UK Civil Aviation Authority

C2 Link Policy Concept – Consultation Response Summary

CAP 3248

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Chapter 1

Overview

Background

1.1 There is strong industry demand for Beyond Visual Line of Sight (BVLOS) operation of Specific category unmanned aircraft systems (UAS) and certified category Remote Piloted Aircraft Systems (RPAS) within the UK. Whilst forecast estimates vary, they consistently show a large increase in the sector over the next decade.

1.2 A key enabler for BLVOS operations is sufficiently robust command and control (C2) links that can take advantage of the radio links and telecoms services that are available to best suit each operation.

1.3 This work forms part of the Future Air Traffic Management and Air Navigations (Future ATM/ANS) program within the CAA that works to deliver to the aims of the UK Government Future of Flight Industry Group.

1.4 This document summarises the review of the responses to the C2 link policy concept consultation (CAP 3154) that ran from 23 September 2025 to 9 January 2026. This consultation was in support of Specific category operations operating BVLOS assessed in SAIL 1 to 3, and that would apply using the UK SORA (UK Specific Operations Risk Assessment) process detailed in [1].

1.5 This formal consultation has been supported and will be supported with ongoing informal conversations with a variety of stakeholders and stakeholder groups.

The responses

1.6 The C2 link policy development team in the CAA is very grateful for the detailed analytical responses provided from twelve responders.

1.7 Eleven responded on behalf of their organisation, of which nine agreed to their responses to be quoted albeit anonymously and six are available for reading online.

1.8 There was a mix of respondents with different stakes in the safe operation of UAs including telecoms service providers, equipment manufacturers, UA manufacturers and operators, along with a trade body.

1.9 The respondents provided useful detailed responses, and these are considered in the following sections.

[1] AMC1 Article 11 Conducting a UK Specific Operation Risk Assessment (UK SORA)

Chapter 2

Feedback on Standards, Technical Options, and Technology for use cases

Overview

2.1 This chapter looks at the responses to the technical questions ask that were not specifically directed to the UK SORA and CAA's related proposals.

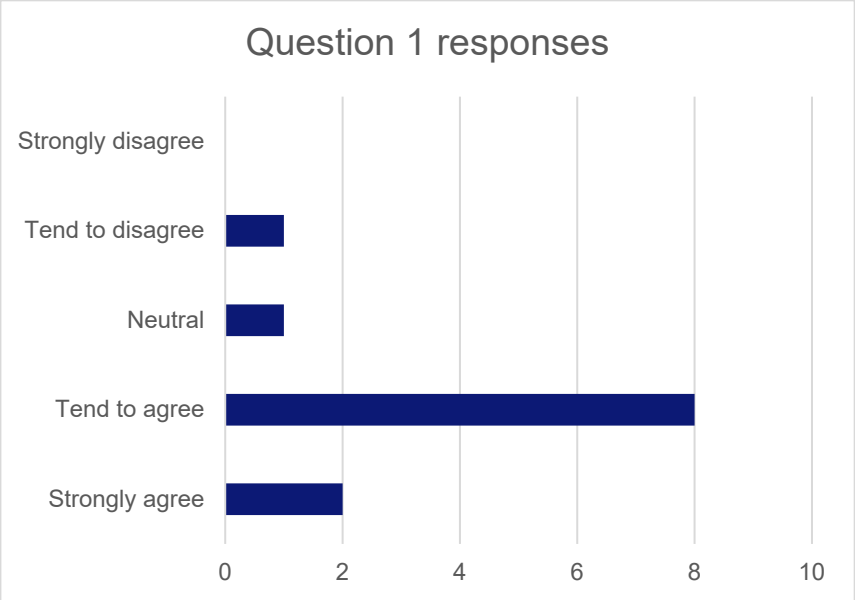
Standards and guidelines

2.2 Two questions were asked about the CAA's review of standards, and guidelines that may apply to the provision and operation of C2 Links from both aeronautical and telecoms sectors:

1. Question – How strongly do you agree with our approach to existing telecoms standards and guidelines?

2. Question – Are there any specific guidelines, standards, regulations or gaps you feel we've missed

2.3 The graph below shows the distribution of responses to question 1.



2.4 Overall there is general support for the use of existing standards including those from the telecoms sector, though several responders emphasised the need for this to be proportionate from SAIL 1 to SAIL 3. The most concerned wrote "Whilst reference to specific standards, or specific sections of standards, is supported in theory, the applicability of specific standards and their proportionality should in our opinion also be the subject of further industry consultation. Rather no standard than the wrong one."

2.5 One respondent asks for clarity that this shows clearly that this refers to "Safety-of-flight C2 data not the mission payload data links (treat C2 as safety-critical)"; this is the CAA's intent.

2.6 A number of additional standards were suggested[2]:

a) *DO-377 as an example methodology for UAS designers to define RLP parameter values based on UAS hazard/safety assessment (mostly applicable to >= SAIL 3).*

b) *DO-377 as an example methodology for UAS designers to define RLP parameter values based on UAS hazard/safety assessment (mostly applicable to >= SAIL 3). Add guidance so that UAS designers/operators may have consistent conclusions on specifying RLP values.*

c) *Some additional materials from GSMA such as; Reference Method for assessing Cellular C2 Link Performance and RF Environment Characterization for UAS - Smart Mobility, Skydio - Skydio-Statement-of-Requirements-GSMA-Fusion-2.10.25-1.pdf, MNO Drone Services Business Models - Smart Mobility.*

d) *Technical Standards Order C-213A is the FAA TSO for Unmanned Aircraft Systems Control and Non-Payload Communications [C band] Terrestrial Link System, based on RTCA/DO-362A and RTCA/DO-377A.*

e) *We suggest the ICAO AMS(R)S Technical Manual, which accompanies the AMS(R)S SARPS, be added to the table, as it provides helpful information not directly included in the SARPS themselves.*

f) *Although it is now a bit dated, the CAA may wish to reference RTCA DO-400 for work on Lost Link Procedures (chapter 5) – CAA notes that it is working on Lost C2 link procedures in parallel with this work.*

[2] Many of the responses throughout this document are *quoted largely verbatim* – please see the appendix for any undefined abbreviations.

g) *RTCA DO-278 may also provide valuable guidance for ground-based equipment supporting the C2 link where a High (H) level of robustness is required (SAIL 5 & 6 operations) – CAA notes that it will be looking at C2 links at SAIL 4 & 5 operations this year."*

2.7 We understand that the general approach in using existing standards is likely to be beneficial as long as these are applied proportionally to the SAIL and more explicit detail is needed; we will now:

a) Identify specific standards/guidelines then draft some acceptable means of compliance and guidance material (AMC and GM) for SAIL 1 to 3 referencing these specific standards, or groups of standards, or specific parts of standards based on this feedback in a proportionate for the increasing SAIL;

b) Update the list given in the appendix to the consultation when it further consults on C2 link policy concepts for SAIL 4 & 5 and lost C2 link policy concepts for SAIL 1 – 3.

