Airspace Modernisation Strategy

Electronic Conspicuity Solutions

A call for evidence on a new strategy

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Introduction

Background

1. Airspace is a crucial part of the UK's infrastructure. It must be maintained and enhanced to meet the demand for safe, secure and sustainable aviation. The government set out its objective to modernise airspace in its Aviation Strategy Green Paper.[1] As the UK's specialist aviation regulator, we were asked by the government to develop a more detailed strategy to meet this objective. In response, we published the Airspace Modernisation Strategy (AMS) that describes the main initiatives required to upgrade the airspace structure and improve air traffic management (ATM).[2] We are now looking at how the AMS initiatives should be delivered and how we might facilitate the aerospace sector to harness innovative technologies that meet the challenges and opportunities of aviation expansion in the broadest sense.

2. Electronic conspicuity (EC) is one of the most important AMS initiatives because of its potential to increase safety benefits and save lives by reducing the likelihood of mid-air collisions and infringements (when an aircraft makes an unauthorised entry into controlled airspace). EC is an umbrella term for technologies that can help airspace users and air traffic services (ATS) to be more aware of the aircraft operating in the same piece of airspace, strengthening 'see and avoid' with the ability to 'detect and be detected'. The phrase EC solutions refers to the devices, systems and infrastructure that bring these technologies to market and ensure they are interoperable. Airborne transponders, moving map displays, air traffic data displays (TDDs), ground-based antennas and satellite surveillance services are all examples of EC solutions. The information generated by EC solutions can be presented to

[1] Aviation 2050, the future of UK aviation, DfT, December 2018

[2] CAP1711, The CAA's Airspace Modernisation Strategy, CAA, December 2018

pilots and air traffic services (ATS) visually, audibly or both. Full adoption of EC solutions means 100% of users operating in a designated block of airspace can be detected electronically.

3. At the heart of our strategy is the adoption of interoperable EC solutions in targeted blocks of airspace to: enhance situational awareness; transform airspace by integrating different types of operation (e.g. general aviation, military, small commercial operators); and lay the foundations for new users such as unmanned aerial systems (UAS) to operate far more extensively than they do today (i.e. beyond visual line of sight or BVLOS).

4. The risk of mid-air collisions (MAC) in uncontrolled airspace is a major concern because of the wide range of general aviation (GA), commercial and military users that operate in the same areas following the principle of 'see and avoid' and its known limitations. Infringements into controlled airspace create further MAC risks when a simple loss of awareness in a complex environment leads to an aircraft inadvertently flying into an area without clearance. They can also result in disruption and delay to commercial operations and increased workload for air traffic control, leading to possible knock on safety issues.

5. Much has been done since 2011 when the CAA first launched the Future Airspace Strategy (FAS), which set out the potential for EC solutions to enhance safety:

- Aviation stakeholders have been sharing their goals and requirements for EC solutions in forums like the EC Working Group.
- New lower power / lower cost EC devices are now available for airborne carriage; and
- Traffic Data Displays (TDDs) that present the outputs of EC devices to ATS units without primary or secondary surveillance radars (SSR) are being trialled with some success.

6. As a result, many stakeholders have already invested in EC solutions. This has increased situational awareness for pilots and ATS and offered some users greater access to the airspace. Voluntary investment has not led to fully interoperable solutions or the widespread adoption that we believe is essential to maximise the benefits and integrate new users – especially BVLOS UAS operations. As a result, the stakeholders that have already invested are not benefiting as much as they might from EC solutions, others continue to defer adopting the technology and the lack of interoperability between different solutions remains an issue. The next stage in the process of EC deployment is for us to coordinate the full adoption of interoperable EC solutions in targeted blocks of airspace where the safety benefits are greatest and there is a clear demand to integrate GA, commercial, military and UAS operations.

Call for evidence

7. This document is a call for evidence that describes our suggested approach to coordinating the full adoption of EC solutions in targeted blocks of airspace and aims to test whether:

- The proposed approach is correct;
- We are considering the right issues;
- We have developed the right options or whether others are needed; and
- The right stakeholders are engaged.

8. The approach focuses on targeting blocks of airspace where EC solutions can solve a clearly identifiable problem. We expect the transition to full adoption of EC solutions across all areas of UK airspace to be the eventual conclusion of this targeted approach, as the cumulative benefits of shared situational awareness are realised and the market for more advanced and cost-effective solutions matures. We expect that the full adoption of EC solutions will be delivered and funded by a range of organisations, and a wide mix of stakeholders will need to be engaged in the process.

How to respond

9. We would like stakeholders to consider the approach set out in this document then provide their responses to the questions set out in box 1.

Box 1: Call for evidence questions

CLOSED QUESTIONS

1. **Should the CAA act to coordinate the adoption of interoperable EC solutions in targeted blocks of airspace?** Yes / No / Don't Know
2. **Do you agree with our strategy to coordinate the full adoption of interoperable EC solutions in targeted blocks by using location specific mandates?** Yes / No / Don't Know
3. **What EC functions should the CAA focus on when coordinating adoption?** 1) Transmit only, 2) transmit and receive, 3) transmit, receive and rebroadcast, or 4) a combination depending on the need.

OPEN QUESTIONS

4. **What evidence should be used?** This question considers whether the best available evidence is being used and if there is anything that could be done to improve the data available to decision makers.
5. **Have all the options been considered?** This question considers whether there are other approaches that could also be considered.
6. **Do you have any specific feedback on the suggested approach?** This question aims to gather feedback from stakeholders on the scenarios presented in Part 2, the technical functions for EC solutions outlined in Part 3 and our suggested approach to coordinating deployment proposed in Part 4.

10. This call for evidence is open from 18th March to 25th May 2019. Responses should be submitted via: https://consultations.caa.co.uk/corporate-communications/e-conspicuity-solutions

11. When responding, please state whether you are responding as an individual or representing the views of an organisation. If responding on behalf of a larger organisation, please make it clear who the organisation represents and, where applicable, how the views of members were assembled. If you would like to share supporting documents or data, they can be uploaded here. We intend to publish all responses unless they are clearly marked confidential. The CAA is subject to the Freedom of Information Act.

Intended audiences

12. The intended audiences for this call for evidence are set out in table 1.

Sector	Stakeholder group
All airspace users	General aviation (including but not limited to fixed wing light aircraft, gliders, paramotors, hang gliders, parachutists, model aircraft operators and balloonists).
	Charter and business aviation (fixed wing and rotary)
	Scheduled commercial air transport
	Offshore helicopter operations
	Helicopter emergency medical services and search and rescue
	Military airspace users
	UAS operators
	Space planes
All aerodromes	EASA licensed, larger commercial aerodromes

	UK licensed smaller aerodromes Non-licensed aerodromes Heliports
All air traffic services	NATS (En Route) plc - NERL Airport / airfield air navigation service providers (ANSPs) Lower airspace radar services (LARS) Unmanned Traffic Management (UTM) service providers Combined air navigation service provision with the Irish Aviation Authority in the UK/Ireland Functional Airspace Block (FAB)
All manufactures and suppliers of EC solutions	Airborne device manufacturers and suppliers Ground-based EC solution manufacturers and suppliers Infrastructure providers Unmanned Traffic Management system and software developers
Key institutions	European Aviation Safety Agency (EASA) EUROCONTROL UK Department for Transport UK Ministry of Defence The Office of Communications (Ofcom)

Table 1

Document structure

13. The call for evidence is split into four main parts that set out our proposed approach:

Part 1: Considers the drivers for full adoption of EC solutions, the vision for EC deployment in the UK, some guiding principles that underpin our proposed approach and the areas in which we intend to measure benefits and disbenefits.

