House of Commons

Science and Technology Committee

Commercial and recreational drone use in the UK

Twenty-Second Report of Session 2017–19

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Report, together with formal minutes relating to the report

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Science and Technology Committee

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The integration of drones into society carried substantial opportunities and risks that the Government must address. We heard that the Government had already taken some action to reduce the risks posed by drones, and had announced plans to introduce a Drones Bill in late 2019, but that much more was needed to ensure current drone users were not unfairly penalised, and that criminal drone users faced substantial punishments.

We recognise the importance of extending Flight Restriction Zones to five kilometres. However, these restriction zones are not clearly or consistently enforced. The lack of a standardised process results in inconsistent denials and permissions being granted to those applying. This is unacceptable. The Government should commission the production of a standardised and unified system through which drone operators can request access to Flight Restriction Zones.

Further, there is a compelling case for the Government to introduce a registration scheme to be able to identify all lawful operators and to ensure that there is a knowledge test for drone users. Flying a drone is a skill and therefore it is appropriate for there to be a test to make sure the operator is fit to operate a drone. The Government, or the appropriate regulatory body, such as the Civil Aviation Authority, should review the proposed online test one year after it has been in operation.

In addition to this, if the registration fee dissuades individuals from registering, then this defies the purpose of the system—to improve the safety of our airspace. The Government should conduct a review of the cost of the registration scheme. If the Government believes it is appropriate for the fee to remain at £16.50, then they should clearly set out their rationale for the cost and the renewal period should be three years rather than yearly.

We recommend that the Government consider a system which allows organised clubs and societies to register as one entity, so as not to financially burden each member. However, it must be mandatory for every individual user to adhere to the required safety standards.

Finally, in terms of the proposed registration system, the Government should acknowledge that the scheme will do little to mitigate the risks from nefarious drone users who will simply bypass registration and testing. We recommend a sliding scale of penalties for failure to register, starting with a warning, and culminating in a fine and a prison sentence.

We are concerned that the Government does not appear to have made any independent assessment of the potential economic benefits and opportunities that arise from the

growing drone industry. To properly harness the benefits of drones the Government will need to analyse their potential economic contribution. The Government should provide an assessment of how the growing drone industry might contribute to the UK's economy by the time of the 2020 Spring Statement.

Throughout the inquiry, we heard that drones can have a positive effect on society, including through medical delivery and emergency service provision. By utilising drones, emergency services can conduct missions that were previously unsafe or not possible, as well as being able to respond quicker to incidents. We are encouraged to see the Government has allowed exemptions for emergency services to use drones beyond the visual line of sight in their operations, however, this provision does not apply to other organisations (such as Mountain Rescue) who might be involved in emergency service-led rescue missions. The Civil Aviation Authority should make it possible for organisations which are used in emergency missions to apply for emergency service exemptions to the Air Navigation Order 2016.

In terms of the risks that drones pose, we are concerned that there are differing accounts within the aviation community about the likely severity of damage of a drone collision with an airplane. Furthermore, there are differing accounts of the number of near misses and the reliability of airprox reports has been disputed. The Committee is concerned that there is no agreed position on the likely consequences of a drone-airplane impact. The Government should complete a substantive risk assessment of the risks drones pose to manned commercial aircraft and publish the findings of this assessment by the end of 2020.

Further, we recommend the Government make the weaponisation of a drone a specific criminal offence within the upcoming Drones Bill and consider stringent penalties for those who take such action, such as those introduced in the USA. We also recommend that the Ministry of Defence make malicious drone use a top intelligence priority.

There is a notable distrust towards drones among the general public that needs addressing if the UK is to maximise the opportunities presented by drones. The Government should act to improve public perception and awareness of drones by launching a public awareness campaign, no later than Summer 2020, that highlights the opportunities presented by drones and informs the public on the reality of the risks posed by drones.

We heard that drone safety education was vital for the safe use of drone by recreational users. The Government should mandate that a copy of the Drone Code is provided with each drone sold in the UK. The Drone Code should also be publicised in common drone flying areas. This should be rolled out as quickly as possible and implemented in full no later than the end of April 2020.

There is no justifiable reason why a drone should not have in-built safety features as standard. The Government must ensure that all manufacturers include safety features, such as geo-fencing and electronic conspicuity as standard in their drones. Further, it should be a criminal offence to disable such features. Penalties for doing so should be set out clearly in the forthcoming Drones Bill. The Government should ensure all drones, including existing drones, are electronically conspicuous within two years.

We recognise that drone technology is moving at pace, carrying with it a multitude of opportunities and risks. The Government needs to act to ensure that it can stay ahead of the curve in the future. The Government should produce a White Paper by Summer 2020 that outlines the vision for how drones will be integrated into UK communities over the coming years.

1 Introduction

Drones in the UK

1.   Drones—also referred to as Unmanned Aerial Vehicles (UAVs), Remotely Piloted Aircraft Systems (RPAs) or Unmanned Aerial Systems (UASs)—have been the focus of significant media attention. For example, reports of drone sightings at Gatwick Airport in December 2018 caused significant disruption and highlighted the need for further recognition of the substantial rise in the purchase and use of commercial and civilian drones more widely. A February 2019 House of Commons Library briefing cited an estimation from the Civil Aviation Authority that British consumers purchased 530,000 drones in 2014 and that over the Christmas period in 2017, a further 1.5 million were anticipated to be sold.[1] Further, a 2018 Report from Nesta, an innovation foundation based in the UK, explained that in August 2018 there were 4,530 operators with permission for commercial operation of drones in the UK.[2] This number represented a massive increase on the last few years: in 2010 there were five commercial permissions for operation, 110 in 2013 and 1,769 in mid-2016.[3] Drones can also include those that operate in water or on land, however, in this Report we have only focused on aerial drones and their integration into the airspace. When we refer to drones, we are referring to airborne drones.

2.   All these factors therefore raised questions about the future use of drones and the opportunities and risks of such usage. Throughout this inquiry, we were told by many witnesses, including PwC, Thales, Nesta and the then Minister for Aviation, that the use of drones had many societal and economic benefits, and were currently being used in a number of different industries including:

- photography;

- videography;

- infrastructure inspection;

- search and rescue missions; and

- organ delivery.[4]

We also heard that Amazon had already successfully trialled the use of drones to deliver goods in the UK in 2016, and that in America in 2020, drone taxis would be trialled for the first time.[5] In a recent report from PwC, *Skies without limits: Drones - taking the UK's economy to new heights*, they predicted that by 2030, 628,000 people would be working in the drone industry in the UK and this would have a £42 billion net positive impact on the economy.[6]

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1   "Civilian Drones", Briefing paper CBP 7734, House of Commons Library, February 2019
2   Duffy, R, "Mapping the UK drone industry", Nesta, September 2018
3   Ibid
4   PwC, "Skies without limits: Drones - taking the UK's economy to new heights", 2018; Thales (RDU0134); Q441; Nesta, 'Flying High: The future of drone technology in UK cities' (July 2018)
5   Q274, Q294
6   PwC, "Skies without limits: Drones - taking the UK's economy to new heights", 2018

3.   However, we were also told throughout the inquiry that drones might present a substantial risk to both safety and privacy as they were incorporated into our airspace. Captain Tim Pottage, representing the British Airline Pilots Association, told us that the risk of a drone colliding with an aircraft was "very real", and could potentially cause fatalities if it collided with the windscreen of a plane.[7] Further, according to the UK Airprox Board, near-misses between manned aircraft and drones rose from 71 incidents in 2016 to 125 in 2018.[8] Just under 90% of all Airprox reports in 2018 were suspected drone incursions.[9] We also heard from equally reputable groups that the reliability of Airprox reports and accounts of collision of a drone with an airliner are disputed, and this will be explored in further detail in paragraphs 72 to 74.[10] Further to this, we also heard evidence from the Royal Aeronautical Society that 75% of the public were concerned about drones being used to spy on them at home, whilst our colleagues on the Defence Committee heard evidence for their ongoing inquiry, *Domestic Threat of Drones*, that drone technology could present a new opportunity for terrorist weaponry.[11]

4.   The Department for Transport told us that "the Government has implemented legislation to ensure drones are used safely and responsibly, to help place the UK at the forefront of this fast-growing industry, whilst harnessing the benefits as this technology develops."[12] In 2018, the Government amended the 2016 Air Navigation Order 2016, which stated that a person must not recklessly endanger aircraft, to include new measures which:

> a) prohibited drones from flying above 400 feet and restricted within one kilometre of a protected airport boundary; and
>
> b) required all operators intending to fly drones over 250g to register and required all drone pilots intending to fly drones over 250g to complete a competency test—these measures will apply from November 2019.[13]

The Department for Transport further set out its plans to introduce a Drones Bill in the next Parliamentary Session which they told us would extend police powers to investigate reports of criminal and negligent drone use.[14]

What is a "drone"?

5.   The term 'drone' is used as an alternative to 'Unmanned Aerial Vehicle' (UAV) or 'Unmanned Aircraft' (UA). As mentioned at paragraph 1, the term drone can also refer to other robotic machines that can be used in water or on land, but for the purposes of this Report, we only focus on UAVs/UAs. A 2019 House of Commons library briefing

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7   [Q206](#)
8   UK Airprox Board, "Analysis of Airprox in UK Airspace", [Report Number 34](#), (January 2018 to December 2018) and UK Airprox Board, "Analysis of Airprox in UK Airspace", [Report Number 32](#), (January 2016 to December 2016)
9   UK Airprox Board, "Analysis of Airprox in UK Airspace", [Report Number 34](#), (January 2018 to December 2018)
10   Flight Safety Board ([RDU0107](#)) para 13; British Model Flying Association, Scottish Aeromodellers Association, First Person View UK, and the Large Model Association ([RDU0192](#)) para 3–9
11   Royal Aeronautical Society ([RDU0086](#))
12   Department for Transport ([RDU0103](#)) para 28
13   Department for Transport ([RDU0103](#)) para 30
14   Department for Transport ([RDU0103](#)) para 34

explained that a drone could be wide-ranging in size, from "small hand-held types up to large aircraft" and could either be "piloted or autonomous, although the latter are at an early stage of development".[15]

6.   The Civil Aviation Authority (CAA), the chief independent statutory body responsible for the regulation of drones, elaborated on this definition and has implemented a number of regulations that govern drone use in the UK and by extension define a drone.[16]

7.   A recreational drone is defined by the CAA as "any unmanned aircraft, other than a balloon or a kite, having a mass of not more than 20kg without its fuel but including any articles or equipment installed in or attached to the aircraft at the commencement of its flight."[17] They further stipulated that a drone user should abide by the following guidance:

- The drone user has responsibility for flying their drone in a safe manner;

- The drone user should always keep their drone in their direct sight so as to ensure that it does not collide with anything, especially other aircraft;

- The drone user must not endanger anyone, or anything, with their drone, including any articles that they drop from it.

- They should not fly more than 400ft above the surface; and

- They should not fly within the 5km Flight Restriction Zone of a protected aerodrome.[18]

8.   If a drone user wishes to operate outside the limits as set by these restrictions, they must be granted commercial operating permission by the CAA. This permission involves demonstration of remote pilot competence and a sufficient understanding of aviation theory, as well as completion of a practical flight examination and preparation of an Operations Manual.[19] The CAA approves commercial organisations, known as National Qualified Entities (NQEs) to do this assessment on their behalf.[20] This will be explored in further detail in Chapter 5.

9.   The British Model Flying Association told us that the legal definition of a drone now encompasses model aircraft, and as such, any resulting legislative changes or regulations will impact upon both model aircraft and colloquially understood "drones".[21]

Our inquiry

10.   In light of the high profile and increasing relevance of airborne drone use in the UK, we decided to launch an inquiry to assess the success of the actions that the Government has taken to enable the opportunities from drones to be harnessed while mitigating the associated risks. The Defence Committee was also conducting an inquiry into the *Domestic Threat of Drones*, which looked specifically at drones in the UK from a defence

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15   "Civilian Drones", Briefing paper CBP 7734, House of Commons Library, February 2019, p 4
16   The Air Navigation (Amendment) Order 2019 No. 261
17   Ibid.
18   Drone safe, "The Drone Code", accessed 3 October 2019
19   Civil Aviation Authority, "Permissions and exemptions for commercial work involving small unmanned aircraft and drones", accessed 3 October 2019
20   Ibid.
21   British Model Flying Association (RDU0082) para 2

and security perspective. For this reason, we decided to conduct our first evidence session jointly with the Defence Committee but conducted separate inquiries and are producing separate Reports.

11.   We launched a call for written submissions in March 2019. We sought submissions that addressed the following terms of reference:

- The ethical implications of civilian drones on citizen privacy and safety in the UK;

- The effectiveness of built-in drone safety features, such as tracking and monitoring capabilities, in mitigating the risks of civilian drones;

- The effectiveness of anti-drone technology in mitigating the risks of civilian drones;

- The economic opportunities arising from the growth of drone technology;

- The success, or otherwise, of regulatory frameworks for civilian drones and what should be covered in the forthcoming 'Drones Bill';

- The plans for registration of civilian drones in the UK;

- The current state of drone safety education and research in the UK; and

- International comparators with exemplary drone-interference prevention policies.[22]

12.   We received over 180 pieces of written submissions from a variety of sources, including drone users, the Government, technology manufacturers, aeronautical societies and organisations and emergency services. The evidence we have received is available on our website.[23]

13.   We also visited the Aerial Robotics Lab at Imperial University to hear about the usage of drones for digital infrastructure systems, including diagnostics and repairs, both in the air and under water. A summary note of this visit is at Annex 1. In addition to this, we held a roundtable event with recreational and commercial drone users, where we heard their perspectives on drone regulation and registration, a summary of these discussions at Annex 2. We had been hoping to also visit Surrey Search and Rescue to learn more about the use of drones in emergency services, however, Parliamentary business meant we were unable to find a suitable date to conduct such a visit. To further assist with our inquiry, we appointed Dr Anna Jackman, lecturer in Political Geography at Royal Holloway University, as a Specialist Adviser for this inquiry.[24] We are grateful to all those who contributed to our inquiry.

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22   "MPs set to investigate the risks of drones", Commons Select Committees, (March 2019)
23   "Commercial and recreational drone use in the UK inquiry - publications", Science and Technology Committee, accessed 3 October 2019
24   Dr Anna Jackman declared her interests on Tuesday 21 May

Aims of this Report

14.   In this Report we make recommendations relating to what the Government, mainly the Department for Transport, should do to regulate drones in the future and to maximise the opportunities they offer and minimise any risks. We recognise that some issues may equally apply to land and sea drones, but we are focusing solely on recommendations for UAVs. In addition, we make a small number of recommendations directed at the Civil Aviation Authority. Specifically:

- In Chapter 2, we explore the success of the current regulations and analyse the impact of future regulations;

- In Chapter 3, we outline the evidence relating to the potential economic, social and humanitarian opportunities presented by the growing drone industry;

- In Chapter 4, we explore the potential risks of the growing use of drones in the UK and the extent to which the Government has been successful in their mitigation;

- In Chapter 5, we assess the state of drone safety education in the UK;

- In Chapter 6, we consider the technology required for the safe and beneficial integration of drones in the UK; and

- Finally, in Chapter 7, we consider the case for the UK Government to set out its vision for the future of drones in the UK.

2   Current regulations

15.   This Chapter outlines the current state of play with regard to the legal requirements underpinning drones in the UK and the efficacy of the future regulations announced by the Government.

Current legislation

16.   Relevant legislation concerning the operation of unmanned aerial vehicles (UAVs) and aerospace more generally is contained primarily in the Civil Aviation Act 1982 and the Air Navigation Order 2016, as amended in 2018.[25] Detailed guidance is also set out in the Civil Aviation Authority's Unmanned Aircraft System Operations in UK Airspace.[26] The Civil Aviation Authority is the independent statutory authority responsible for regulating civil aircraft, including drones. With regard to drones, the CAA said its aim was to "enable the full and safe integration of all Unmanned Aerial Systems, or Drones, into the UK's total aviation system".[27]

Flight Restriction Zones

17.   The 2019 amendment to the 2016 Air Navigation Order (ANO) extended the Flight Restriction Zone around protected airports from 1km to 5km. Flight Restriction Zones refer to areas where drones are not permitted to enter without specific authorisation from the Civil Aviation Authority. The new extended Flight Restriction Zone consisted of:

(1)   The Aerodrome Traffic Zone: a 2 or 2.5 nautical mile radius 'cylinder' around the aerodrome, extending 2,000 feet above ground level, centred on the longest runway.

