Unsegregated sharing of airspace: Views of the Uncrewed Aerial Vehicle (UAV) industry expressed at the E-Drone drone operators meeting (03/08/21) v.1

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1 Introduction

The E-Drone project (https://www.e-drone.org/) is a research consortium led by the University of Southampton aimed at assessing the societal and environmental benefits of using Uncrewed Aerial Vehicles (UAVs) as part of logistics fleets for public service applications.

The UAV industry, including both commercial UAV operators and other attendant organisations (e.g., regulators, industry associations, manufacturers, R&D institutions), is experiencing rapid development and expansion. Currently, there are an increasing number of commercial operators of UAVs (commonly known as drones) offering services such as video, photography, inspection, monitoring, surveying, and logistics. Drone industry expansion is taking place within the context of a wider aviation community historically dominated by the operation of traditional crewed aircraft, producing competing demands on the finite supply of usable airspace.

A key issue with operating drones, particularly Beyond Visual Line of Sight (BVLOS), is approving and setting up Temporary Danger Areas (TDAs), which effectively reserve segregated areas of airspace for drone operations at the expense of other air users. TDAs are a blunt instrument for managing airspace, can take considerable time to get approved, and only last for a specific time period. Hence, there is an increasingly urgent requirement to consider methods by which drones can be integrated harmoniously and efficiently into shared airspace with crewed aircraft. The E-Drone project therefore ran a national workshop to discuss drone integration in shared airspace on 03/08/2021 to which a large number of groups that represented the drone industry were invited.

The purpose of the August workshop was to:

- Brief the drone industry regarding current drone operations and plans within the E-drone, Solent FTZ (Future Transport Zone) and other connected consortia.
- Discuss alternatives to Temporary Danger Areas (TDAs) for allocating airspace.
- Allow the drone industry to voice their concerns and make suggestions.
- Record, analyse and respond to all the comments and issues raised.
- Determine next steps.

The workshop outlined an alternative to TDAs that is referred to as 'Class Lima'. It should be noted that, subsequent to the research described in this report, the Class Lima concept has been renamed, and is now known as 'Project Lima'. However, 'Class Lima' was the term used during the research and is therefore retained in this report. Class Lima is: i) an interim step towards UAV Traffic Management (UTM); and ii) a permanent, decentralised, versatile shared airspace solution for low-risk areas.

2 Code Topics and Predominant Themes

There were ~300 participants' comments recorded during the two-hour workshop. The relationships between the code topics identified during the thematic analysis and the predominant themes into which they were grouped are shown in Figure 1. Discussion summaries of participants' concerns and issues for each topic are provided in subsequent sections, grouped according to their associated over-arching themes. In addition, selected examples of participants' comments have been tabulated according to topic for all three themes (Table 1, Table 2 and Table 3 for Theme 1, Theme 2 and Theme 3, respectively), although it should be noted that some comments were relevant to multiple topics.

