation (EU) 2018/1139 on common rules in the field of civil aviation and establishing a European Union Safety Agency, art 1(1).

10 UK Regulation (EU) 2018/1139 on common rules in the field of civil aviation and establishing a European Union Safety Agency, art 7(1).

11 Annex 19 to the Chicago Convention, Second Edition, 2016, including amendment 1. The Chicago Convention is addressed further at para 5.14.

12 https://www.caa.co.uk/safety-initiatives-and-resources/how-we-regulate/state-safety-programme/safety-policy-objectives-and-resources/acceptable-level-of-safety-performance/.

13 Civil Aviation Authority ("CAA"), *Unmanned Aircraft System Operations in UK Airspace – Policy and Guidance* (2022) (CAP 722) para 1.1.1.

Calculating safety

1.39 Safety requirements within aviation are commonly expressed as a calculation of the probability of particular types of accident (usually negligible, minor, major, hazardous or catastrophic).

1.40 ICAO defines "catastrophic" as a failure resulting in the destruction of aircraft and equipment, and/or multiple deaths. Hazardous incidents are defined as those involving "a large reduction in safety margins, physical distress or a workload such that operational personnel cannot be relied upon to perform their tasks accurately or completely", serious injury and/or major equipment damage.[14] For UAS in the specific category, the CAA uses slightly different definitions, which focus on injury to persons. Catastrophic is defined as resulting in "fatality of one or more people" and hazardous as "very serious injury or serious injuries to multiple people".[15]

1.41 The approach taken reflects the fact that modern aircraft contain multiple complex systems. The likelihood of failure of individual parts both separately and together has to be considered, to evaluate the effect on the system(s) as a whole.[16]

1.42 This is reflected in the Basic Regulation, which requires that:

> aircraft systems and equipment, considered separately and in relation to each other, must be designed such that any catastrophic failure condition does not result from a single failure not shown to be extremely improbable and an inverse relationship must exist between the probability of a failure condition and the severity of its effect on the aircraft and its occupants.[17]

1.43 To take a more specific example, equipment and systems for VTOL aircraft which fall within the "enhanced" category (those that fly over congested areas or conduct commercial air transport of passengers) must be designed and installed so that:

(1) each catastrophic failure condition is extremely improbable and does not result from a single failure;

(2) each hazardous failure condition is extremely remote; and

(3) each major failure condition is remote.[18]

1.44 The CAA's acceptable means of compliance, which supports the special condition, ascribes acceptable probabilities (or "safety conditions") to these outcomes. The probabilities are based on the likelihood of a failure per flight hour.[19] For the enhanced

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14 ICAO, *Safety management manual* (4th ed 2018), Doc 9859, table 2.

15 CAA, *Unmanned Aircraft System Operations in UK airspace – Operating Safety Cases* (December 2022) (CAP722A), para 3.4.

16 For more detail, see E Lloyd and W Tye, *Systematic Safety* (July 1982) ch 1.

17 UK Regulation (EU) 2018/1139 on common rules in the field of civil aviation and establishing a European Union Aviation Safety Agency, annex II, para 1.3.3.

18 European Aviation Safety Agency ("EASA"), *Special Condition Vertical Take off and Landing (VTOL) Aircraft* (Doc No SC-VTOL-01) (July 2019) p 25.

19 EASA, *Means of Compliance with Special Condition VTOL* (Doc No MOC SC VTOL) (May 2021), Table 1.

category of VTOLs, the safety condition is ≤ 10^{-9}, which is equal to or less than one catastrophic failure every billion flight hours.

Just culture

1.45 One of the hallmarks of the investigation of air accidents is "just culture". In essence this means that the aim of the investigation of an accident is to discover what has gone wrong, rather than to assign blame. As explained by Christopher Hodges:

> A just culture means that everyone will have confidence that there are always consequences in response to new information, and these are aimed at everyone making a common contribution to improving performance and safety. Standards of behaviour require professional competence, openness, sharing, and taking responsibility for one's mistakes by correcting them and improving. The typical consequences that arise in a traditional legal system are almost irrelevant, on the basis that people demonstrate their commitment to the outcomes of increased safety, performance and learning.[20]

1.46 This principle is built into the regulatory regime around air accidents. By way of example, the Civil Aviation (Investigation of Air Accidents and Incidents) Regulations 2018 state that:

> The sole objective of a safety investigation which is undertaken pursuant to Regulation 996/2010, Annex 13 [to the Chicago Convention] or these Regulations is the prevention of accidents and incidents, without the apportionment of blame or liability.[21]

1.47 Practical implications include the fact that accidents are investigated not by the CAA but by the Air Accidents Investigation Branch, which can only disclose information it learns in the course of a safety investigation in order to maintain or improve safety.[22] The court may also order that records are disclosed in limited circumstances where the benefits of the disclosure of the record concerned outweigh the adverse domestic and international impact.[23] We discuss reporting requirements in more detail in Appendix 1.

1.48 With novel forms of aviation, it will be more important than ever to ensure that this approach is preserved, and that lessons from air accidents are learnt and disseminated quickly.

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20 C Hodges, *Outcome-based cooperation: in communities, business regulation, and dispute resolution* (2022) p 396.

21 The Civil Aviation (Investigation of Air Accidents and Incidents) Regulations 2018 SI No 321, reg 8.

22 UK Regulation (EU) 376/2014 on the reporting, analysis, and follow-up of occurrences in civil aviation, art 15(2).

23 The Civil Aviation (Investigation of Air Accidents and Incidents) Regulations 2018 SI No 321, reg 25.

Equitable access to airspace

1.49 Airspace is a valuable and limited resource. One principle that appears in the literature is therefore that of fair (or equitable) access to airspace.[24] However, there are concerns from several quarters about what "equitable access" will look like given the growth of both drones and urban air mobility. We will consider throughout this project how our use cases impact on other airspace users and, where appropriate, the need to balance airspace use.

CAA regulatory principles

1.50 The CAA have a set of five regulatory principles which articulate their general approach to regulation.[25] Principles 1, 3 and 4 are particularly relevant to this project.[26]

(1) **Principle 1.** Understanding and addressing risk: the CAA will understand and address safety, security, and consumer protection risks across the aviation sector for the benefit of consumers and the general public, placing primary responsibility on those performing an activity and requiring them to show how they manage their own risk.

(2) **Principle 3.** Acting proportionately: the CAA will explore different ways of achieving outcomes, regulating only when necessary and understanding the differences between the organisations and individuals it regulates.

(3) **Principle 4.** Engaging proactively and transparently: the CAA will look outwards to prepare for sectoral and technological innovation and new challenges. The CAA will also publish information about how their decisions affect stakeholders and make information clear and accessible where appropriate.

1.51 Adherence to these principles is designed to improve the safety, security and consumer protection outcomes for which the CAA is responsible.

1.52 The CAA also has a number of consumer principles to structure its thinking about the interests of consumers.[27] The CAA's consumer panel has produced guidance on how best to apply the consumer principles to advanced air mobility.[28]

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[24] See also the Civil Aviation Authority (Air Navigation) Directions 2023. Direction 3(c) requires the CAA "seek to ensure that the amount of controlled airspace is the minimum required to maintain a high standard of air safety and, subject to overriding national security or defence requirements, that the needs of all airspace users are reflected on an equitable basis".

[25] CAA, *Our Regulatory Approach,* https://www.caa.co.uk/our-work/about-us/our-regulatory-approach/our-regulatory-approach/.

[26] Principle 2 is "delivering unique value" and 5 is "acting on our combined insight".

[27] CAA Consumer Panel, *CAA consumer panel consumer principles,* https://publicapps.caa.co.uk/docs/33/CAA%20Consumer%20Panel%20Consumer%20Principles.pdf.

[28] CAA Consumer Panel, *Guide to Applying the Civil Aviation Authority's (CAA) Consumer Principles to the Advanced Air Mobility (AAM) industry* (May 2023) (CAP 2539).

STRUCTURE OF AVIATION REGULATION

Introduction

1.53 The regulation of aviation is complex. There are multiple sources: multilateral treaties at the international level; bilateral treaties signed between the UK and other states; standards developed by international aviation bodies; EU law; law created in consequence of the UK's withdrawal from the EU; domestic safety regulation; and other domestic laws that supplement the above and ensure that there is a complete scheme of aviation regulation in the UK. Here we set out at a high level the various sources.

The international nature of aviation regulation

1.54 In the UK's legal system, directly enforceable legal rights and obligations are found only at the level of domestic law. Simply ratifying a treaty is not enough to make it part of domestic law.[29] In practice, however, aviation law in the UK is heavily influenced by international law. This is either because domestic law has been enacted to give effect to rights and obligations under a treaty, or because the effect of domestic law is influenced by international standards or guidelines.

1.55 International law is particularly important in the aviation field because it is one of the ways in which states coordinate between each other, in order to make international air travel easier and safer. The UK has ratified multiple international treaties, covering topics ranging from airline liability for damaged luggage to offences committed on board an aircraft to leasing arrangements for aircraft equipment.

1.56 The most important treaty is the Chicago Convention. The treaty facilitates a common approach to international aviation in numerous areas. It has been ratified by almost every state in the world and is considered to be the primary source of aviation law, with much of aviation regulation – particularly aviation safety regulation – made to give effect to the requirements of the Convention.

The Chicago Convention

1.57 The Chicago Convention governs the rights and obligations of States with respect to international civil aviation,[30] and sets down baseline rules and principles to facilitate international air travel.

1.58 Front and centre of the Chicago Convention is the recognition in Article 1 that states have complete and exclusive sovereignty over the airspace above their territory.[31] Linked to the idea of state sovereignty is the ability of states to regulate aviation within their territory.[32] States must, however, keep their regulations consistent "to the

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29 *R (Miller and another) v Secretary of State for Exiting the European Union* [2017] UKSC 5, [2018] AC 61 at [56], [167] and [244].

30 The Convention is only applicable to "civil aircraft" and does not apply to "state" aircraft: art 3a. "State aircraft" is not a term defined in the Convention, but art 3b provides that aircraft used in military, customs and police services are deemed to be state aircraft.

31 The concept of state sovereignty over airspace had already been recognised in the Paris Convention relating to the regulation of aerial navigation (1919), art 1.

32 Chicago Convention, Ninth Edition (2006), art 11.

greatest possible extent," with the standards and recommended practices established under the Convention.[33]

1.59 The Convention lays down key principles for the regulation of air navigation. For example, article 29 stipulates the documents to be carried on board.[34] The Convention also requires certificates of airworthiness for aircraft and personnel licences for pilots and crew are also required. So long as minimum standards are met, these must be recognised by other contracting states.[35]

1.60 Having laid down the key principles for the regulation of air navigation, the Chicago Convention goes on to establish ICAO[36] and gives the organisation the task of "develop[ing] the principles and techniques of international air navigation and foster[ing] the planning and development of international air transport".[37] The organisation is not a global regulator; instead it is a framework organisation which helps to facilitate, organise and coordinate international civil aviation.

1.61 The most important function of ICAO is the development of standards and recommended practices ("SARPs"), which are contained within annexes to the Convention.[38] The development of SARPs is largely the responsibility of the Air Navigation Commission, which has several technical panels focusing on particular areas.[39]

1.62 The adoption of SARPs contained within annexes to the Convention has become an integral component of global aviation safety. In total there are 19 annexes to the Convention, covering matters from "rules of the air" to operation and airworthiness of aircraft, to accident investigation. We refer frequently to these throughout this paper.

1.63 SARPs comprise both standards and recommended practices. Standards are specifications where compliance is recognised as "necessary" for the safety or regularity of international air navigation. If a state cannot comply, Article 38 requires it to notify the Council. Recommended practices are specifications where compliance is "desirable", rather than "necessary". States are only required to *endeavour* to conform with recommended practices.[40]

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33 Chicago Convention, Ninth Edition (2006), art 12. The Convention also makes clear in art 11 that states must apply their laws and regulations in a non-discriminatory fashion.

34 These documents include: certificate of registration; certificate of airworthiness; licenses for crew members; journey log book; aircraft radio station license; passenger list; and cargo declarations.

35 Chicago Convention, Ninth Edition (2006), art 33.

36 Chicago Convention Ninth Edition (2006), art 43.

37 Chicago Convention, Ninth Edition (2006), art 44.

38 Chicago Convention, Ninth Edition (2006), arts 54(l) and 90.

39 Chicago Convention, Ninth Edition (2006), art 90. For instance, the Remotely Piloted Aircraft Systems Panel works on the development of SARPs in relation to remotely piloted aircraft systems and proposes amendments to the existing annexes.

40 The ICAO Assembly adopted this definition at its first meeting. This definition can also be found in the annexes to the Convention.

1.64 In practice, the scope for departing from SARPS is limited by the status accorded to SARPs by the international aviation community: they represent the "gold standard" for aviation safety. In the UK, the CAA is required to act consistently with the obligations placed on the United Kingdom under the Chicago Convention and it is required to consider whether it is necessary to amend UK aviation legislation to ensure appropriate implementation of an ICAO provision.[41]

Other international law

1.65 As well as the Chicago Convention, the UK has ratified several other important multilateral aviation treaties. One example is the Montreal Convention 1999, which deals with the liability of air carriers for death or injury to passengers.[42]

1.66 Bilateral international agreements (often in the form of "Air Services Agreements") are also used to agree commercial rights for airlines to fly between states. In practice the work of the CAA is also informed by that of other national aviation authorities, including the US Federal Aviation Administration ("FAA") and European Aviation Safety Agency ("EASA").

1.67 In addition to international treaties agreed between states, a notable feature of aviation regulation at the international level is the role played by other bodies that facilitate coordination. For example, standards bodies provide technical support and can assist with developing policy. Another example which we have considered in the course of the project is the Joint Authorities for Rulemaking of Unmanned Systems ("JARUS") group. This is a group of experts with regulatory expertise, who represent the national aviation authorities of 63 countries (as well as EASA). The purpose of the group is to "recommend a single set of technical, safety and operational requirements for all aspects linked to the safe operation of UAS".[43] The work of JARUS is discussed in Chapter 2.[44]

EXISTING DOMESTIC LAW ON AVIATION

The Civil Aviation Act 1982 and the Air Navigation Order 2016

1.68 The main source of the power to regulate civil aviation at the domestic level comes from the Civil Aviation Act 1982. Under section 1(1) of the Act, the Secretary of State for Transport is charged with:

> the general duty of organising, carrying out and encouraging measures for: the development of civil aviation; the designing, development and production of civil aircraft; the promotion of safety and efficiency in the use thereof; research into questions relating to air navigation; and safeguarding the health of persons on board aircraft.[45]

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41 Civil Aviation Authority (Chicago Convention) Directions 2007.

42 It also deals with liability for delay and damage in respect of cargo and baggage.

43 http://jarus-rpas.org/who-we-are.

44 In particular, Joint Authorities for Rulemaking on Unmanned Systems' ("JARUS") recently published methodology for the evaluation of automation for UAS operations.

45 The last aim is contained in s 1(1A).

1.69 The Act establishes the CAA as the UK's aviation regulator.[46] The CAA has a wide range of functions.[47] Broadly speaking, it is responsible for the economic regulation of the aviation industry, air safety regulation, airspace regulation and aviation consumer protection.[48]

1.70 An important power is contained in section 60 of the 1982 Act, which enables His Majesty to make regulations by Order in Council "generally for regulating civil aviation".[49] The most important of these orders is the Air Navigation Order 2016 ("ANO"), which contains many of the rules regulating civil aviation in the UK, and is in many cases how the UK achieves compliance with the requirements of the Chicago Convention.[50]

1.71 The Air Navigation Order 2016 has provisions addressing a wide range of matters relating to aviation safety and aircraft navigation. It deals with subject matters such as: the registration of aircraft; the airworthiness of aircraft, operational rules – including the duties of the pilot-in-command; rules about air traffic services; flight crew licensing and the licensing of air traffic controllers; requirements for aerodromes; and a range of other matters. It also sets out prohibited behaviours, as well as prescribing criminal sanctions for breaches of its provisions (and those of other legislation).

1.72 The Secretary of State can also make further regulations under powers conferred by the ANO itself, such as the Rules of the Air Regulations 2015[51] and the Air Navigation (Dangerous Goods) Regulations 2002.[52]

Domestic law derived from EU law

1.73 Since the 1990s, aviation has been increasingly regulated within the EU member states by legislation enacted at the EU level. EU aviation legislation contributes to harmonising EU member states' aviation law, both in areas where compliance with the Chicago Convention is required and beyond. It also replaces bilateral agreements between EU member states with a common system.

1.74 A key regulation within the EU legislative scheme is the Basic Regulation, which aimed to consolidate "the scope of European Union competence to cover the full spectrum of the aviation landscape and reinforce the European aviation system as a whole".[53] EASA exists pursuant to this Regulation. Changes to EU law introduced by the Basic Regulation meant that EASA's regulatory powers included powers in respect

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46 The CAA is a body corporate and is not a servant or agent of the Crown. It was first established by the Civil Aviation Act 1971.

47 These functions are described in s 3 of the Civil Aviation Act 1981. Functions are also set out in the Airports Act 1986 and the Transport Act 2000.

48 This summary of the CAA's functions comes from: The Work of the Civil Aviation Authority, Report of the House of Commons Transport Committee (2005-06) HC 809.

49 Civil Aviation Act 1982, s 60(2)(b).

50 SI 2016 No 765.

51 SI 2015 No 840.

52 SI 2002 No 2786.

53 R Sousa Uva and G Rebane, "EASA Regulations and the Operation of Unmanned Aircraft: An Overview" in B Scott, The Law of Unmanned Aircraft Systems (2nd ed 2022).

of all unmanned, or uncrewed aircraft.[54] Essential requirements in relation to a number of aviation fields are fleshed out in annexes to the Basic Regulation. These essential requirements are then elaborated on in "implementing" and "delegated" regulations made by the European Commission. Many contain annexes, which are often referred to as "Parts".

1.75 Documents that EASA issues in relation to the Basic Regulation and the implementing and delegated regulations are also important in the EU regulatory scheme. The Agency develops certification specifications and other detailed specifications, acceptable means of compliance, and guidance material.[55]

1.76 The purpose of these publications is to provide further guidance and technical assistance in the implementation of the binding requirements. Acceptable means of compliance ("AMC") for instance, demonstrate how member states can meet the requisite requirements.[56] Following an AMC guarantees compliance with the law. Certification specifications are technical standards used for certifying that designs for aircraft or parts of aircraft are airworthy.[57] Guidance material ("GM"), meanwhile, is made up of explanatory and interpretation material. Since EU exit, many of these documents have now been adopted by the CAA.

Assimilated law

1.77 For many years, EU aviation regulation was a component of UK aviation regulation. The position changed following the UK's exit from the EU, since law made by the EU institutions is no longer part of the UK's legal system. It can still be instructive to look at the law in force in the EU. Often the laws in force in the UK and in the EU are materially equivalent, allowing for useful comparison both in their current application and how they may develop in future. For example, EASA issues opinions[58] and recommendations[59] to the European Commission when EASA considers that changes to the legislative framework are necessary. Some of these consider issues discussed in this paper. The geographical proximity of the EU countries to the UK also creates a

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54 UK Regulation (EU) 2018/1139 on common rules in the field of civil aviation and establishing a European Union Safety Agency, annex1, lists the exceptions which remain under national competence (certain small, tethered aircraft).

55 Basic Regulation (EU) No 2018/1139 Official Journal L 212 of 22.8.2018 p 1,art 76(3).

56 Member states and national aviation authorities can propose "Alternative Means of Compliance" if they believe they can meet the requirements using other means.

57 For more information, see Chapter 6 on the role of certification.

58 Opinions can take two forms. First, they can be documents that EASA submits to the Commission, upon request, in order to assist the Commission in the preparation of proposals for amendments to the Basic Regulation and the delegated and implementing acts (Basic Regulation, art 76(1)). Second, they can be opinions on the individual flight time specification schemes proposed by member states (Basic Regulation, art 76(7)).

59 Art 76(2) of the Basic Regulation. In essence, a recommendation refers to a situation where EASA recommends to the Commission that an amendment to any delegated or implementing act is necessary in response to an immediate problem presenting a serious risk to aviation safety (art 70(2)). It can also refer to a situation where a member state has granted an exemption from the requirements of the Basic Regulation to a natural or legal person in urgent unforeseeable circumstances, and EASA carries out an assessment of this exemption and makes a recommendation to the Commission regarding its outcome (art 71(2)).

need for awareness of the EU's regulatory environment for aviation, particularly where cross-border operations are concerned.

1.78 The EU Withdrawal Act 2018 ("EUWA") established a framework for preserving EU law within domestic law after the UK's exit from the EU. Much aviation regulation which formerly took effect in the UK as EU law now forms part of domestic law. This body of law was previously known as "retained EU law", but since the end of 2023 has become "assimilated law".[60]

1.79 Powers contained in the EUWA 2018 were used to amend retained EU Regulations consequent upon EU exit. For example, references to the EU Commission and EASA have been amended to refer to the Secretary of State and/or the CAA as appropriate;[61] references to the territory of "the member states" have been replaced by references to the territory of the United Kingdom.[62]

1.80 The main piece of assimilated law in relation to aviation in the UK is the assimilated version of the Basic Regulation. The implementing and delegated regulations have also been assimilated into domestic law.[63]

1.81 Aircraft falling within the scope of assimilated law, are known as "Part 21" aircraft. These aircraft are subject to the operational and licensing requirements of the Basic Regulation. Non-Part 21 aircraft are instead subject to airworthiness, operational and licensing rules found in the Air Navigation Order 2016 and British Civil Airworthiness Requirements.[64]

Relationship between assimilated law and other domestic law

1.82 The subject matter of assimilated law can overlap with the subject matter of other domestic aviation law. For example, the ANO contains rules on airworthiness, but there is also an assimilated Regulation on the same topic. In these cases, the applicable rules depend on the circumstances, including matters like the activity and the type of aircraft in question.

1.83 It is possible for an activity to be within the scope of assimilated law and at the same time regulated by other domestic law such as the ANO. Assimilated law does not apply to all aircraft in the UK, and the ANO and other domestic law contains important safety provisions that may apply alongside the assimilated law. This may be the case

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60 Retained EU Law (Revocation and Reform) Act 2023, s 5.

61 See, for example, Parts 3 and 4 of the Aviation Safety (Amendment etc.) (EU Exit) Regulations 2019.

62 See, for example, Parts 3 and 4 of the Aviation Safety (Amendment etc.) (EU Exit) Regulations 2019.

63 Commission Regulation 104/2004 (Board of Appeal); Commission Regulation 646/2012 (fines and penalties); Commission Regulation 628/2013 (standardisation inspections); and Commission Regulation 319/2014 (fees and charges) were revoked by the Aviation Safety (Amendment etc.) (EU Exit) Regulations 2019 SI No 645. Any regulations made after 31 January 2020 were not retained.

64 Non-Part 21 aircraft are listed in annex I to the Basic Regulation. They include certain historic aircraft, aircraft designed for research, experimental or scientific purposes, some smaller aircraft, and some balloons and airships. This Consultation Paper is primarily concerned with Part 21 aircraft, as we expect our use cases to fall within this category.

where, for example, the ANO sets out the sanction for breach of a requirement contained within an assimilated regulation.

1.84 An example of how the various sources of law, including assimilated law and other domestic law, can regulate the same subject matter can be seen in the different sources of the rules of the air.

(1) Annex 2 to the Chicago Convention sets out SARPs pertaining to the rules of the air. These are universal and form the basis for the making of regulations on the rules of the air by states around the world.

(2) On the basis of Annex 2 to the Chicago Convention, the EU adopted Standardised European Rules of the Air – SERA (Regulation 923/2012). These are directly effective in the member states of the EU.

(3) Following EU exit, the UK has retained SERA - now called UK SERA. Amendments were made, in accordance with the scheme set down by the EU Withdrawal Act 2018, to make the EU rules of the air make sense following the UK's exit from the EU.

(4) UK SERA is supplemented by the Rules of the Air Regulations 2015, made under the Air Navigation Order 2016. These regulations act as a gap-filler where UK SERA does not cover an issue.

1.85 UK SERA and the Rules of the Air Regulations 2015 therefore work alongside each other to set down the rules of the air within the UK and give them legal effect. They both regulate the same subject matter.

Citation of assimilated law in this paper

1.86 In this paper assimilated law instruments are referred to by the title of the EU instrument preceded by "UK". In the body of the paper these are referred to by a short description assigned by us – eg the "Basic Regulation". A list of the assimilated law instruments referred to in this paper, together with a short form of their titles, is at pages xvii and xviii above.

Other domestic law

1.87 While much of the important domestic safety legislation stems from the Civil Aviation Act 1982 and the Basic Regulation, it is important to recognise that there is a lot of other domestic law relating to the aviation system in the UK. For example, there is legislation covering topics such as security, the regulation of aerodromes, immigration, tax, the environment, and criminal law. The Transport Act 2000 is one important example, which (among other topics) deals with the economic regulation of air traffic services. Other common law principles, such as the law regarding negligence and nuisance, are also relevant.

UAS REGULATION: AN OVERVIEW

1.88 We give a brief overview here; a more detailed explanation of UAS regulation is given in Chapter 3. The bulk of regulation of uncrewed aircraft can be found in a specific regulatory regime for UAS which now forms part of assimilated law.[65]

1.89 There are two key regulations. UK Regulation (EU) 2019/945 (the "UAS Delegated Regulation") sets out requirements in relation to the design and production of UAS, as well as the rules that economic operators (manufacturers, distributors or importers) must follow when placing UAS on the market. UK Regulation (EU) 2019/947 (the "UAS Implementing Regulation") contains rules governing the operation of a UAS. The requirements in the regulations are complementary and form one single regulatory regime.

1.90 For the purposes of the regulations, an "unmanned aircraft system" means "an unmanned aircraft and the equipment to control it remotely".[66] The overall approach underpinning the UAS regulatory regime is that the applicable rules and procedures should be proportionate to the nature and risk of the operation in question. This means that the characteristics of the intended UAS operation determine the applicable rules at both the design and production stage and the operation stage.

1.91 The UAS Regulations establish three categories of operations: "open", "specific" and "certified". The categorisation is based on a combination of the characteristics of both the UAS and its operation. Operations in the "open" category present the lowest risk and do not require prior authorisation. Operations in the "specific" category present a greater risk and require authorisation by the CAA before the operation can take place. Operations in the "certified" category require the certification of the UAS and the operator and, where applicable, the licensing of the remote pilot.[67]

Air Navigation Order 2016

1.92 The Air Navigation Order 2016, discussed above at paragraph 1.70, contains important provisions on matters such as operational requirements and personnel licensing which must be followed by civil aircraft. Because of the detailed provision for these categories in the assimilated regulations, the Order largely exempts UAS in the open and specific categories from its provisions.[68] The provisions that remain applicable to UAS are those that contain rules that do not conflict or overlap with the rules in the assimilated UAS regulatory regime, or that complement the UAS regulatory regime by filling in necessary gaps.

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65 UK Regulation (EU) 2019/947 on the rules and procedures for the operation of unmanned aircraft and UK Regulation (EU) 2019/945 on unmanned aircraft systems and on third-country operators of unmanned aircraft systems.

66 UK Regulation (EU) 2019/947 on the rules and procedures for the operation of unmanned aircraft, art 2; UK Regulation (EU) 2019/945 on unmanned aircraft systems and on third-country operators of unmanned aircraft systems, art 3.

67 UK Regulation (EU) 2019/947 on the rules and procedures for the operation of unmanned aircraft, art 3. Remote pilots in other categories are subject to less stringent requirements than licensing. In the open category, a "flyer ID" is required, while the specific category imposes competency requirements on pilots.

68 SI 2016 No 765, art 23.

1.93 Examples are:

(1) provisions that sanction failure to comply with the UAS implementing and delegated regulations, primarily by creating criminal offences;[69]

(2) provisions that supplement the general requirements of the UAS regulations; for example, article 94A elaborates on the rules for UAS operations in the open and specific category in relation to flight restriction zones;[70] and

(3) a small number of requirements and powers that apply to UAS as well as to crewed aircraft. For example, article 241 stipulates that "a person must not recklessly or negligently cause or permit an aircraft to endanger any person or property".[71] Likewise, article 91 provides that aircraft must not be used for the dropping of articles for agriculture, horticulture or forestry unless an aerial application certificate has been granted by the CAA. Powers to prohibit or restrict flying in certain circumstances also apply to crewed and uncrewed aircraft.[72]

1.94 The penalties and enforcement powers associated with these requirements and powers are also made applicable to UAS. It is an offence to fail to comply with article 91 or article 241 requirements or to contravene directions not to fly.[73] The CAA also has the power to revoke, suspend and vary certificates and licences.[74]

1.95 The ANO applies in full to UAS subject to certification.[75] In other words, the rules in the ANO on matters such as equipment requirements, operational rules and personnel licensing continue to apply to UAS that fall within the "certified" category.[76] The rules are the same as those applicable to crewed aviation.[77]

ACKNOWLEDGEMENTS AND THANKS

1.96 We have held many meetings with individuals and organisations contributing to this paper, and we are very grateful to them for giving us their time and expertise. We

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69 SI 2016 No 765, arts 265A, 265B, 265C and 265D.

70 See also SI 2016 No 765, arts 94B and 94BA.

71 Our preliminary view is that article 240 is applicable to UAS. It provides that "a person must not recklessly or negligently act in a manner likely to endanger an aircraft, or any person in an aircraft." It is not included as one of the articles that apply in article 23: but that article only exempts unmanned aircraft from the provisions of the ANO. Art 240 however concerns the actions of an individual in terms of endangering an aircraft (without specifying further any particular type of aircraft).

72 SI 2016 No 765, arts 239 and 257.

73 In relation to contravention of article 241: art 23(3) read with art 265(7) and sch 13. In relation to contravention of art 91: art 23(3) read with art 265(6) and sch 13. In relation to contravention of art 239: art 23(3) read with article 239(4), art 265(6) and sch 13. In relation to contravention of art 257: art 23(3) read with art 265(7) and sch 13.

74 SI 2016 No 765, arts 23(3) and 253.

75 SI 2016 No 765, art 23(1)(c).

76 Unless exempted by the CAA: SI 2016 No 765, art 266.

77 For completion, it is worth noting that the ANO has specific rules for UAS that are moored, tethered or towed (see arts 92 and 265E).

have also attended conferences which have helped develop our understanding of the diverse and rapidly changing aviation ecosystem in the UK and internationally. We look forward to receiving responses from these stakeholders as well as from other stakeholders and the general public.

THE TEAM WORKING ON THE PROJECT

1.97 The Commissioners would like to record their thanks to the following members of staff who worked on this Consultation Paper: Henni Ouahes (team manager); Connor Champ and Sarah Smith (lawyers in the public law and law in Wales team); Eleanor Bennett, Ethan George and Emma-Jane Harris (current research assistants); and Alexander Ewing (former research assistant), who contributed to the initial research.

Chapter 2: Key concepts and terminology

2.1 Aviation is a field with a great deal of specialist terminology. The area we are considering is no exception. Where new use cases for aircraft and new possibilities for autonomous flying are regularly emerging, it can be difficult to agree on the right vocabulary. The position is further complicated by use of vocabulary borrowed from other sectors, which is often similar but not identical. The lack of consistency can cause problems both for experts and for members of the public.

2.2 In this chapter, we start by describing the Joint Authorities for Rulemaking on Unmanned Systems ("JARUS") levels of automation and those used by the European Aviation Safety Agency ("EASA"): just two of several key frameworks which have emerged for classifying the level of autonomy of aircraft systems. These aim to provide a common language to describe the roles of humans and aircraft systems at different levels of automation.

2.3 We then look at the terminology used in this area. We discuss what exactly is meant by "autonomous" and "autonomy" in the context of aviation. We then review terminology commonly used for aircraft which fall within this project and explain the terminology choices we have made within this paper.

2.4 Finally, we provide an overview of some of the key roles within aviation which are likely to be particularly affected by the introduction of more highly automated and autonomous systems and which we discuss in more detail in later chapters of the paper. These include not just the pilot and remote pilot, but also operators, air traffic controllers, and flight information service officers.

FRAMEWORKS FOR DESCRIBING LEVELS OF AUTONOMY

JARUS levels of automation

2.5 In 2023, JARUS published its detailed methodology for evaluation of automation for unmanned aircraft systems ("UAS"), set out in full below.[78] The JARUS levels range from level 0 (manual operation) to level 5 (full automation) and provide criteria for each. It is important to note that the JARUS levels apply at the level of individual "functions" of an aircraft (such as an automatic traffic collision and avoidance system), rather than necessarily the whole aircraft.[79]

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78 Joint Authorities for Rulemaking of Unmanned Systems (JARUS), *JARUS methodology for evaluation of automation for UAS operations* (April 2023) p 21. http://jarus-rpas.org/wp-content/uploads/2023/06/jar_21_doc_JARUS_Methodology_for_Evaluation_of_Automation_for_UAS_Operations.pdf.

79 JARUS, *JARUS methodology for evaluation of automation for UAS operations* (April 2023) p 21. http://jarus-rpas.org/wp-content/uploads/2023/06/jar_21_doc_JARUS_Methodology_for_Evaluation_of_Automation_for_UAS_Operations.pdf.

2.6 The taxonomy is set out below. It uses the phrases “human-in-the-loop”, “human-on-the-loop” and “human-out-of-the-loop”. These are commonly used when discussing levels of autonomy and express different types of human/machine collaboration.

(1) **Human-in-the-loop**. Here a human must interact with a machine before the system can perform an action.

(2) **Human-on-the-loop**. The machine can perform actions with or without human oversight; a human can provide guidance or override an action.

(3) **Human-out-of-the-loop (sometimes referred to as “off” the loop).** The machine operates independently without human oversight or intervention.

2.7 Machines may also be described as “off” or “out of” the loop, where their involvement is not necessary to the completion of a function by a human. They can also take on an “in-the-loop” role, where interaction with them is required before the function can be completed.

2.8 The levels are as follows:

(1) **Level 0 – Manual operation**: the human is fully responsible for function execution, with no machine support.

(2) **Level 1 – Assisted operation**: the machine operates in an out-of-the-loop supporting role to the human in executing the function, for example, by the provision of relevant information.

(3) **Level 2 – Task reduction**: the machine operates in an in-the-loop management role in reducing human workload to accomplish the task. For example, the machine could provide a “conflict alert” and “resolution advisory” (advice as to what action to take) based on predicted flight paths.

(4) **Level 3 – Supervised automation**: the machine executes the function under the supervision of the human who is expected to monitor and intervene as required.

(5) **Level 4 – Manage by exception**: the machine executes the function alerting the human in the event of an issue. The human is not required to monitor the function in real time and is able to intervene at any time after being alerted by the machine to an issue.

(6) **Level 5 – Full automation**: the machine is fully responsible for function execution. The human is unable to intervene in real-time either due to practical limitations or deliberate exclusion within the operational design domain (the conditions and limitations under which a system is designed to function).

2.9 The methodology draws a distinction between Levels 0 – 2 (where the human is "in control") and 3 – 5 (where the machine is "in control").[80]

2.10 The JARUS levels enable a very clear description of exactly what functions of an aircraft are performing at what level. It would be difficult however to translate them directly into legislation. Instead of operating at the level of "functions" of parts of a system, the current legislative framework, and our proposals, ultimately require an assessment and determination of the overall capacity of an aircraft and its supporting systems (ie whether it is "remotely piloted" or "autonomous").

2.11 This clear line helps to differentiate how an aircraft and its crew should be treated for all sorts of purposes, from airworthiness, through to operational requirements, applicable rules of the air and accident investigation. It is also important to enable clarity about the role of the pilot. In the law as it stands, the pilot has broader responsibilities than those that relate to individual functions. For example, the pilot-in-command is, in law, held responsible for the "operation and safety of the aircraft" (see paragraphs 6.25 and 6.26 for further discussion).

2.12 The approach we take here is in line with that adopted by the law for automated vehicles. There a key test is whether a vehicle is or is not "self-driving": that is, whether it is designed or adapted with the intention that a feature of the vehicle will allow it to travel autonomously (and the vehicle is capable of doing so safely and legally).[81]

EASA AI roadmap

2.13 EASA's artificial intelligence ("AI") roadmap, now updated in a second version, outlines the Agency's vision for the safe introduction of AI in aviation. It includes an action plan, broken down into the stages in which EASA anticipates AI will be introduced. To help formulate this action plan, the roadmap classifies AI applications into three levels. As the levels increase, the level of human involvement in the system decreases.[82] They reflect broadly the staged approach that industry is expected to take when deploying AI applications.

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80 JARUS, JARUS methodology for evaluation of automation for UAS operations (April 2023) p 19. http://jarus-rpas.org/wp-content/uploads/2023/06/jar_21_doc_JARUS_Methodology_for_Evaluation_of_Automation_for_UAS_Operations.pdf.

81 Automated Vehicles Bill, cl 1(2), presented to the House of Commons on 20th February 2024.

82 European Union Aviation Safety Agency (EASA), *Artificial intelligence roadmap 2.0* (May 2023), p 18 figure 4.

Level 1 AI: assistance to human	Level 2 AI: advanced automation	Level 3 AI: human-AI teaming
Level 1A – Human augmentation Level 1B – Human cognitive assistance in decision and action selection	Level 2A – Human and AI-based system cooperation Level 2B – Human and AI-based system collaboration	Level 3A – The AI-based system performs decisions and actions, overridable by the human Level 3B – the AI-based system performs non-overridable decisions and actions (for example, to support safety upon loss of human oversight)

2.14 These levels are used by EASA to prioritise its work in this area. In February 2023, EASA published a concept paper with a first set of objectives for applicants hoping to use AI systems at Levels 1 and 2. The objectives fall under the broad headings of "trustworthiness analysis", "AI assurance", "human factors for AI" and "safety risk mitigation". For example, Objective CO-01 requires an applicant wishing to use artificial intelligence or machine learning applications in their projects to:

> identify the list of end users that are intended to interact with the AI-based system, together with their roles, their responsibilities and their expected expertise (including assumptions made on the level of training, qualification and skills).[83]

2.15 The concept paper anticipates that there will be further EASA guidance and requirements in the future for safety-related machine learning applications.[84]

2.16 EASA anticipates that there will have to be a further split within level 3 to accommodate fully autonomous flight. EASA does not expect this to occur until after 2050.[85]

"AUTONOMOUS" AND "AUTOMATED"

2.17 Great strides in the field of AI have been made in recent decades. In particular, progress in the field of machine learning together with an exponential increase in computational power has driven dramatic advances in the capability of systems. Ultimately, we expect this to lead to aircraft which can operate independently of human control: often referred to as "autonomous". Exactly what is meant by this is explored below.

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83 EASA, *EASA concept paper: guidance for level 1 and 2 machine learning applications* (February 2023), p 20.

84 EASA, *EASA concept paper: guidance for level 1 and 2 machine learning applications* (February 2023), p 4.

85 EASA, *Artificial intelligence roadmap 2.0* (May 2023) p 18.

Definitions of autonomy

2.18 Below we set out definitions of autonomy and automation both in the existing law and in the wider aviation literature. Not all definitions operate at the same level. Some are concerned with labelling a particular function of an aircraft as automated or autonomous. Others refer to the whole operation conducted by an aircraft. In practice many aircraft have different modes of operation: a function may be automated (for example, if autopilot is engaged) but equally may be performed by a human.

In the law: UK Regulation (EU) 2019/947 (the "UAS implementing regulation")

2.19 UK Regulation (EU) 2019/947 on the rules and procedures for the operation of unmanned aircraft systems (the "UAS implementing regulation") defines an autonomous operation as "an operation during which an unmanned aircraft operates without the remote pilot being able to intervene".[86]

2.20 An assumption here is that there will be a remote pilot without the ability to control the aircraft. A related assumption is that there will be a command and control link between the aircraft and the pilot. This is made clear by the guidance material. The guidance explains that the implementation of a pre-programmed emergency procedure (for example, an automatic "return to home" function if the command and control link is lost) does not amount to an autonomous operation.

2.21 A further feature of the definition is that it applies to an operation conducted by an aircraft, rather than the aircraft itself (or a function of the aircraft). It appears to apply to whole operations, rather than just a phase of a flight.

2.22 The guidance material adds that:

> An autonomous operation should not be confused with an automatic or automated operation, which refers to an operation following pre-programmed instructions that the UAS executes while the remote pilot is still able to intervene in the flight.[87]

2.23 This definition is not unique to the EU and the UK. For example, in Canada, "autonomous", in the context of remotely piloted aircraft systems, is defined as meaning that "the system is not designed to allow pilot intervention in the management of a flight".[88]

2.24 For the purposes of this paper, we adopt the definition used in UK law of autonomous operation, as set out at paragraph 2.19 above. When we refer to an autonomous aircraft, we mean one capable of conducting such an operation. We summarise below however some of the current debate around the use of "autonomous".

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86 UK Regulation (EU) 2019/947 on the rules and procedures for the operation of unmanned aircraft, art 2(17).

87 UK Regulation (EU) 2019/947 on the rules and procedures for the operation of unmanned aircraft, GM1 art 2(17).

88 Canadian Aviation Regulations, part IX, division I, 900.01.

In the literature

2.25 Most stakeholders distinguish between systems that are automated, and those that are autonomous. Commentators by and large agree that there is a spectrum of automation, dictated by the amount of interaction still required by a human actor. An "autonomous" function or operation is qualitatively different. It is usually thought of as requiring no input or supervision from a human to perform a task. If this is a complex task, then the autonomous function or operation will be required to evaluate data, select from a number of possible actions, and then take those actions. Some stakeholders are of the view that for a system to be autonomous there is a further requirement: that it should be adaptive. Essentially, this means that the system should be able to respond suitably to complex and varied inputs without having to be explicitly programmed to handle them in a particular way.

2.26 By way of illustration, EASA's AI roadmap 2.0 defines automation and autonomy as follows:

> Automation - the use of control systems and information technologies reducing the need for human input, typically for repetitive tasks.[89]
>
> Autonomy – characteristic of a system that is capable of modifying its intended domain of use or goal without external intervention, control or oversight[90]
>
> Advanced automation – the use of a system that, under specified conditions, functions without human intervention[91]

2.27 Similar definitions used by JARUS in its methodology for the evaluation of automation for UAS operations are as follows:

> Automation: The use of machines or computers instead of people to perform a task (Adapted from ASTM TR-1 EB).
>
> Autonomous systems: have the ability and authority of decision making, problem-solving and/or self governance under possibly bounded, variable or abnormal conditions (deterministic or non-deterministic; adapted from National Research Council of Canada).[92]

2.28 The same document later notes that "full automation at a function or system level occurs when a human supervisor is not required (or able) to interfere".

2.29 As mentioned above, one distinction which is used by some to distinguish between autonomous and automated systems is whether a system is (a) adaptive or (b)

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89 EASA, *Artificial intelligence roadmap 2.0* (May 2023), p 30.

90 EASA, *Artificial intelligence roadmap 2.0* (May 2023), p 30. Adapted from ISO/IEC 22989:2022(en), 3.1.7.

91 EASA, *Artificial intelligence roadmap 2.0* (May 2023), p 30. Adapted from ISO/IEC 22989:2022(en), 3.1.7.

92 JARUS, *JARUS methodology for evaluation of automation for UAS operations* (April 2023) p 11. http://jarus-rpas.org/wp-content/uploads/2023/06/jar_21_doc_JARUS_Methodology_for_Evaluation_of_Automation_for_UAS_Operations.pdf.

deterministic or predictable. This distinction informs the CAA's guidance on "Unmanned Aircraft System Operations in UK Airspace" (CAP 722).[93] It states that the existing certification specifications mean that "at this point in time all UAS systems are required to perform deterministically", meaning that "their response to any set of inputs must be the result of a pre-designed data evaluation output activation process".[94]

2.30 The CAA guidance prefers the term "high authority automated systems", meaning systems that "can evaluate data, select a course of action and implement that action without the need for human input" (for example, flight control systems). These high authority automated systems may however combine to form an "autonomous UAS". An "autonomous" UAS is "a system that will do everything for itself using high authority automated systems".[95] It will be able to:

> follow the planned route, communicate with Aircraft Controllers and other airspace users, detect, diagnose and recover from faults and operate at least as safely as a system with continuous human involvement. In essence, an autonomous UAS will be equipped with high authority control systems that can act without input from a human.[96]

At present the CAA is unaware of any UAS which meet this definition of "autonomous".

TERMINOLOGY

2.31 The frameworks described above are designed to describe the level of automation of particular functions of an aircraft. They are useful frameworks for understanding exactly what role different systems are playing in any given aircraft, and for enabling effective conversations and the development of standards. However, they cannot be directly translated into legal rules (for example, about liability, or training and licensing). As well as the level of automation of particular systems, regulation must take into account higher level questions: what is the overall effect of automating different systems, and is a pilot required? If so, where is the pilot located? Are there passengers? Similar questions can be asked regarding the role of humans providing traffic management and navigation services, such as the air traffic controller.

Some key questions

2.32 There has been much disagreement around terminology in this area. This is problematic, as explained by Mikko Huttunen:

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93 Civil Aviation Authority (CAA), *Unmanned Aircraft System Operations in UK: Airspace – Policy and Guidance* (December 2022) (CAP 722).

94 CAA, *Unmanned Aircraft System Operations in UK: Airspace – Policy and Guidance* (2022) (CAP 722) para 4.5.1.

95 CAA, *Unmanned Aircraft System Operations in UK: Airspace – Policy and Guidance* (2022) (CAP 722) para 4.5.1.

96 CAA, *Unmanned Aircraft System Operations in UK: Airspace – Policy and Guidance* (2022) (CAP 722).

> The use of improper terms or definitions can easily introduce legal gaps into regulations, while adopting too many concepts can lead to excessive complexity and incoherence.[97]

2.33 One of the challenges is that the various terms highlight different features as being definitive of a type of aircraft. The key features are set out below.

(1) Who is piloting the aircraft – a person, or a machine? Or a combination?

(2) If there is a pilot, where are they?

(3) Are any passengers on board?

2.34 Some of these questions have very clear answers; either there is a passenger on board or there is not. But the question of "who is piloting" is more difficult. Modern aircraft have an increasing number of automated features, with the result that there is a spectrum of control. As explained by Benjamyn Scott and Giowana Nunes de Pinho Veloso, modern aircraft already:

> utilise detect and avoid technologies, are equipped with autopilot, analyse wind currents to ensure stability and can initiate a default landing when it senses that it is no longer capable of safe flight. The lines [between autonomous and existing unmanned aircraft] are blurred.[98]

Possible terms

2.35 Below we set out the terminology that is in use at the moment, before explaining the choices we have made for this paper. When selecting this terminology, we have focused on terms which explain concepts that are particularly relevant to this paper. These are:

(1) Aircraft with no people on board at all (whether flight crew, cabin crew, or passengers).

(2) Aircraft where there is no pilot on board, including

(a) aircraft with a pilot, but the pilot is not on board; and

(b) aircraft with no human pilot.

We also explore what term to use in relation to the newly popular form of aircraft which is expected to enter widespread commercial service shortly: the "vertical take-off and landing" (or "VTOL") aircraft.

Vertical take-off and landing aircraft

2.36 The VTOL is a novel form of aircraft. The abbreviation stands for "vertical take-off and landing". Its ability to take off and land vertically arises from the use of multiple small

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97 M Huttunen, "Unmanned, remotely piloted or something else? Analysing the terminological dogfight" (2017) 42(3) *Air and Space Law* 349, p 350.

98 B Scott and G Nunes de Pinho Veloso, *The law of unmanned aircraft systems* (2022) ch 2, p 15.

propellers, rotors, fans and jets often referred to as a "distributed propulsion system". Because these can be placed in a variety of different configurations, there is considerable variety in the models of VTOLs that are being designed. Many of the manufacturers of these aircraft currently intend to use electric propulsion systems, and therefore use the term eVTOL.

2.37 The terminology used by regulators to describe this form of aircraft varies. In the EU, until recently "VTOL aircraft" was favoured. As a result, the EU produced the "Special Condition VTOL", which sets out the initial airworthiness standards that must be met for the aircraft (and which has been adopted by the UK as its certification basis for these aircraft). The Special Condition notes it is applicable to:

> aircraft with lift/thrust units used to generate powered lift and control and with more than two lift/thrust units used to provide lift during vertical take-off or landing.

2.38 EASA now prefers to use the abbreviation VCA, standing for "VTOL-capable aircraft". This has a very similar definition to the one for VTOL given above, but makes clear that it excludes aeroplanes and rotorcraft:

> a power-driven, heavier-than-air aircraft, other than aeroplane or rotorcraft, capable of performing vertical take-off and landing by means of lift and thrust units used to provide lift during take-off and landing.[99]

2.39 This was preferred to the phrase used by the International Civil Aviation Organisation ("ICAO") and the Federal Aviation Authority ("FAA"), which is "powered lift", defined in Annex 1 to the Chicago Convention as:

> A heavier-than-air aircraft capable of vertical take-off, vertical landing, and low-speed flight, which depends principally on engine-driven lift devices or engine thrust for the lift during these flight regimes and on non-rotating aerofoil(s) for lift during horizontal flight.[100]

2.40 In this paper, we adopt the term "VTOL" and the definition used by the CAA's recent policy statement on type certification of VTOL aircraft: a heavier-than-air aircraft, other than an aeroplane or helicopter, capable of performing vertical procedures by means of more than two lift/thrust units and certified for one or more occupants.[101]

Drone

2.41 The popular conception of a drone is usually of a small, non-passenger carrying aircraft without a pilot on board. For the average member of the public, the term brings to mind drones used for aerial photography, or for light shows. It also has military connotations. However, despite being regularly used by the media and being well-known by the public, the term "drone" is not legally defined. Instead, both ICAO and

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99 EASA Opinion No 3/2023, p 9

100 Annex 1 to the Chicago Convention, Fourteenth Edition, 2022, including amendment 178, para 1.1.

101 CAA, *Policy statement on type-certification of VTOL aircraft* (October 2023) p 1 https://consultations.caa.co.uk/policy-development/type-certification-of-vtol-aircraft/supporting_documents/Policy%20Statement%20%20VTOL%20Initial%20Airworthiness.pdf

air authorities tend to use more technical terms. This is partly because the ambit of the term "drone" is not clear: it has been used to refer both to remotely piloted and autonomous aircraft. It has also been used in popular discourse to refer to land and/or marine-based vehicles.

2.42 Because of its popularity however, the term is often used for UK Government policy-making and communicating with the public. For example, it has been used in the Department for Business, Energy and Industrial Strategy ("BEIS"), as it then was, and Department for Transport policy paper "Advancing airborne autonomy: use of commercial drones in the UK", as well as two influential "Skies without limits" reports produced by PricewaterhouseCoopers International Ltd ("PwC") (the latter report in collaboration with BEIS).[102] That report focuses on "commercial drones", excluding "drones used by hobbyists, drones used to transport passengers and counter-drone solutions". The term is also used for public communication by the FAA[103] and EASA.[104]

"Without a pilot"

2.43 The expression "without a pilot" is little used today.[105] It appears in article 8 of the Chicago Convention, which provides that:

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

2.44 It is not clear from the face of the Convention whether the expression "without a pilot" means that there is no pilot on board, or no human pilot at all. A literal reading would suggest that it excludes aircraft piloted by a human, regardless of that human's location. However, ICAO has interpreted "pilotless aircraft" to mean the same as "unmanned aircraft", meaning that an aircraft can be "pilotless" for the purposes of article 8 even when it is controlled by a remote pilot.[106]

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102 PwC, BEIS and DfT, *Skies without limits* (2018); PwC, *Skies without limits v 2.0* (2022) https://www.pwc.co.uk/issues/emerging-technologies/drones/the-impact-of-drones-on-the-uk-economy.html

103 See for example, https://www.faa.gov/uas.

104 EASA, *Technical opinion to advance notice of proposed amendment (A-NPA) 2015-10: introduction of a regulatory framework for the operation of unmanned aircraft* (2015) p 5.

105 For a brief overview of the history of unmanned aircraft, see A Hobbs, *Remotely piloted aircraft systems*, Chapter for Human Factors in Aviation (3rd ed) https://ntrs.nasa.gov/api/citations/20210013529/downloads/CH0016_Hobbs_v1.pdf

106 See for example International Civil Aviation Organisation (ICAO), *Manual on remotely piloted aircraft systems (RPAS)* Doc 10019, First edition (2015) paras 1.2.3 to 1.2.7. For a more detailed analysis, see M Huttunen, "Unmanned, remotely piloted, or something else? Analysing the terminological dogfight" (2017) 42(3) *Air and space law* 349 p 356.

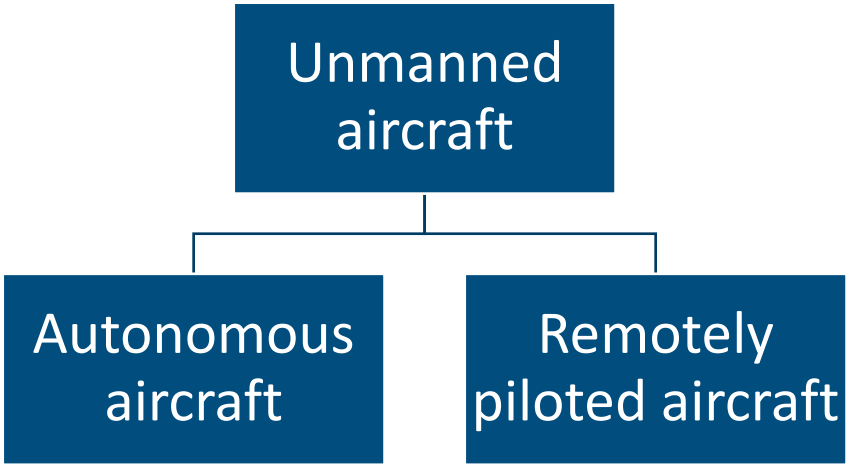
2.45 The term pilotless is used once in the Air Navigation Order 2016. That uses the phrase "pilotless flying machine" when defining the phrase "in flight".[107]

Unmanned aircraft (system) ("UAS")

2.46 The term "unmanned aircraft" is used both by ICAO and also within assimilated law. An "unmanned aircraft" is defined by the UK Basic Regulation as "any aircraft operating or designed to operate autonomously or to be piloted remotely without a pilot on board", as illustrated below.[108]

2.47 A similar approach is adopted by ICAO. ICAO has called an unmanned aircraft an aircraft "which is intended to operate with no pilot on board".[109] Finally, the FAA has also defined "unmanned aircraft" as meaning "an aircraft operated without the possibility of direct human intervention from within or on the aircraft".[110]

2.48 What these definitions tend to agree on is that the general class of "unmanned aircraft" can be divided into two: autonomous aircraft and remotely piloted aircraft (as illustrated and explored further below).



2.49 It should be noted that "unmanned" does not necessarily mean there are no humans at all in the aircraft. The focus on the pilot or operational role in the definitions above suggest there is no conceptual difficulty with an "unmanned" aircraft carrying human passengers or crew.

2.50 In the US, the FAA use an additional category of "small unmanned aircraft", meaning "an unmanned aircraft weighing less than 55 pounds on take-off, including everything that is on board or otherwise attached to the aircraft".[111] Similar definitions are used in

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107 Air Navigation Order 2016 SI No 765, art 3(b).

108 UK Regulation (EU) 2018/1139 on common rules in the field of civil aviation and establishing a European Union Safety Agency, art 3(3).

109 ICAO, *Unmanned aircraft systems (UAS)* Cir 328 AN/190 (2011) p x.

110 Code of Federal Regulations Title 14: Aeronautics and Space, § 1.1.

111 Code of Federal Regulations Title 14: Aeronautics and Space, § 1.1.

Jersey and Guernsey, although the limit there is 20kg, without fuel but including articles or equipment installed in or attached to the aircraft at the start of the flight.[112]

Unmanned aerial vehicle ("UAV")

2.51 A term that has been used in the past, but is less common now, is "unmanned aerial vehicle", or "UAV".[113] One objection to it is that there is no need within the aviation sphere to use two words ("aerial vehicle") where one, commonly used and accepted word ("aircraft") will do.

Remotely piloted aircraft (system) ("RPAS")

2.52 Annex 1 to the Chicago Convention defines a remotely piloted aircraft as "an unmanned aircraft which is piloted from a remote pilot station".

2.53 It further defines a remotely piloted aircraft system 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.[114]

2.54 A remote pilot is defined as:

> 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.

2.55 The UK UAS Delegated Regulation has a slightly different definition of remote pilot:

> a natural person responsible for safely conducting the flight of an unmanned aircraft by operating its flight controls, either manually or, when the unmanned aircraft flies automatically, by monitoring its course and remaining able to intervene and change its course at any time.[115]

2.56 In practice the distinction between a remotely piloted and an autonomous aircraft can be difficult to draw. In order to operate safely, a remotely piloted aircraft must be able to handle loss of connection with the "pilot". As explained by Alan Hobbs:

> A remotely piloted aircraft that relied on continuous pilot control inputs to maintain stable flight would be difficult to control via a satellite link, and would also be unable to tolerate link interruptions. For these reasons, virtually all

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112 Air Navigation (Jersey) Law 2014, art 1; Aviation (Bailiwick of Guernsey) Law 2012, arts 37(10)(a) and 152.

113 ICAO refer to the term as "obsolete": see *Unmanned aircraft systems (UAS)* Cir 328 AN/190 (2011) p vii and paras 1.3 – 1.4.

114 This definition differs slightly from that which will be applicable in Annex 8 (on airworthiness) from November 2026. That definition refers to a "C2 link" as opposed to a "command and control link". A C2 link is in turn defined as "the data link between the remotely piloted aircraft and the remote pilot station for the purposes of managing the flight".

