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Civilian Drones

Civilian use of unmanned aircraft (UA) is increasing rapidly as the technology improves and becomes more affordable. The UK has technical expertise in this area and is also at the forefront of national and international regulatory discussions. This briefing provides an overview of the current and future applications, opportunities and barriers surrounding civilian use.

Overview

- Drones, also known as unmanned aircraft (UA), are flown without a pilot on board.
- The UK has technical and regulatory expertise in this area.
- Current civilian applications of UA include aerial photography and filming, mapping and monitoring.
- The biggest challenges for civilian UA are safe and effective integration with other users of airspace, including how they are controlled by users, as well as insurance and privacy.
- In the near future, UA are expected to be a routine part of air traffic, once they are able to integrate safely with other airspace users.
- Policies governing UA in UK, EU and international airspace are informed by national and international aviation bodies.

Background

What are Unmanned Aircraft?

In the popular media, unmanned aircraft are referred to as 'drones'. Since 'drone' can refer to things other than unmanned aircraft (UA), this note uses UA throughout. Unmanned aircraft are reusable, aerodynamic flying systems that can be remotely piloted via a joystick or digital interface supported by different levels of automatic control.[1] UA are supported by infrastructure such as control stations and data links, which collectively are referred to as 'Unmanned Aircraft Systems' (UAS).[1] All civilian UA currently in use in the UK require a remote pilot. In other literature, these may be referred to as 'Remotely Piloted Aircraft Systems' (RPAS).[2]

UA are either helicopter-like with rotary blades or aeroplane-like with fixed wings. UA were originally developed for military purposes and are still frequently deployed in high-risk military settings.[3] In 2013, the Minister for Universities and Science included 'Robotics and Autonomous Systems' as one of the '8 Great Technologies' where the UK has technical expertise and business capacity (see also POSTnote 443).[4] For regulatory purposes UA are allocated to different weight categories:

- **Small UA** (20 kg or less) are regulated at the national level by the UK Civil Aviation Authority (CAA). Box 1 outlines legislation for operators, which makes some distinction between 0 to 7 kg and over 7 to 20 kg. They are generally battery powered, with a typical flight time of less than an hour and a payload of several kilos.[5] They cost from a few hundred pounds and are widely used by hobbyists and increasingly by commercial operators.
- **Light UA** (over 20 kg to 150 kg) are also licensed at national level (CAA); however, regulation is stricter than small UA because of an increased potential for harm should an accident occur. Their flight time and payload capabilities fall between small and large UA.
- **Large UA** (over 150 kg) are licensed at the European level by the European Aviation Safety Agency (EASA), with stricter regulation than small or light UA. They are generally powered by internal combustion engines, with a flight time of 16 hours or more.[6,7] They are currently not widely used in the UK and Europe, as they require significant investment costs. Their payloads range from tens to hundreds of kilogrammes.[2,8] There is one large UA in use in the UK, Watchkeeper, operated by the Ministry of Defence since March 2014, which is designed to be used for intelligence, surveillance and reconnaissance.[9]

Box 1. UK Legislation for UA

UK law states that that UA over 7 kg should not be routinely flown:

- in controlled airspace (e.g. around airports), except with the permission of an air traffic control (ATC) unit
- in any aerodrome traffic zone except with the permission of ATC or the person in charge of the aerodrome
- at a height exceeding 400 ft above the surface.

In visual line of sight operation, UA should not be routinely flown at a distance beyond the visual range of the remote pilot or observer, or a maximum range of 500 m, whichever is less.

Small UA for surveillance should not be routinely flown:

- over or within 150 m in any direction of any densely populated areas.
- within 50 m of any person, vessel, vehicle or structure, except during take-off or landing, nor within 30 m of any person, unless persons or objects are under the control (or instruction) of the Remote Pilot.

Current use

It is difficult to quantify the current use of UA in the UK. The small UA that dominate the market are cheap and easily purchased, and are not formally accounted for. Commercial users of UA of all sizes must register with the CAA, which has seen a significant rise in the number of applications.[2] In 2014 there were 230 applications for commercial users in the UK, an increase from five in 2010, all in the small UA category.[10] The CAA and other bodies have noted a need for clear regulation to ensure safe integration of UA into national and international airspace.[11]

Uses of Civilian Unmanned Aircraft

The main applications of UA are broadly defined as:

- looking: using sensors to measure surroundings
- carrying: transporting useful payload including freight.