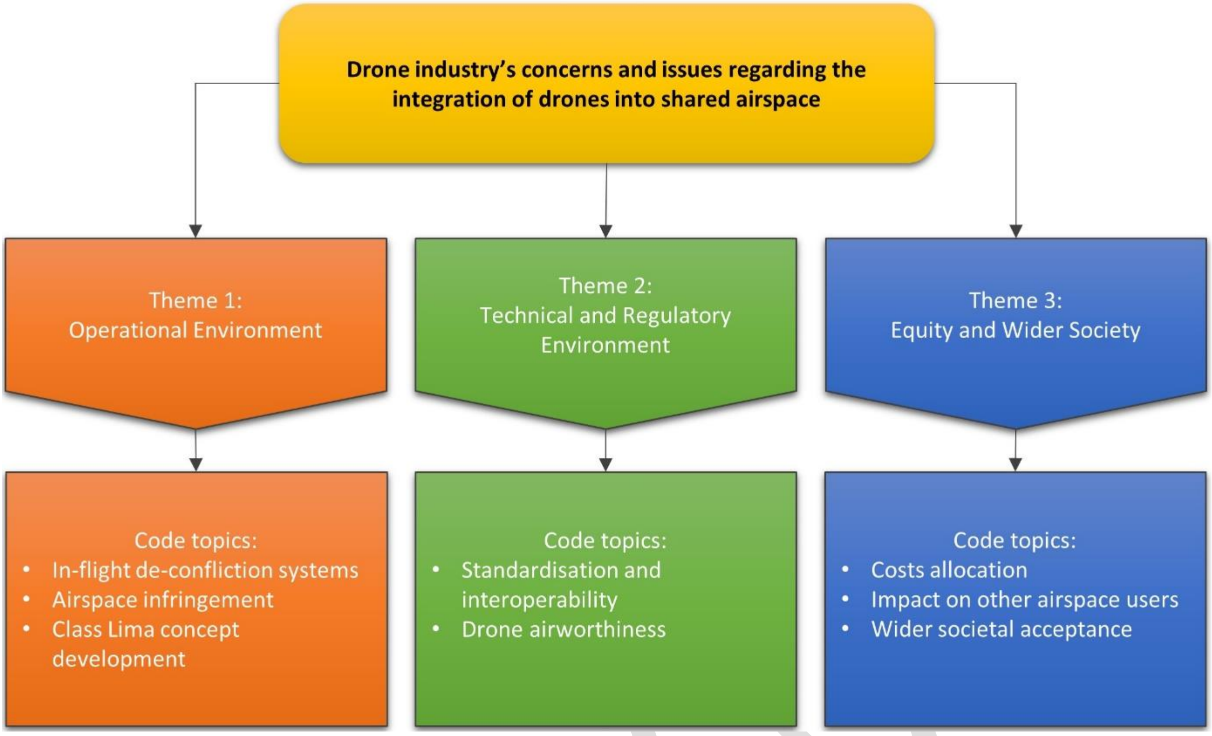

Figure 1: Diagram of code topics and over-arching themes.

3 Theme 1: Operational Environment

3.1 In-Flight De-Confliction Systems

Participants were in broad agreement that some form of Detect-And-Avoid (DAA) system based on aircraft carrying Electronic Conspicuity (EC) equipment to enable collision avoidance was essential for the safe integration of drones and crewed aircraft in shared airspace, where EC is an umbrella term to describe devices that allow airspace users to detect each other electronically. Whilst many different EC technologies exist, the option supported by the vast majority of participants was Automatic Dependent Surveillance-Broadcast (ADS-B), which is a system whereby an on-board device broadcasts information such as aircraft position, identification, altitude and velocity.

ADS-B has a strong position as the foremost technology for EC because it is the option favoured by the Federal Aviation Administration (FAA, the National Aviation Authority in the USA), as evidenced by the recent (2020) adoption of regulations mandating the carriage of ADS-B devices in most controlled airspace within the USA. The USA is also implementing Traffic Information Service-Broadcast (TIS-B), which uses ADS-B data to display in the cockpit of crewed aircraft a plan view of other traffic in the vicinity of the aircraft (i.e., similar to the Traffic Collision Avoidance System display based on Secondary Surveillance Radar

Mode-S transponder data routinely fitted to commercial airliners). However, there were some concerns among participants about the long-term viability of ADS-B due to frequency spectrum congestion. The ADS-B system in the USA uses a dual link interface based on frequencies of 978 and 1090 MHz. One participant who was an EC equipment manufacturer suggested frequency congestion was not a significant issue because the approach used in the USA can be followed to resolve this.

Participants raised Electro-Optical (EO) sensors fitted to drones to enable automatic collision avoidance as a potential alternative method for DAA. However, this appeared to be regarded as unsuitable by many participants, with one drone operator reporting that they were disappointed with their EO system after trials. This is because EO sensors suffer from similar problems to the See-And-Avoid (SAA) method of collision avoidance routinely performed by pilots of crewed aircraft actively searching for conflicting traffic, with human visual detection performance found to be an unacceptable basis for DAA systems, particularly in relation to detecting small aircraft such as drones with sufficient time remaining to complete avoiding action (Clothier *et al.* 2017).