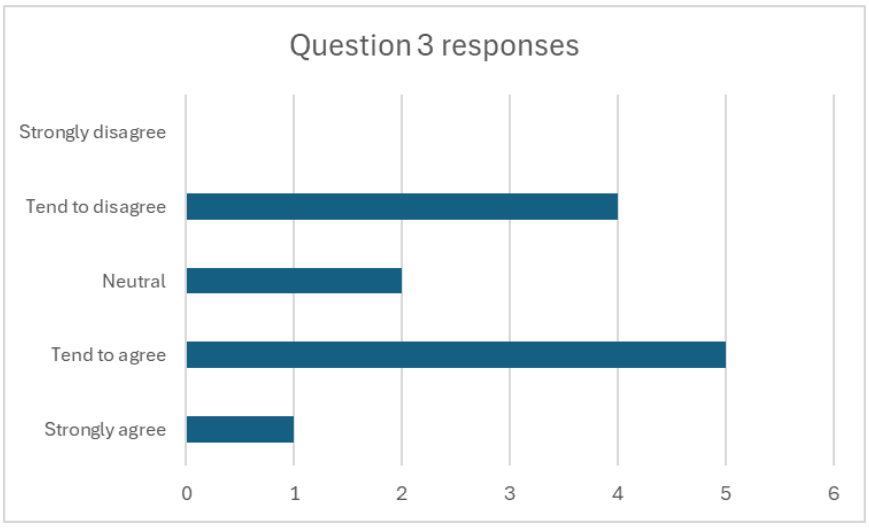
Technical Options

2.8 The Joint Authorities for Rulemaking on Unmanned Systems (or JARUS) has published a document "Required C2 Link Performance (RLP) concept" in 2016.[3] We asked two questions related to the adoption of this:

3. Question – How strongly do you agree with adopting the JARUS RLP concept?

4. Question – Is there a preferred alternative approach?

2.9 The graph below shows the distribution of responses to question 3.



[3] RPAS C2 link Required Communication Performance (C2 RCP) Concept

2.10 For context: the current UK SORA (UK Regulation (EU) 2019/947 Article 11) states in its GM.OSO6 “The Applicant should refer to International Civil Aviation Organization (ICAO) references for definitions, and to JARUS RPAS ‘Required C2 Link Performance’ (RLP) concept”.

2.11 The overall position might be summarised as there is support for the use of the JARUS RLP as a baseline performance framework, but not as a prescriptive certification regime. They expressed the need to ensure clarity, realism, and adaptability to support current and future communication technologies and differing UAS implementations; requirements should align proportionately with the UK SORA SAILs, avoiding excessive burden for low-to-medium risk operations.

2.12 One response expressed some insightful and detailed concerns which some others also hinted at:

i. *“JARUS RLP concept appears to be based heavily on ATC communications requirements and is likely to be excessive for modern day lower SAIL RPAS operations (especially in airspace where the RPAS operates without interacting with other aircraft (manned or unmanned). Rather than following the prescriptive approach in the JARUS RLP, it would be better for the RPAS designer to state the C2 requirements to safely carry out flights and then to be assessed based on satisfying those criteria.*

ii. *JARUS RLP concept assumes specialised and dedicated C2 Communications service providers which do not exist.*

iii. *When the JARUS RLP concept was published in 2016 there were four UK public mobile networks providing a combination of 2G, 3G and 4G across the country. The scenario has changed significantly in the last 9 years with 5G networks undergoing significant deployment across the country and 2G and 3G being switched off. Furthermore, the coverage and capabilities of mobile networks have improved significantly, and these networks are currently capable of supporting RPAS applications far better. In addition, there have been developments in several other standards of long-range low power wireless networks such as LTE M, NB IoT, LoRaWan, 5G Red cap; and the UK is undergoing a fixed connectivity transformation with the retiring of PSTN network and installation of pervasive fibre connectivity which has higher performance (including higher reliability). All these options of networks can be used to support C2 links – including fibre connectivity in the scenarios where the remote pilot’s control centre is connected to the wireless segment (e.g. mobile network) of the C2 link via fibre networks. Parameters associated with these networks vary depending on several factors such as contention from other users and network management strategies implemented by the service provider.*

Having strict requirements to meet RLP types might not be possible due to the varying nature of these networks and the practicalities associated with measuring the data in the intended operational environments.

iv. *The JARUS RLP concept needs to be updated to reflect current RPAS designs and candidate C3 network characteristics.*"

2.13 They also raised an issue regarding the scope of OSO6:

a) "*Our understanding is that OSO6 must assess C3 links which include all communications links required for the safety of flight and goes beyond the C2 link (e.g. GNSS and ADS B links). There appears to be inconsistent definitions between the policy document and consultation document which leads to ambiguity on the C2 and C3 link as this consultation excludes links other than the C2 link. Consistency of the definition along with a holistic approach towards OSO6 (instead of just C2 link) would be helpful.*

b) *There are BVLOS operations using automatic UAS that fly automatically to a defined flight path using other communication links other than C2 and ATC (e.g. GNSS and ADS-B). Does it make sense for OSO6 to assess the performance of these links along with the C2 and ATC? Otherwise, where is the adequacy of these links assessed? It would be more practical for these links to be assessed under OSO6.*"

2.14 We confirm that, in line with organisations such as ICAO and European Union Aviation Safety Agency (EASA) amongst others, the C2 link carries the Control and Non-Payload Communications (CNPC) data between the unmanned aircraft (UA) and the command unit (CU). The policy and requirements related to GNSS and ADS-B connectivity are defined elsewhere and may ultimately lead to AMC and GM perhaps under UK SORA, but that work is out of scope of this C2 Link consultation and review process. We do understand the need for proportionality which can and will vary significantly depending on how the UAS is implemented, its capabilities and the operational volume being considered. Aspects of this will be considered in the Lost C2 link policy concept that is being developed and is planned to be consulted on later this year.

2.15 No specific alternative was suggested other than one respondent mentioned that DO-377 provides some additional clarification on some terms, and another emphasised the need to keep things appropriately simple to allow innovation.

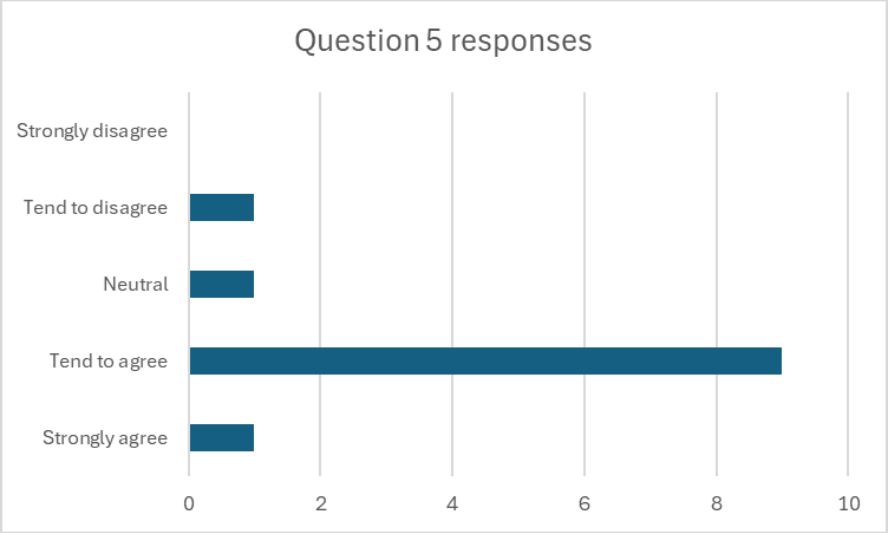
2.16 We will update the UK SORA GM referring to JARUS RLP to clarify this should be considered as a framework and applied proportionately to the SAIL, noting the UAS capabilities.