(2)   Runway Protection Zones: A rectangle extending 5km from the threshold of the runway away from the aerodrome, along the extended runway centreline, and 500 metres either side, also to a height of 2,000 feet above ground level.[28]

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25   Civil Aviation Act 1982 and The Air Navigation (Amendment) Order 2019 No. 261
26   Civil Aviation Authority, "Unmanned Aircraft System Operations in UK Airspace – Guidance & Policy", CAP 722, May 2019
27   Civil Aviation Authority, "An introduction to unmanned aircraft systems", accessed 3 October 2019
28   The Civil Aviation Authority, "Airspace restrictions for unmanned aircraft and drones", accessed 3 October 2019
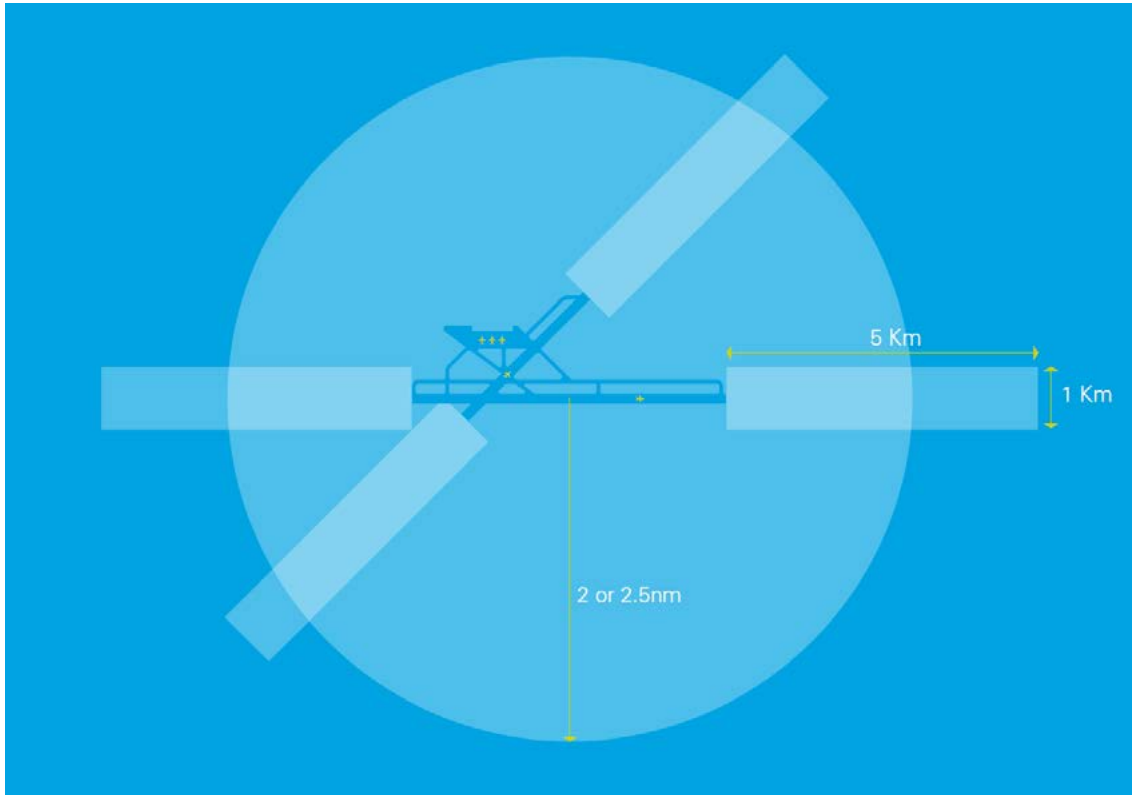
Source: P19 – Civil Aviation Authority, "Airspace restrictions for unmanned aircraft and drones", accessed 9/10/2019

18.   We heard mixed evidence regarding the efficacy of these zones. Captain Tim Pottage, representing the British Airline Pilots Association (BALPA), said:

> The flight restriction zone is adequate as it is. It was not previously. The previous 1 km was woefully inadequate; 5 km is the bare minimum to keep aircraft and drones separated during their landing and take-off phases.[29]

In addition to this, drone user, Brian Galbraith, told us he believed that the restrictions were fair.[30]

19.   However, evidence submitted by Liverpool John Moores University explained that the exact requirements of these zones was poorly communicated and unclear:

> The latest set of changes to the Flight Restrictions Zones (FRZs) at airports was communicated extremely poorly with vague phrases such as " … either two or two and a half nautical miles, or five kilometres … " being used.[31]

20.   Further, the Committee received evidence that the system for requesting access to Flight Restriction Zones took a long and varied amount of time. For example, Gorilla Drones, a commercial drone operator, told us that the current system for requesting access was "not a workable solution" for commercial drone operators as some application processes could take as long as 21 working days, and different aerodromes implemented the restrictions differently, leading to an inconsistent and inaccessible service.[32] Similarly, Mr Arron Banfield claimed that airport requirements for 3–4 weeks advanced notice

29   Q174
30   Brian Galbraith (RDU0093) para 2
31   Liverpool John Moores University (RDU0079) p 2
32   Gorilla Drones (RDU0094) p 3

was "unworkable."[33] During the recreational and commercial drone user roundtable (see Annex 2), some participants told us that the permissions access system was disruptive to hobbyist drone users, who were now bound by restrictions that meant they were not able to pursue their hobby as flexibly as before.

21.   We were also told during the roundtable that aerodromes had inconsistent reasonings for acceptance or denial, and for imposing charges that varied according to operator. Mekdem Ltd, a small unmanned aircraft commercial operator, explained that the implementation of flight restriction zones had hampered business for small commercial operators as "many airport operators have now started to charge drone owners for requesting clearance to fly within the 5km zone".[34] DB Training Solutions Ltd, a drone training consultancy company, stated that "unfortunately of recent times, some airport ATC's [Air Traffic Control] have taken it upon themselves to impose caveats, restrictions and even refusals for drone flights within their zone".[35] Sky Held Cameras, a commercial drone operator, also told us that a number of Air Traffic Control providers "have either given blanket denials or imposed charges for such permission."[36]

22.   The Committee received evidence from the National Air Traffic System (NATS), a major service for the provision of a safe airspace, on its app the 'Airspace User's Portal' which it has developed to help deal with the issue of requesting access to Flight Restriction Zones:

> We have made the step of implementing what we have called the airspace user portal, which provides the public and commercial operators with a single place through which permission can be granted. We can then forward requests to the appropriate authorities that have the permission. That delivers a consistent means of access to the public […] As well as giving consistent means of access to the public, it means that, when disruption occurs, the airport and the police are much better placed to undertake an assessment of the risk and to identify those who are acting responsibly, because they have some knowledge of who is meant to be flying there at the same time.[37]

23.   When we asked the then Minister what action the Government was taking to make the permissions system more consistent, she told us that it was difficult to create a unified system for permissions due to the different needs of different aerodromes, and local regulations and restrictions: "flight restriction zones could be at Heathrow airport or an airport that has five flights a day, so we have different elements. It is up to the local air traffic control unit to provide permission".[38] However, the then Minister, Baroness Vere of Norbiton, also told us that the Government did recognise that this was an issue and explained that the CAA was currently working to review all permissions granted, to improve the system to request access.[39]

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33   Arron Banfield (RDU0138) p 10
34   Mekdem LTD (RDU0159) p 1
35   DB Training Solutions Ltd (RDU0033)
36   SkyHeld Cameras (RDU0161) p 2
37   Q195
38   Q463
39   Q463

24. **We recognise the importance of extending Flight Restriction Zones to five kilometres. However, these restriction zones are not clearly or consistently enforced. The lack of a standardised process results in inconsistent denials and permissions being granted to those applying. This is unacceptable.**

25. *The Government should commission the production of a standardised and unified system through which drone operators can request access to Flight Restriction Zones. This could be achieved by working with National Air Traffic Services on its development of an Airspace User's Portal. This should be completed no later than summer 2020.*

Agreed forthcoming regulations

Drones Bill

26. In January 2019 the Government published its response to its consultation on the Drones Bill that it intends to bring forward in November 2019. Possible content of a Drones Bill, as outlined in *Taking Flight: the future of Drones in the UK: Government response*, is covered in the paragraphs that follow.

Police powers relating to drones:

27. The Government proposed the following action with regard to increasing police powers relating to drones:

(1) Require the production of evidence in specific circumstances for: drone operator registration, remote pilot acknowledgement of competency; and other requirements for specific flights (such as permission for commercial drone use or exemptions from the Civil Aviation Authority from any Air Navigation Order (ANO) 2016 articles; and

(2) Obtain information such as the names and addresses of a registered drone operator and/or remote pilot believed to be in charge of the drone in specific circumstances (such as where there is suspicion of a reasonable offence).[40]

Registration fee and online test

28. From the end of November 2019, it will be a legal requirement for operators of drones weighing more than 250 grams to register and pass an online test.[41] After a CAA consultation in 2018 on the registration charge, the annual fee was set at £16.50 per individual user, but the online test would be free. The then Minister for Aviation told us that the purpose of registration was to improve the safety of the public and the airspace, in line with other measures such as electronic conspicuity (mentioned in more detail at paragraph 120):

> [These things together] will go a long way to making sure that our lower airspace is safer and that the public feel it is safer, rather than just thinking, "I don't want a random object flying down my street and nobody knows

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40   Department for Transport, "Taking Flight: The Future of Drones in the UK Government Response" January 2019, para 3.2

41   Ibid, para 1.21

what it is and where it is coming from. It might be a bit noisy. Quite frankly, it is going to my neighbour's house and not to me. I don't like it." The safety element is critical.[42]

29.   We received evidence that was widely supportive of a registration scheme. The Airport Operators Association, for example, explained that "a compulsory registration regime for drone operators [...] is an effective measure which increases safety".[43] The British Airline Pilots Association (BALPA) compared drones to cars and guns: "in the same way that vehicles and guns have to be identifiable and registered so should be the case with drones which are capable of significant harm."[44] Notably, Dr Stephen Wright, at the University of the West of England, argued that "limited legislation (e.g. registration) is generally welcomed by the skilled community" and this was supported by drone user Mr Michael Clarke who stated that "this sounds like an excellent scheme and one which I wholly endorse".[45]

30.   Drone users were also widely supportive of the proposed registration scheme. Mr David Laverik, for example, told us "I would support a system of registration of drones and their users and a requirement for drone pilots to pass some test of competency".[46] Further, Mr Jonathan Ridgway told us he viewed the necessity of registering a drone as no different to being registered on the DVLA database for car use.[47] These views were also echoed in the roundtable event we held with recreational and commercial drone users (Annex 2).

31.   We also received evidence in support of the online test that would accompany the registration scheme. Drone user Martin Hall told us that he was supportive of the idea of an online test, as did Richard Parker from Altitude Angel.[48] However, during the roundtable event (see Annex 2), those who had been asked to pilot the test raised concerns that it might be too easy to pass as most of the answers could be easily found online and others critiqued the small number of questions that formed the test. Further, during the roundtable, many raised concerns that it was unfair for commercial drone users to be required to take the online test and pay the registration fee, as they were already subject to rigorous tests in order to commercially operate their drone.

32.   **There is a compelling case that the Government should introduce a registration scheme to be able to identify all lawful operators and to ensure that there is a knowledge test for drone users. Flying a drone is a skill and therefore it is appropriate for there to be a test to make sure the operator is fit to operate a drone.**

33.   *The Government, or the appropriate regulatory body, such as the Civil Aviation Authority, should review the online test one year after it has been in operation. Specifically, the Government should determine if it is an adequate test for ensuring safe drone use.*

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42   Q442
43   Airport Operators Association (RDU0076) para 9
44   BALPA (RDU0121) p 5
45   University of the West of England (RDU0029) para 8.6, Mr Michael Clarke (RDU0049) p 6
46   Mr David Laverick (RDU0027) p 1
47   Mr Jonathan Ridgeway (RDU0028) para 11
48   Martin Hall (RDU0035) p 2; Q19

34. We heard further protestation from the drone user community about the cost of registration. Brendan Schulman representing DJI, the world's largest drone manufacturer, told us:

> My understanding is that the proposal or suggestion is over £16. That is more than 12 times the cost of registration in the United States. Frankly, I do not understand why it would cost so much, and I worry that everything that follows from registrations–things such as remote ID and UTM–will be subject to a negative impact if that cost is too high.[49]

35. This perspective was also shared by some who attended our roundtable event (see Annex 2). For example, our attention was drawn to the French system of drone registration, which is free and involved a more rigorous test. Some went on to explain that the UK's proposed scheme would not tackle the problem of nefarious drone use, as only those who intended to be compliant would register, and authorities were unlikely to be able to track down those who did not. Mr Christopher Llewellyn explained that the lack of detail provided by the Government about how the registration scheme would work meant people were less likely to register their drones, as "the longer this goes on the more likelihood that people will ignore it, as they will not have a reasonable time to register, and then perhaps not bother at all".[50]

36. In the CAA response to the Government consultation on registration, they set out the rationale for the registration fee:

> This is to cover the costs of running the registration scheme, which includes the IT hosting and security costs, CAA personnel and helpdesk, identity verification, a national education and awareness campaign and costs of further upgrades to the initial drone registration service. We have based our costs on an assumption of 170,000 assumed registrations over the initial 18-month period, though we would welcome through this consultation any additional information about the numbers of drone and model aircraft users. We will review the drone registration charge after its introduction and implement any changes from April 2021, including whether a three year rather than annual renewal period is more appropriate.[51]

37. Further, the then Minister told us that she thought the proposed fee of £16.50 was a "very reasonable sum" and that the registration system would "improve the safety of our airspace, not just for model aircraft but for everybody flying any sort of aircraft in the sky".[52]

38. **If the registration fee dissuades individuals from registering, then this defies the purpose of the system—to improve the safety of our airspace.** *The Government should conduct a review of the cost of the registration scheme. If the Government believes it is appropriate for the fee to remain at £16.50, then they should clearly set out their rationale for the cost and the renewal period should be three years rather than yearly.*

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49   Q92
50   Mr Christopher Llewellyn (RDU0008) p 4
51   Civil Aviation Authority, "2019 Drone Registration Scheme: Charge Proposal Consultation Document", April 2019, para 1.6
52   Q491

39. Further, we also received some evidence that questioned the registration fee, particularly in its application to the model flying community. David Phipps, representing the British Model Flying Association, noted that "there is also the danger that it may drive some activity out of organised associations or communities if the fees and bureaucratic requirements are set too high."[53] This particular point was also made in written evidence from the British Model Flying Association who argued that their hobby had gone undisturbed for many years, but they were now technically classified as "Unmanned Aviation Vehicle" users and as such were subject to excess fees.[54] In the drone roundtable event (Annex 2), some advocated that those who operated model aircraft as part of a club should be exempted from registration and societies and clubs should be able to register as one entity.