Also included within the discussion of EO sensors, mention was made by participants of First Person View (FPV) cameras that relay live video from drones to remote screens or goggles. However, many participants suggested strongly that this was not a reliable method for collision avoidance, most likely because of the same concerns about human visual detection performance as described previously in relation to EO sensors. In general, it appears that the development of DAA systems for drones represents an opportunity to improve upon the performance of the human eyeball, rather than reverting to a reimplementation of it as represented by EO sensors or FPV cameras.

VHF-Out is a system involving drones broadcasting continual, automated position reports over a VHF audio frequency to enhance situational awareness of potential conflicting traffic. However, participants had concerns about the use of such a system, in particular that the requirement to monitor another frequency would add to pilot workloads and require aircraft to be equipped with at least two VHF radio receivers, and that pilots would not be able to parse the sheer amount of information being received.

3.2 Airspace Infringement

Participants discussed the prospect of airspace infringements involving unauthorised entry (either intentional or inadvertent) to designated shared airspace zones by interloping aircraft. For example, aircraft operating within shared airspace when they are not appropriately equipped with EC devices or experiencing EC equipment failure. Many protocols, procedures and regulations aimed at minimising the possibility of airspace infringements are in place. For example, the CAP 1404 document published by the UK Civil Aviation Authority (CAA) (2021) referred to in some participants' comments that details the process for investigating reported infringements and implementing any remedial measures deemed necessary to prevent recurrence. Despite this, minimising the risk of collisions with interlopers was still viewed as a challenge by participants. In circumstances where an interloper is not appropriately equipped with EC (i.e., an uncooperative target), EO sensors offer an advantage over EC devices because they are absolute sensors that do not rely on other aircraft being suitably equipped to achieve collision avoidance.

3.3 Class Lima Concept Development

Many comments from participants related to development pathways for the Class Lima shared airspace concept (now called Project Lima). It was suggested that there was a need to quantify and compare the risks associated with the different approaches to use of airspace by drones, i.e., to compare TDA, Class Lima and UTM solutions. Some participants suggested Class Lima may involve less risk than TDAs because TDAs are temporary, and pilots are therefore more likely to be unaware of their existence leading to increased risk of inadvertent airspace infringements compared to the more permanent Class Lima with which pilots would become familiar. However, other participants expressed a contrasting view, suggesting the more permanent nature of Class Lima would increase exposure to infringements compared to the time limited TDAs (i.e., more time in which infringements could occur for Class Lima).

Some participants suggested zones of Class Lima airspace should be restricted to relatively low levels (i.e., below 1,000 ft Above Ground Level; AGL). However, this seems to negate the main purpose of Class Lima, which is to open-up airspace by allowing drones and crewed aircraft to operate alongside each other with as much freedom as possible, rather than to quasi-segregate drones by restricting operations to below 1,000 ft AGL. Also suggested was that Class Lima should have a defined maximum traffic density limit above which a UTM shared airspace solution would be more appropriate instead. This suggestion aligns with the intentions for Class Lima, in that it is intended for use in low traffic density regions.

Participants raised the possibility that Class Lima could be developed and tested in countries with more permissible airspace rules and structures, before being imported into countries with busier, more complex airspace environments such as the UK. However, this may not be a feasible in the timeframe available because the need for a shared airspace solution in countries with busy/complex airspace (like the UK) is increasingly urgent and full roll-out of UTM is still some years away.

Table 1: Examples of participants' comments relating to topics in Theme 1.