Civilian use of UA has increased across a range of applications, including in remote and inaccessible settings that would be challenging to human aircrew.[12] They are also used where human life or health may be put at risk. Some UA are designed to be relatively expendable and therefore suited to hazardous environments.[13] Potential applications are significantly broader than this.

The most common payloads on small UA systems in use in the UK include cameras or other imaging apparatus. Small UA have been used in a range of civilian applications:[14]

- photography and filming for research and commercial use (e.g. broadcast TV)[15]
- environmental monitoring – atmosphere, biodiversity, conservation, habitat mapping, geology, ice and snow[16,17]
- informing the precision application of agricultural treatments[18]
- mapping[19]
- infrastructure inspection, e.g. oil and gas pipelines[20]
- emergency services, e.g. search and rescue, fire and policing.[21]

An example of current use in the UK is by URSULA Agriculture, an agricultural data company that combines images from UA, manned aircraft and satellites to produce maps to inform agricultural management decisions such as the precise application of fertilizers and pesticides.[22]

Box 2. Existing Civil Aviation Legislation

International

- The Chicago Convention on Civil Aviation (1944) established the International Civil Aviation Organisation (ICAO) to oversee the introduction of common rules for international airspace.[23]

UK

- The Air Navigation Order (ANO) 2009 draws together legislation covering aircraft, air traffic control, crew, passengers and cargo.[24]
- Rules of the Air Regulations (RoA) 2007 sets out general flight rules and guidance for aerodrome traffic. Small UA are specifically exempt (ANO makes the person in charge responsible for flight safety).[25]

Societal and Public Attitudes

Public opinion of UA is likely to shape how they are used and thus industry development.[26] Currently UA are perceived to carry military connotations because of their widely reported use in conflicts.[27] A significant proportion of the discussion on UA surrounds their use in warfare and the ethical implications regarding the decisions and actions of 'autonomous' vehicles.[28] Many operators have designed information campaigns for the public and media to promote the use of UA in civilian contexts and to encourage 'positive' perceptions of the technology.[29] Concern also exists around uncontrolled growth and lack of regulation for UA, leading to potential overcrowding of airspace and safety issues.[30]

Legislation and Regulation

UA must adhere to existing international aviation legislation governing flight and air travel (Box 2). The aviation authorities of many countries provide their own national level regulatory guidance and are considering requirements for integrating UA into their national airspace. Operations have the potential to span international geographic boundaries, presenting challenges for standardising guidance across numerous national regulators.

International Guidance

All civil aircraft (manned and unmanned) operate subject to the Chicago Convention (Box 2). The International Civil Aviation Organisation (ICAO), a UN agency that oversees the development and safety of air transport, has set timelines for integrating all UA classes:

- by 2018 – initial integration into air traffic in non-segregated airspace
- by 2028 – full integration so that there is 'transparent operation within the airspace' and UA are visible to, and able to communicate with, air traffic control.[31]

Integration is important to ensure the long-term safety of UA in shared airspace, allowing full operation with all other airspace users. The US Congress recently passed legislation that mandates the US airspace regulator (Federal Aviation Administration) to open up its airspace to UA by 2015.[32] This legislation calls for the definition of technical, airspace and safety standards. EC Regulation 1592/2002 currently provides UA-specific guidance, which applies to UA over 150 kg not designed for research or military purposes.[33] The EU published a working paper in 2012 setting out its aim to integrate UA into European air traffic by 2016.[34] EASA, an EU agency that regulates air safety, has developed a roadmap proposing steps to achieve UA integration into European air space from 2016.[35] It considers safety, technological developments and societal aspects, setting progressive integration targets based on all of these factors.