115 UK Regulation (EU) 2019/945 on unmanned aircraft systems and on third-country operators of unmanned aircraft systems, art 3(27). A "natural person" is a term used in the law to distinguish an individual human person from bodies such as companies.

> remotely piloted aircraft require some level of on-board automation, and the role of the pilot becomes that of a supervisory controller rather than a human-in-the-loop manual controller.[116]

2.57 The result is that remotely piloted aircraft are likely to operate independently under particular conditions. Both the Chicago Convention's Annexes 1 and 8 and assimilated law definitions of remote pilot are drafted to reflect this.

2.58 As most commonly used (including by ICAO), the term RPAS is neutral as to the size of the aircraft or whether passengers are being carried. However, some users treat the phrases "RPAS" and "drone" as equivalents: for example, the Civil Aviation Safety Authority for Australia uses the term RPAS to mean "operations that use smaller aircraft with no passengers onboard".[117]

Autonomous or automated aircraft

2.59 For completeness, we include here the "autonomous" aircraft. More detail on what exactly is meant by "autonomous" in this context can be found above in the section starting at paragraph 2.17. We only note here that the phrase "automated" aircraft does not appear to be often used (unlike in the automated vehicles area). This may be partly because many aircraft functions have already been automated. The further jump to a self-piloting aircraft needs therefore to be given another name: hence "autonomous".

What about systems?

2.60 The word "system" is frequently added to both the terms "unmanned aircraft" and "remotely piloted aircraft" to include not just the aircraft, but any associated equipment. This gives the abbreviations "UAS" and "RPAS". The definition in Annex 2 to the Chicago Convention of a remotely piloted aircraft system is:

> 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.[118]

2.61 The UK UAS Implementing Regulation 2019/947 on the rules and procedures for the operation of unmanned aircraft defines "unmanned aircraft system" as an unmanned aircraft "and the equipment to control it remotely".[119]

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116 A Hobbs, *Remotely piloted aircraft systems*, Chapter for Human Factors in Aviation (3rd ed), p 5. https://ntrs.nasa.gov/api/citations/20210013529/downloads/CH0016_Hobbs_v1.pdf.

117 Civil Aviation Safety Authority for Australia, *The RPAS and AAM strategic regulatory roadmap* (2022) p 3 https://www.casa.gov.au/sites/default/files/2022-06/the-rpas-and-aam-roadmap.pdf.

118 Annex 2 to the Chicago Convention, Tenth Edition, 2005, including amendment 46, ch 1. This definition is applicable until 25 November 2026. From 26 November 2026 amendment 47 to the annex will apply, and the reference to "command and control links" will be replaced by a reference to "the required C2 Link(s)". This reflects a general change in the terminology from "command and control link" to "C2 Link"; both are however defined as "the data link between the remotely piloted aircraft and the remote pilot station for the purposes of managing the flight".

119 UK Regulation (EU) 2019/947 on the rules and procedures for the operation of unmanned aircraft, art 2(1).

2.62 Finally, the FAA also has a definition of an "unmanned aircraft system":

> an unmanned aircraft and its associated elements (including communication links and the components that control the unmanned aircraft) that are required for the safe and efficient operation of the unmanned aircraft in the airspace of the United States.[120]

2.63 The definition of "small UAS" is similar (see above at paragraph 2.50 for the definition of a "small unmanned aircraft").

2.64 It is worth noting that the word "system" is often used in the context of aviation. A modern aircraft is often already a "system of systems", even without factoring in equipment external to the aircraft itself.

RPAS and UAS: a difference in emphasis?

2.65 It was explained above that ICAO and EASA use "unmanned aircraft" as a generic term for aircraft operating with no pilot on board, and that the class can be broken down into aircraft piloted from outside the aircraft (RPAS) and autonomous aircraft. However, the two organisations have taken different approaches to the prominence to give to these terms. This is largely driven by the state of development of the technology, with RPAS expected by some to be used more widely in the short term.

2.66 ICAO's starting point has been to focus on RPAS, on the grounds that only these "could be integrated alongside manned aircraft in non-segregated airspace and at aerodromes".[121] This is reflected in its ongoing work to update the Annexes to the Convention; several of these (such as Annexes 1 and 2) now refer to RPAS, but do not discuss autonomous aircraft.[122] On the other hand, EASA has chosen to focus on the broader category of unmanned aircraft, precisely because it also accommodates autonomous aircraft.[123]

2.67 The CAA's recent guidance on "unmanned aircraft systems operations in UK airspace" explains that:

> The term 'Remotely Piloted Aircraft System (RPAS) is used interchangeably with the term UAS. The CAA now considers "RPAS" as the preferred terminology, rather than UAS, because it is gender inclusive.[124]

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120 Code of Federal Regulations Title 14: Aeronautics and Space, § 1.1.

121 ICAO, Manual on remotely piloted aircraft systems (RPAS) Doc 10019, First edition (2015) para 1.2.14. In addition, it is not focusing on the carriage of people as part of its initial regulatory framework: see ICAO, *Manual on Remotely Piloted Aircraft Systems (RPAS)* (2015), para 2.3.5.

122 See also ICAO, *Remotely piloted aircraft system (RPAS) concept of operations for international IFR (instrument flight rules) operations*, p 3. This does not consider fully autonomous flight, though may be updated to do so in the future. https://www.icao.int/safety/UA/Documents/ICAO%20RPAS%20CONOPS.pdf.

123 Technical Opinion to Advance Notice of Proposed Amendment (A-NPA) 2015-10: *Introduction of a regulatory framework for the operation of unmanned aircraft* (EASA 2015), p 4.

124 CAA, *Unmanned Aircraft System Operations in UK Airspace – Policy and Guidance* (December 2022) (CAP 722) p 12.

Gender

2.68 A further complicating factor is that aviation law contains a number of gendered terms. As explained above, this has driven the CAA's preference for "RPAS" as opposed to UAS. Other authorities are also concerned. As a result, there has been a general move away from some terms: for example, "Notices to Airmen" has generally been replaced by "Notices to Aviation" or "Notices to Air Missions". However, some terms remain, such as "unmanned". This is particularly difficult to get away from for the EU[125] and UK, where the bulk of legislation uses the phrase.

2.69 Various different attempts have been made to find an alternative. As noted above, the CAA generally use the term RPAS when not quoting from legislation.

2.70 Other actors use the phrase uncrewed, rather than unmanned. This approach has been adopted in the UK in the recently published BSI Flex on future flight systems vocabulary,[126] and has also been recommended as a short-term measure by the FAA's drone advisory committee.[127]

2.71 "Uncrewed" has the benefit of being able to keep the widely recognised abbreviation, UAS. However, there are two potential problems with it:

(1) It is not completely coterminous with "unmanned". "Unmanned" is generally accepted as meaning that there is no pilot on board an aircraft: it does not exclude the possibility of a remote pilot. However, a reasonable reader might expect "uncrewed" to mean there are no crew anywhere.

(2) There might be use cases in the future where aircraft operate with a cabin crew but no pilot. We are not aware of any suggestions of this at present, but it is a possibility.

The approach taken in this paper

What does successful terminology deliver?

2.72 Our terminology needs to capture accurately the different characteristics that matter for regulating aviation. That means it needs to:

(1) accommodate systems, as well as aircraft. The reality is that most uncrewed aircraft will be part of a broader system: there will be some element of ground control (whether this is sufficient to be classed as involving a "pilot" or not) and there will be communication links between the two.

(2) accommodate the fact that aircraft will have a variety of features, some displaying higher automation than others. Further, it is likely that aircraft will use

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125 In English and some other languages. Others use terminology corresponding to "without a crew".

126 British Standards Institution, *BSI Flex 1903 v 1.0 2023-08, Future flight systems – vocabulary* (August 2023).

127 Drone Advisory Committee, *FAA Gender-free Style Guide Recommendations* (2021). https://context-cdn.washingtonpost.com/notes/prod/default/documents/88fc49d7-0ded-4544-92fc-e2f467edb434/note/aa86295f-fb39-4f43-8849-6ba9be98f2ca.

more or less automated functions during different phases of the same operation.

2.73 There are also more general requirements that we would like our terminology to meet too. These include:

(1) **Clarity for the reader**. Given the diversity of terminology, most readers with any familiarity with aviation will expect to spend some time understanding the terminology used. However, in an ideal world, the term should convey as much of its meaning to the reader as possible. For this reason, and in the context of our project (which focuses on the long-term future of aviation), we intend to avoid using the term "RPAS" in the case of a system where there is no identifiable pilot.

(2) **Gender neutrality.**

(3) **Technological neutrality.** So far as possible, we should try to use technologically neutral terminology. For example, ideally terminology should avoid specifying that artificial intelligence, or any particular type of artificial intelligence (such as machine learning), must be involved. This should help any future system of regulation remain current, despite the rapid pace of development in this area.

What terminology have we adopted?

2.74 Our project requires terms for:

(1) **Aircraft where there are no people on board at all**. Our choice for this is "unoccupied" aircraft or, in some cases, "drone" (see further below).

(2) **Aircraft where there is no pilot on board**. The best suggestion we have found to date in existing literature is "uncrewed aircraft" ("UA" or "UAS", as appropriate): however, it is important to be clear that this term does not, in our view, exclude the possibility of a remote crew. Where it is necessary to specify that such aircraft carry passengers, our choice for this is "passenger only".

(a) **Aircraft where there is a pilot able to intervene during an aircraft's operation, but the pilot is not on board**. The obvious candidate here is "remotely piloted aircraft (system)", or RPAS.

(b) **Aircraft where there is no human pilot (or, if there is, where the pilot is not able to intervene during the normal course of the aircraft's operation).** We adopt here the term "autonomous". This is in line with the existing definition in UK law.

(c) **Aircraft with no pilots on board, that are under collective control and in flight simultaneously**. We use the term "multiple simultaneous operations" or "MSO" in this paper. See Chapter 6, paragraphs 6.111 for further discussion.

2.75 None of these terms implies the use of any particular technology (such as machine learning).

2.76 Additionally, we must decide on the terminology we use to describe our two use cases. One of the use cases we have been asked to look at is "drones". As discussed above, "drone" is not a legal term and there is no universally accepted definition. In the subsequent chapters of this consultation paper, we use the term as it is generally understood by the public, namely to refer to uncrewed aircraft generally smaller than traditional aircraft, which are unoccupied and can be remotely piloted or are autonomous.

KEY EXISTING ROLES

2.77 We outline here some of the key roles played in the operation of an aircraft today, focusing on those which are likely to be significantly affected by greater automation or autonomous operations. We do not cover here those involved in initial and ongoing airworthiness: for an in-depth discussion, see Chapter 4 paragraph 4.36 to 4.40. Readers familiar with aviation may wish to move past this section.

Aircraft operators

2.78 An operator is defined for the purposes of the Air Navigation Order 2016 as "in relation to any particular aircraft… the person who at the relevant time has the management of that aircraft."[128] The operator has a broad range of responsibilities relating to the operation and safety of the aircraft used. These include ensuring that aircraft are maintained, staffing aircraft with sufficient personnel, holding insurance and ensuring ground infrastructure.

2.79 To carry out commercial air transport operations, the operator must hold an air operator certificate. In the UK, the CAA is responsible for issuing these certificates and overseeing the operator's conduct following the granting of a certificate.

2.80 Where an aircraft is leased without a crew (a "dry lease") the aircraft is operated under the lessee's air operator certificate. Where the lessor provides the aircraft and crew (a "wet lease") the aircraft is operated under the lessor's certificate.[129]

2.81 Operators are likely to be particularly affected by autonomous flight. Even if pilots are no longer part of the equation, operators will remain ultimately responsible for managing aircraft and ensuring their safe operation.

Aircrew

2.82 At present, aircraft are staffed by aircrew: a term encompassing flight crew and cabin crew.[130]

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128 SI 2016 No 765, art 4(1).

129 UK Regulation (EU) 965/2012 laying down technical requirements and administrative procedures related to air operations, annex I, paras 40 and 127.

130 UK Regulation (EU) 1178/2011 laying down technical requirements and administrative procedures related to civil aviation aircrew, art 2(12).

Flight crew

2.83 Flight crew are responsible for the operation of aircraft during flight. Flight crew includes any member of crew acting as a pilot, flight navigator, flight engineer, or flight radiotelephony operator.[131]

2.84 While these roles still exist in the law, the general trend in aviation is for a decreasing number of flight crew, with most modern commercial aircraft operating with just two pilots.[132] To the extent that they have not been made obsolete by technology, the other roles are combined with that of the pilot. A high level overview of each role is provided below. Given its importance in modern aviation, the role of the pilot is considered separately. A more detailed exploration of the responsibilities of the pilot and the impact of removing the role can be found in Chapter 6.63 to 6.72.

(1) **Flight navigators** are responsible for the navigation of aircraft, planning the aircraft's route and ensuring the pilot stays on course. Additionally, the navigator responds to obstructions, adapting routes accordingly. Flight navigators are no longer found on modern aircraft, with new technologies making the role obsolete.

(2) **Flight engineers** monitor the functioning of aircraft and control various systems. In the event of a fault arising, engineers diagnose and, if possible, fix the issue. We understand that the role of the onboard flight engineer is now also largely obsolete, as technological advances mean that the monitoring and adjusting of systems can be done automatically.

(3) **Flight radiotelephony operators** are licensed to operate aircraft radio apparatus. The relevant licence is usually held in conjunction with another flight crew licence (eg pilot).[133]

Pilots and remote pilots

2.85 The pilot is the most central member of the flight crew: Timothy Schultz explains that "the traditional paradigm of manned flight places the pilot at the centre of the aviation universe".[134] The Chicago Convention defines the role of the pilot as being to "manipulate the flight controls of aircraft during flight".[135]

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131 Air Navigation Order 2016 SI No 765, sch 1(1). Although note that the number of pilots required will depend on the aircraft and length of flight, with some long-haul flights requiring four pilots.

132 EASA, *An approach to new operational concepts involving extended minimum crew operations and single-pilot operations* (August 2022) paras 2.2 and 2.3. https://www.icao.int/Meetings/a41/Documents/WP/wp_101_en.pdf

133 https://www.caa.co.uk/general-aviation/pilot-licences/flight-radio-telephony-operator-licence/#:~:text=The%20Flight%20Radiotelephony%20Operator%27s%20Licence,with%20another%20Flight%20Crew%20licence.

134 T P Schultz, *The problem with pilots* (2018) p 159.

135 Annex 1 to the Chicago Convention, Fourteenth Edition, 2022, including amendment 178, ch 1; UK Regulation (EU) 923/2012 laying down the common rules of the air and operational provisions regarding services and procedures in air navigation, art 2(100).

2.86 The number of pilots required will depend on the aircraft and length of flight;[136] commercial aircraft will typically have two pilots on board. Of these, the pilot-in-command is "in command and charged with the safe conduct of the flight".[137] Other pilots are referred to as co-pilots.[138]

2.87 The definitions of remote pilot are similar to that of "pilot". As noted above, the Chicago Convention defines a remote pilot as "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".[139]

2.88 The UK UAS Delegated Regulation has a slightly more complex definition of a remote pilot:

> a natural person responsible for safely conducting the flight of a UA by operating its flight controls, either manually or, when the UA flies automatically, by monitoring its course and remaining able to intervene and change its course at any time.[140]

2.89 Both definitions reflect the fact that a remotely piloted aircraft is likely to be highly automated and will not require a pilot to be constantly adjusting its flight controls.

2.90 The introduction of remote piloting has given rise to a new possibility in aviation: having one remote pilot controlling multiple aircraft. There is no specific term in legislation for this in the UK. One which has been suggested by BSI is "supervisory remote pilot in command", meaning the remote pilot "designated as having responsibility for all uncrewed aircraft engaged in a multiple simultaneous operation".[141]

Air traffic controllers and flight information service operators

2.91 The background paper on air traffic management and air navigation services (available on our website) sets out in more detail what services are provided in UK airspace and how these are structured. Here we identify the individuals and organisations involved in providing these services. Air traffic controllers and flight information service operators provide air traffic management and air navigation

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136 https://www.caa.co.uk/commercial-industry/airlines/flight-time-limitations/flight-time-limitations-guidance-and-resources/

137 Annex 1 to the Chicago Convention, Fourteenth Edition, 2022, including amendment 178, ch 1; UK Regulation (EU) 923/2012 laying down the common rules of the air and operational provisions regarding services and procedures in air navigation, art 2(100).

138 Annex 1 to the Chicago Convention, Fourteenth Edition, 2022, including amendment 178, ch 1.

139 Annex 1 to the Chicago Convention, Fourteenth Edition, 2022, including amendment 178, ch 1.

140 UK Regulation (EU) 2019/945 on unmanned aircraft systems and on third-country operators of unmanned aircraft systems, art 3(27).

141 British Standards Institution, *BSI Flex 1903 v 1.0 2023-08, Future flight systems – vocabulary* (August 2023) para 3.1.80.

services.[142] The provider and nature of the service depends on the class and structure of the airspace, as well as the type of flight.[143]

2.92 In controlled airspace, information is provided by an air traffic controller. Before take-off and after landing, air traffic controllers assist pilots to taxi around aerodromes. Air traffic controllers also provide support during take-off, informing the pilot when it is safe to begin flight. Once in the air, air traffic controllers provide navigation services, and in particular ensure a safe distance is maintained between aircraft. During flight, an aircraft's location will determine its assigned air traffic controller, who are assigned to sectors of airspace rather than routes. Upon arrival at their destination, a pilot will contact the aerodrome's air traffic controllers, who will give the pilot clearance to land and provide guidance around the aerodrome.

2.93 The role of the air traffic controller is limited in uncontrolled airspace where aircraft may be flown without air traffic control clearance or air traffic services (typically in more remote areas).[144] Instead, flight information service officers will often provide a basic service (including weather information, general airspace activity and aerodrome facilities) upon request.[145] Air traffic controllers may also provide this information, particularly if flight information service officers do not provide a 24/7 service.[146]

2.94 In uncontrolled airspace, there is no obligation to be in contact with an air traffic controller or flight information service officer. Pilots may request these services if desired; however, availability of services will vary depending on capacity, the time of day, and other factors.

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142 CAA, *Airspace Fundamentals and the Future of Flight* (July 2023)(CAP 2530), para 1.11.

143 See https://www.nats.aero/ae-home/introduction-to-airspace/

144 For one example, see Shobdon Airfield, located in Herefordshire. https://www.visitherefordshire.co.uk/discover/shobdon-airfield

145 This Basic Service is one of four services which are collectively known as UK Flight Information Services (UK FIS). See CAA, *Airspace Fundamentals and the Future of Flight* (July 2023) (CAP 2530) p 46.

146 https://nats.aero/blog/2015/11/what-is-a-fiso/

Chapter 3: UAS regulation

3.1 This chapter gives an overview of the regulatory framework that governs the use of uncrewed aircraft systems ("UAS") in the UK, providing background for the policy issues and provisional proposals that are discussed in following chapters (and in particular Chapter 6 and Chapter 7). Readers who are already familiar with the legal and regulatory framework may wish to move on to later chapters.

3.2 The Civil Aviation Act 1982 does not contain a definition of aircraft. Nonetheless, our view is that the Civil Aviation Act 1982 and the Air Navigation Order 2016 ("ANO") probably do apply to uncrewed aircraft, except to the extent specified otherwise in the ANO. Uncrewed aircraft are also within the scope of UK Regulation (EU) 2018/1139 (the "Basic Regulation"). This applies to aircraft registered in, or operated by an operator registered in, the UK, and to unregistered unmanned aircraft that are operated within the UK. A specific regulatory regime for UAS has been devised in EU law in Regulations made under the Basic Regulation; these now form part of assimilated law. This specific regime consists of two complementary regulations:

(1) UK Regulation (EU) 2019/945 (the "UAS Delegated Regulation"), which sets out requirements in relation to the design and production of UAS; and

(2) UK Regulation (EU) 2019/947 (the "UAS Implementing Regulation"), which contains rules governing the operation of a UAS.[147]

3.3 The overall approach underpinning the UAS regulatory regime is that the applicable rules and procedures should be proportionate to the nature and risk of the operation in question. This means that the characteristics of the intended UAS operation determine the applicable rules at both the design and production stage and the operation stage.

3.4 The UAS Regulations establish three categories of operations.

(1) **Open**: operations in the "open" category present the lowest risk and do not require prior authorisation. Autonomous operations are not permitted, and flights must be kept within the line of sight of the remote pilot. There is a maximum weight limit of 25kg, and there are restrictions in relation to flying altitude and proximity to people.

(2) **Specific**: operations in the "specific" category present a greater risk and require an authorisation by the Civil Aviation Authority ("CAA") that is specific to the operation.

(3) **Certified**: Operations in the "certified" category require the certification of the UAS and the operator and, where applicable, the licensing of the remote pilot.

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147 UK Regulation (EU) 2019/947 on the rules and procedures for the operation of unmanned aircraft and UK Regulation (EU) 2019/945 on unmanned aircraft systems and on third-country operators of unmanned aircraft systems.

> Operations fall into this category if they involve an aircraft of over 3m in size, or if they carry people or high risk dangerous goods.

3.5 The "open" category is subdivided into three further sub-categories which we discuss below.[148] As currently structured, the open category is of limited practical application to new forms of UAS. Most proposed uses for drones, for example, involve flying beyond the visual line of sight of the pilot (known as "BVLOS") and would therefore fall within the specific or certified categories. Our other use case, VTOLs, involves carrying passengers, and therefore would fall within the certified category. As far as we are aware, there are no certified UAS in the UK at present. One key blocker is the lack of agreed certification standards (or "specifications") to which such UAS could be designed and built.

3.6 In this paper we use the current terminology for the existing categories. We note however that the CAA has recently closed a consultation on UAS legislation, having carried out a call for input over the summer of 2023. This included a proposal to rename sub-categories within the open category, and improve the clarity of the operational rules for UAS within the open category.[149]

Class marking: transitional provisions

3.7 The UAS Delegated Regulation sets out design requirements applicable to UAS in the open and specific categories.[150] It establishes and describes seven "classes" of UAS: Classes C0 to C6.

3.8 Once a UAS has passed a conformity assessment, the UAS Delegated Regulation requires manufacturers to draw up a certificate of conformity and affix a class marking indicating the class into which the UAS falls.

3.9 However, as noted in CAA guidance:

> Currently, it is not possible for manufacturers to comply with these requirements in the UK, due to the lack of designated standards, or Conformity Assessment Bodies, established under this regulation. As such, there are currently no UAS in the UK which are class marked in accordance with this regulation. This is subject to a regulatory review to be conducted by the DfT and the CAA in due course.[151]

3.10 In a recent consultation the CAA has proposed to implement UK class marking from 1 January 2026.[152] UAS which are marked with a class mark, in accordance with the EU

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148 UK Regulation (EU) 2019/947 on the rules and procedures for the operation of unmanned aircraft, art 4(2) and annex, part A.

149 Civil Aviation Authority, *Consultation: review of UK UAS regulations* (November 2023) (CAP 2610).

150 UK Regulation (EU) 2019/945 on unmanned aircraft systems and on third-country operators of unmanned aircraft systems, arts 2(1), 4 and annex, parts 1 to 5 and 16 to 17.

151 CAA, *Unmanned aircraft system operations in UK airspace – policy and guidance* (December 2022) (CAP 722) para 2.2.1.3.

152 CAA, *Consultation: Review of UK Unmanned Aircraft Systems (UAS)* (November 2023) (CAP 2610) pp 19 to 20. The CAA proposes to continue to align UK class marking and product standards with the EU "unless

version of this regulation, are not recognised in the UK as being class marked, and must be flown under other open category provisions (ie legacy, transition, or non-class marked).[153]

3.11 Transitional provisions have been put in place to allow UAS which are not class-marked to be flown up until January 2026.[154] According to these provisions, UAS which are not class-marked are permitted if they meet certain criteria relating to operational requirements and maximum take-off mass. This is subject to a regulatory review to be conducted by the DfT and the CAA. [155] Legacy UAS, that is UAS products which (a) are not privately built, (b) do not conform to the class markings, and (c) are placed on the market before 1 January 2026, may only be used in the A1 and A3 subcategory of open category operations, subject to mass requirements.[156]

Design requirements

3.12 As noted above, the UAS Delegated Regulation contains design requirements for seven "classes" of UAS within the open and specific categories. Maximum take-off mass ("MTOM") is an important characteristic for each of the classes. Class C0 UAS craft must have a MTOM of less than 250g, including any payload.[157] Class C1 craft must either have a MTOM including payload of less than 900g or be designed to transmit energy of less than 80 joules to a human head in the event of impact at terminal velocity. Class C2 craft must have a MTOM including payload of less than 4 kg, while class C3 and class C4 craft must be less than 25 kg.

3.13 Classes C1 to C3 craft must be equipped with a "geo-awareness" system. This means a function that detects potential breaches of airspace limitations and alerts pilots so

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there is a safety, security or user benefit that requires divergence." It is envisaged Secretary of State will designate technical standards that have been adopted by the British Standards Institute (BSI) by which manufacturers can be judged against. These drones will then be labelled with a UK specific identification label so that, for example, the C1 drone would have a marking which reads "UK1".

153 CAA, *Unmanned aircraft system operations in UK airspace – policy and guidance* (December 2022) (CAP 722) para 2.2.1.3. According to the guidance "legacy" UAS refers to UAS products (not privately built) which have been placed on the market before 1 January 2026 but do not confirm to the class marking regime. The "transition category" (called transitional arrangements in CAA guidance) refers to the transitional provisions in art 22 of the UAS Implementing Regulation. This applies before 1 January 2026 and allows UAS which do not conform with Parts 1 to 5 of the annex to the UAS Delegated Regulation (the class marking provisions) to operate subject to conditions relating to MTOM. "Non-class marked" is not defined in the CAA guidance but presumably relates to privately built UAS which are not class marked.

154 UK Regulation (EU) 2019/947 on the rules and procedures for the operation of unmanned aircraft, art 22. The transitional provisions are needed because, as noted above, there are currently no UAS in the UK which are class marked in accordance with the UAS Delegated Regulation. The CAA has also proposed in a consultation that the existing transitional arrangements be extended to 1 January 2028. See CAA, *Consultation: Review of UK Unmanned Aircraft Systems (UAS)* (November 2023) (CAP 2610) pp 30 to 31.

155 CAA, *Unmanned aircraft system operations in UK airspace – policy and guidance* (December 2022) (CAP 722) para 2.2.1.3.

156 CAA, *Unmanned aircraft system operations in UK airspace – policy and guidance* (December 2022) (CAP 722) para 2.2.1.3.

157 "Payload" is defined as "instrument, mechanism, equipment, part, apparatus, appurtenance, or accessory, including communications equipment, that is installed in or attached to the aircraft and is not used or intended to be used in operating or controlling an aircraft in flight, and is not part of an airframe, engine, or propeller". UK Regulation (EU) 2019/945 on unmanned aircraft systems and on third-country operators of unmanned aircraft systems, art 3(29).

they can take immediate action. Such systems are based on information provided by the CAA.[158] Airspace limitations are conditions attached to how a UAS may operate in a specific geographical zone. They may include: complete prohibitions of UAS operations; specified environmental standards; restrictions of certain UAS classes; and requirements to carry certain equipment.[159] At present there are no geographical zones established within the UK as the preferred approach is to rely on airspace restrictions under article 239 of the ANO.[160] The CAA has consulted on plans to extend airspace limitations to include any airspace restriction applicable to UAS.[161]

3.14 Recently, the CAA has consulted on whether to extend geo-awareness requirements to class C0 aircraft with cameras. It has also consulted on whether all operations in the open category should be required to have an active geofencing function for classes C1 to C3 UAS and C0 UAS with cameras, which would automatically limit the airspace the aircraft could enter.[162]

3.15 Class C5 and class C6 UAS must adhere to almost all the requirements of a class C3 UAS. However, unlike class C3 UAS, class C5 and class C6 UAS are not limited to a maximum altitude of 120m.[163] Furthermore, they do not have the same requirements to be equipped with geo-awareness system. Class C6 UAS are also exempt from the requirement to be powered exclusively by electricity.[164] Because class C5 and class C6 UAS do not have to comply with the altitude requirement of 120m from the closest point of the surface of the earth, class C5 and class C6 drones must be used in the specific category.

3.16 Manufacturers must ensure when placing a class C0 to C6 UAS on the market that it has been designed and manufactured in compliance with the design requirements set out in the annex to the UAS Delegated Regulation. To do this, they must carry out a conformity assessment procedure.[165] Alternatively, the conformity assessment

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158 UK Regulation (EU) 2019/945 on unmanned aircraft systems and on third-country operators of unmanned aircraft systems, art 3(32).

159 See UK Regulation (EU) 2019/945 on unmanned aircraft systems and on third-country operators of unmanned aircraft systems, art 15.

160 UK Regulation (EU) 2019/947 on the rules and procedures for the operation of unmanned aircraft, GM1 UAS.OPEN.060(1)(b); see also CAA, *Unmanned Aircraft Systems: UAS Airspace Restrictions Guidance and Policy,* 2nd ed (December 2022) (CAP 722C) section 1.1.

161 CAA, *Consultation: Review of UK Unmanned Aircraft Systems (UAS)* (November 2023) (CAP 2610) p 28.

162 CAA, *Consultation: Review of UK Unmanned Aircraft Systems (UAS)* (November 2023) (CAP 2610) pp 26 to 29. In order to implement geo-awareness fully, the CAA proposes to complete technical changes such as making temporary airspace restrictions machine readable, as currently only permanent restrictions are standardised for geo-fencing.

163 UK Regulation (EU) 2019/945 on unmanned aircraft systems and on third-country operators of unmanned aircraft systems, annex, parts 16 to 17.

164 UK Regulation (EU) 2019/945 on unmanned aircraft systems and on third-country operators of unmanned aircraft systems, annex, part 17.

165 UK Regulation (EU) 2019/945 on unmanned aircraft systems and on third-country operators of unmanned aircraft systems, annex, parts 7 to 9.

procedure can be outsourced to a conformity assessment body, which has been approved by the Secretary of State.[166]

3.17 Importers and distributors have obligations to ensure products that they place on the market adhere to the requirements of the UAS delegated Regulation.[167] In particular, they must verify that the product bears the requisite UK marking.

3.18 We examine each of the operation categories in turn.

OPEN CATEGORY

3.19 The open category is intended for low-risk flights. Article 4 of the UAS Implementing Regulation sets the following cumulative criteria for an operation to fall within the open category:

(1) the UAS must belong to one of the classes set out in the UAS Delegated Regulation or be privately built;[168]

(2) aircraft must have a maximum take-off mass of less than 25 kg;

(3) the remote pilot must ensure that the craft is kept at a safe distance from people and that it is not flown over assemblies of people;[169]

(4) the remote pilot must ensure that the craft is kept in visual line of sight ("VLOS") at all times except when flying in "follow-me" mode or when using an unmanned aircraft observer;[170]

(5) during flight, the craft must be maintained within 120m of the closest point of the surface of the earth, except when overflying an obstacle; and

(6) the craft must not carry dangerous goods and must not drop any material.[171]

3.20 Autonomous operations are not allowed in the open category: the remote pilot must also be able to take control of the aircraft at any time, except in the event of a lost-link

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166 UK Regulation (EU) 2019/945 on unmanned aircraft systems and on third-country operators of unmanned aircraft systems, art 18.

167 UK Regulation (EU) 2019/945 on unmanned aircraft systems and on third-country operators of unmanned aircraft systems, arts 8 and 9.

168 UAS which do not meet these criteria are permitted if they are placed on the market before 1 January 2026.

169 "Assemblies of people" are defined as "gatherings where persons are unable to move away due to the density of the people present": UK Regulation (EU) 2019/945 on unmanned aircraft systems and on third-country operators of unmanned aircraft systems, art 3(37); UK Regulation (EU) 2019/947 on the rules and procedures for the operation of unmanned aircraft, art 2(3).

170 UK Regulation (EU) 2019/947 on the rules and procedures for the operation of unmanned aircraft, art 2(14) defines "follow-me mode" as "a mode of operation of a UAS where the unmanned aircraft constantly follows the remote pilot within a predetermined radius". An unmanned aircraft observer is an observer positioned alongside the remote pilot.

171 UK Regulation (EU) 2019/947 on the rules and procedures for the operation of unmanned aircraft, art 4(1).

condition or a free-flight uncrewed aircraft.[172] Additional guidance, in the form of "acceptable means of compliance" ("AMC") makes it clear that the remote pilot should only operate one such aircraft at a time.[173]

Open category – operational rules

3.21 The Implementing Regulation places some general obligations on the remote pilot and UAS operator for all operations in the open category. It further divides the open category into subcategories A1, A2 and A3 (largely based on how close an operation is to people) and lays down some rules specific to each.[174]

3.22 First of all, the operator must do a number of basic things such as develop operational procedures adapted to the type of operation and risk involved;[175] and designate a remote pilot who must, along with any other personnel involved, fulfil a number of criteria.[176] They must also ensure that all operations effectively use and support the efficient use of radio spectrum in order to avoid harmful interference;[177] and update the information into the geo-awareness system, when applicable, according to the intended location of operation.[178] Finally, the operator must ensure that for A2 and A3 operations, all involved persons present in the area of the operation have been informed of the risks and have explicitly agreed to participate.[179]

3.23 The remote pilot has responsibilities both before and during the UAS operation. Before the operation, there are responsibilities in relation to the condition of the UAS[180] and the operating environment, including the presence of obstacles or any

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172 UK Regulation (EU) 2019/947 on the rules and procedures for the operation of unmanned aircraft, GM2 UAS.OPEN.060 (2)(d). This explains that a "free-flight" UA is one that flies without external control.

173 UK Regulation (EU) 2019/947 on the rules and procedures for the operation of unmanned aircraft AMC1 UAS.OPEN.060 (2)(d) (CAA ORS9 Decision No.16).

174 The CAA as part of its most recent UAS consultation have proposed to change the names of these categories to "Over", "Near" and "Far" which are thought to be more intuitive and reflect the key operational differences between each category which is the allowed distance of uninvolved persons. See CAA, *Consultation: Review of UK Unmanned Aircraft Systems (UAS*) (November 2023) (CAP 2610) p 13.

175 UK Regulation (EU) 2019/947 on the rules and procedures for the operation of unmanned aircraft, annex, UAS.OPEN.050(1).

176 UK Regulation (EU) 2019/947 on the rules and procedures for the operation of unmanned aircraft, annex, UAS.OPEN.050(3) and (4). The criteria that must be fulfilled by the remote pilot include matters such as having appropriate competency (ie, completed the requisite training), being familiar with the operator's procedures, and being familiar with the manufacturer's instructions.

177 UK Regulation (EU) 2019/947 on the rules and procedures for the operation of unmanned aircraft, annex, UAS.OPEN.050(2).

178 UK Regulation (EU) 2019/947 on the rules and procedures for the operation of unmanned aircraft, annex, UAS.OPEN.050(5).

179 UK Regulation (EU) 2019/947 on the rules and procedures for the operation of unmanned aircraft, annex, UAS.OPEN.050(7).

180 UK Regulation (EU) 2019/947 on the rules and procedures for the operation of unmanned aircraft, annex, UAS.OPEN.060(1)(d).

uninvolved persons.[181] There are further obligations to check the mass of the UAS[182] and to obtain updated information on any geographical zones delimiting the operation.[183]

3.24 During the flight, the remote pilot must:

(1) not perform duties under the influence of psychoactive substances or alcohol or when unfit due to injury, fatigue, medication, sickness or other causes;

(2) keep the unmanned aircraft in VLOS, maintain a thorough visual scan of the airspace surrounding the unmanned aircraft in order to avoid any risk of collision with any manned aircraft, and discontinue the flight if the operation poses a risk to other aircraft, people, animals, environment or property;

(3) comply with the operational limitations in geographical zones defined in accordance with article 15 of the UAS Implementing Regulation;

(4) have the ability to maintain control of the unmanned aircraft, except in the case of a lost link or when operating a free-flight unmanned aircraft;

(5) operate the UAS in accordance with manufacturer's instructions provided by the manufacturer, including any applicable limitations; and

(6) comply with the operator's procedures when available. [184]

3.25 There is also a requirement in the original EU regulation to ensure the UA has on it an activated flashing light when operating at night. This, however, only became applicable after the end of the transition period following the UK's exit from the EU, and as such it does not form part of assimilated law. However, the CAA has proposed to introduce this obligation in UK regulation in the future.[185]

3.26 All operations in the open category must take place at a distance less than 120m from the closest point on the surface of the earth.[186]

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181 UK Regulation (EU) 2019/947 on the rules and procedures for the operation of unmanned aircraft, annex, UAS.OPEN.060(1)(c).

182 UK Regulation (EU) 2019/947 on the rules and procedures for the operation of unmanned aircraft, annex, UAS.OPEN.060(1)(e).

183 UK Regulation (EU) 2019/947 on the rules and procedures for the operation of unmanned aircraft, annex, UAS.OPEN.060(1)(b).

184 UK Regulation (EU) 2019/947 on the rules and procedures for the operation of unmanned aircraft, annex, UAS.OPEN.060(2).

185 CAA, *Consultation: Review of UK Unmanned Aircraft Systems (UAS)* (November 2023) (CAP 2610) p 29.

186 UK Regulation (EU) 2019/947 on the rules and procedures for the operation of unmanned aircraft, annex, UAS.OPEN.010(2) and (3). This is the general rule. There are some exceptions; for example, the maximum height of the operation may be increased by up to 15m if the UAS is being flown within 50m from an artificial obstacle taller than 105m (at the request of the entity responsible for the obstacle, whose permission to fly within 50m of the obstacle is required).

3.27 As already noted, open category operations are sub-divided into three categories. Particular operational rules apply to each of these categories.

SPECIFIC CATEGORY

3.28 The specific category of operations can be seen as a residual category, covering operations which do not fall into either the open or certified categories.[187] For such operations, the operator must apply to the CAA for a "specific" operational authorisation; this involves submission of a risk assessment.

3.29 On the basis of the risk assessment, the CAA may determine that the risks of an operation cannot be adequately mitigated without certification of the system and the operator. The CAA may also determine that the licensing of the remote pilot (if there is one) is necessary.[188] In these cases, the operation will need to be conducted in the certified category.

Authorisation

3.30 As part of the risk assessment, the UAS operator must propose mitigating measures to keep the UAS operation safe in all phases of flight. Article 11 of the UAS Implementing Regulation sets out the rules for conducting an operational risk assessment.[189]

3.31 The CAA must then evaluate the risk assessment and mitigating measures before it can grant operational authorisation.[190] The operational authorisation will detail the required technical capabilities of the UAS.[191]

3.32 Applicants may also use a template risk assessment, which has been pre-defined and published in advance by the CAA. These are known as pre-defined risk assessments ("PDRA") and apply to repeatable and low risk operations in the specific category.[192] Two PDRAs were in use by the CAA in 2020 and 2021.

3.33 PDRA 01 applies to VLOS operations within 150m of any residential, commercial, industrial or recreational areas for UAS with a MTOM less than 25kg. It is the more commonly used of the two, with 4,267 applications granted in 2021. By contrast, only six applications have been granted in relation to PDRA 02, which applies to short term initial research and development flights for UAS with a MTOM between 25kg and 250kg.

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187 UK Regulation (EU) 2019/947 on the rules and procedures for the operation of unmanned aircraft, arts 5(1) and 6.

188 UK Regulation (EU) 2019/947 on the rules and procedures for the operation of unmanned aircraft, art 6(2).

189 The CAA is currently adapting AMC for art 11.

190 UK Regulation (EU) 2019/947 on the rules and procedures for the operation of unmanned aircraft, art 12(1).

191 UK Regulation (EU) 2019/945 on unmanned aircraft systems and on third-country operators of unmanned aircraft systems, art 40(3).

192 CAA, *Specific category operations: pre-defined risk assessment requirements, guidance and policy* (August 2023) (CAP 722H) para 1.1.

3.34 The CAA is currently reviewing its PDRAs. Only PDRA 01 is available at the moment. Our understanding is that PDRA 02 is currently under review and initial and renewal applications are not being accepted. Further template PDRAs, including in relation to BVLOS flight, have been developed by the Joint Authorities for Rulemaking on Unmanned Systems.[193]

3.35 There are two circumstances in which an operational authorisation is not required. The first is where the operation is performed by an operator holding a light UAS operator's certificate.[194] This certificate grants the holder certain privileges, including being able to authorise parts of their own operation. The second is where the operation is conducted within the framework of model aircraft clubs and associations.[195]

Specific category – operational rules

3.36 The UAS Implementing Regulation places responsibilities on the operator and remote pilot for operations in the specific category. Many of the responsibilities of the operator overlap with the responsibilities prescribed for operations in the open category. In general, the responsibilities of an operator are slightly more detailed, especially in terms of the procedures to be established.[196] Notably, the possibility of autonomous flight is alluded to, with the operator required to designate a remote pilot for each flight

> or, *in the case of autonomous operations*, ensure that during all phases of flight, responsibilities and tasks…are properly allocated in accordance with the procedures established [in line with the Regulation's requirements].[197]

3.37 Guidance material issued by the CAA elaborates on the possibility of autonomous flight in the specific category. The risk assessment of autonomous operations should ensure, as with any other operation, that the risk is mitigated to an acceptable level.[198]

3.38 The responsibilities of the remote pilot are similar to those prescribed for operations in the open category. One added responsibility is:

> to ensure that the information about the operation has been made available to the relevant air traffic service ("ATS") unit, other airspace users and relevant

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193 See for example, *PDRA 5 for Aerial Work Operations* (December 2022), http://67.217.59.217/jarus/wp-content/uploads/2023/06/jar_20_doc_PDRA-05_edition-1.0.pdf .

194 UK Regulation (EU) 2019/947 on the rules and procedures for the operation of unmanned aircraft, art 5(6)(a).

195 UK Regulation (EU) 2019/947 on the rules and procedures for the operation of unmanned aircraft, art 5(6)(b). A separate authorisation process exists for this.

196 UK Regulation (EU) 2019/947 on the rules and procedures for the operation of unmanned aircraft, annex, part B, UAS.SPEC.050. In general, the responsibilities are slightly more detailed, especially in terms of the procedures to be established. There are a couple of other differences, including a reference to the human/machine interface being such as "to minimise the risk of pilot error and not cause unreasonable fatigue".

197 UK Regulation (EU) 2019/947 on the rules and procedures for the operation of unmanned aircraft, annex, part B, UAS.SPEC.050(1)(b).

198 UK Regulation (EU) 2019/947 on the rules and procedures for the operation of unmanned aircraft, GM1 UAS.SPEC.050(1)(b).

stakeholders, as required by the operational authorisation or by the conditions designated by the Secretary of State for the geographical zone of operation in accordance with article 15.[199]

In the case of autonomous operations, responsibility for ensuring that the UAS is in a safe condition attaches to the operator (as there is no remote pilot).[200]

3.39 A small number of provisions of the UK Standardised European Rules of the Air ("UK SERA") are applied to operations in the specific category pursuant to article 7(2) of the UAS Implementing Regulation. These are listed in the accompanying AMC. Operators must consider the listed requirements and consider their relevance to the operation. Relevant requirements should be included within the operations manual, with the result that they become mandatory for the operator to follow. The CAA may also apply any additional applicable requirements of the rules of the air as a condition of an operational authorisation.

3.40 The AMC suggests that the following apply to all specific category UAS operations.

(1) SERA.2020: No person whose function is critical to the safety of aviation … shall undertake that function while under the influence of any psychoactive substance, by reason of which human performance is impaired. No such person shall engage in any kind of problematic use of substances.

(2) SERA.3101: An aircraft shall not be operated in a negligent or reckless manner so as to endanger life or property of others.

(3) SERA.3145: Aircraft shall not be flown in a prohibited area, or in a restricted area, the particulars of which have been duly published, except in accordance with the conditions of the restrictions or by permission of the Secretary of State.

(4) SERA.3205: An aircraft shall not be operated in such proximity to other aircraft as to create a collision hazard.

3.41 Other requirements are highlighted but their applicability is marked as "as required". These include SERA.3201 (collision avoidance), and SERA.3210 (right of way). [201]

3.42 The Rules of the Air Regulations 2015, which supplement UK SERA, do not apply to UAS in the specific category (for a more detailed explanation of how these regulations interact with UK SERA, see paragraph 5.24-5.28). Moreover, UAS in the specific category are excepted from almost the whole of the ANO.[202]

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199 UK Regulation (EU) 2019/947 on the rules and procedures for the operation of unmanned aircraft, annex, UAS.SPEC.060(2)(d).

200 See UK Regulation (EU) 2019/947 on the rules and procedures for the operation of unmanned aircraft, AMC1 UAS.SPEC.060(2)(c).

201 It is important to note that UK SERA.6001 (classification of airspace) is not included in AMC1 to Art 7(2) of the UAS Implementing Regulation, and therefore does not apply to UAS operations in the specific category.

202 SI 2016 No 765, art 23.

CERTIFIED CATEGORY

3.43 Operations in the certified category are the highest risk operations. Generally, they are subject to the same regulatory regime as crewed aviation. Operations are in the certified category if they:

(1) involve a UA with a characteristic dimension of 3m or more being flown over assemblies of people;[203] or

(2) involve the transport of people; or

(3) involve the carriage of dangerous goods, that may result in high risk for third parties in case of accident.[204]

Certified category – design and production rules

3.44 UAS in the certified category must comply with the same requirements imposed on traditional crewed aviation in terms of design and manufacture. This means that UAS in the certified category are subject to the "applicable requirements" of UK Regulation (EU) 748/2012 (the "Initial Airworthiness Regulation"), Regulation 2015/640 (the "Additional Airworthiness Specifications Regulation") and UK Regulation (EU) 1321/2014 (the "Continuing Airworthiness Regulation").[205] The "applicable requirements" have not yet been specified. In practice, certification of the aircraft is not possible at present, due to a lack of certification specifications.

Command units for UAS

3.45 For crewed aircraft which are certified, components are integrated, and it is the aircraft itself which is the focus of any airworthiness assessment. However, for a certified UAS, equipment used to control the UAS remotely is also a crucial part of the overall system.

3.46 The UAS Implementing Regulation uses the phrase "command unit" to describe the equipment used to control a certified UA remotely. Article 2 of the UAS Implementing Regulation defines a command unit as:

> the equipment or system of equipment to control unmanned aircraft remotely as defined in point 32 of article 3 of Regulation (EU) 2018/1139 which supports the control or the monitoring of the unmanned aircraft during any

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203 For the EU, EASA has proposed to change this requirement such that it does not apply to lighter-than-air aircraft (balloons and airships) which have less kinetic energy and in theory are less risk to people and structures on the ground. See EASA Opinion No 3/2023, *Introduction of a regulatory framework for the operations of drones- Enabling innovative air mobility with manned VTOL-capable aircraft, the initial airworthiness of unmanned aircraft systems subject to certification, and the continuing airworthiness of those unmanned aircraft systems operated in the 'specific' category* (August 2023), 2.3.3.2.

204 UK Regulation (EU) 2019/947 on unmanned aircraft systems and on third-country operators of unmanned aircraft systems, art 6.

205 UK Regulation (EU) 2019/945 on unmanned aircraft systems and on third-country operators of unmanned aircraft systems, art 40(2).

phase of flight, with the exception of any infrastructure supporting the command and control ("C2") link service.[206]

3.47 ICAO also define this equipment in the context of Remotely Piloted Aircraft Systems ("RPAS"), describing it as a "remote pilot station".[207] However, we understand the term "command unit" is preferred by the CAA: CAP 722D explains that "Remote Pilot Station is a legacy term and has been replaced by Command Unit".[208]

3.48 Currently, for any UAS requiring certification, the command unit would be assessed as part of the overall system and not as a separate component. We note though that in the EU, EASA has recently published Opinion No 03/2023. This Opinion sets out an intention to amend the Initial Airworthiness Regulation to include provision for separate certification of command units.[209] EASA has also proposed the term "control and monitoring unit" ("CMU") to replace command unit. EASA believes the former is a more accurate description of the technology.[210]

3.49 Any command unit (or CMU) for a UAS presents several unique human factor challenges. These can include: the absence of sensory cues; accommodating for latency in the control of aircraft; and optimisation of the remote pilot's workspace (including a consideration of how to prioritise alerts). CAA guidance on UAS operations notes that "due to the nature of remote operation, the command unit need no longer be constrained to follow a traditional flight deck design philosophy" but also that the command unit "must be designed to fit the new operator role".[211]

3.50 Currently, the human factors associated with the design and operation of a UAS in the certified category must be considered as part of the operator's Safety Management

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206 EASA proposes to change "command unit" to "control and monitoring unit (CMU)" (EASA Opinion No 3/2023, *Introduction of a regulatory framework for the operations of drones- Enabling innovative air mobility with manned VTOL-capable aircraft, the initial airworthiness of unmanned aircraft systems subject to certification, and the continuing airworthiness of those unmanned aircraft systems operated in the 'specific' category* (August 2023) pp 21 to 22.

207 Annex 2 to the Chicago Convention, Tenth Edition, 2022, including amendment 46, ch 1. The remote pilot station is defined as "The component of the remotely piloted aircraft system containing the equipment used to pilot the remotely piloted aircraft".

208 CAA, *Unmanned aircraft system operations in UK airspace: abbreviations and master glossary* (December 2022) (CAP 722D) p 21.

209 EASA Opinion No 3/2023, *Introduction of a regulatory framework for the operations of drones- Enabling innovative air mobility with manned VTOL-capable aircraft, the initial airworthiness of unmanned aircraft systems subject to certification, and the continuing airworthiness of those unmanned aircraft systems operated in the 'specific' category* (August 2023) pp 12 to 15.

210 EASA note that the operational assumptions underpinning the regulatory framework for UAS assume that a human is always in command. Such authority may be exercised either directly by executing the flight operation, or by directing other individuals/organisations involved in the flight operation. By comparison "control" only denotes the management and execution of functions and required for flight operation. For this reason, EASA feel "control monitoring unit" is a clearer description of how what such units do. See EASA Opinion No 3/2023, *Introduction of a regulatory framework for the operations of drones- Enabling innovative air mobility with manned VTOL-capable aircraft, the initial airworthiness of unmanned aircraft systems subject to certification, and the continuing airworthiness of those unmanned aircraft systems operated in the 'specific' category* (August 2023) pp 21 to 22.

211 CAA, *Unmanned aircraft system operations in UK airspace – policy and guidance* (December 2022) (CAP 722) pp 130 to 131.

System (discussed in VTOL Chapter 6). Operators must take steps to identify hazards, implement safety reporting, risk management, performance measurement and safety assurance. As of yet, there are no in-depth certification specifications which detail how command units should be designed to mitigate human factor considerations.

Certified category – operational rules

3.51 The UAS Implementing Regulation provides that:

> UAS operations in the certified category shall be subject to the applicable operational requirements laid down in Implementing Regulation (EU) No 923/2012 and Commission Regulations (EU) No 965/2012 and (EU) No 1332/2011.[212]

3.52 The regulations referred to are: UK SERA (the rules of the air); UK Regulation (EU) No 965/2012 on technical requirements and administrative procedures related to air operations; and UK Regulation (EU) No 1332/2011 on common airspace usage requirements and operating procedures for airborne collision avoidance.

3.53 Unlike operations in the open and specific categories, which are excepted from most of the ANO, UAS in the certified category are subject to that order.[213] Therefore, it is an offence to fail to comply with the rules of the air for certified category operations except to the extent that departure is permissible to avoid immediate danger.[214]

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212 UK Regulation (EU) 2019/947 on the rules and procedures for the operation of unmanned aircraft, art 7(3).

213 SI 2016 No 765, art 23(1)(c).

214 SI 2016 No 765, art 249(3)(a).

Chapter 4: Airworthiness and certification

4.1 Safety is at the forefront of aviation. Aircraft and their components are subject to strict standards of airworthiness and certification. Airworthiness regulations ensure that aircraft and aviation systems are acceptably safe both before they are deployed and on a continuing basis.

4.2 As the use and operation of innovative aircraft can differ from conventional aircraft, new challenges and considerations arise. The current system of assessing airworthiness is, to a large extent, prescriptive. A detailed set of standards and rules ensure that the likelihood of design flaws and safety critical errors is limited. However, uncrewed and unoccupied aircraft present new issues for developers. Many of these aircraft will have highly automated or autonomous features which will rely on AI technologies that are difficult to certify. Additionally, many uncrewed aircraft and drones have novel designs which are unlike those of crewed aircraft. Existing and well-defined industry standards are not as readily applicable to these types of aircraft.

4.3 Removing the on-board pilot and other crew members creates additional challenges. Aircraft today are certified as airworthy on the assumption that they will be operated by humans. It is not yet clear how safety functions which are currently performed by the crew of an aircraft will be fulfilled on uncrewed aircraft.

4.4 This chapter reviews the current framework for certifying the airworthiness of aircraft. Using that review for context, it then considers the main challenges that autonomy presents to the current airworthiness and certification system. Readers familiar with the current framework may wish to start with the discussion of "future challenges" at paragraph 4.43.

AIRWORTHINESS AND CERTIFICATION

4.5 Airworthiness describes the fitness of an aircraft or of other airborne equipment or of a system to be operated in flight. In general, this requires the aircraft, equipment, or system to be acceptably safe, presenting no significant hazards.

4.6 Annex 8 to the Convention on International Civil Aviation (the "Chicago Convention") sets out the contracting states' obligations in relation to airworthiness under the treaty. It defines airworthy as:

> the status of an aircraft, engine, propeller or part when it conforms to its approved design and is in a condition for safe operation.[215]

4.7 This definition reflects two aspects of airworthiness: initial airworthiness; and continuing airworthiness. Initial airworthiness requires that aircraft or airborne equipment to conform to their design specifications. Ongoing airworthiness requires that the aircraft or airborne equipment should be maintained in a condition such that

[215] Annex 8 to the Chicago Convention, Thirteenth Edition, 2022, including amendment 109, part I.

they can be operated without presenting a hazard to aircrew, ground crew, passengers or third parties.

4.8 For most aircraft systems to be recognised as airworthy they must undergo an initial process of certification. Certification requires that aircraft and airborne equipment are checked against both high-level and specific requirements. If they meet these requirements, they are then "certified" by the relevant authority. Certification also applies to other aspects of aviation. For example, aerodromes, aircraft crew and air navigation service providers ("ANSPs") must also undergo a process of certification.

4.9 Certification requirements for the airworthiness of civil aircraft are derived from Annex 8 to the Chicago Convention. Each contracting state must establish a legal framework to implement the standards and recommended practices which are established by the International Civil Aviation Organization ("ICAO") pursuant to the convention.

4.10 In the UK those aircraft which fall within the scope of the UK Regulation (EU) 2018/1139 (the "Basic Regulation") are referred to as "Part 21 aircraft"[216] and are subject to the Basic Regulation's airworthiness requirements. The airworthiness of non-Part 21 aircraft is regulated under the Air Navigation Order 2016,[217] with airworthiness requirements set out in the British Civil Airworthiness Requirements.[218]

4.11 In the UK, the Civil Aviation Authority ("CAA") is the relevant authority for issuing Certificates of Airworthiness and ensuring that aircraft on the UK register of aircraft comply with ongoing airworthiness requirements.

Certification of initial airworthiness

4.12 Initial airworthiness regulations include procedures for the approval of the design of aircraft, airborne systems and equipment. If a design is approved by a contracting state to the Chicago Convention, it will issue a design "type certification". Type certification describes the approved design and certifies that it meets the initial airworthiness requirements of the issuing state.[219] The issuing state is then referred to as the "State of Design" for the approved design.

4.13 Subject to limited exceptions, to create and/or produce a certified design, organisations must gain design organisation approval ("DOA") and/or production organisation approval ("POA").[220] Only once DOA and POA have been granted, is an

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216 The term "Part 21" was adopted by EASA from its predecessor, the Joint Aviation Authority (JAA). The JAA published joint aviation requirements (JAR), with the airworthiness requirement named JAR 21. EASA adopted these requirements, retaining the "21". EASA Opinion No 2/2003, *For a Commission Regulation on the airworthiness and environmental certification of aircraft and related products, parts and appliances, as well as for the certification of design and production organisations* (August 2003) para 13.

217 SI 2016 No 765.

218 https://www.caa.co.uk/commercial-industry/aircraft/airworthiness/organisation-and-maintenance-programme-approvals/bcar/.

219 Annex 8 to the Chicago Convention, Thirteenth Edition, 2022, including amendment 109, part I.

220 UK Regulation (EU) 2018/1139 on common rules in the field of civil aviation and establishing a European Union Safety Agency, art 15.

organisation eligible to begin the process of applying for certification of its design or products.

4.14 The certification process can be long and complex. In the UK, an applicant organisation must propose an initial certification programme to the CAA. This programme will include the proposed certification basis, which is the set of criteria governing the certification of a particular system or component. The programme will also include the means of compliance and describe the CAA's level of involvement and timescales.[221] To aid organisations in this process the CAA publishes acceptable means of compliance, guidance material and certification specifications.[222]

Demonstration of compliance

4.15 After the certification programme has been agreed, the applicant must show that its product complies with the relevant certification basis for that type of product. For example, a rotorcraft design must comply with certification specifications for rotorcraft. The CAA will evaluate compliance through witnessing testing activities and/or reviewing documentation which records compliance. The nature of the CAA's role will vary according to the level of involvement agreed earlier in the approval process.

Type certificates

4.16 If a DOA applicant successfully demonstrates compliance with the certification basis, the CAA will issue design approval.

4.17 Where the application refers to an aircraft, a type certificate, type certificate data sheet, and a type certificate data sheet for noise will be issued.