Participants' Comments
In-Flight De-Confliction Systems (Section 3.1): • "EC is a great idea and, of course, will be mandated." • "A key part of BVLOS will be Detect-And-Avoid – [for example] the paramotor is protecting himself by transmitting ADS-B on 1090 MHz, the drone…will detect the paramotor and algorithms can ensure it avoids. Mandatory EC for drones is a key part of BVLOS." • "EC based detection does not have the uncertainty of vision-based/sound-based detection." • "We're already working with drone manufacturers to build ADS-B conspicuity into their devices. We currently put it into separate boxes, which have to be carried, we can make them very, very small, but you still have to integrate it onto your drone." • "Can ADS-B be scaled up given the potential number of airborne drones in the future (lots of messages!)? Agree it's a great EC technology." • "Spectrum congestion on 1090 Mhz can be overcome by putting drone EC onto 978 Mhz and utilising TIS-B to rebroadcast between the two networks (as in USA)." • "We're already looking at using 978 MHz [for ADS-B] in the UK and the trials we're doing right now are using 978 MHz on the drones to Detect-And-Avoid and we cross fertilize between 1090 MHz and 978 MHz, and…that's been successful in the States." • "Collision avoidance detection is strongly biased to electronic conspicuity, is there no room for vision- and audio-based systems?" • "EO works just fine at low level in certain ways, filtering out false positives is of course a challenge, but we have made great in-roads with this recently and it is better than not having it." • "Not suggesting a specific EO is mandated. I am suggesting a responsible operator will want to fit one for the last-ditch collision avoidance manoeuvre." • "There would need to be some form of electrical-optical last-ditch collision avoidance."

- "[Commercial drone operator] integrated an EO camera last summer, and we were kind of disappointed with the overall performance."
- "What concerns me…is that we would get significant false positives out of EO."
- "I haven't seen an EO that would meet my specification yet."
- "At low operating altitudes, EO is not a robust solution."
- "We will happily fit them [EO sensors] when they are cheap enough and good enough. Currently, this is not a 'solved problem'. I agree entirely they might be a useful last-ditch safety feature."
- "We are strongly against mandating EO-based detection systems. EC works today – no research needed, just engineering. Not against adding a working EO system in the future which adds safety, but not required in our view for this initiative [Class Lima] where the 'zone' is clearly defined, and GA [General Aviation] pilots will know they are required to have an EC device."
- "You've got the Mark 1 Eyeball, but you've also got to remember that it's been proven that the Mark 1 Eyeball is only good 39-51% of the time, and if you look at the UK Airprox Board's annual summary, you'll see the amount of near misses that happened because the Mark 1 Eyeball didn't work for the majority of the time."
- "I personally am terrified of the idea that drones would actually be flown manually and that FPV cameras would be used for de-confliction."
- "I do agree with you, it's worthwhile trialling [VHF-Out]."
- "I don't honestly see a single VHF position reporting frequency [VHF-Out] is viable. Unless aircraft have two radios, they are unlikely to be on the frequency as working other units. It's likely to be beyond the ability of some GA pilots to take in the information as it will task-saturate them."
- "That kind of new information [VHF-Out] you just can't take it in and, with the best will in the world, there are pilots out there who cannot take it in, and frankly it's just going to overload them."
- "Position reports [VHF-Out] are perfectly fine when flying over places such as Africa with a lack of communications to listen to with ATC. Around the UK, with GA aircraft sometimes only having one radio, they will not give up flight information with a basic traffic service to listen-out to drone position reports."

Airspace Infringement (Section 3.2):

- "We need to look at the risk of those that potentially are not [EC] equipped or equipment failure."
- "It's not quite good enough to hang on to CAP 1404 [because] a rule doesn't mean people don't break it, whether inadvertently or intentionally, responsible operators will have to have some form of collision avoidance."
- "Interlopers will be there, the fact that there's a CAP [CAP 1404] to say that they shouldn't be isn't going to be a good enough mitigator if we do 'swap paint' with an interloper."
- "We will always have interlopers… so, to say that EC is the only solution might not be capturing all of the risks. So, I wouldn't say that an electro-optical system should be