40. *Taking Flight: The Future of Drones in the UK Government Response*, published in 2019, stated:

> The Government will continue working with model aircraft associations to discuss the possibility of future exemptions. We are keen to minimise, if possible, the burden on those members of model aircraft associations who are already registered through a club and have already passed certain competency tests. However, this must be achieved without imposing undue burden on the state and the taxpayer, whilst also being efficient and enforceable, without compromising the integrity of the policy. A blanket exemption from registration and competency tests, as suggested in many of the consultation responses submitted by model fliers, will not meet these criteria.[55]

Further to this, the then Minister told us:

> I say to the model aircraft associations that I absolutely respect their position as people who care deeply about safety, and the safety of our airspace. Therefore, if that is the case, why would they not wholeheartedly support a registration system that we feel would improve the safety of our airspace, not just for model aircraft but for everybody flying any sort of aircraft in the sky?[56]

41. ***We recommend that the Government consider a system which allows organised clubs and societies to register as one entity, so as not to financially burden each member. However, it must be mandatory for every individual user to adhere to the required safety standards. The Government should set out in response to this Report whether this should be demonstrated by the completion of an online test or an obligation on clubs to ensure their members have appropriate safety standards.***

Enforcing registration

42. Some individuals told us that they were concerned about how the Government would police the registration system. Stephen Ogborne, a drone user, explained that criminals

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53   Q375
54   British Model Flying Association (RDU0082), para 2
55   Department for Transport, "Taking Flight: The Future of Drones in the UK Government Response" January 2019, para 2.29
56   Q491

would not register their drones, and only "law abiding citizens" will, which meant that registration would not help law enforcement to track down rogue, terrorist or criminal drone use.[57] This perspective was shared by Melvyn Bond, amongst others.[58] This view was also shared by Blue Dot UAV Imaging, a commercial drone company, and Blighter Surveillance Systems Ltd., a counter UAV company, who argued that while law-abiding drone operators would register previous drones, those wishing to act illegally would not.[59]

43. Melvyn Bond, also pointed out that it would be very difficult for the Government to ensure that those who had drones before the registration system came into force, had registered previously purchased drones.[60]

44. Tim Johnson, representing the CAA, acknowledged that the registration scheme would not be effective against criminal drone use:

> The purpose of the registration scheme is to educate and register those who operate lawfully. We are designing it in such a way as to make it as easy as possible for people to access and use and take the online test, but it is for those who are aware of it and choose to operate lawfully.[61]

45. However, Professor Dunn from the University of Birmingham explained that registration should be heavily enforced, and a policy of deterrence, in the form of strict penalties for drone use, was the best way to decrease drone criminality.[62] The then Minister also told us that there would be strict fixed penalty notices or "serious" action taken for those who ignore registration.[63]

46. **The Government should acknowledge that the proposed registration scheme will do little to mitigate the risks from nefarious drone users who will simply bypass registration and testing.** *Penalties for those who avoid registration should be set out clearly in the forthcoming Drones Bill. We recommend a sliding scale of penalties for failure to register, starting with a warning, and culminating in a fine and a prison sentence.*

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57   Stephen Ogborne (RDU0012) para 6
58   Melvyn Bond (RDU0024) para 4; Mr Bernhart Dambacher (RDU0021)
59   Blue Dot UAV Imaging (RDU0129); Blighter Surveillance Systems Ltd. (RDU0132) para 2.6
60   Melvyn Bond (RDU0024) para 4.4
61   Q30
62   Q393
63   Q490

3   Opportunities

47. This Chapter outlines the evidence relating to the potential economic, social and humanitarian opportunities presented by the growing drone industry. This Chapter outlines the regulatory changes and technological advancements required to enable to the UK to benefit from these potential opportunities.

Hobbyist drone operators

48. Throughout our inquiry, we heard much evidence from the recreational drone user community who told us that drones had given communities a fun and rewarding hobby. For example, Mr Peter Hague, a drone user, told us that recreational drone use had enabled him to advance his skill and interest in photography:

> The recreational side of drone flying also has […] a great increased opportunity for social benefit as this is a new hobby attracting many people who previously had no real interest in photography or videography, as the images from just a hundred or so feet are fundamentally different and attractive.[64]

William Legge, another drone user, also referenced the sense of "community" that recreational drone users had, and this point was echoed by Mr Martin Cocking and Mr Fraser Steen, who explained that "model aviation is a fantastic community with a deep history".[65]

49. Further, Melvyn Bond told us that drone racing was a "popular hobby".[66] Member of the public, Arron Banfield, also told us that BT Sport had already begun to invest in a drone racing series.[67] We learned that there were several drone racing events across the UK that competitors could take part in, such as the UK Drone Racing Open International World Cup Event and the Westland Drone Racing event, amongst many others.[68]

50. However, we were also told that the potential risks of the hobbyist drone user community needed to be considered. For example, Professor David Dunn and Dr Christopher Wyatt from the University of Birmingham told us about the dangers of what they referred to as "blunderers"—ill-informed recreational drone users who inadvertently caused accidents by not being properly educated or taking tests to ensure that they operated their drones safely.[69] They explained that this was because drone safety education in the UK was not adequate:

> Someone buying a drone may not know that there are rules and may not know to look on the CAA website or look up the Drone Code online. There are leaflets in COTS drones bought in the UK but, at that point, the purchaser gets the information only after they have bought the drone.[70]

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64   Mr Peter Hague (RDU0102) para 4
65   William Legge (RDU0115); Mr Martin Cocking (RDU0122), Mr Fraser Steen (RDU0123) para 1
66   Melvyn Bond (RDU0024) para 1
67   Arron Banfield (RDU0138) p 2
68   BDRA, "The home of British Drone Racing", accessed 7/10/2019
69   University of Birmingham (RDU0036) para 7.6
70   University of Birmingham (RDU0036) para 7.1

Others, such as Dr Stephen Wright and drone user, Mr Geoffrey Hirst, also told us that there was a proportion of the recreational drone community who were reckless, whether inadvertently or not.[71] However, Mr Hirst pointed out, that many other hobbies also involved individuals who might carelessly or cluelessly disobey the law or act dangerously, such as those who drove cars.[72]

51.   However, the then Minister told us that drone safety and the education of drone users was a priority for the Government, the then Minister told us that she understood that model flying was a "very long-standing traditional hobby" and she viewed the "vast majority of all unmanned aircraft users to have a good safety record".[73] This view was backed up by National Air Traffic System (NATS) who explained that:

> NATS fully acknowledge that the vast majority of drone pilots act completely responsibly and safely […] At NATS we work closely with the drone pilot community and value their input enormously–input which is helping us to ensure they have the best and safest experience they can when flying. We do not want the many to be tarnished by the misdeeds of the few.[74]

52.   **It is vital that the Government respects recreational drone use and model flying communities and ensures that any further regulation or legislation does not dissuade people from joining such communities.**

Economic opportunities

53.   The Committee received a significant amount of evidence relating to the economic opportunities presented by the growing drone industry. In a 2019 Report from PwC, *Skies without limits: Drones—taking the UK's economy to new heights*, PwC performed a comprehensive analysis of the economic effects of the development of the drone industry. They stated that:

> Our study into the impact of drones shows that, by 2030, there could be: £42 billion increase in UK gross domestic product (GDP); £16 billion in net cost savings to the UK economy; 76,000 drones operating in the UK's skies and 628,000 jobs in the drone's economy.[75]

54.   The University of Birmingham also shared this view about the positive effect drones could have on the UK economy: "the use of unmanned systems will change the way that many industries will operate. Logistics, delivery, surveying, repairs and maintenance are just some of the areas where unmanned technologies will be game changing."[76] Nesta explained that in addition to the applications of drones in "media, construction, real-estate, agriculture, search and rescue and more", there were also emerging services that support the drone industry including "insurance, training, maintenance and drone strategy consulting"; supporting technology including "data analytics, data management, sensors and subsystems" and furthermore, technology to support integration "including

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71   University of the West of England (RDU0029) para 7; Mr Geoffrey Hirst (RDU0061) p 5
72   Mr Geoffrey Hirst (RDU0061) p 5
73   Q504
74   NATS (RDU0175)
75   PwC, "Skies without limits: Drones - taking the UK's economy to new Heights", (2019), p 2
76   University of Birmingham (RDU0036) para 4.1

flight planning and management, as well as counter drone systems."[77] This view was also shared by many members of the public, such as Mr Christopher Llewelyn and Mr Andy Dubreuil amongst others.[78]

55.   However, we also heard concerns that as drones increasingly replaced roles currently undertaken by humans, people might lose their jobs and businesses would be affected. Martin Hall told us that the "one hour delivery" prediction of Amazon would lead to "a faster decline in the British high street and an even bigger stranglehold by the multi-national co-operations" and could further see "home-delivery drivers out of work".[79] A 2016 report from PwC, *Clarity from above*, predicted that drones could replace $127 billion worth of human labour globally.[80] These concerns were echoed by the University of Exeter, who explained that some within policing were concerned that the use of drones for law enforcement could cause a loss of jobs.[81]

56.   However, Sean Cassidy, the Director of Safety and Regulatory Affairs at Amazon, explained that Amazon was using automation programmes, such as through its use of drones, to grow the economy and create more jobs:

> In the United Kingdom over the last decade, we have invested something in the order of £9.3 billion in the economy here and created over 27,000 jobs. That is a good example of how automation and economic growth work hand in hand.[82]

Furthermore, Elaine Whyte from PwC told us that the increased use of commercial drones in the UK would lead to the creation of highly skilled jobs, and the skills would be needed to analyse and use the data that drones were able to collect:

> I am much more interested in the relevance of the data going back to my client's business. It is much more about business understanding and the human insight you get from the business understanding that integrates that technology back into the business.[83]

As such, PwC saw drones as a means of creating a new profession of data analysis for humans.

57.   In addition, Professor David Dunn and Dr Christopher Wyatt from the University of Birmingham told us that although it was important to recognise the economic benefits of the growing drone industry, it was also important for this growth to happen in an "orderly and well-regulated way" as the "the perception should be avoided that the sector is being grown regardless of safety and the potential cost in lives".[84] The Security Institute also argued that though the economic benefits of drones were important, regulation had a vital role to play in ensuring that it was done safely and beneficially. They explained:

77   Nesta, "Flying High: the future of drone technology in UK cities", July 2018
78   Mr Christopher Llewellyn (RDU0008); Mr Andy Dubreuil (RDU0011)
79   Martin Hall (RDU0035)
80   PwC, "Clarity from above", accessed 7/10/2019
81   Professor Jason Reifler, Professor Thomas Scotto, Dr Catarina Thomson and Dr Judd Thornton (RDU0092), p 5
82   Q282
83   Ibid.
84   University of Birmingham (RDU0036) para 4.3

> Regulators need to achieve the right balance between allowing the nascent industry to develop at a pace for commercial and leisure applications, and ensuring adequate levels of privacy, safety and security.[85]

The then Minister for Aviation, Baroness Vere, told us that the Civil Aviation Authority was responsible for looking at the regulatory and innovative environment, whilst the Department for Transport had a team that were looking to see if the suggested regulations were appropriate.[86] One example flagged to us of changing regulations was in the use of drones for crop spraying. Throughout the inquiry, we heard that drones had been often used for data analysis and surveillance within agriculture, and recently the CAA granted permission to "Crop Angel"—an agricultural company based in Norfolk—to trial the spraying of wheat crops via drone. Though it remains illegal for drones to drop many agrochemicals, founder of Crop Angel and farmer Chris Eglington told a local newspaper that the success of this trial had demonstrated how this technology could be further applied.[87] The issue of future regulations will be looked at in due course (Chapter 7).

58. In particular, much of the evidence that the Committee received with regard to the economic opportunities presented by drones related to parcel delivery. Aaron Banfield, a commercial drone user, set out the societal benefits of drone deliveries including:

- Significantly reduce congestion;

- Reduce emissions caused by traditional motor vehicles and traffic;

- Increase resilience by being less reliant on traditional infrastructure (road blocks, environmental and policy shifts);

- Direct flight will increase efficiency;

- Delivery speeds will decrease–last mile deliveries can take minutes; and

- Deliveries to remote destinations will become feasible (new markets and business growth opportunities).[88]

With regard to the impact of drones on decarbonisation, Amazon explained, in its blog, that "Prime Air is one of many sustainability initiatives to help achieve Shipment Zero, the company's vision to make all Amazon shipments net zero carbon, with 50% of all shipments net zero by 2030."[89] Mr Shaun Madill, a member of the public, the National Air Traffic Services (NATS) and others also pointed to the reduction in carbon emissions that could be achieved as a result of increased drone deliveries .[90]

59. Amazon representative Sean Cassidy was asked on what timescale Amazon Prime Air was expected to be a delivery option for Amazon customers. He responded, "I am very confident that we will be doing something within the next five years."[91] The then Aviation Minister also told us that she had expected amazon delivery via drone to begin within the next five years. The UK Civil Aviation Authority has also acknowledged the benefits

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85   Security Institute (RDU0106) para 3
86   Q435
87   Hill, C., "WATCH: Crop-spraying drone offers glimpse into farming's future", Eastern Daily Press (February 2019)
88   Arron Banfield (RDU0138)
89   Wilke, J., "A drone program taking flight", June 2019
90   Mr Shaun Madill (RDU0078); NATS (RDU0124) para 3
91   Q279

of parcel delivery, working with Amazon in their "innovation sandbox"[92] to develop a "future delivery system from Amazon designed to safely get packages to customers in 30 minutes or less using unmanned aerial vehicles".[93]

60. We also heard some evidence that raised concerns about drone delivery. For example, member of the public and recreational drone user William Legge explained that he was concerned that deliveries might not be safe, as many houses lacked gardens and as such deliveries could block roads.[94] Furthermore, Nesta told us that 44% of the 2,000 respondents to its survey on drones in cities, who were recruited online and paid to participate, were opposed or strongly opposed to drone use for parcel delivery.[95] In a further survey undertaken in the US by the United States Postal Service, it found that while 44% of 1,465 respondents liked the idea of drone delivery, 23% neither liked nor disliked it and a further 34% disliked it.[96] Further, the Department for Transport's *Public Dialogue on Drone Use in the UK* explained that while the public were less concerned about the safety risks posed by commercial users, the public did have "concerns about the pace of current development of the commercial sector and the future trajectory of drones."[97]

61. We also heard evidence regarding human transportation via drone, or "drone taxis". Julia Jiggins, representing Thales, was asked about human transportation via drone, she told us that:

> A trial in the United States is meant to be starting next year, taking people from the airport to downtown New York, on a dedicated route with a certain duration. It is not fully flexible—it is not able to go just anywhere—but the technology is there.[98]

Dr Mirko Kovac, from Imperial College, explained during our visit, as set out at Annex 1, that human transportation via drones would certainly occur during the next 10 years and he stated that he believed journeys such as Manchester to London would be possible within this timeframe. We also heard that a company called Skyports had begun exploring how to install "vertiports"—facilities for aircraft that take off and land vertically—on London rooftops so that drones deliveries could land easily once the regulatory environment allowed.[99]

62. The then Minister for Aviation told us that there was ongoing work in this area to create the right sort of regulatory and innovative environment to ensure that society could take full advantage of these technologies: "all of it is ongoing. Obviously, further work is going on in the DfT as well in the drones' team as to how all of this is going to interact. Deliveries are not immediately imminent in this country."[100]

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92   "The Regulatory Sandbox provides a capability for users to work with the CAA to test and trial innovative solutions in a safe environment, in particular those solutions that do not fit within the existing scope of regulations, permissions, and exemptions."
93   Civil Aviation Authority, "The CAA regulatory sandbox", accessed 7/10/2019
94   William Legge (RDU0115)
95   Nesta, "Understanding the public perception of drones", accessed 7/10/2019
96   Ibid.
97   Department for Transport and Ministry of Defence, "Public dialogue on drone use in the UK: Moving Britain Ahead", para 3.1
98   Q294
99   Skyports, "Introducing Volo-Port, the world's first vertiport", accessed 9/10/2019
100   Q443

63.   **The Government does not appear to have made any independent assessment of the potential economic benefits and opportunities that arise from the growing drone industry. To properly harness the benefits of drones the Government will need to analyse their potential economic contribution.** *The Government should provide an assessment of how the growing drone industry might contribute to the UK's economy by the time of the 2020 Spring Statement. This should focus on the regulatory requirements and the technological advancements required for innovations, such as parcel delivery and human transportation. Further, it should investigate the potential environmental impact of these innovations and in particular the potential for commercial drone use to contribute to decarbonisation of the economy. It should then set out a strategy and a timeframe required for any actions it wishes to take and should publish its findings no later than Autumn 2020.*

Humanitarian and emergency service provision

64.   The Committee received evidence relating to the capacity for drones to be used for social good within a humanitarian context. Evidence set out how drones were already being used by the emergency services and the capacity for drones to be used in the field of medical delivery—including blood and organs. In particular, the use of drones to deliver blood in Africa and the developing world was made by Elaine Whyte, PwC and Sean Cassidy, Amazon.[101]

65.   Further, Devon, Cornwall and Dorset Police noted that drones could be used to support emergency services, such as police actions in a number of ways: to "provide an overview to make better tactical decisions […] to provide information without putting officers in harm's way or without provoking a reaction from a subject."[102] Special Sergeant Kevin Taylor outlined the work of Lincolnshire Police's Drone Unit:

> Our drone unit has been active for 20 months. In that time, we have done more than 450 deployments. Without a shadow of a doubt, people are alive today who would not have been alive if it was not for the drone in Lincolnshire.[103]

66.   Similarly, Surrey Search and Rescue set out how it used drones "to support all areas of [their] work" including "to search dangerous or inaccessible areas" and to provide "situational awareness at large fires."[104] With regard to medical delivery and drones within the NHS, Tris Dyson at Nesta stated: "Quite a lot of that currently relies on couriers on motorcycles or blue-light vehicles going through busy traffic areas, and it could make a difference to people's life expectancy."[105] When questioned on the timescale of this development, Tris Dyson explained that due to "current limitations" they were currently unable to use drones in this way, however, "if you could fly Amazon parcels around London, you would be able to do the same thing, more or less."[106] He further added that allowing these drone operators to fly beyond visual line of sight would further enhance the successful implementation of drones in emergency service operations, "the transformation

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101   Q322, Q326
102   Devon and Cornwall Police and Dorset Police (RDU0171), p 1
103   Q234
104   Surrey Search and Rescue (RDU0125) para 1
105   Q289
106   Q291

that can happen is when they are able to fly beyond visual line of sight (BVLOS) and get there ahead of the emergency services."[107] He, alongside Julia Jiggins representing Thales UK, explained that BVLOS technology was available and being utilised in other countries such as Finland, Switzerland, Austria and the US, but regulation in the UK and airspace control prevented its operation in the UK.[108] We explore the specifics of BVLOS in further detail at paragraph 140.