4.18 A type certificate states that the design has met initial airworthiness standards. In some cases, a restricted type certificate will be issued if an aircraft cannot comply with all of the essential requirements set out in annex II to the Basic Regulation but safety can be ensured via restrictions or mitigating measures. For a restricted type certificate to be issued, the applicant must show that the design complies with the certification basis and that the design of the aircraft is adequate, in terms of airworthiness and environment, for its intended use.[223]

4.19 The type certificate data sheet will set out general information about the design. These are published on the CAA website.[224]

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221 Civil Aviation Authority ("CAA"), *Guide for Innovators: On the Path to Certification* (November 2021) (CAP 2289) p 6.

222 UK Regulation (EU) 2018/1139 on common rules in the field of civil aviation and establishing a European Union Safety Agency, art 115.

223 UK Regulation (EU) 2018/1139 on common rules in the field of civil aviation and establishing a European Union Safety Agency, art 18(1)(b).

224 https://www.caa.co.uk/commercial-industry/aircraft/airworthiness/type-certificate-and-type-approval-data-sheets/part-21/.

Certificates of airworthiness

4.20 The certification of a type design does not mean that all aircraft of that design are automatically approved — individual aircraft must also be certified as airworthy.[225] A certificate of airworthiness will be issued by the CAA to aircraft which conform to the relevant type certificate. If the aircraft conforms to a restricted type certificate, a restricted certificate of airworthiness will be issued.[226]

4.21 Individual aircraft must meet the airworthiness requirements of their certification basis. These requirements are set out in "certification specifications" issued by the CAA. For example:

(1) CS-25 sets out the certification specifications of large aeroplanes;[227]

(2) CS-27 concerns small rotorcraft;[228]

(3) CS-29 concerns large rotorcraft;[229] and

(4) CS-23 concerns normal category aeroplanes (those with a passenger seating configuration of 19 or less and a maximum certified take-off mass of 8618 kg or less).[230]

4.22 Certificates of airworthiness do not expire, but are revalidated annually by an airworthiness review certificate, which verifies the ongoing airworthiness of the aircraft.

New technologies

4.23 As a sector, aviation has generally been adept at adopting new technologies. The existing certification framework is flexible and can accommodate new products as well as existing products used in a different way.

4.24 To certify new technology, aviation authorities can put in place "special conditions". Special conditions can be used to fill gaps that emerge in the certification framework.[231] An example of this is the special condition designed by the European Union Aviation Safety Agency ("EASA") and adopted by the CAA in relation to vertical

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225 UK Regulation (EU) 2018/1139 on common rules in the field of civil aviation and establishing a European Union Safety Agency, art 14.

226 UK Regulation (EU) 748/2012 laying down implementing rules for the airworthiness and environmental certification of aircraft and related products, parts and appliances, as well as for the certification of design and production organisations, annex I, 21.A.173.

227 https://regulatorylibrary.caa.co.uk/cs/Content/PDF%20Files/Inital%20Airworthiness%20Adopted%20CS-25%20Amd%2027.pdf.

228 https://regulatorylibrary.caa.co.uk/cs/Content/PDF%20Files/Inital%20Airworthiness%20Adopted%20CS-27%20Amd%2010.pdf.

229 regulatorylibrary.caa.co.uk/cs/Content/PDF Files/Inital Airworthiness Adopted CS-29 Amd 11.pdf.

230 https://regulatorylibrary.caa.co.uk/cs/Content/PDF%20Files/Inital%20Airworthiness%20Adopted%20CS-23%20Amd%206%20to%20Issue%204.pdf.

231 UK Regulation (EU) 748/2012 laying down implementing rules for the airworthiness and environmental certification of aircraft and related products, parts and appliances, as well as for the certification of design and production organisations, annex I, 21.B.75.

take-off and landing ("VTOL") aircraft.[232]. These special conditions may be supported by existing certification specifications for other types of aircraft; for example, where there are no relevant means of compliance in relation to special condition VTOL ("SC-VTOL"), an appropriate acceptable means of compliance from CS-23, CS-25, CS-27 or CS-29 can be proposed by the applicant. If there is no suitable means of compliance in relation to the four certification specifications listed, the applicant must work with the CAA to develop a means of ensuring an appropriate level of safety.[233]

4.25 Special conditions may eventually become certification specifications. An aircraft's certification basis may include both certification specifications and special conditions, which together help to prove adherence to the higher-level requirements of the Basic Regulation.[234]

UAS certification

Under article 6 of the UAS Implementing Regulation and article 40 of the UAS Delegated Regulation, the design, production and maintenance of an uncrewed aircraft system ("UAS") must be certified if:

(1) it has a characteristic dimension of 3 metres or more and is designed to be operated over assemblies of people;

(2) it is designed for transporting people; or

(3) it is designed for the purpose of transporting dangerous goods and requires a high level of robustness to mitigate the risks for third parties in case of an accident.

4.26 Further, operations falling in the "specific" category require certification where following a risk assessment, the CAA finds that the operations pose too high a safety risk and cannot be sufficiently mitigated.

4.27 However, at present there are no specifications with which to certify a UAS for initial airworthiness. In Europe, EASA has proposed additions and amendments to the regulatory framework which would address the initial airworthiness of UAS subject to certification as well as the continuing airworthiness of UAS in the 'specific' category. We discuss these proposed changes in more detail below at paragraph 4.46 to 4.50.

Continuing airworthiness

4.28 The term "continuing airworthiness" refers to:

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232 https://www.caa.co.uk/news/uk-determines-certification-standards-for-new-electric-vertical-take-off-and-landing-aircraft/.

233 CAA, *Policy statement on type-certification of VTOL aircraft* (October 2023), https://consultations.caa.co.uk/policy-development/type-certification-of-vtol-aircraft/supporting_documents/Policy%20Statement%20%20VTOL%20Initial%20Airworthiness.pdf.

234 For example, see the Type Certificate Data Sheet of the common, large aircraft Airbus A330. EASA, *Type-certificate data sheet for Airbus A330* (2020),https://www.easa.europa.eu/sites/default/files/dfu/A330%20EASA%20TCDS%20A.004%20-%20Issue%2056.pdf.

all of the processes ensuring that, at any time in its operating life, the aircraft complies with the airworthiness requirements in force and is in a condition for safe operation.[235]

4.29 Having certified an aircraft as initially airworthy, the CAA has a duty to ensure its airworthiness on a continued basis. As we discuss below, the CAA approves and monitors organisations involved in aircraft maintenance. Additionally, if a safety issue comes to light, the CAA can issue binding Airworthiness Directives to address the problem.[236] These directives can be applied to any aircraft on the UK Register of aircraft. Airworthiness Directives should provide an explanation of the safety issue and detail appropriate mitigating measures. For example, an Airworthiness Directive may require specific equipment or systems to be inspected and the results reported.[237] Airworthiness Directives may also be used to prohibit the operation of certain aircraft where there is a serious safety concern.[238]

4.30 The regulation of maintenance in assimilated law is less prescriptive than the regulation of initial airworthiness. This is because, prior to the UK's withdrawal from the EU, EASA rather than national aviation authorities was responsible for setting initial airworthiness standards. However, in the case of continuing airworthiness, national aviation authorities had more freedom and were able to impose different standards based on national industry standards. As such, the framework for methods of compliance in continuing airworthiness is not contained entirely within UK Regulation (EU) 1321/2014 ("the Continuing Airworthiness Regulation") — national standards are also relevant.[239]

Part M and Part ML

4.31 As is the case with initial airworthiness, the relevant rules governing continuing airworthiness differ for Part 21 and non-Part 21 aircraft. Within the category of Part 21 aircraft, a distinction is made between aircraft governed by annex I (known as Part M) of the Continuing Airworthiness Regulation and annex Vb (known as Part ML) of the same regulation.

4.32 The distinction between Part M and Part ML aircraft was introduced in 2020. Part ML aircraft are those Part 21 aircraft which are light, non-complex and motor-powered.[240]

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235 UK Regulation (EU) 1321/2014 on the continuing airworthiness of aircraft and aeronautical products, parts and appliances, and on the approval of organisations and personnel involved in these tasks, art 2(d).

236 UK Regulation (EU) 2018/1139 on common rules in the field of civil aviation and establishing a European Union Safety Agency, art 77(h).

237 For example, see CAA, *G-2021-0003: Survitec Emergency Breathing System (EBS) fitted to Halo Passenger Lifejacket: Equipment / Furnishings – Life Jacket – Inspection* (2021), https://publicapps.caa.co.uk/modalapplication.aspx?catid=1&pagetype=65&appid=11&mode=detail&id=10455.

238 CAA, *Airworthiness Directive G-2021-0001* (14 May 2021).

239 For example, the relevant standards for the calibration of tools in the UK are those created by the United Kingdom Accreditation Service (UKAS).

240 Note that VTOL aircraft will be treated, for the purpose of continuing airworthiness, as complex motor-powered aircraft. As such, VTOL aircraft would fall under Part M. CAA, *Policy statement on the rules applicable to continuing airworthiness of VTOL aircraft* (October 2023) para 5.1,

The continuing airworthiness requirements for Part ML aircraft are less stringent to reflect the lower risk presented by these aircraft.[241] Part ML applies to the following aircraft:[242]

(1) aeroplanes of 2730 kg maximum take-off mass (MTOM) or less;

(2) rotorcraft of 1200 kg MTOM or less, certified for a maximum of up to 4 occupants;

(3) other ELA2 aircraft.[243]

4.33 The standard position for both Part M and Part ML aircraft is that the aircraft owner is responsible for ensuring the ongoing airworthiness of their aircraft.[244] The owner must ensure that an aircraft is:

(1) maintained and airworthy;

(2) correctly fitted with working operational and emergency equipment;

(3) the recipient of a valid airworthiness certificate; and

(4) maintained in accordance with the relevant regulation.[245]

4.34 As we discuss below, depending on the type of aircraft, some of these duties must be performed by organisations approved by the CAA.

4.35 No distinction is made in either Part M or Part ML between crewed and uncrewed aircraft. Consequently, the same ongoing airworthiness requirements for both crewed

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https://consultations.caa.co.uk/policy-development/continuing-airworthiness-of-vtol-aircraft/supporting_documents/Policy%20statement%20%20VTOL%20Continuing%20Airworthiness.pdf

241 https://www.caa.co.uk/commercial-industry/aircraft/airworthiness/organisation-and-maintenance-programme-approvals/part-ml/.

242 UK Regulation (EU) 1321/2014 on the continuing airworthiness of aircraft and aeronautical products, parts and appliances, and on the approval of organisations and personnel involved in these tasks, annex Vb.

243 Defined in UK Regulation (EU) 748/2012 laying down implementing rules for the airworthiness and environmental certification of aircraft and related products, parts and appliances, as well as for the certification of design and production organisations, art 1(2)(i) as "the following manned European Light Aircraft: (i) an aeroplane with a Maximum Take-off Mass (MTOM) of 2 000 kg or less that is not classified as complex motor-powered aircraft; (ii) a sailplane or powered sailplane of 2 000 kg MTOM or less; (iii) a balloon; (iv) a hot air airship; (v) a gas airship complying with all of the following characteristics: 3% maximum static heaviness, non-vectored thrust (except reverse thrust), conventional and simple design of: structure, control system and ballonet system, non-power assisted controls; (vi) a very light rotorcraft."

244 UK Regulation (EU) 1321/2014 on the continuing airworthiness of aircraft and aeronautical products, parts and appliances, and on the approval of organisations and personnel involved in these tasks, annex I, M.A.201; UK Regulation (EU) 1321/2014 on the continuing airworthiness of aircraft and aeronautical products, parts and appliances, and on the approval of organisations and personnel involved in these tasks, annex Vb, ML.A.201.

245 UK Regulation (EU) 1321/2014 on the continuing airworthiness of aircraft and aeronautical products, parts and appliances, and on the approval of organisations and personnel involved in these tasks, annex I, M.A.201; UK Regulation (EU) 1321/2014 on the continuing airworthiness of aircraft and aeronautical products, parts and appliances, and on the approval of organisations and personnel involved in these tasks, annex Vb, ML.A.201.

and uncrewed aircraft in the certified category apply. EASA has proposed that EU legislation be enacted to address the continuing airworthiness of uncrewed aircraft.[246] This legislation will not apply automatically in the UK. Responsibility for regulation lies with the Department for Transport, which would be advised by the CAA whether or not to introduce specific continuing airworthiness requirements for uncrewed aircraft.

Organisations involved in continuing airworthiness

4.36 The CAA is responsible for approving and monitoring organisations involved in the maintenance, and therefore continuing airworthiness, of aircraft. Maintenance of Part 21 aircraft must be conducted by a "maintenance organisation" approved by the CAA.[247]

4.37 The requirements to be satisfied by maintenance organisations depend on the category of aircraft. Complex, motor-powered aircraft[248] must be maintained by an organisation approved under annex II (Part 145) of the Continuing Airworthiness Regulation.[249]

4.38 Where the aircraft is not a complex, motor-powered aircraft, the requirements of Part 145 do not apply. Instead, depending on the circumstances, maintenance may be performed by a combined maintenance and airworthiness organisation ("CAO") or a continuing airworthiness management organisation ("CAMO") or pilot-owner.[250]

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246 EASA Opinion No 3/2023, *Introduction of a regulatory framework for the operations of drones- Enabling innovative air mobility with manned VTOL-capable aircraft, the initial airworthiness of unmanned aircraft systems subject to certification, and the continuing airworthiness of those unmanned aircraft systems operated in the 'specific' category* (August 2023) pp 16-18.

247 UK Regulation (EU) 1321/2014 on the continuing airworthiness of aircraft and aeronautical products, parts and appliances, and on the approval of organisations and personnel involved in these tasks, art 4(1).

248 UK Regulation (EU) 2018/1139 on common rules in the field of civil aviation and establishing a European Union Safety Agency, art 140(2)(b) refers to the definition set out in UK Regulation (EC) 216/2008, art 3(j). "A complex motor-powered aircraft shall mean: (a) an aeroplane: with a maximum certified take-off mass exceeding 5700 kg, certificated for a maximum passenger seating configuration of more than nineteen, or certificated for operation with a minimum crew of at least two pilots, or equipped with (a) turbojet engine(s) or more than one turboprop engine, or (ii) a helicopter certificated: for a maximum take-off mass exceeding 3 175 kg, or for a maximum passenger seating configuration of more than nine, or for operation with a minimum crew of at least two pilots, or (iii) a tilt rotor aircraft."

249 UK Regulation (EU) 1321/2014 on the continuing airworthiness of aircraft and aeronautical products, parts and appliances, and on the approval of organisations and personnel involved in these tasks, annex II.

250 UK Regulation (EU) 1321/2014 on the continuing airworthiness of aircraft and aeronautical products, parts and appliances, and on the approval of organisations and personnel involved in these tasks, GM to arts 3 and 4, sets out in tabular form which requirements apply to which classes of aircraft.

Ongoing airworthiness for Part M aircraft

4.39 Maintenance programmes for Part M aircraft must be approved by the CAA.[251] Any defect or damage to the aircraft must be rectified before flight.[252] When necessary, the aircraft should be flown to prove its airworthiness following maintenance.[253]

4.40 An airworthiness review will be conducted periodically to validate the aircraft's certificate of airworthiness. Amongst other requirements, for an airworthiness review certificate to be issued, it must be shown that the aircraft's maintenance programme has been carried out, applicable airworthiness directives have been complied with and all defects have been corrected or managed.[254]

4.41 Continuing airworthiness is further ensured through pre-flight inspections, which must be carried out by a pilot or other qualified person.[255] If any safety issues are found during continuing airworthiness checks (in accordance with the maintenance programme or pre-flight) these must be reported to the CAA and the organisation responsible for the type design within 72 hours.[256]

Continuing airworthiness for Part ML aircraft

4.42 As Part ML is a simplified version of Part M, the two annexes are similar. However, the CAA does not need to approve maintenance programmes of Part ML aircraft. Instead, the owner or maintenance organisation can approve such programmes.[257] Maintenance can be performed by a CAO or (in some cases) a pilot-owner.[258]

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251 UK Regulation (EU) 1321/2014 on the continuing airworthiness of aircraft and aeronautical products, parts and appliances, and on the approval of organisations and personnel involved in these tasks, annex I, M.A.302.

252 UK Regulation (EU) 1321/2014 on the continuing airworthiness of aircraft and aeronautical products, parts and appliances, and on the approval of organisations and personnel involved in these tasks, annex I, M.A.304. A supplementary type certificate is issued by the CAA to applicants other than the type certificate holder to ratify approvals of major changes to the approved type design.

253 UK Regulation (EU) 1321/2014 on the continuing airworthiness of aircraft and aeronautical products, parts and appliances, and on the approval of organisations and personnel involved in these tasks, annex I, M.A.301.

254 CAA, *Airworthiness review certificates*, https://www.caa.co.uk/commercial-industry/aircraft/airworthiness/certificates-and-permits/certificates-of-airworthiness/airworthiness-review-certificates/airworthiness-review-certificates-issue-recommendation/.

255 UK Regulation (EU) 1321/2014 on the continuing airworthiness of aircraft and aeronautical products, parts and appliances, and on the approval of organisations and personnel involved in these tasks, annex I, M.A.201.

256 UK Regulation (EU) 1321/2014 on the continuing airworthiness of aircraft and aeronautical products, parts and appliances, and on the approval of organisations and personnel involved in these tasks, annex I, M.A.202.

257 UK Regulation (EU) 1321/2014 on the continuing airworthiness of aircraft and aeronautical products, parts and appliances, and on the approval of organisations and personnel involved in these tasks, annex Vb, ML.A.302.

258 UK Regulation (EU) 1321/2014 on the continuing airworthiness of aircraft and aeronautical products, parts and appliances, and on the approval of organisations and personnel involved in these tasks, annex Vb, ML.A.302.

Furthermore, a larger number of bodies are able to issue airworthiness review certificates under Part ML.[259]

FUTURE CHALLENGES

4.43 We see two key challenges to the existing airworthiness and certification framework. The first is simply that there currently are gaps: there are certification specifications for conventional aircraft, but no specifications for UAS in the certified category. The second is that to enable autonomous flight aircraft will have to rely on complex AI technologies which may make certification of the aircraft difficult.

Certification of UAS

4.44 As discussed above and in Chapter 3, most operations falling within the 'open' and 'specific' categories are regulated by the UAS Implementing and Delegated Regulations.[260] Only UAS falling within the 'certified' category, and some within the 'specific' category, are subject to certification.

4.45 Certifying UAS in accordance with existing standards can be challenging – existing rules were designed with conventional forms of aircraft in mind. For example, the following risks may be associated with UAS operations:

(1) the increased risk of ground damage (to infrastructure and people) presented by UAS due to their use in urban areas at lower altitudes;

(2) the increased risk of mid-air collision caused by adding UAS to the urban air environment;

(3) security concerns (both physical and cyber).

4.46 These risks are common to all aircraft but more of an issue for UAS because many will be specifically designed to operate at lower altitudes and more UAS will mean more aircraft in the same volume of airspace. These risks suggest specific measures may be required to ensure the safe introduction of UAS. In Europe, EASA has proposed to create a "comprehensive regulatory framework" to address the issues presented by UAS. To create this framework, in August 2023 EASA proposed additions and amendments to the current regulatory framework via an Opinion.[261]

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259 UK Regulation (EU) 1321/2014 on the continuing airworthiness of aircraft and aeronautical products, parts and appliances, and on the approval of organisations and personnel involved in these tasks, annex Vb, ML.A.901.

260 UK Regulation (EU) 748/2012 laying down implementing rules for the airworthiness and environmental certification of aircraft and related products, parts and appliances, as well as for the certification of design and production organisations; UK Regulation (EU) 2019/947 on the rules and procedures for the operation of unmanned aircraft.

261 EASA Opinion No 3/2023, *Introduction of a regulatory framework for the operations of drones— Enabling innovative air mobility with manned VTOL-capable aircraft, the initial airworthiness of unmanned aircraft systems subject to certification, and the continuing airworthiness of those unmanned aircraft systems operated in the 'specific' category* (August 2023).

These amendments would address the initial airworthiness of UAS subject to certification and the continuing airworthiness of UAS in the 'specific' category.[262]

4.47 In relation to initial airworthiness, the Opinion contemplates manufacturers being able to modify a manned aircraft to create hybrid "optionally piloted" or "unmanned" versions. The configuration of such a hybrid aircraft would then be listed on a single type certificate. This would allow a single certificate of airworthiness to be issued for individual aircraft, rather than multiple certificates.[263] Our understanding is that this would simplify the initial airworthiness certification of these aircraft.

4.48 Perhaps most significantly however, EASA has also suggested changes in relation to control and monitoring units which are commonly called "command units". [264] Command units describe equipment used to control a UAS remotely and are central to the operation of UASs. EASA has proposed to introduce a dedicated type certificate for command units. This would mean that a command unit could be assessed together with or separately from its aircraft. Whether assessed separately or as part of the UAS, the type certificate will need to address the interface between command unit and the UAS technology and would need be installed in accordance with the specifications of the unit's type design.[265] The continuing airworthiness of the command unit would also be addressed by a separate delegated act.[266]

4.49 Furthermore, the Opinion acknowledges the need for different reliability flight tests according to the risk presented by the UAS. For example, complex passenger-only

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262 We note that ICAO have also undertaken similar work in relation to remotely piloted aircraft systems (RPAS). An amendment to Annex 8 to the Chicago Convention was adopted by the Council in March 2021 to address the airworthiness of RPAS, C2 links and remote pilot stations. The change will become applicable from 26 November 2026 (Amendment 108 to Annex 8 to the Convention on International Civil Aviation).

263 EASA Opinion No 3/2023, *Introduction of a regulatory framework for the operations of drones— Enabling innovative air mobility with manned VTOL-capable aircraft, the initial airworthiness of unmanned aircraft systems subject to certification, and the continuing airworthiness of those unmanned aircraft systems operated in the 'specific' category* (August 2023) p 13.

264 Defined in UK Regulation (EU) 2019/947, art 2(26) as "the equipment or system of equipment to control unmanned aircraft remotely … which supports the control or the monitoring of the unmanned aircraft during any phase of flight, with the exception of any infrastructure supporting the command and control (C2) link service". The new terminology of "control and monitoring unit" (CMU) would be defined as "the equipment to control and monitor unmanned aircraft remotely as defined in point (32) of Article 3 of Regulation (EU) 2018/1139"(EASA Opinion No 3/2023, *Introduction of a regulatory framework for the operations of drones— Enabling innovative air mobility with manned VTOL-capable aircraft, the initial airworthiness of unmanned aircraft systems subject to certification, and the continuing airworthiness of those unmanned aircraft systems operated in the 'specific' category* (August 2023) pp 21 to 22.

265 EASA Opinion No 3/2023, *Introduction of a regulatory framework for the operations of drones— Enabling innovative air mobility with manned VTOL-capable aircraft, the initial airworthiness of unmanned aircraft systems subject to certification, and the continuing airworthiness of those unmanned aircraft systems operated in the 'specific' category* (August 2023) pp 14 to 15.

266 EASA Opinion No 3/2023, *Introduction of a regulatory framework for the operations of drones— Enabling innovative air mobility with manned VTOL-capable aircraft, the initial airworthiness of unmanned aircraft systems subject to certification, and the continuing airworthiness of those unmanned aircraft systems operated in the 'specific' category* (August 2023) pp 16 to 18.

aircraft may need hundreds of hours of flight testing whereas less critical operations such as delivery drones may need much less.[267]

4.50 It is worth noting that any changes made by EASA to aviation regulations would not apply to the assimilated UK versions. However, it is worthwhile considering whether similar amendments relating to hybrid versions of aircraft and control units would be useful for addressing the same gaps in the UK framework. We invite views on such amendments.

Consultation Question 1.

4.51 We seek views on how current airworthiness and certification regulation might need to be adapted or developed in light of highly automated and autonomous aircraft. In particular, should provisions be adopted which allow for:

(1) the certification of optionally piloted and uncrewed or unoccupied versions of conventional aircraft (hybrid versions); and

(2) the separate certification of command units?

Certifying autonomous systems

4.52 The use of AI technologies is central to the development of autonomous flight. As noted by EASA:

> [Air taxi systems] will inevitably have to rely on systems to enable complex decisions, eg to ensure the safe flight and landing or to manage the separation between air vehicles with reduced distances compared to current ATM practices. This is where AI comes into play: to enable advanced automation, very powerful AI models will be necessary to process and use the huge amount of data generated by the embedded sensors and by the machine-to-machine communications to support flights without human intervention.[268]

4.53 However, AI technologies are difficult to certify for three main reasons:

(1) a lack of predictability and explainability;

(2) the importance of data sets; and

(3) adaptability.

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267 EASA, Opinion No 03/2023: *Introduction of a regulatory framework for the operation of drones— Enabling innovative air mobility with manned VTOL-capable aircraft, the initial airworthiness of unmanned aircraft systems subject to certification, and the continuing airworthiness of those unmanned aircraft systems operated in the 'specific' category* (August 2023) p 13.

268 EASA, *Artificial Intelligence Roadmap 2.0* (May 2023) p 10, https://www.easa.europa.eu/en/newsroom-and-events/news/easa-artificial-intelligence-roadmap-20-published

We look at each of these in turn.

Predictability and explainability

4.54 Much of the current focus in terms of AI development is in relation to machine learning ("ML") and deep learning ("DL") approaches.[269] These types of AI involve algorithms whose performance can change and improve as they are exposed to data. This ability to change and improve can generate impressive results and to some extent emulate human decision making. However, these systems can be unpredictable. EASA explains predictability as follows:

> The degree to which a correct forecast of a system's state can be made quantitatively. Limitations on predictability could be caused by factors such as a lack of information or excessive complexity.[270]

4.55 Because ML and DL approaches have the potential to generate unanticipated outputs and results, they have the potential to be unpredictable. This makes certification difficult as the performance of the system may not be able to be reliably assured.

4.56 Another important concept is that of explainability. EASA has defined explainability as:

> the capability to provide the human with understandable, reliable, and relevant information with the appropriate level of details and with appropriate timing on how an AI/ML application produces its results.[271]

EASA subdivides explainability into two for the purposes of aircraft development and assurance: operational explainability and development explainability.[272]

(1) Operational explainability: can end users predict and explain the conclusions of AI systems?

(2) Development explainability: can stakeholders involved in the development of the system predict and explain the conclusions of AI systems?

4.57 Both forms of explainability will be crucial to the safe development and operation of autonomous aircraft. However, in the context of initial airworthiness and certification, the second is perhaps more important: in order to certify systems, an explanation of

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269 Machine learning is an approach to AI which uses data and algorithms to give computers the ability to improve with experience without the need for explicit programming. Deep learning is a type of machine learning which uses many layers of "artificial neurons" to solve complex problems. Artificial neurons are connected to each other, with each node receiving data from several nodes in the previous layer and outputting data to nodes in the next layer. Nodes attach values to the data they receive and do not pass this information on if a specific threshold is not met. This approach is often used to classify information from images and text.

270 EASA, *Artificial intelligence roadmap 2.0* (May 2023) p 32, https://www.easa.europa.eu/en/newsroom-and-events/news/easa-artificial-intelligence-roadmap-20-published.

271 EASA, *Concept paper: guidance for Level 1&2 machine learning applications* (February 2023) p 14,https://www.easa.europa.eu/en/document-library/general-publications/easa-artificial-intelligence-concept-paper-proposed-issue-2.

272 EASA, *Concept paper: guidance for Level 1&2 machine learning applications* (February 2023) p 13 https://www.easa.europa.eu/en/document-library/general-publications/easa-artificial-intelligence-concept-paper-proposed-issue-2.

the behaviour of AI is needed as this contributes to a strong understanding of the system and, in turn, its safety. As accepted by EASA, certification authorities will need "deep insight into AI-based system explainability" before AI systems can be safely introduced.[273]

4.58 The complexity of some AI systems such as those developed via machine learning and deep learning approaches means that they may not be easily explainable to those who are certifying them. Such systems are often criticised for being a black box— how the AI system uses data to produce a conclusion is not understood.[274] Without this understanding, it is difficult to assure and have confidence in the safety of a system.

The importance of data sets

4.59 Data is crucial for training and developing AI models. The behaviours of an AI system will be dependent on the knowledge bases and data sets that are used to develop it. The quality of the knowledge bases and data sets therefore becomes a crucial aspect of AI development.

4.60 In the context of certification, this raises a new problem: should requirements be put in place for both the AI systems and the knowledge bases and data sets used to develop the model? This is especially relevant for ML approaches as data sets are the main inputs for ML models. Because of this, for ML approaches, EASA has proposed extending the certification process to include assurance of the "correctness and completeness/representativeness of the data".[275]

4.61 However, potential certification of datasets is unlikely to be straightforward:

> Ensuring the quality of a ML system dataset is difficult, in particular because the relation between the characteristics of the data and their effect on the compliance of the ML system to its requirements is notoriously complex and difficult to establish. Even worse, the set of characteristics itself is difficult to establish.[276]

4.62 Another issue is that AI systems are also susceptible to bias. Depending on the knowledge base or data set used, biases towards a certain type of output may become part of the normal operation of the AI system. These biases can also be introduced over time as AI systems are updated throughout their lifetime. Ensuring that such biases can be identified and mitigated is another challenge to the current certification process.

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273 EASA, *Concept paper: guidance for Level 1&2 machine learning applications* (February 2023) p 73. https://www.easa.europa.eu/en/document-library/general-publications/easa-artificial-intelligence-concept-paper-proposed-issue-2.

274 Horizon, *Opening the 'black box' of artificial intelligence'* (2020), https://ec.europa.eu/research-and-innovation/en/horizon-magazine/opening-black-box-artificial-intelligence.

275 EASA, *Concept paper: guidance for Level 1&2 machine learning applications* (February 2023) p 13, https://www.easa.europa.eu/en/document-library/general-publications/easa-artificial-intelligence-concept-paper-proposed-issue-2.

276 S Picard, C Chapdelaine, C Cappi, L Gardes, E Jenn, B Lafevre, T Soumarmon, *Ensuring dataset quality for machine learning* (2021). https://hal.science/hal-03355371/document.

Adaptability

4.63 While existing regulation accommodates changes to software, it is unlikely it could support the significant adaptability of some forms of AI.

4.64 The current regulatory position is that once software is certified, it may be possible to update it without further certification. For example, a database could be updated without repeating the stringent certification process. However, this position is subject to limitations – only minor updates can be used without additional certification. For example, changes to an operating system would not be acceptable without further testing and certification. Overall, this process of software updates is controlled—changes are designed and implemented by a human with the amount of intervention required dependent on the significance of the update.

4.65 In contrast, at the core of some forms of AI such as ML, is the ability to adapt and produce different outputs. Unlike traditional software updates, these outputs may be unpredictable and/or lack explainability. Consequently, the certification of such adaptive systems would be particularly difficult, especially in a safety-critical context.

4.66 These challenges have been identified by EASA. For this reason, its current useable guidance on ML applications in aviation only applies to systems where the model and the way it produces outputs are "frozen" and do not change based on new data.[277] Overall, it is unclear whether the use of adaptive machine learning systems in safety critical aviation contexts will be feasible, even in the long term.

Current work on certifying AI

4.67 In partnership with Daedalean.ai, EASA have explored the certification of AI and ML, addressing the issues outlined above. In relation to knowledge bases and data sets, EASA and Daedalean.ai have proposed imposing requirements for "learning assurance".[278] This involves extending certification to "the datasets used for development, the development process itself, and verification of the system behaviour both during development and operation".[279]

4.68 Following the joint report, EASA published concept papers in 2021 and 2023 concerning how safety assurance can be achieved for Level 1 and 2 AI/ML, ie those systems which assist and "collaborate" with humans during their operation.[280] The

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277 EASA, *Concept paper: guidance for Level 1&2 machine learning applications* (February 2023) p 19, https://www.easa.europa.eu/en/document-library/general-publications/easa-artificial-intelligence-concept-paper-proposed-issue-2.

278 EASA AI Task Force and Daedalean.ai, *Concepts of design assurance for neural networks* (CoDANN) (31 March 2020) p 43.

279 EASA AI Task Force and Daedalean.ai, *Concepts of design assurance for neural networks* (CoDANN) (31 March 2020) p 43.

280 EASA, *Concept paper: first usable guidance for Level 1 machine learning applications* (April 2021); EASA, *Concept paper: first usable guidance for Level 1 & 2 machine learning applications* (February 2023). The contents of each level of autonomy have been refined in EASA, *Artificial Intelligence Roadmap 2.0* (May 2023), https://www.easa.europa.eu/en/newsroom-and-events/news/easa-artificial-intelligence-roadmap-10-published. As the concept of operations papers referred to here use the classifications set out in EASA, *Artificial intelligence roadmap: a human-centric approach to AI in innovation* (February 2020)

intention is for the papers to serve as a basis for Phase II of the EASA AI roadmap when formal regulatory development begins.

4.69 Both of EASA's concept papers attempted to identify the impact of AI on certification. For product design and operations, the 2023 concept paper concluded that

> the current implementing rules (Part 21) and certification specifications already offer an open framework for the introduction of AI/ML solutions. Existing requirements are considered to still be valid for evaluating the safety of AI-based systems, provided additional means of compliance and standards are developed.[281]

4.70 As such, having considered particular challenges presented by AI and ML, the concept papers suggest that the existing framework is likely suitable for lower levels of automation with AI ie those which still involve humans in some capacity.[282] However, the document concludes that this assumption will need to be revisited for higher levels of AI and leaves open the question as to the types of changes needed to enable higher levels of autonomy.

4.71 We invite consultee views on what changes might be necessary to address the issues identified above, and enable the use of higher automation and autonomy in aviation.

Consultation Question 2.

4.72 We welcome views on what changes to the certification system might be necessary to enable higher automation and autonomy in aviation.

MEETING THE CHALLENGES OF AUTONOMY

4.73 As discussed in the previous section, for automation which provides assistance to humans, the current system of certification is likely to be sufficient. Only at higher levels of autonomy will high-level certification requirements need to be re-evaluated.

4.74 Before that re-evaluation can take place, it will be necessary to gather more data and more experience with highly automated use-cases. It remains to be seen whether adaptable AI systems will ever be appropriate for placement in safety critical systems in aircraft. It is possible instead that AI systems may be required to be "frozen" before they are deployed during standard operations. As EASA has noted in its latest AI

https://www.easa.europa.eu/en/downloads/109668/en; this classification has been maintained here to avoid confusion. Note that in January 2024, CAA launched a consultation on the adoption of a number of EASA Special Conditions, including SC-AI-01 which requires that AI-based systems must be developed in accordance with, and demonstrably comply with, the objectives set out in Chapter C of EASA's first usable guidance for Level 1 machine learning applications.

281 EASA, *Concept paper: first usable guidance for Level 1 & 2 machine learning applications* (February 2023) p 118.

282 See Chapter 2 for an overview of levels of automation.

roadmap, it may also be the case that hybrid solutions are found, with adaptable systems based on ML and DL forming only part of the autonomy use-case.[283]

4.75 The current regulatory structure has several tools which can support the development of new technologies. Although our project's focus is the use of innovative aircraft at scale, experimental flight and testing are important stages in their development. We give an overview of the several tools which relate to these stages in the following section.

Conducting experimental flights

4.76 The stringent certification process does not lend itself well to creators of innovative aircraft wishing to conduct test flights. For this reason, the current regulatory structure does make provision for experimental aircraft and prototypes.

Crewed aircraft

4.77 The Basic Regulation does not apply to "[manned] aircraft specifically designed or modified for research, experimental or scientific purposes, and likely to be produced in very limited numbers".[284] In these cases, the CAA enables test flights through two forms of approval:

(1) permits to fly ("PtF"); and

(2) E conditions.

4.78 Permits to fly are typically issued by the CAA where a certificate of airworthiness cannot be issued; for example, where the product to be flown is a prototype.[285] There are several different legal bases under which a permit to fly can be issued: in the case of experimental crewed flights, a permit may be issued under article 40 of the Air Navigation Order 2016.[286]

4.79 Permits to fly are issued if the CAA is satisfied the relevant aircraft is capable of safe flight under defined conditions or is fit to fly having regard to the airworthiness of the aircraft and the conditions to be attached to the permit. Requirements for PtFs are set out in the British Civil Airworthiness Requirements ("BCAR").[287] A PtF does not offer the same freedoms as a certificate of airworthiness. For example, an aircraft with a PtF will normally only be entitled to fly during the day where the weather permits good visibility and in areas free from congestion.[288] The aircraft may not fly outside the UK.

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283 EASA, *Artificial Intelligence Roadmap 2.0* (May 2023) p 10, https://www.easa.europa.eu/en/newsroom-and-events/news/easa-artificial-intelligence-roadmap-20-published

284 UK Regulation (EU) 2018/1139 on common rules in the field of civil aviation and establishing a European Union Safety Agency, annex I, para 1(b).

285 CAA, *Getting Your Prototype off the Ground* (November 2021) (CAP 2290) p 4.

286 SI 2016 No 765, art 40.

287 CAA, *BCAR Section A* (December 2017) (CAP 553) ch A3-7.

288 CAA, *Permit to Fly Aircraft* (June 2004) (CAP 733) p 2.

E conditions can be used to fly experimental aircraft without applying for a Certificate of Airworthiness or PtF.[289] E Conditions are used in limited circumstances[290] and flight is subject to limitations[291] – the CAA recommends that applicants who are hoping to obtain a certificate of airworthiness in future instead apply for a PtF.[292]

Uncrewed aircraft

4.80 The legislative framework in theory permits for an uncrewed aircraft subject to certification to be issued a permit to fly, both under article 56 of the Basic Regulation and article 40 of the Air Navigation Order 2016.[293] However, we understand from the CAA that there is, at present, no framework under which the CAA would issue a permit to fly to an uncrewed aircraft.

4.81 Instead, to facilitate innovation, the CAA has introduced "regulatory sandboxes." Innovators work closely with the CAA to safely test uncrewed aircraft. [294] These tests help to identify gaps in existing regulations and inform the CAA's approach to future regulation.[295]

Regulatory sandboxes

4.82 The CAA has used "regulatory sandboxes" to promote innovation and develop its understanding of how regulations should develop to accommodate new technologies. Regulatory sandboxes have been described as "controlled environments allowing innovators to test products, services, or new business models without having to follow all the standard regulations".[296] Sandboxes create a framework for closer interaction between regulators and innovators. Alongside new technologies, new regulations can also be trialled, tested and evaluated.

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289 The "E" in E Conditions is not defined in CAA guidance.

290 For example, E conditions are only available for aircraft with at least one pilot and a maximum take-off weight of 2000 kg and aircraft cannot carry cargo or passengers.

291 For example, the aircraft may only fly in accordance with a test programme, not exceeding a period of 12 months (Air Navigation Order 2016 SI No 765, sch 3, ch 3, para 3(2). Another restriction is that commercial operations, including hire and reward, as well as public exhibitions cannot be performed under E Conditions (CAA, *Operation of experimental aircraft under E conditions* (November 2019) (CAP 1220), chs 3 & 4).

292 CAA, *Getting Your Prototype off the Ground* (November 2021) (CAP 2290) p 5.

293 Article 56 of the Basic Regulation provides a certificate may be required for the design, production, maintenance and operation of unmanned aircraft, in accordance with regulations made under articles 57 and 58. Article 77(1)(c) requires the CAA to issue approval for associated flight conditions related to the design for aircraft for which a permit to fly has been applied for in accordance with Article 56(1). It is therefore clearly envisaged by the Basic Regulation that uncrewed aircraft may be the subject of an application of a permit to fly. However, the topic is not addressed in the UAS Implementing Regulation (made under article 58 of the Basic Regulation). As mentioned above, article 40 of the UAS Implementing Regulation simply applies the existing regulations in relation to crewed aviation.

294 CAA, *Regulatory challenges for innovation in aviation*, https://www.caa.co.uk/our-work/innovation/regulatory-challenges-for-innovation-in-aviation/.

295 CAA, *Regulatory Sandbox Guidance for the Future Flight Challenge* (January 2021) (CAP 2130).

296 Deloitte, Deloitte Centre for Government Insights, *The future of regulation: Principles for regulating emerging technologies*, 2018, https://www2.deloitte.com/content/dam/insights/us/articles/4538_Future-of-regulation/DI_Future-of-regulation.pdf, 12.

4.83 Regulatory sandboxes, however, do not predispose decision-making on the part of the regulator. A regulatory sandbox will usually end before innovators file a formal application for an authorisation, permit, or certification.

4.84 As an example, the CAA has launched a regulatory sandbox for trials of uncrewed aircraft flying beyond visual line of sight ("BVLOS")[297] using a type of airspace structure known as a temporary reserved area ("TRA"). A TRA is a defined volume of airspace that is temporarily reserved for a particular use. A TRA can be activated when required and can have conditions put in place for its use. Individual organisations and consortia can apply to test BVLOS concepts in a TRA. Once accepted into the sandbox trial, the organisation will then be able to trial via a TRA which will be put in place for that purpose.

Meeting the challenges of autonomy: our provisional view

4.85 As we have described, the current regulatory structure has several tools which can support the development of new aviation technologies. These are intended to strike a balance between innovation and safety and should allow developers a path to testing their highly automated and autonomous technologies. At present these tools appear adequate but we seek consultee views.

Consultation Question 3.

4.86 We seek views on whether current regulatory tools to support the development of highly automated and autonomous aviation technologies are adequate.

[297] See https://www.caa.co.uk/our-work/innovation/beyond-visual-line-of-sight-airspace-sandbox-trial/ for an overview of this sandbox.

Chapter 5: Rules of the air

5.1 Highly automated and autonomous flight presents many new issues. One of the most pressing is how the rules which govern flight operations should apply to remotely piloted and autonomous aircraft.

5.2 In this chapter, we first describe how automating the rules intended for humans is far from straightforward. Rules for humans tend to be subject to judgement or interpretation. Humans are often expected to act outside certain rules if circumstances require it. In an emergency, a human pilot might be expected to disregard certain rules, such as those relating to flight speed or cruising height, in the interests of safety. Programming an autonomous aircraft to disregard certain rules, at the right time, and in unusual circumstances, may be extraordinarily difficult.

5.3 We then set out an overview of the "rules of the air". The rules of the air are the core set of directions that must be followed when conducting aircraft operations. The key elements of the rules of the air are established by the Chicago Convention. However, the main source of rules of the air in the UK is UK Regulation (EU) 923/2012 on the Standardised European Rules of the Air ("UK SERA"). The assimilated Regulation is also supplemented by various other regulations.

5.4 We also discuss how the current rules of the air create uncertainties and ambiguities for autonomous and remotely piloted flight operations. The rules of the air establish that the most important actor in the rules of the air is the pilot-in-command. The pilot-in-command is responsible for ensuring that aircraft operations adhere to the rules of the air at all times. However, the rules were written with the assumption that the pilot-in-command would be a human in the aircraft itself.

5.5 Finally, we outline three potential options moving forward for adapting rules of the air to autonomous operations.

APPLYING HUMAN RULES TO MACHINES

5.6 Many of the rules that govern transport are based on having a human driver or pilot in control. While some rules, such as speed limits, are prescriptive and must be followed strictly, other rules set standards which are more open-textured. For example, drivers of road vehicles must drive with "due care and attention" and not "recklessly" or "dangerously".[298] Traffic rules are a mixture of both determinate rules and these more open-textured standards.

5.7 To complicate matters, even simple rules are subject to judgement or interpretation when they are applied in practice, especially when safety is at risk. This is reflected in the current rules of the air. Pilots are responsible for ensuring that the aircraft they

[298] For example, dangerous driving is an offence under section 2 of the Road Traffic Act 1988, while careless or inconsiderate driving is an offence under section 3 of that Act. These standards are accompanied by many rules about complying with speed limits, traffic signs, traffic regulation orders, and not driving in places other than a road.

command operate in accordance with the rules of the air at all times. However, circumstances may require the pilot-in-command to deviate from them. The Rules of the Air provide:

> The pilot-in-command of an aircraft shall, whether manipulating the controls or not, be responsible for the operation of the aircraft in accordance with the rules of the air, except that the pilot-in command may depart from these rules in circumstances that render such departure absolutely necessary in the interests of safety.[299]

5.8 What is "absolutely necessary" in the interests of safety will be a question of fact and degree. It may be difficult for programmers to determine when and how a highly automated or autonomous aircraft should depart from the rules. It requires programmers of automated systems to foresee all the possible situations the aircraft might encounter, as well as all of the appropriate interpretations of the applicable rules together with any exceptions. Part of that exercise would also require a formalisation of human discretion and personal value judgements.

5.9 The difficulties in programming for discretion and unusual situations has led some to suggest that a comprehensive rulebook approach to transport automation will, in practice, be extraordinarily difficult to produce. It would also involve policy makers and developers working closely together in a way which is unprecedented.

5.10 But it is also clear that the current rules governing flight operations were never intended to account for the possibility that there will be no crew onboard an aircraft. For example, many of the current rules of the air require the human pilot in the aircraft to: perform visual checks whilst flying; maintain verbal contact with air traffic control; and communicate with persons on the ground via hand signals. Stakeholders have indicated to us that continuing to have these requirements may restrict or block the development of automated technologies in aviation. For this reason, adaptation of the current rules or a new set of rules will be needed.

5.11 In the sections to come, we will examine the current rules of the air and outline why they need to be adapted for autonomous operations. We will also consider whether new rules should be created specifically for autonomous flight.

RULES OF THE AIR

5.12 The rules of the air are indispensable to civil aviation. They facilitate air transport by laying down detailed operational rules for pilots to follow. This allows flying to take place safely which has, in turn, allowed the aviation industry to expand and innovation to take place.

5.13 In this section, we describe: the legal basis for the rules of air; the rules of the air applying in the UK; the difference between visual flight rules and instrument flight rules; and the role of the "pilot-in-command" which is key to the operation of the current rules.

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[299] Annex 2 to the Chicago Convention, Tenth Edition, 2005, including amendment 46, 2.3.1; see also UK Regulation (EU) 923/2012 on the Standardised European Rules of the Air, annex, SERA.2010(a).

Rules of the air in the Chicago Convention

5.14 The starting point in considering the rules of the air in international civil aviation is the Chicago Convention. The "rules of the air" are only referenced twice in the main body of the Convention: in the title of article 12, and in article 37, as an example of the standards and recommended practices to be adopted by the International Civil Aviation Organisation ("ICAO"). The main detail on the rules of the air is instead found in annex 2 to the Convention.

Article 12

5.15 Article 12 requires contracting states to establish rules of the air. It provides:

> Each contracting State undertakes to adopt measures to insure that every aircraft flying over or manoeuvring within its territory and that every aircraft carrying its nationality mark, wherever such aircraft may be, shall comply with the rules and regulations relating to the flight and manoeuvre of aircraft there in force. Each contracting State undertakes to keep its own regulations in these respects uniform, to the greatest possible extent, with those established from time to time under [the] Convention. Over the high seas, the rules in force shall be those established under [the] Convention. Each contracting State undertakes to insure the prosecution of all persons violating the regulations applicable.

5.16 Article 12 has two significant features.

5.17 First, it envisages States adopting their own rules of the air. The obligation is not to comply with annex 2 itself, but for states to keep their own regulations as consistent as possible with the rules established under the Convention. The rules of the air as set out in the Chicago Convention are not a uniform worldwide code. Rather, the rules of the air in annex 2 are simply the basis for country-specific regulation and the rules of the air therefore can (and do) differ between countries. Though, as stated in penultimate sentence of Article 12, they operate as a universal code over the high seas.

5.18 That said, the possibility of significant deviation is, in practice, limited. This is reflective of the approach taken by the Chicago Convention more widely and illustrates how the relationship between the Chicago Convention and domestic law works. The UK has its own regulations on the rules of the air - UK SERA and the Rules of the Air Regulations 2015[300] - and these pieces of legislation are required to be consistent with Annex 2 of the Chicago Convention, unless deviation from Annex 2 has been notified.

5.19 Secondly, the final sentence of article 12 requires prosecution of failures to comply with the relevant domestic regulations setting out the rules of the air. This is reflected in article 249 of the Air Navigation Order 2016 which makes such a failure to comply an offence.[301]

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300 SI 2015 No 840.

301 SI 2016 No 765, art 249.

Annex 2

5.20 The main treatment of the rules of the air in the Chicago Convention is to be found in annex 2. The annex sets out the ICAO standards on the subject and has several important appendices.

5.21 The rules of the air in annex 2 are divided into general rules, visual flight rules ("VFR") and instrument flight rules ("IFR"). An aircraft is in compliance with the rules of the air when it observes the general rules and flies in accordance with either VFR or IFR and the applicable airspace classification. Responsibility for compliance lies with the pilot-in-command of the aircraft.[302]

5.22 The distinction between VFR and IFR is an important one. The pilot must choose which set of rules to follow. VFR are premised on the aircraft being operated in visual meteorological conditions ("VMC"). This means that the flight must be operated in clear conditions because visibility is key to the functioning of the rules.

5.23 On the other hand, IFR does not need clear visibility. A flight following IFR can be operated in what are known as instrument meteorological conditions ("IMC"). This is because the use of instruments compensates for the lack of visibility.

Overview of UK SERA

5.24 The main source of the rules of the air in the UK is UK Regulation (EU) 923/2012 establishing the Standardised European Rules of the Air ("UK SERA"). The rules themselves are found in the Annex to the Regulation. UK SERA is supplemented by the Rules of the Air Regulations 2015,[303] and some provisions in the Air Navigation Order 2016.[304] Some provisions of UK Regulation (EU) 965/2012 ("Air Operations Regulation") also set requirements which must be followed by the pilot-in-command of an aircraft.[305] The UK rules of the air apply to all aircraft engaged in general air traffic operating into, within or out of the United Kingdom.[306]

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302 Annex 2 to the Chicago Convention, Tenth Edition (2005), including amendment 46, 2.3.1; see also UK Regulation (EU) 923/2012 on the Standardised European Rules of the Air, annex, SERA.2010(a).

303 SI 2015 No 840. The rules of the air in the UK were previously contained in the Rules of the Air Regulations 2007, which implemented the standards in Annex 2 to the Chicago Convention. When the Commission Implementing Regulation (EU) No 923/2012 ("UK SERA") was implemented, the Rules of the Air Regulations 2015 were passed in order to revoke the 2007 Regulations and preserve some additional rules which were not found in the SERA Regulation. These include requirements relating to acrobatic flight over congested areas, lighting of airships by day, and flight rules within aerodrome traffic zones. The 2015 Regulations grant some exemptions from the requirements of UK SERA.

304 The Civil Aviation Authority ("CAA") has also issued a series of (general) exceptions, permissions, and authorisations to UK SERA. These exemptions can be granted for special types of operations listed in article 4 of UK SERA. Exemptions granted include one for search and rescue operations conducted by the Maritime and Coastal Authority (MCA). See CAA,*SERA Search and Rescue Operations in Accordance with an Air Operator's Certificate* (ORS No 1527), https://publicapps.caa.co.uk/docs/33/ORS4%20No.1527.pdf.

305 UK Regulation (EU) 965/2012 laying down technical requirements and administrative procedures related to air operations.

306 UK Regulation (EU) 923/2012 on the Standardised European Rules of the Air, art 1(2). The rules also apply to air traffic bearing the nationality and registration marks of the UK when operating in foreign airspace to the extent that UK SERA does not conflict with the rules established by the other country.

5.25 The rules have a broad scope. They include rules about: protecting third parties; collision avoidance; regulating unusual use cases (eg aerobatic and formation flights); signalling; flight plans; air space classification; air traffic control systems; emergency procedures; and voice communication procedures. Many of the rules are directed towards coordinating the movement of aircraft: for example, SERA.3210 determines which aircraft has right of way over another.[307]

5.26 Uncrewed aircraft systems ("UAS") in the certified category are only subject to the "applicable requirements" of UK SERA (for an overview of the different categories of UAS, see chapter 3). Those requirements are set out by the relevant acceptable means of compliance ("AMCs") and guidance material ("GM") to the UAS Implementing Regulation.[308] However, at present there are no AMCs or guidance on which of the operational requirements within UK SERA are applicable to the UAS in the certified category.[309]

5.27 Currently, a small number of "applicable requirements" of UK SERA are applied to UAS operations in the specific category pursuant to article 7(2) of the UAS Implementing Regulation. These are listed in the accompanying AMC and include provisions related to: collision avoidance; rights of way; and flying in prohibited and restricted airspace.[310] The CAA may also apply any additional applicable requirements of the rules of the air as a condition of an operational authorisation.

5.28 The rules of the air do not apply to UAS operations in the open category. These operations are low risk, flying at lower altitudes and generally further away from uninvolved persons.

IFR and VFR

5.29 The distinction before IFR and VFR derives from rule 2.2 of Annex 2 to the Chicago Convention, which states that:

> The operation of an aircraft either in flight or on the movement area of an aerodrome shall be in compliance with the general rules and, in addition, when in flight, either with:
>
> a) the visual flight rules; or
>
> b) the instrument flight rules.

5.30 This distinction is replicated in the UK rules of the air, specifically in UK SERA section 2, SERA.2005, and further elaborated on in UK SERA section 5.[311]

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307 UK Regulation (EU) 923/2012 on the Standardised European Rules of the Air, annex, SERA.3210.

308 See para 1.76 for an explanation of these types of guidance.

309 UK Regulation (EU) 2019/947 on the rules and procedures for the operation of unmanned aircraft, art 7(3).

310 UK Regulation (EU) 2019/947 on the rules and procedures for the operation of unmanned aircraft, AMC1 art 7(2).

311 UK Regulation (EU) 923/2012 on the Standardised European Rules of the Air, annex, section 5. This section also provides for "special" visual flight rules.

5.31 VFR are premised on the aircraft being operated in visual meteorological conditions ("VMC"). Visibility is key to the functioning of the VFR. It is not possible to fly using VFR in cloud, and more difficult to fly VFR at night (which is why VFR flights at night are subject to more restrictions).[312]

5.32 The VFR have requirements as to visibility and distances from clouds for different flights at different levels or altitudes and in different airspace classes.[313] The VFR also set requirements for aspects of visual flight such as minimum operating heights and place restrictions on the classes of airspace a flight operating under the VFR can enter.

5.33 By contrast, a flight following IFR can be operated whether visibility is good or poor.

5.34 Under IFR, a pilot can rely on the instruments. However, with the pilot's ability to detect hazards diminished, they are also more reliant on air traffic control to make sure that they maintain separation from other aircraft and, ultimately, maintain safe flight.

5.35 The distinction between VFR and IFR also feeds into the classification of airspace: for example, in class A airspace, only instrument flight rules flights are permitted. VFR and IFR also impact the types of air traffic services provided in different airspace classes. For example, air traffic control service is provided to IFR flights in Class E airspace but traffic information is only provided to VFR flights as far as practical.[314]

5.36 Each mode of flying comes with benefits and drawbacks. The benefit of flying under VFR is that the pilot has more freedom to determine their own path. The disadvantage is that VFR flying can only be undertaken in clear conditions. IFR allow aircraft to fly in lower visibility, but flying using IFR involves the additional specific requirement of a detailed flight plan outlining route, time, distance, speed and altitude. It creates extra workload for the pilot and air traffic control.

The pilot-in-command

5.37 The central actor in the rules of the air is the "pilot-in-command", defined in Annex 2 to the Chicago Convention and UK law as "the pilot designated by the operator, or in the case of general aviation, the owner, as being in command and charged with the safe conduct of a flight".[315]

5.38 Aside from the pilot-in-command, many rules also place requirements on the operator or those involved in Air Traffic Services ("ATS") or Air Traffic Control ("ATC") Services. However, ultimately, it is the "pilot-in-command" who has "final authority" and is

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312 See for example UK Regulation (EU) 923/2012 laying down the common rules of the air and operational provisions regarding services and procedures in air navigation, annex, SERA.5005 and ORS 1496.

313 UK Regulation (EU) 923/2012 on the Standardised European Rules of the Air, annex, section 5.

314 UK Regulation (EU) 923/2012 on the Standardised European Rules of the Air, annex, SERA.6001, Appendix IV. See annex, section 6 for an overview of the different airspace classes.

315 Annex 2 to the Chicago Convention, Tenth Edition, 2005, including amendment 46, pp 1 to 7. UK Regulation (EU) 923/2012 on the Standardised European Rules of the Air, art 2 para 100; Air Navigation Order 2016 SI No 765, sch 1. For further discussion of definitions of "pilot", and "pilot-in-command", see chapter 6 paragraphs 6.14 to 6.21.

responsible for the safe conduct of a flight.[316] As already noted above, the pilot-in-command has the power to depart from the rules "in circumstances that render such departure absolutely necessary in the interests of safety".[317]

5.39 The rules currently operate on the presumption that there will be a human in the aircraft who can undertake relevant requirements. For example, UK SERA.14026 indicates that it is expected that communications should be "spoken". Further to this, the protocols governing communication with air traffic control services set out in detail the standard phraseology which should be used for voice communications.[318] Elsewhere in the rules, the pilot-in-command is expected to maintain visual line of sight with other aircraft in certain circumstances.[319] The rules of the air also prescribe standard hand signals which a pilot must be able to use and interpret from other actors.

5.40 At this point, it is important to distinguish between those aircraft that will operate with a remote pilot and those that will operate autonomously. In the following chapters, we discuss how, in our view, a remote pilot of an aircraft should still be considered a pilot-in-command and continue to have responsibility for the safe conduct of a flight. As we discuss, some current obligations will require adjustments such that the remote pilot can still fulfil their duties as pilot-in-command of an aircraft. This might be accomplished via a range of technological solutions as well as ground crew who assist the remote pilot with their duties. However, even so, many rules of the air will need to be adjusted to account for the fact that there is no pilot present in the aircraft.