mandated, but responsible operators should perhaps consider the fitment of an electro-optical last-ditch collision avoidance system.” • “EC just one part of the collision avoidance picture, looks like a lot of reliance on EC for Class Lima, does not cope with interlopers. Onboard self-generated collision avoidance is needed, [such as] EO sensors.”
Class Lima Concept Development (Section 3.3): • “I think there is a need to clarify the reduction in risk that Class Lima will bring compared with where we are now and where we will be in the future with full UTM, etc.” • “There is no completely safe interim step to full UTM. An acceptance of less safety (higher risk) to either the public or other airspace users (including other drones) is the only way forward.” • “I'd say that a TDA is more likely to be infringed due to people not expecting it… [Class Lima] can be permanent so risk is lower from a human factors perspective.” • “[Class Lima] could actually reduce [risk of infringements] because people are becoming habitualised to the fact that the airspace is that way now.” • “[Class Lima] can be a permanent change to the airspace, thus less confusing for airspace users.” • “The amount of exposure we suddenly then have to interlopers is presumably greater [for Class Lima] than a time limited TDA.” • “Why can't [Class Lima] just be up to 500 ft or 1,000 ft AGL? Takes up a lot less airspace for GA and makes the brick wall in the sky… more of a speed bump for them.” • “We may stray into UTM if the density of traffic gets beyond X, we have to collectively decide what X is.” • “What happens when traffic density goes up… I think there would have to be an upper threshold where we need more sophisticated solutions.” • “How about a dress-rehearsal [of Class Lima] in a country with more permissive rule sets, and when we have operated together there, bring it back [to the UK].”

4 Theme 2: Technical and Regulatory Environment

4.1 Standardisation and Interoperability

Standardisation and interoperability were raised by participants as issues, especially in relation to EC equipment. There are many different EC technologies on the market, and it was seen as important for regulators to adopt a standardised format enabling interoperability of devices. The current front runner for adoption appears to be ADS-B (Section 3.1). Many participants also supported mandating by regulators of the carriage of EC equipment as a prerequisite for entry to shared airspace, but this would require convergence on a common standardised format first and could take a considerable amount of time to enact.

Participants identified that specification of the required minimum equipment to enter shared airspace will be necessary at some point prior to roll-out. It was suggested that this should be a binary specification, involving clear compliance criteria laid-out by regulators, rather than optional equipment that is a “nice to have”. In general, however, it was acknowledged that it will be challenging to get all stakeholders (i.e., the wider aviation community) to agree on all the standards necessary for the implementation of shared airspace, such as standards for equipment carriage, drone airworthiness and operational procedures.

4.2 Drone Airworthiness

The conventional aerospace design principle of failover for aircraft systems, whereby functionality is recovered through redundancy, was discussed by participants, in particular in relation to in-flight de-confliction systems. There was agreement that failover systems were required to prevent EC equipment being a single point of failure for DAA, and it was suggested that, whilst they may not be robust systems in isolation, both EO sensors and/or VHF-Out could serve as back-up systems for DAA. For example, if EC equipment were to fail, a pilot could tune a published VHF-Out frequency to receive drone position reports, mitigating the risk of a collision with a drone.

Some participants suggested that the CAA approval process for drone airworthiness in the UK takes too long, and that the introduction of an experimental category could be an option to accelerate drone development without demanding too much of the CAA’s capacity. There is currently no regime for drone airworthiness certification in the UK, with approvals granted on a case-specific basis instead (Grote *et al.* 2021). Introduction of such a regime (as is the case for type certification of crewed aircraft) may be a way to hasten the process but is likely to involve a considerable up-front investment of time and effort on behalf of the CAA to establish.

Table 2: Examples of participants’ comments relating to topics in Theme 2.

Participants’ Comments
Standardisation and Interoperability (Section 4.1): • “We're going to have to write down some compliance criteria for drones operating in that area [shared airspace] and it has to be binary, you either have to, or you don't. We can't say well let's make it a nice option, so I think we've got to be clear on what we tell people, and we can't make it an optional extra.” • “I think the writing’s on the wall, I think actually we're going to have to force airspace users generally to fit EC.”