2.17 Two further questions were are asked about the CAAs observations when comparing C2 Link radio technologies; these questions were:

5. Question – How strongly do you agree with summary assessment of different C2 Link radio technologies for SAIL 1–3 operations?

6. Question – Which technologies (if any) do you feel have been inaccurately characterised or omitted, and why?

2.18 The graph below shows the distribution of responses to question 5.



2.19 The feedback is that the assessment is reasonable but with a number of caveats. One repeated comment is that this assessment reflects reasonably well today's situation, but the terrestrial and satellite telecoms markets are undergoing constant and often rapid changes. Another feedback is that this table under-assesses the more complex C2 links with multiple connections. Some asked about the absence of 5G in the table.

2.20 The one respondent who replied "tend to disagree" was concerned about supporting air traffic communications given the stringent requirements. We will look at this in the future when we consider beyond visual line-of-sight (BVLOS) operations in more complex airspace where ATC may be required.

2.21 We did not include 5G for this first iteration due to the limited geographic coverage compared with 4G (especially for the full 5G standalone capabilities) and the unavailability of any UAS specific 5G service at the time of writing. We will review the feedback in detail and update the table whilst extending it to cover in addition SAIL 4 and 5; whilst adding clarity on terminology. This may be published in a future consultation on the C2 link concept and would add some review of hybrid connections (e.g. cellular as the primary connection and a satellite link as the alternate) with some discussion on aspects such as capacity and latency.

2.22 This analysis is unlikely to be included as AMC/GM under UK SORA as this will continue to follow a technology neutral approach that allows the operators to apply based on their risk assessment.

Technology for use cases

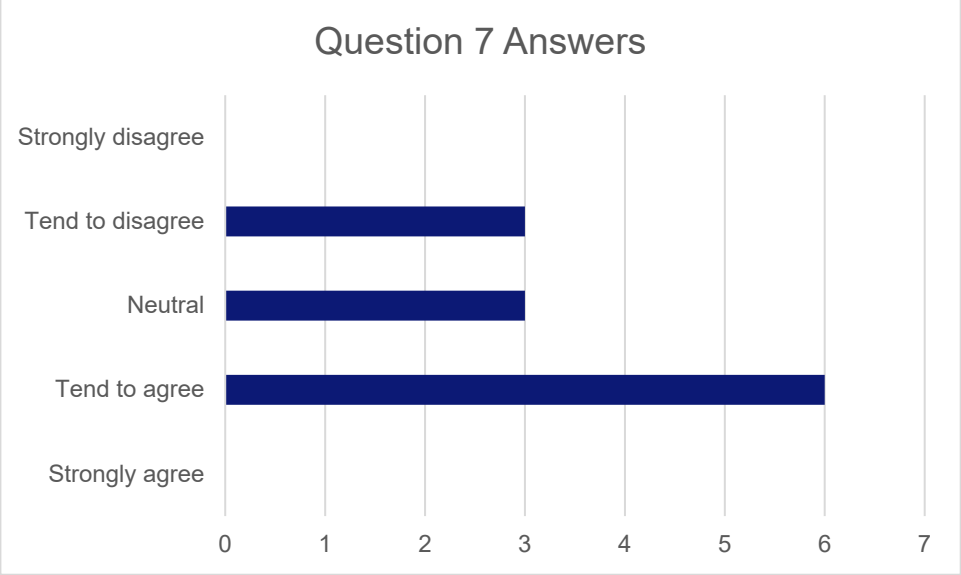
2.23 In the consultation we summarised an indicative review of radio connection technologies for each of the partial use cases the viability and scalability findings for each technical solution for the radio connection part of the C2 Link which was shown in the consultation as Table 2. This table is not intended to be prescriptive; it has been included to provide a guide as to which kind of solution is potentially an appropriate fit.

2.24 Two questions were asked about this review:

7. Question – How strongly do you agree with summary the analysis of these partial use cases is provided?

8. Question – Are there other technologies (e.g. LDACS - L-band Digital Aeronautical Communications System) or communication services you would like us to consider to ensure that this policy concept is practical?

2.25 The graph below shows the distribution of responses to question 7.



2.26 There are a lot of significant detailed critiques raised by these questions and we are grateful for these.

2.27 In general the following points were common across multiple responders:

a) The use of partial use cases to explore options was useful but needs real clarity that these are non-prescriptive.

b) The table does not explicitly address coverage limitations.

2.28 The following significant points were also raised by individual responders, including:

a) The concern that terms such "emergency connection", "probably" and "possibly" are not defined.

b) Mention that not all IoT protocols allow mobility.

c) The C2CSP concept was not mentioned or considered.

d) Aircraft designed for higher SAIL use may be deployed for low SAIL use

e) *Change the MSS for SAIL 2 & 3 to be a bit more encompassing "MSS L-band satellite providers' applicability: SAIL I: Unlikely to be a good fit, SAIL II: May be viable for primary or secondary for very remote and offshore operation, SAIL III: May be viable for primary or secondary*.

2.29 A number of other technologies were mentioned that could be included such as:

a) Other Low Power WAN technologies such as NB IoT, LTE M, SigFox, etc.

b) Aviation-protected LOS digital comms options.

c) Satellite augmentation of terrestrial [cellular] services using non-terrestrial networks (NTN).

d) More analysis on 5G especially 5G standalone capabilities as coverage increases.

e) Emphasis on technology neutrality in the regulations to allow the use other technologies and services if as and when they become available.

2.30 We will update our understanding of this complex trade-off space and further refine this analysis. We may provide an updated version of this in a future C2 link concept policy consultation

Chapter 3

Feedback on C2 link proposals for UK SORA

Overview

3.1 The UK SORA defines a process to determine the SAIL (Specific Assurance and Integrity Level) and this defines the level of robustness needed for the relevant OSOs. We identified some proposals related to OSO 6 and OSO 13 in the policy concept consultation.

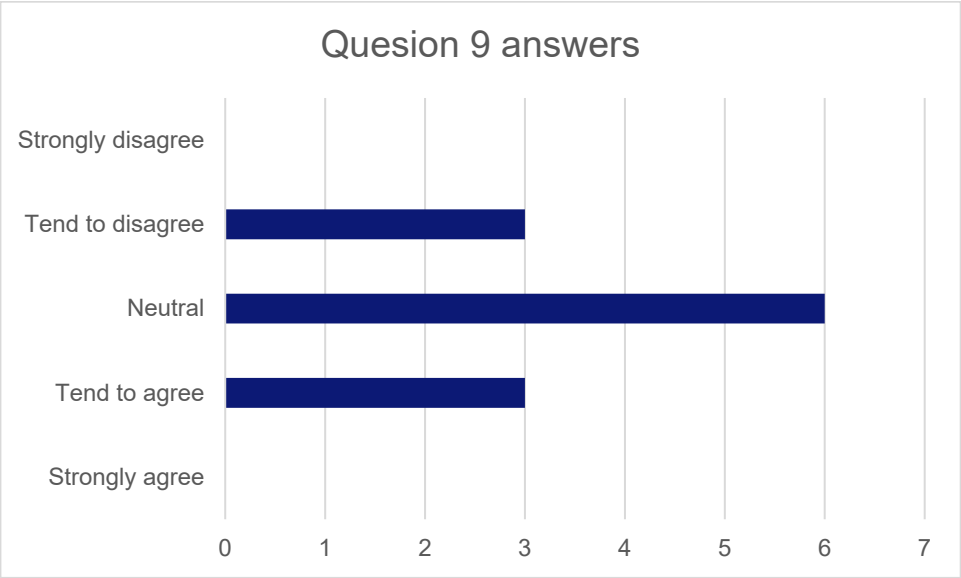
OSO6

3.2 In the policy concept consultation we identified three proposals related to UK SORA OSO6 “C3 Link performance is appropriate for the operation” and asked the following questions:

9. Question – How strongly do you agree with proposals related to OSO6 for SAIL 1 to SAIL 3?

10. Question – What other evidence or mitigations do you believe would be acceptable to demonstrate OSO6 compliance for SAIL 1 to 3?