67. We were told that there were still considerable barriers to drones being appropriately utilised for emergency services. The CAA still had certain requisites for drones that were being used by emergency services, which included:

- The pilot must have permissions to fly the aircraft;

- The pilot must stay below 400 feet or 100 feet above the highest obstacle;

- The flight must be within agreements set out by the Joint Emergency Services Interoperability Programme which included the Police, Fire and Rescue and Ambulance services;

- The pilot must keep the aircraft within the control limits detailed in the user manual; and

- The drone must stay within 1,000 metres of the pilot unless permission is given by the On-Scene Incident Commander or 2000 metres unless the Tactical Commander gives permission.[109]

68. However, earlier this year the CAA announced that any member of the UK emergency services who was operating a drone during a situation that presented a major risk to life could be exempt from the 2016 Air Navigation Order and would be able to fly it beyond visual line of sight and around people and buildings.[110] Despite this, Surrey Search and Rescue told us that further exemptions still needed to be made for commercial organisations that used drones for emergency service operations, as currently the legislation only applied to those who were employed by an emergency service organisation:

> Organisations belonging to Lowland Rescue, Mountain Rescue and the RNLI are not considered to be Emergency Services by the CAA despite being requested by and deployed on behalf of the Emergency Services. Discussion and legislation changes are required to allow drones assisting Emergency Services to be able to use the E5406 Emergency Services exemption if suitably authorised. In these times of cost cutting and lack of resources the Emergency Services are relying more on civilian drones to help them operationally.[111]

69. Notably, Nesta told the Committee that in order to increase public perception of drone technology "public benefit use cases" such as use within the emergency services was a good place to start:

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107   Q265
108   Qq267–269
109   Civil Aviation Authority, "Small Unmanned Aircraft - Emergency Services Operations", General Exemption E 4506, Air Navigation Order 2016, 31 July 2017
110   Civil Aviation Authority, "Applications for unmanned aircraft operational authorisations", accessed 7/10/2019
111   Surrey Search and Rescue (RDU0125) para 6.5

From the public perception perspective, we think that will familiarise people with the public benefit use cases and help them to think about where drones may or may not operate in cities. That lays the groundwork for the type of decision-making infrastructure and thinking that will allow for some of the other commercial opportunities, including parcel delivery and others.[112]

70.   **Drones can have a positive effect on society, including through medical delivery and emergency service provision. By utilising drones, emergency services can conduct missions that were previously unsafe or not possible, as well as being able to respond quicker to incidents. We are encouraged to see the Government has allowed exemptions for emergency services to use drones beyond the visual line of sight in their operations, however, this provision does not apply to other organisations (such as Mountain Rescue) who might be involved in emergency service-led rescue missions.** *The Civil Aviation Authority should make it possible for organisations which are used in emergency missions to apply for emergency service exemptions to the Air Navigation Order 2016.*

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112   Q311

4   Risks

71. This Chapter outlines the evidence that we received relating to the risks posed by the growing drone industry. It specifically focuses on risks posed to manned aircraft in addition to those posed to safety and malign intent, as well as privacy.

Manned Aviation

72. During this inquiry, witnesses voiced concerns about the risks posed by drones to manned aircraft (such as airplanes or helicopters). Specifically, evidence from the British Model Flying Association and Captain Tim Pottage representing the British Airline Pilots Association, referenced the increased number of Airprox reports involving a drone.[113] An Airprox is:

> A situation in which, in the opinion of a pilot or air traffic services personnel, the distance between aircraft as well as their relative positions and speed have been such that the safety of the aircraft involved may have been compromised.[114]

According to the Civil Aviation Authority, in 2017, drone incidents accounted for 93 out of the 113 (c. 82%) Airprox reports, and in 2018 they accounted for 125 out of 139 (c. 90%).[115] The British Airline Pilots Association's (BALPA) representative Captain Tim Pottage was asked about the accuracy of recent increased airprox reports. Captain Pottage told us: "Yes, they are [accurate]. They are certainly not an overestimate—put it that way. They may indeed be an underestimate".[116]

73. Evidence from the British Model Flying Association and the Flight Safety Board, a board set up to inform flight safety, regulatory and political community on drone airprox likelihood and risk, however, disputed the accuracy and validity of Airprox reports. The Flight Safety Board told us that "we now have airline pilots conditioned to expect to see drones, operating on a hair-trigger" due to media that has "convinced" aircraft pilots that "the skies around UK airports are infested with drones".[117] Furthermore, the BMFA suggested a reason for potential inaccuracies:

> Manned vs manned airproxes are usually verified by obtaining reports from the pilots of both aircraft involved. The reports of airproxes involving drones are mostly fleeting observations by one pilot and are not verified by any other evidence. Many of the reports amount to a pilot saying he briefly saw something that he believed was a drone. There must therefore be some doubt that the numbers for drone sightings taken from airprox reports are accurate.[118]

These views were also heard during the roundtable as set out at Annex 2.

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113   British Model Flying Association (RDU0082) para 9; Q204
114   Civil Aviation Authority, "Airprox", accessed 7/10/2019
115   UK Airprox Board, "Analysis of Airprox in UK Airspace", Report Number 34, (January 2018 to December 2018) and UK Airprox Board, "Analysis of Airprox in UK Airspace", Report Number 32, (January 2016 to December 2016)
116   Q204
117   Flight Safety Board (RDU0107) para 4
118   British Model Flying Association (RDU0082) para 11

74. Professor David Dunn from the University of Birmingham disputed the view that airprox's were often fleeting, inaccurate observations, explaining that:

> The airprox reports are often very detailed in what they describe, where they are and what they are doing. Therefore, it is not as if it is just a plastic bag in the way, as some people have suggested. The details are there. Just because a drone is near an aircraft, it does not mean that it has been sighted. It is still a danger whether or not it has been sighted. All the airprox reports we have are where drones have been sighted. The number may be 10 times more than that where drones are not sighted but are still a danger to the aircraft.[119]

Risks to aircraft

75. We also heard evidence that the actual severity of a plane colliding with a drone was not fully known nor was there a consensus on the likely consequences of such a collision. For example, the Civil Aviation Authority offered a less severe analysis of the risk that drones posed to manned aircraft:

> It is considered unlikely that a small drone would cause significant damage to a modern turbo-fan jet engine; even if it did, a multi-engine aircraft would still be likely to be able to land safely. The likelihood of a small drone being in proximity of a passenger aircraft when it is travelling fast enough to potentially damage its windscreen is currently about two per million flights. And; the likelihood of a small drone hitting a passenger aircraft windscreen at sufficient speed to rupture it is much smaller than the probability of it being in the proximity of an aircraft.[120]

76. Captain Tim Pottage, representing BALPA, voiced caution about the CAA's position. Captain Pottage said that he was:

> Concerned that the CAA had that view. There has been no testing of a drone against a large commercial high bypass jet engine—none at all. Anecdotal evidence suggests that it would cause a catastrophic failure, causing a blade to shed and not to be contained within the engine cell.[121]

We are not aware of any independent tests that have reinforced the above comments from Captain Tim Pottage.

77. The evidence supplied by the Department for Transport referenced recent Airprox figures as an example of the increasing "misuse of drones to threaten safety, privacy and security".[122] They also commissioned a study in 2016, in collaboration with BALPA and the Military Aviation Authority, into the effects of a mid-air collision between small remotely piloted aircraft systems (RPAS, commonly known as a drones) and manned aircraft. Such

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119   Q389
120   Civil Aviation Authority (RDU0130) para 9
121   Q206
122   Department for Transport (RDU0103) para 8

a test concluded that drones could cause significant damage to both a helicopter and an airliner under the correct circumstances. This was done with computer testing and under laboratory conditions.[123]

78. In addition to this, evidence from the UK Model Flying Association disputed the likelihood of drone colliding with an aircraft. They explained that, in recent tests carried out by one of their associated organisations, it had established that the maximum altitude performance of a drone, plus its limited battery life, meant that "pilots who have reported encounters with multi-rotor drones above 6000ft must have been mistaken":

> This absolute performance limit was established by repeatedly climbing to 400ft and descending to the ground until the battery was exhausted. An example of the popular "DJI Phantom 3 Advanced" multi-rotor drone was used. [...] It is emphasised that this performance test result is valid for vertical ascent and descent in zero wind only; with no hovering at any height and no movement in any direction. The maximum height is only achievable momentarily and directly above the launch point. Loitering at any height, holding position in any appreciable wind or manoeuvring the aircraft in any direction would drain the battery at a faster rate and reduce the maximum achievable height.[124]

79. **We are concerned that there are differing accounts within the aviation community about the likely severity of damage of a drone collision with an airplane. Furthermore, there are differing accounts of the number of near misses and the reliability of airprox reports has been disputed. The Committee is concerned that there is no agreed position on the likely consequences of a drone-airplane impact. T*he Government should complete a substantive risk assessment of the risks drones pose to manned commercial aircraft and publish the findings of this assessment by the end of 2020. If it is not possible to publish the result of this assessment due to security concerns, the Government must provide this Committee with evidential assurances that this work has been done.***

Risks to helicopters

80. Several witnesses differentiated between the risk posed to larger manned aircraft and those posed to helicopters. The CAA explained:

> The windscreens of small helicopters and light aircraft are more susceptible to rupture if struck by a small drone, even when flying below normal cruising speed [...] Helicopters face more risks because of the additional susceptibility of helicopter rotors to damage from a collision with a drone, and their operating patterns which typically involve lower-level flying and take-off and landing from a range of sites.[125]

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123   Military Aviation Authority, BALPA, Department for Transport, "Small Remotely Piloted Aircraft Systems (drones) Mid-Air Collision Study", 2016

124   British Model Flying Association, Scottish Aeromodellers Association, First Person View UK, and the Large Model Association (RDU0192)

125   Civil Aviation Authority (RDU0130) para 9

BALPA set out three reasons as to why helicopter safety needed significant attention:

(1) "Helicopters are supremely susceptible to catastrophic damage in the event of a drone strike to any part of the aircraft including the windscreen and main and tail rotors";

(2) "Helicopters are often required to be flown in dense urban areas or in mission critical scenarios where the margin for error is very small"; and

(3) "A large number of helicopter missions are to incidents where there is likely to be an increase in drone activity anyway, such as traffic incidents, police incidents etc."[126]

In addition to this, Babcock International, the largest air ambulance operator in the UK, told us that "drones pose a significant danger to aircraft" and "Helicopter Emergency Medical Service (HEMS) aircraft–air ambulances, are at particular risk of drone collisions".[127]

81.   Currently, there are no restriction zones for drones around helicopter landing sites to prevent drone incursion. Babcock International explained that current restrictions failed to mitigate the risk of collision under 400 feet, as the Air Navigation Order 2018 and 2019 amendments stated:

> With the obvious exception of take-off and landing, the majority of manned aircraft fly at heights greater than 500ft from the surface. While there are some other exceptions where manned aircraft are permitted to fly at 'low level' (such as Police, Air Ambulance and Search and Rescue helicopters, as well as military aircraft), flying a small unmanned aircraft below 400ft significantly reduces the likelihood of an encounter with a manned aircraft.[128]

82.   Both Babcock International and Captain Tim Pottage, representing BALPA, called for temporary flight restriction zones around helicopter landing sites to mitigate the increased risk to helicopters:

> We still feel strongly that there is a need for a temporary flight restriction zone to be placed around the landing sites of ad hoc landing zones for emergency helicopter activity […] The first thing would be to require that there is a temporary restriction zone. We would suggest 1 km, unless it is co-ordinated with the helicopter pilot.[129]

83.   ***The Government should introduce temporary drone flight restriction zones around helicopter landing zones. The Government should publish findings from a review on this and legislate accordingly within the next twelve months.***

126   BALPA (RDU0121)
127   Babcock International (RDU0088)
128   Babcock International (RDU0088)
129   Q175

Malign intent and individual safety

84.   We also received evidence relating to the risks posed by drones when harnessed for criminal and malign intent, and the threats these posed to the safety of individuals. Areas of concern highlighted to us included drones being used as drug delivery vehicles for prisons and to conduct surveillance by organised crime gangs.

85.   Drones also have the capacity to carry items, leading to concerns about them being misused. The carrying capacity of drones has been used in criminal cases, including the use of drones to smuggle contraband into prisons, leading to a number of prosecutions.[130] Special Sergeant Kevin Taylor discussed an instance at a prison when "six people got together and flew six drones at once" with the purpose of "drug delivery."[131] He also outlined other potential criminal uses for drones:

> At the moment, in Lincolnshire there is no proven link between that and organised crime, but we should keep an open mind. The likelihood is that organised crime gangs use [drones] for carrying out such recces, potentially where they are looking to steal plant machinery and for ATM-type jobs. That is a real risk.[132]

86.   Written evidence provided by recreational drone user Malcom Bailey and others was fully supportive of the use of geo-fencing technology around prisons to prevent drone incursion and felt that if utilised properly it would be effective against accidental drone incursion. Geo-fencing is a software built in to drones with GPS capability to prevent them from flying near certain pre-programmed geographical areas and will be explored in greater detail at paragraph 125. However, others, such as Stephen Ogbourne and Dr Stephen Wright, noted that the technology might not be advanced enough to fully prevent organised criminal gangs from incursion, as GPS software can be over-ridden quite easily by those who have the intent to do so.[133]

87.   The then Aviation Minister explained to us that concerns around prisons would be addressed in the forthcoming Drones Bill:

> Obviously, the use of unmanned aircraft around prisons is an issue. There are already offences, but it is the gap between commission and conviction where there could be a bit more help for the police. That is what is included in that Bill.[134]

88.   ***The Government should consider rolling out geo-fencing as a compulsory measure around prisons and high security areas.***

Terrorist use of drones

89.   We were also told about the likelihood of the terrorist use of drones in the future by Professor Dunn and Professor Scanlan.[135] There were also concerns raised by Richard Parker from Altitude Angel and others that the registration scheme and other proposed

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130   "Seven jailed over plot to fly drugs into UK prisons with drones", The Guardian, October 2018
131   Q219
132   Q228
133   Stephen Ogbornе (RDU0012) para 3; University of the West of England (RDU0029) para 8.4
134   Q462
135   Q339; Q123

regulations would not be adequate to prevent criminal drone use.[136] Professor Scanlan, amongst others, felt that there was very little that could be done to prevent terrorist drone use as "terrorists and criminals will not follow regulations, and there is a lot of technology they could assemble and put together and do very annoying, very dangerous, very economically damaging things with."[137]

90. During a Defence Committee session for their inquiry into the domestic threat of drones, Dr Anna Jackman, from Royal Holloway University and Specialist Adviser to our inquiry, explained that she felt it was a matter of time until drones were used in a large-sale domestic attack, given both existing and weaponised and disruptive deployments in and beyond battlefields, as well as the drone's evolving capabilities in speed, intelligent manoeuvring, carrying and broadcast capabilities.[138] Further to this, *The Financial Times* reported in June 2019 that "Police in Europe disrupted plans for 2 drone attacks in their infancy", suggesting that the use of as a weapon of terror had already begun.[139] This is something that our colleagues on the Defence Committee will be looking at in more detail, so we will not comment on this further.