Part 2: Considers three simple scenarios for the full adoption of EC solutions in different blocks of airspace and the potential benefits and disbenefits.

Part 3: Considers the main technical functions that EC solutions must, should or could provide for air to air, air to ground and ground to air interactions.

Part 4: Considers the approach to coordinating the full adoption of EC solutions in targeted blocks of airspace and conducting live trials to test key parts of our suggested approach.

Part 1: Drivers, vision and guiding principles for EC deployment

Drivers

14. The full adoption of EC solutions in targeted blocks of airspace is one of the most cost-effective ways to significantly enhance aviation safety and efficiency. Full adoption of EC solutions is also considered a critical enabler for the integration of UAS, especially operating beyond visual line of sight (BVLOS) in non-segregated airspace alongside conventional air traffic operations. As a result, we propose that the three main drivers for the full adoption of EC solutions are:

- **to maintain and enhance safety** by mitigating the risk of airspace infringements and mid-air collisions;
- **to improve efficiency** by seeking to offer airspace users access to the airspace they require to conduct their operations most effectively; and
- **to enable UAS integration** by establishing a comprehensive foundation of EC that UAS operators can rely on to detect and avoid other airspace users remotely or automatically using connected technologies.

Guiding principles

15. We have four principles to guide our work on the full adoption of EC solutions:

- **User-focused:** putting airspace users, passengers and businesses that rely on aviation at the centre of the approach.
- **Evidence led:** targeting our activity to solve specific problems and deliver tangible benefits and avoiding activity that does not address a need.
- **Market-driven:** focusing on the enablers required to help the market for EC solutions to work effectively.
- **Interoperable:** focusing on the functions that EC solutions should provide to ensure interoperable connectivity.

Vision

Our EC vision for targeted blocks of airspace defines what we believe can be achieved in targeted airspace blocks in the circa 2023 and is set out in box 2.

Box 2: EC deployment 2023 vision – for targeted blocks of airspace

- **where required, every airborne vehicle in UK airspace can detect and be detected using interoperable EC solutions;**
- **the surveillance coverage created by full adoption of EC solutions can be provided to as much of the UK's airspace as the sector demands;**
- **a mature and competitive market for interoperable EC solutions exists to allow airspace users and air traffic services to make cost-effective investments.**

Measuring benefits and disbenefits

16. We suggest that the potential benefits and dis-benefits of coordinating the full adoption of EC solutions that will inform our decisions about the deployment approach should be measured in five areas, described in table 1.

Area	Measure
Safety	Changes in the current levels of safety performance.
Flight efficiency and cost-effectiveness	Changes in pilot/ATS workload/interaction and aircraft equipage and operating costs.
Airspace access and capacity	Changes to the total number of airspace users that can access blocks of airspace and the volume that can be safely accommodated in a given timeframe.

Environmental	Changes in the environmental impacts of aviation on local communities.
Economic	Changes in the economic value of aviation to the nation.

Table 2

Part 2: EC deployment scenarios

17. We expect that some areas of airspace will have greater potential to realise benefits from the full adoption of EC solutions than others and we think this should be factored in when considering our role in the approach to coordinating deployment.

18. The scenarios described in this part of our approach aim to examine to possible benefits and disbenefits of introducing EC solutions with different required levels of functionality into different blocks of airspace. Three scenarios and three levels of functionality are considered.

Scenario A: A block of uncontrolled airspace from the ground to 5,000ft.

Scenario B: A block of uncontrolled airspace from 5,000ft. to Flight Level 195.

Scenario C: A block of controlled airspace surrounding an aerodrome.

Functionality level 1, transmit only: All airspace users operating in the designated block of airspace must transmit their location and altitude using an interoperable EC solution. ATS units and UTM providers can invest voluntarily in interoperable ground-based solutions as they require.

Functionality level 2, transmit and receive: All airspace users operating in the designated block of airspace must transmit and receive location and altitude information to/from all other airspace users using interoperable EC solutions; and, all ATS and UTM providers operating in the designated block of airspace must receive location and altitude information from airspace users using an interoperable ground-based solution.

Functionality level 3, transmit, receive and rebroadcast: All airspace users in the designated block of airspace must transmit and receive as in level 2. All ATS and UTM providers must receive EC information and must rebroadcast the information to all other operators, potentially with 'value-add' services like weather information or routeing options.

Scenario A

19. Scenario A concentrates on blocks of uncontrolled airspace from the ground to 5,000ft where the full adoption of EC solutions may have the greatest potential to generate benefits, although some potential disbenefits would need to be carefully managed.

20. Significant portions of the UK's airspace from the ground to 5,000ft is uncontrolled. A broad range of different airspace users operate at the same time in this airspace without segregation, including powered and non-powered GA, corporate and business aviation (fixed wing and rotary), commercial air transport, all types of military aircraft and UAS operators flying in visual line of sight (VLOS).

21. Although coverage is not universal throughout the UK a layer of conventional primary surveillance coverage is available in uncontrolled airspace from approximately 1,500ft, provided by the UK LARS (Lower Airspace Radar Service). The local topography of many regions can impact on the quality of surveillance coverage offered by LARS below 1,500ft (and in some areas higher). Airspace users can choose to receive either a basic, traffic, deconfliction or procedural service from the LARS that is delivered by radio communications with an air traffic controller. Airspace users are able to choose whether or not to make use of any such services. Regardless of any service chosen, airspace users remain responsible for avoiding other aircraft.

22. There are limitations to the effectiveness of the LARS for creating and maintaining a known traffic environment. For example, pilots may experience information overload (it is not uncommon for ATS to offer information on two or three aircraft one after another). Conversely, pilots may not receive enough information at the right times. For example, LARS may notify pilots of a delay in the provision of traffic information, and possibly provide no information, due to high levels of controller workload. This situation may often occur on busy

days when greater situational awareness from the creation of a known traffic environment is most important.

Scenario A / level 1, transmit only

23. In this scenario we have assumed that the CAA has acted to require that all airspace users in a designated block of uncontrolled airspace from the ground to 5,000ft must transmit location and altitude information using an interoperable EC solution to a minimum standard of quality and reliability. There is no requirement for users to receive EC information. As a result, the designated block of airspace has become a full and permanent known traffic environment, but only for those stakeholders that choose to voluntarily invest in additional interoperable solutions that can receive EC information.

24. **Safety aspects:** The impact on safety can be assessed in terms of an enhancement or degradation in current levels of safety performance. Direct safety impacts will only arise for those stakeholders that decide to voluntarily invest in additional solutions that can receive EC information, or already have suitable equipment. The safety enhancements that arise for these users may be increased significantly by the assurance that all aircraft in the designated block of airspace are required to at least transmit EC information. Safety performance levels may be enhanced by improvements in the ability to:

- Manage mid-air collision risks
- Offer greater assurance for commercial operations in Class G
- Manage the risk of infringement into controlled airspace
- Manage the risk of controlled flight into terrain; and
- Manage the risks of unexpected degradations in weather conditions and visibility

Airspace users that choose not to make additional investments and transmit only may experience indirect safety enhancements from the net increase in the average levels of safety performance across all aircraft, driven by those users with the capability to receive EC information.