3.3 The graph below shows the distribution of responses to question 9:



3.4 Several replies correctly identified a typo in paragraph 6.3 of the consultation where “**SAIL 2:** No defined robustness” should have read “**SAIL 1:** No defined robustness”.

Proposal 1.1

3.5 Regarding proposal 1.1 – Use of TCP/IP…: Most responders were reasonably happy with this proposal though a couple noted that in some circumstances the use UDP/IP or proprietary protocols might be preferable, perhaps with application-based integrity checking. There was a comment that the level of integrity needed depends on the UAS design, for example how well the DAA performed when in the Lost C2 link state. Another comment was that EASA's means of compliance (MOC, as per Proposal 1.3.) requires "*Where integrity equivalent to that provided by a CRC32 with Ethernet standard polynomial or solution with equivalent robustness is sufficient*".

3.6 This feedback reflects our intent that the integrity needed is dependent on the UAS implementation and that there are different ways to achieve this integrity. EASA's MOC provides a good baseline, and the use of TCP/IP is inherently sufficient for SAIL 1 to 3 use. AMC/GM for OSO 6 in UK SORA will be drafted on this basis.

Proposal 1.2

3.7 Regarding proposal 1.2 – A periodic log should be maintained…: Most responders who commented specifically on this agreed with this proposal. One suggested that some additional guidance as to what is logged might be useful and a second felt that "*mandat*[ing] *periodic logs of every active C2 connection and its status* [would] *be unnecessarily prescriptive and disproportionate*". There was a suggestion that service provider data may be sufficient performance records.

3.8 We would note that there is a third-party report created by industry that provides some suggestions on the sort of data that should be logged: specifically the Aerial Connectivity Joint Activity (ACJA) provides[4] a document entitled "reference method for assessing cellular C2 Link performance and RF environment characterization for UAS".

4 https://gutma.org/acja/publications/#:~:text=Reference%20Method%20for%20assessing%20Cellular,%2C%20regulators%2C%20and%20other%20stakeholders.

3.9 We recognise the need to avoid prescription and that regulations should be proportionate. AMC and/or GM will be drafted to reflect that C2 link periodic log files should be recorded appropriate for the complexity of the operation reflected in the SAIL, the development state of the UAS, and the C2 link implementation. This log file should be described in the operators' concepts of operation. This will also clarify that the use of service provider performance data may be sufficient, but the UAS operator needs to ensure all the requisite information is recorded to determine the link met the design requirements (for example latency, integrity, availability, and continuity).

Proposal 1.3

3.10 Regarding Proposal 1.3 – EASA's means of compliance…: There was a general agreement with caveats such as these specific points raised:

a) One responder asked for "*Greater recognition of [the situational awareness capabilities of modern mode aircraft] capabilities, and a pathway for standardised short-range BVLOS operations outside of full SORA/SAIL, would better align OSO6 with current technology and real-world operational practice*".

b) Another asked why "*OSO6 has LI for SAIL 2 and 3, whilst it only has an LA for SAIL 3, resulting in SAIL 2 not having any assurance. Can the CAA confirm that no assurance is require for SAIL 1 and 2?*".

c) Whilst another supports the recognition of EASA's SAIL 3 MoC for OSO 6 as one acceptable means of compliance, whilst they advocate for granting applicants the flexibility to determine suitable performance metrics / parameters and thresholds, provided these demonstrably achieve a positive safety outcome that aligns with both the ConOps – including the level of automation – and the SAIL.

d) There were number of detailed concerns relating to latency in support of ATC if carried over the C2 link, and the limitations of proving long-term performance from short test flights.

e) Finally one asked "*how this applies when multiple connections are used to achieve continuity, for example how can they demonstrate link redundancy and/or fail over. Demonstrate both links are operational, and entirety of test doesn't just rely on single link. Additionally, signal quality of both links and which link(s) are active should be logged and included in post-test analysis*".

3.11 As with proposal 1.2, for proposal 1.3 we recognise the need to avoid prescription and that regulations should be proportionate. We can confirm that no assurance is currently required for OSO6 SAIL 1 and 2. The updated AMC/GM for OSO6 will be clear that EASA MOC is one acceptable means of compliance.

3.12 We will consider also how this allows for different UAS implementations with varying levels of autonomous operation under lost C2 link conditions. This may need further work before any AMC/GM can be drafted in this respect.

3.13 We consider the need to carry ATC voice in SAIL 1-3 operations to be low so such applications will be considered on a case-by-case basis for now. We will be looking at this in more detail as we consider higher SAIL operations.

Other feedback related to OSO 6

3.14 An additional clarification response was provided for online under question 10 that asked "*What other evidence or mitigations do you believe would be acceptable to demonstrate OSO6 compliance for SAIL 1 to SAIL 3? - What other evidence or mitigations do you believe would be acceptable to demonstrate OSO6 compliance for SAIL 1 to 3?*". Some insightful responses were provided including:

a) *"For SAIL 1 to SAIL 3 operations, OSO6 compliance could be acceptably demonstrated through a combination of operational evidence, system capability, and proportionate procedural mitigations rather than formalised SORA-based analysis in all cases.*

b) *We propose guidance is added for OSO6.L.I that makes clear what the applicant is expected to provide? For example:*
   1. *Definition of links required to safely conduct the intended operation.*
   2. *Performance requirements of these links to safely conduct the intended operation.*
   3. *Evidence as to how these performance requirements confirm the operation can be conducted safely as intended.*
   4. *Architecture of all the C3 links and how they interface with other systems on the UAV.*
   5. *Evidence of radio licences obtained from Ofcom where necessary*

c) One felt that "*It is imperative to have proportionality for SAIL I and II. i.e. only the basic information to be provided up to SAIL II (no test data, in-depth system description, etc.)*"

d) *Is there a requirement for CE/UKCA markings on the radio equipment to be used, along with whether radio equipment with FCC marking/acceptance will be acceptable instead of CE/UKCA marked equipment?*

e) *If voice communications with ATC over the C2 link is required, this should be demonstrated along with C2 data. To avoid disruption to ATC, a VHF test frequency may be used with a test operator to represent ATC*.

f) A responder considers *"that a statistical or analytical assessment demonstrating that the C2 link is sufficient for the intended use case and operating environment,*

accounting for the degree of mitigation available for temporary or permanent link loss, should also be accepted as a valid means of compliance."

g) A responder noted that "*the suitability of a C2 system depends very strongly on the capability of the system to deal with individual C2 link failures, not only on the individual C2 link capability*".

h) For example assuming that we know we need a certain amount of bandwidth and latency in the C2 system and that we're using a system with multiple 4G modems. How can any company know in advance what the performance of the 4G network in any given flight path is going to be prior to actually flying it. The information available from the networks itself is not sufficient for an operator to figure this out, and it's even doubtful whether any of the network operators themselves would be able to provide the answer.