91. We also heard about the capacity for the weaponisation of drones, which Dr Stephen Wright from the University of West England described as "a salient risk […] which will not be countered by legislation and requires active policing and countermeasures".[140] Currently, there is no explicit legislation on the weaponisation of drones as a criminal offence. The Civil Aviation Authority explained that "you must not endanger anyone, or anything with your UAS, including any articles that you drop from it" and the Air Navigation Order 2016, article 241 explained that "a person must not recklessly or negligently cause or permit an aircraft to endanger any person or property", but there is nothing explicit about the attachment of weapons to a drone.[141] The US Federal Aviation Administration (FAA) made it illegal to do so, according to Section 363 of the 2018 FAA Reauthorization Act enacted on 5 October 2018.[142] If an individual is found in violation of that, they might be subject to a civil penalty of up to $25,000.

92. The then Minister told us that the Government had begun to take the necessary action to address gaps in police powers to tackle criminal and malign drone use. When asked about the upcoming Drones Bill, which focuses on extending police powers, the then Aviation Minister said:

> It plugs the gap that the police have told us they feel exists at the moment. The registration system comes in at the end of November. The unmanned aircraft Bill will make sure that there are appropriate offences for not being registered. It will include stop and search. At the moment, a police constable cannot stop and search somebody if they suspect they have committed an offence with an unmanned aircraft and shoved it in their bag. We need to fill that particular gap. It covers entry to a house looking for a specific unmanned aircraft—all those sorts of thing.[143]

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136   Q13
137   Q123
138   Qq170–172
139   Financial Times, "Concerns rise over use of drones in a swarm attack", 2018
140   University of the West of England (RDU0029), para 3
141   The Air Navigation (Amendment) Order 2019 No. 261
142   Federal Aviation Authority, "Drones and Weapons: A Dangerous Mix", accessed 7/10/2019
143   Q462

93. **There are considerable risks to safety arising from drones, and we welcome that the Government will be addressing malign and criminal drone use in its forthcoming Drones Bill.**

94. *The Government should introduce the Drones Bill by November 2019. Once the Bill has been passed and come into force, the Government must keep under review the success of the legislation in enabling the police to better tackle criminal and negligent behaviour. 12 months after enactment, the Government should publish an analysis of the success of the legislation, ensuring that it asks law enforcement agencies directly if they feel that the increase in their powers has helped them to better tackle criminal drone use. The Government must then respond accordingly to any issues that are raised.*

95. *We recommend the Government make the weaponisation of a drone a specific criminal offence within the upcoming Drones Bill and consider stringent penalties for those who take such action, such as those introduced in the USA.*

96. *We recommend that the Ministry of Defence make malicious drone use a top intelligence priority.*

Privacy

97. We received evidence relating to how drones might cause a concern for the privacy of individuals. Much of the concern we heard was in relation to drones collecting data on individuals without their knowledge or consent. For example, the UK Computing Research Committee explained that the ethical issues related to drones included the operators "ability to observe and record private property where citizens have a reasonable expectation of privacy".[144] Furthermore, the Information Commissioner's Office (ICO), told us:

> The Committee is right to also look at the ethical considerations around citizens' privacy as this is an area the public are concerned about. Drones fitted with video or audio equipment are highly capable of advanced overt surveillance. There is a risk that they can be used either deliberately or inadvertently to capture vast amounts of personal data including images and the location of individuals without their informed consent. This is highly privacy intrusive and recent media reports have highlighted the potential harms when drones are misused.[145]

98. For commercial drone operators, the ICO outlined that personal data, such as location or personal images, was protected by General Data Protection Regulations and the Data Protection Act 2018. For hobbyists, or recreational drone users, the ICO explained that "personal data processed in the course of a purely personal or household activity, with no connection to a professional or commercial activity, is outside the GDPR's scope." This means, according to the ICO, that:

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144   UK Computing Research Committee ([RDU0031](#)), para 1
145   Information Commissioner's Office ([RDU0170](#)) para 1

Hobbyists still needed to be alive to the potential privacy intrusion their drone might cause others as this was often an area of contention. Domestic users should therefore adopt a common-sense approach and always operate drones in a responsible way to respect the privacy of others.[146]

99. The Department for Transport told us that there were currently a number of laws in place which also protected citizen privacy in the UK:

(1) "Article 95 of the ANO 2016 (Air Navigation Order 2016) which restricts a small surveillance drone from being flown over or within 150m of congested areas, an organised open-air assembly of more than 1000 people, or within 50m of any vessels, vehicle, structure or people";

(2) "In addition to complying with the aviation-specific rules, a drone user must also comply with the law more generally. For example, if a drone user is flying over the property of another person, their action could amount to trespass if the aircraft is not flying at a height which is reasonable in all the circumstances, even if the provisions of the ANO 2016 have been complied with"; and

(3) "The Countryside and Rights of Way Act 2000 also restricts any undertaking of commercial activity, such as filming or photography, on open access land without the permission of the landowner."[147]

100. We heard from others, such as the Royal Aeronautical Society and the Royal Academy of Engineering, that, due to this legislation, the threat to privacy from a drone was no greater than that of a mobile photograph or other recording device.[148] The Royal Aeronautical Society told us that "it would be wrong to assume that drones are more dangerous to the public than road vehicles or that they threaten privacy more than mobile phone cameras".[149] Similarly, the Royal Academy of Engineering explained that the risks were "unlikely to be greater than those existing from smart phone cameras, and as such, these issues are already adequately covered by existing UK privacy legislation".[150] Further, recreational drone user Mr Christopher Murr told us that the current regulations that governed drone use were adequate for protecting the privacy of the general public, including no flying over built-up crowds and no flying within 50m of people.[151]

101. Furthermore, we also heard from many recreational and commercial drone users that the ability for an individual to use a drone to capture high quality data on an individual, or "spy", was limited due to the limitations of recreational drones. For example, Mr Christopher Llewellyn told us that the focal length of the lens would be too short to successfully capture an individual's features: "it effectively renders facial details indistinguishable from 50ft of more elevation".[152] This perspective was supported by other witnesses, including Mr Howard Lewis and Stephen Ogborne, amongst others.[153] Gemma Alcock, representing Skybound rescuer, also concurred with this perspective in

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146   Ibid.
147   Department for Transport (RDU0103) para 2
148   Royal Aeronautical Society (RDU0086), para 2.2.1
149   Ibid.
150   Royal Academy of Engineering (RDU0111)
151   Mr Christopher Murr (RDU0015)
152   Mr Christopher Llewellyn (RDU0008)
153   Mr Howard Lewis (RDU0009); Stephen Ogborne (RDU0012) para 1

her evidence.[154] Furthermore, recreational drone user Mr Wynne Davies explained that "the likelihood of a drone being used to spy on someone is very low due to the noise it produces with its blades" and that it would make much more sense for a long telephoto lens to be used to capture ones image.[155]

102. ADS Group, a trade organisation representing the aerospace community, highlighted the significant role that education could play in lessening the privacy risks from drones: "this risk is best mitigated, though not eliminated, instead through an expansion of the existing Dronecode campaign, teaching all drone users how to avoid unnecessary infringements on personal privacy."[156]

103. **Though the images of individuals collected by commercial drones are protected by legislation, educating the public and drone users about data collection is key to addressing concerns over privacy. We note the assurances that current cameras are not high definition enough to capture identifiable photos and that this may be true now but with technological developments and advancements the risk to privacy is likely to increase over time.** *The upcoming Drones Bill should clarify the legislation in relation to the privacy risks posed by drones for i) commercial users; and ii) recreational users. Furthermore, the Government should ensure that the Drones Bill makes clear that it is a criminal offence for both a private drone user and a commercial operator to capture an individual's data without their consent, and what the penalties are for such action. This information should then be made available to both drone operators and the general public via the Drone Code.*

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154   Q430
155   Mr Wynne Davies (RDU0007)
156   ADS Group (RDU0085)

5   Drone safety education

104. This Chapter explains why increasing drone safety education for the general public, commercial and recreational drone users and emergency service drone operators is important and should be promoted and supported by the Government.

Education

105. The Committee received a significant amount of evidence relating to drone safety education. The British Model Flying Association (BMFA) explained that "based on many decades of experience with model aircraft, we believe that the way to facilitate the safe operation of drones in UK airspace is through education of the operators/ owners and pilots".[157] Many recreational drone users, including Stephen Ogborne, Mr Bernhart Dambacher and John Snape, also agreed that education was vital for safe drone use in the UK.[158]

106. A number of submissions asserted that drone safety education was effective in preventing ill-informed drone misuse but would not prevent criminal drone use. For example, drone user Mr Ian Bastin explained that "it's clear the people who will break the law are likely to […] whatever rules and laws are introduced, I myself think education and competency of the drone community is where the gains will be made".[159] DJI, one the world's largest drone manufacturers, told us that:

> increasing awareness of drone regulations across the UK is one of the most effective ways to tackle non-compliance and thus increase safety, due to the fact that a significant proportion of Air Navigation Order breaches are due to ignorance rather than malicious intent.[160]

107. Furthermore, the Association of Remotely Piloted Aircraft Systems UK, (ARPAS-UK), also explained that "the case of the distressed or unaware friendly remote pilot can be considered as a matter of information dissemination training, and regular law enforcement".[161]

108. Despite the weight given by drone manufacturers and the public to drone safety education, many people and organisations argued that the current level of drone safety education was not sufficient. For example, Mr Christopher Llewellyn explained that he felt drone safety education in the UK was "lacking" and depended on drone users proactively seeking it "as drones are perhaps still considered as toys by many (irrespective of the prices paid), and in most cases toys don't tend to have any legal restrictions placed upon them."[162] Martin Hall, a drone user, also stated that drone safety education was "far too hidden".[163] Professor Dunn from the University of Birmingham told us that current level of drone education was not sufficient and that:

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157   British Model Flying Association (RDU0082) para 46
158   Stephen Ogborne (RDU0012) para 7; Mr Bernhart Dambacher (RDU0021) p 2; John Snape (RDU0166) p 5
159   Ian Bastin (RDU0139) p 1
160   DJI (RDU0096) para 16
161   ARPAS-UK (RDU0164) para 3
162   Mr Christopher Llewellyn (RDU0008) p 4
163   Martin Hall (RDU0035) p 3

The optimal way to improve this is by public messaging and advertising so that those buying COTS (commercial off the shelf) drones or those building them or buying and flying model aircraft not in societies can be aware of their responsibilities before purchasing takes place.[164]

109. Gemma Alcock, the Founder of SkyBound Rescuer, an organisation of specialists in the use of drones for public safety, told us that improvements needed to be made in educating those who were about to purchase drones as this was the point "at which most people ask questions about any form of technology "[165]

Drone Code

110. The Civil Aviation Authority has produced an online "Drone Code" guide that outlines the current drone regulations in an infographic.[166] The Drone Code states that:

(1)   Always keep your drone in sight;

(2)   It's against the law to fly your drone over 400ft;

(3)   From 30th November 2019 and for drones over 250g, you must pass the drone test and register with the CAA before you fly;

(4)   You are responsible for each flight;

(5)   Keep the right distance from people and property (150ft and 500ft respectively); and

(6)   Stay well away from aircraft, airports and airfields when flying any drone.[167]
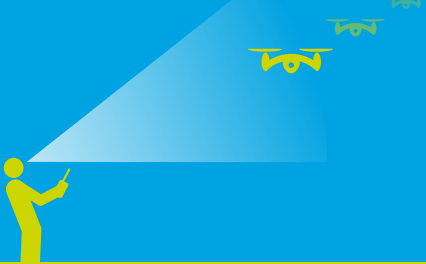
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164   University of Birmingham (RDU0036), para 7.2
165   Q337
166   Drone Safe, "The Drone Code", accessed 8/10/2019
167   Drone Safe, "The Drone Code", accessed 8/10/2019

BE DRONE SAFE

Always keep your drone in sight

This means you can **see** and **avoid** other things while flying

It's against the law to fly your drone over 400ft (120m)

400ft (120m)

This reduces the likelihood of a **conflict** with manned aircraft

From 30th November 2019 and for drones over 250g, you must pass the drone test and register with the CAA before you fly

Civil Aviation Authority

PASS ✓

Pass No.   GBR4321
Registration No. GBR1234

Passing the **test** and **registering** will help keep you and others safe

Keep the right distance from people and property

150m

50m

People and properties – **150ft (50m)**
Crowds and built up areas – **500ft (150m) and don't overfly**

You are responsible for each flight

Legal responsibility lies with **you**
Failure to fly responsibly could result in **criminal prosecution**

Stay well away from aircraft, airports and airfields when flying any drone.

1 km   5 km   5 km   1 km

It is **illegal** to fly them inside the airport's flight restriction zone without permission.
See **dronesafe.uk** for info

2 or 2.5nm

If your drone endangers the safety of an aircraft it is a **criminal offence** and you could go to prison for five years

Source: P73 – Civil Aviation Authority, "The Drone Code", July 2019

111. The Civil Aviation Authority (CAA) told us that the Drone Code "is a simple explanation of the drone flying rules."[168] The CAA also explained that "in the past three years awareness of the Drone Code among drone users has risen from under 20% to over 70%.", but they continued "to work closely with the Government to build on the success of this campaign".[169] Mr Jonathan Thursby a drone user, commented:

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168   Civil Aviation Authority (RDU0130) para 37
169   Ibid

The CAA have done some very good work with their Drone safe website and the Drone Code which clearly set out the regulations that apply, many of which are common sense. They have also published a detailed map which shows where the restricted zones are. This is easily accessible.[170]

112. Conversely, we also received evidence that there was a lack of awareness of the Drone Code amongst drone users. For example, Surrey Search and Rescue explained: "Improvements are needed in drone safety education. Currently anyone can buy a drone on the internet or High street and fly it without any awareness of the Drone Code or legislation."[171] The Security Institute noted that while the "CAA has created some good educational material for users, a broad campaign promoting a drone code of practice could be targeted at non-commercial operators."[172] A CAA survey from 2016 stated that "69% of owners [of drones] thought retailers were responsible for education at the point of sale, but only 36% were made aware of the Drone Code when buying a drone".[173] In the roundtable with drone users (see Annex 2), we heard from drone users that while they saw the Drone Code as having an important role to play in the education of drone users it needed to be updated as further legislation came into force, and that more needed to be done to publicise it. Many told us that they supported making it compulsory for retailers to provide the Drone Code at the point of sale, whilst others told us they found the contents of the code not to be that helpful. Gemma Alcock, founder of Skyrescuer, told us that the Drone Code was helpful, but that the problem was in the lack of awareness of its existence.[174]

113. The then Minister for Aviation told us that "awareness of the Drone Code has gone up from 54% in 2017 to 71% in 2018",[175] but conceded that a priority of the CAA and the Government was in further promoting the Drone Code: "we are working with clubs to make sure that they understand what is out there."[176]

114. *The Government should mandate that a copy of the Drone Code is provided with each drone sold in the UK. The Drone Code should also be publicised in common drone flying areas. This should be rolled out as quickly as possible and implemented in full no later than the end of April 2020.*

Commercial drone users

115. In terms of the education of commercial drone users, the Civil Aviation Authority explained that commercial drone operators must demonstrate remote pilot competence and a sufficient understanding of aviation theory (airmanship, airspace, aviation law and good flying practice) and pass a practical flight assessment.[177] The CAA approves commercial organisations, known as National Qualified Entities (NQEs) to do this assessment on their behalf. Liverpool John Moores University stated that the NQE process was lacking and that there was no requirement for pilots to be periodically re-assessed:

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170   Mr Jonathan Thursby (RDU0149) para 8
171   Surrey Search and Rescue (RDU0125) para 8.1
172   Security Institute (RDU0106) para 3
173   Drone Safe, "Consumer Drone Users Report", 2016
174   Q337
175   Q496
176   Q497
177   Civil Aviation Authority (RDU0130) para 26–27

Unfortunately, the education system of commercial drone operators is also very poor in places […] I have experience with many newly qualified operators from a number of NQEs who do not possess anywhere near the requisite amount of knowledge of experience to operate safely.[178]

116. Gemma Alcock explained that currently emergency service operators were required to go through the same training as commercial operators—using the NQE system. There were only two NQEs in the UK that specialised in emergency service operations. Gemma Alcock told the Committee that the level of training for emergency operators was "at a good level, especially if they have gone to one of the emergency services NQEs and have incorporated a high level of flying as part of the training." However, she continued:

> What could perhaps be improved is tactics. That will come only as we better understand how best to use the technology in different use cases. There are constantly different use cases for emergency services using drones. Because it has grown on a rapid scale, it was difficult to use them in the most optimal way from day one, but it is constantly improving as the life-saving, life-preserving and public safety applications of drones grow worldwide.