5.41 In the following section, we describe significant issues the rules of the air present for remote pilots and autonomous operations.

APPLYING THE RULES OF THE AIR TO REMOTE PILOTING AND AUTONOMOUS OPERATIONS

5.42 An initial survey of the rules of the air reveals some requirements which appear to present less difficulty translating to remotely piloted and autonomous systems. For example, both IFR and VFR have requirements for minimum heights or cruising levels when undertaking each mode of flight. The details of these requirements are set out in Appendix III to UK SERA and are given in quantitative units such as metres or feet. Prescriptive requirements of this sort are likely to be relatively easier to program.

5.43 Some of the responsibilities currently undertaken by the pilot-in-command are related to the physical, operational or flight status of the aircraft. These might also be able to be automated with the correct technology. For example:

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316 UK Regulation (EU) 923/2012 on the Standardised European Rules of the Air, annex, SERA.2015.

317 UK Regulation (EU) 923/2012 on the Standardised European Rules of the Air, annex, SERA.2010(a).

318 UK Regulation (EU) 923/2012 on the Standardised European Rules of the Air, annex, SERA.14001 and appendix I.

319 Such as when they are intercepted by other aircraft. UK Regulation (EU) 923/2012 on the Standardised European Rules of the Air, GM2 SERA.11015.

(1) The pilot-in-command can only commence take-off if the aircraft is clear of any deposit that might adversely affect the performance or controllability of the aircraft.[320]

(2) The pilot-in-command must check at regular intervals that the amount of usable fuel remaining in flight is not less than the fuel required to proceed to a weather-permissible aerodrome or operating site and the planned reserve fuel.[321]

(3) When undue proximity to the ground is detected by the pilot-in-command or by a ground proximity warning system, the pilot-in-command must take corrective action immediately in order to establish safe flight conditions.[322]

(4) Before beginning a flight, the pilot also has a duty to become familiar with all available information appropriate to the intended operation. For all IFR flights, this includes a "careful study of available current weather reports and forecasts, taking into consideration fuel requirements and alternative course of action if the flight cannot be completed as planned". [323]

5.44 In principle, a combination of sensors, advanced automation or ground staff might be able to undertake these functions.

5.45 However, for other rules of the air, practically speaking, compliance will need to be automated for highly automated or completely autonomous flights to be viable in the long term. Right of way rules are particularly important in this respect. For example, when two aircraft are approaching head-on, or approximately so, and there is danger of collision, each must alter its heading to the right.[324] When two aircraft are converging at approximately the same level, the aircraft that has the other on its right must give way.[325]

5.46 But these basic rules about rights of way are subject to further provision which might complicate automation. For example, when an aircraft is aware that the manoeuvrability of another aircraft is impaired, it shall give way to that aircraft.[326] This requires that an autonomous aircraft have some way of knowing that another aircraft

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320 UK Regulation (EU) 965/2012 laying down technical requirements and administrative procedures related to air operations, annex VII, subpart B, NCOOP165.

321 UK Regulation (EU) 965/2012 laying down technical requirements and administrative procedures related to air operations, annex VII, subpart B, NCOOP185.

322 UK Regulation (EU) 965/2012 laying down technical requirements and administrative procedures related to air operations, annex VII, subpart B, NCOOP195.

323 UK Regulation (EU) 923/2012 on the Standardised European Rules of the Air, annex, SERA.2010(b).

324 UK Regulation (EU) 923/2012 on the Standardised European Rules of the Air, annex, SERA.3210(c)(1).

325 With the notable exception that power-driven heavier-than-air aircraft shall give way to airships, sailplanes (a type of "glider" aeroplane which is unpowered) and balloons. There are similar requirements on overtaking, landing and surface movement, as well as water operations. Power driven aircraft in general must give way to aircraft which are towing other aircraft or objects. See UK Regulation (EU) 923/2012 on the Standardised European Rules of the Air, annex SERA.3210(c)(2) for the full rule.

326 UK Regulation (EU) 923/2012 on the Standardised European Rules of the Air, annex, SERA.3210(b).

is having manoeuvrability issues. There are also exemptions to the basic converging rule. An aircraft on the right must give way except as follows:

(1) power-driven heavier-than-air aircraft must give way to airships;

(2) airships must give way to sailplanes and balloons;

(3) sailplanes must give way to balloons;

(4) power-driven aircraft must give way to aircraft which are seen to be towing other aircraft or object.[327]

5.47 There are similar provisos that must be observed when landing, undertaking surface movement, or performing water operations.[328] Technological solutions will need to account for these, or other measures will need to be put in place to allow autonomous flights to be conducted safely. Our understanding is that the CAA is currently working on amending the rights of way to account for UAS and remotely piloted aircraft system operations which will no doubt also have applicability to autonomous operations.

5.48 Below we highlight two further areas which, in our view, are particularly problematic. Firstly, emergency situations, because human pilots are afforded discretion to act outside the rules of the air in these circumstances. Secondly, the rules around communications which rely on verbal and visual communication from a human to humans.

Emergency situations

5.49 In emergencies, the pilot-in-command is responsible for ensuring that the aircraft lands safely. CAA guidance provides an overview of the actions typically taken by pilots of crewed aircraft in the event of an emergency.[329] It acknowledges that each aircraft emergency will be different, meaning the response to each emergency will necessarily be different.[330] Guidance on the rules of the air reflects this. For example, in the event of a sudden decompression or malfunction requiring emergency descent, a pilot should, if able:

> remain on the assigned route or track whilst carrying out the emergency descent unless doing so would endanger the aircraft, in which case navigate as deemed appropriate by the pilot.[331]

5.50 The pilot is given considerable discretion as to what is appropriate in the circumstances. This aligns with the provision, already discussed, that allows the pilot-

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327 UK Regulation (EU) 923/2012 on the Standardised European Rules of the Air, annex, SERA.2010(c).

328 For water operation see UK Regulation (EU) 923/2012 on the Standardised European Rules of the Air, annex, SERA.3230.

329 CAA, *Aircraft emergencies – considerations for air traffic controllers* (March 2005) (CAP 745).

330 CAA, *Aircraft emergencies – considerations for air traffic controllers* (March 2005) (CAP 745) p 7.

331 UK Regulation (EU) 923/2012 on the Standardised European Rules of the Air, GM1 SERA.11001.

in-command to depart from the rules of the air where it is appropriate in the interests of safety.[332]

5.51 There are several other emergency circumstances which, whilst comparatively rare, are scenarios that an autonomous aircraft might expect to encounter. These include: bird strikes;[333] icing;[334] sudden loss of fuel and power; and aircraft becoming lost or "strayed". These emergency scenarios may lead a pilot to choose to disregard rules such as height restrictions or airspace prohibitions if it means they can achieve a safer outcome.

5.52 These emergency scenarios may also require a pilot to conduct an emergency landing. Emergency landings require the pilot to take account of circumstances and use their discretion to achieve a safe outcome. Sometimes the correct decision is not straightforward. Two examples demonstrate this.

5.53 Firstly, the landing of US Airways Flight 1549 on the Hudson River in 2009 is an example of pilot discretion leading to a successful outcome. The aircraft in question experienced a complete loss of thrust following a bird strike, necessitating an emergency landing. The pilot decided to ditch the aircraft in the Hudson River, rather than returning to the aerodrome. The subsequent investigation concluded that the pilot's decision provided the highest probability that the accident would be survivable.[335]

5.54 The example of Flight 1549 can be contrasted with an incident where the pilots made a less optimal decision in an emergency scenario. In 2010, a general aviation aircraft was ditched in the River Derwent, Derbyshire following engine failure. This approach was criticised by the Air Accident Investigation Branch which, after an investigation, determined that landing in a field immediately beyond the river would have been a safer alternative.[336]

5.55 It important to consider whether such similar freedom to disregard rules of the air in emergencies should be available to highly automated and autonomous aircraft. Such freedom could result in safer outcomes overall even if worse outcomes occur in some circumstances. The opposite is also possible.

5.56 The Law Commissions have previously consulted on whether, in the interests of safety, some freedom should be given to automated vehicles to break road rules. The Commissions presented several scenarios including one where automated vehicles

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332 UK Regulation (EU) 923/2012 on the Standardised European Rules of the Air, annex, SERA.2010.

333 Birds hitting aircraft at speed can cause considerable damage to an aircraft. CAA have published statistics indicating that of the 100 bird strike incidents that occur every year, roughly 5% resulted in damage or caused an effect on the flight. See CAA, *Bird avoidance* (January 2013) p 1.

334 Icing on an aerofoil changes its properties, reducing lift and increasing drag. On a propeller blade, it reduces the efficiency of the propeller and reduces thrust. The weight of ice also increases the aircraft weight, requiring more lift.

335 National Transportation Safety Board, *Aircraft Accident Report* NTSB/AAR-10/01 PB2010-9210403 (adopted May 2010) p 89.

336 Air Accidents Investigation Branch ("AAIB"), *Pierre Robin R2160 Alpha Sport, G-SAC* (Accident Report 2010).

were given the freedom to mount the pavement (a manoeuvre that is prohibited by law) to avoid an accident.[337]

5.57 The issue proved controversial and only a small majority of respondents (52%) thought automated vehicles should be able to mount the pavement to avoid an accident.[338] Those that agreed believed that, in principle, to achieve safer outcomes, automated vehicles should be programmed to have all the options that humans have available to them, even if this meant breaking the law. Others were against the proposition on the basis that it would pose a potential risk to others outside the vehicle.[339] The Law Commissions concluded that it would be difficult to set hard rules to deal with situations of this type. Instead, the Law Commissions recommended that a forum for collaboration on how road rules should be applied to automated driving should be established.[340]

5.58 Emergency scenarios are relatively rare in aviation. However, when they do occur the consequences can be catastrophic and can result in a significant loss of life and damage. It needs to be considered how much freedom highly automated or autonomous aircraft should be given to operate outside the usual rules of the air in the interests of safety. It may be safest overall to program autonomous aircraft with a range of options available, even if this does not always result in the best option being taken by the aircraft. Alternatively, it might be safer overall to develop detailed rules for emergency situations involving autonomous aircraft. In emergency scenarios the aircraft would be programmed to act in certain prescribed ways. We seek views from consultees.

Consultation Question 4.

5.59 We seek views on how highly automated and autonomous aircraft should act in emergency scenarios. In particular:

(1) should highly automated and autonomous aircraft be given the freedom to operate outside the rules of the air in emergency circumstances; or

(2) should a comprehensive set of rules be developed for highly automated and autonomous aircraft in emergency situations.

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337 Automated Vehicles (2018), Law Commission Consultation Paper No 240; Scottish Law Commission Discussion Paper No 166, ch 9.

338 Law Commissions, *Automated Vehicles: Analysis of responses to the preliminary consultation paper* p 145, https://cloud-platform-e218f50a4812967ba1215eaecede923f.s3.amazonaws.com/uploads/sites/30/2019/06/Automated-Vehicles-Analysis-of-Responses.pdf.

339 Law Commissions, *Automated Vehicles: Analysis of responses to the preliminary consultation paper* p 145, https://cloud-platform-e218f50a4812967ba1215eaecede923f.s3.amazonaws.com/uploads/sites/30/2019/06/Automated-Vehicles-Analysis-of-Responses.pdf.

340 Law Commission Automated Vehicles (2022) Law Com No 404; Scot Law Com 258, p 117.

5.60 How highly automated and autonomous aircraft act in emergency scenarios will also be relevant to use cases which involve a remote pilot. As we described in Chapter 2, in practice, the distinction between a remotely piloted and an autonomous aircraft may be difficult to draw. To operate safely, a remotely piloted aircraft must be able to handle the loss of connection to the pilot. This means that remotely piloted aircraft will need to be able to operate independently in particular circumstances. This would include emergency scenarios that involve a loss of connectivity.

5.61 Remotely piloted use cases may also present other challenges in emergency situations. The Law Commission has previously looked at the issue of remote driving of road vehicles. Aside from connectivity, respondents to the Law Commissions Issues Paper on remote driving highlighted several other safety challenges. For example, a lack of situational awareness was cited as a concern. Drivers within a vehicle can use non-visual cues such as acceleration or how an engine sounds to more quickly assess a given situation.[341] Another safety challenge highlighted by respondents was that a driver who is not at personal risk from a collision would have a greater sense of detachment. This detachment might affect their decision making, lessening the sense that their actions have real life consequences.[342]

5.62 Remote piloting in the aviation context is different to the remote driving of road vehicles. However, remotely operating an aircraft in emergency situations may present similar safety challenges. We seek consultee views about what challenges remotely piloting an aircraft in an emergency scenario presents and how these might be addressed.

Consultation Question 5.

5.63 We seek consultee views about what challenges remotely piloting an aircraft in an emergency scenario presents and how these might be addressed.

Communications

5.64 Throughout UK SERA, there are requirements for aircraft to maintain air-ground voice communications, which is defined as "two-way communication between aircraft and stations or locations on the surface of the earth".[343] This is premised on there being a pilot on board the aircraft who can communicate by voice to those on the ground.

5.65 All aircraft in controlled airspaces other than class E airspace, and IFR flights in uncontrolled airspace must be "capable of establishing air-ground voice communications".[344] Furthermore, VFR flights operating in parts of uncontrolled airspace designated as a radio mandatory zone ("RMZ") must establish two-way

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341 Law Commission: Remote Driving Advice to Government (2023) p. 15.

342 Law Commission: Remote Driving Advice to Government (2023) p 16.

343 UK Regulation (EU) 923/2012 on the Standardised European Rules of the Air art 2(22). See also annex, SERA.6001, section 14, and appendix IV.

344 UK Regulation (EU) 923/2012 on the Standardised European Rules of the Air, annex, SERA.6001.

communication on the relevant channel. The rules of the air require that before entering the RMZ zone, the pilot must make:

> an initial call containing the designation of the station being called, call sign, type of aircraft, position, level, the intentions of the flight and other information as prescribed by the competent authority...[345]

5.66 The rules of the air also impose numerous duties on ATS to provide information to pilots. For example, pilots are to be informed by ATS when a controlled flight is on a conflicting path with another unknown aircraft.[346] The rules of the air also require flight information services to be provided by the appropriate air traffic services unit to all "aircraft which are likely to be affected by the information". [347] This presents a problem for autonomous aircraft which will not have a pilot and will likely require information to be provided in a manner other than voice communications.

5.67 There are other aspects of communication that create difficulty in UK SERA, such as the duties of pilots to make special aircraft observations and reports when certain meteorological irregularities occur (ie moderate or severe turbulence, icing, thunderstorms etc).[348] These observations should be reported during the flight by voice communication when the observation is made or as soon as is practicable thereafter.[349]

5.68 Removal of a human pilot from the equation may also create problems in relation to the rules of the air which prescribe "signals" communication. Some rules of the air require a human pilot to exchange hand signals with others such as signalpersons and emergency services.[350] These signals rules are particularly important when aircraft are moving on the ground. The "signals" rules are designed with conventional aircraft in mind, and several require some level of human judgement. For example, there are several distress signals requiring an assessment of whether the aircraft is in "grave and imminent danger". There are also a whole host of marshalling signals which involve a signalperson communicating with hand signals to the on-board pilot.[351]

5.69 In some critical circumstances, aircraft may also need to be intercepted by relevant authorities (eg, the RAF). Such circumstances may include where an aircraft is no longer communicating with the ATC or they have entered prohibited airspace.

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345 UK Regulation (EU) 923/2012 on the Standardised European Rules of the Air, annex, SERA.6005.

346 UK Regulation (EU) 923/2012 on the Standardised European Rules of the Air, annex, SERA.7002.

347 UK Regulation (EU) 923/2012 on the Standardised European Rules of the Air, annex, SERA.9001. The provision applies to aircraft which are provided with air traffic services generally, or which are known to the relevant air traffic service unit.

348 UK Regulation (EU) 923/2012 on the Standardised European Rules of the Air, annex, SERA.12005.

349 UK Regulation (EU) 923/2012 on the Standardised European Rules of the Air, annex, SERA.12015.

350 A signalperson is responsible for marshalling the aircraft on the ground, providing nonverbal signals which indicate to the pilot of an aircraft a range of information such as when to slow down, where to stop the plane, and when to shut down engines.

351 UK Regulation (EU) 923/2012 on the Standardised European Rules of the Air, annex, appendix I, section 4.

5.70 The current rules of the air require the pilot-in-command to follow instructions by looking for and responding to visual signals during an interception. For example, an intercepting aircraft conveys the message "you have been intercepted. Follow me" by rocking the aircraft and flashing navigational lights at irregular intervals from a position slightly above, ahead of, and normally to the left of, the intercepted aircraft. If the intercepted aircraft wishes to convey the message "understood, will comply", the pilot must rock the aircraft, flashing navigational lights at irregular intervals and then following.[352]

5.71 The rules also envisage the intercepting pilot will make radio contact with the intercepted aircraft,[353] and require ATS to attempt to establish two-way communication with all of the aircraft involved.[354] ATS may be required to relay messages between the intercepting and intercepted aircraft.[355] For these scenarios, communication with a highly automated or autonomous aircraft could prove difficult.

5.72 Given the paramount importance of communications during aviation operations, we seek consultees' views on how the rules of the air relating to communication should be adapted for remotely piloted and autonomous aircraft.

Consultation Question 6.

5.73 We seek consultees' views on whether the rules of the air relating to communication should be adapted for remotely piloted and autonomous aircraft.

POTENTIAL OPTIONS FOR ADAPTATION

5.74 As we have described, the current rules of the air present difficulties for autonomous operations. They are predicated on there being a human pilot-in-command of the aircraft. The rules are also subject to caveats and instances where human discretion must be exercised. In some situations, the human pilot-in-command can be expected to operate outside the rules of the air to ensure the safety of the aircraft.

5.75 Earlier in this chapter, we described how the current rules of the air were never intended for operations where there was no crew onboard the aircraft. We have highlighted the difficulties this creates and asked for views on how certain rules might be adapted. Going forward, more rules of the air will need to be reviewed in light of remote and autonomous operations. A more systemic approach to adaptation is therefore desirable. We outline three options for adaptation below.

Amending the current rules

5.76 One option for adaptation is to amend the current rules of the air to account for operations which are autonomous or where there is no human pilot on board. This

352 UK Regulation (EU) 923/2012 on the Standardised European Rules of the Air, annex, SERA.11015.

353 UK Regulation (EU) 923/2012 on the Standardised European Rules of the Air, annex, SERA.11015(d).

354 UK Regulation (EU) 923/2012 on the Standardised European Rules of the Air, annex, SERA.11015(f).

355 UK Regulation (EU) 923/2012 on the Standardised European Rules of the Air, annex, SERA.11015(g).

would have the benefit of having one set of rules of the air which were applicable to aircraft operations in general. This might also have the benefit of future-proofing the rules of the air as aviation technology progresses.

5.77 However, the task would be considerable. Firstly, although UK SERA is the main body of relevant rules, rules of the air, as well as cross references to the rules of the air, are also found in many different pieces of legislation and regulation. To amend the current rules of the air would require a comprehensive review of all relevant legislation and regulation.

5.78 Secondly, it could be difficult to amend the rules in such a way to account both for flights with a pilot and those without. For example, the rules of the air which relate to communication would need to account for operations with a human pilot, who can communicate verbally, as well as autonomous operations without a pilot. In the future, the complexity of this proposition is likely to increase as air navigation services will also become increasingly automated. Adapting or expanding the rules in such a way might make them unwieldy or difficult to navigate.

5.79 Thirdly, current rules of the air are largely derived from Annex 2 to the Chicago Convention. Although contracting states to the convention have the freedom to develop their own rules of the air, adapting the current rules for autonomy and remote piloting such that they continue to align with Annex 2 may be difficult. Amongst other reasons, the pilot-in-command is the central actor in Annex 2 and new rules which deviate from this may not be reconcilable.

5.80 Finally, it may be problematic to attempt to adapt the current rules of the air whilst autonomous use cases are still in their relative infancy. The pace at which the technology is developing is likely to outstrip the pace of law making. It is possible that the way the technology develops means that solutions are found for some of the issues created by the current rules of the air. For instance, it may be possible in the future for many autonomous and conventional aircraft to communicate information about their position and flight path without the need for human oversight or voice communications.[356] This may solve some of the issues higher automation and autonomy creates for communications and other aspects of the rules of the air such as avoidance of mid-air collisions. Attempting to amend the current rules of the air now would change the current rules for all airspace users whilst ultimately proving to be premature.

Applying “applicable requirements”

5.81 As described in the earlier part of the chapter, UAS operations in the open category are not subject to the rules of the air. This reflects the low-risk nature of these operations. UAS operations in both the specific and certified categories are only subject to “applicable requirements" of UK SERA. At present there is guidance for which requirements apply to operations in the specific category but not the certified category.

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[356] Electronic conspicuity refers to technology which enables airspace users to detect and be detected by other airspaces users. See CAA, *Airspace Modernisation Strategy 2023-2040* (January 2023) (CAP 1711) 2.19.

5.82 The Acceptable Means of Compliance for the UAS Implementing Regulation affirms that only a small number of requirements within UK SERA are applicable to UAS in the Specific category.[357] Operators in the specific category are asked to consider the requirements listed in the AMC and their applicability to their individual operations. These include the UK SERA rules on proximity, collision avoidance and right of way but notably not in relation to UK SERA rules on voice communications or signals. The CAA can require additional rules of the air, above and beyond those listed in the AMC, to be adhered to as part of the authorisation of the operations.

5.83 Therefore, operations in the specific category can be conducted with fewer rules of the air being applicable. To ensure safety, the CAA assess each application for an operation in the specific category and authorisation can be granted subject to any appropriate conditions or limitations the CAA chooses to impose.[358]

5.84 This approach has considerable flexibility, allowing autonomous operations to be conducted without conflicting with any of rules of the air. The CAA assesses the relative risk of an operation and decides whether the operation can be conducted safely, even if the autonomous operation cannot be conducted in line with all rules of the air.

5.85 At present, there is no guidance about which rules of the air are applicable to autonomous operations in the certified category. However, if the approach taken to the specific category was applied to the certified category, then only certain core rules of the air might be applicable to these types of operations. As part of operator licensing, the CAA could then put in place appropriate conditions or requirements to ensure that the operation is safe.

5.86 The benefit of this approach is that there could be considerable flexibility for operators to make applications for their particular use cases. Use cases which cannot comply with all of the rules of the air might be able to be approved subject to any appropriate conditions the CAA saw fit to impose to ensure safety.

5.87 A potential drawback though is that such a process would be intensive for both potential applicants and the regulator. Potential operators would need to be scrutinised more intensively before the appropriate conditions could be formulated for their particular operations. This would also create more uncertainty for potential operators.

5.88 There is also a limit to what can be achieved by this approach. The ultimate aim is for UAS to operate in the same airspace as crewed aircraft. To make that work, there will need to be certain common standards of behaviour that are met. Another aircraft would need to have some certainty about how the UAS would behave in certain scenarios (for example, when it was necessary for one aircraft to give way).

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357 UK Regulation (EU) 2019/947 on the rules and procedures for the operation of unmanned aircraft, AMC1 art 7(2).

358 UK Regulation (EU) 2019/947 on the rules and procedures for the operation of unmanned aircraft, art 12(4).

A new set of rules of the air for remotely piloted and autonomous operations

5.89 A third possibility is that an entirely new set of rules should be developed for remotely piloted and autonomous operations. These rules would stand alone and apply only to these types of operations.

5.90 This idea for a new set of flight rules for highly automated and autonomous flight is not new. In 2020, National Aeronautics and Space Administration ("NASA") proposed a new set of "digital" flight rules ("DFR") in order to accommodate and help facilitate new advances in aviation.[359] The NASA paper proposed the creation of these digital flight rules to complement the existing VFR and IFR.

5.91 NASA proposed that this new set of rules would be based on digital information sent between aircraft. This information would allow for the separation of individual aircraft in airspace that would otherwise be achieved by air traffic control or visual observation. Put another way, flights operating under DFR would be able to share information about their position and flight plan with other airspace users via onboard technology. This would not solve all the issues autonomy presents for the current rules of the air but would go some way to addressing those related to communications and rights of way.

5.92 The development of a new set of rules of the air for remote piloting and autonomous operations would have the benefit of taking much of the uncertainly out of these types of operations. There would be no ambiguity about the applicability of any of the rules. The requirements for autonomous flight would be clearly set out for operators.

5.93 A potential drawback of this approach, however, is the amount of time it would take to develop a comprehensive set of rules for remotely piloted and autonomous flight. Both of these types of operation are still in a period of intense development and the relevant standards and best practices and technologies are still being developed.[360] Although NASA has developed its concept of digital flight rules for over a decade, it does not provide any timeframe for their adoption but rather emphasises building a community of developers and the creation of standards.[361] We also understand that certain technologies and systems will be required on aircraft to enable their use of digital flight rules and these are not yet commonplace.[362]

5.94 Another issue is that a new set of flight rules will need to coexist alongside current flight rules. For the foreseeable future, remotely piloted and autonomous aircraft will

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359 National Aeronautics and Space Administration, *Digital flight: a new cooperative operating mode to complement VFR and IFR* (September 2022),https://ntrs.nasa.gov/api/citations/20220013225/downloads/NASA-TM-20220013225.pdf

360 EASA, Artificial Intelligence Roadmap 2.0 (May 2023) p 27, https://www.easa.europa.eu/en/newsroom-and-events/news/easa-artificial-intelligence-roadmap-20-published.

361 National Aeronautics and Space Administration, *Digital flight: a new cooperative operating mode to complement VFR and IFR* (September 2022), section 5, https://ntrs.nasa.gov/api/citations/20220013225/downloads/NASA-TM-20220013225.pdf

362 Amongst other requirements aircraft need to be able to have equipment that allows them to "maintain a digital model of the operating environment for use by decision-making automation" and have technical features which enable the automation of separation between aircraft. National Aeronautics and Space Administration, *Digital flight: a new cooperative operating mode to complement VFR and IFR* (September 2022), section 3.5, https://ntrs.nasa.gov/api/citations/20220013225/downloads/NASA-TM-20220013225.pdf

need to interact with conventional aircraft. The solutions arrived at in a new set of rules of the air must also be compatible with conventional operations. For example, a new set of rules of the air may not require autonomous aircraft to use voice communications. However, the new rules would still need to provide for communication with other conventional aircraft, air traffic control as well as other pilots in unusual circumstances (eg interception events).

Consultation Question 7.

5.95 We ask for consultees' views on how the rules of the air might be adapted or developed for remotely piloted or autonomous flight.

Chapter 6: VTOLs

INTRODUCTION

6.1 This chapter focuses on the legal problems posed by the introduction of uncrewed, passenger carrying aircraft. In particular, we look at uncrewed vertical take-off and landing aircrafts ("VTOLs") as a form of "urban air mobility": that is, short trips in urban locations. Several manufacturers are developing these aircraft. Initially, operations will be controlled by a pilot within the aircraft (though they will still feature a high degree of automation). Most manufacturers, however, are aiming to eventually remove the pilot from the aircraft altogether.[363] The Future Flight roadmap envisages "autonomous advanced air mobility operations" (with a remote pilot in a control centre) being certified in the UK by 2030.[364]

6.2 Many aviation authorities are developing frameworks for the regulation of crewed VTOLs. But the next step in the development of VTOLs, the removal of the pilot from the aircraft, raises fundamental questions. How do we make sure that the many aspects of the role of the pilot are not overlooked when their responsibilities are transferred elsewhere? We consider here the level of remote supervision required for someone to be called a "remote pilot", and whether (and how) a remote pilot could fulfil all of the duties that are currently held by the pilot-in-command. We also consider how we can make these new services as safe and accessible as possible for those who have different travel needs.

REGULATING CREWED VTOLS

6.3 At present, the Chicago Convention ("the Chicago Convention") envisages remotely piloted aircraft systems ("RPAS"), but the existing regulatory framework does not extend explicitly to the carrying of passengers.[365] Other jurisdictions have started grappling with the changes that are required to the regulatory framework in order to accommodate VTOLs in the short-term. For example, both the Federal Aviation Authority ("FAA") and the European Union Aviation Safety Authority ("EASA") have been developing their own regulatory frameworks for the operation of VTOLs, including pilot certification.[366] The FAA has published parts of proposed airworthiness

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363 See for example the appearance of Andrew Macmillan, Chief Strategy Officer at Vertical Aerospace, in response to question 5 from the Chair. House of Commons Transport Committee, oral evidence: Electric Vertical take-off and landing vehicles, 22 February 2023, HC 1154, https://committees.parliament.uk/oralevidence/12711/pdf/.

364 UKRI, *Future flight vision and roadmap*, (August 2021) p 14, https://www.ukri.org/wp-content/uploads/2021/08/UKRI-130821-FutureFlightVisionRoadmap.pdf.

365 ICAO, *Manual on Remotely Piloted Aircraft Systems (RPAS)* (2015) para 2.3.5.

366 FAA, https://www.federalregister.gov/documents/2023/06/14/2023-11497/integration-of-powered-lift-pilot-certification-and-operations-miscellaneous-amendments-related-to. EASA: Opinion No 3/2023, *Introduction of a regulatory framework for the operations of drones- Enabling innovative air mobility with manned VTOL-capable aircraft, the initial airworthiness of unmanned aircraft systems subject to certification, and the continuing airworthiness of those unmanned aircraft systems operated in the 'specific' category* (August 2023) 2.3.5 pp 32 to 33.

criteria for a VTOL produced by Joby Aviation. EASA has also adopted criteria for airworthiness of VTOLs, as well as suggesting changes to existing rules on air operations, flight crew licensing and the standardised European rules of the air.[367] At present, these changes would only extend to accommodate crewed VTOLs, though EASA intends to propose changes to accommodate passenger-carrying uncrewed aircraft in the future.[368]

6.4 The focus of this chapter is on the legal challenges which arise when uncrewed VTOLs enter the market. We are therefore assuming that some of the legal framework which is necessary for crewed VTOLs will have been introduced. For the most part, this will be similar to regulation used for existing aircraft. For example, we expect that there will be legislation and/or guidance introduced to cover:

(1) pilot and crew licensing;

(2) operating licences;

(3) air operations (for example rules on take-off and equipping of seat belts);

(4) aerodromes (sometimes referred to as "vertiports" when designed specifically for VTOLs);[369]

(5) emergency procedures; and

(6) areas of operation.

6.5 This chapter focuses on the impact of removing the pilot from the aircraft. We consider the role of the remote pilot (if any), and the consequences for passengers.

WHAT WILL FUTURE SERVICES LOOK LIKE?

6.6 It is not yet clear whether uncrewed VTOLs will always require a remote pilot or will become fully autonomous. In its high-level plan for future regulation in this area, EASA suggests that "VTOL[s]…will start operating with a pilot on board while their level of automation will evolve until they are remotely piloted and even autonomous".[370]

6.7 However, most of the discussion to date has envisaged having some level of continuing human involvement. For example, the FAA envisages that even at a mature stage of operations, a remote pilot-in-command will be necessary for urban air mobility. At the mature stage, the FAA's concept of operations suggests that the "aircraft automation level" will be what they describe as "human-over-the-loop"

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367 EASA Opinion No 3/2023, *Introduction of a regulatory framework for the operations of drones- Enabling innovative air mobility with manned VTOL-capable aircraft, the initial airworthiness of unmanned aircraft systems subject to certification, and the continuing airworthiness of those unmanned aircraft systems operated in the 'specific' category* (August 2023). .

368 EASA, *Terms of Reference: RMT.0230* (Issue 4, December 2022) p 8.

369 See for example the Civil Aviation Authority's Innovation Hub, *Considerations for Aerodromes and Vertiports planning to operate Vertical Take-off and Landing Aircraft (VTOL)* (April 2023) (CAP 2538).

370 EASA, *Terms of Reference: RMT.0230* (Issue 4, December 2022) p 3.

meaning that a human passively monitors a system and is informed by automation whether action is required and if so, what.[371]

6.8 Industry has also been turning its mind to the future of urban air mobility. EHang, a Chinese company, has conducted multiple test flights of uncrewed, passenger-carrying aircraft including in Spain. It uses a command and control centre for controlling the aircraft. The special condition for the aircraft (EH216-S) makes clear that remote crew are able to intervene where necessary.[372]

6.9 A "concept of operations" published by Boeing and Wisk focuses on urban air mobility, by which they mean a subset of advanced air mobility focusing on lower-altitude operations within urban environments. The piloting function on the aircraft will be automated. The concept envisages a "fleet operations centre" (not necessarily in the same place that passengers will board and disembark) which will accommodate the following staff.

(1) Fleet managers. These will be responsible for (amongst other things) fleet and resource scheduling; pre-departure planning, and dispatch; and adjusting the planning of operations in response to any disruptions.

(2) Multi-vehicle supervisors. These will be responsible for supervising multiple aircraft. They "will not function as a remote pilot, as the piloting functions will be automated (onboard and in the fleet operations centres)". However, they will "have the ability and command authority to override vehicle actions of aircraft under their control throughout flight".

(3) Remote passenger hospitality personnel. These staff will "be responsible for passenger health and provide safety communications to passengers before, during and after flights".[373]

6.10 The new role is that of the multi-vehicle supervisor ("MVS"). MVS workstations will allow the MVS to supervise checks which are either automated or performed by ground management. This will include checking that passengers have received a safety briefing. The station will also allow MVSs to conduct cybersecurity checks, monitor aircraft and airspace operational status, and communicate with air traffic control.[374] There will be procedures setting out how MVSs will hand over control of aircraft during shift changes, or if necessary, during emergencies.

THE CURRENT ROLE OF THE PILOT

6.11 The pilot is one of the key actors in the regulation of aviation and holds many responsibilities. The term often used in legislation is "pilot-in-command". The pilot-in-

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371 Federal Aviation Administration, *Urban Air Mobility Concept of Operations* (April 2023) p 7, https://www.faa.gov/sites/faa.gov/files/Urban%20Air%20Mobility%20%28UAM%29%20Concept%20of%20Operations%202.0_0.pdf.

372 https://www.icao.int/Meetings/a41/Documents/WP/wp_444_en.pdf.

373 Boeing and Wisk, *Concept of operations for uncrewed urban air mobility – v 2* (2023) p 24, https://wisk.aero/wp-content/uploads/2023/12/Concept-of-Operations-for-Uncrewed-Urban-Air-Mobility-v2.0.pdf.

374 Boeing and Wisk, *Concept of operations for uncrewed urban air* mobility (2022), pp 28 to 29.

command is ultimately in charge of the flight and must ensure its safe conduct. The pilot-in-command may be the only pilot on an aircraft, or one of several pilots. For commercial air transport operations, an operator is required to designate one pilot among the flight crew as the pilot-in-command.[375]

6.12 In practice, the source of a pilot's obligations in the UK will depend on whether they are flying a Part 21 or non-Part 21 aircraft discussed at 1.81. The role of the pilot for non-Part 21 aircraft is dealt with largely by the Air Navigation Order 2016.[376] For Part-21 aircraft, requirements can be found in the UK Regulation (EU) 2018/1139 (the "Basic Regulation") the UK Regulation (EU) 1178/2011 (the "Aircrew Regulation") and the UK Regulation (EU) 965/2012 (the "Air Operations Regulation").[377]

6.13 As the law is currently structured, a pilotless VTOL engaged in the carrying of passengers would most likely be classified as Part-21 aircraft. However, in practice, the obligations under each regime are similar, and it is possible that the distinction between Part 21 and non-Part 21 may fall away in future. This section of the chapter therefore focuses more on the types of responsibilities and powers that are held by a pilot and, more specifically, a pilot-in-command, rather than on their current location in the legislative scheme. Given that we expect VTOLs to be used within the UK initially, we do not explore the additional responsibilities of pilots associated with international flight.

Definitions: "pilot"

6.14 Annexes 1 and 2 to the Chicago Convention (which address personnel licensing and rules of the air) give an active definition of the pilot: their role is to "manipulate the flight controls of an aircraft during flight time". Another term which is often used is "pilot-in-command"; usually meaning the pilot who is in charge of a flight.

6.15 Annexes 1 and 2 to the Chicago Convention define a pilot-in-command as: "The pilot designated by the operator, or in the case of general aviation, the owner, as being in command and charged with the safe conduct of the flight".

6.16 The same definition of pilot-in-command is adopted by article 2 of Annex I to UK Regulation (EU) 923/2012 on the Standardised European Rules of the Air ("UK SERA"). A similar definition of pilot-in-command is also used by annex 1 to the Aircrew Regulation, which defines the pilot-in-command simply as the "pilot designated as being in command and charged with the safe conduct of the flight".[378]

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375 UK Regulation (EU) 2018/1139 on common rules in the field of civil aviation and establishing a European Union Safety Agency, annex V, para 8.6. The requirement applies to commercial air transport and other operations subject to a certification or declaration requirement performed with aeroplanes, helicopters or tilt rotor aircraft.

376 SI 2016 No 765.

377 UK Regulation (EU) 2018/1139 on common rules in the field of civil aviation and establishing a European Union Safety Agency; UK Regulation (EU) 1178/2011 laying down technical requirements and administrative procedures related to civil aviation aircrew; and UK Regulation (EU) 965/2012 laying down technical requirements and administrative procedures related to air operations.

378 UK Regulation (EU) 1178/2011 laying down technical requirements and administrative procedures related to civil aviation aircrew, annex I, FCL.010.

6.17 The Air Operations Regulation adds that "for the purpose of commercial air transport operations, the 'pilot-in-command' shall be termed the 'commander'".[379]

6.18 Section 94(7) of the Civil Aviation Act 1982 (which sets out the powers of the commander of an aircraft, and also applies to the Air Navigation Order 2016) defines the commander in relation to an aircraft as:

> the member of the crew designated as commander of that aircraft by the operator thereof, or, failing such a person, the person who is for the time being the pilot-in-command of the aircraft.

6.19 The pilot-in-command, in turn, is defined in relation to an aircraft as "a person who for the time being is in charge of the piloting of the aircraft without being under the direction of any other pilot in the aircraft".

6.20 For the most part, these terms do not suggest that the pilot must be present in the aircraft. The exception is the definition of pilot-in-command in section 94(7) of the Civil Aviation Act 1982, where the phrase "any other pilot **in the aircraft**" suggests that at least one pilot is expected to be on board.

6.21 There is some uncertainty as to whether the Air Operations Regulation and UK SERA definitions would apply to remotely piloted or autonomous VTOLs. This is because at present only "applicable operational requirements" of those regulations apply to uncrewed aircraft systems ("UAS") in the certified category.[380] There is not yet however guidance as to which of the operational requirements are applicable to the certified category.

Definitions: remote pilot

6.22 The definition of a "remote pilot" was introduced by the UK Regulation (EU) 2019/945 ("UAS Delegated Regulation"), which defines a remote pilot as:

> a natural person responsible for safely conducting the flight of an unmanned aircraft by operating its flight controls, either manually or, when the unmanned aircraft flies automatically, by monitoring its course and remaining able to intervene and change its course at any time.[381]

6.23 This is similar to the definition included in Annex 1 to the Chicago Convention:

> 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.[382]

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379 UK Regulation (EU) 965/2012 laying down technical requirements and administrative procedures related to air operations, annex I, para 96.

380 UK Regulation (EU) 2019/947 on the rules and procedures for the operation of unmanned aircraft, art 7(3).

381 UK Regulation (EU) 2019/945 on unmanned aircraft systems and on third-country operators of unmanned aircraft systems, art 3(27).

382 Annex 1 to the Chicago Convention, Fourteenth Edition, 2022, including amendment 178, ch 1.

6.24 The Chicago Convention also contains a definition of remote pilot-in-command: "he remote pilot designated by the operator as being in command and charged with the safe conduct of a flight".[383]

The core duties of a pilot

6.25 The Basic Regulation states that the pilot-in-command is responsible for the "operation and safety of the aircraft and for the safety of all crew members, passengers and cargo on board".[384] The Air Operations Regulation elaborates on this. Commanders of commercial air transport operations (such as those we expect to be conducted by VTOLs) are responsible for:

(1) the safety of all crew members, passengers and cargo on board, as soon as the commander arrives on board the aircraft, until the commander leaves the aircraft at the end of the flight; and

(2) the operation and safety of the aircraft:

(a) for aeroplanes, from the moment the aeroplane is first ready to move for the purpose of taxiing prior to take-off, until the moment it finally comes to rest at the end of the flight and the engine(s) used as primary propulsion unit(s) is (are) shut down; and

(b) for helicopters, when the rotors are turning.[385]

6.26 At its heart then, the role of the pilot-in-command has two facets: ensuring the safe operation of the aircraft itself, and also ensuring the safety of people and cargo onboard.

Responsibilities: operating the aircraft

6.27 The core duties outlined above are complemented by numerous more specific ones. Some relate to the task of piloting and the operation of the aircraft. For example, a commander must ensure that all operational procedures and checklists are complied with in accordance with the operations manual (see paragraph 6.105 below).[386] In preparation for flight, the pilot-in-command must be satisfied that:

(1) the aircraft is airworthy;

(2) the aircraft is registered (if required);

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383 Annex 1 to the Chicago Convention, Fourteenth Edition, 2022, including amendment 178, ch 1.

384 UK Regulation (EU) 2018/1139 on common rules in the field of civil aviation and establishing a European Union Safety Agency, annex V, para 1.3.

385 Regulation (EU) 965/2012 laying down technical requirements and administrative procedures related to air operations, annex IV, CAT.GEN.MPA.105(a)(1) and (2). A commercial air transport operation is defined in the UK Regulation (EU) 21018/1139 on common rules in the field of civil aviation and establishing a European Union Safety Agency, art 3(24) as "an aircraft operation to transport passengers, cargo or mail for remuneration or other valuable consideration".

386 UK Regulation (EU) 965/2012 laying down technical requirements and administrative procedures related to air operations, annex IV, CAT.GEN.MPA.105(8).

(3) specified instruments and equipment are installed and operative;[387]

(4) the mass of the aircraft and centre of gravity location are such that the flight can be conducted within limits prescribed in the airworthiness documentation;

(5) all cabin baggage, hold luggage and cargo is properly loaded and secured; and

(6) aircraft operating limitations (for example, in relation to air-speed, or any restrictions on operating in particular meteorological conditions) will not be exceeded at any time during the flight.[388]

6.28 At present these requirements do not apply to uncrewed aircraft.[389]

6.29 All flight crew members required to be on flight deck duty, including the pilot-in-command, must be and remain at their station, with their seatbelts fastened except en-route for physiological or operational needs.[390]

6.30 The overriding aim is safety. Ultimately, annex V to the Basic Regulation makes it clear that:

> In an emergency situation, which endangers the operation or the safety of the aircraft and/or persons on board, the pilot-in-command must take any action he/she considers necessary in the interest of safety. When such action involves a violation of local regulations or procedures, the pilot-in-command must be responsible for notifying the appropriate local authority without delay.[391]

6.31 Similarly, UK SERA states that the pilot-in-command may depart from the rules "in circumstances that render such departure absolutely necessary in the interests of

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387 UK Regulation (EU) 2018/1139 on common rules in the field of civil aviation and establishing a European Union Safety Agency, annex V. Instruments and equipment are specified in point 5. Para 5.1 requires that "an aircraft must be equipped with all navigation, communication and other equipment necessary for the intended flight, taking account of air traffic regulations and rules of the air applicable during any phase of the flight". Para 5.2 adds that "when relevant, an aircraft must be equipped with all necessary safety, medical, evacuation and survival equipment, taking account of the risks associated to the areas of operation, the routes to be flown, the flight altitude and the duration of the flight." Finally para 5.3 requires that "all data necessary for the execution of the flight by the crew must be updated and available on board the aircraft taking account of applicable air traffic regulations, rules of the air, flight altitudes and areas of operation". See also Air Navigation Order 2016 SI No 765, art 69(8)(b).

388 For all the requirements, see UK Regulation (EU) 2018/1139 on common rules in the field of civil aviation and establishing a European Union Safety Agency, annex V, para 2(c). For crewed aircraft, operating limitations are typically considered as part of the certification process and contained within the aircraft's flight manual.

389 UK Regulation (EU) 2018/1139 on common rules in the field of civil aviation and establishing a European Union Safety Agency, art 29.

390 UK Regulation (EU) 2018/1139 on common rules in the field of civil aviation and establishing a European Union Safety Agency, annex V, para 3(b).

391 UK Regulation (EU) 2018/1139 on common rules in the field of civil aviation and establishing a European Union Safety Agency, art 29 and annex V, para 7.3. The Air Navigation Order 2016 SI No 765, art 249(5) also states that if a pilot-in-command departs from the Rules of the Air, or any obligation in SERA in order to avoid immediate danger, and that departure would otherwise be an offence under the Order, the pilot must notify the CAA (or other competent authority).

safety".[392] Article 249 of the Air Navigation Order 2016 makes it clear that it is lawful to depart from the rules of the air or "any obligation in SERA" if this is necessary to avoid immediate danger, even where such a departure would otherwise be an offence.[393]

6.32 Understandably, a key duty is to avoid collisions. UK SERA explains that:

> Nothing in this Regulation shall relieve the pilot-in-command of an aircraft from the responsibility of taking such action, including collision avoidance manoeuvres based on resolution advisories provided by ACAS equipment, as will best avert collision.[394]

Responsibilities: the conduct of the flight

6.33 As well as being in charge of flying the aircraft, the pilot-in-command has ultimate responsibility for the safety of the passengers on the aircraft. That general duty is supported by more specific ones to ensure that passengers know what to do to keep themselves safe, both during normal flight and in emergencies.

6.34 For example, the pilot-in-command is responsible for making sure that passengers are properly seated and secured, and that crew members are seated during take-off and landing and whenever else deemed necessary.[395] Under the Air Navigation Order 2016, it is also the pilot-in-command who must make sure passengers are given a demonstration of how to use life jackets, oxygen and other emergency equipment and proceedings.[396]

6.35 In addition to making sure passengers know what to do in an emergency, the pilot is also generally responsible for the good conduct of the passengers onboard the aircraft. As a result, a pilot-in-command must take all necessary measures to minimise the consequences on a flight of disruptive passenger behaviour.[397]

6.36 A commander has additional responsibilities over and above those of the pilot-in-command, given their involvement in commercial air transport (ie services provided to the public). They must not allow a person to be carried in the aircraft who appears to be under the influence of alcohol or drugs to the extent that the safety of the aircraft or

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392 UK Regulation (EU) 923/2012 laying down the common rules of the air and operational provisions regarding services and procedures in air navigation, annex I, SERA.2010(a). See discussion at Chapter 5, paragraphs 5.7 and 5.8.

393 SI 2016 No 765, art 249(3).

394 UK Regulation (EU) 923/2012 laying down the common rules of the air and operational provisions regarding services and procedures in air navigation, annex, SERA.3201.

395 UK Regulation (EU) 2018/1139 on common rules in the field of civil aviation and establishing a European Union Safety Agency, art 29 and annex V, para 3(a); Air Navigation Order 2016 SI No 765, art 71.

396 SI 2016 No 765, arts 73, 106 and 107. Again, the UK Regulation (EU) 2018/1139 on common rules in the field of civil aviation and establishing a European Union Safety Agency requires that information on emergency procedures and use of cabin safety equipment is given to crew and passengers but does not make this the responsibility of the pilot-in-command. Under annex V, para 3(f) however the pilot-in-command is responsible in an emergency situation for making sure passengers are instructed in what emergency action to take.

397 UK Regulation (EU) 2018/1139 on common rules in the field of civil aviation and establishing a European Union Safety Agency, art 29 and annex V, para 3(g). Art 29 makes clear that the requirements in annex V specifically do not apply to unmanned aircraft.

its occupants is likely to be endangered.[398] They may also refuse to transport passengers if their carriage increases the risk to the safety of the aircraft or its occupants.[399]

6.37 The corollary is that article 244 of the Air Navigation Order 2016 requires everyone else on the aircraft to:

> obey all lawful commands which the pilot-in-command of that aircraft may give for the purpose of securing the safety of the aircraft and of persons or property carried in the aircraft, or the safety, efficiency or regularity of air navigation.[400]

6.38 The Air Navigation Order 2016 also prohibits anyone from:

(1) entering an aircraft when drunk, or being drunk in an aircraft (article 242);[401]

(2) acting in a disruptive manner (article 245);[402]

(3) recklessly or negligently acting in a manner likely to endanger an aircraft, or any person in an aircraft (article 240);[403] or

(4) recklessly or negligently causing or permitting an aircraft to endanger any person or property (article 241).[404]

6.39 Breach of these prohibitions is a criminal offence, punishable by a fine of up to £2,500 (in the case of breach of articles 245(a) and (b)), an unlimited fine and a custodial sentence of up to two years (articles 241, 242 and 245(c)) or an unlimited fine and custodial sentence of up to five years (article 245).[405]

6.40 To enable them to fulfil these responsibilities, the commander has broad powers.[406] They may take reasonable measures against people on board the aircraft (including restraint) to protect the safety of the aircraft or of persons or property onboard; to

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398 UK Regulation (EU) 965/2012 laying down technical requirements and administrative procedures related to air operations, annex IV, CAT.GEN.MPA.105(a)(5).

399 UK Regulation (EU) 965/2012 laying down technical requirements and administrative procedures related to air operations, annex IV, CAT.GEN.MPA.105(a)(6).

400 SI 2016 No 765, art 244.

401 SI 2016 No 765, art 242(1).

402 SI 2016 No 765, art 245.

403 SI 2016 No 765, art 240.

404 SI 2016 No 765, art 241.

405 SI 2016 No 765, arts 240, 241, 242, 244, 245 and 265. See Chapter 9, paragraphs 9.19 to 9.28 for an explanation of how criminal sanctions can attach to breaches of the Air Navigation Order 2016.

406 Havel and Sanchez refer to these "near-plenary" powers to restore order as a "microjurisdiction". B Havel and G Sanchez, *The principles and practice of international aviation law* (2014) 5.7.1.

maintain good order and discipline; or to disembark or deliver the person in question to a constable or immigration officer.[407]

6.41 These measures may be taken if a commander has reasonable grounds to believe that a person on board the aircraft has done, or is about to do anything which could jeopardise:

(a) the safety of the aircraft or of persons or property on board the aircraft, or

(b) good order and discipline on board the aircraft.[408]

6.42 The measures can also be taken if the commander believes that a person, while in flight, has committed a serious offence under the law where the aircraft is registered. There is an exception for laws of a political nature, or based on racial or religious discrimination.[409] Any member of the aircraft or other person on board the aircraft may, at the request of the commander, render assistance in restraining a person if the tests above are met. Even without the authority of the commander, a crew member or other person can take the measures set out above if they have reasonable grounds to believe that the measures are "immediately necessary to protect the safety of the aircraft or of persons or property on board the aircraft."[410]

Condition of the pilot

6.43 The pilot (along with the rest of the crew) must be sober and alert. The Air Navigation Order 2016 specifically requires that:

> a person must not, when acting as a member of the crew of any aircraft… be under the influence of drink or a drug to such an extent as to impair their capacity to so act.[411]

It is a criminal offence in the UK for a person to act as the pilot of an aircraft during flight when their ability to perform the function is impaired because of drink or drugs.[412]

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407 Civil Aviation Act 1982, s 94(2).

408 Civil Aviation Act 1982, s 94(2)(a).

409 Civil Aviation Act 1982, s 94(2)(b).

410 Civil Aviation Act 1982, s 94(3).

411 SI 2016 No 765, art 242(2). UK Regulation (EU) 923/2012 laying down the common rules of the air and operational provisions regarding services and procedures in air navigation, annex, SERA.2020 also prohibits any person whose function is critical to the safety of aviation undertaking that function while under the influence of any psychoactive substance, or from generally engaging in "any kind of problematic use" of a psychoactive substance.

412 Railways and Transport Safety Act 2003, ss 92 and 94. Section 92 refers to performing an "aviation function"; section 94 then defines this to include the pilot, along with other members of the flight crew. Section 93 also creates an offence if a person performs an aviation function when the level of alcohol in their breath, blood or urine exceeds a prescribed limit.

6.44 A similar prohibition appears in the Basic Regulation, which also prohibits a person performing duties on board when unfit due to "injury, fatigue, medication, sickness or other similar causes".[413]

Accidents and near-accidents

6.45 A final category of responsibilities of the pilot relates to accidents and near-accidents. Under the Air Operations Regulation, the pilot is responsible for making sure that flight recorders are operating properly.[414] If the aircraft, while in flight, has to manoeuvre in response to an airborne collision avoidance system, the commander must submit a report to the competent authority.[415] After landing, the commander must also report any bird strikes that cause significant damage to the aircraft or loss or malfunction of any essential services.[416] Potential bird hazards must also be reported to the air traffic service unit as soon as workload allows.[417]

Qualifications: licences and medical certificates

6.46 The Chicago Convention envisages that pilots and crew of aircraft engaged in international navigation will have certificates of competence and licences issued by the state.[418] In the UK, this means that for both for Part 21 and non-Part 21 aircraft, pilots are required to have a pilot's licence and a medical certificate.[419] Both the pilot's licence and medical certificate must be carried with the pilot when flying.[420] A pilot is also required to keep a record of their flight time.[421]

6.47 In the UK, in order to fly Part 21 aircraft, a licence under the Aircrew Regulation is required. The Regulation provides for:

(1) light aircraft pilot licences;

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413 UK Regulation (EU) 2018/1139 on common rules in the field of civil aviation and establishing a European Union Safety Agency, annex V, para 7.6.

414 UK Regulation (EU) 965/2012 laying down technical requirements and administrative procedures related to air operations, annex IV, CAT.GEN.MPA.105(a)(10). The Air Navigation Order 2016 SI No 765 stipulates that, where a flight data recorder is required, it must be in use for the entire flight (see art 231) but does not explicitly make this the responsibility of the pilot.

415 UK Regulation (EU) 965/2012 laying down technical requirements and administrative procedures related to air operations, annex IV, CAT.GEN.MPA.105(c).

416 UK Regulation (EU) 965/2012 laying down technical requirements and administrative procedures related to air operations, annex IV, CAT.GEN.MPA.105(d)(2). It is thought that incidence of bird strikes may increase for VTOLs, which are expected to fly more quietly and at lower altitudes than existing aircraft.

417 UK Regulation (EU) 965/2012 laying down technical requirements and administrative procedures related to air operations, annex IV, CAT.GEN.MPA.105(d)(1).

418 Chicago Convention, Ninth Edition (2006), art 32.

419 UK Regulation (EU) 2018/1139 on common rules in the field of civil aviation and establishing a European Union Safety Agency, art 21; Air Navigation Order 2016 SI No 765, art 136(1).

420 UK Regulation (EU) 1178/2011 laying down technical requirements and administrative procedures related to civil aviation aircrew, annex I, FCL.045(a).

421 UK Regulation (EU) 1178/2011 laying down technical requirements and administrative procedures related to civil aviation aircrew, annex I, FCL.050.

(2) private pilot licences;

(3) commercial pilot licences;

(4) multi-crew pilot licences; and

(5) airline transport pilot licences.[422]

6.48 In most cases, holders of licences can only act as pilots if they have a class or type rating.[423] The rating will determine the type of aircraft that can be flown by the holder, as well as the conditions under which the aircraft can be flown including whether the licence holder can fly at night and whether they can take paying passengers. Class ratings are used for aircraft which are grouped by features; for example, single-engine piston aeroplanes can be flown with the class rating "SEP (land)". More complex aircraft require type ratings, rather than class ratings. These are specific to the model of aircraft being flown. For example, to fly a Boeing 737, a type rating for the series of Boeing 737 is required. VTOL pilots will require a type rating for each type of VTOL operated by the pilot.[424]

6.49 Annex IV to the Basic Regulation has high-level requirements for pilot training, while annex I to the Aircrew Regulation contains detailed requirements for the issue of pilot licences, and conditions for their validity.

6.50 Applicants for licences are required to demonstrate both theoretical and practical knowledge. One aspect of the skill test is demonstration of what is known as "airmanship": defined in the Aircrew Regulation as "the consistent use of good judgement and well-developed knowledge, skills and attitudes to accomplish flight objectives".[425] As well as being able to fly the aircraft, a pilot must also have a certain level of language proficiency in English.[426]

6.51 The Civil Aviation Authority's ("CAA") intended approach to licensing of VTOL operations is to use existing legislation to the greatest extent possible. VTOL training courses will be developed by manufacturers and approved by the CAA, and should be specific to the VTOL being flown.[427] As VTOL aircraft have features of aeroplanes and

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422 UK Regulation (EU) 1178/2011 laying down technical requirements and administrative procedures related to civil aviation aircrew, annex I, subparts B, C, D, E and F for requirements.

423 UK Regulation (EU) 1178/2011 laying down technical requirements and administrative procedures related to civil aviation aircrew, annex I, FCL.700(a). Exceptions are made for holders of licences exercising the privileges of a light aircraft pilot licence; if they take skill tests or proficiency checks for renewal of class or type ratings; if they receive flight instruction, or if they hold a rating for flight tests, issued under FCL.820.

424 CAA, *Policy statement on licensing pilots of VTOL aircraft performing commercial air transport operations* (October 2023), para 5.6, https://consultations.caa.co.uk/policy-development/licensing-pilots-of-vtol-capable-aircraft/supporting_documents/Policy%20Statement%20%20VTOL%20pilot%20licensing.pdf.

425 UK Regulation (EU) 1178/2011 laying down technical requirements and administrative procedures related to civil aviation aircrew, annex I, FCL.010.

426 UK Regulation (EU) 1178/2011 laying down technical requirements and administrative procedures related to civil aviation aircrew, annex I, FCL.055.