The potential for a direct degradation in safety performance will similarly only fall to those users that have voluntarily invest in additional solutions that can receive EC information. Safety performance levels may be degraded by an increase in the risk that:

- Pilots become distracted and/or overloaded by additional EC information and make unsafe manoeuvres
- Pilots become over reliant on additional EC information and fail to see and avoid.

The ability for all ATS providers to receive EC information may create additional safety enhancements from improvements in:

- Awareness of the evolving traffic situation and the ability to detect and resolve potential conflicts earlier.
- Awareness of pending airspace infringements and decision making about the most effective response.

If users decide not to invest in additional solutions to receive EC information, then the safety impacts of requiring airspace users to transmit only, may be significantly reduced.

25. **Flight efficiency and cost effectiveness impacts:** The impact on flight efficiency can be assessed in terms of changes in pilot/ATS workload and aircraft equipage and operating costs. Similar to safety impacts, direct flight efficiency benefits may be generated by improvements in users' ability to use EC information to:

- Establish a full and permanent known traffic environment, reducing the need for radio communications between pilots and air traffic controllers, reducing cockpit and ATM workload.

- Plan (pre-flight) and re-plan (during flight) more efficient flight paths, thus reducing aircraft operating costs.
- Avoid airspace bottlenecks, restrictions and poor weather by changing departure times or re-routeing (for example because ATC are able to offer enhanced services based on accurate knowledge of the altitude and location of airspace users).
- Integrate UAS operating far more extensively beyond visual line of sight.

The equipage and maintenance requirements associated with EC solutions creates an additional input required to complete flight operations that could be considered a comparative decrease in cost efficiency.

The incentive for ATS providers to invest in TDDs that generate an EC picture for stakeholders on the ground is increased by the assurance that all users are captured by the requirement to transmit.

However, if stakeholders do not invest in solutions to receive EC information, then the efficiency impacts are likely to be significantly reduced.

26. **Airspace access and capacity impacts:** The impact on airspace access and capacity can be assessed in terms of changes to the total number of airspace users that can access blocks of airspace and the volume of users that can be accommodated in a given timeframe. The main improvements in airspace access fall to GA users and UAS operators because:

- The full and permanent known environment created by the requirement for all airspace users to transmit EC information is a foundation from which to develop and deploy solutions for airspace integration and for UAS operators to fly BVLOS in uncontrolled airspace.

The demand for UAS operations is forecast to grow significantly over the next decade. By 2030, UAS operating at lower altitudes are expected to make up a significant proportion of all air traffic movements. In the same timeframe commercial and GA traffic levels will continue to increase.

- Comparative reductions in airspace capacity may arise from the ability for UAS operators to fly BVLOS in uncontrolled airspace because the net increase in unmanned traffic movements in uncontrolled airspace and may at times reduce the volume of available capacity for conventional manned airspace users.

27. **Environmental impacts:** The impact on environmental performance can be assessed in terms of the impacts of aircraft noise and visual intrusion that affect local communities. Environmental performance may be improved by:

- Creating new opportunities to better manage the impact of aircraft noise and visual intrusion on local communities.

Environmental performance may also be degraded due to the increase in UAS operations at lower altitudes in uncontrolled airspace causing additional aircraft noise and visual intrusion for local communities.

28. **Economic impacts:** The impact on economic outputs can be assessed in terms of changes in the potential for aviation stakeholders to generate national economic value by increasing the production and consumption of goods and services. The requirement for all airspace users in the designated block of airspace to transmit EC information generates the full and permanent known traffic environment that UTM providers require to develop and deploy solutions for UAS operators to fly BVLOS in uncontrolled airspace.

- The ability for UAS operators to fly BVLOS in uncontrolled airspace is expected to generate significant economic value through the provision of new goods and services from package delivery, search and reduce, high value manufacturing and surveying to unmanned urban air transport.

Scenario A / level 2, transmit and receive

29. In the step to level 2 of this scenario we have assumed that the CAA has acted to require that all airspace users operating in the designated block of airspace must transmit and receive location and altitude information to/from all other airspace users using interoperable EC solutions; and, all ATS and UTM

providers operating in the designated block of airspace must receive location and altitude information from airspace users using an interoperable ground-based solution. Although the CAA will not be prescriptive, we have assumed that the requirement to receive EC information is always accompanied by the appropriate means to present the information to operational personnel. As a result, the block of airspace from the ground to 5,000ft. has become a full and permanent known traffic environment for all airspace users, ATS and UTM providers.

30. **Safety impacts:** Direct safety impacts arise for all airspace users because the ability to detect and be detected by means of an interoperable EC solution is ubiquitous in the designated block of airspace. Safety performance levels may be enhanced significantly by the collective and cumulative improvement in all users' ability to:

- manage mid-air collision risks;
- manage the risk of infringement into controlled airspace;
- manage the risk of controlled flight into terrain; and
- manage the risks of unexpected degradations in visibility that limit pilots' ability to see and avoid (e.g. unexpected haze).

The potential for a degradation in safety performance levels due to the risks associated with distraction, information overload and overreliance are similarly exacerbated by the collective and cumulative impact on full adoption.

The ability for all ATS providers to receive EC information may create additional safety enhancements from improvements in:

- Awareness of the evolving traffic situation and the ability to detect and resolve potential conflicts earlier.
- Awareness of pending airspace infringements and decision making about the most effective response.

31. **Flight efficiency and cost effectiveness impacts:** Flight efficiency impacts arise for all airspace users because full knowledge of the traffic environment is ubiquitous in the designated block of airspace. The flight efficiency improvements outlined above, to reduced pilot and controller workload, plan and fly more efficient flight paths and avoid the inefficiencies associated with bottlenecks, restrictions and poor weather, are extended to all airspace users.

    The ability for ATS providers to receive EC information may further increase flight efficiency by improving awareness of the evolving traffic situation and the ability to redirect traffic flows towards less congested airspace enabling users to follow more efficient flight paths.

32. **Airspace access and capacity impacts:** The total number of airspace users that can be accommodated in the designated block of airspace is expected to increase because all airspace users and ATS providers have a shared situational awareness that informs decisions to optimise the overall capacity of the airspace.

    The BVLOS concept of operations developed for UAS integration may evolve from Step 1 if UTM providers are assured that all airspace users can receive electronic surveillance information.

33. **Environmental impacts:** The environmental performance improvements outlined above will be increased further as the known traffic situation is extended to all users and ATS providers.

34. **Economic impacts:** The requirement for all airspace users, ATS and UTM providers to adopt EC solutions introduces an incentive for manufacturers and suppliers to further develop their offerings, expanding the supply and functionality of the products that can enable the range of benefits considered throughout this scenario to be realised.