117. **National Qualified Entities (NQEs) are key for providing necessary drone education to commercial drone users in the UK.** *The Civil Aviation Authority needs to monitor the effectiveness and adequacy of NQEs annually and report areas of concern to the Secretary of State. If NQEs do not meet the required standard there must be a mechanism for terminating their right to operate.*

118. *The CAA should introduce periodic re-assessment of commercial drone users and a compulsory renewal of their licence to ensure that they are up-to-date with technology advances and legislative changes.*

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178   Liverpool John Moores University (RDU0079) p 3

6   Technology required

Purpose of the Chapter

119. This Chapter outlines the evidence received relating to the technology required, both within drone devices and as part of the infrastructure, to mitigate the risks posed by drones and to enable the opportunities presented by the growing industry.

Drone devices

Identification and electronic conspicuity

120. A key technological advancement highlighted by a large number of witnesses was a requirement to make all drones electronically conspicuous. Electronic Conspicuity (EC) is an umbrella term for a range of technologies that, in their most basic form, transmit the position of the host aircraft to other airspace users operating compatible equipment. More advanced devices can also transmit and receive, displaying and alerting pilots to other/ conflicting traffic who have compatible EC devices. EC devices turn the traditional 'see and avoid' concept into 'see, BE SEEN, and avoid'.[179] Nesta described electronic conspicuity as "a class of technologies that make an object such as a drone visible to electronic systems such as air traffic control".[180] In its report, *Flying High,* Nesta recommended that "electronic conspicuity devices are fitted to all air traffic and integrated into a system, to improve safety, security, privacy and positive public perception".[181] The Civil Aviation Authority and the British Airline Pilots Association also recognised the importance of increased electronic conspicuity of drones.[182]

121. Tim Johnson, representing the CAA, told us that electronic conspicuity:

> Will make sure that everything that is flying is electronically visible. That would give a better picture of everything that is flying around and allow a much more system-wide understanding about who is flying where. That is clearly dependent on participation in that system, and operators being aware of their responsibilities and actively participating in the system, to make sure they are visible and following the rules.[183]

122. We heard concerns from Blighter Surveillance Systems, who argued that the current technology that is used for conspicuity may be too heavy for smaller drones. These concerns were echoed by drone users at the roundtable event (see Annex 2), who explained that the conspicuity of devices could affect the operating ability of their drones. Tim Johnson, who represented the Civil Aviation Authority, told us, however, that the technology was getting smaller.[184] Richard Parker representing Altitude Angel, also explained that it might not be necessary for the device to sit on the drone itself:

179   Civil Aviation Authority, "Electronic Conspicuity devices", accessed 8/10/2019
180   Nesta, "Flying High: the future of drone technology in UK cities", July 2018, Glossary
181   Nesta, "Flying High: the future of drone technology in UK cities", July 2018
182   Civil Aviation Authority (RDU0130) para 44; British Airline Pilots Association (RDU0186) p 3
183   Q56
184   Q63

Most drones are controlled today by, maybe, a mobile phone or some other controller. It is quite common for manufacturers to look at putting a kind of relay for the drone's actual location to pick up that information from the controller and relay that elsewhere.[185]

123. Baroness Vere of Norbiton, the then Aviation Minister, explained that electronic conspicuity "is a very important development" and the Government had completed a consultation on the subject—*Aviation 2050*—which it was expecting to respond to by the end of the year.[186] The then Aviation Minister told us:

We will look at how that [the consultation] progresses, but it is my view that, all other things being equal, unless there is a particular issue brought to our attention, both manned and unmanned aircraft should be conspicuous in future.[187]

In further evidence supplied to the Committee by the then Minister, she explained that the forthcoming White Paper would set out how the Government intended to do this.[188] When the then Aviation Minister was asked about retrofitting drones with electronic conspicuity, she said she did not know if this would be the case and explained that this question formed part of the consultation.[189]

124. *The Government should ensure all drones, including existing drones, are electronically conspicuous within two years.*

Geo-fencing and embedded safety features

125. A further technology to mitigate the risks of drones is geo-fencing. Geo-fencing is a software built in to drones with GPS capability to prevent them from flying near certain pre-programmed geographical areas. Brendan Schulman, representing the world's largest small drone manufacturer, DJI, told us that DJI had done a lot of work over the course of several years to ensure that there were safety features built into its drones.[190]

126. A number of those who provided evidence, including ARPAS-UK, BALPA and the University of Birmingham, explained that while in-built safety technologies were effective at stopping accidental incursions they failed to protect against deliberate criminal use of drones.[191] The UK Computing Research Committee argued that it was "increasingly possible to disable protection mechanisms" and customise off-the-shelf drones in such a way as to bypass in-built safety technologies.[192] Dr Stephen Wright, based at the University of the West of England, argued that due to the commonness of in-built safety features, specifically geo-fencing, amongst off-the-shelf drones "geo-fencing override ('jailbreaking') tools [are] becoming widely available to skilled amateurs."[193] Further

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185   Q63

186   Q457

187   Ibid

188   Department for Transport (RDU0182)

189   Q485

190   Q93

191   ARPAS-UK (RDU0164); British Airline Pilots Association (RDU0186); University of Birmingham (RDU0036)

192   UK Computing Research Committee (RDU0031) para 4

193   University of the West of England (RDU0029) para 8.2

to this, BMFA member, Mr Bernhart Dambacher, told us that there would be immense difficulties in regulating smaller recreational and homemade drones as "tracking and monitoring is only available on the off the shelves more expensive machines".[194]

127. At the drone user roundtable (see Annex 2), some participants told us that they believed it should be a criminal offence to disable in-built safety technologies, and that penalties for doing so should be clearly set out in the forthcoming Drones Bill. Some also explained that it would be wise for it to be a legal requirement for all manufacturers to ensure that their drones had in-built safety standards, whilst others felt that putting liability on the manufacturer over the user was unfair. Drone user Michael Clark said that all drones in the UK should adhere to the same safety standards as DJI, and Mr Jonathan Ridgeway also explained that there should be standard safety features on all drones over a certain weight.[195] Mr Paul Harvey similarly explained: "I would be happy to see a ban on any drones/aircraft that do not have at least some of these features".[196]

128. However, Mr John Irvine stated that such technology only unfairly penalised hobbyists as it increased the cost of small drones.[197] Further to this, others argued that the compulsory introduction of such technology was ineffective and would cause unnecessary expense. The BMFA and drone users Mr Bernhart Dambacher and Mr Simon Barkle, argued that this would be difficult to police:

> It's fine having tracking technology on a drone but how and what is that information going to be used for and by who? It won't be able to tell you who's flying it and it certainly won't make the drone any safer than it already is. So why introduce it?[198]

129. Further, at the roundtable event (see Annex 2), an individual compared a drone to a car—the manufacturer made it possible for a car to travel at high speed, but it was the onus of the driver to ensure that they stuck within the speed limits.

130. The then Aviation Minister told us that, according to recent EU regulations, it had recently become mandatory for certain safety features, such as electronic conspicuity and geo-fencing, to be included in all drones within a three-year transition period.[199]

131. **There is no justifiable reason why a drone should not have in-built safety features as standard. *The Government must ensure that all manufacturers include safety features, such as geo-fencing and electronic conspicuity as standard in their drones. Further, it should be a criminal offence to disable such features. Penalties for doing so should be set out clearly in the forthcoming Drones Bill.***

132. ***The Government should also ensure that all existing drones are retrofitted with electronic conspicuity within the next two years.***

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194   Mr Bernhart Dambacher (RDU0021) p 1
195   Mr Michael Clarke (RDU0049) para 2; Mr Jonathan Ridgeway (RDU0028) para 6
196   Mr Paul Harvey (RDU0044) p 1
197   Mr John Irvine (RDU0073) p 1
198   Mr Bernhart Dambacher (RDU0021); Mr Simon Barkle (RDU0069) para 2
199   Q494

International standards

133. The British Airline Pilots Association (BALPA) argued that for in-built safety features to be sufficiently reliable "those capabilities will have to be designed, built and certified to recognised and accepted international standards".[200] Further, Professor Scanlan, representing the University of Southampton, advocated international standards for drone safety.[201] Sir Brian Burridge, the CEO of the Royal Aeronautical Society, went on to explain that "as a generality, international standards promote investment in research and technology in a particularly efficient way, compared with having to stovepipe it for different markets."[202]

134. EASA (the European Aviation Safety Agency) developed specific proposals for European states to abide by as a framework for Unmanned Aerial Vehicles (UAVs) and utilised the expertise of different interest groups within Europe to create these. These included regulations about flying a UAV in a crowded urban area, keeping one's drone in visual line of sight and general safety regulations about flying drones within specific airspace.[203]

135. The previous Prime Minister set out her ambition to stay in the EASA (European Aviation Safety Agency) after the UK has left the European Union:

> We want to explore with the EU, the terms on which the UK could remain part of EU agencies such as […] the European Aviation Safety Agency. We would, of course, accept that this would mean abiding by the rules of those agencies and making an appropriate financial contribution.[204]

136. **As aviation crosses borders and the use of drones is taking place internationally, it is important that the UK engages in best practice and knowledge sharing with other countries.** *The Government should continue to pursue its ambition to stay in the European Aviation Safety Agency after Brexit. Further, the Government should seek to secure international agreement on international mandatory standards for drones.*

Infrastructure

Unmanned traffic management system (UTMS)

137. The Committee received a significant amount of evidence relating to the establishment of an Unmanned Traffic Management System (UTMS). Richard Parker, from Altitude Angel, told us that the establishment of an unmanned traffic management system was reliant upon drones being electronically conspicuous: "a key component of that UTM, as a manufacturer of UTMs, is having access to identify information to be able to share that with different participants involved in security, legitimate drone operations and so on."[205]

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200   British Airline Pilots Association (RDU0186) p 2
201   Q132
202   Q134
203   EASA, "Civil drones (Unmanned aircraft)", accessed 8/10/2019
204   GOV.UK, PM speech on our future economic partnership with the European Union, 2 March 2018
205   Q60

138. Richard Parker also said that one of the key challenges faced by his business, as a manufacturer of UTMs, was "that there apparently is not a single body responsible for overseeing the different requirements of the commercial industry, the aviation safety standards and the security services."[206] He went on to recommend that the Government appoint "someone in the UK who has the responsibility to determine what is required to mitigate some of the risks we are talking about today, as well as to welcome the very legitimate uses of drones that many people seek to embrace."[207]

139. Tim Johnson representing the CAA discussed the benefits of Operation Zenith, which is the codename for a programme of live demonstrations of Air Traffic Management (ATM) and Unmanned Traffic Management (UTM) integration in controlled airspace, deeming it "a really good piece of work".[208] He further explained that "there will need to be more such trials to test the different elements of UTM".[209] The then Aviation Minister also discussed the establishment of an Unmanned Traffic Management system:

> That is how we see the system working, and we think that is fair and future-proofed […] If somebody puts a drone or an unmanned aircraft up in the sky with a beacon on it and it is beeping, and that drone is not in the registration system, we will be able to say, 'What's going on there?' That is quite important.[210]

This relates to other comments that the then Minister made that we have outlined at paragraph 28 where the Government argued that electronic conspicuity was important for all UAVs, including model aircraft, as it was important to track what was in the sky to ensure safety for the public.

140. We were further informed that establishing an Unmanned Traffic Management system was particularly important if the UK was to allow—and reap the benefits of—Beyond Visual Line of Sight (BLVOS) operations. When discussing BVLOS, Richard Parker explained that:

> it is quite common to see drones being deployed for safety of life type of scenarios. The challenge today is that it is not possible to use drones in all the ways that people wish to because there is no unifying traffic management system.[211]

141. Tris Dyson, representing Nesta, was asked if the technology existed to allow BVLOS operations. He pointed to the creation of an Unmanned Traffic Management system:

> A lot of testing and development needs to happen to prove that it is safe and to prove it is effective, and that it will integrate effectively with services. […] At present, that is happening outside the UK. That is the disappointing thing. A lot of the testing development is happening in cities in the US. There are already beyond visual line of sight services operating in places like Finland, Switzerland and Australia.[212]

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206   Ibid
207   Ibid
208   Q75
209   Q75
210   Q492
211   Q63
212   Q267

This perspective was also shared by Julia Jiggins representing Thales.[213]

142. *The Government must establish and fund further testing facilities in which Unmanned Traffic Management (UTM) systems and related technologies, including beyond visual line of sight operations, can be tested. Clear plans should be set out for this as soon as possible and further testing should begin no later than Summer 2020.*

Tracking and counter-UAV

143. The Committee heard from Andy Sage, who represented NATS, that there was a need for drones to be remotely identified and tracked: "anything that can emerge through regulation to make it mandatory for drones to be remotely identified and tracked will help us manage that traffic."[214] Captain Tim Pottage told the Committee that detection technologies were "pretty effective", however, "to cover all eventualities there probably needs to be a suite of sensors and, ultimately, they need to be optically identified."[215]

144. Captain Tim Pottage emphasised the importance of the 'detection' element of counter-drone technologies:

> The most important element for pilots is detection. Don't let the desire to have some mechanism for defeating drones hold up the implementation of detection equipment. If we know where they are and, more importantly, where it is safe or where one is in the way, we can take action to avoid an accident.[216]

145. Andy Sage, representing NATS, stated that detection software was useless without the ability to identify drones as either friend or foe:

> If all we did was switch on radars, take the raw data and present it to air traffic controllers, there would be chaos. It is only when you can correlate that with the identity of those flights and their expected flight plans that you can see the outliers and those who are where they should not be.[217]

146. The Committee received limited evidence relating to 'defeat' technologies. Special Sergeant Taylor told us: "the most effective [defeat method] is electronically jamming them through radio frequencies and GPS. That is probably the most contentious because of the fall-out from doing so. That has been looked at; trials have taken place."[218] However, Special Sergeant Taylor explained that while jamming was "the most effective way" to defeat a drone, "the issue is around legislation" as "legislation will prevent it […] it would be classed as aircraft interference]."[219] To enable organisations to use this defeat technology, Special Sergeant Taylor told us there would "absolutely" have to be a change in law to provide for that.[220]

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213   Q268
214   Q238
215   Q240
216   Ibid
217   Q242
218   Q249
219   Qq253–254
220   Q255

147. Drone users, including Stephen Ogborne and Mr Michael Clarke, warned against the use of jamming technologies as they potentially presented a risk to human life.[221] Dr Alan McKenna, a law lecturer at the University of Kent also argued that jamming technologies might have specific legal and cost implications:

> This does however lead to questions over what sites would be expected to install such equipment and the level of resources that would be considered necessary to be acquired in order to provide a reasonable level of protection. Outside of those sites that would be 'expected' to deploy such equipment it could be envisaged that a variety of both public and private organisations may also wish to deploy such equipment, and even perhaps certain individuals. This does however raise questions over who may be allowed to deploy such technology and the process by which permission may be granted.[222]

148. Currently, the use of jamming technologies is illegal. The Wireless Telegraphy Act 2006 makes it illegal to block signals.[223] The then Minister however told us that the Government had discussed counter-UAV technology extensively:

> a lot of airports have already done an analysis of where the most likely launch sites are and where they want to deploy their capabilities. It will never be one size fits all, but the Government do what they can to test the technology that is coming through.[224]

She also told us that the Home Office and the Department for Transport were working on their counter-UAV strategy.[225]

149. *The Government should seek to publish its counter-Unmanned Aerial Vehicle (UAVs) strategy by Spring 2020 and this should include clarifications on whether the Government intends to amend legislation to enable certain organisations such as the police to use jamming technologies.*

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221   Stephen Ogborne (RDU0012) para 3; Mr Michael Clarke (RDU0049) para 3
222   Dr Alan Mckenna (RDU0098) paras 11–14
223   GOV.uk, "Wireless Telegraphy Act 2006", accessed 8/10/2019
224   Q450
225   Q449

7 Vision for the future

Purpose of the chapter

150. This Chapter sets out the need for the Government to develop a coherent strategy for the integration of drones into society in order to maximise the opportunities offered by drones and to mitigate the risks posed by drones.