- "A government mandate [for EC equipment] and applicable EU/UK standard will be required from a compliance point of view as otherwise there is zero incentive for commercial/retail UAS/Drone manufacturers to get involved. The reality is these standards will need to be written into the appropriate legislation."
- "No single EC carriage will be perfect, so we have to accept interoperability."
- "To mandate the carriage equipage will require regulatory change. This could take a considerable amount of time."
- "I agree, ADS-B will be the future."
- "Needs to be based on common, standard technology – namely ADS-B."
- "The key to having an EC system that can be used reliably for de-confliction is to make it mandatory for all – drones included. Ideally the technology should be uniform – ADS-B is reliably used for this purpose in USA."
- "What will make it work is a government mandate for, in my opinion, ADS-B, that is the technology of the future. There are parties around that want to make it EC system agnostic, I don't think you can, it needs to be a single technology, and I think that technology is ADS-B."
- "It is going to be challenging to get all stakeholders to agree on standards such as airworthiness, EC and operations."

Drone Airworthiness (Section 4.2):

- "A blend of all is required, EC and EO."
- "There is no one [DAA] solution that's going to be 100%..., we layer up the defences, the more we've got, the less chance of an accident getting through."
- "You cannot rely on EC or EO in isolation, so a blend is required."
- "A final last-ditch collision avoidance manoeuvre through an electro-optical sensor is perhaps what responsible operators should fit."
- "Having an FPV camera while flying BVLOS, or using an EO based collision avoidance system, whilst not reliable, it would provide a form of mitigation in the case of non-compliance or EC failure."
- The process for [drone] airworthiness takes too long, and an aircraft will be obsolete before getting an approval. CAA has to speed up."
- "The need for an experimental category [for drones] to accelerate development without soaking up CAA bandwidth."

5 Theme 3: Equity and Wider Society

5.1 Costs Allocation

During the discussions, there was very little suggestion of a resistance to paying the costs involved with equipping drones to operate in shared airspace, principally the costs of installing any EC equipment required, indicating this is not seen as an issue for drone operators. This could be because the drone operators are commercial companies more willing to offset the expense against potential revenue generation opportunities, in contrast to individuals using airspace for sport and leisure purposes who may be more resistant to spending personal money.

In fact, several participants went beyond consideration of their own costs and suggested that the drone industry should bear part/all of the costs incurred by all the parties intending to use shared airspace. In other words, the drone industry should fund any changes necessitated by the introduction of shared airspace, including providing required equipment for all airspace users.

5.2 Impact on Other Airspace Users

There appeared to be an understanding among participants of the need to ensure that the shared airspace concept was supported by the wider aviation community and that access to airspace was equitable for all. In particular, the sports and leisure flying community (referred to as General Aviation (GA) in this paper) was identified as an important stakeholder (e.g., private light aeroplanes and helicopters, gliders, microlights, hang gliders, paragliders, paramotors, hot air balloons, model aircraft flyers, etc.). This is because drone operations predominantly take place in uncontrolled airspace, of which GA is an extensive user, and if areas of uncontrolled airspace are to be designated as shared airspace zones, GA airspace users are likely to be significantly impacted. Participants suggested that the wider aviation community should be engaged in the co-development and design of the shared airspace concept from the very start, and that the potential benefits for all airspace users (e.g., safer skies for all) should be stressed. The E-Drone project has contributed an important initial step in engaging other airspace users through conducting a national workshop for the GA community (similar to the one for the drone industry described in this report) on 26/3/21, a report on which is available from the E-Drone website (https://www.e-drone.org/).

One barrier to widespread support identified by participants was the requirement to fit EC equipment in order to access shared airspace. This was seen as likely to meet opposition from some within the GA community, most often for reasons of the costs involved. Whilst not specifically mentioned by participants, a related issue that can be reasonably foreseen is that if regulators do mandate a common standardised format for EC equipment (as suggested by participants in Section 4.1), there is likely to be considerable pushback from airspace users already committed to alternative EC formats or to not carrying EC at all.

5.3 Wider Societal Acceptance

The issue of gaining wider societal acceptance for the shared airspace concept was raised by participants. It was suggested that it was important to demonstrate to the public that the shared airspace concept is low risk in the case of both ground and air risks, and that this should be done through a quantified assessment of the risks involved. Alongside this, it was suggested that the potential of drone operations facilitated by the introduction of shared airspace to deliver considerable benefits to society should be emphasised, in particular to focus on especially beneficial use cases such as healthcare logistics, for example National Health Service (NHS) logistics in the UK.