Scenario A / level 3, transmit, receive and rebroadcast

35. In the step to level 3 of this scenario, we have assumed that the CAA has intervened to require that all airspace users in the designated block of

airspace from the ground to 5,000ft must transmit and receive as in level 2. All ATS and UTM providers must receive EC information and rebroadcast the information to all other operators with ‘value-add’ services like weather information or routeing options. As a result, the block of airspace has become a full and permanent known traffic environment for all airspace users, ATS and UTM providers and users also rely on the provision of value-add EC information that is rebroadcasted from ground-based solutions.

36. ATS and UTM providers may have offered some value-add services voluntarily in the first two steps of this scenario, because they are commercially incentivised to deliver for their customers. In the step to level 3, the CAA requires the provision of some specific value-add services from ground-based EC solutions because they are considered essential for users to optimise the safety and efficiency of their operations. Value-add services may include:

- Weather information
- Routeing options for safer or more efficient flight paths
- Airspace boundaries and restrictions (permanent and temporary)
- Conflict detection and alerting information
- NOTAM information
- Information about planned and unplanned events

37. **Safety impacts:** Direct safety impacts arise for all airspace users because rebroadcast services are provided to all aircraft as a CAA requirement. Safety performance levels may be enhanced significantly because the rebroadcast services are focused on the provision of safety critical information. The potential for a degradation in safety performance levels due to the risks associated with EC information distraction, overload and overreliance still exist and require careful management. However, the intended role of ground-based solutions that collate all EC data and rebroadcast the value-add parts, is to reduce the burden on pilots to understand and interpret raw location and

altitude information about all other users without additional analysis or insights.

38. **Flight efficiency and cost effectiveness impacts:** Flight efficiency impacts arise for all airspace users because, following the provision of safety critical information, the secondary priority of rebroadcast services is to offer more efficient routeing options. The flight efficiency improvements outlined above, e.g. to optimise flight paths and avoid inefficient areas of airspace, are enhanced because rebroadcast services remove the need for pilots to expend workload understanding and interpreting raw EC information.

39. **Airspace access and capacity impacts:** The total number of airspace users that can be accommodated in the designated block of airspace is expected to increase further with the rebroadcast of value-add services to all aircraft. The additional services that ground-based solutions might develop from raw EC information are expected to optimise the overall capacity of the airspace.

In a sense, UAS operators rely on rebroadcast services from UTM providers in level 1 (transmit only) of this scenario onwards. The ability to collate and rebroadcast EC information is a core function for UTM providers to deliver their services to UAS operators using connected technologies. BVLOS operations are based on drones automatically following the safety related, flight efficiency and access/capacity instructions broadcast from the ground-based UTM providers.

40. **Environmental impacts:** The environmental performance improvements outlined above will be increased further as the known traffic situation is extended to all users and further optimised by the required use of value-add services.

41. **Economic impacts:** The additional requirement for the rebroadcast of value-add services offers further incentive for manufacturers and suppliers to develop their offerings, expanding the supply and functionality of the products that can enable the benefits considered throughout this scenario to be

realised and mitigate some of the potential disbenefits associated with EC information distraction, overload and overreliance.

Scenario B

42. Scenario B concentrates on blocks of uncontrolled airspace from 5,000ft to FL195 where the full adoption of EC solutions may have benefits in addition to those considered in scenario A.

43. A similar range of airspace users operate in the uncontrolled airspace from 5,000ft to FL195, but the traffic mix at higher altitudes is different. Fewer powered and non-powered GA users operate above 5,000ft. However, there are many notable exceptions; for example, parachute drop zones would often reach above 5,000ft; Operations in some areas of Scotland would require users to fly above 5,000ft. to reach the minimum safe altitude because of the local topography of the region; users conducting aerobatic routines may prefer higher altitudes to provide a sufficient safety buffer; and soaring gliders regularly climb above 5,000ft.

44. Climbing above 10,000ft. is relatively rare for powered GA aircraft due to the service limit and need for a pressurised cabin or special oxygen equipment.

45. The proportion of commercial air transport, business jet and military users in the traffic mix is greater above 5,000ft, meaning aircraft are typically larger, travelling faster and covering further distances in this airspace. Many larger aircraft are already equipped with airborne EC devices and the ATS providers offering services in this area will be able to draw on more primary radar and SSR coverage.[3]

Scenario B / level 1, transmit only

46. In this scenario we have assumed that the CAA has intervened to require that all airspace users in a designated block of uncontrolled airspace from 5,000ft to FL195 must transmit location and altitude information using an

[3] Reference EASA SPI-IR

interoperable EC solution. As a result, the designated block of airspace has become a full and permanent known traffic environment, but only for those stakeholders that choose to voluntarily invest in additional interoperable solutions that can receive EC information.

47. **Safety impact:** The impact on safety is limited because many larger aircraft operating above 5,000ft in uncontrolled airspace will be flying IFR, already carrying an EC solution and may well be in receipt of a deconfliction service from a local ATS provider. Many users operating VFR above 5,000ft. would already be visible to ATS via primary radar and SSR. If ATS providers choose to invest in TDDs that can receive EC information, those VFR users that do not carry a Mode S transponder and were previously undetected by SSR would become visible by electronic means, establishing a known traffic environment.

48. **Flight efficiency impacts:** Flight efficiency impacts are limited for the same reasons.

49. **Airspace access and capacity impacts:** The impact on airspace access and capacity for manned airspace users are likely to be limited for the same reasons as the safety and flight efficiency impacts. The improvements for UAS operators are also likely to be limited. Although UTM providers can use the full and known traffic environment to offer BVLOS operations, far fewer UAS operators require access to the airspace above 5,000ft.

Scenario B / level 2, transmit and receive

50. In the step to level 2 we have assumed the requirement for all users operating in the designated block of airspace to transmit and receive. And, all ATS and UTM providers must receive EC information using an interoperable ground-based solution. Although the CAA would not be prescriptive, we have assumed that the requirement to receive EC information is always accompanied by the appropriate means to present the information to operational personnel. As a result, the block of airspace from 5,000ft to FL195

has become a full and permanent known traffic environment for all airspace users, ATS and UTM providers.

51. **Safety impact:** Direct safety impacts are expected to arise for airspace users operating VFR that now have the ability to detect and be detected by means of an interoperable EC solution, bringing their safety performance levels more in line with those users flying IFR with a deconfliction service.

The potential for a degradation in safety performance levels for VFR users due to the risks associated with EC information distraction, overload and overreliance are less acute above 5,000ft where there are comparatively fewer aircraft in the same volumes of airspace.

The ability for all ATS providers to receive EC information from the minority of VFR operators above 5,000ft that were not previously visible may create additional safety enhancements from improvements in:

- Awareness of the evolving traffic situation and the ability to detect and resolve potential conflicts earlier.
- Awareness of pending airspace infringements and decision making about the most effective response.

52. **Flight efficiency impacts:** Flight efficiency impacts are expected to arise for VFR users that can use the ability to detect and be detected to reduce workload and plan/fly more efficient flight paths.

Scenario B / level 3, transmit, receive and rebroadcast

53. In the step to level 3, we have assumed that all ATS and UTM providers must receive EC information and rebroadcast to all other operators with ‘value add’ services. VFR users operating above 5,000ft can rely on the provision of value-add EC information like weather information, routeing options and conflict detection.

54. **Safety impacts:** Safety performance levels may be enhanced significantly because the rebroadcast services are focused on the provision of safety

critical information like conflict alerts to VFR users operating in the same environment as IFR users.