Vision and international comparisons

151. As mentioned in Chapter 3, we heard that the use of drones in commercial business, humanitarian aid and in the airspace could have considerable economic benefits for society. Despite this, we also heard that much of the action that the Government has so far taken to ensure the safe and successful integration of drones into the airspace was reactive, such as the fitting of electronic safety features and registration. When we asked the then Minister if there was a central, coordinating strategy for the vision of drones in society, she explained "we have a vision and it is very clear what the Government's vision is." However, when asked "Is it stated anywhere?" she responded, "Not as such."[226]

152. We received evidence from PwC that that the UK needed a central co-ordinator and a strategy to enable the UK to make the most of the growing drone industry. Elaine Whyte, representing PwC, told us:

> I would like to see a vision of where we want to go and some guiding principles to deliver that vision […] There needs to be a co-ordinating authority, and that would fall to the Government. Within that vision, we need some guiding principles.[227]

Similarly, Tris Dyson, representing Nesta, explained that there was a need for a co-ordinated approach: "We need a more co-ordinated and iterative approach, and we need a champion, which is perhaps difficult, given that there is a lot of political transition at the moment. That is needed to drive this forward."[228]

153. We also heard evidence that the UK was somewhat behind other countries with regard to drone policy. For example, Mr Adrian Belcher explained that the UK needed to "join other countries with safety research" and the then Minister also admitted that the UK was potentially behind other countries in terms of the deployment of counter-UAV technology.[229] Further, Tris Dyson from Nesta explained that the UK was considerably behind countries such as Finland, Australia and Switzerland, who had already developed Beyond Visual Line of Sight (BVLOS) operations: "at present, that is happening outside the UK. That is the disappointing thing. A lot of the testing development is happening in cities in the US."[230]

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226   Qq436–437
227   Q296
228   Q297
229   Mr Adrian Belcher (RDU0056) para 6; Q450
230   Q267

154. However, Elaine Whyte from PwC explained that she thought the UK was taking action to ensure the integration of future drone technology, as demonstrated by Operation Zenith.[231] She presented further examples to us of the UK doing much in the way of innovation for drone technology, but explained that it simply was not well documented:

> What we need to achieve potentially in this country is more transparency and more sharing of what we are achieving in all those examples. I reflect on what we have achieved with CCAV, the centre for autonomous vehicles. That is one centre of excellence bringing together an understanding of the research and investment that is taking place.[232]

155. **We recognise that drone technology is moving at pace, carrying with it a multitude of opportunities and risks. The Government needs to act to ensure that it can stay ahead of the curve in the future.** *The Government should produce a White Paper by Summer 2020 that outlines the vision for how drones will be integrated into UK communities over the coming years. At a minimum, the White Paper should cover the role of registration, regulation, maximising the opportunities, minimising the risks, drone safety education and the technology required in order to implement their vision of drone integration into society in the next 20 years. The document should also set out a clear roadmap that outlines the steps that the Government and other agencies will take to achieve this future vision.*

Universities and testing

156. As explained in detail at Annex 1, we attended the Aerial Robotics Lab at Imperial College as part of our inquiry. Dr Mirko Kovac, Director of the Lab, explained that significant work on drone innovation and development was taking place at universities across the UK. However, he also raised concerns that universities were in a 'grey area' when it came to being classified as either recreational or commercial drone users in the eyes of the Civil Aviation Authority. As such, he explained that there was confusion over regulations that govern these areas, and that this impinged upon universities ability to test new technologies.

157. Further, Liverpool John Moores University agreed that universities played a key role in "delivering successful teaching and research programmes on drones", but that this was reliant on the "flexibility given by the CAA to relaxing restrictions if a sufficiently thorough safety case can be made".[233] They went on to explain that there was, however, a lack of "dedicated funding streams for drone technology", meaning that a number of other countries were overtaking the UK.[234]

158. *The Government should open a dialogue with UK universities working on drones to discuss how they might best be classified and funded to ensure that the requirement to register as commercial operators does not hamper innovation and development of the industry. A comprehensive and clear regime should be established to facilitate academic development work no later than Summer 2020.*

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231   Q272
232   Q272
233   Liverpool John Moores University (RDU0079) p 3
234   Ibid

159. Dr Mirko Kovac also told us that the UK needed to create more 'test bed' environments in which drone technologies could be tested. This call was echoed by other witnesses, for example Julia Jiggins, Head of Civil Avionics at Thales explained:

> The big thing about moving from visual line of sight to beyond visual line of sight is the fact that you increase the range significantly. Therefore, you need to integrate more technology, and you are getting to the limit of the technology, particularly on battery life and durability. How a drone safely lands is a key technology at the moment, and a limiting factor. We are building the corridors and we need more safe test areas in the UK.[235]

Further, Elaine Whyte, UK Drones Lead at PwC, stated that:

> In the UK, the challenge will be how we work in an urban environment, and we have heard the complexities involved there. The important thing is to get the test and evaluation environment right so that we can learn and share that learning and try to grow together at the right pace.[236]

160. **Technological advancement is needed for drones to be utilised successfully and with optimal results for society.** *The Government should set out how it intends to provide support and funding to current testbeds at universities and whether there is an appetite to create* **more** *testbeds. It should announce its plans and funding expectations by the end of 2019.*

Public perception

161. We received evidence relating to the importance of improving the public's perception of drone technology. Nesta explained that "in addition to technical and regulatory barriers to developing an urban drone system, public acceptance will be key if drones are to integrate into city life".[237] Many other witnesses, including recreational drone users, acknowledged the societal resistance to drone use in the UK: "We need the public to trust drone users know the rules and know what they're doing rather than instantly get their backs up..".[238] PwC also explained that societal acceptance was an essential step to "unlock the full potential of drones."[239] Further, research from PwC showed that public perception was a key barrier to effective drone use in the UK:

> Less than a third of the public, (31%) feel positively towards drones, while more than two thirds are concerned about the potential use of drones for criminal purposes. This contrasts with 56% of business leaders who are positive about drones and their benefits. Including those already using drones in their business this rises to 83%.[240]

235   Q268
236   Q322
237   Nesta, 'Flying High: The future of drone technology in UK cities' (July 2018)
238   Mr Jacques Le Roux (RDU0030)
239   PwC, "Building trust in drones - public concerns remain a barrier to drone adoption", (June 2019)
240   PwC, "Building trust in drones - public concerns remain a barrier to drone adoption", (June 2019)

162. Both Nesta and the Department for Transport argued that increasing levels of awareness amongst the general public would play a critical role in changing public perception.[241] They demonstrated that positive shifts in perception occurred when individuals learned more about drones and their current and potential applications. The Department for Transport suggested that raising public awareness and specifically "focusing on the benefits to citizens and society" would build trust in the drone industry.[242]

163. **There is a notable distrust towards drones among the general public that needs addressing if the UK is to maximise the opportunities presented by drones.** *The Government should act to improve public perception and awareness of drones by launching a public awareness campaign, no later than Summer 2020, that highlights the opportunities presented by drones and informs the public on the reality of the risks posed by drones. This issue should also be addressed in the White Paper that we have called for in this Report.*

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241   Nesta, 'Flying High: The future of drone technology in UK cities' (July 2018); Department for Transport (RDU0103) para 5

242   Department for Transport (RDU0103) paras 23 - 27

Conclusions and recommendations

Current regulations

1. We recognise the importance of extending Flight Restriction Zones to five kilometres. However, these restriction zones are not clearly or consistently enforced. The lack of a standardised process results in inconsistent denials and permissions being granted to those applying. This is unacceptable. (Paragraph 24)

2. *The Government should commission the production of a standardised and unified system through which drone operators can request access to Flight Restriction Zones. This could be achieved by working with National Air Traffic Services on its development of an Airspace User's Portal. This should be completed no later than summer 2020. (Paragraph 25)*

3. There is a compelling case that the Government should introduce a registration scheme to be able to identify all lawful operators and to ensure that there is a knowledge test for drone users. Flying a drone is a skill and therefore it is appropriate for there to be a test to make sure the operator is fit to operate a drone. (Paragraph 32)

4. *The Government, or the appropriate regulatory body, such as the Civil Aviation Authority, should review the online test one year after it has been in operation. Specifically, the Government should determine if it is an adequate test for ensuring safe drone use. (Paragraph 33)*

5. If the registration fee dissuades individuals from registering, then this defies the purpose of the system—to improve the safety of our airspace. *The Government should conduct a review of the cost of the registration scheme. If the Government believes it is appropriate for the fee to remain at £16.50, then they should clearly set out their rationale for the cost and the renewal period should be three years rather than yearly. (Paragraph 38)*

6. *We recommend that the Government consider a system which allows organised clubs and societies to register as one entity, so as not to financially burden each member. However, it must be mandatory for every individual user to adhere to the required safety standards. The Government should set out in response to this Report whether this should be demonstrated by the completion of an online test or an obligation on clubs to ensure their members have appropriate safety standards. (Paragraph 41)*

7. The Government should acknowledge that the proposed registration scheme will do little to mitigate the risks from nefarious drone users who will simply bypass registration and testing. Penalties for those who avoid registration should be set out clearly in the forthcoming Drones Bill. *Penalties for those who avoid registration should be set out clearly in the forthcoming Drones Bill. We recommend a sliding scale of penalties for failure to register, starting with a warning, and culminating in a fine and a prison sentence. (Paragraph 46)*

Opportunities

8. It is vital that the Government respects recreational drone use and model flying communities and ensures that any further regulation or legislation does not dissuade people from joining such communities. (Paragraph 52)

9. The Government does not appear to have made any independent assessment of the potential economic benefits and opportunities that arise from the growing drone industry. To properly harness the benefits of drones the Government will need to analyse their potential economic contribution. *The Government should provide an assessment of how the growing drone industry might contribute to the UK's economy by the time of the 2020 Spring Statement. This should focus on the regulatory requirements and the technological advancements required for innovations, such as parcel delivery and human transportation. Further, it should investigate the potential environmental impact of these innovations and in particular the potential for commercial drone use to contribute to decarbonisation of the economy. It should then set out a strategy and a timeframe required for any actions it wishes to take and should publish its findings no later than Autumn 2020.* (Paragraph 63)

10. Drones can have a positive effect on society, including through medical delivery and emergency service provision. By utilising drones, emergency services can conduct missions that were previously unsafe or not possible, as well as being able to respond quicker to incidents. We are encouraged to see the Government has allowed exemptions for emergency services to use drones beyond the visual line of sight in their operations, however, this provision does not apply to other organisations (such as Mountain Rescue) who might be involved in emergency service-led rescue missions. *The Civil Aviation Authority should make it possible for organisations which are used in emergency missions to apply for emergency service exemptions to the Air Navigation Order 2016.* (Paragraph 70)

Risks

11. We are concerned that there are differing accounts within the aviation community about the likely severity of damage of a drone collision with an airplane. Furthermore, there are differing accounts of the number of near misses and the reliability of airprox reports has been disputed. The Committee is concerned that there is no agreed position on the likely consequences of a drone-airplane impact. *The Government should complete a substantive risk assessment of the risks drones pose to manned commercial aircraft and publish the findings of this assessment by the end of 2020. If it is not possible to publish the result of this assessment due to security concerns, the Government must provide this Committee with evidential assurances that this work has been done.* (Paragraph 79)

12. *The Government should introduce temporary drone flight restriction zones around helicopter landing zones. The Government should publish findings from a review on this and legislate accordingly within the next twelve months.* (Paragraph 83)

13. *The Government should consider rolling out geo-fencing as a compulsory measure around prisons and high security areas.* (Paragraph 88)

14. There are considerable risks to safety arising from drones, and we welcome that the Government will be addressing malign and criminal drone use in its forthcoming Drones Bill. (Paragraph 93)

15. *The Government should introduce the Drones Bill by November 2019. Once the Bill has been passed and come into force, the Government must keep under review the success of the legislation in enabling the police to better tackle criminal and negligent behaviour. 12 months after enactment, the Government should publish an analysis of the success of the legislation, ensuring that it asks law enforcement agencies directly if they feel that the increase in their powers has helped them to better tackle criminal drone use. The Government must then respond accordingly to any issues that are raised.* (Paragraph 94)

16. *We recommend the Government make the weaponisation of a drone a specific criminal offence within the upcoming Drones Bill and consider stringent penalties for those who take such action, such as those introduced in the USA.* (Paragraph 95)

17. *We recommend that the Ministry of Defence make malicious drone use a top intelligence priority.* (Paragraph 96)

18. Though the images of individuals collected by commercial drones are protected by legislation, educating the public and drone users about data collection is key to addressing concerns over privacy. We note the assurances that current cameras are not high definition enough to capture identifiable photos and that this may be true now but with technological developments and advancements the risk to privacy is likely to increase over time. *The upcoming Drones Bill should clarify the legislation in relation to the privacy risks posed by drones for i) commercial users; and ii) recreational users. Furthermore, the Government should ensure that the Drones Bill makes clear that it is a criminal offence for both a private drone user and a commercial operator to capture an individual's data without their consent, and what the penalties are for such action. This information should then be made available to both drone operators and the general public via the Drone Code.* (Paragraph 103)

Drone safety education

19. *The Government should mandate that a copy of the Drone Code is provided with each drone sold in the UK. The Drone Code should also be publicised in common drone flying areas. This should be rolled out as quickly as possible and implemented in full no later than the end of April 2020.* (Paragraph 114)

20. National Qualified Entities (NQEs) are key for providing necessary drone education to commercial drone users in the UK. *The Civil Aviation Authority needs to monitor the effectiveness and adequacy of NQEs annually and report areas of concern to the Secretary of State. If NQEs do not meet the required standard there must be a mechanism for terminating their right to operate.* (Paragraph 117)

21. *The CAA should introduce periodic re-assessment of commercial drone users and a compulsory renewal of their licence to ensure that they are up-to-date with technology advances and legislative changes.* (Paragraph 118)

Technology required

22. *The Government should ensure all drones, including existing drones, are electronically conspicuous within two years.* (Paragraph 124)

23. There is no justifiable reason why a drone should not have in-built safety features as standard. *The Government must ensure that all manufacturers include safety features, such as geo-fencing and electronic conspicuity as standard in their drones. Further, it should be a criminal offence to disable such features. Penalties for doing so should be set out clearly in the forthcoming Drones Bill.* (Paragraph 131)

24. *The Government should also ensure that all existing drones are retrofitted with electronic conspicuity within the next two years.* (Paragraph 132)

25. As aviation crosses borders and the use of drones is taking place internationally, it is important that the UK engages in best practice and knowledge sharing with other countries. *The Government should continue to pursue its ambition to stay in the European Aviation Safety Agency after Brexit. Further, the Government should seek to secure international agreement on international mandatory standards for drones.* (Paragraph 136)

26. *The Government must establish and fund further testing facilities in which Unmanned Traffic Management (UTM) systems and related technologies, including beyond visual line of sight operations, can be tested. Clear plans should be set out for this as soon as possible and further testing should begin no later than Summer 2020.* (Paragraph 142)

27. *The Government should seek to publish its counter-Unmanned Aerial Vehicle (UAVs) strategy by Spring 2020 and this should include clarifications on whether the Government intends to amend legislation to enable certain organisations such as the police to use jamming technologies.* (Paragraph 149)

Vision for the future

28. We recognise that drone technology is moving at pace, carrying with it a multitude of opportunities and risks. The Government needs to act to ensure that it can stay ahead of the curve in the future. *The Government should produce a White Paper by Summer 2020 that outlines the vision for how drones will be integrated into UK communities over the coming years. At a minimum, the White Paper should cover the role of registration, regulation, maximising the opportunities, minimising the risks, drone safety education and the technology required in order to implement their vision of drone integration into society in the next 20 years. The document should also set out a clear roadmap that outlines the steps that the Government and other agencies will take to achieve this future vision.* (Paragraph 156)

29. *The Government should open a dialogue with UK universities working on drones to discuss how they might best be classified and funded to ensure that the requirement to register as commercial operators does not hamper innovation and development of the industry. A comprehensive and clear regime should be established to facilitate academic development work no later than Summer 2020.* (Paragraph 159)

30.   Technological advancement is needed for drones to be utilised successfully and with optimal results for society. *The Government should set out how it intends to provide support and funding to current testbeds at universities and whether there is an appetite to create more testbeds. It should announce its plans and funding expectations by the end of 2019.* (Paragraph 161)

31.   There is a notable distrust towards drones among the general public that needs addressing if the UK is to maximise the opportunities presented by drones. *The Government should act to improve public perception and awareness of drones by launching a public awareness campaign, no later than Summer 2020, that highlights the opportunities presented by drones and informs the public on the reality of the risks posed by drones. This issue should also be addressed in the White Paper that we have called for in this Report.* (Paragraph 164)

Annex 1: Visit to Imperial University

1) On Thursday 4 July, the Chair of the Committee, Rt Hon Norman Lamb MP, and Stephen Metcalfe MP, Bill Grant MP and Sam Gyimah MP visited Imperial College's Brahmal Vasudevan Multi Terrain Aerial Robotics Arena, hosted by Dr Mirko Kovac, Director of the Aerial Robotics Laboratory.