427 CAA, *Policy statement on licensing pilots of VTOL aircraft performing commercial air transport operations* (October 2023), paras 1.2 and 5.4, https://consultations.caa.co.uk/policy-development/licensing-pilots-of-vtol-capable-aircraft/supporting_documents/Policy%20Statement%20%20VTOL%20pilot%20licensing.pdf.

helicopters, the CAA recommends that pilots with experience flying fixed-wing aircraft may benefit from greater familiarity with rotorcraft, and vice-versa.[428]

6.52 Even once a licence is obtained, it is necessary in some cases to demonstrate "recent experience". For example, a pilot may not operate an aircraft in commercial air transport or carry passengers unless they have carried out a certain number of take-offs, approaches and landings as pilot-in-command or co-pilot in the preceding 90 days.[429]

6.53 Most pilots, including VTOL pilots, must also have medical certificates.[430] According to annex IV to the Basic Regulation, "all pilots must periodically demonstrate medical fitness to satisfactorily execute their functions, taking into account the type of activity". Medical fitness is defined as not suffering from any disease or disability which makes the pilot unable:

(1) to execute the tasks necessary to operate an aircraft;

(2) to perform assigned duties at any time; or

(3) to perceive correctly his or her environment.[431]

6.54 Certificates may only be issued by aero-medical examiners, who are themselves certified. Aero-medical centres must also be certified.[432]

6.55 The rigour of the process and the capacities that must be demonstrated depend on the type of licences and any privileges that accompany it. For example, additional requirements must be met for holders of some licences wishing to exercise night rating privileges.[433]

THE FUTURE ROLE OF THE REMOTE PILOT

6.56 In this section we consider how the role of a multi-vehicle supervisor should be understood. Should it be classed as "remote pilot", or as a new, different role? And what responsibilities should attach to the role?

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428 CAA, *Policy statement on licensing pilots of VTOL aircraft performing commercial air transport operations* (October 2023), para 5.3, https://consultations.caa.co.uk/policy-development/licensing-pilots-of-vtol-capable-aircraft/supporting_documents/Policy%20Statement%20%20VTOL%20pilot%20licensing.pdf.

429 SI 2016 No 765, sch 8(1); UK Regulation (EU) 1178/2011 laying down technical requirements and administrative procedures related to civil aviation aircrew, annex I, FCL 0.60.

430 SI 2016 No 765, art 160 and part 6, ch 3 generally; UK Regulation (EU) 1178/2011 laying down technical requirements and administrative procedures related to civil aviation aircrew, annex IV, generally; CAA, *Policy statement on licensing pilots of VTOL aircraft performing commercial air transport operations* (October 2023) para 5.2, https://consultations.caa.co.uk/policy-development/licensing-pilots-of-vtol-capable-aircraft/supporting_documents/Policy%20Statement%20%20VTOL%20pilot%20licensing.pdf.

431 UK Regulation (EU) 2018/1139 on common rules in the field of civil aviation and establishing a European Union Safety Agency, annex IV, para 3.1.1.

432 UK Regulation (EU) 2018/1139 on common rules in the field of civil aviation and establishing a European Union Safety Agency, art 24(1).

433 SI 2016 No 765, art 163(7).

A remote pilot?

6.57 As noted above, the definition in UK law of a remote pilot is of:

> a natural person responsible for safely conducting the flight of an unmanned aircraft by operating its flight controls, either manually or, when the unmanned aircraft flies automatically, by monitoring its course and remaining able to intervene and change its course at any time.[434]

6.58 This requires a relatively low level of direct involvement with the flight controls. In particular, there is no suggestion that the monitoring must be continual, or active. Our view therefore is that the role envisaged by the FAA and Boeing/Wisk would fall within this existing definition. This is because, while the aircraft would be flown automatically, the person overseeing it would have the ability to override the system where necessary.

6.59 The legal definition, however, does not map neatly on to the Joint Authorities for Rulemaking on Unmanned Systems ("JARUS") levels. The requirement for both monitoring a course and being able to intervene at any time appears closest to JARUS level 3 (supervised automation). For more discussion of the JARUS levels, see paragraphs 2.5 to 2.12. In legal terms, this ability to intervene (even if only by exception) suggests to us that the person overseeing the flight would be classified as a remote pilot.

6.60 An alternative to treating the person overseeing the flight as a "remote pilot" would be to create a new legal role: that of a flight "supervisor". This, however, is not the approach we have provisionally adopted for two reasons. Firstly, we believe it would be difficult to distinguish between a flight "supervisor" and a remote "pilot". The difference would probably lie in the degree of control of the aircraft, but selecting a point on the spectrum of control would inevitably be arbitrary. Secondly, continuing to describe the oversight role as a "remote pilot" also has the benefit of consistency with the existing UAS regulatory regime, and the framework of the Chicago Convention.

6.61 One disadvantage is that describing someone who is not constantly operating the flight controls as a pilot may risk misleading members of the public. Our provisional view, however, is that this potential drawback does not outweigh the advantages highlighted above.

Consultation Question 8.

6.62 We provisionally propose that a person overseeing a VTOL flying automatically, who monitors its course and is able to intervene and change its course at any time should continue to be classified as a "remote pilot".

Do you agree?

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[434] UK Regulation (EU) 2019/945 on unmanned aircraft systems and on third-country operators of unmanned aircraft systems, art 3(27).

Responsibilities of the remote pilot

6.63 UK Regulation (EU) 2019/947 ("UAS Implementing Regulation") explains that UAS operations in the certified category are subject to "applicable operational requirements" laid down in UK SERA, the Air Operations Regulation and the Airspace Usage Requirements (ACAS II) Regulation.[435] Which operational requirements are applicable has not yet been specified. Nor is there currently provision for assessing the competency of remote pilots in the certified category.

6.64 In the absence of existing regulation for UAS, we take as our starting point therefore the responsibilities of a pilot of a traditional crewed aircraft, and in particular a commander of a commercial air transport operation. Despite our view that the legal definition of "remote pilot" would apply to the scenarios discussed at paragraphs 6.6 to 6.10, it is clear that there are several aspects of the traditional pilot's role that a remote pilot would find difficult to replicate. We set out the key adjustments that we provisionally consider to be necessary below.

6.65 As a starting point, we propose that the law should make clear that a remote pilot is capable of being the commander of a commercial air transport operation, for the purposes of the Air Operations Regulation.

Consultation Question 9.

6.66 We provisionally propose that in a commercial air transport operation a remote pilot as defined in the UK UAS Delegated Regulation 2019/945 should have the responsibilities of the commander of an operation within the meaning of the UK Air Operations Regulation 965/2012.

Do you agree?

Responsibilities: operating the aircraft

6.67 Some of the responsibilities in relation to operating the aircraft held by existing pilots can be replicated by remote pilots easily. For example, it should be relatively simple for a remote pilot to check before the flight that an aircraft is registered.

6.68 Other pre-flight checks could be conducted through a mixture of information provided by the aircraft, and checks done by crew based on the ground, following the approach taken at present. In our view, the following checks fall into this category:

(1) that the aircraft is airworthy;

(2) that specified instruments and equipment are installed and operative;[436]

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435 UK Regulation (EU) 2019/947 on the rules and procedures for the operation of unmanned aircraft, art 7(3).

436 The type of instruments and equipment is set out in UK Regulation (EU) 2018/1139 on common rules in the field of civil aviation and establishing a European Union Safety Agency, annex V, paras 5.1 to 5.3. See also SI 2016 No 765, art 69(8)(b).

(3) that the mass of the aircraft and centre of gravity location are such that the flight can be conducted within prescribed limits; and

(4) that all cabin baggage, hold luggage and cargo is properly loaded and secured.[437]

6.69 The "specific instruments and equipment" that must be checked are:

(1) "all navigation, communication and other equipment necessary for the intended flight, taking account of air traffic regulations and rules of the air applicable during any phase of the flight";[438]

(2) where relevant, "all necessary safety, medical, evacuation and survival equipment, taking account of the risks associated to the areas of operation, the routes to be flown, the flight altitude and the duration of the flight;"[439] and

(3) "all data necessary for the execution of the flight by the crew", which must be "updated and available on board the aircraft taking account of applicable air traffic regulations, rules of the air, flight altitudes and areas of operation".[440]

6.70 In our view, the requirements are sufficiently high level to accommodate any changes in instruments and equipment necessary for the safe operation of a UAS. We expect that it will be particularly important for remotely piloted aircraft that checks are done for communications equipment. In our view there is value in having one person ultimately responsible for these checks before each flight, even if the way the checks are completed is through compiling information from different sources.

6.71 One responsibility that cannot be fulfilled by crew on the ground is that the aircraft operating limitations will not be exceeded at any time during the flight. In our view, this should remain the responsibility of the remote pilot.

6.72 The discussion so far has been on the existing responsibilities of the pilot, and whether these can be fulfilled remotely. It is however possible that a remote pilot of a passenger-carrying aircraft should have additional responsibilities. We welcome views on this.

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437 UK Regulation (EU) 2018/1139 on common rules in the field of civil aviation and establishing a European Union Safety Agency, art 29 and annex V, para 2(c)(i), (iii) (iv) and (v).

438 UK Regulation (EU) 2018/1139 on common rules in the field of civil aviation and establishing a European Union Safety Agency, annex V, para 5.1.

439 UK Regulation (EU) 2018/1139 on common rules in the field of civil aviation and establishing a European Union Safety Agency, annex V, para 5.2.

440 UK Regulation (EU) 2018/1139 on common rules in the field of civil aviation and establishing a European Union Safety Agency, annex V, para 5.3.

Consultation Question 10.

6.73 We provisionally propose that the remote pilot of a VTOL should be required to ensure that:

(1) the aircraft is airworthy;

(2) specified instruments and equipment are installed and operative;

(3) the mass of the aircraft and centre of gravity location are such that the flight can be conducted within prescribed limits;

(4) all cabin baggage, hold luggage and cargo is properly loaded and secured; and

(5) aircraft operating limitations will not be exceeded at any time during flight.

Do you agree?

Consultation Question 11.

6.74 We seek views as to whether there are additional operational responsibilities that a remote VTOL pilot should be required to fulfil.

Responsibilities: conduct

Safety checks and briefings

6.75 Passenger safety briefings, while at present the responsibility of the pilot-in-command, are currently usually done by cabin crew. Similarly, checks to make sure passengers are seated during take-off and landing, and wearing seatbelts, are often not done by the pilot themselves. With a remote pilot, these functions could be fulfilled by a mixture of remote or pre-recorded briefings, and video footage of the passengers. As such our initial view is that the pilot-in-command could remain responsible for these checks.

Maintaining good order

6.76 Maintaining good order on an aircraft where there is no crew physically present is however more challenging. A remote pilot would not be able to order crew to restrain a passenger, although they could issue instructions to passengers, divert a flight, and call for police assistance to meet an aircraft on landing.

6.77 Without crew onboard to affect the behaviour of passengers, it will be particularly important to ensure that passengers are not drunk or under the influence of drugs. In our view, however, it is unrealistic to expect a remote pilot to be able to form an assessment of this before passengers embark. In our view, it should be the responsibility of the operator (delegated to crew on the ground) to make sure that:

(1) passengers whose carriage would endanger the safety of the aircraft or others; and

(2) passengers who appear to be drunk or under the influence of drugs are not able to board the aircraft.

6.78 To ensure good order, our provisional view is that a remote pilot should have the powers set out in the Civil Aviation Act 1982 to take reasonable measures to protect the safety of the aircraft or persons or property onboard; to maintain good order and discipline; or to enable the commander to disembark or deliver the person in question.

6.79 We are not aware of any business models which propose the presence of crew onboard a VTOL aircraft. If this does occur, in our view the crew should have powers under the Civil Aviation Act 1982 to take reasonable measures "necessary to protect the safety of the aircraft or of persons or property on board the aircraft".[441] Onboard crew may also be instructed by the remote pilot to assist with the fulfilment of the remote pilot's duties set out above. This may however not be sufficient if the communications link with the remote pilot is lost and the crew cannot receive instructions. One option to resolve this would be to extend the powers of onboard crew to reflect the existing powers of the commander (as set out in paragraphs 6.40 and 6.41).

6.80 Our provisional view is that other passengers should also be able to take such measures that they reasonably believe are necessary to protect the safety of the aircraft, or persons or property on board. Permitting passengers to take such action (as discussed at paragraph 6.42) may be more dangerous for them, as they will not have crew to give support if necessary. However, passengers will still be able to hear instructions from the remote pilot.

Giving instructions to passengers

6.81 In order to give any instructions to passengers on board, it will be necessary for the pilot to be able to communicate with passengers. In our view, any passenger-carrying UAS should be required to have this facility. This is consistent with similar provisions for trains, where operators must make sure passengers have "suitable and sufficient means" to "communicate with a person who is in a position to take appropriate action in the event of an emergency".[442]

6.82 The next question is whether the passengers should be able to communicate directly with the pilot. We expect that the remote pilot will need periods of time to focus on the operation of the aircraft without distractions. In our view therefore, passengers should be able to contact a representative of the operator at all times during an operation. Members of crew would then be responsible for relaying messages to the pilot if necessary.

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441 Civil Aviation Act 1982, s 94(3).

442 Railway Safety (Miscellaneous Provisions) Regulations SI 1997 No 553, reg 4.

Consultation Question 12.

6.83 We provisionally propose that the remote pilot-in-command should be responsible for, amongst other things, ensuring passengers are:

(1) given a safety briefing; and

(2) seated and wear seat belts during take-off and landing.

Do you agree?

Consultation Question 13.

6.84 We provisionally propose that air operators (rather than the remote pilot-in-command) should be responsible for preventing passengers from boarding:

(1) who appear drunk or under the influence of drugs; or

(2) whose carriage would, in the view of the operator's employees, endanger the safety of the aircraft or other passengers.

Do you agree?

Consultation Question 14.

6.85 We provisionally propose that the remote pilot-in-command should have the power to take reasonable measures, including authorising the restraint of passengers, as set out in section 94 of the Civil Aviation Act 1982.

Do you agree?

Consultation Question 15.

6.86 We provisionally propose that a person on board a VTOL aircraft (other than a crew member) should be able to take reasonable measures to protect the safety of the aircraft or of persons or property on board.

Do you agree?

Consultation Question 16.

6.87 We seek views on whether the powers of crew on board a VTOL aircraft should be broadened to reflect those of the pilot-in-command under the Civil Aviation Act 1982 to:

(1) take reasonable measures to protect the safety of the aircraft or persons or property on board;

(2) maintain good order and discipline; or

(3) enable the crew to disembark or deliver a person.

Consultation Question 17.

6.88 We provisionally propose that passengers should be able to contact a member of crew at all times during an operation.

Do you agree?

Condition of the pilot

6.89 In our view, the standards that apply to the condition of a pilot of crewed aviation should apply to remote pilots of VTOLs. They should not be permitted to pilot the aircraft when incapacitated due to injury, fatigue, medication, sickness or other similar causes. We are also of the view that the criminal offences contained in sections 92 and 93 of the Railways and Transport Safety Act 2003 should apply to remote pilots of VTOLs. This would make it a criminal offence to act as the remote pilot of an aircraft during flight when a remote pilot's ability to perform the function is impaired because of drink or drugs. It would also be a criminal offence to act as a remote pilot when the level of alcohol in the remote pilot's breath, blood or urine exceeds a prescribed limit.

6.90 We note that UK Government intends to legislate to introduce alcohol limits for those operating a UAS when Parliamentary time allows.[443] These limits will be the same as those that currently apply to crewed aircraft.

[443] Department for Transport, *Future of Transport Regulatory Review: Future of Flight response* (September 2023) pp 54 to 55. https://assets.publishing.service.gov.uk/media/64f9b46c9ee0f2000fb7c04a/future-of-transport-regulatory-review-zero-future-of-flight-government-response.pdf. At present, guidance material to the UAS Implementing Regulation advises that alcohol levels in the Railways and Transport Safety Act 2003 should apply to remote pilots in the specific category, but this is not compulsory. See UK Regulation (EU) 2019/947 on the rules and procedures for the operation of unmanned aircraft, GM1 UAS.SPEC.060(1)(a).

Consultation Question 18.

6.91 We provisionally propose that it should be a criminal offence for a remote pilot of a VTOL to act in that capacity when their performance is impaired through drink or drugs.

Do you agree?

Consultation Question 19.

6.92 We provisionally propose that it should be a criminal offence for a person to act as the remote pilot of a VTOL when the level of alcohol in their blood, breath or urine is over a prescribed limit.

Do you agree?

Accidents and near-accidents

6.93 As explained above, under the UK Air Operations Regulation pilots are currently responsible for making sure flight recorders are operating properly. They must also inform the competent authority if the aircraft has to manoeuvre in response to an airborne collision avoidance system. Finally, they must also report any bird strikes that cause significant damage to the aircraft or loss or malfunction of essential services, and report potential bird hazards to the air traffic service unit.

6.94 In our view, all of these responsibilities could be fulfilled by the remote pilot. For the pilot to fulfil these responsibilities, the aircraft itself must be able to alert the pilot to these situations.

Consultation Question 20.

6.95 We provisionally propose that the remote pilot should be subject to the reporting obligations currently applicable to pilots under the Air Operations Regulation.

Do you agree?

Consultation Question 21.

6.96 We provisionally propose that a remotely piloted VTOL should be required to be capable of detecting and recording information relating to accidents and near accidents for the purposes of reporting it.

Do you agree?

Licensing

6.97 As explained above at paragraph 6.4, we expect that licences for crewed VTOL pilots will be introduced before uncrewed VTOLs come into service in the UK. The CAA's current position is that a specific type rating will be required for each VTOL flown by the pilot. Our expectation is that a similar type of licence would have to be issued for particular types of VTOL which are remotely piloted. Appropriate adaptations would have to be made to reflect the necessary skills for remote pilots.

6.98 We understand that the CAA is currently developing a framework for remote pilot licences for the certified category of UAS. While these follow ICAO's framework, and therefore will not be designed for passenger-carrying aircraft, it is likely that aspects of that licensing framework will be relevant to remotely piloted VTOLs that do carry passengers.

Consultation Question 22.

6.99 We provisionally propose that licences should be required for remote VTOL pilots. So far as appropriate, these should follow the classes and ratings adopted for crewed VTOLs.

Do you agree?

THE ROLE OF THE OPERATOR IN COMMERCIAL AIR TRANSPORT

Certification

6.100 Because uncrewed VTOLs fall within the "certified" category of UAS, the UAS Implementing Regulation requires their operator to be certified.[444] This approach is consistent with that taken for commercial air transport, where the certification of the air operator is required. In practice, this involves the issuance of an air operator certificate and the adoption of a safety management system.

6.101 An application for an air operator certificate is a rigorous process. The applicant must supply to the CAA specified information and documentation, including a description of the proposed operation, a description of its management system, and a copy of its

444 UK Regulation (EU) 2019/947 on the rules and procedures for the operation of unmanned aircraft, art 6.

operations manual.[445] Applicants also have to demonstrate that they comply with the requirements of:

(1) annex V (essential requirements for aircraft operations) to the Basic Regulation;

(2) annexes III (Part-ORO), IV (Part-CAT) and V (Part-SPA) to the Air Operations Regulation; and

(3) annex I to the Additional Airworthiness Regulation 2015/640.[446]

6.102 All aircraft must have a certificate of airworthiness.[447] The applicant also has to show that its organisation and management are suitable and properly matched to the scale and scope of the operation.[448] Aircraft operators must also secure a licence from the CAA.[449]

An operator's responsibilities

6.103 An operator has many responsibilities in relation to commercial air transport. We highlight the key ones below.

(1) The aircraft operator must have the means necessary for the scale and scope of operations planned. This includes aircraft, facilities, management structure, personnel, equipment, documentation of tasks, responsibilities and procedures, access to relevant data and record keeping.

(2) The operator must use only suitably qualified and trained personnel. It must ensure this training is kept up to date.

(3) It must implement a management system to ensure safety and other essential requirements included in annex V to the Basic Regulation. This must include an occurrence reporting system.

(4) Operations must only take place in accordance with the operations manual (see paragraph 6.105 below).

(5) It must establish procedures to minimise the consequences to safe flight operations of disruptive passenger behaviour.

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445 UK Regulation (EU) 965/2012 laying down technical requirements and administrative procedures related to air operations, annex III, ORO.AOC.100(b).

446 UK Regulation (EU) 965/2012 laying down technical requirements and administrative procedures related to air operations, annex III, ORO.AOC.100(c)(1).

447 UK Regulation (EU) 965/2012 laying down technical requirements and administrative procedures related to air operations, annex III, ORO.AOC.100(c)(2). An exception is made for aircraft registered in a third country which have been dry-leased, with the approval of the CAA. See UK Regulation (EU) 965/2012, annex III, ORO.AOC.110(d).

448 UK Regulation (EU) 965/2012 laying down technical requirements and administrative procedures related to air operations, annex III, ORO.AOC.100(c)(3).

449 UK Regulation (EC) 1008/2008 on common rules for the operation of air services, art 3(1).

(6) It must develop and maintain security programmes suitable for the aircraft and type of operation, including protection of electronic and computer systems to prevent intentional and non-intentional system interference.

(7) It must have a management system to prevent fatigue.

(8) It must ensure the continuing airworthiness of the aircraft, including by relying on continuing airworthiness organisations.

(9) It must make available a checklist system for use by crew in all phases of the operation, covering normal, abnormal and emergency conditions and situations. Procedures must be established for any reasonably foreseeable emergency situation.

6.104 Our preliminary view is that all of these are applicable to remotely piloted VTOLs. While there may not be a pilot on board, it will still be important to ensure that remote crew are not too fatigued or otherwise physically unable to carry out their duties. Some of the detail of these responsibilities may not be applicable; for example, the requirement to establish security programmes refers explicitly to the need to keep the flight crew compartment secure. Remote pilots may not operate from a compartment, but there will still be a need to ensure the security of their workstations.

The operations manual

6.105 Operators for commercial air transport operations (as well as some others) must have an operations manual.[450] The manual contains all the instructions, information and procedures for the aircraft operated. It includes topics such as flight time limitations, and duty and rest periods. Detailed requirements are set out in annexes III, IV, V VI and VIII to the Basic Regulation. The manual must not contravene the conditions contained in the operation specifications to the air operator certificate.[451]

Adaptations for uncrewed VTOLs

6.106 In our view, the requirement that operators of remotely piloted VTOLs should be certified is a sensible one. With no pilot physically in the aircraft, it will be important to make sure that operators are responsible persons who take the appropriate steps to promote safety. We see the requirement for a safety management system, in particular, as being an important tool in ensuring the safety of uncrewed aircraft. We therefore provisionally propose that operators of remotely piloted VTOLs should continue to require certification.

6.107 We note however that further details about how air operations are structured and regulated is likely to depend on how crewed VTOLs are regulated in the UK. For example, EASA intends to divide its regulation of VTOL operations between those that operate over urban areas, and those that do not. Any similar decision the UK made along these lines for crewed VTOLs is likely to be applicable to uncrewed VTOLs.

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450 UK Regulation (EU) 2018/1139 on common rules in the field of civil aviation and establishing a European Union Safety Agency, annex V, paras 1.2 and 8.2.

451 UK Regulation (EU) 965/2012 laying down technical requirements and administrative procedures related to air operations, annex III, ORO.MLR.100(a) and (b).

Consultation Question 23.

6.108 We provisionally propose that operators of remotely piloted VTOLs should be certified.

Do you agree?

Consultation Question 24.

6.109 We provisionally propose that operators of remotely piloted VTOLs should continue to be required to:

(1) have the means necessary for the scale and scope of operations planned;

(2) use only suitably qualified and trained personnel;

(3) implement a management system to ensure safety;

(4) ensure operations only take place in accordance with the operations manual;

(5) establish procedures to minimise the consequences to safe flight operations of disruptive passenger behaviour;

(6) develop and maintain security programmes suitable for the aircraft and type of operation;

(7) have a management system to prevent fatigue;

(8) ensure the continuing airworthiness of the aircraft; and

(9) establish procedures for any reasonably foreseeable emergency situation.

Do you agree?

Consultation Question 25.

6.110 We seek views as to whether there are additional responsibilities that operators of remotely piloted VTOLs should need to fulfil.

PILOTING MULTIPLE AIRCRAFT

6.111 The ability to pilot multiple aircraft remotely (often referred to as “multiple simultaneous operations”, or “MSO”) represents a large shift in aviation regulation,

and a new challenge in aviation regulation generally. It is also a key issue for drones and is discussed at paragraphs 7.42 to 7.51.

6.112 Piloting multiple aircraft is not, generally speaking, prohibited in the law. This is probably simply because this has not been physically possible until now. It is however a capability that we expect to be much in demand from operators in the future (see above at paragraphs 6.9 and 6.10 for a summary of how Boeing and Wisk envisage multi-vehicle supervisors operating).

6.113 We are aware of only one specific prohibition against piloting multiple aircraft: it is forbidden in the open category by the UAS regulations.[452] As explained above, remotely piloted VTOLs fall within the certified category of UAS regulation, and therefore this prohibition does not apply. However, it is an open question whether the volume of a remote pilot's responsibilities will mean in practice that they are unable to pilot more than one aircraft at a time.

6.114 We seek views below on whether the law should allow this, and if it does, what safeguards should be required. Safeguards could be implemented through the following tools, amongst others:

(1) certification standards, both for the aircraft itself and for command units;

(2) specific pilot licensing and appropriate training, this could include a new rating for passenger-carrying MSO;

(3) operational rules which reflect the particular challenges of passenger-carrying MSO; and

(4) updating the rules of the air.

6.115 It will be important that the operator has processes in place to allow for handovers of control, where a remote pilot is required to pay urgent attention to more than one aircraft under their command.

6.116 In practice, there will be a limit to the number of aircraft safe for a pilot to control at one time. It is not clear however whether it would be useful or practical for the law to prescribe an across-the-board limit. Without a clearer idea of exact aircraft and operation involved, imposing such a limit risks being arbitrary and may fail to keep up with the development of the technology. An alternative might be to include consideration of this at the initial airworthiness stage, with appropriate limits included in the flight manual for the aircraft.

6.117 One other relevant consideration will be whether flights should be staggered so that a pilot should not have to monitor multiple aircraft all going through the same phases of flight. We understand that, for example for conventional pilots, take-off and landing are the most demanding stages of flight. VTOLs spend more time than conventional

[452] UK Regulation (EU) 2019/947 on the rules and procedures for the operation of unmanned aircraft, AMC1 UAS.OPEN.060(2)(d).

aircraft in these stages of flight, and so may be more demanding of remote pilot time and attention.

Consultation Question 26.

6.118 We seek views as to whether the law should permit remote pilots to act as pilot-in-command for more than one VTOL at the same time.

Consultation Question 27.

6.119 We seek views on whether there should be an upper limit to the number of VTOLs for which a remote pilot can act as pilot-in-command at the same time.

Consultation Question 28.

6.120 We seek views as to what additional safeguards should be introduced for remote pilots piloting multiple VTOLs.

AUTONOMOUS OPERATIONS

6.121 As far as we are aware, there are no manufacturers currently intending for their VTOL to operate to provide a commercial service entirely autonomously (ie with no ability for a human to intervene and change the course of the aircraft). In the long-term, however, as the technology matures and lessons are learned from autonomous drone flights, this may become a possibility.

6.122 This section is inevitably more speculative, as there is less evidence available about how a completely autonomous VTOL would be operated. However, we understand that some of industry at least is working towards that goal. The analysis above provides a starting point.

6.123 We envisage that the role of the operator would continue to exist in much its existing form. The more difficult question is what should be done with the various responsibilities of the pilot which do not relate to the piloting task itself. We analyse these below.

6.124 Without that central responsibility for the safe operation of the aircraft, is there still a case for allocating responsibilities relating to pre-flight checks and/or to passenger safeguarding to one individual, identified by the law?

6.125 Doing so would underline the importance the law places in particular on the safeguarding of passengers. Having one individual would also have the advantage that providers of air traffic services and other authorities would have an obvious

human point of contact in relation to the activities of the VTOL. Even if that individual were unable to intervene in the course of the flight, they could still provide information to the authorities in the event that the VTOL itself was unresponsive.

6.126 In our initial view, referring to such a role as a "pilot" of any kind would be misleading. One possibility might be to refer to them as a flight "supervisor". A problem that would have to be considered carefully is how such a role would meet the requirements of the Chicago Convention, which clearly envisages the involvement of a pilot.

6.127 Another problem would be scoping out the extent of the "supervisor's" duties. We consider this below, under the same headings used for analysing the existing position and the future role of a remote pilot.

Core duties

6.128 As explained above at paragraph 6.26 the role of the pilot-in-command has two essential aspects. One is the safe operation of the aircraft itself. The other is ensuring the safety of people and cargo onboard. It would be clearly inappropriate for someone who was not a pilot of any kind (because they were unable to intervene and change the course of the aircraft), to be legally responsible for the safe operation of the aircraft. The more difficult question is whether they could realistically have responsibility for the safety of people and cargo onboard.

Responsibilities: operation of the aircraft

6.129 Many operational responsibilities could not be placed on a supervisor. For example, the duty to avoid collisions under UK SERA would be inapplicable, and in our view, would have to fall to the operator of the aircraft.

6.130 However, some pre-flight checks could continue to be the responsibility of someone who had no control over the operation of the aircraft. At paragraph 6.67 to 6.72 above we set out the pre-flight checks which are currently expected and how we envisage these could be fulfilled by remote pilots. In our view, it would be possible for a supervisor to complete the majority of these (with assistance from ground crew or automated systems, as necessary), with appropriate training. One exception might be the check that aircraft operating limitations will not be exceeded at any time during the flight.

Responsibilities: the conduct of the flight

6.131 Again, we envisage that some pre-flight checks could be made the responsibility of a supervisor. These could include making sure that passengers are seated and briefed on what to expect in an emergency.

6.132 Maintaining good order, without the power even to change the course of an aircraft to ensure a swift landing, may prove a difficult task. A supervisor could fulfil this function by issuing instructions to passengers (for example, to stop doing something, or to return to their seats). Such instructions could be supported through the use of a criminal sanction. As noted above at paragraph 6.37, under the existing law any person on board an aircraft must obey lawful commands of the pilot-in-command when these are given for safety purposes. In a situation without a pilot, that obligation could be extended to instructions given by a supervisor.

Accidents and near-accidents

6.133 As explained above at paragraph 6.45, pilots are currently responsible for:

(1) making sure flight recorders are operating properly;

(2) informing the competent authority if the aircraft has to manoeuvre in response to an airborne collision avoidance system; and

(3) reporting certain bird strikes and potential bird hazards.

6.134 We concluded above at paragraph 6.94 that these responsibilities could be fulfilled by the remote pilot. In our view these responsibilities could equally attach to the role of a supervisor of an aircraft.

Consultation Question 29.

6.135 We seek views as to whether there should be a role for a person supervising the flight of an autonomous passenger-carrying VTOL and acting as a point of contact in relation to it. What powers or responsibilities should such a person have?

MOVING BETWEEN REMOTELY PILOTED AND AUTONOMOUS FLIGHT

6.136 One question which is not addressed in the current UAS legislative framework is whether it should be possible to transition between remotely piloted and autonomously piloted phases of flight, within the same operation. At present, the UAS Implementing Regulation only contains a definition of an "autonomous operation", which suggests that breaking down operations into different phases of flight is not an option.[453] We have not seen any discussion of VTOLs working in this way yet. In the more immediate term, this possibility may be of more interest to the drone industry, and we ask a question on that point in Chapter 7.

6.137 It is, however, a way of operating that has been adopted for other transport modes. The Automated Vehicles Bill, which was presented to the House of Commons on 20th February 2024, allows for a vehicle to move between different modes during a single journey. If an "authorised self-driving feature" is engaged, the vehicle must issue a "transition demand" in order to be able to hand back control to the user-in-charge of the vehicle.[454]

6.138 Any change in status between a remotely and autonomously piloted phase of an operation would need to be signalled clearly to a remote pilot. There would need to be a timely "transition demand" to enable them to react to the change in status and the aircraft would have to be able to continue to operate safely even if the remote pilot failed to respond to the transition demand.

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[453] UK Regulation (EU) 2019/947 on the rules and procedures for the operation of unmanned aircraft, art 2(17).

[454] Automated Vehicles Bill as presented to the House of Commons on 20th February 2024, cl 7.

6.139 In the absence of detailed discussion within the industry of whether this type of transition should be possible, we have not made any provisional proposals on this topic. We do however seek views on whether the law should permit an aircraft to transition between remotely piloted and autonomous flight during the course of a single operation. We would welcome thoughts on whether this type of functionality would be of interest to VTOL operators.

Consultation Question 30.

6.140 Should the law permit an uncrewed VTOL to transition between remotely piloted and autonomous flight during an operation?

ACCESSIBILITY

6.141 The Department for Transport's Inclusive Transport Strategy, published in 2018 and updated in 2020, sets out five themes. One of these is the "future of inclusive transport – ensuring that technological advances and new business models provide opportunities for all, and that disabled people are involved from the outset in their design". It is key that the new world of urban air mobility is open to older people and those with disabilities.

6.142 We consider here the existing law relating to access to aircraft by disabled persons. Later in the chapter we reflect on the impact of providing a public transport service without a pilot (or cabin crew) and what adaptations might need to be made to ensure that urban air mobility is accessible to all.

UK Persons with Reduced Mobility Regulation

6.143 UK Regulation (EU) 1107/2006 (the "Persons with Reduced Mobility Regulation") establishes rules for the "protection of and provision of assistance to disabled persons and persons with reduced mobility travelling by air".[455] It applies to commercial air transport services, defined as a:

> passenger air transport service operated by an air carrier through a scheduled or non-scheduled flight offered to the general public for valuable consideration, whether on its own or as part of a package.[456]

6.144 The Persons with Reduced Mobility Regulation provides that disabled persons cannot be refused carriage because of their disability, unless this would conflict with the safety requirements of the air operator's certificate or if the aircraft or its doors are too small to enable the passenger to board.[457]

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455 UK Regulation (EC) 1107/2006 concerning the rights of disabled persons and persons with reduced mobility when travelling by air, art 1(1).

456 UK Regulation (EC) 1107/2006 concerning the rights of disabled persons and persons with reduced mobility when travelling by air, art 2(l).

457 UK Regulation (EC) 1107/2006 concerning the rights of disabled persons and persons with reduced mobility when travelling by air, art 4(1).

6.145 The Regulation also provides that free assistance must be provided by airports and air carriers.[458] The specific assistance to be provided is detailed in annex I (which covers responsibilities of managing bodies of airports) and annex II (which deals with responsibilities of air carriers). Annex II requires:

(1) carriage of recognised assistance dogs in the cabin, subject to national regulations;

(2) transport of up to two pieces of mobility equipment per passenger (subject to possible limitations of space aboard the aircraft, and with advance warning);

(3) communication of essential information concerning a flight in accessible formats;

(4) all reasonable efforts to arrange seating to meet the needs of individuals with a disability or reduced mobility, subject to safety requirements and availability;

(5) assistance in moving to toilet facilities, if required; and

(6) all reasonable efforts to provide any accompanying person with a seat next to the passenger.

6.146 When an air carrier, its agent or a tour operator become aware of a passenger's need for assistance, it must inform the managing bodies of the relevant airports as soon as possible.[459]

6.147 Alongside ensuring that assistance is provided, and that staff are aware how to meet the needs of disabled passengers, air carriers and airports must provide staff with disability-equality and disability-awareness training.[460] Interpretative guidelines, originally issued by the European Commission but now adopted by the CAA, contain more detail on how the Persons with Reduced Mobility Regulation should be understood.[461]

The Equality Act 2010

6.148 The Equality Act 2010 ("the 2010 Act") has limited application. Section 29 of the 2010 Act, which concerns the provision of services, does not apply to transporting people by air, or a service provided on a vehicle for transporting people by air. Nor does

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458 UK Regulation (EC) 1107/2006 concerning the rights of disabled persons and persons with reduced mobility when travelling by air, arts 7 and 10.

459 UK Regulation (EC) 1107/2006 concerning the rights of disabled persons and persons with reduced mobility when travelling by air, art 6(2) and (3).

460 UK Regulation (EC) 1107/2006 concerning the rights of disabled persons and persons with reduced mobility when travelling by air, art 11.

461 Interpretative Guidelines on the application of Regulation (EC) No 1107/2006 of the European Parliament and of the Council of 5 July 2006 concerning the rights of disabled persons and persons with reduced mobility when travelling by air (adopted by the CAA in CAP 2241).

section 29 apply to anything governed by the Persons with Reduced Mobility Regulation.[462]

Chicago Convention

6.149 A section of Annex 9 to the Chicago Convention is dedicated to the facilitation of transport of persons with disabilities. It includes a number of recommended practices designed to improve accessibility at airports and during flight, to make sure that disability aids can be carried with the passenger, that information is provided in an accessible format, and that assistants can travel alongside a passenger. In general, the focus of the section is on the use of existing aircraft. However, there is a recommended practice in relation to aircraft design:

> Contracting States should introduce provisions by which aircraft coming newly into service or after major refurbishment should conform, where aircraft type, size and configuration permit, to minimum uniform standards of accessibility with respect to equipment on board aircraft which would include moveable armrests, on-board wheelchairs, accessible washrooms and suitable lighting and signs.[463]

6.150 More detailed guidance on Annex 9 can be found in ICAO's manual on access to air transport by persons with disabilities. Chapter 9 considers accessible aircraft features and elaborates on the recommended practice quoted above. For example, it suggests that aircraft with more than one aisle should have at least one on-board wheelchair that can be moved around the cabin.[464]

Legislation for other forms of transport

6.151 The business model for urban air mobility is more like a traditional taxi than a long-distance commercial flight. It may therefore be helpful to consider how the law approaches access for people with disabilities or reduced mobility in those contexts.

6.152 The Public Service Vehicles Accessibility Regulations 2000, for example, specify how public service vehicles, such as buses and coaches, must be laid out to accommodate a wheelchair.[465]

6.153 Part 12 of the Equality Act 2010 also imposes accessibility obligations on providers of taxis and private hire vehicles. For example, under section 165 of the Equality Act 2010 "designated" taxis and private hire vehicles must carry wheelchair users. A vehicle is "designated" if it appears on a list maintained by its licensing authority.[466]

Regulation of uncrewed VTOLs

6.154 In principle, VTOLs fall within the scope of the UK Persons with Reduced Mobility Regulation. Nevertheless, it will be important to reflect on whether those provisions

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462 Equality Act 2010, s 31(10) and sch 3(33)(2).

463 Annex 9 to the Chicago Convention, Sixteenth Edition (2022), including amendment 29, 8.36.

464 ICAO, *Manual on Access to Air Transport by Persons with Disabilities* (2013), para 9.1.

465 SI 2000 No 1970.

466 Equality Act 2010, s 167.

are sufficient to ensure access to this new form of transport. Accessibility needs to be considered at multiple stages: from the design of aircraft, through to its operation and the services provided at airports or vertiports.

6.155 Some of these questions are outside the scope of our project, which focuses particularly on the impact of greater autonomy. There are likely however to be some impacts on accessibility which are linked closely to the use of autonomous systems and the removal of cabin crew and the pilot from an aircraft.

6.156 At present, accessibility requirements in aviation do not extend to the design of the aircraft. Instead, the focus is on what additional help is required to allow a person with disabilities or reduced mobility to use that aircraft. The help afforded usually comes with the caveat that it is subject to safety requirements.

6.157 Some of that assistance can be replicated with passenger-only VTOLs. For example, ground crew can assist with boarding and disembarking. This approach is however obviously more difficult when staff are not physically present in the cabin to offer assistance. If people with disabilities or reduced mobility are not to be excluded from this new form of transportation, it will be important to make sure that aircraft are designed for them to use with as little human assistance as possible.

6.158 We invite views as to whether special conditions (or, in time, certification specifications) for passenger-only VTOLs should include standards in relation to accessibility for those with disabilities and reduced mobility. The advantage of this approach would be that passenger-only VTOLs designed and manufactured in the UK would be designed to fly safely with passengers with reduced mobility or disabilities from their introduction. There are however potential drawbacks. Having different standards in the UK from those recognised globally may put UK manufacturers at a disadvantage.

6.159 Another possible method for ensuring the provision of accessible services is through conditions placed in operators' licences. These could provide, for example, that a certain proportion of an uncrewed VTOL fleet should be capable of carrying mobility equipment, or an assistance dog. This approach depends, however, on uncrewed VTOLs which meet these standards being commercially available. We invite views.

Consultation Question 31.

6.160 We seek views as to whether initial airworthiness standards for uncrewed VTOLs should include accessibility standards for persons with disabilities and reduced mobility.

Consultation Question 32.

6.161 We seek views as to whether the CAA should be able to include accessibility standards within the licences granted to uncrewed VTOL operators.

Further issues

6.162 We have highlighted in this chapter the major issues that we can see with the current regulatory framework for remotely piloted and autonomous VTOLs. However, we invite consultees to draw our attention to any other gaps, blockers or inconsistencies in the current legal framework relating to these topics.

Consultation Question 33.

6.163 We seek consultees' views on any other issues with the current legal framework as it relates to operations involving remotely piloted and autonomous VTOLs.

Chapter 7: Drones

7.1 The subject of this chapter is one of the use cases forming part of this project - “drones”. As explained in chapter 2, we use the term “drones” to refer to uncrewed aircraft which are generally smaller than traditional aircraft and unoccupied. They can be remotely piloted or autonomous.

7.2 New applications of drone technology are being suggested and trialled on a regular basis.

7.3 Perhaps the most high-profile use case for drones is in the delivery sector, as a means by which companies can transport goods. According to analysis by the consulting firm McKinsey, by early 2022, more than 2,000 commercial drone deliveries were occurring every day worldwide.[467]

7.4 In the UK there are already several examples of drones being trialled for the delivery of goods. For example, Royal Mail in cooperation with SkyportsDrone services have begun to operate a delivery operation in Orkney, where drones take letters and parcels from Stromness to staff in Graemsay and Hoy to carry out their usual rounds. The drones can carry payloads of up to 6 kg and if effective, the so-called Orkney I-Port operations could be made permanent. Drones are particularly useful for Orkney as the geography and weather makes it difficult for traditional methods to make deliveries on time.[468] Royal Mail has also partnered with other drone operators to trial parcel deliveries from the Cornish mainland to the Isles of Scilly; on the Shetland Islands; and on the Isle of Mull, among other remote locations in the UK.[469]

7.5 Also in the UK, the technology company Neuron has worked with several healthcare organisations to trial the use of drones for delivering test samples or prescriptions to hospitals. Drones have the potential to speed up the delivery process.[470] Several UKRI-funded Future Flight Challenge projects are also planning to trial the delivery of blood samples and vaccines using drones.[471]

7.6 Beyond deliveries, drones are also being developed for use in emergency response; infrastructure inspection; agriculture; wildlife and historical conservation; surveillance; construction and manufacturing; and temporary flying cellular networks. It is clear that

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467 https://www.mckinsey.com/industries/aerospace-and-defense/our-insights/future-air-mobility-blog/drones-take-to-the-sky-potentially-disrupting-last-mile-delivery.

468 https://news.sky.com/story/royal-mail-launches-uks-first-drone-delivery-service-12931621#:~:text=The%20joint%20operation%2C%20by%20Royal,carry%20out%20their%20usual%20rounds.

469 https://www.royalmail.com/sustainability/environment/drones-connecting-remote-communities-across-the-uk.

470 https://www.ardengemcsu.nhs.uk/showcase/blogs/blogs/what-potential-does-drone-technology-offer-healthcare/.

471 https://www.ukri.org/what-we-do/our-main-funds-and-areas-of-support/browse-our-areas-of-investment-and-support/future-flight/.

drones, if safely deployed, have the potential to provide significant benefits in a wide variety of fields.

7.7 Many of these use cases require a higher level of automation than has been common to date. For example, several of the use cases require a drone to be able to fly beyond the visual line of sight of an operator, or "BVLOS". Operating a drone beyond visual line of sight usually requires a high level of automation because the pilot (if there is one) will be unable to spot obstacles or other aircraft. Instead, the drone itself will need the technical capability to recognise objects in its path and take action to avoid a collision (a function known as "detect and avoid").[472] The detect and avoid function could be built into the drone or provided by ground infrastructure. Automation will also make it increasingly possible for one pilot to control multiple drones with very little intervention.

7.8 A key question when considering how regulation can accommodate the use of automated drones is the level of risk they pose to other airspace users and the public more generally. Clearly, a non-passenger carrying drone will pose no danger to passengers or crew onboard. However, it will pose a danger to other aircraft, and to those on the ground. The risk increases if drones are used in highly populated environments or in uncontrolled airspace with other aircraft.[473]

7.9 In chapter 3, we gave an overview of the current regulatory regime for uncrewed aircraft system ("UAS"), including drones. Here we outline some of the regulatory gaps that currently exist in the regime.

ISSUES WITH THE CURRENT REGULATORY FRAMEWORK

7.10 The current regulatory framework has much to commend it. The UAS framework provides an adequate framework to prevent unsafe drones. Low risk drones are permitted subject to conditions, whilst higher risk drones and operations must be approved or certified.

7.11 Innovation is also catered for via the specific category, which allows new drone operations outside the certified category to be authorised on a case-by-case basis.

7.12 Our provisional view is that the current regulatory framework also uses a definition of "remote pilot" which is appropriate for use in regulating drones. This definition of "remote pilot" was introduced by the UK UAS Delegated Regulation, and defines a remote pilot as:

> a natural person responsible for safely conducting the flight of an unmanned aircraft by operating its flight controls, either manually or, when the unmanned

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472 BVLOS operations can also be flown without this capability in circumstances where there are operational safeguards such as airspace segregation: Civil Aviation Authority (CAA), *Unmanned aircraft system operations in UK airspace – policy and guidance* (December 2022) (CAP 722) para 2.1.3.

473 For an analysis of the risk posed by drones, see CAA, *Drone safety risk: an assessment* (January 2018) (CAP 1627). In uncontrolled airspace there may be aircraft which do not broadcast their location and are not capable of detecting other aircraft which increases the risk of a mid-air collision.

aircraft flies automatically, by monitoring its course and remaining able to intervene and change its course at any time.[474]

7.13 We provisionally propose to retain this definition of remote pilot for drone operations.

Consultation Question 34.

7.14 We provisionally propose that a remote pilot for drones should continue to be defined as "a natural person responsible for safely conducting the flight of an unmanned aircraft by operating its flight controls, either manually or, when the unmanned aircraft flies automatically, by monitoring its course and remaining able to intervene and change its course at any time".

Do you agree?

7.15 While our initial view is that the approach to categorisation of operations and the definition of remote pilot is sound, we have identified a number of issues in relation to autonomous operations of drones. We seek stakeholder views on these.

Autonomy in the open category

7.16 At present, autonomous operations and those involving BVLOS are generally considered riskier and are therefore prohibited in the open category of operations. As discussed above, the present position is that all autonomous or BVLOS operations which fall outside the certified category must instead be performed in the specific category. Such operations therefore require individual scrutiny from the regulator. This requires a risk assessment and an individual operational procedure.

7.17 While this is not strictly speaking a legal gap, in the long term, the growth of the drone industry may be inhibited by the requirement for individual attention from the regulator. Even if pre-defined risk assessments are available, large numbers of applications could be difficult to administer.

7.18 In the future, as the technology matures, and the CAA and industry gain more experience of these operations, the risk posed by such operations may change. In practice, some autonomous or BVLOS operations may be low risk and suitable for the open category subject to appropriate requirements. We note that the open category is already divided into risk-based subcategories (A1- A3), each with their own set of conditions.

7.19 We ask for consultees' views on whether it is feasible for some autonomous or BVLOS drone operations to be conducted in the open category.

[474] UK Regulation (EU) 2019/945 on unmanned aircraft systems and on third-country operators of unmanned aircraft systems, art 3(27).

Consultation Question 35.

7.20 We seek views on whether some low risk autonomous drone operations or drone operations conducted beyond visual line of sight might be accommodated in the open category. In particular:

(1) whether there are any such use cases which might be suitable for the open category; and

(2) if so, what conditions should be attached to these use cases if operated in the open category.

Lack of detailed rules – specific category

7.21 While the possibility of autonomous operations is briefly accounted for in the UAS Regulations, there is a lack of detail in the legislation, applicable guidance material and acceptable means of compliance ("AMC"); particularly by comparison to other types of operation. Although the framework in theory accommodates autonomous operations, the rules in the specific category are designed for remotely piloted operations, and there are therefore several gaps.

7.22 For example, there are many requirements in the specific category placed on the remote pilot. These requirements are imposed at the pre-flight stage and during the flight. Before the flight, the remote pilot must do things like ensure that the UAS is in a safe condition to complete the intended flight safely. During the flight, the requirements include avoiding any risk of collision with crewed aircraft and discontinuing a flight when it may pose a risk to other aircraft. With autonomous operations, there is either no remote pilot at all, or none that can intervene. Clearly, this means that a remote pilot cannot be responsible for complying with these requirements.

7.23 The solution arrived at by the legislation is to impose responsibility on the UAS operator to ensure that these functions are "properly allocated".[475] But in the case of the requirements applying during the flight, it is not clear whether and to whom these tasks can be allocated.[476]

7.24 As an example, remote pilots are currently required to avoid the risk of collision with other aircraft.[477] It is unclear how this should be interpreted for autonomous

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475 UK Regulation (EU) 2019/947 on the rules and procedures for the operation of unmanned aircraft, annex, UAS.SPEC.050(1)(b).

476 Currently, the legislation only provides a general requirement that UAS operators adopt correct "procedures" in this regard (see the reference to "procedures and limitations" in UK Regulation (EU) 2019/947 on the rules and procedures for the operation of unmanned aircraft, annex, UAS.SPEC.050(1)(b)). It is then for the individual operator to decide what the correct procedures are for their UAS operations, and for the CAA to accept those procedures when evaluating an application for an operational authorisation in the specific category.

477 UK Regulation (EU) 2019/947 on the rules and procedures for the operation of unmanned aircraft, annex, UAS.SPEC.060(3)(b).

operations. In practical terms, the function will be performed by the detect and avoid capabilities of the drone (or by connected ground based infrastructure) and so it is questionable whether the UAS operator can realistically be expected to have control over this aspect of the drone's performance. This is especially the case when the drone has been designed and built by other parties.

7.25 Similarly, the requirement that the remote pilot discontinue the flight when it may pose a risk to other aircraft[478] places responsibility on the remote pilot to make that judgement call. It is therefore appropriate that the remote pilot be held to account for failing to comply with that requirement. However, for autonomous operations it may be the case that the UAS operator is not able to intervene in the flight of the drone. Thus, the requirement which makes sense for remote pilots is less meaningful when transposed to UAS operators.

7.26 The other requirements that have to be fulfilled during the flight by the remote pilot, or someone "allocated" by the UAS operator, are to comply with:

(1) the authorised [...] limitations and conditions;

(2) operational limitations in designated geographical zones;

(3) the operator's procedures; and

(4) not fly close to or inside areas where an emergency response effort is ongoing unless they have permission to do so from the responsible emergency response services.[479]

7.27 In practice, our view is that if there is no remote pilot (at least for some stages of the flight), then there may be no one to whom the UAS operator can delegate these requirements. We therefore provisionally propose that the UAS operator should be made responsible for only using a UAS designed in a manner that it can comply with the requirements itself.

[478] UK Regulation (EU) 2019/947 on the rules and procedures for the operation of unmanned aircraft, annex, UAS.SPEC.060(3)(b).

[479] UK Regulation (EU) 2019/947 on the rules and procedures for the operation of unmanned aircraft, annex, UAS.SPEC.060.060(3).

Consultation Question 36.

7.28 We provisionally propose that for autonomous operations in the specific category, a UAS operator should be required to use a UAS which can:

(1) comply with the authorised limitations and conditions;

(2) avoid any risk of collision with any crewed aircraft and discontinue a flight when continuing it may pose a risk to other aircraft, people, animals, environment or property;

(3) comply with the operational limitations in designated geographical zones or airspace;

(4) comply with the operator's procedures; and

(5) not fly close to or inside areas where an emergency response effort is ongoing unless they have permission to do so from the responsible emergency response services.

Do you agree?

Lack of detailed rules – certified category

7.29 Like the specific category, there is a lack of provision within the certified category for autonomous drone operations. As set out in Chapter 3, the UAS Regulations only contain detailed rules for the design, production and operation of drones in the open and specific category. For drones in the certified category, the regulations applicable to crewed aviation must be complied with.

7.30 This means that UAS operations in the certified category suffer from several legal gaps. The applicable rules in place assume there is a pilot physically on board. For instance, the Air Navigation Order 2016[480] ("ANO") places several requirements on the pilot and some of these suggest that the pilot should be on board (for further discussion, see chapter 6). These are not an issue for drones in the open and specific category because the UAS Regulations apply instead; however, operations in the certified category face difficulty because of the current lack of specific legal rules applicable to high-risk uncrewed aircraft operations.

7.31 For autonomous operations specifically, the lack of dedicated provisions on the certification of autonomous systems is a significant gap.[481]

7.32 It is in this context that the European Aviation Safety Agency ("EASA") is introducing a certification process specifically applicable to UAS. This process involves amending existing regulations for crewed aviation and the development of a new delegated regulation. As discussed in chapter 4 at paragraphs 4.50 to 4.54, in August 2023

480 SI 2016 No 765.

481 See Chapter 4, paras 4.56 to 4.75.

EASA published Opinion No 03/2023. In this Opinion, EASA proposes changes to address the initial and continuing airworthiness of UAS subject to certification.[482] New operational rules for UAS in the certified category will also be made in due course and the rules of the air will be progressively updated in two phases. Phase one will involve a review of the rules to:

> identify potential issues that could hamper the scale-up of UAS operations and to propose limited rule changes or guidelines to resolve these issues without affected manned-aviation operations.[483]

7.33 Phase 2 will then develop more detailed rules of the air, including additional flight rules to enable the integration of UAS with existing airspace users.

7.34 More generally, the gaps in the certified category may be addressed to some extent by the implementation of standards and recommended practices developed by the International Civil Aviation Organisation ("ICAO"). We understand that several expert groups within ICAO are currently considering the regulatory framework around remotely piloted aircraft systems, advanced air mobility use cases as well as "unmanned" aircraft systems.[484]

Rules of the air

7.35 As discussed in chapter 5 at paragraph 5.26, "applicable operational requirements" of the UK Standardised Rules of the Air also apply to operations in the specific and certified categories. One major issue going forward is the lack of clarity about what "applicable operational requirements" entails.

7.36 Again, as explained in chapter 5 at paragraph 5.27, for operations in the specific category, some elaboration is provided by the AMC. AMC article 7(2) lists a limited number of UK Standardised European Rules of the Air ("SERA") provisions that have "applicable operational requirements". The CAA can also attach UK SERA provisions as a condition of operational authorisation. Otherwise, UK SERA does not apply to operations in the specific category.

7.37 For operations in the certified category, there is no elaboration of "applicable operational requirements" in AMC or guidance material. There is also the added complication that in the certified category, failure to comply with the rules of the air is an offence under the Air Navigation Order 2016.[485]

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482 EASA Opinion No 3/2023, *Introduction of a regulatory framework for the operations of drones- Enabling innovative air mobility with manned VTOL-capable aircraft, the initial airworthiness of unmanned aircraft systems subject to certification, and the continuing airworthiness of those unmanned aircraft systems operated in the 'specific' category* (August 2023).

483 EASA, Terms of reference for rulemaking task RMT-0230, *Introduction of a regulatory framework for the operation of unmanned aircraft systems and for urban air mobility in the European Union aviation system,* Issue 4, (December 2022), p 6, https://www.easa.europa.eu/en/document-library/terms-of-reference-and-group-compositions/tor-rmt0230-0.

484 https://www.icao.int/safety/ua/Pages/default.aspx.

485 SI 2016 No 765, art 249(2).

7.38 The lack of clarity about "applicable operational requirements" is problematic for autonomous and BVLOS drone operations in both categories. However, it is especially problematic in the certified category where there is a tension between:

(1) the application of the "applicable operational requirements" of UK SERA;

(2) the lack of further indication about what constitutes "applicable operational requirements" for UAS in this category; and

(3) the requirement under the ANO for operations in the certified category to comply with the rules of the air.

7.39 The tension is less pronounced in the specific category for the reasons stated above but it too would benefit from further consideration of which provisions should apply to autonomous operations.

7.40 As discussed in chapter 5, future options for reform may include the possibility of amending the current rules of the air or creating a new set of rules for remotely piloted and autonomous operations. Another option is to continue to only apply "applicable operational requirements" from the rules of the air to UAS, including drones, in the specific and certified categories. We seek consultees' views about what "operational requirements" should be applied to autonomous and BVLOS drone operations in these categories.

Consultation Question 37.

7.41 We seek views on what operational requirements should be applied to autonomous drone operations and drones that operate beyond visual line of sight in the specific and certified categories.

Using multiple drones simultaneously

7.42 Some use cases of drones may involve multiple drones working together to accomplish a task or objective. Recently the British Standards Institute ("BSI") has referred to such operations as "multiple simultaneous operations ("MSO")" and defined them as:

> Multiple uncrewed aircraft which are under collective control and are in flight simultaneously.[486]

7.43 The term "collective control" is defined as "multiple uncrewed aircraft being under the command of a single supervisory remote pilot-in-command".[487]

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[486] British Standards Institution, *BSI Flex 1903 v 1.0 2023-08*, Future flight systems – vocabulary (August 2023), para 3.1.65.

[487] British Standards Institution, *BSI Flex 1903 v 1.0 2023-08, Future flight systems – vocabulary* (August 2023), para 3.1.65.