55. **Flight efficiency impacts:** Flight efficiency impacts are expected to arise because rebroadcast services offer more efficient routeing options to VFR users.

56. **Airspace access and capacity impacts:** The total number of airspace users that can be accommodated in the designated block of airspace is expected to increase further with the rebroadcast of value-add services to VFR users that optimise the safety and efficiency of their operations.

Scenario C

57. Scenario C concentrates on a block of controlled airspace around an aerodrome where the full adoption of EC solutions by VFR users operating adjacent uncontrolled airspace in the vicinity may generate benefits.

58. Busy aerodromes that primarily serve commercial air transport operate in controlled airspace (typically Class D) that is implemented at lower altitudes to protect inbound and outbound traffic flows. ATS providers at busy aerodromes can offer users flying VFR in the uncontrolled airspace nearby with a service to support their operations and enable them to transfer through controlled airspace.

59. A major concern for IFR users and ATS in controlled airspace is the risk of unintended infringements from aircraft flying in the vicinity. These concerns are particularly acute in higher risk areas where:

- Multiple busy aerodromes operate in close proximity, creating a patch work of overlapping controlled airspace structures with small gaps of uncontrolled airspace in between.
- Popular GA airfields are situated below the base of a busy aerodrome’s controlled airspace.

Scenario C / level 1, transmit only

60. In this scenario we have assumed that the CAA have intervened to require all users in the vicinity of a busy aerodrome's controlled airspace to transmit location and altitude information using an interoperable EC solution. As a result, the designated block of airspace has become a full and permanent known traffic environment, but only if ATS operating in controlled airspace invest in the solutions to receive EC information.

61. **Safety impact:** Direct safety impacts will only arise if ATS providers invest in ground-based solutions to receive the EC information. The safety enhancements for ATS and IFR users in controlled airspace are driven by the assurance that all aircraft in the vicinity are transmitting EC information. Safety performance levels may be enhanced by improvements in the ATS providers ability to manage the infringements into controlled airspace.

62. There is also a potential benefit for ATC with GA aircraft crossing the airport's control zone that would now all be transmitting, relative to today's environment where a transiting aircraft could have no EC and ATC have less information available as it crosses.

    If ATS providers in controlled airspace are not sufficiently incentivised to invest in additional solutions to receive EC information, then the safety impacts of requiring airspace users in adjacent uncontrolled airspace to transmit would be significantly reduced.

63. **Flight efficiency impact:** Similar to safety impacts, direct flight efficiency impacts will only arise if ATS providers voluntarily invest in solutions to receive EC information. If this is the case, increases in flight efficiency may be generated by improvements in the ability of ATS providers to better manage the impact on IFR operations of an infringement.

64. **Airspace access and capacity impacts:** If ATS providers invest in solutions to receive EC information the total number of airspace users that can access the controlled airspace and the volume of users that can be accommodated in a given timeframe are likely to increase due to the creation of a known traffic

environment in the wider area of airspace. For example, the ATS workload associated with monitoring VFR traffic crossing controlled airspace or managing potential infringements may reduce.

65. The BVLOS concept of operations developed for UAS integration may evolve from scenario A to incorporate some areas of controlled airspace if UTM providers are assured that all airspace users in the vicinity are transmitting EC information.

Scenario C / level 2, transmit and receive

66. In the step to level 2, we have assumed the requirement for all users in the vicinity of controlled airspace to transmit and receive and for ATS and UTM providers to receive EC information. As a result, the areas in the vicinity of controlled airspace have become a full and permanent known traffic environment for all airspace users, ATS and UTM providers.

67. **Safety impacts:** Safety performance levels may be enhanced further by the collective and cumulative improvement in the ability of both ATS providers and VFR users to manage the risk of infringements into controlled airspace. The potential for a degradation in safety performance levels for VFR users due to the risks associated with distraction, information overload and overreliance are similar to scenario A and must be carefully managed.

68. **Flight efficiency impacts:** The flight efficiency improvements outlined in level 1 of scenario C, to better manage the impact on IFR operations of an infringement, are likely to be enhanced because VFR users can also receive EC information that is used to support their mitigating actions.

69. **Airspace access and capacity impacts:** The total number of users that can be accommodated in controlled airspace is expected to increase further because VFR users can also receive EC information that is used to support controlled airspace transits.

70. **Economic impacts:** The economic impact on commercial air transport operations of infringements into controlled airspace are potentially significant.

Mitigating actions implemented by ATS to manage safety typically result in delays that prevent the timely delivery of aviation products and services. These delays create economic disbenefits for users, passengers and companies that rely on aviation to conduct their business. The requirement for EC solutions that reduce the likelihood of infringements and better manage the impact on IFR operations when they do occur, will reduce the overall economic disbenefits.

Scenario C / level 3, transmit, receive and rebroadcast

71. In the step to level 3, we have assumed that all ATS providers must receive EC information and rebroadcast to other operators with value-add services. VFR users in the vicinity of controlled airspace can rely on the provision of value-add EC information to help prevent infringements and better manage the impacts if they do occur. As a result, the safety, flight efficiency, access/capacity and economic benefits outlined above in scenario C / level 2 are further enhanced.

72. The potential for a degradation in the safety performance levels of VFR users due to the risks associated with distraction, information overload and overreliance are mitigated because the burden on pilots to understand and interpret raw EC information is reduced by the provision of value-add services.

Part 3: Technical functions of EC solutions

73. Establishing a common set of technical functions and minimum standards or requirements for interoperable EC solutions is likely to be a necessary step to help manufacturers to develop products with the right capabilities and for airspace users, ATS and UTM providers to make the right investments.

74. Our proposed approach to coordinating the full adoption of EC solutions in targeted blocks of airspace does not seek to promote a particular technology upon which to base the technical functions or standards. However, given the global market, commercial and regulatory developments, ADS-B (Automatic Dependent Surveillance – Broadcast) enabled and interoperable platforms are considered one of the most likely technologies in the UK to deliver the vision over the short to medium term.

75. We do not propose to rule out any alternative technologies. The key point is that any technology used to support EC solutions must be fully interoperable for the purpose of achieving the three outcomes set out in the vision, that:

- where required, every airborne vehicle in UK airspace can detect and be detected using interoperable EC solutions;
- the surveillance coverage created by full adoption of EC solutions can be provided to as much of the UK's airspace as the sector demands; and
- a mature and competitive market for interoperable EC solutions exists to allow airspace users and air traffic services to make cost-effective investments.

76. The following sections consider some of the technical functions and possible minimum standards or requirements that EC solutions should deliver, concentrating on air-to-air, air-to-ground, ground-to-air, frequency spectrum and space-based interactions.

Technical functions for air-to-air and air-to-ground interactions

77. When it comes to EC solutions, the requirements of airspace users for air-to-air interactions are varied, complex and can change over time. It is important that our approach is based on a clear understanding of how different users intend to fly, the information they need and the protection they require in different circumstances. The simple scenarios described in part 2 of the call for evidence aim to help us shape this understanding through the feedback provided by stakeholders.

78. The scenarios consider the full adoption of EC solutions across all airspace user groups. The first and most basic level of technical functionality for air-to-air interactions is the ability to transmit location and altitude information. The second level of functionality assumes the implementation of EC solutions that transmit and receive EC information. Air-to-air interactions may be supported by moving map displays in the cockpit or audible messaging to a headset that alerts users to the presence of others around them, supplementing the pilots' ability to see and avoid with a detect and be detected capability.