It follows from this that a C2 link does not need to guarantee any predefined level of performance as long as the C2 system as a whole can deal with it and guarantee the required level of performance at a system level.

This means that for an operator it is also crucial that any requirements put on the physical C2 link itself are not taken in isolation but very tightly linked to the behaviour of the system when using multiple redundant links and in the event of C2 loss i.e. the note in Chapter 5 Lost Link, has to be an intrinsic part of the evaluation as this should reduce and or relax the required performance level of the C2 links used."

3.15 We recognise that BVLOS UAS is an emerging sector and that not everything is clear. We plan to consult on the policy concept for Lost C2 link for SAIL 1-3 later this year that will in turn inform additional draft UK SORA AMC/GM. These will recognise proportionality as the SAIL increases from 1 to 3.

3.16 We also recognise the optimum way to analyse and complete the risk assessment related to C2 links and Lost C2link may not clear to everyone – we aim to work with industry and build experience to optimise this whilst maintaining adequate safety levels as the sector grows in scale. This also applies to the predicted MNO connection performance along the flight path. We would encourage UAS operators to discuss this the cellular operators (MNOs) as they do have some tools to help and will also benefit from real flight experience to refine these tools.

Feedback related to wider UK SORA

3.17 One additional point was raised by more than one respondent that is not directly related to our proposals but does provide good feedback when the UK SORA assurance levels related to OSO6 and OSO 13 is next reviewed:

a) *"Referring to Table 13 – Operational Safety Objectives (OSO) of the [UK SORA] policy document (page 78); there is inconsistency with the robustness levels required for C2 links depending on the SAIL number. Is this intention? With both OSO6 and OSO13 assessing for the adequacy of the C3 communication; It might be worth having OSO6 consistent with OSO13 as otherwise, there could be SAIL 1, 3 and 4 applications that are assessed differently depending on how they achieve their C2 and C3 links. E.g. A SAIL 1 UAS achieving its C3 link using a point-to-point radio link will not have any OSO6 assessment whilst a SAIL 1 UAS achieving its C3 links via external services (such as a mobile network combined with GNSS and fixed/fibre connectivity) will be assessed as per OSO13.L.I and OSO13.L.A. A similar situation arises with SAIL 3 and 4 applications*."

3.18 Whilst this is a wider point than was anticipated in this consultation, we recognise this is relevant therefore the C2 link team within the CAA will communicate this with the wider CAA regarding UK SORA, OSOs, and Robustness. We would note that this is derived from the international work at JARUS that led to its SORA 2.5 being issued.

3.19 Another raised this concern:

a) "*It would be beneficial to have further clarity on the boundary between OSO6 and OSO13. For example, does OSO13 assess the performance of the external service providers is ensured for the C3 link performance requirements for safe operations as established by OSO6 (via an SLA perhaps)? Currently there is a lack of clarity on the assessments carried out under OSO6 and OSO13 when an external service provider (such as a mobile network operator connected via a fixed operator) is used to achieve the C3 link*."

3.20 We recognise there could be some ambiguity between where and when to apply OSO6 and OSO13 when considering all aspects of C2 links and we will seek to add clarity in the future AMC/GM.

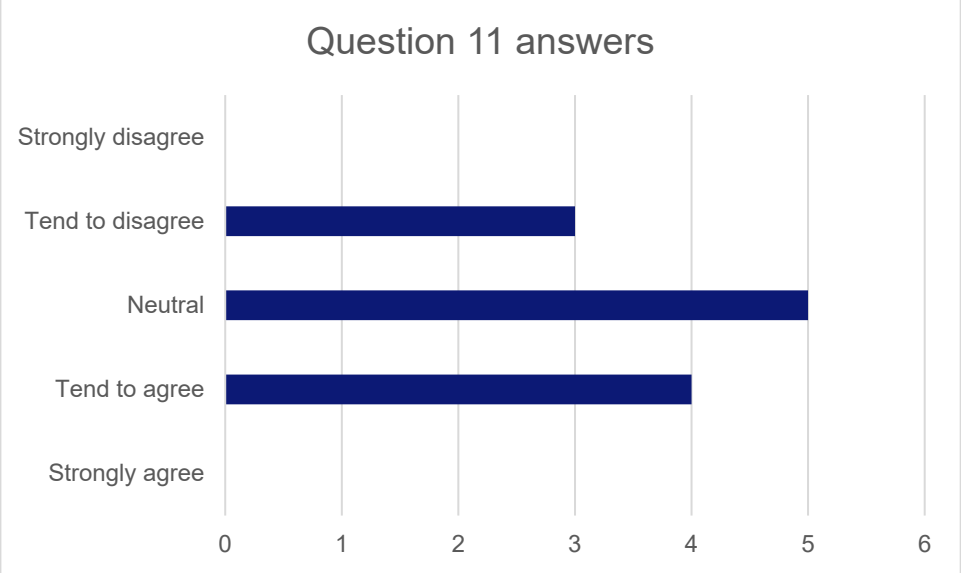
OSO13

3.21 In the policy concept consultation we identified six proposals related to UK SORA OSO13 “External services supporting UAS operations are adequate to the operation” and asked the following questions:

11. Question – How strongly do you agree with proposals related to OSO13 and C2 links for SAIL 1 to SAIL 3?

12. Question – What other evidence or mitigations do you believe would be acceptable to demonstrate OSO13 compliance for and C2 links for SAIL 1 to SAIL 3?

3.22 The graph below shows the distribution of responses to question 11:



3.23 The comments provided suggest that the proposals are generally reasonable as long as they are applied in a performance-based, proportionate (to both SAIL and UA autonomy) and technology neutral fashion.

3.24 There were some requests for clarification of which C2 link aspects best fit within OSO6 and OSO13. Similarly questions were asked why the robustness levels were different between these two OSOs at SAIL 1 and SAIL 3.

Proposal 1.4

3.25 Regarding Proposal 1.4 – Where the data is routed via the Internet…: there were a couple of specific comments:

a) One respondent wrote “*could be overkill for SAIL 1 & 2*”.

b) The other wrote “*encryption requirements should also apply to RLoS links using a networked backhaul*”.

c) Another mentioned that "*4G/5G services can be provided such that the data is kept separate from the Internet*".

3.26 We feel that some basic cyber-security is reasonable when connecting the UA to the CU over the Internet and modern hardware should allow for this; noting that not all 4G (and in future 5G) services need to connect via the Internet. We expect that AMC/GM will be added to OSO13 regarding this, noting that this may be combined with feedback from CAP3098[5].

3.27 We agree this should reasonably apply also to RLoS links where they use an Internet backhaul noting that this is out of scope of this consultation which was about BVLOS operation in specific category under UK SORA.

Proposal 1.5

3.28 Regarding Proposal 1.5 – The primary ISP connection…: Only two comments were made, the first wondering "*if this restricts competition*" and the second wanting confirmation "*that the UAS operator was responsible for defining the SLA needed*".

3.29 We recognise this might be disproportionate for SAIL 1 applications. We will draft AMC/GM on this reflecting a performance-based, proportionate and technology neutral fashion.