2) Dr Kovac outlined his research on the usage of drones for digital infrastructure systems, both in the air and underwater. He demonstrated how drones would be key for the future of diagnostic and repair work.

3) Dr Kovac explained how the lab used examples from the natural world to inform their technologies. For example, drone crash resilience properties had been in part developed through studying bees' crash resilience as they landed from flight.

4) Dr Kovac showed the Committee a number of demonstrations of drones being used for these purposes.

5) Dr Kovac outlined four key priorities that regulators should take into account when enhancing the innovative environment for licence exemptions for universities. These were:

- Exemptions for university drone licences;

- More available testing spaces;

- Regulation around drones' interaction; and

- A stronger focus on the mechanics of drones.

Annex 2: Roundtable with recreational and commercial drone users

1)   On Wednesday 4 September 2019 the Chair of the Committee, Rt Hon. Norman Lamb MP, alongside Stephen Metcalfe MP, met with 17 recreational and commercial drone users to discuss drones.

2)   The following questions were asked:

- Should it be compulsory for drone manufacturers to provide a copy of the Drone Code with every purchase?

- Should model aircraft be included in the rules and regulations that govern drone use in the UK?

- Would it be helpful for a standardised system to be implemented where you could access permissions to Flight Restriction Zones? If so, how could this work?

- Would the registration fee being proposed by the Government dissuade you from registering your drone?

- Do you think the current online test is fit for purpose?

- Should in-built safety features become mandatory for manufacturers?

Points of discussion

3)   Ambiguities were highlighted in the drone code (e.g. the 50m rule and congested areas) and a lot of people, including the general public and some drone users, did not understand the code. Despite this, many thought that with the correct amendments, the drone code should be handed out as mandatory at the point of sale to raise awareness of drone safety. One thought was that it should be a legal obligation for the retailers to include.

4)   Some explained that the CAA should contact drone users to help design a drone code that was fit for purpose.

5)   Some expressed a view that flying at a club should be exempted from regulations: it was different because flying generally took place in remote, open spaces and the model aircraft community had self-regulated for almost a century and there had been no problems.

6)   Some participants believed that the public had lost trust in drones because of inaccurate stories published every month about collisions with aircraft. Participants were sceptical about the validity of many sightings.

7)   Many wanted to see a rapid change to the system for access to flight restriction zones, as the current system provided by NATS was not transparent enough, and sometimes resulted in inconsistent and inconvenient denials and permissions that could cost large amounts and disrupt business as usual for commercial drone operators.

8)   The proposed registration fee was unfairly high in comparison to other countries such as France. Further, some felt that the current proposals did little more than build a database on the assumption of potential criminality. As such, some expressed the view that the current registration process would dissuade people from registering.

9)   Many commercial operators thought it was unfair that, alongside the other tests and fees they had to pay to operate a drone commercially, they would now also be obliged to register and take a simple online test.

10)   There was some support for serious penalties for non-registration if the cost of registering was low or free.

11)   Those who had seen the proposed online test thought it might not be fit for purpose as it was too simplistic.

12)   Some noted that putting liability upon manufacturers to include in-built safety technologies was unfair—much in the same way that car manufacturers were not responsible for people speeding. Others said that manufacturers should ensure there were safety features that were not easily disabled within their technology.

13)   Many thought that there should be strong penalties for individuals disabling safety features, and that the onus for liability should be on the user.

Formal minutes

Tuesday 8 October 2019

Members present:

Norman Lamb in the Chair

Bill Grant	Carol Monaghan
Mr Sam Gyimah	Graham Stringer
Stephen Metcalfe	Martin Whitfield

Draft Report (*Commercial and recreational drone use in the UK*), proposed by the Chair, brought up and read.

Ordered, That the draft Report be read a second time, paragraph by paragraph.

Paragraphs 1 to 163 read and agreed to.

Annexes and Summary agreed to.

Resolved, That the Report be the Twenty-Second Report of the Committee to the House.

Ordered, That the Chair make the Report to the House.

Ordered, That embargoed copies of the Report be made available (Standing Order No. 134).

[Adjourned till Tuesday 15 October at 9.00am

Witnesses

The following witnesses gave evidence. Transcripts can be viewed on the inquiry publications page of the Committee's website.

Tuesday 11 June 2019

Wednesday 26 June 2019

Tuesday 9 July 2019

Published written evidence

The following written evidence was received and can be viewed on the inquiry publications page of the Committee's website.

RDU numbers are generated by the evidence processing system and so may not be complete.

1   3DAssurance Ltd (RDU0108)

2   A drone user (RDU0066)

3   A drone user (RDU0119)

4   ADS Group (RDU0085)

5   Air Visual Ltd (RDU0090)

6   Airport Operators Association (RDU0076)

7   Altitude Angel (RDU0174)

8   Amazon (RDU0189)

9   Anthony Robson (RDU0070)

10   ARPAS-UK (RDU0164), (RDU0181)

11   Arron Banfield (RDU0138)

12   Babcock International (RDU0088)

13   BALPA (RDU0121)

14   Blighter Surveillance Systems Ltd. (RDU0132)

15   Blue Dot UAV Imaging (RDU0129)

16   Brian Galbraith (RDU0093)

17   British Airline Pilots Association (RDU0186)

18   British Model Flying Association (RDU0082), (RDU0188)

19   British Model Flying Association, Scottish Aeromodellers Association, First Person View UK, and the Large Model Association (RDU0192)

20   Cadent (RDU0075)

21   Cameradrone (RDU0002)

22   Carl Simpson-Smith (RDU0043)

23   Caspar Harte (RDU0162)

24   Civil Aviation Authority (RDU0130), (RDU0180)

25   David Parkes (RDU0006)

26   DB Training Solutions Ltd (RDU0033)

27   Department for Transport (RDU0103), (RDU0182)

28   Devon and Cornwall Police and Dorset Police (RDU0171)

29   DJI (RDU0096), (RDU0185)

30   Dr Alan Mckenna (RDU0098), (RDU0183)

31   Dr Alan Mckenna

32   Dr Dale Richards (RDU0059)

33   Dr David Rose (RDU0032)

34   Dr Sean Goodhart (RDU0039)

35   Drone User Magazine (RDU0017)

36   Dylan Baldwin (RDU0095)

37   Engineering Construction Industry Training Board (ECITB) (RDU0104)

38   Flight Safety Board (RDU0107)

39   Flock (RDU0143)

40   Frank Aldous (RDU0065)

41   Gary Tan (RDU0165)

42   Gorilla Drones (RDU0094)

43   Granta Network Solutions Ltd (RDU0140)

44   HAWQ Ltd (RDU0110)

45   Helixcopters Ltd (RDU0060)

46   Hummingbird SUA Ltd (RDU0160)

47   Ian Bastin (RDU0139)

48   Information Commissioner's Office (RDU0170)

49   John Snape (RDU0166)

50   John Tregunna (RDU0023)

51   Julian Dean (RDU0074)

52   Kennedys (RDU0168)

53   Lea Freeman (RDU0067)

54   Liverpool John Moores University (RDU0079)

55   Louth and District Model Aero Club (RDU0191)

56   Mal (RDU0047)

57   Malcolm Bailey (RDU0133)

58   Maritime Filming UK (RDU0097)

59   Mark Dale (RDU0190)

60   Mark O'neill (RDU0113)

61   Mark Wingad (RDU0156)

62   Martin Hall (RDU0035)

63   Maurice Greenland (RDU0087)

64   Mekdem LTD (RDU0159)

65   Melvyn Bond (RDU0024)

66   Miss Joanne Cooper (RDU0100)

67   Miss Natalie Woods (RDU0018)

68   Mr Adam Stout (RDU0010)

69   Mr Adrian Belcher (RDU0056)

70   Mr Adrian Speight (RDU0148)

71   Mr Alex Larmour (RDU0114)

72   Mr Andrew Kibbler ([RDU0091](RDU0091))

73   Mr Andy Dubreuil ([RDU0011](RDU0011))

74   Mr Anthony Byne ([RDU0109](RDU0109))

75   Mr Anthony Parkinson-Johns ([RDU0120](RDU0120))

76   Mr Anthony Stein ([RDU0063](RDU0063))

77   Mr Anthony Stephens ([RDU0151](RDU0151))

78   Mr Arthur Charles ([RDU0050](RDU0050))

79   Mr Barry Cridland ([RDU0077](RDU0077))

80   Mr Barry Tree ([RDU0141](RDU0141))

81   Mr Bernhart Dambacher ([RDU0021](RDU0021))

82   Mr Bryan Chitty ([RDU0014](RDU0014))

83   Mr Carl Pendle ([RDU0040](RDU0040))

84   Mr Christopher Fox ([RDU0055](RDU0055))

85   Mr Christopher Llewellyn ([RDU0008](RDU0008))

86   Mr Christopher Murr ([RDU0015](RDU0015))

87   Mr Craig Allsobrook ([RDU0158](RDU0158))

88   Mr Dale Harper ([RDU0145](RDU0145))

89   Mr David Arundell ([RDU0169](RDU0169))

90   Mr David Carlisle ([RDU0064](RDU0064))

91   Mr David Laverick ([RDU0027](RDU0027))

92   Mr Derek Evans ([RDU0004](RDU0004))

93   Mr Fraser Steen ([RDU0123](RDU0123))

94   Mr Geoffrey Hirst ([RDU0061](RDU0061))

95   Mr Geoffrey Protheroe ([RDU0026](RDU0026))

96   Mr Geraint Edwards ([RDU0137](RDU0137))

97   Mr Gerald McGivern ([RDU0053](RDU0053))

98   Mr Graham Perry ([RDU0048](RDU0048))

99   Mr Graham Waters ([RDU0072](RDU0072))

100   Mr Howard Lewis ([RDU0009](RDU0009))

101   Mr Howell Morris ([RDU0016](RDU0016))

102   Mr Ian Conradi ([RDU0045](RDU0045))

103   Mr Ian Savage ([RDU0152](RDU0152))

104   Mr Ian Webster ([RDU0163](RDU0163))

105   Mr Jacques Le Roux ([RDU0030](RDU0030))

106   Mr Jeremy Wilkins ([RDU0177](RDU0177))

107   Mr John Armstrong ([RDU0071](RDU0071))

108   Mr John Hastie ([RDU0013](RDU0013))

109   Mr John Irvine ([RDU0073](RDU0073))

110   Mr John N Miller (RDU0150)

111   Mr John Norman (RDU0178)

112   Mr Jonathan Ridgeway (RDU0028)

113   Mr Jonathan Thursby (RDU0149)

114   Mr Jonathan Welford (RDU0020)

115   Mr Kevin Crofts (RDU0042)

116   Mr Lee Tookey (RDU0126)

117   Mr Luke Padfield (RDU0127)

118   Mr Malcolm Hitch (RDU0146)

119   Mr Mark Heffer (RDU0051)

120   Mr Martin Cocking (RDU0122)

121   Mr Martin Dilly (RDU0179)

122   Mr Melvin Robson (RDU0019)

123   Mr Michael Brett (RDU0068)

124   Mr Michael Clarke (RDU0049)

125   Mr Mike Brown (RDU0038)

126   Mr Mike Smale (RDU0105)

127   Mr Neil Winnington (RDU0155)

128   Mr Paul Harvey (RDU0044)

129   Mr Paul Tholen (RDU0147)

130   Mr Pete Guy (RDU0041)

131   Mr Peter Hague (RDU0102)

132   Mr Robert Brewer (RDU0101)

133   Mr Rod Hutchinson (RDU0131)

134   Mr Roger Newark (RDU0057)

135   Mr Shaun Madill (RDU0078)

136   Mr Simon Barkle (RDU0069)

137   Mr Stephen Royall (RDU0084)

138   Mr Steven Butt (RDU0025)

139   Mr Stuart Thorniley (RDU0099)

140   Mr Terry Rensch (RDU0005)

141   Mr Tim Wayne (RDU0112)

142   Mr Tomasz Dzieciolowski (RDU0144)

143   Mr Victor Kirby (RDU0003)

144   Mr Wynne Davies (RDU0007)

145   Mrs Rebecca Ford (RDU0157)

146   Ms Kelly Foxhall-Ridgeway (RDU0037)

147   National Physical Laboratory (RDU0083)

148 NATS ([RDU0124](#)), ([RDU0175](#)), ([RDU0187](#))

149 Nick Giles ([RDU0136](#))

150 Paul Clarkson ([RDU0142](#))

151 Professor James P Scanlan ([RDU0176](#))

152 Professor Jason Reifler, Professor Thomas Scotto, Dr Catarina Thomson and Dr Judd Thornton ([RDU0092](#))

153 RAVEN DroneWorks ([RDU0046](#))

154 River Mersey ([RDU0062](#))

155 Robert Parker ([RDU0167](#))

156 Roger Williams ([RDU0022](#))

157 Royal Academy of Engineering ([RDU0111](#))

158 Royal Aeronautical Society ([RDU0086](#)), ([RDU0184](#))

159 RS Bristowe ([RDU0081](#))

160 Security Institute ([RDU0106](#))

161 ShawPix ([RDU0154](#))

162 SkyHeld Cameras ([RDU0161](#))

163 Stephen Ogborne ([RDU0012](#))

164 Surrey Search and Rescue ([RDU0125](#))

165 techUK ([RDU0117](#))

166 Tethered Drone Systems ([RDU0058](#))

167 Thales ([RDU0134](#))

168 Tony Carter ([RDU0054](#))

169 UK Computing Research Committee ([RDU0031](#))

170 University of Birmingham ([RDU0036](#))

171 University of Hertfordshire ([RDU0089](#))

172 University of the West of England ([RDU0029](#))

173 Unmanned Images ([RDU0135](#))

174 West Lothian Archaeological Trust ([RDU0001](#))

175 William Legge ([RDU0115](#))

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All publications from the Committee are available on the [publications page](#) of the Committee's website. The reference number of the Government's response to each Report is printed in brackets after the HC printing number.

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Thirteenth Special Report	Japanese knotweed and the built environment: Government Response to the Committee's Seventeenth Report	HC 2600