79. The interoperability of EC solutions is a key principle of our suggested approach. The technical functions to support air-to-air interactions must consider the need to integrate existing EC solutions that are based on different technologies, removing the need for users to reinvest in an interoperable solution.

80. Many airspace users are investing voluntarily in a range of EC solutions that use different technologies, including ADS-B (Automatic Dependent Surveillance – Broadcast), Mode S and FLARM (Flight Alarm). Voluntary investment in EC solutions is a positive endorsement of their potential benefits, but without a set of common technical functions and minimum standards for interoperability, solutions based on different technologies are creating a disparate and incompatible environment. A lack of interoperability would mean that the potential for the full adoption of EC solutions to create a full and permanent known traffic environment would not be realised and many

of the benefits outlined in part 2 would be lost. This in turn reduces the voluntary incentives to invest in EC solutions.

81. Table 3 sets out our views on the essential technical functions that airborne EC solutions should provide for air-to-air and air-to-ground interactions, along with other desirable and optional functions that may be used in different scenarios.

Technical functions of EC solutions for air-to-air and air-to-ground interactions

Essential Functions	• Airborne EC devices for air-to-air interactions must transmit GNSS location and barometric altitude information that can be detected by all other interoperable airborne solutions. • In addition, for air-to-ground interactions the information from airborne devices must be transmitted with sufficient power, continuity and integrity for ATS and UTM providers to use the data for its intended purpose.
Desirable functions	• Airborne EC devices should receive GNSS location and barometric altitude information from all other interoperable airborne solutions. • Our suggested approach is not prescriptive about the method by which location and altitude information received by an airborne device is then presented to the pilot and used. • EC information about the locations and altitudes of other airspace users may be presented to a pilot visually on a moving map display. Alternatively, the information may be communicated as an audio message, or it might be used by an algorithm in an

	automated system to inform decisions with no human inputs (for example in the case of BVOLS UAS operations).
Optional functions	• Airborne EC devices could transmit additional information that can be detected by all other interoperable airborne and ground-based solutions, such as the user's planned trajectory. • Airborne devices could receive additional information from other airborne and ground-based solutions, including weather data and routeing options.

Table 3

Technical functions for ground-based traffic data displays

82. The requirements, specifications and regulatory standards to define what is acceptable for ground equipment that is used to detect and display aircraft with electronic surveillance devices is currently being updated by the CAA, working closely with industry partners.

83. Ground-based data displays (TDDs) are intended for the visual display of aircraft positioning in the airspace around aerodromes, based on EC information with no primary or secondary surveillance radar and by UTM providers to enable BVLOS UAS operations.

84. The technical functionality for TDDs must define what is acceptable in terms of EC information display, integrity, and an appropriate human machine interface. The ATM procedures required to accompany the use of TDDs by ATS providers to offer basic, traffic or deconfliction services are being refined and updated by the CAA during 2019.

85. Initially, we envisaged the core functions of TDDs will focus on supporting the provision of a basic service within Class E and Class G airspace. This is to ensure that the information presented remains a cross-check only for an existing flight information service, since (though existing trialling is demonstrating good aircraft position display accuracy) insufficient time has passed to allow enough evidence to justify the use of such data for providing tactical clearances and instructions. Table 4 sets out our views on the essential technical functions that TDDs should provide for air-to-ground interactions, along with other desirable and optional functions that may be used in different scenarios.

Technical functions of TDDs	
Essential Functions	• TDDs <u>must</u> receive GNSS location and barometric altitude information from all interoperable airborne EC devices. • TDDs <u>must</u> present EC information in accurate and timely form to ATS providers.
Desirable functions	• TDDs <u>should</u> determine the levels of quality and integrity of the EC information received and distinguish it clearly for the user.
Optional functions	• TDDs <u>could</u> provide other basic functions like the trajectory of pre-planned flights and alerting for deviations. However, TDDs are intended to be low cost, low functionality systems that encourage widespread adoption. Introducing a range of additional optional services are likely to make the systems more expensive.

Table 4

Technical functions for ground-to-air interactions

86. Ground-based EC information systems may be further developed to receive location, altitude (and potentially additional) information from all interoperable airborne solutions and collate it with other operational data, like weather information or airspace capacity conditions, to be rebroadcast to airspace users, ATS or UTM provider as value-add information services. The capability of airspace users, ATS and UTM providers to receive and use rebroadcast services may be a compulsory or optional depending on the scenario. Table 5 sets out the essential functions of systems to rebroadcast EC information as a value-add service, along with other desirable and optional functions that may be used in different scenarios.

Technical functions for ground-based rebroadcast solutions	
Essential Functions	• Ground-based rebroadcast systems must receive GNSS location and barometric altitude information from all interoperable airborne EC devices. • Ground-based rebroadcast systems must transmit location and altitude information services that can be detected by all interoperable airborne EC solutions.
Desirable functions	• Ground-based rebroadcast systems should transmit other value adding information services like MET data, routeing options etc. that can be detected by all interoperable airborne EC solutions.
Optional functions	• Ground-based rebroadcast systems could transmit core location and altitude information and/or other value-add information to other ground-based systems to supplement their existing services.

Table 5

Frequency spectrum interactions

87. This section considers how frequency spectrum interactions and usage should be managed to enable interoperable EC solutions for GA, UAS and other airspace users.

88. Any EC solution will be subject to broadcast capability limitations based on the spectrum it uses. This will also potentially limit the scope of the solutions interoperability with existing and proposed systems. We think the challenge of delivering interoperable EC solutions will contain a spectrum element whichever route is adopted. Spectrum is the mechanism that allows solutions to interact, air-to-air, air-to-ground and ground-to-air.

89. The existing and developing EC solutions largely fall into two camps both with spectrum-related limitations. All known existing and proposed EC solutions are reliant on the GNSS network which has the potential for common mode failure. Table 6 sets out some of the known spectrum issues associated with existing and proposed EC solutions that do not sit within the traditional Aviation frequency bands. Table 7 sets out the issues around using conspicuity frequencies within the Aviation frequency bands.

Issues associated with non-aviation spectrum	
Protection criteria	• Development of EC on free to broadcast licence exempt spectrum limits the protection that can be afforded by the CAA in respect of long term frequency management and known jamming activities within the UK. Some of these frequencies are issued on a no protection basis which would limit the powers of Ofcom to intervened should interference occur.
Limited power	• The existing and emerging non-aviation frequencies are all limited by power levels which although in most cases have proven to be adequate for Air to

	Air detection are not designed to promulgate the range required for Air to Ground use that would facilitate airspace modernisation and allow for a common situational awareness picture on the ground and in the air. When looking at ground-based solutions third party network coverage can be a limiting factor.
Interoperability with existing aviation systems	• The development of separate eco systems using different spectrum has led to a situation that means interoperability is limited between systems, specifically, those systems that are already mandated on commercial aircraft under EU regulations.