7.44 The BSI note that that there are two main types of MSO:

(1) operations where uncrewed aircraft operate relative to each other; and

(2) operations where uncrewed aircraft are independent of each other.[488]

7.45 The first type of MSO describes a group of UAs which have been programmed to fly together in a particular manner. When undertaken with drones, the resulting flying group is sometimes referred to as a "drone swarm". Currently, the most common use of drone swarms is for entertainment purposes, most notably light shows. Drones are programmed to fly in a synchronised manner in various aerial formations.[489]

7.46 The second type of MSO describes UAs which might operate independently but still subject to collective control. For example, a fleet of drones may be used for logistical purposes, for example, to deliver goods to multiple locations, or to inspect large infrastructure on the ground.

7.47 There are many proposed use cases for drone MSO. For example, it has been suggested that teams of drones might be used for environmental monitoring, for example, to detect wildfires.[490] Groups of drones could also be used to create temporary cellular telephony networks.[491] Such scenarios might involve groups of drones with cellular communication modules being deployed over a particular area. This may be useful for rescue operations in remote areas or as a temporary measure where land-based infrastructure has been damaged. Drone swarms could also be used for emergency response in some circumstances.[492]

7.48 At the moment, there are several impediments to drone MSO. MSO are currently not possible in the open category because there is a requirement that remote pilots only operate one UAS at a time.[493] There is no such requirement for remote pilots of operations in the specific category. However, although the CAA has published some guidance, there remains a lack of detailed provisions to address any unique characteristics of this type of operation in the specific category.[494]

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488 British Standards Institution, BSI Flex 1903 v 1.0 2023-08, Future flight systems – vocabulary (August 2023), para 3.1.65.

489 M Abdelkader, S Guler, H Jaleel, and J S Shamma, "Aerial Swarms: Recent Applications and Challenges" (2021) 2 *Current Robotic Reports* 309.

490 https://www.ukri.org/news/future-flight-challenge-announces-phase-three-winners/.

491 https://www.bbc.co.uk/news/uk-wales-63400436.

492 Ausino, E and others. "Drone Swarms in Fire Suppression Activities: a conceptual framework" (2021) 5(1) *Drones* 17, https://doi.org/10.3390/drones5010017.

493 UK Regulation (EU) 2019/947 on the rules and procedures for the operation of unmanned aircraft, AMC1 UAS.OPEN.060(2)(d). We note that, by way of comparison, in the United States a person is prohibited from acting as a remote pilot-in-command in the operation of "more than one unmanned aircraft at the same time". See Code of Federal Regulations Title 14: Aeronautics and Space, § 107.35.

494 Though, there is CAA guidance on drone swarms within the visual line of sight. See CAA, *Unmanned Aircraft Systems Rotary Wing Swarm Operations – Visual Line of Sight – Requirements, Guidance and Policy* (December 2022) (CAP 722E).

7.49 As discussed above, the requirements placed on remote pilots for operations in the specific category assume a certain level of control over the aircraft and make them responsible for the safe flight of the UAS. The current definition of a UAS remote pilot is a pilot charged with "monitoring its course and remaining able to intervene and change its course at any time".[495] Whilst this may be possible for MSO of a smaller scale it may become increasingly difficult as operations become larger. We ask below whether there should be a maximum number of drones that can participate in MSO.

7.50 More generally, the difficulty with drone MSO is that it may no longer be possible for the remote pilot to meet the current set of requirements in respect of every aircraft that is part of the MSO. High levels of automation/autonomy may be necessary for exactly this reason - with individual drones having some capability to fly without input from the remote pilot. In some scenarios, such as those involving multiple drones flying in formation, it may be safer if the remote pilot cannot intervene to change the course of individual drones.

7.51 It is questionable then whether remote pilots of drone MSO should be subject to the same requirements of single drone operations. It is also questionable whether the current concept of a remote pilot is altogether compatible with drone MSO. Because of the high levels of autonomy involved, the roles necessary for safe drone MSO may prove to be significantly different. If so, the law arguably should reflect this. We invite views from stakeholders.

Consultation Question 38.

7.52 We seek views on whether the current concept of a "remote pilot" is compatible with drone MSO. We also seek views on whether the remote pilots of drone MSO should continue to be subject to the same responsibilities as remote pilots for single drone operations.

Consultation Question 39.

7.53 We seek views on whether there should be an upper limit to the number of drones for which an individual remote pilot is responsible.

Consultation Question 40.

7.54 We seek views as to what additional safeguards should be introduced for remote pilots responsible for multiple drones.

[495] UK Regulation (EU) 2018/1139 on common rules in the field of civil aviation and establishing a European Union Safety Agency, art 3(31).

Flight data recording for autonomous operations

7.55 Investigating and learning from any accidents will be key to enabling autonomous operations to take place faster. We give an overview in Appendix 2 of the role of the Air Accident Investigation Branch and their approach to investigations, as well as reporting obligations. To support investigations, it will be important that autonomous drones are capable of recording relevant flight data.

7.56 At present, whether a flight data recorder system or device is required will depend on the category of operation. For example, in the specific category, a UAS operator is required to keep and maintain an up-to-date record of information on UAS operations, including "unusual technical or operational occurrences and other data as required by the operational authorisation" for a minimum of 3 years.[496] Guidance material issued in relation to that requirement explains that:

> Although there is no legal requirement to make use of a flight data recording system (device, or service), it is recommended that UAS Operators make use of such systems to assist with the regulatory requirement [to keep and maintain an up-to-date record].[497]

7.57 For autonomous operations, where there may be no remote pilot to observe unusual technical or operational occurrences, it is important to ensure that flight data recorder systems can be used to support any future investigations. We therefore provisionally propose that use of such systems should be mandatory for autonomous drone operations.

Consultation Question 41.

7.58 We provisionally propose that use of flight data recorder systems or devices should be mandatory for autonomous drone operations.

Do you agree?

Moving between remotely piloted and autonomous flight

7.59 In Chapter 6 at paragraphs 6.136 to 6.140 we discuss whether the law should allow UAS to transition between remotely piloted and autonomous modes throughout an operation. We discussed the need for timely "transition demands" when an aircraft moved between these phases. We have not seen detailed discussion of this topic, but believe it may be of interest to drone users. We therefore ask a question seeking consultees' views below.

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496 UK Regulation (EU) 2019/947 on the rules and procedures for the operation of unmanned aircraft, annex, UAS.SPEC.050(1)(g)(iii).

497 UK Regulation (EU) 2019/947 on the rules and procedures for the operation of unmanned aircraft, GM1 UAS.SPEC.050(1)(g)(iii).

Consultation Question 42.

7.60 Should the law permit a drone to transition between remotely piloted and autonomous flight during an operation?

Further issues

7.61 We have attempted to highlight the major issues with the current regulatory framework for drones. However, we invite stakeholders to draw our attention to any other gaps, blockers or inconsistencies in the current legal framework, which relate to operations involving autonomous drones.

Consultation Question 43.

7.62 We seek stakeholder views on any other issues with the current legal framework as it relates to operations involving autonomous drones.

Chapter 8: Civil liability and insurance

8.1 In this chapter we explore what civil liability attaches to those involved in the operations of uncrewed aircraft systems ("UAS"), both following an accident and in relation to their day-to-day operations. From the earliest days of aviation, having straightforward mechanisms for compensation following an accident has been seen as key to its commercial success. This will continue to be important as uncrewed aircraft become more prevalent. This area is also affected by the broader question of how best to compensate those who have been adversely affected by "AI" systems.

8.2 We also discuss insurance requirements placed on air carriers and operators and consider the application of the existing framework to uncrewed aircraft. We intend to return to the topic of liability in the context of air traffic management and air navigation services in the planned second consultation paper.

8.3 It is important to bear in mind when reading this chapter that the law has various mechanisms for making people responsible for accidents. Some are specific to aviation, and some are not. The result is that the law may place operational responsibilities on actors within the aviation system (such as the pilot) without necessarily making them liable to pay damages to persons who are injured because of a breach of those responsibilities. By way of example, UK SERA explains that the pilot-in-command is responsible for:

> taking such action, including collision avoidance manoeuvres based on resolution advisories provided by ACAS equipment, as will best avert collision.[498]

8.4 Depending on the circumstances, breaching that provision could be a criminal offence, and result in a fine for the pilot (and we discuss how this mechanism works in chapter 9 at paragraphs 9.19 to 9.28).[499] If breaching the provision involved fault on the part of the pilot, and caused damage, the pilot could potentially be civilly liable. But this is not automatic.

CIVIL LIABILITY IN THE CASE OF ACCIDENTS

8.5 This section discusses liability within the aviation industry for: death or injury caused to passengers; damage to their baggage; damage to cargo; and damage caused to people and property on the ground. It also considers the liability of designers and manufacturers of aircraft systems and components.

8.6 The law in relation to the carriage of passengers and cargo is generally referred to as the law of "carriage by air". The majority of the law in this area comes from international conventions, as implemented in domestic law. Of particular relevance is the Montreal Convention 1999 (the "Montreal Convention"), which deals with liability

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498 UK Regulation (EU) 923/2012 laying down the common rules of the air and operational provisions regarding services and procedures in air navigation, annex, SERA.3201.

499 Air Navigation Order 2016 SI No 765, art 265(6) and sch 13, pt 2, ch 6.

for death or injury to passengers, and damage to baggage and cargo. While there is a body of common law which addresses these questions, it now only applies to carriage provided free of charge otherwise than by an air transport undertaking or the Crown.[500]

8.7 The UK ratified the Montreal Convention in 2004 and a statutory instrument implementing its contents came into effect in the same year.[501] The Montreal Convention was intended to replace its predecessor, the Warsaw System.[502] However, not all states party to the Chicago Convention have yet ratified the Montreal Convention, with the result that the Warsaw System remains in force.[503]

8.8 Legislation has extended the scope of the Montreal Convention beyond international carriage to include domestic carriage of passengers and baggage. We focus in this section on domestic use cases.

Air carrier liability for injury or death of passengers

The current law

8.9 UK air carriers engaged in the carriage of persons or their baggage are subject to UK Council Regulation 2027/97. That regulation (as amended) applies provisions of the Montreal Convention to both national and international air carriage.[504]

8.10 The Convention deals with liability of air carriers for passengers, baggage, cargo and delay. Article 17 provides that an air carrier is liable for death or bodily injury which results from an accident occurring on board an aircraft (or in the course of embarking or disembarking). There is no particular requirement that there should be a pilot. Our view is therefore that the provision applies to uncrewed aircraft.

8.11 The primary person liable under the Convention is the air carrier, rather than the pilot or any other actor. An air carrier is defined as “an air transport undertaking with a valid operating licence” and a UK air carrier as an air carrier granted an operating licence by the CAA.[505] Neither an air carrier nor an air transport undertaking is defined in the conventions. The Transport Act 2000 however defines a UK air transport undertaking, for the purpose of that Act, as “an undertaking… which includes the provision of services for the carriage by air of passengers or cargo for hire or reward”.[506]

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500 Montreal Convention 1999 art 1(1); Carriage by Air Acts (Application of Provisions) Order 2004 SI No 1899, art 8.

501 The Carriage by Air Acts (Implementation of the Montreal Convention 1999) Order 2002 SI No 263.

502 https://applications.icao.int/postalhistory/the_warsaw_system_on_air_carriers_liability.htm.

503 For an overview, see https://treaties.un.org/Pages/showDetails.aspx?objid=0800000280078e04.

504 UK Council Regulation (EC) No 2027/97 on air carrier liability in the event of accidents, arts 1 and 3.

505 UK Council Regulation (EC) No 2027/97 on air carrier liability in the event of accidents, art 2.

506 Transport Act 2000, s 95(5). Shawcross and Beaumont argue that “a person, firm or company will be an 'air transport undertaking' for convention purposes if the carriage of passengers or goods by air for reward is part of its regular business, even if it also carries on other forms of business, and even if air transport is only a small or subordinate part of the whole business”: Shawcross and Beaumont, *Air Law* (Issue 181 2022), VII [312].

8.12 For damages up to a set amount, the carrier may not exclude or limit its liability. That amount was originally expressed in gold francs, but is now expressed in Special Drawing Rights, or "SDRs".[507] The current figure (applicable in the UK for death or injury to passengers) is 128,821 SDRs, or just under £140,000.[508] Up to that limit the scheme is one of "strict liability"; in other words, it is not necessary to show that the air carrier was at fault. Above that point, the carrier will not be liable for damages if the air carrier can prove that the damage:

(a) was not due to the negligence or other wrongful act or omission of the carrier or its servants or agents; or

(b) was solely due to the negligence or other wrongful act or omission of the person claiming compensation (or the person from whom the claimant derives their rights).[509]

8.13 The Montreal Convention envisages that claims may be brought against the air carrier's staff, such as the pilot. It therefore allows staff to benefit from the limitations set out in the Convention, so long as they were acting in the scope of their employment and the damage was not done "with intent to cause damage or recklessly and with knowledge that damage would probably result".[510] The total damages claimed from the air carrier and employee or agent must however not exceed the overall limits referred to above in paragraph 8.12.[511] Because air carriers will usually have greater resources, there is little incentive for someone who is injured to claim against an employee or agent rather than the air carrier.

8.14 The term "accident" is not defined in the conventions but has been the subject of case law in other jurisdictions. Its ambit can be broad: a United States decision has held that sexual assault by a fellow passenger was an "accident",[512] a position that was followed by the Court of Appeal of England and Wales.[513] The current position appears to be that "bodily injury" does not include psychiatric injury, unless resulting from physical damage to the body, including the brain.[514]

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507 Special Drawing Rights ("SDRs") is an international currency unit created by the International Monetary Fund. As at February 2024, 1 SDR = approximately 0.95 GBP.

508 Montreal Convention 1999, art 21(1) applied via UK Council Regulation (EC) 2027/97, art 1. This sets a limit of 100,000 SDRs, which has subsequently been increased by two decisions of the ICAO Council.

509 Montreal Convention 1999, art 21(2).

510 Montreal Convention 1999, art 30.

511 Montreal Convention 1999, art 30(2).

512 *Wallace v Korean Air*, 214 F. 3d 293 (2000), 2nd Cir. See generally *Chitty on Contracts*, (35th ed 2023) para [38-031].

513 *Morris v KLM Royal Dutch Airlines* [2001] EWCA Civ 790, [2002] QB 100 at p 112; an appeal was made to the House of Lords, but the Court of Appeal's finding that a sexual assault could constitute an accident was not appealed. *Morris v KLM Royal Dutch Airlines, King v Bristow Helicopters Ltd* [2002] UKHL 7, [2002] 2 AC 628 at [72]. It has been argued that a change in wording between the Warsaw Convention and the Montreal Convention makes it more likely that a claim for psychiatric injury would be successful, but the position has not yet been decided. See *Delaney v Jet2.com Ltd* [2019] Rep LR 56.

514 *Morris v KLM Royal Dutch Airlines* [2001] EWCA Civ 790, [2001] 3 All ER 126 at p 128.

8.15 The regime introduced by the Montreal Convention is designed to be exhaustive: it provides a statutory cause of action which then displaces other possible claims in contract or tort (including claims under the Occupiers' Liability Act 1957).[515]

8.16 The Montreal Convention also provides for liability for damage, destruction or loss of baggage. The carrier will be liable for damage to checked baggage on the condition that the event causing the damage took place on board the aircraft, or otherwise when the baggage was in the charge of the carrier. For unchecked baggage, the carrier is only liable if the damage arises from its own fault (or that of its employees or agents). There is a financial limit to the amount that can be claimed; this is 1,288 SDRs per passenger.[516]

Application to uncrewed aircraft

8.17 The strict liability regime is designed primarily to enable compensation from the carrier, rather than the pilot. In our provisional view, the replacement of a pilot by a remote pilot, or the removal of the pilot altogether, will not make any significant difference to the effectiveness of the current regime. In the vast majority of cases, an air carrier will be much better placed to compensate claimants.

8.18 In practice, it is possible that the regime may operate slightly differently. At present, carriers are liable for "accidents" which cause damage. As noted above at paragraph 8.14, "accident" has been construed widely, to include damage caused by other passengers in the aircraft. This type of incident may become more common without the restraining influence of cabin and flight crew.

8.19 One question that arises in relation to UAS is who exactly the "air carrier" is. In our view, this will be the operator of a remotely piloted or autonomous VTOL. As discussed in Chapter 6 at paragraph 6.4, we expect that such operators will be required to hold a valid operating licence in order to transport passengers, and will therefore fall under the definition of "air carrier" as discussed above at paragraph 8.11. It is unnecessary to consider the position of operators in the open and specific categories, as passengers will not be carried as part of these operations (for an explanation of these categories, see chapter 3).

Consultation Question 44.

8.20 We provisionally consider that the current law governing air carrier liability for injury or death of passengers in the UK is adequate for the introduction of remotely piloted and autonomous operations.

Do you agree?

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515 UK Council Regulation (EC) No 2027/97 on air carrier liability in the event of accidents, art 3 and Montreal Convention 1999, art 29. The Occupiers' Liability Act 1957 explicitly extends to aircraft: see s 1(3)(a). In practice however claims against air carriers in relation to passengers and their baggage would have to be brought subject to the Montreal Convention.

516 Approximately £1223 as at February 2024.

Air carrier liability for cargo

The current law

8.21 Air carriers that carry cargo within the UK fall under a modified version of the Montreal Convention system, introduced by schedule 1 to the Carriage by Air Acts (Application of Provisions) Order 2004.[517] It applies to "all carriage of persons, baggage or cargo performed by aircraft for reward", and gratuitous carriage by aircraft "performed by an air transport undertaking".[518] Its scope is therefore different from that of UK Council Regulation 2027/97: there is no need for the carrier to have an operating licence.

8.22 Article 18 provides that the carrier will be liable for:

> damage sustained in the event of the destruction or loss of, or damage to, cargo upon condition only that the event which caused the damage so sustained took place during the carriage by air.[519]

8.23 As with liability for death or bodily injury, there is a limit to the liability, which operates by weight.[520] The weight limit may however be displaced if the sender makes a "special declaration" and, if required, pays an additional fee. The air carrier may rely on a defence of contributory negligence, if the carrier proves that the damage was caused or contributed to by the negligence or other wrongful act or omission of the person claiming compensation.[521]

8.24 An air carrier will also escape liability if the destruction, loss or damage was due to:

(1) an inherent defect, quality or vice in the cargo;

(2) defective packing of the cargo by another person;

(3) an act of war or armed conflict; or

(4) an "act of public authority" carried out in connection with the entry, exit or transit of the cargo.[522]

Application to uncrewed aircraft

8.25 There is nothing in the law that confines liability to any particular type of aircraft. We are provisionally of the view that liability will apply to UAS.

8.26 In practice it seems likely that cargo carried by smaller drones will be of a greater value than the current limit of 17 SDRs per kilogram. As a result, greater use is likely

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517 This in turn amends Schedule 1B to the Carriage by Air Act 1961. For further detail, see *Chitty on Contracts* (35th ed 2023) para [38-104].

518 Carriage by Air Act 1961, sch 1B, art 1, as applied by the Carriage by Air Acts (Application of Provisions) Order 2004 SI No 1899, sch 1.

519 Carriage by Air Act 1961, sch 1B, art 18, as applied by SI 2004 No 1899, sch 1.

520 Carriage by Air Act 1961, sch 1B, art 22(3) gives a limit of 17 SDRs per kilogram (as applied by SI 2004 No 1899, sch 1).

521 Carriage by Air Act 1961, sch 1B, art 20, as applied by SI 2004 No 1899, sch 1.

522 Carriage by Air Act 1961, sch 1B, art 18(2), as applied by SI 2004 No 1899, sch 1.

to be made of special declarations and additional fees. At present we do not see that this requires a change to the existing law.

Consultation Question 45.

8.27 We provisionally consider that the current law governing liability for damage to cargo in the UK is adequate for the introduction of remotely piloted and autonomous operations.

Do you agree?

Liability for "surface damage"

The current law

8.28 Section 76(2) of the Civil Aviation Act 1982 Act provides compensation for damage sustained at ground level. In particular it enables damages to be claimed "where material loss or damage is caused to any person or property on land or water by, or by a person in, or an article, animal or person falling from, an aircraft while in flight, taking off or landing".[523]

8.29 Liability is strict: damages can be claimed "without proof of negligence or intention or other cause of action, as if the loss or damage had been caused by the wilful act, neglect, or default of the owner of the aircraft".[524] However, the section states that such damages will not be recoverable if "the loss or damage was caused or contributed to by the negligence of the person by whom it was suffered". It is unclear whether negligence by the person who has suffered the damage is a complete defence to a claim under section 76(2), or only a partial defence.[525]

8.30 The person liable for any damage is the owner of the aircraft.[526] However, if:

(1) the aircraft has been demised, let out or hired for a period exceeding 14 days to any other person; and

(2) no pilot, commander, navigator or operative member of the crew of the aircraft is in the employment of the owner (a situation often referred to as a "dry lease"),

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523 Civil Aviation Act 1982, s 76(2).

524 Civil Aviation Act 1982, s 76(2).

525 Civil Aviation Act 1982, s 76(2). It is undecided in England and Wales whether section 1 of the Law Reform (Contributory Negligence) Act 1945 applies to this subsection. The principles underpinning when that Act will apply have been articulated by Lord Hoffmann in *Standard Chartered Bank v Pakistan National Shipping Corporation (No 2)* [2002] UKHL 43, [2003] 1 AC 959 at [11] and [12]. We note that Shawcross and Beaumont take the view that the Law Reform (Contributory Negligence) Act 1945 applies to claims under the subsection, referring to a decision by the Supreme Court of New South Wales: *Southgate v Commonwealth of Australia* (1987) 13 NSWLR 188 (NSW SC). See Shawcross and Beaumont, Air Law (Issue 181 2022), V [916].

526 The term "owner" is not defined in the Civil Aviation Act 1982. We suggest that it means someone with a general property interest in the aircraft: see Sale of Goods Act 1972, s 61.

then the liability falls on the lessee.[527] An air carrier who is not the owner may be liable under section 76, depending on the terms on which the aircraft is leased.

8.31 The liability created by the section is not exhaustive; damage to people or property on the surface may give rise to other types of liability on the part of the owner, operator or pilot. As explained by Shawcross and Beaumont,

> … the pilot may be liable in negligence, and a plaintiff may have a choice of defendants. Selecting the owner will avert the need to prove negligence, but other factors (such as jurisdictional issues, or insurance matters) may point to a different choice in a particular case.[528]

8.32 It is also possible that a claim could be brought against the manufacturer under the product liability regime (see below, at paragraphs 8.72 to 8.76).

8.33 It is worth noting that the terminology used in this section is not typical of aviation law. It would be more typical to refer to an "operator" than an owner. The use of the word "owner" dates back to the early days of aviation law and the Air Navigation Act 1920.[529] It may be desirable for the law to be updated here, and mirror terminology that is currently in use. This is however a general problem with aviation law, rather than one specific to UAS, and in our view is beyond the scope of this project.

Application to uncrewed aircraft

8.34 The strict liability regime for surface damage simply places liability upon the owner or lessee of the aircraft. As a result, our provisional view is that the absence of an onboard pilot, or their replacement with a remote pilot (or multi-vehicle supervisor) will not make a difference to the way the regime works.

8.35 At present, while it is theoretically possible to bring an action against the pilot in negligence, in practice this seems unlikely. The pilot is likely to have fewer resources than an owner or lessee, making them a less attractive target in a civil claim. A claimant would also have to demonstrate fault on the part of the pilot. As a result, our preliminary view is that the lack of scope for a claim against a pilot will make little difference to the position of a potential claimant.

8.36 One question that arises is what impact the shift in liability from an owner to a lessee will have for uncrewed aircraft. At present a lessee would be liable for surface damage if the aircraft is "demised, let out or hired" for more than 14 days and the owner does not employ any "pilot, commander, navigator or operative member of the crew of the aircraft". Again, this wording dates back to the Air Navigation Act 1920.[530] The phrase "demised, let out or hired" does not correspond to the various types of aviation lease which feature in modern aviation law.

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527 Civil Aviation Act 1982 s 76(4). For a more detailed explanation of "dry" and "wet" leasing see paragraphs 8.40 and 8.41.

528 Shawcross and Beaumont, *Air Law* (Issue 181 2022), V [920].

529 Air Navigation Act 1920, s 9(2) (repealed).

530 Air Navigation Act 1920, s 9(2) (repealed).

8.37 In any event, the logic appears to be that, for shorter leases, the owner remains responsible for and involved in the maintenance of the aircraft and should therefore be responsible for accidents. For leases where the owner continues to employ crew, the owner still enjoys a degree of control over the operation which makes it appropriate that they should be responsible for surface damage.

8.38 We do not yet know to what extent leasing will be a feature of the market for VTOLs in the UK, although we are aware that several aircraft leasing companies have placed pre-orders for Vertical Aerospace's VX4.[531] The picture may change again once uncrewed VTOL are introduced. If the existing pattern of aircraft leasing in the UK is replicated for VTOL, most leases will be for longer than 14 days. The future picture is also unclear for drones, though we expect that leasing will form part of the market.

8.39 For many use cases, ground crew will still play a role, even in the absence of a pilot (see for example paragraph 6.157 on the role we see for ground crew in autonomous operations). We would expect such ground crew to fall within the definition of "operative crew", with the result that section 76(2) would allocate liability depending on who employed them. There may however be cases where there is no crew at all. What then would be the impact on UAS?

8.40 The distinction between leases of aircraft with and without crew, referred to in section 76(4), is commonly referred to as wet and dry leasing; these are both terms with their origin in the maritime context. So called "wet leasing" is a lease where crew continue to be employed by the original operator and their services are supplied with the aircraft. Leasing an aircraft without its crew is known as a "dry lease". However, the legal definition is slightly different. The UK Air Operations Regulation defines a wet lease agreement as an agreement:

(1) in the case of commercial air transport operations, between air carriers pursuant to which the aircraft is operated under the air operator's certificate of the lessor; or

(2) in the case of commercial operations other than commercial air transport operations, between operators pursuant to which the aircraft is operated under the responsibility of the lessor.[532]

8.41 A dry lease agreement is defined as:

> an agreement between undertakings pursuant to which the aircraft is operated under the air operator certificate of the lessee or, in the case of commercial operations other than commercial air transport, under the responsibility of the lessee.[533]

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531 https://vertical-aerospace.com/wp-content/uploads/2023/11/Avolon-exceeds-pre-order-commitments-and-places-over-500-VX4-aircraft-with-leading-airlines.pdf.

532 UK Regulation (EU) 965/2012 laying down technical requirements and administrative procedures related to air operations, annex I, para 127.

533 UK Regulation (EU) 965/2012 laying down technical requirements and administrative procedures related to air operations, annex I, para 40.

8.42 How the regulation of wet leases applies to UAS is not entirely clear. "Applicable operational requirements" of the UK Air Operations Regulation do apply to the certified category of UAS.[534] At present there is no guidance as to which requirements are applicable and which are not. UAS in the specific and open categories are not subject to the requirements.

8.43 Leaving the section unamended would mean that for UAS without crew, any lease of over 14 days would make the lessee responsible for surface damage. That would be the case even if the lease was functionally (even if not in law) a "wet lease" and the parties had agreed operational responsibility should remain with the lessor. In practice, this could be dealt with by the lessee of the aircraft seeking a contractual indemnity from the lessor in respect of any liability.[535] However, in our view, the law would be clearer if it reflected the agreement between the parties involved. We therefore provisionally propose that, in the case of UAS, responsibility for surface damage should only transfer from the owner to the lessee if (a) the lease is for over 14 days, and (b) the parties agree that responsibility should transfer (the lease is "dry").

Consultation Question 46.

8.44 We provisionally propose that liability for surface damage, in the case of UAS, should transfer to the lessee when the lease:

(1) is for more than 14 days; and

(2) specifies the aircraft is to be operated under the responsibility of the lessee.

Do you agree?

Trespass and nuisance

The current law

8.45 This section considers liability at common law for the torts[536] of private nuisance and trespass.

8.46 At common law, an owner's rights in relation to the airspace above the land are restricted to such height as is necessary for the ordinary use and enjoyment of the land and the structures upon it. As a result, in *Bernstein of Leigh v Skyviews &*

534 UK Regulation (EU) 2019/947 on the rules and procedures for the operation of unmanned aircraft, art 7. The application of the Air Operations Regulation to the specific category is not mentioned as a possibility in art 7(2), which only refers to UK SERA.

535 See Shawcross and Beaumont, *Air Law* (Issue 181 2022), V [917] fn 2.

536 Civil wrongs for which a remedy can be claimed.

General Ltd, an aerial photography company was found not to be trespassing.[537] We are not aware of any case law which considers in any detail trespass by a UAS.[538]

8.47 Private nuisance is a wrongful interference with the claimant's enjoyment of rights over land.[539] It is possible that the use of UAS might constitute a private nuisance if its use constituted a substantial and unreasonable interference with a claimant's land or their use or enjoyment of that land. The most commonly claimed remedies are injunctions (meaning a court order to stop the behaviour) or damages.

8.48 Trespass concerns unlawful presence on someone else's land. It is not necessary to prove that the presence has caused damage.[540] If a UAS flies over land belonging to someone else, it is possible that this may amount to trespass, particularly if the UAS is lingering at very low altitude.

8.49 The Civil Aviation Act 1982 excludes liability for trespass or in nuisance in respect of a flight or the "ordinary incidents" of a flight, so long as:

(1) the flight is "at a height above the ground which, having regard to wind, weather and all the circumstances of the case is reasonable"; and

(2) provisions of any Air Navigation Order, or order under section 62 of the Civil Aviation Act 1982 are complied with.[541]

8.50 This exclusion dates from the Air Navigation Act 1920.[542] The "ordinary incidents" of flight were considered in *Bernstein of Leigh (Baron) v Skyviews & General Ltd*, where it was held that:

> "Incidents" means things which happen while the flight is going on… "Incidents" must in its natural ordinary meaning include things that happen incidentally to the flight and the taking of a photograph is these days something which is regarded as properly incidental and ordinarily incidental, as opposed to extraordinarily incidental, to the flight.[543]

8.51 The judge also stated that, generally, the taking of a single photograph did not amount to nuisance. However, if a claimant was subjected to "the harassment of constant surveillance of his house from the air, accompanied by the photographing of his every activity", a court might regard that as actionable nuisance.[544] The case might not be

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537 *Bernstein of Leigh v Skyviews & General Ltd* [1978] QB 479 at p 488.

538 This question is discussed by E Cracknell, "Drone regulation is not a zero-sum game" (2022) 172 *New Law Journal* 7962, p 13.

539 The tort of nuisance was recently summarised by the Supreme Court in *Fearn and others v Board of Trustees of the Tate Gallery* [2023] UKSC 4, [2024] AC 1.

540 M Hones and A Dugdale, *Clerk & Lindsell on Torts* (24th ed 2023) para [18-08].

541 Civil Aviation Act 1982, s 76(1). The section also requires compliance with any orders made under section 62 of the Civil Aviation Act 1982, which was repealed by the Transport Act 2000.

542 Air Navigation Act 1920, s 9(1) (repealed).

543 [1978] QB 479 at p 481.

544 [1978] QB 479 at p 489.

decided the same way today. It is also likely that claims now would be brought under the law of data protection or privacy, rather than nuisance.

Application to uncrewed aircraft

8.52 In our view, section 76(1) of the Civil Aviation Act 1982 applies to uncrewed aircraft. Its application to VTOLs, which are expected to behave in some ways like traditional aircraft, may be fairly straightforward, although we note that data on the noise generated by VTOLs is not yet available.[545] However, drones are expected to operate differently, with in some case more descents, which raises some questions.

8.53 The first is about the question of "reasonable height". Most aircraft fly with a *minimum* operating height of between 150 to 600 metres, to avoid the risk of collisions and to minimise disturbance to those on the ground.[546] In the open category, however, drones have a *maximum* height; usually 120m above ground.[547] This height limit has also been adopted in the specific category for the pre-defined risk assessment outlined in CAA guidance.[548]

8.54 The height limit is partly to reduce the risk to those on the ground; the greater the height from which it falls, the greater the kinetic energy an aircraft will have on impact with the ground, and the more damage it can cause. The maximum height also helps to segregate UAS in the open and specific categories from traditional aircraft. A "reasonable height" is therefore likely to be interpreted differently for drones flying over properties than for traditional aircraft.

8.55 Other possible questions are whether the criterion of "reasonable height" remains appropriate for drones and whether it should be supplemented by other requirements such as limits on the frequency of flights.

8.56 In some ways, drones may be less intrusive than traditional aircraft flying at a similar height. They are generally quieter, particularly when powered with electricity. However, there is some evidence to suggest that people find drone noise more annoying than traditional aircraft or road noise.[549] The impact of drone noise is one which is being explored by researchers.[550]

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545 Civil Aviation Authority, *Noise measurements from eVTOL aircraft: a review of available data* (March 2023) (CAP 2506) para 1.2.

546 UK Regulation (EU) 923/2012 laying down the common rules of the air and operational provisions regarding services and procedures in air navigation, annex, SERA.5005(c)(5); SERA.5005(f) and SERA.5015(b).

547 UK Regulation (EU) 2019/947 on unmanned aircraft systems and on third-country operators of unmanned aircraft systems, art 4(1)(e). Some subcategories of the open category also have a minimum distance: UAS.OPEN.040(2) requires flights to be conducted at a "safe horizontal distance of at least 150 metres from residential, commercial, industrial or recreational areas".

548 CAA, *Unmanned Aircraft Systems Specific Category Operations - Pre-defined Risk Assessment Requirements, Guidance & Policy* (August 2023) (CAP 722H) p 11.

549 CAA, *Emerging technologies: The effects of eVTOL aircraft noise on humans* (March 2023) (CAP 2505) para 4.11.

550 CAA, *Noise measurements from eVTOL aircraft: a review of available data* (March 2023) (CAP 2506); and Civil Aviation Authority, *Emerging technologies: The effects of eVTOL aircraft noise on humans* (March 2023) (CAP 2505).

8.57 The level of intrusion caused by drones will also be affected by the volume of flights. In future it is expected that more drones will be flown beyond the visual line of sight. This in turn is expected to make delivery business models more viable, with the result that drones may fly over properties much more often than current aircraft do. A 2021 report published by the Regulatory Horizons Council notes that drones have been unpopular in residential areas due to noise, and:

> this is especially likely to be an issue with consumer deliveries which have yet to be trialled at scale in urban areas.[551]

8.58 Drones are also likely to be very dependent on cameras and other sensors, to avoid mid-air collisions and to ensure that they are making deliveries in the correct location. The use of cameras could also increase the level of intrusion experienced by those on the ground, whose privacy may be affected.

8.59 We anticipate that problems of intrusive operation of drones (for example, in residential areas) will be dealt with by regulation of matters such as flying altitude, data capture and frequency of flights and/or descents. We provisionally regard such regulation as a better means of controlling intrusion than introducing additional criteria into the statutory defence to nuisance and trespass (beyond the existing requirement that a flight be in accordance with the requirements of aviation legislation).

8.60 At present the exclusion of liability for nuisance and trespass is only available if the provisions of "any Air Navigation Order, or under section 62 of the Civil Aviation Act 1982" are complied with. Section 62 has been repealed. There are several air navigation orders in force regulating matters that may be unrelated to the intrusion complained of (for example, failure to register an aircraft). Many requirements potentially relevant to intrusion are contained not in air navigation orders but in assimilated law. This is not a problem that is unique to UAS. As the regulation of aviation generally has become increasingly governed by EU law, rather than by domestic air navigation orders, the number of requirements that have to be complied with as conditions of the exclusion of liability has decreased.

8.61 However, UAS regulation is almost entirely outside air navigation orders, to the extent that the requirement of compliance with air navigation orders has little meaning. Our provisional view is that section 76 should be modified in its application to UAS in such a way that the reference to compliance with aviation legislation requires compliance with requirements relevant to intrusiveness. One possibility might be to single out requirements that relate to operating height, relevant airspace restrictions, methods of propulsion, and the time of day that flights may take place.

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551 Regulatory Horizons Council, *The regulation of drones: an exploratory study* (November 2021) p 14.

Consultation Question 47.

8.62 We provisionally propose that the conditions of exemption from liability for private nuisance and trespass in section 76 of the Civil Aviation Act 1982 should be modified in their application to UAS so as to require compliance with requirements of aviation legislation that are relevant to limiting intrusion into the claimant's land.

Do you agree?

Liability of designers and manufacturers

8.63 It can be seen from the preceding sections that much of the focus of existing strict liability regimes is on the air carrier or the owner or lessee of an aircraft. As aircraft systems take on a greater role in their own operation however, more attention is likely to be directed at the potential liability of manufacturers and software designers. An example of the type of issue that may arise are the tragic accidents involving the Boeing 737 Max (Lion Air Flight 610 on 29 October 2018, and Ethiopian Airlines Flight 302 on 10 March 2019). These were caused partly by problems with the aircraft's "manoeuvring characteristics augmentation system", or "MCAS".[552]

8.64 The relationship between operators (and/or owners or lessors) and manufacturers and software designers will be complex and involve a series of contracts. Those will typically include warranties about the software being provided. Since liability will depend on the terms of individual contracts, we do not address the contractual law point further here.

8.65 We do however consider the two principal forms of claim against manufacturers and designers under the general law. These are claims against producers of products under the Consumer Protection Act 1987 and against manufacturers and designers based on the tort of negligence. Air carriers and operators are required to have insurance cover in relation to their liabilities for death and personal injury caused by accidents, loss or destruction of or damage to baggage and cargo and damage caused on the ground (discussed at paragraphs 8.5 to 8.44).[553] Given that fact, it is likely that operators will claim on their insurance and that insurers will claim against designers or manufacturers (a practice known as "subrogation").

Negligence

8.66 Manufacturers and designers owe a duty of care to the consumers of their products. This extends to those who are injured by the products in foreseeable circumstances. In order to succeed, the claimant must show that:

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552 The causes of these crashes are complex and include difficulties in the relationship between Boeing and the US Federal Aviation Administration. For one account, see the US House of Representatives House Committee on Transportation and Infrastructure, *The design, development & certification of the Boeing 737 MAX: final committee report* (September 2020).

553 UK Regulation (EC) 785/2004 on insurance requirements for air carriers and aircraft operators, art 4(1); *Chitty on Contracts* (35th ed 2023) para [38-024].

(1) a duty was owed to them;

(2) the duty was breached;

(3) the breach caused a loss to the claimant; and

(4) the loss was not too remote.

8.67 It is possible that, following an accident, an air operator could sue a manufacturer or software developer in negligence. The standard of the duty is likely to be that of the reasonable manufacturer or designer: in other contexts designers have been found to owe a duty of "reasonable skill and care" when designing products.[554]

8.68 In some cases negligence may be inferred if the circumstances of an accident suggest that negligence was involved and the defendant cannot offer an alternative explanation. This principle is known in Latin as *res ipsa loquitur* ("the thing speaks for itself") and has been applied in the aviation context in the past. In the Privy Council case of *George v Eagle Air Services Ltd*,[555] Lord Mance noted:

> Aircraft, even small aircraft, do not usually crash, and certainly should not do so. And, if they do, then, especially where the crash is on land as here, it is not unreasonable to suppose that their owner/operators will inform themselves of any unusual causes and not unreasonable to place on them the burden of producing an explanation which is at least consistent with absence of fault on their part. The respondents have in fact never suggested or attempted to suggest any explanation of the accident or any reason preventing them giving an explanation. In the Board's opinion, they have in the result failed to displace the inference of negligence which in the circumstances results from the crash itself.

8.69 While that case related to operators, it is possible a similar inference could be drawn in a claim against manufacturers or designers, although the factual basis for such an interference arising could be more complex in causal terms.

8.70 In cases where an accident has injured or killed passengers, the damage or loss caused by any negligence would be relatively obvious. Such a risk would also in most cases be reasonably foreseeable by a manufacturer or designer involved in the manufacture or design of a safety-critical system.

8.71 Given that systems that rely on machine learning are not designed to be readily understood by humans,[556] it is likely that evidential issues would arise in this regard.

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554 See for example *IBA v EMI (Electronics) Ltd* (1981) [1955-95] Professional Negligence and Liability Reports 179.

555 [2009] UKPC 21, [2009] 1 WLR 2133 at [13].

556 This is a widely recognised concern: one of the UK Government's five principles for the development and use of AI is "appropriate transparency and explainability". See Department for Science, Innovation and Technology and Office for Artificial Intelligence, *A pro-innovation approach to AI regulation* (2023). For a discussion of some of the problems in relation to negligence and artificial intelligence, see B Soyer and A Tettenborn, "Artificial intelligence and civil liability – do we need a new regime?" (2022) 30 *International Journal of Law and Information Technology* 385.

This is an undoubtably a complex area and the law has not yet "caught up" with the novel aspects that arise.

Consumer Protection Act 1987

8.72 The Consumer Protection Act 1987 sets out a strict liability regime covering damage caused by "products", a term which explicitly applies to aircraft.[557] The Act implements the EU Product Liability Directive 1985, which was not written with software in mind.

8.73 The 1987 Act provides that where damage is caused wholly or partly by a defect in a product, the producer of the product will be liable (as well as any person who held themselves out as the producer or imported the product).[558] Importantly for our purposes, liability does not extend to the designer of a product.[559] Where two or more people are liable, the liability will be joint and several.[560]

8.74 Section 3 of the 1987 Act provides that there will be a defect in the product if "the safety of the product is not such as persons generally are entitled to expect". When determining what people are entitled to expect, "all the circumstances shall be taken into account", including:

(1) the marketing of the product and any instructions given as to how the product is to be used;

(2) what might reasonably be expected to be done with or in relation to the product; and

(3) the time when the product was supplied by its producer to another.[561]

8.75 The damage covered includes death and personal injury. It also includes damage to personal property, so long as that property is ordinarily intended for private use, occupation or consumption.[562]

8.76 A number of defences are available. One of the most significant for our purposes is if the defendant can show that:

> the state of scientific and technical knowledge at the relevant time was not such that a producer of products of the same description as the product in question might be expected to have discovered the defect if it had existed in his products while they were under his control.[563]

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557 Consumer Protection Act 1987, s 45(1). "Goods" is defined as including "substances, growing crops and things comprised in land by virtue of being attached to it and any ship, aircraft or vehicle".

558 Consumer Protection Act 1987, s 2.

559 Shawcross and Beaumont, *Air Law* (Issue 181 2022), IV [407].

560 Consumer Protection Act 1987, s 2(5). Joint and several liability means, broadly, that each defendant can be sued for the whole of the loss, but can claim a contribution from the others.

561 Consumer Protection Act 1987, s 3.

562 Consumer Protection Act 1987, s 5.

563 Consumer Protection Act 1987, s 4(1)(e) and (2).

Another is that the defect did not exist in the product at the time the product was supplied.[564] The second defence is arguably inappropriate for products which are designed to learn and adapt during use.[565]

Application to uncrewed aircraft: negligence

8.77 Bringing a claim in negligence against a manufacturer is already difficult, even with the current state of technology. Shawcross and Beaumont note that:

> to succeed in a products liability case based on liability in negligence, a plaintiff must establish that the defendant was at fault in being negligent in respect of the design or manufacture of the product. In an aviation context, given the technical sophistication of the industry, this may be a difficult task.[566]

8.78 That is not to say it is impossible; there has been at least one successful claim brought in the Spanish courts against the manufacturer of a collision avoidance system. The claim was brought on the basis of product liability regimes in Arizona and New Jersey (where the manufacturers were based).[567] It is however difficult.

8.79 The difficulty of the task will only increase with the addition of machine learning models and systems, and the problems of explainability. As noted above, the manufacturer or designer will be required to perform their duties with reasonable skill and care. However, there may be times when it is not possible to tell why an automated system has acted the way it has, and therefore whether the problem could be ascribed to any breach of the duty.

8.80 Toby Riley-Smith QC and Lucy McCormick in *The law of artificial intelligence* give the example of an automated vehicle which has crashed into a lamppost. Despite the crash, the vehicle might have been functioning properly: the collision could have occurred in order to avoid hitting a pedestrian. If the vehicle had been developed using conventional software programming, it might be possible to interrogate the system and understand why the action has been taken. However, they note that "if the autonomous vehicle had been developed using machine learning, even an expert might not be able to determine the rationale for the 'decision'".[568]

8.81 The problem may be lessened if the courts follow the approach taken in professional negligence. The test for whether a standard of care has been met in professional negligence is whether the defendant's actions were in accordance with a practice accepted by a responsible body of professional opinion (known as the "*Bolam*

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564 Consumer Protection Act 1987, s 4(1)(d) and (2).

565 B Soyer and A Tettenborn, "Artificial intelligence and civil liability – do we need a new regime?" (2022) 30 *International Journal of Law and Information Technology* 385, 392.

566 Shawcross and Beaumont, *Air Law* (Issue 181 2022), IV [406].

567 Judgment of the Supreme Court of 13 Jan. 2015, ECLI:ES:TS:2015:181. The case applied US law, due to Spain's ratification of the Hague Convention on Product Liability. See discussion in H Schebesta, "Risk regulation through liability allocation: transnational product liability and the role of certification" (2017) 42 Journal of Air and Space Law 107.

568 M Hervey and M Lavy, *The law of artificial intelligence* (2021) para [5-018].

test").[569] This may be more viable once standards for development of systems using machine learning have been developed and adopted. This approach is however untested in this context.

Application to uncrewed aircraft: the Consumer Protection Act 1987

8.82 The product liability regime under the Consumer Protection Act 1987 has limited application in this context. Its key limitation is that it is primarily directed towards consumers. While the 1987 Act covers damage *by* any product, it only applies to damage *to* individuals or their property. Property not ordinarily intended for private use, occupation or consumption does not qualify. A commercial air operator could not bring a claim under the 1987 Act. It would however be open to an individual who had purchased an autonomous drone for private use to bring such a claim.

8.83 As well as this limitation upon who can invoke the 1987 Act, there are also questions about how its provisions apply to software. For example, it is doubtful that software supplied intangibly is a product for the purposes of the 1987 Act.[570]

8.84 It has been agreed within the EU that the Product Liability Directive (on which the 1987 Act is based) requires significant updating in order to accommodate new challenges posed by artificial intelligence. There are a number of measures in train to remedy the situation. A revised directive on liability for defective products will make it clear that software and digital manufacturing files fall within the definition of a product and will extend the range of occasions on which liability can be assessed (for example, where software updates are provided).[571] The European Commission has also published a proposal for a directive on adapting non-contractual civil liability rules to artificial intelligence. This proposed "AI liability directive" would make pursuing claims involving AI easier.[572]

8.85 The problems we identify above and that the EU intends to address with its proposed reforms are not specific to aviation. The Law Commissions' final report on automated vehicles identified similar problems. In that report it was recommended that the UK Government should review product liability law (including the Consumer Protection Act 1987) to take account of the challenges of emerging technologies generally.[573]

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569 *Bolam v Friern Hospital Management Committee* [1957] 1 WLR 582.

570 *St Albans CDC v International Computers Ltd* [1996] 4 All ER 481; Automated Vehicles: a joint preliminary consultation paper (2018) Law Commission Consultation Paper No 240, Scottish Law Commission Discussion Paper No 119, paras 6.65 to 6.92. In another context, under the Commercial Agents (Council Directive) Regulations 1993, software provided electronically has been found to amount to "goods"; see Case C-410/19 *Software Incubator Ltd v Computer Associates (UK) Ltd* [2021] ECR-I 742.

571 Proposal for a Directive of the European Parliament and of the Council on liability for defective products COM (2022) 495, explanatory memorandum p 12.

572 For more detail, see https://commission.europa.eu/business-economy-euro/doing-business-eu/contract-rules/digital-contracts/liability-rules-artificial-intelligence_en.

573 Automated Vehicles: joint report (2022) Law Com No 404; Scot Law Com No 258 Recommendation 71, para 13.34. The Government's response notes that the recommendation "highlights a very important issue and we will be engaging more widely with government to understand next steps". HM Government, *Connected and automated mobility 2025: realising the benefits of self-driving vehicles in the UK* (August 2022) p

8.86 Since then the UK Government has published its policy paper, "A pro-innovation approach to AI regulation".[574] The framework set out in the paper is based on five principles, which are not intended to be placed on a legal footing (at least initially). These are:

(1) safety, security and robustness;

(2) appropriate transparency and explainability;

(3) fairness;

(4) accountability and governance; and

(5) contestability and redress.[575]

8.87 The paper notes that "the clear allocation of accountability and legal responsibility is important for effective AI governance". Further, the paper proposes that "legal responsibility for compliance with the principles [identified in the paper] should be allocated to the actors in the AI life cycle best able to identify, assess and mitigate AI risks effectively". However it takes the view that inappropriate allocation of AI risk and liability throughout an AI supply chain could stifle innovation. The paper concludes that:

> It is too soon to make decisions about liability as it is a complex, rapidly evolving issue which must be handled properly to ensure the success of our wider AI ecosystem… It may become apparent that current legal frameworks, when combined with implementation of our AI principles by regulators, will allocate legal responsibility and liability across the supply chain in a way that is not fair or effective. We would consider proportionate interventions to address such issues which could otherwise undermine our pro-innovation approach to AI regulation.[576]

8.88 The paper proposes to engage a range of experts, including technicians and lawyers, to consider the problem. We agree that a thorough review of the law in this area is required, ideally supported by public consultation. We make a provisional proposal here in line with the recommendation we made in our report on automated vehicles.

126,https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1099173/cam-2025-realising-benefits-self-driving-vehicles.pdf.

574 Department for Science, Innovation and Technology and Office for Artificial Intelligence, *Policy paper, A pro-innovation approach to AI regulation* (March 2023, updated August 2023), https://assets.publishing.service.gov.uk/media/64cb71a547915a00142a91c4/a-pro-innovation-approach-to-ai-regulation-amended-web-ready.pdf.

575 Department for Science, Innovation and Technology and Office for Artificial Intelligence, *Policy paper, A pro-innovation approach to AI regulation* (March 2023, updated August 2023), para 10,https://assets.publishing.service.gov.uk/media/64cb71a547915a00142a91c4/a-pro-innovation-approach-to-ai-regulation-amended-web-ready.pdf.

576 Department for Science, Innovation and Technology and Office for Artificial Intelligence, *Policy paper, A pro-innovation approach to AI regulation* (March 2023, updated August 2023), para 83, https://assets.publishing.service.gov.uk/media/64cb71a547915a00142a91c4/a-pro-innovation-approach-to-ai-regulation-amended-web-ready.pdf.

Consultation Question 48.

8.89 We provisionally propose that there should be a review of product liability law (including the Consumer Protection Act 1987) to take account of the challenges of emerging technologies. The review should cover product liability as a whole, rather than be confined to aviation or automated vehicles.

Do you agree?

Liability for mid-air collisions

The current law

8.90 Section 76 of the Civil Aviation Act 1982 applies to damage caused to property or people on the surface, but it does not apply to mid-air collisions. There is no specific legal regime for these. Claims for personal injury or damage to baggage fall under the Montreal Convention, which is exhaustive. However, it is possible for claims for other sorts of damage (for example, for death or personal injury of a pilot, or damage to an aircraft) to be brought; possibilities include negligence, or breach of a statutory duty. Depending on the circumstances, the defendant could be the owner or the operator of an aircraft, the pilot or remote pilot, or possibly an air traffic controller.[577]

8.91 Statutory duties are obligations imposed by legislation. For example, the Air Navigation Order 2016 imposes several duties on the pilot-in-command of an aircraft.[578] There are two potential impacts of these types of duties for civil liability.

8.92 First, a breach of statutory duty might provide the basis for a cause of action. In some instances, the statute explicitly states that breach of the duty is actionable if loss has been suffered. The Airports (Groundhandling) Regulations 1997 are one such example.[579]

8.93 More commonly, a statute is silent on whether breach of a duty imposed by it gives rise to civil liability. Here, breach of a statutory duty will only give rise to a private law cause of action where the duty protects a limited class of people affected and if Parliament impliedly intended a private law right to arise.[580] For example, if a pilot breached one of the duties in the Air Navigation Order 2016 causing loss to a third party, this might, depending on the circumstances, give rise to an actionable claim for breach of statutory duty.

8.94 Statutory duties are also relevant because proof of the breach of a statutory duty is likely to assist in proving negligence. This is particularly likely to be the case where the breach of statutory duty gives rise to criminal liability under the statute (while

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577 Shawcross and Beaumont, *Air Law* (Issue 181 2022), V [810].

578 Air Navigation Order 2016 SI No 765.

579 SI 1997 No 2389, reg 26.

580 *X (Minors) v Bedfordshire County Council* [1995] 2 AC 633 at p 731.

remaining silent on civil liability).[581] This is the case with a number of the duties in the Air Navigation Order 2016. Section 11 of the Civil Evidence Act 1968 allows a party to rely on the fact of criminal conviction as evidence in civil proceedings.

Application to uncrewed aircraft

8.95 In our preliminary view, the main difficulty in relation to future negligence claims for mid-air collisions caused by autonomous and remotely piloted aircraft will be those outlined above at paragraph 8.72 to 8.81. There is a risk that greater use of sophisticated systems will make it harder to prove what went wrong in a mid-air collision, and to establish fault.

8.96 We have however provisionally concluded that the position of the passenger is adequately protected by the current law, which allows them to claim against their own air carrier. We therefore do not believe that reforming the law in this area is necessary for the industry to develop. We expect that the majority of claims will fall under the headings of injury or death of passengers, or damage to cargo or baggage, or surface damage. As we set out above, our preliminary view is that the current law is adequate to deal with these types of damage. However, we seek views as to whether consultees agree with our assessment of the law concerning mid-air collisions and UAS.

Consultation Question 49.

8.97 We seek views as to whether the current law regarding liability for mid-air collisions is satisfactory in the case of collisions involving uncrewed aircraft systems.

INSURANCE

8.98 While the existing regulatory framework mandates the insurance of aircraft, it is important to note that even without this requirement, insurance would be necessary in many cases. As noted by Shawcross and Beaumont, national licensing authorities typically require air carriers to hold insurance before issuing an air transport licence.[582]

International law and air carrier liability

8.99 The origins of international, mandatory insurance stem from the Warsaw Convention 1929. The Warsaw Convention responded to the threat of conflicting, domestic law on air carrier liability and was the first international convention governing aviation law.[583] Importantly, the Warsaw Convention did not prescribe mandatory aviation insurance; however, the introduction of a framework of air carrier liability provided an environment in which the requirement for insurance grew.

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581 *James v The White Lion Hotel* [2021] EWCA Civ 31, [2021] QB 1153 at [100] to [104].

582 Shawcross and Beaumont, *Air Law* (Issue 181 2022), IX [2].

583 ICAO, *The Warsaw System on air carriers liability*, https://applications.icao.int/postalhistory/the_warsaw_system_on_air_carriers_liability.htm.

8.100 The Montreal Convention sought to consolidate and clarify the Warsaw System. As well as increasing the levels of compensation available to passengers in the event of an accident, the Convention stipulated that:

> States Parties shall require their carriers to maintain adequate insurance covering their liability under this Convention.[584]

Domestic regulation

8.101 In response to the introduction of Article 50 of the Montreal Convention, the EU introduced Regulation 785/2004 (the "Insurance Regulation").[585] In the UK, this was supported by the Civil Aviation (Insurance) Regulations 2005.[586] Following the UK's exit from the EU, the assimilated Insurance Regulation[587] remains the primary source of aviation insurance law.

8.102 The assimilated Insurance Regulation establishes minimum insurance requirements for air carriers and air operators (but not pilots):

> 'air carrier' means an air transport undertaking with a valid operating licence;[588]
>
> 'aircraft operator' means the person or entity, not being an air carrier, who has continual effective disposal of the use or operation of the aircraft; the natural or legal person in whose name the aircraft is registered shall be presumed to be the operator, unless that person can prove that another person is the operator.[589]

8.103 The Insurance Regulation requires that "each and every flight" must be covered by insurance.[590] Model aircraft with a maximum take-off mass of less than 20kg are excluded.[591] While the Insurance Regulation does not provide a definition of "model aircraft", the CAA defines the term, for insurance purposes, as "any unmanned aircraft which is being used for sport or recreational purposes only".[592] As a result, UAS under 20kg which are not used for commercial purposes are not currently required to have insurance.

8.104 Minimum levels of insurance cover are expressed in Special Drawing Rights, or SDRs (see paragraph 8.12 above). Air carriers must have minimum insurance cover of

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584 Montreal Convention 1999, art 50.

585 Regulation (EC) 785/2004 on insurance requirements for air carriers and aircraft operator, Official Journal L 138 of 30.04.2004 p 1.

586 SI 2005 No 1089.

587 UK Regulation (EU) 785/2004 on insurance requirements for air carriers and aircraft operators.

588 UK Regulation (EU) 785/2004 on insurance requirements for air carriers and aircraft operators, art 3(a).

589 UK Regulation (EU) 785/2004 on insurance requirements for air carriers and aircraft operators, art 3(c).

590 UK Regulation (EU) 785/2004 on insurance requirements for air carriers and aircraft operators, art 4(2).

591 UK Regulation (EU) 785/2004 on insurance requirements for air carriers and aircraft operators, art 2(2)(b).

592 CAA, *Unmanned Aircraft System Operations in UK Airspace* (December 2022) (CAP 722) p 21. This definition in CAP 722 is informed by those set out in UK Regulation (EU) 923/2012 laying down the common rules of the air and operational provisions regarding services and procedures in air navigation.