UK Guidance

All civil aircraft (manned and unmanned) operate subject to the Air Navigation Order 2009 (ANO, Box 2).[24] ANO Articles 166 and 167 provide specific guidance on safety, and information for small UA. The UK CAA has detailed guidance, Civil Aviation Publication (CAP) 722, which addresses airworthiness and operational standards for UA in UK civil airspace including legal issues, operating principles, airspace permissions, technical issues, safety, cross-border operations and human factors such as training, ergonomics and exemptions, for example for certain operations beyond visual line of sight.[2] Commercial operators, in addition to this, must be registered, trained and insured prior to commencing commercial work. The CAA advises that to integrate with other airspace users, UA operators must demonstrate equivalent compliance with the rules and procedures that apply to manned aircraft.[2]

UK Role in Developing Future Regulation

UK CAA's CAP 722 is frequently cited in the development of international guidance for UA.[36] Should UK standards be adapted internationally, as a precedent for other regulatory systems, industry and operators expect that this would put the UK in a strong market position. Regulatory development is taking place amid growing concerns regarding unregulated or uninsured small commercial operators presenting issues for safety, economy and the overall perception of the sector.[37,38] There is a desire across regulatory communities to keep pace with technological development, to ensure the safe delivery of civilian UA systems to market across a broad range of scales and applications.[39]

Challenges

UA permit a number of exciting practical applications and potential new uses of airspace, however, they face a number of technical, legal and social challenges.

Battery Life, Payload and Flight Time

Modern UA depend largely on the novel application of many existing technological components. Miniaturisation and mass-production of airframes, batteries and sensors have been, and continue to be, key to the development of small UA.[40] Small systems have limited space for carrying batteries and payloads. Any additional loads pose a challenge to battery life and heavy loads may impede flight, which restricts flight time and options for instrumentation.

Detecting and Avoiding Obstacles

An effective 'detect and avoid' (DA) (or 'sense and avoid') system would assist in navigating around obstacles. DA systems equivalent to the performance of a human pilot are required when operating beyond visual line of sight in non-segregated airspace. This enables the system to perform functions that would normally be done visually by the pilot such as navigating difficult terrain and sequencing manoeuvres between multiple air users (e.g. during take-off and landing).[41] DA capabilities for large UA platforms are being developed but tend to be very large and expensive and are not currently scalable to small UA.[42]

Communication with Operators and Other Air Users

There is limited allocated radio spectrum (61MHz) for safety-critical aspects of UA in the UK.[2] At present the two most commonly used frequencies are a band designated for model aircraft and a licence-free band used for a wide range of applications such as car wireless keys and household internet. Although the latter is considered to be far more robust, problems can occur in areas where there are many other users.[2] It is expected that UA will eventually require parts of the spectrum protected for aeronautical use or satellite communications links.[2] Work is ongoing to ensure the integrity of communications links as UA operating using standard GPS systems can be relatively easily hacked and jammed or 'spoofed', whereby they are misdirected to false co-ordinates posing a danger to operators and civilians.[43]

Autonomy

Autonomy is a complex technical and safety issue. The UK CAA defines autonomous systems as having the ability to make a rational evaluation of the "choices available and the possible courses of action that could be taken". Current UA systems are still pre-programmed (i.e. automatic) rather than fully autonomous. For the foreseeable future, direct responsibility via human pilots will still be required for unmanned flights, especially those operating in close proximity to other air users and populations.[2] Contemporary manned aircraft may contain autopilot systems that can act automatically for a number of basic functions, especially safety contingency.[44] It is expected that fully autonomous systems would need full 'situational awareness' being able to follow or plan a route, sense, avoid and communicate with other air users, and find and rectify faults. Levels of potential autonomy are increasing with full autonomy on the technological horizon.[12]

Insurance

The Civil Aviation (Insurance) Regulations 2005 state that aircraft operators are required to hold 'adequate insurance to meet their liabilities in the event of an accident' including third party accident insurance.[45] Liability in autonomous systems is a complex legal and ethical issue and many insurance companies are still working to determine UA risk.[46] No robust guidance currently exists on liability for the actions of a highly autonomous system.