Table 3: Examples of participants' comments relating to topics in Theme 3.

Participants' Comments
Costs Allocation (Section 5.1): • "[The drone industry should] fund any changes." • "GA sometimes get a little bit frustrated even having to put a radio on board their aircraft, let alone any other additional equipment, because it all comes down to a cost." • "[The drone industry should] contribute to an equipage fund." • "[A requirement to carry an EC] transponder at a cost of a couple of thousand pounds, that is what will get the GA community aggravated." • "It's those kinds of rebates [CAA EC equipment 50% rebate] that will make the difference to get the GA community to spend a small amount of money that makes them conspicuous."
Impact on Other Airspace Users (Section 5.2): • Ultimately, we're providing a restriction on them [the GA community] flying where they want to, when they want to… and it's restricting their freedom of access to air space." • "I think that it's the only way to bring the GA community on-board, you've got to get rid of the TDAs as everybody has to be able to operate together, Detect-And-Avoid is all part of that." • "Support from the aviation community in general [will be a potential issue]" • "Bring them [the wider aviation community] in from the get-go, and not just within the consultation exercise, they should be a part of the design." • "Start implementing a just culture and shared lessons learnt platform from the outset, showing their [the wider aviation community's] concerns are shared and addressed pro-actively." • "Engage airspace users to solve some of these issues [associated with shared airspace]." • "Engagement to stress benefits to all." • "Show that it can make the skies safer for the GA community as well, create jobs in the space, show how more money will flow to small regional airports as large UAS come into service improving their [the GA community's] overall experience as well."

• "Mandatory use [of EC] makes the sky safer for everyone." • "Improved safety for all airspace users due to having a better situational awareness of their surrounding airspace [would be a benefit of EC]." • "The paraglider and paramotor community often carry less tech… many would not carry devices for monitoring airspace unless perhaps flying cross country. I fly paramotors myself and made the decision to use an ADS-B (especially due to the 50% CAA rebate)…but note the fact that it is currently not compulsory. I also feel that perhaps it should be [compulsory]." • "Critical to get government operators onboard (police, med-evac, military)."
Wider Societal Acceptance (Section 5.3): • "Understanding of what those [shared airspace] risk reductions are, and what that means to everyone using the airspace and the public beneath the airspace, and also how you would go about having that risk reduction accepted and who's going to accept that, and on behalf of who?" • "Prove that the introduction of drones is not making the airspace any less safe." • "When we talk about risk, we don't know the risks… very rarely do we actually quantify the risk." • "Without data of all air traffic, it'd be difficult to measure the risk. Mandated EC would be key to building-up this map." • "By focusing on the benefits to society and making it clear that the initial stage will be low ground risk and air risk routes with high positive benefit." • "Drones for good use cases, and make the human benefits clear – e.g., cancer treatment, blood transfusions, removal of humans from working at height." • "Focus on societally beneficial use cases – NHS-centric is perfect." • "I'd suggest the missing bit is the use case outcome, i.e., benefits to NHS. The only way to apportion the pain [i.e., any necessary sacrifices/compromises] is to understand the gain – [for example,] if GA does X and drone developers do Y, we can turn around 50% more blood tests in 24 hours or reduce van emissions by Y%."

References

Civil Aviation Authority (CAA) (2021) *Airspace infringements: Review and actions process (CAP 1404)*, Crawley, UK: Civil Aviation Authority.

Clothier R A, Williams B P, Cox K and Hegarty-Cremer S. Human See and Avoid Performance and its Suitability as a Basis for Requirements for UAS Detect and Avoid Systems. 17th AIAA Aviation Technology, Integration, and Operations Conference, 5-9 June 2017, Denver, USA. American Institute of Aeronautics and Astronautics (AIAA).

Grote M, Cherrett T, Oakey A, Royall P G, Whalley S and Dickinson J (2021) 'How Do Dangerous Goods Regulations Apply to Uncrewed Aerial Vehicles Transporting Medical Cargos?', *Drones*, 5(2).

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