Proposal 1.6

3.30 Regarding Proposal 1.6 – Where the CU is connected to the Internet…: There were two detailed responses:

a) *UK's national cyber security centre guidance is quite broad. Recommend setting some additional minimum requirements alongside this, similar to DO-377. Such as: peer entity authentication, data origin authentication, data integrity and anti-replay protection, confidentiality protection.*

b) *That the UK NCSC's advice [should] be implemented as Guidance Material (GM) to ensure proportionality, given its broad and diverse scope. Such guidance would offer reference information and promote sound cybersecurity practices appropriate for a Low (L) level of robustness (SAIL 1 & 2). With greater clarity on how to interpret and apply the relevant UK NCSC guidance, this proposal could then be refined and adopted as an Acceptable Means of Compliance (AMC) for a Medium (M) level of robustness (SAIL 3)*.

5 CAP3098: Guidance on Cyber Safety Objectives for Specific Category Operations | UK Civil Aviation Authority

3.31 We recognise that cyber-security is a wide-ranging and ongoing issue for all data including C2 links. As such this area is undergoing reviews with experts within and outside the CAA. We will draft AMC/GM on this reflecting a performance-based, proportionate and technology neutral fashion that may need to be updated from time-to-time as the UAS capabilities and the cyberthreats evolve.

Proposal 1.7

3.32 Regarding Proposal 1.7 – The use of 4G (and 5G) services should be limited in altitude…: Four comments were provided that we are grateful for:

a) [The 100m AGL limit] "*appears restrictive and not progressive. The UK's major cities have building/skyscrapers taller than 120 m with more to be anticipated. This questions potential height restrictions of not using 4G/5G beyond approximately 120 m AGL. Especially as:*

1. *It is likely for tall buildings to have rooftop antennas*
2. *Mobile networks are likely to configure their networks to provide service to the higher floors of such buildings*
3. *Using UAS to survey these rooftops is likely to be a future (if no current) use case.*

b) *Proposal 1.7 does not consider the possibility of using a 3rd party private 4G/5G network which could be deployed with features that could provide more support towards RPAS operations in comparison to a public 4G/5G network. It might be worth stating that these proposals only apply when using public 4G/5G and not if a private 4G/5G is used.*

c) *Signal quality and latency should be logged. Latency spikes and packet loss due to a dynamic airborne environment (e.g. coverage gaps) should be considered.*

d) *Disagree. What is the research behind 400 feet being chosen. It is arbitrary and, in this context, has clearly been chosen to match the current accepted ceiling for most UAS operations. Is that appropriate?"*

3.33 We defined 400 feet (120m) agl as an initial limit for 4G (and 5G) services for C2 links based on studies produced by organisations such as 3GPP and conversations with the telecoms sector that suggest that operations via public cellular networks at higher altitudes that are optimised for ground level use can lead to reduced performance on the link, increased inter-cell switching leading to increased latency, and increased inter-cell interference on the same network (that is if the UA is connected to MNO 1 then the interference is on MNO 1's network and not to other MNOs) as the number of UA increases. Our position remains therefore for public networks this initial altitude limit is appropriate and will be reflected in the resulting draft AMC/GM with the following caveats that will be included:

a) As the interference only impacts on the MNO, the MNO may allow operation at higher altitudes at their discretion and UA operator needs to understand the risks to signal degradation and latency increases.

b) This only applies to public 4G and 5G networks, C2 links via private 4G/5G networks will need to be considered on a case-by-case basis as these networks are not necessarily optimised for ground level use.

c) We state publicly in the drone code "Less common flying (points 37 to 39 – see [6])" that "If the person or organisation responsible for a very tall structure over 105m asks you to carry out a task related to their structure, you're allowed to fly higher than 120m (400ft). For example, if they ask you to take pictures for a survey. You must never fly more than 15m above the structure. Your drone or model aircraft must be within 50m of the structure horizontally when flying over 120m (400ft)."

d) As real world experience grows, and as the telecoms and UAS sectors gain more experience, then this initial limit may be relaxed.

Proposal 1.8

3.34 Regarding proposal 1.8 – Where 4G/5G services are being considered the use of UAS specific SIMs and service plans…: The following comments were made:

a) "*Proposal 1.8 does not consider the possibility of using a 3rd party private 4G/5G network which could be deployed with features that could provide more support towards RPAS operations in comparison to a public 4G/5G network. It might be worth stating that these proposals only apply when using public 4G/5G and not if a private 4G/5G is used.*

b) Signal quality and latency should be logged. Latency spikes and packet loss due to a dynamic airborne environment (e.g. aircraft banking) should be considered.

c) [Responder] strongly recommends that the requirement specify that 4G/5G SIMs and service plans must be compatible for use by UAS, rather than specific to UAS. Additionally, the proposed requirement for continuous signal-quality logging is considered unnecessarily prescriptive and disproportionate. As noted in our previous response, a performance-based approach would be more suitable, requiring operators to implement mechanisms or procedures to verify that the 4G/5G service characteristics meet defined operational thresholds for a positive outcome, taking into account the ConOps, including the level of automation involved.

d) *Agree (we would do this [logging] as a matter of course as a continuous check)"*.

[6] Less common flying (points 37 to 39) | UK Civil Aviation Authority

3.35 We note this feedback with thanks and will draft AMC/GM noting that:

a) 4G/5G SIMs and service plans must be compatible and appropriate for use by UAS and UAS specific SIMs and service plans are one good way to achieve this.

b) The use of private 4G/5G networks may also be a good way to do this though these need to be evaluated on a case-by-case basis by the UAS operator.

c) Logging of the C2 link performance should be made in a manner defined in the UAS operator conops suitable for the UAS capabilities, the C2 link implementation, and the SAIL.

Proposal 1.9

3.36 Regarding proposal 1.9 – Where satellite services are being considered…: Only one comment was made "*comment; rather than mandating UAS-specific service plans, the requirement should ensure that selected service plans are suitable for UAS operations*".

3.37 We recognise that the satellite sector is undergoing major changes with new services and capabilities being delivered by the ever-increasing number of satellites in orbit. We will derive AMC/GM based on suitability of the service for the UAS operation for SAIL 1-3; noting that SAIL applications at SAIL 4 or higher may mandate at least one satellite link using an UAS specific service plans.