Airspace Operations and Airworthiness

Guidance for the use of UA in the UK aims to ensure safety for all airspace users (Box 1).[47] Technical requirements relate to the ability to operate and stay in the air, under consistent control[2]. Airworthiness takes into account the technical and operational aspects of the systems being operated, providing certification as necessary. As UA can differ considerably in their construction from manned aircraft, framework safety assessments for components are being considered as a means of proving airworthiness.[2]

Licensing and Training of Pilots

There are a growing number of 'recognised' courses that pilots of small UA can attend.[48,49] The Basic National UAS Certificate for Small Unmanned Aircraft (BNUC-S™) and the Remote Pilot Qualification – Small Unmanned Aircraft (RPQ-S) are UA-specific courses recognised by the CAA as evidence of pilot competence for small UA. At present, larger systems tend to be flown by experienced pilots with licenses for manned aviation and in future will require an appropriate regime for remote pilot licensing. Up to 85% of manned aircraft incidents are now thought to be due to pilot error, which is proportionally due to technical issues being removed by improved design processes.[50] Because of differences in construction, piloting and application of UA, different proportions of errors may come from pilots or remote operators and other technical parts of the system.[51]

Surveillance and Privacy

There is notable concern around the use of UA for surveillance and the implications that UA equipped with cameras have for privacy.[52] The current consensus in the UK is that UA will be dealt with under existing legislation covering CCTV surveillance and privacy, such as the Data Protection Act (1998).[53] A number of bodies including Privacy International and Big Brother Watch believe this is insufficient.[54,55] There is no proposed legislation to cover the additional surveillance capabilities (mobility, low visibility and persistence) of UA compared to traditional CCTV.[53]

Future Developments

Market Size Projections

An EU Commission report sees the emergence of civil applications of UA as a source of economic growth and jobs, promoting industrial competitiveness and development of SMEs.[56] The US and Israel are the largest manufacturers because of their long history of military UA development.[57] The UK spent more than £2bn on military UA between 2007 and 2012.[58] Large UA are likely to be unaffordable in the near-term other than to large institutions.[59] Service models for small UA are a potential area of commercial sector growth in the UK, when legislation and technology allow piloting in mixed airspace (and range beyond visual line of sight).[60] To date, adoption pathways for UA technology have taken a bottom-up route with hobbyists and small commercial operators prominent. Small UA dominate the civil sphere in the UK and are likely to do so for around 10 years under current regulations.[61]

Possible New Applications

UA are perceived as an uncertain technology with many opportunities for applications still to be fully realised.[62] Some likely future applications for UA include: inspection and repair, environmental management, disaster response and management, hazardous situations such as nuclear safety, maritime and border surveillance, freight and air transport.[14] Many bodies which currently use UA in their work undertake the same evaluation as other technical options regarding benefits, capabilities and limitations, with safety and cost effectiveness as key considerations. UA may act as substitutes or additional tools with skills for certain jobs; and could be hired rather than bought.[63]

UK Role in Developing UA Sector

The UK is perceived as one of the strongest nations in the international marketplace for civilian UA with respect to regulatory development, technical expertise and existing aerospace infrastructure. Since 2003, a privately owned test site for research and development on UA has been located at West Wales Airport, a converted former military site where UA flights can be conducted in an extensive area of segregated airspace.[64] There are limitations to the types of larger systems that can be flown from this site because of the size and specifications of the runway, and discussions are ongoing regarding the need for the development of additional sites.[65] There are a growing number of UK examples of SMEs using UA in commercial settings and a UK technology strategy for commercial UA.[66,67]

UK Research

UK research in UA is broad ranging across academia, industry and commercial operators.[12] Numerous academic departments have UA research units, working on aspects ranging from novel biologically-inspired airframes and operating modes (such as the ability to control multiple systems through a single operator) to control software and machine intelligence.[68,69,70] Others focus on improving the use and utility of UA in current applications, and trialling in new applications.[9] Industrial and commercial operators have many of the same R&D foci, building more robust and effective components and systems and increasing the technical capabilities of systems in service.[71] There is a stated need to combine further research with test flying of UA technologies, seen as critical to making the safety case in order to review and validate current regulations[72], as currently taking place in phase three of the Autonomous Systems Technology Related Airborne Evaluation & Assessment Programme (ASTREAEA). This £62 million consortium funded by industry, academic and regulatory bodies seeks to develop the technologies and operating procedures for UA in all classes of UK airspace.[73] UA Knowledge Transfer Networks (via Innovate UK and Innovation Hubs in Scotland) are also rolling out community approaches to development and best practice.[12]

Endnotes

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