250,000 SDRs per passenger, except in the case of non-commercial aircraft with a maximum take-off mass of less than or equal to 2,700kg, in respect of which cover must be at least 100,000 SDRs per passenger. For commercial operations, the minimum insurance cover for baggage is 1288 SDRs per passenger for baggage, and 22 SDRs per kg for cargo.[593]

8.105 In addition to requirements to insure against claims concerning passengers, cargo and baggage, the Insurance Regulation prescribes a minimum level of third-party cover.[594] Typically, this covers personal injury and property damage to third parties as a result of the operation of aircraft. There are ten categories of aircraft, divided according to maximum take-off mass. The category determines the level of cover required.[595] Again, the requirements do not apply to model aircraft with a maximum take-off mass of under 20kg.

8.106 Insurance policies must cover "war, terrorism, hijacking, acts of sabotage, unlawful seizure of aircraft and civil commotion".[596] However, insurance obligations regarding war and terrorism do not apply to aircraft with a maximum take-off mass of less than 500kg which are used for non-commercial purposes or local flight instruction which does not involve crossing borders.[597]

8.107 Failure to comply with the requirements of the Insurance Regulation is an offence.[598]

Application of existing framework to unoccupied aircraft and future challenges

8.108 It is clear that the existing regulations discussed above were drafted with traditional, crewed aircraft in mind. The focus of the insurance requirements is therefore on passengers, baggage and cargo. This does not reflect the reality that many uncrewed aircraft will be unoccupied; for example, if they are being used for surveillance. In that case the primary risk will be damage caused to third parties. This risk may be increased by the fact that unoccupied aircraft typically fly at lower altitudes than traditional aircraft, and are therefore more at risk of collisions with ground-based structures.

8.109 It is also potentially unsatisfactory that UAS used for sport and recreational purposes are not subject to mandatory insurance requirements, so long as the UAS has a maximum take-off mass of 20kg or less. Under the UAS Regulations, at present the lowest-regulated category of drone (which may fly over groups of people) is limited to a much lower maximum take-off mass of 250g.[599]

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593 UK Regulation (EU) 2020/1118 amending Regulation (EU) No 785/2004 on insurance requirements for air carriers and aircraft operators, art 1.

594 UK Regulation (EU) 785/2004 on insurance requirements for air carriers and aircraft operators, art 7.

595 CAA, *Minimum insurance levels* (2020). https://www.caa.co.uk/media/xrfgev1r/20200804insurance-minima.pdf

596 UK Regulation (EU) 785/2004 on insurance requirements for air carriers and aircraft operators, art 4(1).

597 UK Regulation (EU) 785/2004 on insurance requirements for air carriers and aircraft operators, art 2(2)(g).

598 Civil Aviation (Insurance) Regulations 2005 SI No 1089, art 4.

599 UK Regulation (EU) 2019/945 on unmanned aircraft systems and on third-country operators of unmanned aircraft systems, arts 2(1), 4 and annex, part 1. See also discussion in ch 3 at para 3.12.

8.110 The UK Government's Future of Flight Regulatory Review has recently considered the question of insurance for UAS.[600] As well as the questions highlighted above, this explored questions including:

(1) whether the requirements should reflect the risk of an operation, which reflects not only maximum take-off mass but also the operation's flightpath and complexity; and

(2) protection of third parties where a UAS which is untraceable or uninsured causes damage.

8.111 As a result of the review, the UK Government has committed to introduce legislation to enable the Secretary of State to make regulations in relation to insurance requirements for new and novel aircraft.[601] The exact form the requirements will take has yet to be finalised, and is to be discussed further with the Future of Flight Industry Group. We welcome this commitment.

8.112 One issue which is not raised in the Future of Flight Regulatory Review and which is particularly relevant to our project is the question of multiple simultaneous operations. As explored in chapter 7 at paragraphs 7.42 to 7.51, these, also called "drone swarms" are expected to be used more often in the future. At present the extent of insurance requirements is largely dependent on the maximum take-off mass of the individual UAS, with that being used as a proxy for the risk of its operation. However, in future it might be necessary for insurance requirements to reflect the risk posed by multiple simultaneous operations. We therefore provisionally propose that this should be considered in the Government's work in this area. We also welcome views from stakeholders about any difficulties they envisage applying existing insurance requirements to the use cases outlined in this consultation paper.

Consultation Question 50.

8.113 We seek consultees' views on whether they expect any difficulties applying existing insurance requirements to uncrewed aircraft systems.

600 Department for Transport, *Future of Transport Regulatory Review: Future of Flight Government Response* (September 2023) pp 22 to 24.

601 Department for Transport, *Future of Transport Regulatory Review: Future of Flight Government Response* (September 2023) p 55.

Consultation Question 51.

8.114 We provisionally propose that multiple simultaneous operations should be considered as the Government develops proposals for the insurance requirements applicable to uncrewed aircraft.

Do you agree?

Chapter 9: Criminal liability

9.1 This chapter is concerned with criminal law aspects of the advent of autonomy in aviation. It sets out the current law's general approach to criminal liability in aviation and highlights specific areas which may give rise to issues.

9.2 There is no single piece of legislation that imposes criminal sanctions for breach of aviation law. The Civil Aviation Act 1982, the Aviation and Security Act 1982, the Aviation and Maritime Security Act 1990 and, in particular, the Air Navigation Order 2016 (the "ANO")[602] all contain important provisions addressing criminal liability.

9.3 The first part of the chapter briefly explains how criminal offences are used in UK civil aviation and their place alongside the regulatory sanctions available to the Civil Aviation Authority ("CAA").

9.4 The second part of the chapter examines how the current law applies to those involved in uncrewed aircraft operations. The ANO criminalises certain breaches of the Basic Regulation and its implementing regulations for all civil aviation generally. These provisions apply to uncrewed aircraft systems ("UAS") operating in the certified category. The ANO also creates specific offences for breach of the UAS Implementing Regulation, which mainly apply to uncrewed operations in the open and specific categories. Additional offences relating to uncrewed aircraft are also found in the Air Traffic Management and Unmanned Aircraft Act 2021 (the "ATMUAA 2021").

9.5 The third part of this chapter discusses offences which relate to the carriage of dangerous goods. The final part of the chapter considers some offences specific to aviation that exist outside the ANO and are targeted at passengers travelling by air and the general public.

9.6 The introduction of autonomy and the operation of uncrewed flight also raises several questions which are not *directly* concerned with criminal liability, but the answers to which may impact upon aspects of criminal liability. For example, the ANO requires that the pilot-in-command of the aircraft ensures passengers are safely seated (article 71); failure to do so is a criminal offence.[603] This raises questions about where responsibility should lie in the absence of a pilot. However, although these scenarios involve criminal offences, the real issue is the underlying requirement rather than the criminal sanction for failure to comply with it. The difficulties presented by situations like this are addressed elsewhere in the paper.[604]

9.7 This chapter does not generally cover criminal offences that can be committed in an aviation setting, such as an assault committed on board an aircraft. The fact that the assault takes place on board an aircraft may affect the gravity of the offence, but its

602 SI 2016 No 765.

603 SI 2016 No 765, art 265(6) and sch 13, pt 2, ch 1.

604 See Chapters 5,6 and 7.

legal basis is not different from other offences of assault.[605] Nor does this chapter discuss terrorism-related offences, as that is outside the scope of the project. Issues of jurisdiction (which are governed by a series of international treaties) are also not covered.

CRIMINAL SANCTIONS IN CIVIL AVIATION

9.8 Before considering how the current law applies to uncrewed aircraft it is useful to situate criminal sanctions for civil aviation offences alongside other regulatory measures.

9.9 One notable feature of criminal law in aviation is that, in addition to the Crown Prosecution Service ("CPS"), the CAA has the power to bring criminal proceedings.[606] This gives the regulator an important enforcement power. For the last decade, the CAA has brought between 2 and 17 successful prosecutions a year, with the annual average steadily declining over that period.[607] The CAA follows the CPS Code for Crown Prosecutors, which states that a prosecution may only be brought if there is a reasonable prospect of securing a conviction and the prosecution is in the public interest.[608]

9.10 Although criminal prosecution is an important tool, it is just one of many "formal enforcement tools" used by the CAA to ensure compliance in the aviation sector. The CAA has, for example, the ability to suspend licences and issue no fly directions to operators.[609]

9.11 Use of regulatory sanctions alongside criminal ones is complementary to the "just culture" approach which is promoted by the CAA and within the aviation sector generally.[610] Under the "just culture" approach, sanctions are aimed at encouraging safety and compliance with applicable regulation rather than punishing breaches of it. This is to promote openness and encourage operators in the aviation field to engage with the regulator when they find themselves in breach of their obligations. This in turn promotes safety by allowing issues to be brought to the regulator's attention and rectified.[611]

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605 Section 2(1)(b) of the Aviation Security Act 1982 provides specifically for an offence of endangering an aircraft by committing an act of violence, including assault.

606 Civil Aviation Act 1982, s 20(1A). The section does not however apply to Scotland, where regulators do not have powers of prosecution.

607 Details of Civil Aviation Agency ("CAA") enforcements and prosecutions are released annually and can be found on their website, https://www.caa.co.uk/our-work/about-us/enforcement-and-prosecutions/.

608 As set out in Crown Prosecution Service ("CPS"), *Code for Crown Prosecutors* (2018), https://www.cps.gov.uk/publication/code-crown-prosecutors. See also, *Safety and Airspace Regulation Enforcement Guidance* (May 2015) (CAP 1074) pp 8-9.

609 CAA, *Regulatory Enforcement Policy* (October 2012) (CAP 1326). See also CAA, *Safety and Airspace Regulation Enforcement Guidance* (May 2015) (CAP 1074). https://publicapps.caa.co.uk/docs/33/CAP1074%20SARG%20Enforcement%20Guidance%20May2015.pdf.

610 CAA, Regulatory Enforcement Policy (October 2012) (CAP 1326), p 4.

611 See Chapter 1 para 1.45 – 1.48 and CAA, *Just Culture,* https://www.caa.co.uk/general-aviation/the-ga-unit/just-culture/.

9.12 Criminal prosecutions carry with them a stigma which may be a deterrent for many organisations in the aviation sector. Arguably though, regulatory sanctions such as suspension or revocation of licences are more effective at motivating organisations to remain compliant with regulations.[612] Whilst large fines are available for many aviation offences,[613] the average fine imposed can be relatively low and may not have much impact on an operator.[614] For example, for offences relating to the carriage of dangerous goods on board aircraft, fines have generally ranged from £500 to £5,000. Fines for the offence of flying without an appropriate licence ranged from £250 to £3,000.[615] These amounts may be small in comparison to the amount of revenue or income lost if an operator or pilot has their licence suspended.

9.13 Consequently, whilst criminal sanctions are a significant tool, compliance in the aviation sector may often be driven by other regulatory enforcement mechanisms.

UNCREWED OPERATIONS: THE CURRENT LAW

9.14 As described above, there is no single Act or regulation that governs criminal law in civil aviation, but a significant piece of legislation in this regard is the ANO. The ANO sets out a broad regime of criminal offences, penalties and defences which apply to operators and pilots of aircraft.

9.15 Uncrewed operations in the certified category are subject to the same ANO provisions as most crewed aircraft. These include operations involving the transport of people.[616] The ANO also has some specific UAS provisions. In the main, these create offences for breach of the requirements of the UAS Implementing Regulation.[617] For UAS in the certified category, the ANO criminalises operations without proper certification[618] and makes it an offence for the owner of an uncrewed aircraft to permit it to fly without registration.[619] For the most part however the UAS provisions apply to uncrewed aircraft in the open and specific categories.[620]

9.16 Most of the provisions of the ANO do not apply to UAS within the scope of the UAS Implementing Regulation. Article 23 of the ANO provides that, save for exceptions in article 23(3) and 23(4), nothing in the ANO applies to "any unmanned aircraft other than an unmanned aircraft subject to certification". Article 23(3) lists a number of

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612 For an in-depth discussion on this point, see Criminal liability in regulatory contexts (2010) Law Commission Consultation Paper 195, appendix A.

613 See paras 9.21 and 9.22 for a brief summary of the fine levels amounts in relation to offences in the ANO.

614 See Automated Vehicles: a joint preliminary consultation paper (2018) Law Commission Consultation Paper No 240; Scottish Law Commission Discussion Paper No 166, para 7.25 for a similar discussion in the context of automated vehicles.

615 Shawcross and Beaumont, *Air Law* (Issue 181 2022) VIII [165].

616 See Chapter 3, paras 3.43 and 3.44.

617 UK Regulation (EU) 2019/947 on unmanned aircraft systems and on third-country operators of unmanned aircraft systems.

618 SI 2016 No 765, arts 265A(1)(c) and 265B(1)(c).

619 SI 2016 No 765, art 265C.

620 These provisions criminalise a range of unlawful activity such as flying an aircraft higher than 120m in the open category or operating a UA in the specific category without valid authorisation from the CAA.

provisions that apply; one of these is article 265. Article 23(4) makes applicable a number of offence-creating provisions contained in articles 265A to 265F, together with article 265(3). These provisions are discussed later in this chapter.

9.17 The Air Traffic Management and Unmanned Aircraft Act 2021 is also noteworthy for uncrewed operations. It gives police powers to ground and search "unmanned aircraft" and issue on the spot fines for offences such as failing to provide evidence of an unmanned aircraft's registration.[621]

9.18 In this section of the chapter, we examine how the current provisions of the ANO and the ATMUAA 2021 apply to uncrewed operations.

Criminal liability under the ANO

9.19 Article 265 of the ANO is the principal provision creating criminal liability. It creates criminal offences and sets penalties for the breach of numerous articles of the ANO. It also establishes offences and penalties for breaches of other regulations, including some of the rules in assimilated aviation safety legislation.[622]

9.20 In total, article 265 attaches criminal liability to over 500 provisions. These are categorised according to seriousness and listed in schedule 13 to the ANO.

9.21 Part 1 of schedule 13 lists provisions, breach of which is punishable on summary conviction by a fine not exceeding level 3 (£1,000) on the standard scale.[623] The offences in part 2 are also summary offences with a maximum penalty of a fine not exceeding level 4 (£2,500).[624]

9.22 Part 3 of schedule 13 then lists more serious offences. Part 3 offences are "triable either way", which means that breach can give rise to either a summary conviction in a magistrates' court or conviction on indictment in the Crown Court, with possible punishments ranging from a fine of any amount to two years' imprisonment.[625] In one case, a defendant was convicted and fined £175,000 (reduced on appeal to £52,000) for making false entries to his pilot's licence (in breach of article 256(4) of the ANO) and for flying without an appropriate pilot's licence (in breach of article 136(1)).[626]

9.23 Part 4 of schedule 13 contains only one offence. It makes breach of article 240 (endangering the safety of an aircraft) an indictable offence triable only in the Crown

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621 Air Traffic Management and Unmanned Aircraft Act 2021, ss 13 to 15 and schs 8 to 10.

622 It also establishes offences and penalties for breaches of regulations made under the Air Navigation Order 2016. In respect of assimilated aviation safety legislation, offences are created for breaches of the Certification Regulation, the Continuing Airworthiness Regulation, the Air Operations Regulation, the Aerodromes Regulation and the Air Crew Regulation and Offences in the Rules of the Air (UK SERA).

623 SI 2016 No 765, art 265(5) and sch 13(1).

624 SI 2016 No 765, art 265(6) and sch 13(2). The monetary amounts for each level are found in s 122 of the Sentencing Act 2020.

625 SI 2016 No 765, art 265(7) and sch 13(3).

626 *CAA v Harbottle* (7 July 2021) Brighton Magistrates' Court (unreported).

Court and punishable by a fine of any amount and a maximum of five years' imprisonment.[627]

9.24 Criminal responsibility for breach of any of the listed provisions attaches to anyone who has "contravened" the relevant provision (which we refer to as a "direct contravention").[628] In addition, article 265(1) provides that if any provision of the ANO (or regulations made under the ANO, or a Safety Regulation)[629] is breached, both the operator and the pilot-in-command are "deemed to have contravened that provision".[630] Article 265(1) thus makes the operator and pilot-in-command of an aircraft vicariously liable for breaches of the ANO or regulations made under it.

9.25 However, vicarious liability under section 265(1) is subject to article 265(2). Article 265(2) provides for a "due diligence defence":

> A person will not be deemed to have contravened a provision … if the person proves that the contravention occurred without that person's consent or connivance and that that person exercised all due diligence to prevent the contravention.

9.26 The opening reference to "deemed" contravention indicates that this defence applies to the deemed contravention by an operator or pilot-in-command in cases where they have not personally contravened the provision. It requires them to show that they did not consent to or connive in the wrongdoing and exercised all due diligence to prevent it.

9.27 For direct contraveners of the ANO (rather than those who are vicariously liable via 265(1)), article 265(3) provides a "reasonable care" defence:

> If it is proved that an act or omission of any person which would otherwise have been a contravention by that person…was due to any cause not avoidable by the exercise of reasonable care by that person, the act or omission will be deemed not to be a contravention by that person of that provision.[631]

9.28 The general approach of the ANO therefore is to place criminal responsibility on anyone who contravenes a selection of important regulatory requirements, with additional criminal responsibility attaching to the pilot and operator.

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627 SI 2016 No 765, art 265(8) and sch 13(4).

628 SI 2016 No 765, art 265(5)-(8).

629 Defined by sch 1, art 2 to the Air Navigation Order 2016 as the Basic Regulation and any implementing rule made under that regulation.

630 In the case of a contravention of article 250 (unauthorised carriage of passengers or cargo for reward), the charterer is also deemed to have contravened the provision.

631 Article 265(4) also establishes a further defence specific to the members of the flight crew of an aircraft when charged with an illegal public transport offence. Essentially, article 265(4) applies where the provision breached relates to commercial operations, and the member of the flight crew neither knew nor suspected the flight was commercial.

UAS offences in the ANO

9.29 Articles 265A to 265C of the ANO create specific offences relating to uncrewed aircraft. These offences mainly relate to contraventions of provisions of the UAS Implementing Regulation which, for the most part, only apply to UAS operations in the open and specific categories.[632]

9.30 The offences can be summarised as follows:

(1) The operator of a UAS must not cause or permit a UAS, other than a tethered small unmanned aircraft, to be flown in the open category unless the requirements in article 4(1) and part A of the annex to the UAS Implementing Regulation are met.[633] These requirements include general provisions such as maximum permitted altitude, flights over uninvolved persons and maximum take-off weight.[634] A UAS operator must ensure that operations in the specific category have the necessary authorisation.[635] An offender is liable on summary conviction in England and Wales to a fine of any amount, or in Scotland and Northern Ireland to a fine not exceeding the statutory maximum.[636]

(2) It is an offence to contravene a "relevant requirement" of the UAS Implementing Regulation;[637] these are listed in the ANO and cover matters such as registration, display of registration number, reporting of safety occurrences, designation and competency of the remote pilot, record keeping and access to records.[638] For specific category operations, the operator must ensure that operations are conducted in line with the conditions in the operational authorisation.[639] An offender is liable on summary conviction[640] to a fine not exceeding level 3 on the standard scale in most cases specified in the ANO[641] and not exceeding level 4 on the standard scale in any other case.[642]

(3) A remote pilot must not fly an unmanned aircraft, other than a tethered small unmanned aircraft, unless the remote pilot reasonably holds the view that the requirements of the UAS Implementing Regulation in relation to an open category flight are met or that a valid operational authorisation for a specific category flight has been granted to the UAS operator.[643] An offender is liable on

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632 SI 2016 No 765, arts 265A and 265B.

633 SI 2016 No 765, art 265A(1)(a).

634 UK Regulation (EU) 2019/947 on the rules and procedures for the operation of unmanned aircraft, annex, UAS.OPEN.010 – UAS.OPEN.020 UAS.

635 SI 2016 No 765, art 265A(1)(b).

636 SI 2015 No 765, art 265F(1). The statutory maximum in Scotland and Northern Ireland is £5000.

637 SI 2016 No 765, art 265A(3).

638 SI 2016 No 765, art 265A(5) – (9).

639 SI 2016 No 765, art 265A(3).

640 SI 2016 No 765, art 265F(2).

641 SI 2016 No 765, art 265F(2)(a).

642 SI 2016 No 765, art 265F(2)(b).

643 SI 2016 No 765, art 265B(1) and (2).

summary conviction in England and Wales to a fine of any amount, or in Scotland and Northern Ireland to a fine not exceeding the statutory maximum (£5,000).[644]

(4) It is an offence for a remote pilot to contravene a "relevant requirement" of the UAS Implementing Regulation, which is listed in the ANO.[645] These cover matters such as maximum operating height, safety checks, fitness to fly, geographical zones, and flying close to or within areas where an emergency response effort is ongoing.[646] An offender is liable on summary conviction[647] to a fine of up to:

(a) level 2 on the standard scale if the offence relates to requirements to carry proof of competency;[648]

(b) level 3 on the standard scale if the offence relates to requirements to have appropriate competency and verify maximum take-off weight;[649] and

(c) level 4 on the standard scale in any other case.[650]

(5) The owner of a certified UAS must not cause or permit the aircraft to be flown unless it has been registered in accordance with the UAS Implementing Regulation.[651] An offender is liable on summary conviction in England and Wales to a fine or in Scotland and Northern Ireland to a fine not exceeding level 3 on the standard scale.[652]

9.31 The ANO also creates specific offences which relate to the operation of tethered, small, unmanned aircraft.[653]

9.32 In the case of offences created by articles 265A to 265F, the only provision of article 265 that applies is article 265(3).[654] The consequence of this is that an operator is only liable for offences committed directly by it, and only the reasonable care defence applies. An operator cannot be vicariously liable for these offences.

644 SI 2016 No 765, art 265F(1).

645 SI 2016 No 765, art 265B(3) and (5).

646 SI 2016 No 765, art 265B(5)–(8).

647 SI 2016 No 765, art 265F(3).

648 SI 2016 No 765, art 265F(3)(a).

649 SI 2016 No 765, art 265F(3)(b).

650 SI 2016 No 765, art 265F(3)(c).

651 SI 2016 No 765, art 265C.

652 SI 2016 No 765, art 265F(4).

653 See SI 2016 No 765, art 265E (1) and (7).

654 SI 2016 No 765, art 23(4).

Does the approach to criminal liability in the ANO work for remotely piloted and autonomous flight?

Liability of an operator

9.33 Remotely piloted operations already take place. We are not aware of any concerns about the operation of the due diligence defence in circumstances where an operator is deemed to have contravened a provision by reason of the behaviour of a remote pilot. We do not see any reason why a move to more highly automated operations involving remote piloting beyond line of sight should create any problems.

9.34 Autonomous operations are not yet common in the UK and, to the best of our knowledge, criminal sanctions have not yet been applied to them. Our provisional view is that the approach set out in the ANO will work for autonomous flight.

9.35 For autonomous operations in the certified category, the deemed liability of the operator for a contravention under article 265(1) applies whether or not there is a pilot. The result is that, subject to the available defences, there will always be a party – the operator – who can be held criminally liable for any offences listed in parts 1 to 4 of schedule 13.

9.36 For uncrewed operations in the open and specific categories, the offences in articles 265A to 265F include offences by operators as well as by remote pilots. Even if there is no remote pilot, the UAS operator's responsibilities will remain.

9.37 One consequence of the absence of a remote pilot may be that the operator's responsibilities will become more prominent. But in principle the defence of reasonable care could be established by showing reasonable reliance on an autonomous system. We discuss this further below.

9.38 Making the operator liable for breach of responsibilities previously placed on the pilot is likely to be desirable in most cases. As described in Chapter 6, operators have a broad range of responsibilities relating to the operation and safety of the aircraft they use. Before undertaking aviation operations, operators must carefully consider the inherent risks and how to mitigate those risks.[655] As a general principle, it seems appropriate that criminal liability should attach to an operator that fails to ensure the safe flight of an uncrewed aircraft that it operates.

Consultation Question 52.

9.39 We provisionally consider that the current approach in the Air Navigation Order 2016 placing criminal liability on an operator is adequate for autonomous operations.

Do you agree?

[655] Additionally, for any operations of a certain risk and complexity, the operator will have to produce an operations manual and provide this to the CAA. This will contain procedures, instructions and guidance for the operation of aircraft, incorporating information from the manufacturer of the aircraft.

The operator's defences in the context of autonomous flight

9.40 Both the "due diligence" and "reasonable care" defences are untested in the context of autonomous operations. An important question is whether these defences continue to work where an offence has occurred because of the behaviour of an autonomous aircraft.

9.41 Taking the example of a certified drone, it is possible that the drone's system responsible for detecting and avoiding obstacles fails, leading to a collision. Assuming the collision is in breach of the applicable operational requirements, and therefore an offence under the ANO, the operator will in principle be criminally liable.[656]

9.42 If the operator is accused of directly committing the offence, it may seek to use the reasonable care defence. In such circumstances the operator would need to prove that the malfunction was from a cause that could not have been avoided by the exercise of reasonable care. The burden of proving the defence lies on the operator, but if the operator has used a certified system and has used and maintained it in line with the manufacturer's instructions and any operational rules, we see no reason why the reasonable care defence would not apply.

9.43 If the operator is charged with an offence by operation of the vicarious liability created by article 265(1), then the defence available to them would be the "due diligence" defence set out in article 265(2). Such a situation would require the operator to show that the contravention had occurred without the operator's consent or connivance and that the operator had exercised all due diligence to prevent the contravention.

9.44 This wording does not seem to us to reflect the reality of the interactions between an operator and an autonomous system. Consent and connivance require the involvement of at least two people, where one consents to or connives with the actions of another. A person might allow an autonomous system to operate but that is not consent or connivance. We seek views from consultees about whether, for autonomous operations, the reasonable care defence would be more suitable. In other words, an operator should not be found vicariously liable for the actions of an autonomous system if they can show the relevant contravention was not avoidable by their exercise of reasonable care.

Consultation Question 53.

9.45 We provisionally consider that the "reasonable care" defence in article 265(3) of the Air Navigation Order 2016 applies adequately for "direct contraventions" under Article 265(5) to (8) involving autonomous operations.

Do you agree?

656 See para 9.33 – 9.38.

Consultation Question 54.

9.46 We seek views on whether for autonomous operations the reasonable care defence should be applicable to the vicarious liability created in article 265(1) of the ANO.

Liability of remote pilots

9.47 As outlined in Chapter 2, there is a distinction between those aircraft which are intended to operate autonomously and those intended to be overseen by a person. Under our provisional proposals a person who can intervene and change the course of the aircraft would be considered a pilot.

9.48 An important question is whether the remote pilot of an uncrewed aircraft should be treated as a pilot-in-command for the purposes of criminal liability. In Chapter 6 we propose that remote pilots should retain the operational responsibilities that pilots have today.[657] Consequently, it seems appropriate that remote pilots should remain criminally liable given the overall responsibility they will have for the safe operation of an uncrewed flight.

9.49 For operations in the open and specific categories, the UAS Regulations already place important responsibilities on remote pilots and failure to comply with these responsibilities is a criminal offence under the ANO.[658] For operations in the certified category, we explained in Chapter 6 how, at present, many essential responsibilities of a pilot-in-command do not apply to uncrewed aircraft in the certified category.[659]

9.50 In line with our proposal that remote pilots in the certified category should retain the operational responsibilities of a pilot-in-command, our view is that the remote pilot should also retain criminal liability for breaches of those responsibilities. We therefore provisionally propose that a remote pilot of a certified aircraft should be treated as a pilot-in-command for the purposes of liability for breach of requirements under the ANO and other applicable safety regulations.

9.51 In Chapter 6 we also proposed that remote pilots of aircraft operating in the certified category should not be permitted to pilot an aircraft when incapacitated due to injury, fatigue, medication, sickness or other similar causes.[660] As we also noted in Chapter 6, the UK Government intends to legislate to introduce alcohol limits for all categories of UAS when parliamentary time allows.[661] For this reason, we do not make any provisional proposals on that issue in this consultation paper.

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657 See para 6.63 to 6.82.

658 SI 2016 No 765, arts 265A and 265B.

659 See UK Regulation (EU) 2018/1139 on common rules in the field of civil aviation and establishing a European Union Safety Agency, art 20. These responsibilities include ensuring that the aircraft is airworthy and that aircraft operating limitations are not exceed at any time during the flight.

660 See para 6.104.

661 The intent is for limits to be the same as those that currently apply to crewed aircraft. Department for Transport, *Future of Transport Regulatory Review: Future of Flight response* (September 2023) p 54.

9.52 Going forward, issues may arise with some of the practical aspects of piloting an aircraft remotely. We highlight two further issues on which we seek views.

Transitioning from autonomous operations

9.53 First, it is possible that some autonomous aircraft may have a remote pilot for some part of their operations. The Joint Authorities for Rulemaking on Unmanned Systems ("JARUS") taxonomy for automation in aircraft, which we discussed in Chapter 2, envisages that a single aircraft can have different features, some of which are "fully automated" and others only to a lesser degree. Aircraft could undertake "mixed" operations where a pilot would be responsible some of the time and the operation would be autonomous at other times. An example of this might be where a remote pilot is required for take-off and landing but the aircraft operates autonomously during the rest of its flight.

9.54 It is unclear at this stage whether such "mixed mode" operations will be safe and approved: we ask a consultation question about whether the law should permit these types of operations in Chapter 6 (paragraphs 6.136 to 6.140). However, if they are, there will be period of flight where the aircraft is operating autonomously and the pilot will not be able to intervene. In such circumstances, it seems reasonable that the pilot should not be criminally liable in relation to functions which are operating autonomously.

9.55 For any such mixed mode operation, there could also be a transition period where control shifts from the pilot to the aircraft and vice versa. During this period the system would undertake a procedure to return control to or take control from the human pilot. We assume that any such transition period will be designed or certified in line with International Civil Aviation Organisation ("ICAO") and CAA standards for airworthiness. We also assume that the design will appropriately account for the human factors involved. However, there is a question about the point in time at which legal responsibility shifts during this transition period.

9.56 In our review of automated vehicle law, the Law Commissions recommended that a transition demand should allow the user of a vehicle time to reacclimatise themselves to operational circumstances before they assume the criminal responsibilities of a driver.[662] If this were applied in the aviation context, a pilot would not become criminally responsible for the operation of an aircraft until the end of a transition period. We seek consultees' views on this point.

Multiple simultaneous operations

9.57 As discussed in Chapters 6 and 7 increased autonomy may make it possible for a single pilot to be simultaneously the pilot-in-command of a number of aircraft. Currently, such operations have only been conducted with drones for entertainment purposes but in the future multiple simultaneous operations ("MSO") could become more common for a variety of use cases including vertical take-off and landing aircraft ("VTOLs").

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662 Automated vehicles (2022) Law Com No 404; Scot Law Com No 258, para 8.122.

9.58 One of the issues raised by MSOs at present is whether it is reasonable to expect an MSO pilot to give the same amount of attention to each aircraft in an MSO as to a single aircraft.

9.59 The matter is further complicated by the fact that MSOs might vary considerably, ranging from large numbers of aircraft conducting low risk operations to low numbers of aircraft conducting high risk operations. If something goes wrong, different types of MSOs may involve very different levels of culpability on the part of the pilot.

9.60 Our provisional view is that the safe operation of any MSO should be secured by appropriate regulation which should avoid the placing of unreasonable or unrealistic demands upon pilots. We do not see a case for a different approach to criminal liability for breach of the requirements that the regulatory system imposes on them. For these reasons we provisionally propose that the pilot-in-command of an MSO should have the same criminal liability as the pilot-in-command of a single aircraft operation.

Consultation Question 55.

9.61 We provisionally propose that a remote pilot of an uncrewed aircraft operating in the certified category should be treated as a pilot-in-command for the purposes of criminal liability pursuant to article 265(1) of the Air Navigation Order 2016.

Do you agree?

Consultation Question 56.

9.62 We ask for consultees' views on the criminal liability of pilots (or remote pilots) when an aircraft operating autonomously returns control to the pilot or vice-versa. In particular, should a pilot (or remote pilot) only become criminally liable for the piloting of the aircraft at the end of a transition period?

Consultation Question 57.

9.63 We provisionally propose that the pilot-in-command of aircraft in a multiple simultaneous operation should be criminally liable for breach of operating requirements in the same way as a pilot-in-command of a single aircraft would be.

Do you agree?

Air Traffic Management and Unmanned Aircraft Act 2021

9.64 The ATMUAA 2021 gives the police and prison officers specific powers relating to the use of "unmanned" aircraft. The long title states that one of the purposes of the Act is:

to confer police powers relating to unmanned aircraft and requirements in Air Navigation Orders and to provide for fixed penalties for certain offences relating to unmanned aircraft.

9.65 An "unmanned aircraft" is defined in the Act as any aircraft operating or designed to operate autonomously or to be piloted remotely without a pilot on board.[663] Schedule 8 to the Act sets out the powers it confers on police officers and prison authorities.[664] Some examples of these powers are:[665]

(1) the power to require such an aircraft to be grounded;

(2) the power to stop and search persons or vehicles; and

(3) the power to enter and search premises under warrant in relation to certain offences involving an unmanned aircraft.

9.66 Schedule 9 to the Act makes provisions regarding the powers of police officers relating to requirements in the ANO.[666] Police officers may, for example, ask a remote pilot to provide evidence of their competency to pilot an unmanned aircraft.[667]

9.67 Schedule 10 to the Act allows police to issue fixed penalty notices for certain prescribed offences relating to unmanned aircraft.[668] It also inserts a new article 265G into the ANO which makes ANO offences subject to Schedule 10's fixed penalty regime if they are prescribed under paragraph 2(2) of Schedule 10. No offences have yet been prescribed.

9.68 At present, we are not aware of any legal issues presented by increased automation or autonomy in relation to the ATMUAA 2021. However, there may be practical issues with its operation of which we are unaware. The Act has broad application, potentially covering remotely piloted and autonomous aircraft in a wide range of use cases; these may involve commercial actors as well as private individuals. We seek consultees' views as to whether there is any need for adaptation of the Act to the use cases being considered in this project.

Consultation Question 58.

9.69 We invite consultees' views on whether the Air Traffic Management and Unmanned Aircraft Act 2021 operates satisfactorily in the case of highly automated and autonomous flight.

663 Air Traffic Management and Unmanned Aircraft Act 2021, s 18.

664 Air Traffic Management and Unmanned Aircraft Act 2021, s 13.

665 This is not an exhaustive list. See Schedule 8 for all powers provided for by the Act.

666 Air Traffic Management and Unmanned Aircraft Act 2021, s 14.

667 Air Traffic Management and Unmanned Aircraft Act 2021, sch 9(1).

668 Air Traffic Management and Unmanned Aircraft Act 2021, s 15.

CARRIAGE OF DANGEROUS GOODS

9.70 There is a demand for the carriage of dangerous goods by uncrewed aircraft.[669] Such goods include toxic medicines, pathology samples (such as blood and urine), goods containing lithium (such as batteries), and fuel for other vehicles.[670] Currently, only UAS in the specific category can be approved by the CAA to carry dangerous goods.[671] The carriage of dangerous goods is not allowed in the open category and there are, as yet, no provisions for the certified category.[672]

9.71 Annex 18 to the Chicago Convention sets broad standards for the safe transportation of dangerous goods by air. Obligations are placed on operators and shippers[673] to ensure the safe transportation of such articles. For example, shippers must ensure that dangerous goods are not in a category forbidden for transport by air and are properly classified, packed, marked, labelled, and accompanied by a properly executed dangerous goods transport document.[674] Broad obligations are placed on operators including duties concerning the acceptance of goods, loading and storage, inspection, and provision of information.[675] Technical instructions add detail to the broad standards in Annex 18.[676]

The Air Operations Regulation

9.72 UK Regulation (EU) 965/2012 (the "Air Operations Regulation") contains three provisions regarding the carriage of dangerous goods, breach of which constitutes a criminal offence under schedule 13 to the ANO.

9.73 The first provision concerns the carriage of weapons or other munitions of war. An operator may only transport such items where approval has been granted by all States whose airspace is intended to be used for the flight. Weapons must be inaccessible to passengers and firearms must be unloaded. The operator must inform the commander of the presence and location of any such items.[677]

9.74 The second provision requires that the transport of dangerous goods be conducted in accordance with Annex 18 to the Chicago Convention as amended by the "technical

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669 CAA, *RPAS Carriage of Dangerous Goods Market Demand Summary* (October 2022) (CAP 2483) p 3.

670 CAA, *RPAS Carriage of Dangerous Goods Market Demand Summary* (October 2022) (CAP 2483) p 3.

671 Dangerous goods that “may result in high risk for third parties in case of accident” are restricted to the certified category.

672 CAA, *Fundamentals: Carriage of Dangerous Goods by Remotely Piloted Aircraft Systems* (September 2021) (CAP 2248) pp 2-6.

673 Those who despatch the goods.

674 Annex 18 to the Chicago Convention, Fourth Edition, 2011, including amendment 12, ch 7.

675 Annex 18 to the Chicago Convention, Fourth Edition, 2011, including amendment 12, chs 8 and 9.

676 International Civil Aviation Authority (“ICAO”), *Technical Instruction for the Safe Transport of Dangerous Goods by Air* (Doc 9284).

677 UK Regulation (EU) 965/2012 uses the term “commander” to refer to pilot-in-command of commercial air transport operation. Article 2 of UK Regulation (EU) 965/2012 defines a commercial operation as meaning any operation of an aircraft, in return for remuneration or other valuable consideration, which is available for the public or, when not made available to the public, which is performed under a contract between an operator and a customer, where the latter has no control over the operator.

instruction for the safe transport of dangerous goods by air". The provisions of Annex 18 are similar to those in the Air Navigation (Dangerous Goods) Regulations 2002, with obligations primarily falling on the operator and shipper. The commander is responsible for informing air traffic services of the carriage of dangerous goods in the event of an emergency.[678]

9.75 The final provision stipulates that, subject to exceptions, an operator must only transport dangerous goods by air if approved by the CAA.[679]

The Air Navigation (Dangerous Goods) Regulations 2002

9.76 Under article 97 of the ANO, the Secretary of State may make regulations concerning the carriage of dangerous goods.[680] Failure to comply with regulations made by the Secretary of State under article 97 is a criminal offence.[681] Article 97 only applies to uncrewed aircraft in the certified category.[682]

9.77 The Air Navigation (Dangerous Goods) Regulations 2002 were made by the Secretary of State under the predecessor to article 97.[683] As such, a breach of the provisions contained within the 2002 Regulations is a criminal offence.[684] The Regulations contain provisions regarding: requirements for the carriage of dangerous goods, the operator's obligations, the shipper's responsibilities, the pilot-in-command's obligations, training, the provision of information to passengers, documents, records, and enforcement powers.[685]

9.78 Most of the obligations under the 2002 Regulations relate to the operator. These obligations include:

(1) a requirement to provide information to crew regarding dangerous goods on board;[686]

(2) a duty to refuse carriage of dangerous goods unless an inspection determines that the goods meet the relevant requirements;[687]

(3) loading requirements for dangerous goods;[688]

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678 Air Navigation (Dangerous Goods) Regulations 2002, reg 12.

679 UK Regulation (EU) 965/2012 laying down technical requirements and administrative procedures related to air operations, annex V, SPA.DG.100.

680 SI 2016 No 765, art 97(1).

681 SI 2016 No 765, art 97(2).

682 SI 2016 No 765, art 23(c).

683 Air Navigation Order 2000, SI No 1562, arts 60(1) and 129(5).

684 Air Navigation Order 2000, SI No 1562, art 60(2).

685 SI 2002 No 2786.

686 SI 2002 No 2786, reg 6.

687 SI 2002 No 2786, reg 7.

688 SI 2002 No 2786, reg 8.

(4) the need to inspect dangerous goods for damage, leakage, or contamination[689] and remove any contamination;[690]

(5) ensuring passengers are aware of the types of dangerous goods which are forbidden;[691]

(6) keeping and producing documentation;[692] and

(7) reporting any specified occurrences to the CAA.[693]

9.79 Most of these requirements are unlikely to be affected by the introduction of increased autonomy in aviation as responsibility primarily falls on the operator.[694]

9.80 Operators may also apply to the CAA for approval to carry dangerous goods. The criteria for such an approval are as follows:

(1) the operator has formally nominated a person to be responsible for the dangerous goods approval;

(2) the ICAO Technical Instructions for the Safe Transport of Dangerous Goods by Air (or International Air Transport Association Dangerous Goods Regulations) are available to the nominated person and all others that need to reference them;

(3) policies and procedures for the transport of dangerous goods are established within the Operations Manual and other manuals;

(4) the dangerous goods training programme is appropriate and effective;

(5) all applicable staff have been trained commensurate with their responsibilities;

(6) procedures are established within the Compliance Monitoring System designed to verify that all relevant requirements of the ICAO Technical Instructions are complied with;

(7) the carriage of dangerous goods is addressed within the scope of the operator's Safety Management System; and

(8) when aircraft carry dangerous goods, a copy of the ICAO publication "Emergency Response Guidance for Aircraft Incidents Involving Dangerous

689 SI 2002 No 2786, reg 9.

690 SI 2002 No 2786, reg 10.

691 SI 2002 No 2786, reg 14.

692 SI 2002 No 2786, reg 16.

693 SI 2002 No 2786, reg 19.

694 See the following for examples of the responsibilities of UAS operators. CAA, *Fundamentals: Carriage of Dangerous Goods by Remotely Piloted Aircraft Systems* (September 2021) (CAP 2248) p 5.

Goods", or another document containing equivalent information, must be available on the aircraft to the crew during the flight.[695]

9.81 Most of these requirements are also unlikely to be affected by the introduction of increased autonomy, but some may need to be adapted. For example, without a pilot or crew on board an aircraft the carriage of ICAO guidance documents on board the aircraft would be redundant.

9.82 We invite views on how operator responsibilities for dangerous goods might need to be adapted in light of autonomous operations.

Removing the pilot

9.83 The drafting of the 2002 Regulations presupposes a pilot-in-command.[696] In the event of an emergency, article 12 imposes a duty on the pilot-in-command to inform air traffic services of dangerous goods on board. Additionally, before flight the operator is required to provide the pilot-in-command with written information about any dangerous goods on board and information for use during an in-flight emergency.[697]

9.84 Both of these requirements could be met in the case of a remote pilot. However, in the event of an autonomous operation, it is possible that an aircraft could crash without air traffic services, or other emergency services, being aware that the aircraft is carrying dangerous goods. Possible solutions to this problem include: a requirement for autonomous aircraft carrying dangerous goods to have a system capable of communicating that fact to air traffic services in the event of an emergency; or requirements for the operator of an autonomous aircraft carrying dangerous goods to inform air traffic services of the fact, either at the outset or when they become aware of an emergency. We ask for consultees' views.

Consultation Question 59.

9.85 We invite views on how operator responsibilities for dangerous goods might need to be adapted in the case of autonomous operations.

OTHER AVIATION OFFENCES

9.86 This section analyses aviation-specific offences that can be committed by persons who are not involved in the operation of aircraft. These are contained in the Civil Aviation Act 1982, the Aviation Security Act 1982 and the Aviation and Maritime Security Act 1990. They comprise offences against the safety of aircraft, hijacking, the carriage of dangerous goods, and offences relating to aerodromes. The remainder of

695 CAA, *Transport of dangerous goods and munition of war,* https://www.caa.co.uk/commercial-industry/airlines/dangerous-goods/transport-of-dangerous-goods-and-munitions-of-war/.

696 The Regulations themselves refer to a "commander of the aircraft". Read with Annex 18 to the Chicago Convention is clear that "commander" in this context is the pilot-in-command.

697 Air Navigation (Dangerous Goods) Regulation 2002, SI No 2786, art 6(2).

the section explores how the introduction of autonomy might impact on these areas of criminal liability.

9.87 There is some overlap between offences in the ANO and offences in other legislation. The CPS guidance on transport offences notes that prosecutors will often have to choose between proceeding under the Aviation Security Act 1982 or other legislation such as the ANO. For criminal behaviour that endangers the safety of an aircraft, the guidance notes that prosecutors may wish to consider charging offensive weapon offences, public order offences, or offences against the person, depending on the facts of the case.[698] The CPS advises prosecutors to consider the likely disposal of the case and level of danger caused by the defendant's actions when making decisions.[699] Prosecutors should select charges which reflect the seriousness and extent of the offending.[700]

Offences against the safety of aircraft

9.88 The Aviation Security Act 1982 sets out a series of offences that can be committed against the safety of an aircraft. While terrorism falls outside our terms of reference, we note that some of these offences are classified as terrorism offences for the purposes of the Terrorism Act 2006.[701]

Hijacking

9.89 Hijacking is punishable by life imprisonment.[702] Section 1(1) of the 1982 Act provides that:

> a person on board an aircraft in flight who unlawfully, by the use of force or by threats of any kind, seizes the aircraft or exercises control of it commits the offence of hijacking.

9.90 The offence can only be committed by a person on board an aircraft. Taking control of an uncrewed aircraft by the use of force or threats outside the aircraft would not qualify as hijacking.

9.91 In theory, it may be possible to hijack a passenger-carrying VTOL by the use of force or threats on board the aircraft. The use of force or threats does not necessarily mean that a pilot has to be overcome by force. A security system could be breached by the use of force, or threats could be directed at fellow passengers or crew, but the result would have to amount to seizing or exercising control.

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698 https://www.cps.gov.uk/legal-guidance/transport-offences

699 https://www.cps.gov.uk/legal-guidance/transport-offences

700 CPS, *The Code for Crown Prosecutors*, para 6.1, https://www.cps.gov.uk/publication/code-crown-prosecutors.

701 Section 1 of the Terrorism Act 2006 makes it an offence to encourage people to commit, prepare or instigate certain offences under the Aviation and Security Act 1982. These are listed in schedule 1(5) of the Terrorism Act 2006 as hijacking (section 1); destroying, damaging or endangering the safety of aircraft (section 2); other acts endangering or likely to endanger the safety of aircraft (section 3); and some ancillary offences (section 6(2). Sections 6 and 8 of the Terrorism Act 2006 Act also make it an offence to receive or provide training of skills in connection to these offences, or to attend a place which provides such training.

702 Aviation Security Act 1982, s 1(3).

Destroying an aircraft in service

9.92 The Aviation Security Act 1982 makes it an offence punishable by life imprisonment to unlawfully and intentionally:

(1) destroy an aircraft in service; or

(2) damage an aircraft in service to render it incapable of flight or so that it is likely to endanger its safety in flight;[703] or

(3) place a device or substance on an aircraft which is likely to destroy the aircraft or damage the aircraft to render it incapable of flight or dangerous to fly.[704]

9.93 Section 2(6) of the 1982 Act provides that "unlawful" in this context means the act must amount to an offence under the law of the part of the UK in which it was done or (if done overseas) in which the prosecution is brought.

Interfering with air navigation

9.94 Section 3 of the Aviation Security Act 1982 makes it an offence liable to life imprisonment to unlawfully and intentionally interfere with property used for air navigation purposes. This includes damaging or destroying the property, or lesser interference. Property includes any land, building or ship used for the provision of air navigation facilities and includes "any apparatus or equipment so used, whether it is on board an aircraft or elsewhere".

9.95 It is also an offence under section 3(3) for any person intentionally to communicate information which is false, misleading or deceptive "in a material particular" where the communication of the information endangers the safety of an aircraft in flight or is likely to endanger the safety of an aircraft in flight.

9.96 There are two defences available under section 3(4):

(1) that the defendant believed and had reasonable grounds for believing that the information was true; or

(2) that the defendant was lawfully employed to perform duties which consisted of or included the communication of information and communicated the information in good faith in the performance of those duties.

Carrying weapons

9.97 Under the Aviation Security Act 1982, it is an offence to carry a firearm, explosive or article made, adapted or intended to damage people or property in an aerodrome or air navigation installation or on an aircraft in or flying over the UK.[705] To commit an offence under the Act, the individual must be in the aircraft or aerodrome and the

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703 Aviation Security Act 1982, s 2(1)(a).

704 Aviation Security Act 1982, s 2(2).

705 Aviation Security Act 1982, s 4. A person guilty of this offence shall be liable on summary conviction, to a fine not exceeding the statutory maximum or to imprisonment for a term not exceeding three months or to both. If found guilty on conviction on indictment, a person shall be liable to a fine or to imprisonment for a term not exceeding five years or to both.

article must form part of the individual's baggage or have been brought by the individual to be carried on to the flight.[706]

9.98 The need for an individual to "have with him" the relevant article means that this offence would not apply in the context of unoccupied aircraft. It would however apply to passenger-carrying aircraft.

Offences against the aircraft: our provisional view

9.99 Our initial view is that the introduction of autonomy is unlikely to cause any fundamental problems with the operation of offences under the Aviation Security Act 1982. These offences concern intentional and unlawful acts committed by an individual intent on causing some sort of damage, destruction or interference. There does not seem to be any major reason why the type of aircraft (whether autonomous or remotely piloted) would render these offences inappropriate or inapplicable.

9.100 However, many of the offences against aircraft were created long before digital communications were widespread or autonomy in aviation was feasible. The offences give effect in domestic law to international treaties which are decades old such as: the 1970 Convention on Unlawful Seizure of Aircraft (the "Hague Hijacking Convention"); the 1971 Convention for the Suppression of Unlawful Acts Against the Safety of Civil Aviation (the "1971 Montreal Convention"); and the 1988 Protocol for the Suppression of Unlawful Acts of Violence at Airports Serving International Civil Aviation ("the Montreal Protocol").[707] It may be the case that some aspects of new advanced air mobility use cases are not adequately captured by the current offences.

9.101 One example of this is the offence of hijacking. The current offence clearly contemplates the use of force or threats by a person on board an aircraft to seize or exercise control of it. It now seems more likely that the unlawful control or seizure of an autonomous or remotely piloted aircraft would be achieved by exploiting weaknesses in its computer systems or programming ("hacking") or by the use of threats or force at a remote operations centre.

9.102 Currently hacking or coercion at a remote operations centre do not constitute hijacking because they do not involve the use of force or threats by a person on the aircraft whilst it is in flight. Arguably though, because of the seriousness and potential safety risks involved, any unlawful seizure or control of an aircraft should be treated as hijacking. At the international level, there have been efforts to address "different forms of hijacking".[708] The Hague Hijacking Convention has now been supplemented by a 2010 "Beijing Protocol". The protocol has expanded hijacking to include "coercion" and

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706 Aviation Security Act 1982, s 4(3).

707 Both the Montreal Convention and the Protocol have been replaced by the 2010 Convention on the Suppression of Unlawful Acts relating to International Civil Aviation (the "Beijing Convention"). The Convention entered into force in 2018, however, the UK has yet to ratify it. Therefore, the earlier Montreal Convention and Protocol remains binding on the UK in international law.

708 See ICAO, *Administrative package for ratification of or accession to the protocol supplementary to the convention for the suppression of unlawful seizures of aircraft (Beijing Protocol, 2010)* para 3, https://www.icao.int/secretariat/legal/Administrative%20Packages/Beijing_protocol_EN.pdf. See also, https://www.icao.int/Newsroom/Pages/Beijing-Protocol-to-enter-into-force-following-Ugandas-ratification.aspx.

"technological means" as a way to commit the offence. It also removed the requirement that someone hijacking the plane must be on board the aircraft.

9.103 The Beijing Protocol has also expanded the period in which hijacking can occur. The offence as set out in the Hague Hijacking Convention requires a plane to be "in flight" for unlawful force or threats on board an aircraft to constitute hijacking. An aircraft is considered to be in flight when all its external doors are closed following embarkation until the moment when such doors are opened for disembarkation.[709] This definition is replicated in the Aviation Security Act 1982 which creates the offence in domestic law.[710] The Beijing Protocol provides that hijacking can be committed during the time an aircraft is "in service". An aircraft is considered to be in service from:

> the beginning of the pre-flight preparation of the aircraft by ground personnel or by the crew for a specific flight until twenty-four hours after any landing.[711]

9.104 This expands the period in which hijacking can occur. Presumably this expansion reflects the fact that a person accomplishing hijacking via technological means has a much larger window of opportunity in which to seize or take control of the aircraft.

9.105 Though the UK has signed the Beijing Protocol, it has yet to ratify or implement it.

9.106 We seek consultees' views on whether the offence of hijacking in domestic law should be updated to reflect the fact that autonomous or remotely piloted aircraft might be seized or controlled by technological means or by persons not on board the aircraft. Further to this, we also ask whether the period in which an autonomous or remotely piloted aircraft can be hijacked should be expanded from when it is "in flight" to when it is "in service". We note that these changes could usefully be discussed for all aircraft and not just autonomous ones. This is outside our terms of reference, but we will pass on any views on the matter by consultees to both the CAA and the Department for Transport.

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709 Article 3, 1970 Convention on Unlawful Seizure of Aircraft. Article 3 also provides that where there is a forced landing the flight is deemed to continue until competent authorities take over the responsibility for the aircraft and for persons and property on board.

710 Aviation Security Act 1982, article 38 (3)(a).

711 Article 3, 2010 Beijing Protocol. Article 3 of the Beijing Protocol also provides, in the same way the 1970 Convention on Unlawful Seizure of Aircraft does, that in the case of a forced landing, the flight is deemed to continue until competent authorities take over the responsibility for the aircraft and for persons and property on board.

Consultation Question 60.

9.107 We ask for consultees' views about whether the offence of hijacking in domestic law should be updated to:

(1) include the unauthorised seizure or control of autonomous or remotely piloted aircraft by technological means or by persons not on board the aircraft; and

(2) expand the period in which hijacking can occur from the period when an autonomous or remotely piloted aircraft is "in flight" to the period when it is "in service".

9.108 We also seek views on whether any other offences against aircraft need to be updated to account for increased autonomy in aviation.

Consultation Question 61.

9.109 We also ask consultees for views on whether any offences against the aircraft other than hijacking need to be updated to account for increased autonomy in aviation.

Chapter 10: Impact

10.1 The introduction of more highly automated and autonomous aircraft is expected to lead to numerous benefits. Not least of these is safety. Human error is an ongoing cause of aviation accidents.[712] If human error can be reduced or eliminated, then it is possible that aviation could be made even safer than it is today.

10.2 Other benefits are many and varied, and depend on the type of aircraft and the operation it is used for. We set out in the introductions to Chapters 6 and 7 the types of operation that VTOLs and drones are expected to undertake. Here, we give a high level overview of the possible associated costs and benefits.

10.3 One of the difficulties with assessing the impact of our project is that it is future-looking. While there has been work to try and assess the future value of the drone and advanced air mobility industries to the UK economy, which we refer to below, this is inevitably speculative. A further problem of assessing the impact of this project is that our focus is on the impact of greater autonomy. We are not considering other developments that are expected to change the future of aviation in this area: for example, the adoption of electric propulsion.

10.4 An example of this problem is that of VTOLs. As yet, there are no VTOLs providing transport services in the UK. Almost all manufacturers expect that when they are first introduced, VTOLs will be piloted. A progression to remotely piloted and, eventually, autonomous VTOLs is expected further in the future.[713] That development and its impact on the UK economy is therefore dependent on the success of the initial, crewed stage.

10.5 Updating the air traffic management and air navigation services provided to uncrewed aircraft in the UK will also be key to unlocking many of the benefits outlined below. We intend to return to this topic in the second consultation paper.

Ongoing costs and benefits: VTOLs

10.6 A recent PwC report assessed the viability of advanced air mobility in the UK based on a comparative analysis of six electrically powered VTOL use cases against current travel options.[714] It found that if the industry developed as expected, the annual

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712 For example, The Air Accident Investigation Branch's 2022 report noted that a "dominant recurring theme" in accidents and serious incidents involving commercial air transport aircraft was mishandling of the aircraft during landing or go-around. See Air Accident Investigation Branch, *Annual Safety Review* (2022), p I, https://assets.publishing.service.gov.uk/media/64492a1ef12683000cca68b6/AAIB_Annual_Safety_Review_2022.pdf.

713 For an overview of estimated timelines, see Bryce Tech, *Advanced air mobility: an assessment of a coming revolution in air transportation and logistics* (September 2023) pp 17-20, https://assets.publishing.service.gov.uk/media/6571b635049516000f49be06/advanced-air-mobility-evidence-review.pdf.

714 PwC, *Advanced Air Mobility: UK Economic Impact Study* (July 2023) p 1, https://www.pwc.co.uk/intelligent-digital/drones/uk-economic-aam-report-2023.pdf.

socioeconomic benefit to the UK (including time, carbon and avoided accidents) would be up to £2.1 billion a year.[715]

10.7 This is based on a model where:

(1) From 2025 – 2030, electric VTOLs are piloted by highly qualified pilots, as are currently deployed by commercial airlines.

(2) Between 2030 and 2035, electric VTOLs are more sophisticated and do not require fully qualified pilots. Pilots will operate the VTOL with support of a remotely qualified pilot if needed.

(3) Between 2035 and 2040, VTOLs only require a remote pilot for emergencies. One remote pilot will be responsible for managing four VTOLs.[716]

10.8 If electrically powered VTOLs are used in place of car journeys, there is the potential for carbon emission savings.[717]

10.9 As with drones, the potential societal costs of the creation of a VTOL industry include noise and visual pollution. The effect of these will vary considerably depending on multiple factors, including how the VTOL is powered, the height at which it is flown, weather conditions, and background noise.

Ongoing costs and benefits: drones

10.10 PwC estimates there will be as many as 923,000 commercial drones in use by 2030, with 270,000 jobs associated with the adoption of drones.[718] These drones could add £45 billion to the UK economy by 2030, equivalent to 1.6% of predicted GDP growth.[719]

10.11 The immediate economic impact to industry will include lower costs and improved productivity. PwC estimates a net cost saving of £22 billion from the uptake of drones.[720] A recent report by GMSA, GMSA Intelligence and BT Group recommends

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715 PwC, *Advanced Air Mobility: UK Economic Impact Study* (July 2023) p 1, https://www.pwc.co.uk/intelligent-digital/drones/uk-economic-aam-report-2023.pdf.