Table 6

Issues associated with the proposed aviation spectrum	
Utilisation	• Existing aviation spectrum in some case is already highly utilised, introducing significant additional users in certain geographical areas has the potential to interfere with existing systems to the detriment of existing surveillance.
Interoperable with existing non-aviation certified devices/proposed EC solutions	• The development of non-aviation certified technology all using different parts of the spectrum has led to a situation that means interoperability is limited between systems.

Table 7

Potential solutions considered in our approach

90. Of the above know issues, some efforts have already been made to address them either by industry or by the CAA. We will continue to work with industry to develop interoperable solutions across all proposed and existing platforms. We will also continue to model the effect of frequency saturation on aviation frequencies and explore options of other frequencies within the allocated aviation protected spectrum. It is recognised that some of the issues highlighted may be resolved by the deployment of ground based infrastructure, the two factors will be explored in parallel as part of our work.

Part 4: Coordinating adoption

Challenges associated with coordinating adoption

91. Many airspace users and some ATS providers have voluntarily invested in EC solutions because they are attracted by the benefits. We believe that some additional form of obligation to invest in EC solutions, over and above individual incentive, will be needed to coordinate adoption for two reasons:

- Without a firm obligation on all stakeholders to invest in EC solutions in a certain timeframe, it may be many years before full adoption is achieved. If full adoption is to be achieved voluntarily, it will be difficult for stakeholders to pinpoint exactly when this will happen and evolve their operations accordingly to realise the benefits. There is also a risk that even once full adoption is achieved, it may be lost again if there is no firm obligation for stakeholders to retain their EC solutions.
- Voluntary investments in EC solutions are driven by the specific benefits they deliver. These benefits vary by stakeholder group. Gliders are incentivised to invest in EC solutions for different reasons to fixed wing private pilots; the incentive for UAS operators is different again. Manufactures will tailor their solutions to maximise the potential benefits for each individual stakeholder group, thereby strengthening the incentive to invest. This market-driven model is likely to generate effective solutions to meet the demands of individual stakeholder groups, but the incentive to ensure interoperability across all solutions and stakeholder groups is less obvious. The benefits of interoperability are derived from improvements in safety, efficiency, access and capacity that are distributed across all airspace users. They are systemic, network wide benefits, that do not fall to any one stakeholder group, so are unlikely to be in demand when individuals are investing voluntarily.

The scope of EC mandates

92. The three most obvious of ways to introduce an obligation on stakeholders to invest in EC solutions (to some common standard of functionality and agreed scope / timeframe) are:

- A European mandate
- A UK national mandate
- A location-specific mandate

European mandates

93. As part of the EU's Single European Sky (SES) initiative, the European Commission and Member States have adopted regulations mandating that airspace users, aerodromes, ATS and (in due course) UTM providers adopt standardised solutions for a range aviation communications, navigation and surveillance functions through a series of Implementing Regulations (IRs). For example, the change to 8.33kHz frequency for GA radio communications was mandated for all airspace users and aerodromes in IR1079/2012. This is a means of leveraging technological developments in radio communications equipment to enable a significant increase in the availability of channels, as a result of scarce capacity. The deadline set by the legislation for the transition was the end of 2018. During 2018 many GA airports set a target date when they would change their equipment. After that date, all GA aircraft wishing to communicate with a ground unit that has converted are legally obliged to have an 8.33kHz capable radio.

94. European IR's typically take a long time to develop. Although UK stakeholders have a strong influence on the content of many SES IRs, ultimately, they must be refined and approved by all EU States, which often leads to several rounds of iteration and can throw up some unforeseen requirements. The benefits of rulemaking at a European level can be significant because the coverage of the required changes is large enough to deliver network-wide performance improvements and generate economies of scale during the implementation

phase. A rule to obligate the full adoption of EC solutions for all airspace users, is a topic under consideration by the European Commission because it aligns with the direction of travel set by previous IRs. However, the scope, timescales and process for establishing such a rule are currently unclear.

95. The UK Government has been clear that as the UK exits the EU, its aim is to ensure continued transport connectivity in support of successful economic and social ties, and as part of a deep and special future relationship. This includes the Governments desire to secure liberal aviation market access arrangements and exploring the terms of participation in EASA. Determining the future relationship is a matter for the UK Government in its negotiations with the EU. The CAA welcomes the ambition for aviation - including exploring participation in EASA.

National mandates

96. The CAA and DfT do retain the legal instruments to establish national mandates. The coverage of the requirements in a national mandate would only be domestic, limiting the potential for network wide improvements and economies of scale. However, the scope, timelines and process for establishing the mandate would be wholly under the UK's control.

97. Over recent years, the feedback from UK stakeholders about a rule to obligate the full adoption of EC solutions at a national level has consistently highlighted the breadth and complexity of the requirements (depending on the areas of airspace and the functions of the EC solutions that are applied). Stakeholders are especially concerned by the risk of a disproportionate outcome. The costs to stakeholders of complying with a national mandate may not be balanced with the benefits in some areas.

Location-specific mandates

98. Location-specific mandates that focus on targeted blocks of airspace narrow the coverage of the required changes even further. The benefits are far less expansive, but the total costs are much lower. It is also easier to apportion the

costs and benefits of introducing a location specific mandate amongst the impacted stakeholders, ensuring that any major misalignments between those required to invest and those that receive the benefits are managed.

99. The functions, processes and timelines associated with location-specific mandates can still be coordinated at a national level. Over time, a programme of well-coordinated, location-specific mandates could create the same widespread, network level changes delivered by national or European mandates, but with less risk of creating unintended consequences and much closer management of the costs and benefits.

100. One of the key questions associated with a programme of location-specific mandates is what areas of airspace to focus on and in what order? There are several methods for determining the focus and sequence of a programme of location-specific mandates, including:

- **ACP-led:** Linking the introduction of EC mandates with airspace change proposals that seek greater airspace segregation (e.g. a proposal for Class D airspace around an aerodrome).
- **Intelligence-led:** Working with a mix of industry stakeholders to identify areas where there is a clear need for an EC mandate.
- **Data-led:** Conducting analysis into airspace usage, capacity, incidents and near misses at a national level to identify those areas that stand out statistically as candidates for the full adoption of EC solutions.

101. We believe that a combination of these methods should be used to establish a rolling programme of locations specific mandates to coordinate adoption at a national level, following a lower risk approach.

EC infrastructure

102. Whatever form of mandate is implemented, all EC solutions will require the necessary infrastructure to connect and share information. Frequency spectrum, ground-based transceivers and space-based satellite constellations all have a potential role in connecting EC solutions and providing the data

transfer rate, capacity, latency and integration required to support their functions.

103. The business case for establishing the infrastructure to connect and share EC information is fundamentally different from the case for organisations and individuals to invest in the solutions themselves. Infrastructure is typically very expensive to establish (e.g. deploying a network of transceivers or launching, or buying spare capacity on existing, satellites) with long pay back periods. An infrastructure provider faced with such high set up costs requires a large base of customers in order to have a meaningful return on investment. This might become a barrier for entry to other providers, that would face the same high set up costs but may only attract a section of the customer base should they try to enter the market. If the barriers to entry are significant, the infrastructure provider may operate as a natural monopoly with no effective competition and a level of market power that might require regulatory intervention to protect the interests of consumers.