Other feedback related to OSO 13

3.38 An additional clarification response was provided for online under question 12 that asked "*What other evidence or mitigations do you believe would be acceptable to demonstrate OSO13 compliance for SAIL 1 to SAIL 3? - What other evidence or mitigations do you believe would be acceptable to demonstrate OSO13 compliance for SAIL 1 to 3?*". Many insightful responses were provided including:

a) "*For SAIL 1 to SAIL 3 operations, OSO13 compliance could be demonstrated through proportionate operational and procedural measures rather than prescriptive external service assurance in all cases*.

b) Acceptable evidence or mitigations could include:

- *Clear identification of whether external services are safety-critical to the operation, with reduced assurance requirements where they are not.*
- *Documented contingency procedures demonstrating that safe flight can be maintained or safely terminated following degradation or loss of an external service.*
- *Evidence of onboard automation and fail-safe behaviours that reduce reliance on continuous external connectivity.*
- *Operational limitations on range, altitude, and operating area appropriate to the use case.*

- *Pre-flight checks confirming service availability where external connectivity is used, rather than ongoing formal service-level guarantees.*
- *Pilot training and operating procedures addressing loss or degradation of external services.*
- *Evidence of previous safe operational use of the same or similar systems*.

c) *These measures would allow operators to demonstrate that external services are adequate to support the operation without requiring extensive contractual or technical assurance that may be disproportionate for low-risk or short-range BVLOS operations.*
- *Evidence of written approval from MNOs if a mobile network is used*
- *Radio coverage maps of the operational area where this is possible, or justifications showing the capability to maintain adequate communications between the RPAS and CU. Especially when using an external service such as a mobile network.*

d) *It would be good to denote that the logs should be shared with the MNO / C2CSP for them to proactively monitor compliance*.

e) *Could add something in here about service schedule of networks, they must provide the operator with notification of any planned maintenance*.

f) *Could add something about predictive coverage tools to assess how coverage is expected to perform ahead of each flight or at the start of each day etc*.

g) *MVNOs: Proposal 1.8 negates the redundancy benefits of [using services from] MVNOs that can roam across multiple LTE* [4G] *MNOs*.

h) *None of the OSO 13 proposals take account of combining multiple datalinks. Combined datalinks enable operations that can fly through areas where one datalink may suffer poor performance (or even fail) because the one of the other datalinks remains operational. This could be MVNOs that allow roaming between MNOs, or combinations of cellular, SATCOM and say C-Band*.

i) [A responder] *believes OSO13 compliance can be demonstrated through a combination of contractual and operational measures, i.e. service level agreements with external system providers.*

j) *In the case of multiple data links and/or networks used for C2, consider logging not just signal quality but end-to-end communication performance (packet loss, latency, packet corruption)*.

3.39 When we reviewed these in detail, we feel they underscore the complexities surrounding how best to regulate C2 links given the breadth of different C2 link technologies and solutions, the UAS, its operating environment, and so on.

3.40 We recognise that using an MVNO eSIM as the alternate connection to allow roaming if the primary connection fails and that this might not need the same levels or robustness as the primary connection for SAIL 1 to 3 applications. We also acknowledge the benefits to the industry of sharing the log files with MNO.

3.41 When we draft the AMC/GM based on the proposals 1.4 to 1.9 we will make it clearer that they do apply to multi-connection C2 links, offering differentiation between when the connection is the primary or alternate connection when appropriate, and including mention of logging end-to-end communication performance; all in a performance-based proportionate fashion allowing for differing approaches, for example mitigating the demands on the C2 link through aircraft autonomy and/or process.

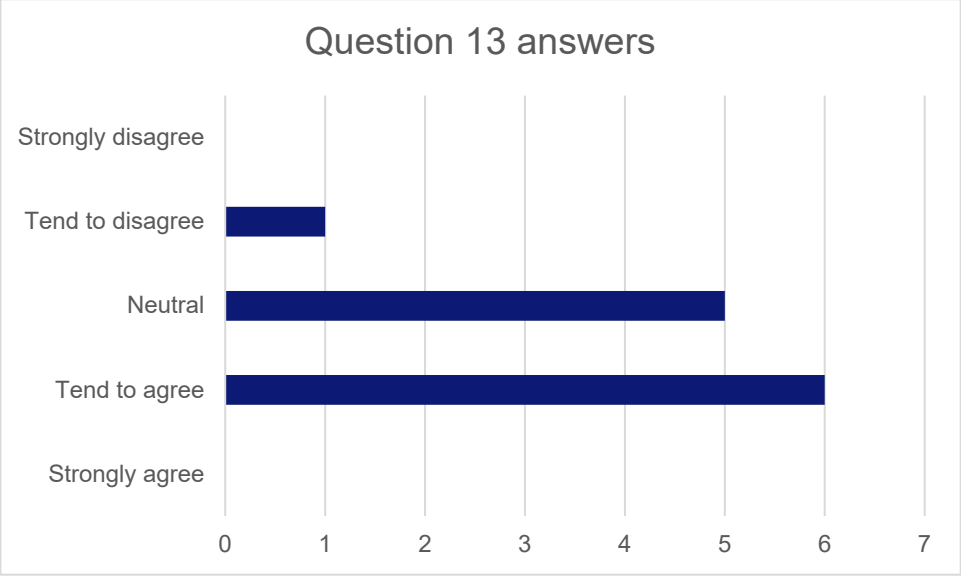
Other OSOs

3.42 In the consultation we identified possible C2 link aspects relating to other UK SORA OSOs and asked the following:

13. Question – How strongly do you agree with there being no specific proposals related to these OSOs?

14. Question – What suggestions do you have for proposals to demonstrate compliance against these OSOs for the C2 links and SAIL 1 to 3?

3.43 The flowing graph shows the distribution of responses to question 13:



3.44 The written responses were generally supportive. The only details being that two noted that Lost C2 link policy concept that is to be published later may result proposals in some of these OSOs, one suggesting OSO5 and 19 might be appropriate, adding "*Consider DO-400 for defining predictable, known, lost link procedures. Depending on class of aircraft and if transponder is equipped for squawk 7400 in case of lost link*".

3.45 We plan to publish our lost C2 link policy concept later this year.

3.46 There was a follow-up question that asked:

What suggestions do you have for proposals to demonstrate compliance against these OSOs for the C2 links and SAIL 1 to SAIL 3?

3.47 The following responses were given:

a) "*For SAIL 1 to SAIL 3 operations, compliance against the relevant OSOs could be demonstrated through a standardised, outcome-based approach rather than additional prescriptive proposals.*

This could include allowing operators to demonstrate compliance through a combination of:

- *Defined operational limitations appropriate to the use case, such as range, altitude, speed, and operating environment*
- *Demonstration of modern onboard UAS capabilities, including obstacle sensing and avoidance, live visual and positional awareness, and automated contingency behaviours*
- *Documented operating procedures and pilot training covering normal, abnormal, and lost-link scenarios*
- *Evidence of pre-flight planning and in-flight monitoring appropriate to the level of risk*
- *Use of proportionate operational risk assessments rather than bespoke SORA submissions for low-risk or short-range BVLOS operations*

b) *Providing a clear pathway for standardised compliance would help ensure that C2 link and OSO requirements are met consistently, while reducing unnecessary administrative burden and better reflecting current UAS technology and real-world operating practices*.

c) *It would be prudent for OSO16 to have considerations towards the C2 or C3 link as multiple crew could use it to monitor and/or control the UAS*.

d) *Connectivity hardware certified by the service provider*?

e) OS*O9 there may be some training components but again could be overkill*?

f) *These OSOs do a poor job of recognising the distinction between a wholly OEM factory manufactured UAV and a purchased UAV where the operator has to integrate the C2 technology. These two scenarios call on very different skillsets. In the first case the operator is truly that – just an operator. In the second case the operator also needs technical design and integration capabilities*.

g) *OSO 7 says "Automatic failover, if implemented, between redundant C2 Link connections needs to be checked." Scenarios where automatic failover is provided via a built-in Link Executive Manager versus one where a homegrown automatic failover system is designed and implemented by the operator need to be called out and addressed in the proposals.*"

h) *It is imperative to have proportionality for SAIL 1 and 2. i.e. only the basic information to be provided up to SAIL 2 (no test data, in-depth system description, etc.)*."