716 PwC, *Advanced Air Mobility: UK Economic Impact Study* (July 2023) p 22, https://www.pwc.co.uk/intelligent-digital/drones/uk-economic-aam-report-2023.pdf.

717 UKRI, *UK advanced air mobility market assessment* (2022) p 17, https://www.ukri.org/wp-content/uploads/2022/11/IUK-02112022-Advanced-Air-Mobility-Demand-Assessment-Report.pdf.

718 PwC, *Skies without limits (v 2): the potential to take the UK's economy to new heights* (2018, updated 2022), pp 12 and 16, https://www.pwc.co.uk/intelligent-digital/drones/skies-without-limits-2022.pdf.

719 PwC, *Skies without limits (v 2): the potential to take the UK's economy to new heights* (2018, updated 2022), p 12, https://www.pwc.co.uk/intelligent-digital/drones/skies-without-limits-2022.pdf .

720 PwC, *Skies without limits (v 2): the potential to take the UK's economy to new heights* (2018, updated 2022), p 12, https://www.pwc.co.uk/intelligent-digital/drones/skies-without-limits-2022.pdf .

that to unlock the benefits of drones, the UK needs clearer regulation for BVLOS flight which enables it to take place at scale.[721]

Transitional costs

10.12 There are a number of transitional costs associated with our proposals. New forms of aircraft within the existing certified category (which includes some drones, and all VTOLs which carry passengers) will require the development of detailed certification specifications to ensure that they are safe. For remotely piloted VTOLs, a new remote pilot's licence will have to be developed, along with dedicated training. Any new aviation role created to supervise an aircraft flying autonomously would also likely require training and licensing.

10.13 There will also be transitional costs associated with rewriting the rules of the air to accommodate remotely piloted and autonomous aircraft, which are discussed in Chapter 4.

10.14 We ask consultees for any quantitative and qualitative evidence on what they believe to be the costs and benefits of our provisional proposals. The information we receive from consultees in response to the questions below will inform an impact assessment to be published with our final report.

Consultation Question 62.

10.15 We invite consultees to tell us if they have views on, or have experience or data to indicate, the likely costs and benefits of our provisional proposals in relation to VTOLs.

Consultation Question 63.

10.16 We invite consultees to tell us if they have views on, or have experience or data to indicate, the likely costs and benefits of our provisional proposals in relation to drones.

Equality impact assessment

10.17 As part of our policy formation process, we consider how our provisional proposals could affect particular groups, or people with particular characteristics. One of the main areas in which we think our provisional proposals could have an impact is in relation to uncrewed VTOLs. Without a pilot or other crew in the aircraft, it will be particularly important that the needs of those with disabilities and reduced mobility are considered at an early stage, when designing both the aircraft itself and the support

[721] GMSA Intelligence, GMSA and BT, *Race to the top: assessing and accelerating drone readiness in the UK, the G7 and other leading nations* (2023) pp 42 to 43, https://www.bt.com/content/dam/bt-plc/assets/documents/newsroom/race-to-the-top.pdf.

systems that are provided alongside it. We discuss this in more detail in Chapter 6, from paragraph 6.141 onwards.

10.18 We also ask a more general question below. This is an opportunity for consultees to inform us if the remainder of our proposals could have equality impacts and, if so, what those might be. Data provided by consultees will be used to produce a full equality impact assessment, which will be published alongside our final report.

Consultation Question 64.

10.19 We invite consultees to tell us if they believe or have evidence or data to suggest that any of our provisional proposals could result in advantages or disadvantages to certain groups or based on particular characteristics (with particular attention to age, disability, transgender identity, marriage and civil partnership, pregnancy and maternity, race, religion or belief, sex or gender, and sexual orientation).

Chapter 11: Consultation Questions

Consultation Question 1.

11.1 We seek views on how current airworthiness and certification regulation might need to be adapted or developed in light of highly automated and autonomous aircraft. In particular, should provisions be adopted which allow for:

(1) the certification of optionally piloted and uncrewed or unoccupied versions of conventional aircraft (hybrid versions); and

(2) the separate certification of command units?

Paragraph 4.51

Consultation Question 2.

11.2 We welcome views on what changes to the certification system might be necessary to enable higher automation and autonomy in aviation.

Paragraph 4.72

Consultation Question 3.

11.3 We seek views on whether current regulatory tools to support the development of highly automated and autonomous aviation technologies are adequate.

Paragraph 4.86

Consultation Question 4.

11.4 We seek views on how highly automated and autonomous aircraft should act in emergency scenarios. In particular:

(1) should highly automated and autonomous aircraft be given the freedom to operate outside the rules of the air in emergency circumstances; or

(2) should a comprehensive set of rules be developed for highly automated and autonomous aircraft in emergency situations.

Paragraph 5.59

Consultation Question 5.

11.5 We seek consultee views about what challenges remotely piloting an aircraft in an emergency scenario presents and how these might be addressed.

Paragraph 5.63

Consultation Question 6.

11.6 We seek consultees' views on whether the rules of the air relating to communication should be adapted for remotely piloted and autonomous aircraft.

Paragraph 5.73

Consultation Question 7.

11.7 We ask for consultees' views on how the rules of the air might be adapted or developed for remotely piloted or autonomous flight.

Paragraph 5.95

Consultation Question 8.

11.8 We provisionally propose that a person overseeing a VTOL flying automatically, who monitors its course and is able to intervene and change its course at any time should continue to be classified as a "remote pilot".

Do you agree?

Paragraph 6.62

Consultation Question 9.

11.9 We provisionally propose that in a commercial air transport operation a remote pilot as defined in the UK UAS Delegated Regulation 2019/945 should have the responsibilities of the commander of an operation within the meaning of the UK Air Operations Regulation 965/2012.

Do you agree?

Paragraph 6.66

Consultation Question 10.

11.10 We provisionally propose that the remote pilot of a VTOL should be required to ensure that:

(1) the aircraft is airworthy;

(2) specified instruments and equipment are installed and operative;

(3) the mass of the aircraft and centre of gravity location are such that the flight can be conducted within prescribed limits;

(4) all cabin baggage, hold luggage and cargo is properly loaded and secured; and

(5) aircraft operating limitations will not be exceeded at any time during flight.

Do you agree?

Paragraph 6.73

Consultation Question 11.

11.11 We seek views as to whether there are additional operational responsibilities that a remote VTOL pilot should be required to fulfil.

Paragraph 6.74

Consultation Question 12.

11.12 We provisionally propose that the remote pilot-in-command should be responsible for, amongst other things, ensuring passengers are:

(1) given a safety briefing; and

(2) seated and wear seat belts during take-off and landing.

Do you agree?

Paragraph 6.83

Consultation Question 13.

11.13 We provisionally propose that air operators (rather than the remote pilot-in-command) should be responsible for preventing passengers from boarding:

(1) who appear drunk or under the influence of drugs; or

(2) whose carriage would, in the view of the operator's employees, endanger the safety of the aircraft or other passengers.

Do you agree?

Paragraph 6.84

Consultation Question 14.

11.14 We provisionally propose that the remote pilot-in-command should have the power to take reasonable measures, including authorising the restraint of passengers, as set out in section 94 of the Civil Aviation Act 1982.

Do you agree?

Paragraph 6.85

Consultation Question 15.

11.15 We provisionally propose that a person on board a VTOL aircraft (other than a crew member) should be able to take reasonable measures to protect the safety of the aircraft or of persons or property on board.

Do you agree?

Paragraph 6.86

Consultation Question 16.

11.16 We seek views on whether the powers of crew on board a VTOL aircraft should be broadened to reflect those of the pilot-in-command under the Civil Aviation Act 1982 to:

(1) take reasonable measures to protect the safety of the aircraft or persons or property on board;

(2) maintain good order and discipline; or

(3) enable the crew to disembark or deliver a person.

Paragraph 6.87

Consultation Question 17.

11.17 We provisionally propose that passengers should be able to contact a member of crew at all times during an operation.

Do you agree?

Paragraph 6.88

Consultation Question 18.

11.18 We provisionally propose that it should be a criminal offence for a remote pilot of a VTOL to act in that capacity when their performance is impaired through drink or drugs.

Do you agree?

Paragraph 6.91

Consultation Question 19.

11.19 We provisionally propose that it should be a criminal offence for a person to act as the remote pilot of a VTOL when the level of alcohol in their blood, breath or urine is over a prescribed limit.

Do you agree?

Paragraph 6.92

Consultation Question 20.

11.20 We provisionally propose that the remote pilot should be subject to the reporting obligations currently applicable to pilots under the Air Operations Regulation.

Do you agree?

Paragraph 6.95

Consultation Question 21.

11.21 We provisionally propose that a remotely piloted VTOL should be required to be capable of detecting and recording information relating to accidents and near accidents for the purposes of reporting it.

Do you agree?

Paragraph 6.96

Consultation Question 22.

11.22 We provisionally propose that licences should be required for remote VTOL pilots. So far as appropriate, these should follow the classes and ratings adopted for crewed VTOLs.

Do you agree?

Paragraph 6.99

Consultation Question 23.

11.23 We provisionally propose that operators of remotely piloted VTOLs should be certified.

Do you agree?

Paragraph 6.108

Consultation Question 24.

11.24 We provisionally propose that operators of remotely piloted VTOLs should continue to be required to:

(1) have the means necessary for the scale and scope of operations planned;

(2) use only suitably qualified and trained personnel;

(3) implement a management system to ensure safety;

(4) ensure operations only take place in accordance with the operations manual;

(5) establish procedures to minimise the consequences to safe flight operations of disruptive passenger behaviour;

(6) develop and maintain security programmes suitable for the aircraft and type of operation;

(7) have a management system to prevent fatigue;

(8) ensure the continuing airworthiness of the aircraft; and

(9) establish procedures for any reasonably foreseeable emergency situation.

Do you agree?

Paragraph 6.109

Consultation Question 25.

11.25 We seek views as to whether there are additional responsibilities that operators of remotely piloted VTOLs should need to fulfil.

Paragraph 6.110

Consultation Question 26.

11.26 We seek views as to whether the law should permit remote pilots to act as pilot-in-command for more than one VTOL at the same time.

Paragraph 6.118

Consultation Question 27.

11.27 We seek views on whether there should be an upper limit to the number of VTOLs for which a remote pilot can act as pilot-in-command at the same time.

Paragraph 6.119

Consultation Question 28.

11.28 We seek views as to what additional safeguards should be introduced for remote pilots piloting multiple VTOLs.

Paragraph 6.120

Consultation Question 29.

11.29 We seek views as to whether there should be a role for a person supervising the flight of an autonomous passenger-carrying VTOL and acting as a point of contact in relation to it. What powers or responsibilities should such a person have?

Paragraph 6.135

Consultation Question 30.

11.30 Should the law permit an uncrewed VTOL to transition between remotely piloted and autonomous flight during an operation?

Paragraph 6.140

Consultation Question 31.

11.31 We seek views as to whether initial airworthiness standards for uncrewed VTOLs should include accessibility standards for persons with disabilities and reduced mobility.

Paragraph 6.160

Consultation Question 32.

11.32 We seek views as to whether the CAA should be able to include accessibility standards within the licences granted to uncrewed VTOL operators.

Paragraph 6.161

Consultation Question 33.

11.33 We seek consultees' views on any other issues with the current legal framework as it relates to operations involving remotely piloted and autonomous VTOLs.

Paragraph 6.163

Consultation Question 34.

11.34 We provisionally propose that a remote pilot for drones should continue to be defined as "a natural person responsible for safely conducting the flight of an unmanned aircraft by operating its flight controls, either manually or, when the unmanned aircraft flies automatically, by monitoring its course and remaining able to intervene and change its course at any time".

Do you agree?

Paragraph 7.14

Consultation Question 35.

11.35 We seek views on whether some low risk autonomous drone operations or drone operations conducted beyond visual line of sight might be accommodated in the open category. In particular:

(1) whether there are any such use cases which might be suitable for the open category; and

(2) if so, what conditions should be attached to these use cases if operated in the open category.

Paragraph 7.20

Consultation Question 36.

11.36 We provisionally propose that for autonomous operations in the specific category, a UAS operator should be required to use a UAS which can:

(1) comply with the authorised limitations and conditions;

(2) avoid any risk of collision with any crewed aircraft and discontinue a flight when continuing it may pose a risk to other aircraft, people, animals, environment or property;

(3) comply with the operational limitations in designated geographical zones or airspace;

(4) comply with the operator's procedures; and

(5) not fly close to or inside areas where an emergency response effort is ongoing unless they have permission to do so from the responsible emergency response services.

Do you agree?

Paragraph 7.28

Consultation Question 37.

11.37 We seek views on what operational requirements should be applied to autonomous drone operations and drones that operate beyond visual line of sight in the specific and certified categories.

Paragraph 7.41

Consultation Question 38.

11.38 We seek views on whether the current concept of a "remote pilot" is compatible with drone MSO. We also seek views on whether the remote pilots of drone MSO should continue to be subject to the same responsibilities as remote pilots for single drone operations.

Paragraph 7.52

Consultation Question 39.

11.39 We seek views on whether there should be an upper limit to the number of drones for which an individual remote pilot is responsible.

Paragraph 7.53

Consultation Question 40.

11.40 We seek views as to what additional safeguards should be introduced for remote pilots responsible for multiple drones.

Paragraph 7.54

Consultation Question 41.

11.41 We provisionally propose that use of flight data recorder systems or devices should be mandatory for autonomous drone operations.

Do you agree?

Paragraph 7.58

Consultation Question 42.

11.42 Should the law permit a drone to transition between remotely piloted and autonomous flight during an operation?

Paragraph 7.60

Consultation Question 43.

11.43 We seek stakeholder views on any other issues with the current legal framework as it relates to operations involving autonomous drones.

Paragraph 7.62

Consultation Question 44.

11.44 We provisionally consider that the current law governing air carrier liability for injury or death of passengers in the UK is adequate for the introduction of remotely piloted and autonomous operations.

Do you agree?

Paragraph 8.20

Consultation Question 45.

11.45 We provisionally consider that the current law governing liability for damage to cargo in the UK is adequate for the introduction of remotely piloted and autonomous operations.

Do you agree?

Paragraph 8.27

Consultation Question 46.

11.46 We provisionally propose that liability for surface damage, in the case of UAS, should transfer to the lessee when the lease:

(1) is for more than 14 days; and

(2) specifies the aircraft is to be operated under the responsibility of the lessee.

Do you agree?

Paragraph 8.44

Consultation Question 47.

11.47 We provisionally propose that the conditions of exemption from liability for private nuisance and trespass in section 76 of the Civil Aviation Act 1982 should be modified in their application to UAS so as to require compliance with requirements of aviation legislation that are relevant to limiting intrusion into the claimant's land.

Do you agree?

Paragraph 8.62

Consultation Question 48.

11.48 We provisionally propose that there should be a review of product liability law (including the Consumer Protection Act 1987) to take account of the challenges of emerging technologies. The review should cover product liability as a whole, rather than be confined to aviation or automated vehicles.

Do you agree?

Paragraph 8.89

Consultation Question 49.

11.49 We seek views as to whether the current law regarding liability for mid-air collisions is satisfactory in the case of collisions involving uncrewed aircraft systems.

Paragraph 8.97

Consultation Question 50.

11.50 We seek consultees' views on whether they expect any difficulties applying existing insurance requirements to uncrewed aircraft systems.

Paragraph 8.113

Consultation Question 51.

11.51 We provisionally propose that multiple simultaneous operations should be considered as the Government develops proposals for the insurance requirements applicable to uncrewed aircraft.

Do you agree?

Paragraph 8.114

Consultation Question 52.

11.52 We provisionally consider that the current approach in the Air Navigation Order 2016 placing criminal liability on an operator is adequate for autonomous operations.

Do you agree?

Paragraph 9.39

Consultation Question 53.

11.53 We provisionally consider that the "reasonable care" defence in article 265(3) of the Air Navigation Order 2016 applies adequately for "direct contraventions" under Article 265(5) to (8) involving autonomous operations.

Do you agree?

Paragraph 9.45

Consultation Question 54.

11.54 We seek views on whether for autonomous operations the reasonable care defence should be applicable to the vicarious liability created in article 265(1) of the ANO.

Paragraph 9.46

Consultation Question 55.

11.55 We provisionally propose that a remote pilot of an uncrewed aircraft operating in the certified category should be treated as a pilot-in-command for the purposes of criminal liability pursuant to article 265(1) of the Air Navigation Order 2016.

Do you agree?

Paragraph 9.61

Consultation Question 56.

11.56 We ask for consultees' views on the criminal liability of pilots (or remote pilots) when an aircraft operating autonomously returns control to the pilot or vice-versa. In particular, should a pilot (or remote pilot) only become criminally liable for the piloting of the aircraft at the end of a transition period?

Paragraph 9.62

Consultation Question 57.

11.57 We provisionally propose that the pilot-in-command of aircraft in a multiple simultaneous operation should be criminally liable for breach of operating requirements in the same way as a pilot-in-command of a single aircraft would be.

Do you agree?

Paragraph 9.63

Consultation Question 58.

11.58 We invite consultees' views on whether the Air Traffic Management and Unmanned Aircraft Act 2021 operates satisfactorily in the case of highly automated and autonomous flight.

Paragraph 9.69

Consultation Question 59.

11.59 We invite views on how operator responsibilities for dangerous goods might need to be adapted in the case of autonomous operations.

Paragraph 9.85

Consultation Question 60.

11.60 We ask for consultees' views about whether the offence of hijacking in domestic law should be updated to:

(1) include the unauthorised seizure or control of autonomous or remotely piloted aircraft by technological means or by persons not on board the aircraft; and

(2) expand the period in which hijacking can occur from the period when an autonomous or remotely piloted aircraft is "in flight" to the period when it is "in service".

Paragraph 9.107

Consultation Question 61.

11.61 We also ask consultees for views on whether any offences against the aircraft other than hijacking need to be updated to account for increased autonomy in aviation.

Paragraph 9.109

Consultation Question 62.

11.62 We invite consultees to tell us if they have views on, or have experience or data to indicate, the likely costs and benefits of our provisional proposals in relation to VTOLs.

Paragraph 10.15

Consultation Question 63.

11.63 We invite consultees to tell us if they have views on, or have experience or data to indicate, the likely costs and benefits of our provisional proposals in relation to drones.

Paragraph 10.16

Consultation Question 64.

11.64 We invite consultees to tell us if they believe or have evidence or data to suggest that any of our provisional proposals could result in advantages or disadvantages to certain groups or based on particular characteristics (with particular attention to age, disability, transgender identity, marriage and civil partnership, pregnancy and maternity, race, religion or belief, sex or gender, and sexual orientation).

Paragraph 10.19

Appendix 1: Air accident investigation

1.1 Despite the safety-centric approach described throughout this paper, accidents inevitably occur. When they do happen, it is important that lessons are learnt, so that levels of aviation safety can be improved. In this appendix we consider how aviation approaches accidents.

1.2 The underlying principle of air accident investigation is the prevention of future accidents. To facilitate achievement of that goal, people should be encouraged to cooperate with air accident investigation authorities. As explained by Edis J (as he then was), in the High Court in a case concerned with the Shoreham air disaster:

> The 2018 Regulations,[722] and EU Regulation 996[723] and Annex 13[724] which underline them, are designed to enable people involved in air accidents to co-operate with the Air Accident Investigation Branch investigation freely and without fear and to encourage them thereby to provide accurate information promptly and without obfuscation. This is to enable those investigations to reach accurate conclusions about the causes of air accidents and incidents so that air safety in the future is achieved. The culture of openness is an essential part of a safe system of air travel. It is called "the just culture".[725]

1.3 This approach to accident investigation is one which is shared with other forms of transport; notably maritime and rail.[726] The Law Commission and Scottish Law Commission have taken the view that it should also be adopted for automated vehicles.[727]

1.4 Within aviation, the approach to accident investigation is based on the Chicago Convention. This sets out the UK's international obligations, which are imposed at a domestic level through assimilated law. Alongside mandatory reporting, voluntary reports of less serious incidents may also be made with a view to preventing recurrences. This section sets out these mandatory and voluntary reporting processes, including the position of uncrewed aircraft systems ("UAS") in the existing framework.

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722 The Civil Aviation (Investigation of Air Accidents and Incidents) Regulations SI 2018 No 321.

723 Now UK Regulation (EU) No 996/2010 on the investigation and prevention of accidents and incidents in civil aviation and repealing Directive 94/56/EC.

724 Annex 13 to the Chicago Convention, Twelfth Edition, 2020, including amendment 18.

725 *The British Broadcasting Corporation, The Press Association v The Secretary of State for Transport, The British Airline Pilots Association* [2019] EWHC 135 (QB), [2019] 4 WLR. 23 at [5].

726 Automated vehicles (2018) Law Commission Consultation Paper No 240; Scottish Law Commission Discussion Paper No 166 para 5.58 discuss the roles of the Marine Accident Investigation Branch (which has as its legislative basis the Merchant Shipping Act 1995, s 267) and the Rail Accident Investigation Branch (established by the Railways and Transport Safety Act 2003, s 3).

727 Automated vehicles (2022) Law Com No 404, Scot Law Com No 258, para 6.154.

THE CHICAGO CONVENTION: INVESTIGATION

1.5 Under the Chicago Convention, the UK is under an obligation to institute an investigation into any accidents occurring within UK territory involving aircraft from a contracting state which involve death, serious injury or which indicate a serious technical defect in air navigation facilities.[728] Annex 13 to the Chicago Convention (referred to in this chapter as "Annex 13") adds detail to the obligation, setting international standards and recommended practices regarding accident investigation.[729]

What is an accident?

1.6 In the context of aviation, an "accident" is "an occurrence associated with the operation of the aircraft" in which:

(1) a person is fatally or seriously injured (including by parts that have been detached from the aircraft, or direct exposure to jet blast); or

(2) the aircraft sustains damage or structural failure; or

(3) the aircraft is missing or completely inaccessible.[730]

1.7 Significantly for our purposes, the definition distinguishes between crewed and uncrewed aviation. The occurrence must take place;

(1) in the case of crewed aircraft, between the time any person boards the aircraft with the intention of flight until such time as all persons have disembarked; or

(2) in the case of uncrewed aircraft, between the time the aircraft is ready to move with the purpose of flight until such time as it comes to rest at the end of the flight and the primary propulsion system is shut down.[731]

Which states are involved?

1.8 Because of the international nature of aviation, a number of states may be interested in an investigation. These include the state of occurrence, the state of registry, the state of design, the state of manufacture, and the state of the operator.[732]

1.9 The state of occurrence is responsible for instigating the investigation of accidents that occur within its territory but may delegate all or part of the investigation to another state or regional accident and investigation organisation through mutual agreement.[733] The investigation is conducted by the state's investigation authority, which must be independent from the state's aviation authority.[734] In the UK, the Air Accident

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728 Chicago Convention, Ninth Edition (2006), art 26.

729 Annex 13 to the Chicago Convention, Twelfth Edition, 2020, including amendment 18.

730 Annex 13 to the Chicago Convention, Twelfth Edition, 2020, including amendment 18, ch 1.

731 Annex 13 to the Chicago Convention, Twelfth Edition, 2020, including amendment 18, ch 1.

732 Annex 13 to the Chicago Convention, Twelfth Edition, 2020 including amendment 18, ch 1.

733 Annex 13 to the Chicago Convention, Twelfth Edition, 2020, including amendment 18, 5.1.

734 Annex 13 to the Chicago Convention, Twelfth Edition,2020, including amendment 18, 3.2.

Investigation Branch ("AAIB") fulfils this role (see below at paragraphs 1.43 to 1.46). As already mentioned, the purpose of the investigation is prospective – prevention, rather than the apportionment of blame or liability, is central to the exercise.[735] The investigation will usually include:

(1) gathering, recording and analysing all relevant information on the accident or incident;

(2) protecting accident and incident investigation records;

(3) issuing safety recommendations;

(4) determining the causes and contributing factors; and

(5) producing a final report.[736]

1.10 The states of the registry, design, operator and manufacturer of the aircraft may each appoint an accredited representative to participate in an investigation conducted by the state of occurrence. This representative will usually be from the state's own accident investigation authority.[737]

The final report

1.11 The accident investigation authority is required to produce a final report as soon as possible, preferably within 12 months of the accident.[738] This report includes factual information, analysis, conclusions and safety recommendations.

1.12 **Factual information.** This section sets out the context of the accident and contains a wide range of information. Suggested contents are set out in appendix 1 to Annex 13. The section should include the history of the flight, including details of the aircraft, a description of events leading up to the accident, and the time and location of the accident. The airworthiness and maintenance of the aircraft should be included, alongside predicted and actual meteorological conditions and the details of personnel and their qualifications. Fatalities and injuries must be recorded alongside a record of damage to the aircraft. This section will include details of wreckage, possibly with photographs attached of the site of the accident and distribution of the wreckage.[739]

1.13 **Analysis.** The information is to be analysed in the process of determining the reasons for the accident. Analysis may only use relevant information set out in the factual information section of the report.[740]

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735 Annex 13 to the Chicago Convention, Twelfth Edition, 2020, including amendment 18, 3.1.

736 Annex 13 to the Chicago Convention, Twelfth Edition, 2020, including amendment 18, 5.4.

737 Annex 13 to the Chicago Convention, Twelfth Edition, 2020, including amendment 18, 5.18.

738 Annex 13 to the Chicago Convention, Twelfth Edition, 2020, including amendment 18, 6.5.

739 Annex 13 to the Chicago Convention, Twelfth Edition, 2020, including amendment 18, appendix 1, 1.

740 Annex 13 to the Chicago Convention, Twelfth Edition, 2020, including amendment 18, appendix 1, 2.

1.14 **Conclusions.** The report presents the findings of the investigation regarding the causes of and contributing factors to the accident. These can include immediate factors (such as the technological failure of a component) and systemic issues.[741]

1.15 **Safety recommendations.** These may be made at any point in the investigation. Usually, these recommendations are issued by the accident investigation authority of the state of occurrence.[742] Other states participating in the investigation may make recommendations following discussions with the state conducting the investigation.[743] These recommendations must be sent to the accident investigation authorities of the relevant states.[744] After a recommendation has been made, recipient states have 90 days to take or commit to taking preventive action or explain why action will not be taken.[745] In this section of the report, preventive measures taken since the accident and prospective recommendations should be stated.[746]

Role of ICAO

1.16 The International Civil Aviation Organisation ("ICAO")'s Accident Investigation Section ("AIG") monitors and assists accident investigation practices in states party to the Chicago Convention.[747] Where an accident involves aircraft over 2,250 kg, the state in charge of the investigation must send a preliminary report to ICAO. Preliminary reports set out information determined in the early stages of an investigation and the investigating state may mark these as confidential.[748] Where an accident involves an aircraft over 5,700 kg, the final report must be sent to ICAO.[749] Unlike preliminary reports, final reports must be made public, and the AIG maintains an open access library of final reports submitted to it.[750]

1.17 Further, the AIG is responsible for updating Annex 13 and other documents to reflect modern practices and values. One of these documents is the Manual of Aircraft Accident and Incident Investigation. The manual consists of four sections covering organisation and planning, procedures and checklists, investigation, and reporting. The manual provides guidance as to how an investigation should be arranged, conducted, and reported.

Reporting

1.18 The Chicago Convention does not prescribe any requirements as to reporting of accidents. In the UK these are contained in assimilated law. This section sets out an overview of the applicable law on reporting obligations before outlining the UK's

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741 Annex 13 to the Chicago Convention, Twelfth Edition, 2020, including amendment 18, appendix 1, 3.

742 Annex 13 to the Chicago Convention, Twelfth Edition, 2020, including amendment 18, 6.8.

743 Annex 13 to the Chicago Convention, Twelfth Edition, 2020, including amendment 18, 6.8.1.

744 Annex 13 to the Chicago Convention, Twelfth Edition, 2020, including amendment 18, 6.9.

745 Annex 13 to the Chicago Convention, Twelfth Edition, 2020, including amendment 18, 6.10.

746 Annex 13 to the Chicago Convention, Twelfth Edition, 2020, including amendment 18, appendix 1, 4.

747 https://www.icao.int/safety/airnavigation/AIG/Pages/About-AIG.aspx.

748 https://www.icao.int/about-icao/FAQ/Pages/icao-frequently-asked-questions-faq-11.aspx.

749 https://www.icao.int/about-icao/FAQ/Pages/icao-frequently-asked-questions-faq-11.aspx.

750 These can be found here: https://applications.icao.int/e5web/default.asp.

mandatory and voluntary reporting systems. The section concludes with consideration of the reporting of incidents involving UAS, drawing on a recent publication by the CAA.

Obligations to report

1.19 UK Regulation (EU) 376/2014 (the "UK Mandatory Occurrence Reporting Regulation")[751] mandates the reporting of occurrences involving:

(1) the operation of aircraft;

(2) technical conditions, maintenance and repair of aircraft;

(3) air navigation services and facilities; and

(4) aerodrome and ground services.[752]

1.20 "Occurrence" is defined at Article 2(7) of the UK Mandatory Occurrence Reporting Regulation as:

> any safety-related event which endangers or which, if not corrected or addressed, could endanger an aircraft, its occupants or any other person and includes in particular an accident or serious incident.

1.21 Following the UK's withdrawal from the EU, the Secretary of State is under an obligation to adopt lists classifying occurrences.[753] At present these are contained in UK Regulation (EU) 2015/1018 (the "UK MOR Occurrences Regulation").[754] For example, ten examples of take-off and landing related occurrences are given, including taxiway or runway excursion and precautionary or forced landings.[755]

1.22 The UK Mandatory Occurrence Reporting Regulation applies to civil aircraft falling within the scope of the UK Basic Regulation.[756] However, it does not apply to incidents involving uncrewed aircraft which fall outside the certified category, unless the incident resulted in serious injury or fatality, or damage to a crewed aircraft.[757] Nonetheless,

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751 UK Regulation (EU) 376/2014 on the reporting, analysis, and follow-up of occurrences in civil aviation.

752 UK Regulation (EU) 376/2014 on the reporting, analysis, and follow-up of occurrences in civil aviation, art 4.

753 UK Regulation (EU) 376/2014 on the reporting, analysis, and follow-up of occurrences in civil aviation, art 4(5).

754 UK Regulation (EU) 2015/1018 laying down a list classifying occurrences in civil aviation to be mandatorily reported according to Regulation (EU) No 376/2014.

755 UK Regulation (EU) 2015/1018 laying down a list classifying occurrences in civil aviation to be mandatorily reported according to Regulation (EU) No 376/2014, annex I, 1.3.

756 UK Regulation (EU) 376/2014 on the reporting, analysis, and follow-up of occurrences in civil aviation, art 3(2).

757 UK Regulation (EU) 376/2014 on the reporting, analysis, and follow-up of occurrences in civil aviation, art 3(2).

the Secretary of State may decide to apply the UK Mandatory Occurrence Reporting Regulation to aircraft to which the Basic Regulation does not apply.[758]

1.23 Those obliged to report occurrences under the UK Mandatory Occurrence Reporting Regulation are:

(1) the pilot-in-command, or, in cases where the pilot-in-command is unable to report the occurrence, any other crew member next in the chain of command;

(2) a person engaged in designing, manufacturing, continuous airworthiness monitoring, maintaining or modifying an aircraft, or any equipment or part thereof, under the oversight of the CAA;

(3) a person who signs an airworthiness review certificate, or a release to service in respect of an aircraft or any equipment or part thereof, under the oversight of the CAA;

(4) a person who performs a function which requires him or her to be authorised by the CAA as a staff member of an air traffic service provider entrusted with responsibilities related to air navigation services or as a flight information service officer;

(5) a person who performs a function connected with the safety management of an airport to which Regulation (EC) No 1008/2008 of the European Parliament and of the Council applies;

(6) a person who performs a function connected with the installation, modification, maintenance, repair, overhaul, flight-checking or inspection of air navigation facilities for which the CAA ensures the oversight;

(7) a person who performs a function connected with the ground handling of aircraft, including fuelling, loadsheet preparation,[759] loading, de-icing and towing at an airport covered by Regulation (EC) No 1008/2008.[760]

1.24 Although neither the UK Mandatory Occurrence Reporting Regulation nor its guidance material appears to refer to any reporting obligation on the part of a UAS operator, the UAS Implementing Regulation requires a UAS operator to report any safety-related occurrence to the CAA in compliance with the UK Mandatory Occurrence Reporting Regulation.[761] Further, under UK Regulation 996/2010 (the “Accident Investigation Regulation") and The Civil Aviation (Investigation of Air Accidents and Incidents) Regulations 2018, the operator of an aircraft involved in an accident or serious

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758 UK Regulation (EU) 376/2014 on the reporting, analysis, and follow-up of occurrences in civil aviation, art 3(2).

759 A loadsheet is a document which enables the pilot-in-command to determine that the aircraft’s mass and balance limits are not exceeded.

760 UK Regulation (EU) 376/2014 on the reporting, analysis, and follow-up of occurrences in civil aviation, art 4(6).

761 UK Regulation (EU) 2019/947 on the rules and procedures for the operation of unmanned aircraft, art 19(2).

incident must notify the AAIB.[762] The 2018 Regulations also provides that a police officer must be informed in the event of an accident.[763]

1.25 Except in exceptional circumstances, occurrences must be reported within 72 hours of the individual becoming aware of the incident.[764] Annex I to the UK Mandatory Occurrence Reporting Regulation sets out the content of an occurrence report. This includes the information to be included regarding the aircraft, air navigation services, airspace, aerodrome, and damage or personal injury.[765]

Reporting systems

Mandatory and voluntary occurrence reporting

1.26 Under the UK Mandatory Occurrence Reporting Regulation, any organisation which provides aviation products or employs or contracts for the services of a person obliged to report an occurrence must establish a reporting system.[766] Any reports must be passed on to the CAA within 72 hours of notification.[767] The CAA must set up a reporting system to collect details of occurrences reported to the relevant organisations.[768]

1.27 In addition to providing a system for mandatory reporting, organisations (as defined) and the CAA must establish systems for voluntary reporting. Voluntary reporting concerns occurrences for which a report is not mandated (such as incidents involving aircraft falling outside the scope of the Basic Regulation) and reports by persons not obliged to report under the UK Mandatory Occurrence Reporting Regulation.[769]

1.28 In the UK, the European Co-ordination Centre for Accident and Incident Reporting Systems enables individuals and organisations to report occurrences to the CAA. Its online platform enables the reporter to submit mandatory and voluntary occurrence reports to the CAA.[770]

1.29 Voluntary occurrence reports may also be made to the Confidential Human Factors Incident Reporting Programme ("CHIRP"). CHIRP is a charity which seeks to limit the risks presented by human error, such as mistakes and misjudgements and non-

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762 UK Regulation (EU) 996/2010, art 9(1) read in line with art 2(11); The Civil Aviation (Investigation of Air Accidents and Incidents) Regulations 2018 SI No 321, reg 20.

763 The Civil Aviation (Investigation of Air Accidents and Incidents) Regulations 2018 SI No 321, reg 20(b).

764 UK Regulation (EU) 376/2014 on the reporting, analysis, and follow-up of occurrences in civil aviation, art 4(7).

765 UK Regulation (EU) 376/2014 on the reporting, analysis, and follow-up of occurrences in civil aviation, annex I.

766 UK Regulation (EU) 376/2014 on the reporting, analysis, and follow-up of occurrences in civil aviation, art 4(2) read according to art 2(8).

767 UK Regulation (EU) 376/2014 on the reporting, analysis, and follow-up of occurrences in civil aviation, art 4(8).

768 UK Regulation (EU) 376/2014 on the reporting, analysis, and follow-up of occurrences in civil aviation, art 4(3).

769 UK Regulation (EU) 376/2014 on the reporting, analysis, and follow-up of occurrences in civil aviation, art 5(4).

770 https://e2.aviationreporting.eu/reporting.

compliance with procedures. CHIRP has aviation and maritime branches. Reports made to CHIRP are anonymised and analysed, with relevant information published to prevent future occurrences. As only voluntarily reportable occurrences may be reported to CHIRP, the programme enables the dissemination of information which may not otherwise be reported.

Airprox

1.30 "Airprox" refers to situations in which the pilot or controller considers the distance between aircraft, combined with their positions and speeds, to be a threat to aviation safety.[771] ICAO mandates that such instances be reported.[772]

1.31 Such reports are made to the UK Airprox Board ("UKAB"), which is an independent organisation sponsored by the CAA and the Military Aviation Authority.[773] Reports can be made through an online form or the UKAB app. The UKAB investigates and publishes findings and recommendations following an airprox report. In the event of serious airprox cases (such as where there was a risk of collision) the AAIB (see below) may conduct a parallel investigation.[774]

Duties following reporting

1.32 Each organisation (as defined above) must appoint one or more persons to handle the collection, evaluation, processing, analysis and storage of mandatory and voluntary reports.[775] Small organisations may work together to provide this function.[776]

1.33 The CAA must establish a mechanism to perform the same functions.[777] The AAIB must have access to the CAA's database of reports.[778]

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771 Civil Aviation Authority ("CAA"), *Manual of Air Traffic Services* (March 2022) (CAP 493), section 1, ch 2, p 15.

772 International Civil Aviation Organisation ("ICAO"), *Procedures for air navigation services* (2016) (Document 1444) 16.3.1.

773 The Military Aviation Authority ("MAA") is responsible for the regulating all aspects of the Defence Air Environment, overseeing the assurance of military air systems and enforcing regulations as they relate to defence air operations.

774 ICAO, *Airprox investigation in the UK* (2007), https://www.icao.int/Meetings/AMC/MA/Assembly%2036th%20Session/wp108_en.pdf.

775 UK Regulation (EU) 376/2014 on the reporting, analysis, and follow-up of occurrences in civil aviation, art 6(1).

776 UK Regulation (EU) 376/2014 on the reporting, analysis, and follow-up of occurrences in civil aviation, art 6(2).

777 UK Regulation (EU) 376/2014 on the reporting, analysis, and follow-up of occurrences in civil aviation, art 6(3)

778 UK Regulation (EU) 376/2014 on the reporting, analysis, and follow-up of occurrences in civil aviation, art 6(9).

1.34 The identities of reporters and other relevant persons must not be revealed, in order to promote a just culture. Consequently, any storage and handling of reports must be sensitive to the need for confidentiality.[779]

1.35 Organisations must establish processes to analyse reports, determining whether any corrective or preventive action is necessary.[780] The CAA must also analyse occurrences reported to it and determine whether action is necessary.

Reporting and UAS

1.36 In May 2022, the CAA published a report concerning the reporting of incidents involving uncrewed aviation systems. The report itself uses the term RPAS, which it uses to include "drones, model aircraft and unmanned aerial systems". The report found that such incidents are under-reported. At the time of publication, the CAA received around 44 mandatory reports a month concerning RPAS.[781] Most of these were made by aerodromes, air traffic controllers or crewed aircraft, with 25% reported by the RPAS user.[782] Depending on the comparator, the CAA concluded that between 67 to 468 RPAS reports should be expected per month.[783]

1.37 The table below sets out the principal reasons for failure to make a mandatory or voluntary report, by category of uncrewed aircraft.[784]

779 UK Regulation (EU) 376/2014 on the reporting, analysis, and follow-up of occurrences in civil aviation, art 6(1).

780 UK Regulation 376/2014 on the reporting, analysis, and follow-up of occurrences in civil aviation, art 13(1).

781 CAA, *CAA RPAS Safety Reporting Project* (June 2022) (CAP 2356) p 10.

782 CAA, *CAA RPAS Safety Reporting Project* (June 2022) (CAP 2356) p 13.

783 CAA, *CAA RPAS Safety Reporting Project* (June 2022) (CAP 2356) p 72.

784 CAA, *CAA RPAS Safety Reporting Project* (June 2022) (CAP 2356) p 18. The "open" and "specific" categories of uncrewed aircraft are explained in Chapter 3.

Open category	Common across open and specific categories	Specific category
Not being aware that the occurrence needed reporting. Not knowing who to report to.	Having to report an occurrence to more than one organisation. Fear of penalisation. Belief that the operation was otherwise safe and legal. The belief that UAS are a tool rather than an aircraft, meaning that users do not view themselves as subject to aviation practices.	Reporting tool did not recognise the characteristics of UAS. Reporting tool does not work on a mobile or tablet device.

Table 12.1

1.38 At the time of writing, the CAA is entering a second discovery phase, in which it seeks to determine:

(1) how users can be encouraged to feel like a part of the aviation community and therefore subject to regulations;

(2) how existing processes can be adapted to cope with an increase in reporting volumes; and

(3) how barriers to safety reporting can be minimised.[785]

INVESTIGATION

1.39 When a report is received, in some circumstances an investigation is mandatory, or is carried out in absence of a mandate. As explained further below, these investigations do not apportion blame: investigations advance a "just culture", with investigations seeking to identify the causes of and contributing factors to an occurrence in order to facilitate the promotion of safety within the aviation community.

Statutory framework

1.40 The investigation of accidents is regulated by assimilated law. The Accident Investigation Regulation implements the Chicago Convention. For example, it is made

[785] CAA, *CAA RPAS Safety Reporting Project* (June 2022) (CAP 2356) p 87.

clear that the purpose of investigation is to prevent future accidents, rather than to apportion blame or liability.[786] Further, the definitions in the Regulation reflect those found in Annex 13.

1.41 The Accident Investigation Regulation applies to accidents or serious incidents in the UK involving aircraft to which the Basic Regulation applies (and some outside the UK, under certain conditions).[787] Incidents involving uncrewed aircraft not subject to certification under the Basic Regulation, or crewed aircraft under 2250 kg where no serious injury resulted from the incident are exempt from the obligation to investigate. Nonetheless, even if there is no duty to investigate, the safety investigation authority may do so.[788]

1.42 The Accident Investigation Regulation stipulates that following an investigation, a report must be made, containing safety recommendations where appropriate.[789] All reports must protect the identities of individuals involved in the incident.[790] A final report should be produced within 12 months; if this is not possible, the safety investigation authority must release an interim statement detailing progress it has made and flagging identified safety issues.[791] The final report must be sent to ICAO, the safety investigation authorities and civil aviation authorities of concerned states, and the addresses of the report's safety recommendations.[792]

The role of the Air Accident Investigation Branch

1.43 Under the Civil Aviation (Investigation of Air Accidents and Incidents) Regulations 2018, the AAIB is the UK's investigating authority for the purpose of Accident Investigation Regulation.[793] Forming part of the Department for Transport, the AAIB is independent of the CAA and the police. In line with Annex 13, AAIB investigations do not apportion blame or liability. The Regulations expressly state that:

> the sole objective of a safety investigation which is undertaken pursuant to Regulation 996/2010, Annex 13 or these Regulations is the prevention of accidents and incidents, without the apportionment of blame or liability.[794]

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786 UK Regulation (EU) 996/2010 on the investigation and prevention of accidents and incidents in civil aviation and repealing Directive 94/56/EC, art 1.

787 UK Regulation (EU) 996/2010 on the investigation and prevention of accidents and incidents in civil aviation and repealing Directive 94/56/EC, art 5.

788 UK Regulation (EU) 996/2010 on the investigation and prevention of accidents and incidents in civil aviation and repealing Directive 94/56/EC, art 5(5).

789 UK Regulation (EU) 996/2010 on the investigation and prevention of accidents and incidents in civil aviation and repealing Directive 94/56/EC, art 16(1).

790 UK Regulation (EU) 996/2010 on the investigation and prevention of accidents and incidents in civil aviation and repealing Directive 94/56/EC, art 16(2).

791 UK Regulation (EU) 996/2010 on the investigation and prevention of accidents and incidents in civil aviation and repealing Directive 94/56/EC, art 16(6).

792 UK Regulation (EU) 996/2010 on the investigation and prevention of accidents and incidents in civil aviation and repealing Directive 94/56/EC, art 16(6).

793 The Civil Aviation (Investigation of Air Accidents and Incidents) Regulations 2018 SI 2018 No 321, reg 7.

794 The Civil Aviation (Investigation of Air Accidents and Incidents) Regulations 2018 SI 2018 No 321, reg 8.

1.44 This means that, while the police may conduct a parallel investigation into an aircraft accident, the AAIB will not assist in a criminal investigation.[795] The focus on the protection of the public, rather than the apportionment of blame, is designed to reassure witnesses and enable the AAIB to gather a large range of evidence. The anonymity of individuals within AAIB reports, as mandated by the Accident Investigation Regulation, adds to the confidence of witnesses. However, findings of the AAIB contained in a published report may be used in a civil or criminal case.[796]

1.45 AAIB investigators are divided into four groups based on expertise: operations inspectors, engineers, flight recorder specialists, and human factors inspectors. Operations investigators hold pilot's licences and are often ex-commercial or test pilots. These investigators consider the context of the accident including its flight path and all passengers and crew on board. Engineers maintain technical knowledge of aircraft developments through courses conducted by aircraft manufacturers. In the case of an accident, engineers may use evidence gathered at the scene in order to determine the circumstances of the accident, such as the angle of a collision and whether a structural failure is indicated by the absence of aircraft components. Flight recorder specialists gather and interpret recorded data, such as that from a cockpit voice recorder, GPS system and cameras.[797] Human factors inspectors consider evidence relating to the actions of people to understand how individuals involved in an accident acted and why.[798]

1.46 Following the report of an accident or serious incident, the AAIB will determine the level of investigation needed. For example, in the event of an accident involving a light aircraft and resulting in no serious injury, the AAIB are likely to be satisfied with the pilot completing a questionnaire. For more serious incidents (around 30 to 40 per year) the AAIB will send inspectors to the site of an accident or location of the aircraft involved in the incident. In these cases, an operations inspector, engineer, and flight recorder specialist will be sent to the scene of the accident, where the wreckage is analysed and recovered. The physical wreckage, alongside any data recovered from the aircraft, is analysed by the relevant specialists. A final report will be published at the end of the investigation, although an interim bulletin may be produced in the case of important findings.[799]

UAS and accident investigation

1.47 UAS are relevant to an overview of accident investigation in two ways: as an aid in accident investigations and as the subject of an investigation.

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795 UK Government, *Memorandum of Understanding between the UK Accident Investigation Branches and the National Police Chiefs' Council,* https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/769054/MOU_Between_AIB_and_NPCC_December_2018.pdf.

796 For discussion of the admissibility of an AAIB report in civil proceedings, see *Rogers v Hoyle* [2014] EWCA Civ 257, [2015] QB 265.

797 https://www.gov.uk/government/organisations/air-accidents-investigation-branch/about.

798 https://www.gov.uk/government/organisations/air-accidents-investigation-branch/about/recruitment#human-factors-investigation-at-the-aaib.

799 https://www.gov.uk/government/organisations/air-accidents-investigation-branch/about.

Using UAS in accident investigation

1.48 Currently, the AAIB uses UAS to gather information at the site of an accident. Drones were first used by the AAIB in 2014 to take aerial photos and videos of an accident site. The use of UAS for photography means the entirety of an accident site can be captured; photographers on the ground are unlikely to be able to capture fully the accident and its surroundings.[800]

1.49 As technology has advanced, UAS have been used to produce 3D images and reconstructions of accident sites. UAS are programmed to fly around the site, capturing images which are used to provide an accurate 3D image.[801] The availability of accurate images of accident sites is particularly useful once the wreckage has been recovered and the evidence can no longer be analysed at the site.

Accident investigation of small UAS

1.50 The AAIB began investigating accidents involving UAS in 2015. There was no obligation on the AAIB to conduct these investigations as at the time, the Accident Investigation Regulation only mandated investigations in cases of UAS weighing more than 150kg and there were no civilian UAS meeting this criterion in the UK. The AAIB exercised its discretion to investigate, with the following objectives:

(1) to prepare for serious accidents or mid-air collisions;

(2) to identify trends which would inform future regulation;

(3) to inform the UAS manufacturers of design issues;

(4) to make safety recommendations to prevent recurrence.[802]

1.51 In 2022, around 18% of notifications received and 21% of safety recommendations made by the AAIB involved UAS.[803] This already significant percentage is likely to increase in view of the move towards the widespread use of UAS. As such, issues of investigatory capacity may need to be addressed.

1.52 Further, the AAIB's 2021 report states that UAS accident investigation is usually conducted through correspondence, although complex cases may warrant a field investigation.[804] As technology advances and more complex, larger UAS are

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800 https://www.gov.uk/government/publications/how-we-use-drones-at-air-accident-sites/how-we-use-drones-at-air-accident-sites.

801 https://www.gov.uk/government/publications/how-we-use-drones-at-air-accident-sites/how-we-use-drones-at-air-accident-sites.

802 AAIB, *Annual Safety Review 2021* (2022) p 5, https://assets.publishing.service.gov.uk/media/62a1c1b1e90e070396c9f75d/Annual_Safety_Review_2021.pdf.

803 Air Accidents Investigation Branch ("AAIB"), *Annual Safety Review 2022* (2023) p 22, https://assets.publishing.service.gov.uk/media/64492a1ef12683000cca68b6/AAIB_Annual_Safety_Review_2022.pdf.

804 AAIB, *Annual Safety Review 2021* (2022) p 6, https://assets.publishing.service.gov.uk/media/62a1c1b1e90e070396c9f75d/Annual_Safety_Review_2021.pdf.

certified,[805] it may be the case that fewer investigations can be conducted through correspondence. Combined with the increasing use of UAS, this may increase the strain on AAIB resources.

1.53 The primary cause of UAS accidents in 2022 was a loss of control in flight, usually caused by the UAS being unresponsive to control inputs or providing unexpected responses.[806] The 2021 report lists some findings from UAS investigations. These include the finding that a 1.4 kg uncrewed aircraft falling from eight metres could cause a fatal injury and a list of some of the technical reasons for such failures. Furthermore, the report notes some flaws in the design and manufacture of UAS. It states that some parts of the UAS industry have no background in aviation and that some issues found in UAS mirror those found in the early days of crewed aviation. For example, a lack of redundancy in design is said to be a "mistake" rectified in crewed aviation decades ago.[807]

FUTURE CHALLENGES

1.54 The use of an independent investigations body and the emphasis on a just culture is one that is firmly embedded within aviation, as well as other transport domains. With novel forms of flight, including autonomous flight, it will become even more important to ensure that lessons are learnt from accidents. There may however be ways in which existing rules and practices will need to be updated to reflect technological advances. Nonetheless, it seems the existing regulatory framework is, at least currently, suitable for the investigation of air accidents involving UAS, with the 2022 report stating:

> With the increase in unmanned aircraft, the AAIB has had to adapt quickly to new technology. The regulations were well suited to allow the investigation of these aircraft which meant there was not much adjustment needed. These established investigation principles have allowed the AAIB to provide valuable learning that has fed into the development of new technologies such as those in urban air mobility, autonomous aircraft and new fuel technologies.[808]

1.55 In relation to investigations, it is likely that the AAIB's existing investigatory methods will require updating to reflect increased autonomy. As discussed in Chapter 4 at paragraphs 4.60 to 4.62, artificial intelligence can lack explainability: the reasons why an autonomous system behaved in a particular way may be difficult or impossible to establish. This poses obvious problems in investigation, as it may be difficult or impossible to determine why an accident has occurred. Consequently, an effective

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805 See Chapter 4 paras 4.48 to 4.54 for a discussion of the certification requirements.

806 AAIB, *Annual Safety Review 2022* (2023) p 30, https://assets.publishing.service.gov.uk/media/64492a1ef12683000cca68b6/AAIB_Annual_Safety_Review_2022.

807 AAIB, *Annual Safety Review 2021* (2022) p 9, https://assets.publishing.service.gov.uk/media/62a1c1b1e90e070396c9f75d/Annual_Safety_Review_2021.pdf.

808 AAIB, *Annual Safety Review 2022* (2023) p 9,

investigation is likely to be possible only if artificial intelligence is (at least to some degree) explainable and the relevant data is made available to the AAIB.

1.56 Further, challenges may arise in relation to obtaining information about software used due to the proprietary concerns of manufacturers. This is not a new issue, but its prevalence may increase due to the introduction of autonomous systems. While obtaining information from manufacturers is rarely an issue in the UK, as the AAIB has the power to obtain this information, it can be more difficult where the software belongs to a foreign manufacturer. In this case, the AAIB will collaborate with the relevant safety investigation authority, which may not have legal powers equivalent in strength to those of the AAIB in relation to obtaining information.[809]

1.57 Our initial review suggests however that these challenges are of a practical and technical nature, rather than legal.

[809] UK Regulation (EU) 996/2010 on the investigation and prevention of accidents and incidents in civil aviation and repealing Directive 94/56/EC, art 6.

Appendix 2: terms of reference

PREPARING FOR AUTONOMY IN AVIATION

1.1 We set out below terms of reference in respect of work for the Law Commission.

Introduction

1.2 Innovation in technology is paving the way for greater automation and autonomy in aviation. This has the potential to bring about substantial benefits to the entire aviation system, UK industry, and the public. For this potential to be realised, it is imperative that the UK's legislative and regulatory framework is both sufficiently agile to facilitate innovation and robust enough to maintain high safety standards. If the existing legislative framework cannot reliably answer questions from operators, insurers, regulators or investors, technological progress may stall.

1.3 Modern pilots are familiar with automated functions within the cockpit that can carry out complex tasks with little intervention. The introduction of unmanned aircraft systems[810] has seen a rapid advance in software and hardware systems that can carry out a whole flight, from take-off to landing, without any remote pilot intervention. This involves a scaling up of the functions that are automated – that is, functions performed through pre-programmed logic, waypoints, or routines designed to achieve end-to-end operation. Beyond even greater automation, there is the prospect of autonomous flight systems based on technology that uses machine learning or artificial intelligence. These are often non-deterministic systems that operate, observe, learn, and adapt without human intervention. They will present new challenges beyond those presented by increased automation in the cockpit.

1.4 We can say with confidence that these challenges will include the following:

(1) High automation and autonomous systems in aviation will change the role of the pilot, or remote pilot, and may in due course remove the need for a pilot in command, in the aircraft or from a remote pilot station.

(2) Traditional liability models (criminal and civil) which rely on human mental states will be strained and safety assurance will require different approaches to regulation.

[810] Also referred to as remotely piloted aircraft systems (RPAS).

(3) New forms of aircraft such as electric vertical take off and landing (eVTOL) craft are being developed with these advances in technology in mind. The advanced air mobility market is attracting significant investment and R&D, and may require adaptation to the legislative framework to accommodate this emerging industry safely.

(4) Safety roles will change; air traffic management / air navigation services systems may themselves benefit from or require increased automation, or the use of autonomous systems, to manage safely a diverse range of air traffic.

1.5 The Civil Aviation Authority (CAA), with the support of Department for Transport (DfT), has asked the Law Commission to undertake a review of aviation legislation to prepare the UK for autonomy in aviation. The aim is:

(1) First, to review the existing legislation with a view to identifying any legislative blockers, gaps or uncertainties to the safe deployment of high automation and autonomous systems in aviation.

(2) Secondly, to propose law reform measures aimed at making sure that the legislative and regulatory framework is ready for the oncoming advances in automation in aviation and autonomous flight.

1.6 The Law Commission will be working closely with the CAA and the Department for Transport in developing its reform proposals. It will engage key stakeholders in the aviation and AI sectors to understand the challenges. The review will be heavily based on consultation and will retain an element of agility in order to be able to deliver on priority areas within the proposed time frame for this project (two years).

Scope

1.7 The scope of the review is as follows:

(1) To consider the reforms necessary to provide a robust and future-proofed legal framework capable of supporting the safe deployment of high automation and autonomous systems in aviation (collectively "autonomous systems"), including the following:

(a) Drones (remotely piloted, non-passenger carrying vehicles);

(b) Advanced Air Mobility (such as electrical vertical take-off and landing vehicles providing short journeys for up to ten people); and

(c) Air Traffic Management and Air Navigation Services (including Communications, Navigation and Surveillance and Aeronautical Information Services).

(2) The review will consider domestic UK legislation (including retained EU legislation) but will have regard to international law, notably the Chicago Convention and Annexes.

(3) In particular, the review will seek to identify:

(a) Areas where the law allocates responsibilities (including safety responsibilities) to a human person (for example, the pilot or air traffic controller), and the issues that arise (including for associated regulatory oversight) where an underlying function is performed by autonomous systems.

(b) Any issues that arise in the attribution of civil and criminal responsibility where control is shared between the autonomous system and a human user, including ramifications for insurance.

1.8 Whilst they are not the focus of the review, in delivering the above-described scope the Law Commission will have regard to the following:

(a) Terminology relating to automation and autonomy in the aviation sector and issues that may arise if this terminology is not used consistently.

(b) The desirability of harmonising approaches to transport autonomy, and the extent to which aviation law might benefit from emerging approaches across the automated and autonomous operation of different types of transport, such as the Law Commission's project on automated vehicles.

(c) Data.

1.9 The project will be confined to civil aviation, and will not extend to:

(a) Defence;

(b) Cybersecurity and terrorism;

(c) Land use; or

(d) Labour relations.

Work products and sequencing

1.10 The **first phase** of the review will focus on the current legislative framework, seeking to identify issues and challenges to the safe deployment of high automation and autonomous systems in aviation, including obstacles, legislative or regulatory gaps, and areas of uncertainty.

1.11 The scope of the second phase will depend on the size of the task identified in phase 1. Following the first phase, a review point will see the Law Commission, CAA and DfT agree which issues identified in the first phase will progress to the second, bearing in mind the available time and resources.

1.12 The **second phase** will, after a public consultation, make recommendations to reform the law aimed at ensuring that the issues identified in the first phase, or priority issues agreed at the review point, are addressed so that the legislative framework is ready for the oncoming advances in automation in aviation and autonomous flight.