104. Depending on the scale and the characteristics of EC infrastructure required, there may be several models capable of delivering it. These might range from placing requirements on existing providers, to competition between new entrants. We would therefore be interested in stakeholders’ views on potential regulatory frameworks, funding models and incentives to invest in a sustainable infrastructure that brings about the EC benefits in the most efficient way.

EC deployment trials

105. We believe EC solutions need to be trialled in live environments to help develop our understanding of the costs and benefits to different stakeholder groups in different scenarios, refine our proposals on the essential, desirable and optional functions of the solutions themselves and test our suggested approach for a rolling programme of location-specific mandates.

Conclusion

106. The UK has some of the most complex and busy airspace in the world with constantly increasing demand for access to both controlled and uncontrolled portions of that airspace from a wide range of users often with competing requirements. Safely accommodating as many of these existing users as possible is a major challenge; adding the emerging rapid growth in UAS numbers is dependent on our ability to share as much airspace as is possible – integration of users, not more segregation.

107. The increasing number of air vehicles, both manned and unmanned, operating in a fixed volume of airspace is likely to increase the density of operations, adding to the risk of mid-air collisions, near misses and infringements unless forward-looking mitigation is put in place ahead of the expected growth. In addition to the safety aspects of this challenge, UK airspace and its efficient and safe utilisation will be a critical enabler to economic growth in the coming years. A key factor in that aspiration and wider economic growth will be safe, effective and efficient use of UK airspace as a national asset.

108. EC solutions are considered one of the “tools of choice” to provide the integrated rather than segregated airspace that will be critical in realising these ambitions. A survey we issued to members of the General Aviation community in 2017 elicited over 1600 responses and came to some broad conclusions: that EC was deemed by 90% of respondents to provide a positive improvement to safety; and, that equipment needed to be lightweight, portable and cheap – with the majority of responders suggesting a £100 to £500 bracket to be ‘reasonable’.

109. We are not proposing an immediate general mandate to require all airspace users to be fully EC compliant. Instead we think a rolling programme of highly focused, location-specific mandates deployed over the next few years can be

used to target areas with the greatest potential to deliver benefits. Location-specific mandates can set out proportionate proposals on which air-to-air, air-to-ground and ground-to-air functions to mandate to achieve full adoption based on interoperability, performance requirements and benefits. If aircraft operators have no need to use the targeted area of airspace, there will be no requirement to equip.

110. In due course, the reality of equipage numbers may mean that at some time from a date to be determined, we would wish to declare the U.K. ‘EC only’ in entirety, thereby confirming the need for all airborne vehicles to carry compliant EC solutions i.e. a blanket mandate. This date will be influenced by the pace of adoption in targeted blocks of airspace, the availability and cost of equipment, the development of ground-based infrastructure and other technological developments.

111. Even with the more basic level of functionality, such as transmitting only, the various deployment scenarios described in this document demonstrate some of the potential benefits of the full adoption of EC solutions. ATC can use the output of transmit only solutions to offer enhanced services to pilots who can now be detected along with all other airspace users in a known environment. Through that mechanism, other transmitting aircraft benefit from EC deployment, even though they do not receive any information. Full adoption of transmit only EC solutions can create performance improvements for other stakeholders as well. For example, useful information could be extracted about traffic flows, which could be used to plan commercial operations, inform future airspace changes and a range of other activities that are not directly associated with traffic avoidance.

112. Transmit and receive functionalities offer enhancements to safety and operational efficiency in all scenarios with the most significant potential benefits in uncontrolled airspace at lower altitudes close to areas of controlled airspace. When it comes to rebroadcasting EC information, reliability, coverage and options for interoperability can be further improved by ground-

based solutions offering, and providers can combine EC information with other sources of flight information to create value-add services.

113. This call for evidence intends to refine and validate our proposed approach. As the programme progresses, attention must be given to human factors and the way that EC information is used by pilots, ATCs, UTM providers and all other involved stakeholders. The risks of possible distractions should be minimised and the real costs of full adoption of interoperable EC solutions must be well understood and carefully managed.

Glossary of terms

ADS-B	Automatic Dependent Surveillance Broadcast
ANSP	Air Navigation Service Provider
AMS	Airspace Modernisation Strategy
ATC	Air Traffic Controller
ATM	Air Traffic Management
ATS	Air Traffic Services
BVLOS	Beyond Visual Line of Sight
CAA	Civil Aviation Authority
CAS	Controlled Airspace
CAT	Commercial Air Transport
EASA	European Aviation Safety Agency
EC	Electronic Conspicuity
FAB	Functional Airspace Block
FAS	Future Airspace Strategy
GA	General Aviation
GHG	Greenhouse Gas
GNSS	Global Navigation Satellite System
ICAO	International Civil Aviation Organisation
IFR	Instrument Flight Rules
IR	Implementing Regulation
LARS	Lower Airspace Radar Service

MAC	Mid-air Collision
MET Information	Meteorological Information
MIL	Military
NATS	National Air Traffic Services
NOTAM	Notice to Airman
SES	Single European Sky
SSR	Secondary Surveillance Radar
TDD	Traffic Data Display
TMA	Terminal Manoeuvring Area
UAS	Unmanned Aerial Systems
UTM	Unmanned Traffic Management
VFR	Visual Flight Rules
VLOS	Visual Line of Sight

Annex 1: Airspace modernisation strategy

114. The Department for Transport (DfT) has set out the government's policy to modernise the UK's airspace system to accommodate the continued growth in demand for air travel, meet the future requirements of all airspace users and improve environmental performance.

115. Specifically, the Aviation Strategy highlights that inefficiencies in the current system will cause significant delays if additional airspace capacity is not introduced. Airspace inefficiencies also lead to longer journeys, poorer connectivity, restricted access, higher costs and prevent improvements being made that could help to mitigate safety and environmental risks.

116. The UK's approach to modernising the airspace is described in the CAA's Airspace Modernisation Strategy (AMS). The CAA drew up the AMS under a mandate from the government and ran a public engagement exercise on its content with industry, military and general aviation stakeholders, local communities and environmental representatives in 2018.

117. The implementation of the AMS Programme is co-sponsored by the DfT and CAA as a key part of the government's Aviation Strategy and one of the UK aviation sector's top priorities.

118. UK airspace is not being modernised in isolation. The Single European Sky (SES) initiative was established to tackle inefficient, costly and fragmented airspace across Europe. The AMS Programme aims to contribute to the implementation of SES objectives by coordinating the UK's deployment of solutions developed at a central European level through the SES ATM Research (SESAR) Programme.

119. Some early SESAR outputs have been prioritised for implementation through the SESAR Pilot Common Project (PCP) – a European Implementing Rule that mandates the introduction of several new concepts for enroute air

navigation services and the ATM operations at Europe’s 25 largest airports (including Heathrow, Gatwick, Stansted and Manchester in the UK). Many of the PCP outputs and other SESAR solutions not included in the PCP have the potential to deliver benefits across all UK airports, airspace user groups and classifications of airspace.

120. In addition, EASA (the European Aviation Safety Agency) is developing a series of Implementing Rules in the areas of Air Traffic Services, Communications, Navigation, Surveillance and the operation of unmanned aerial systems (UAS) that each create airspace modernisation requirements, challenges and opportunities for the UK industry.

121. It is assumed that the SES, SESAR and EASA drivers for airspace modernisation in the UK will remain relevant in some form post Brexit.