3.48 We are grateful for these suggestions which will help future work on these other OSOs related to C2 link aspects. We have ongoing discussions with contacts within the telecoms, UAS, and aviation sectors and we will seek to include conversations with the respondents on this feedback.

Chapter 4

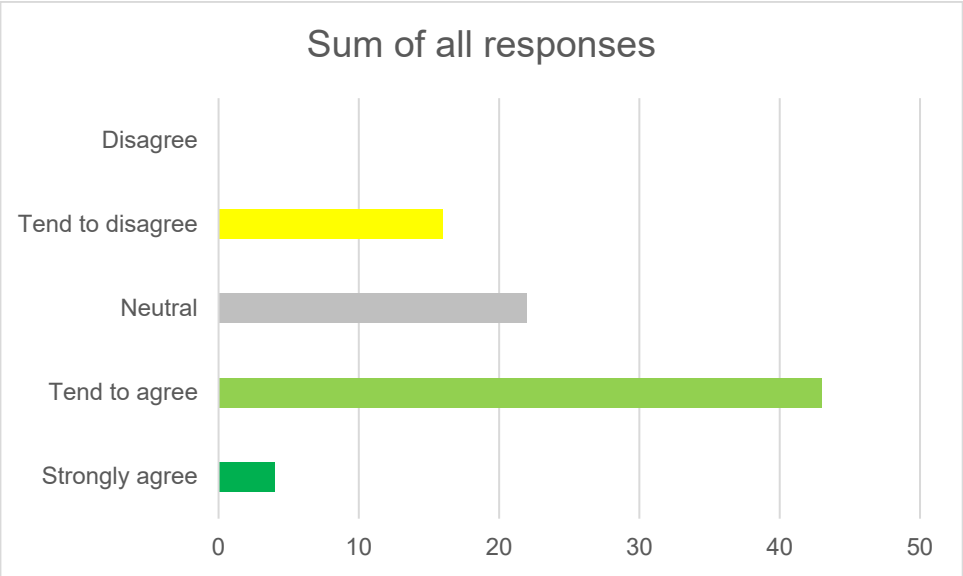
Summary and conclusions

Summary

4.1 The twelve detailed responses represented a good cross-section of the stakeholders including a satellite service provider, an MNO, various others including some UAS operators and manufactures.

4.2 In general the responses were reasonably supportive about the general direction being taken but the need to maintain flexibility and proportionality was a common theme.

4.3 The graph below shows the overall distribution of responses.



4.4 The C2 link team at the CAA really appreciate all the responses and the time taken to compile these.

Conclusions

4.5 We will act on the feedback with an immediate focus on getting draft AMC/GM into updated UK SORA within UAS regulation (UK Regulation (EU) 2019/947) relating to SAIL 1 to 3.

4.6 The table below shows the major actions relating to drafting AMC/GM related to C2 links under UK SORA OSO6 and OSO13. In this we recognise the need to avoid prescription and that means of compliance should be proportionate.

Table 1: Summary of major actions for drafting AMC/GM for UK SORA SAIL 1 to 3

Section	OSO	Summary of action
2.7	6 and 13	We will identify specific standards/guidelines in draft some acceptable means of compliance and guidance material (AMC and GM) for SAIL 1 to 3 referencing these specific standards, or groups of standards, or specific parts of standards based on this feedback in a proportionate for the increasing SAIL.
2.16	6	We will update the UK SORA GM referring to JARUS RLP to clarify this should be considered as a framework and applied proportionately to the SAIL, noting the UAS capabilities
3.6	6 Proposal 1.1	AMC/GM for OSO 6 in UK SORA will be drafted on the basis that EASA's MOC provides a good baseline, and the use of TCP/IP is inherently sufficient for SAIL 1 to 3 use. Our intent that the integrity needed is dependent on the UAS implementation and that there are different ways to achieve this integrity.
3.9	6 Proposal 1.2	AMC and/or GM will be drafted to reflect that C2 link periodic log files should be recorded appropriate for the complexity of the operation reflected in the SAIL, the development state of the UAS, and the C2 link implementation. This log file should be described in the operators' concepts of operation.
3.11	6 Proposal 1.3	The updated AMC/GM for OSO6 will be clear that EASA MOC is one acceptable means of compliance.
3.13	6 Proposal 1.3	We may clarify that the need to carry ATC voice in SAIL 1-3 operations to be low so such applications will be considered on a case-by-case basis for now
3.20	6, 13	We recognise there could be some ambiguity between where and when to apply OSO6 and OSO13 when considering all aspects of C2 links and we will seek to add clarity in the future AMC/GM.
3.26	13 Proposal 1.4	We feel that some basic cyber-security is reasonable for access UA over the Internet and modern hardware should allow for this; noting that not all 4G (and in future 5G) services need to connect via the Internet. We expect that AMC/GM will be added to OSO13 regarding this, noting that this may be combined with feedback from CAP3098.
3.29	13 Proposal 1.5	We will draft AMC/GM on that the ISP connection should have some SLA reflecting a performance-based, proportionate and technology neutral fashion.

Section	OSO	Summary of action
3.31	13 Proposal 1.6	We recognise that cyber-security is a wide-ranging and ongoing issue for all data including C2 links. We will draft AMC/GM on this reflecting a performance-based, proportionate and technology neutral fashion that may need to be updated from time-to-time as both the UAS capabilities and the cyberthreats evolve.
3.33	13 Proposal 1.7	We will draft AMC/GM reflecting that operations using public 4G and 5G networks should be below 120m agl (noting that certain tasks over high buildings may still be allowed) and that we will keep this under review.
3.35	13 Proposal 1.8	We will draft AMC/GM noting that: a) 4G/5G SIMs and service plans must be compatible and appropriate for use by UAS and UAS specific SIMs and service plans are one good way to achieve this. b) The use of private 4G/5G networks may also be a good way to do this though these need to be evaluated on a case-by-case basis by the UAS operator. c) Logging of the C2 link performance should be made in a manner defined in the UAS operator conops suitable for the UAS capabilities, the C2 link implementation, and the SAIL.
3.37	13 Proposal 1.9	We will derive AMC/GM based on suitability of the service for the UAS operation for SAIL 1-3.
3.40	13	We recognise that using an MVNO eSIM as the alternate connection to allow roaming if the primary connection fails and that this might not need the same levels or robustness as the primary connection for SAIL 1 to 3 applications and this may be reflected in AMC/GM.
3.41	13	When we draft the AMC/GM based on the proposals 1.4 to 1.9 we will make it clearer that they do apply to multi-connection C2 links, offering differentiation between when the connection is the primary or alternate connection when appropriate, and including mention of logging end-to-end communication performance; all in a performance-based proportionate fashion allowing for differing approaches.

APPENDIX A

Abbreviations

Abbreviations	
2G	Second generation mobile network
3G	Third generation mobile network
3GPP	Third Generation Partnership Project
4G	Fourth generation mobile network
5G	Fifth generation mobile network
5G Red Cap	5G reduced capability
ACJA	Aerial Connectivity Joint Activity
ADS-B	Automatic dependant surveillance – broadcast
AGL	Above ground level
AMC	Acceptable means of compliance
ATC	Air traffic control
BVLOS	Beyond visual line of sight
C2	Command and control
C2CSP	C2 link communications service provider
C3	Command control and communication
CAA	Civil aviation authority
CE mark	Conformité Européene
CNCPC	Command and non-payload communications
CU	Command unit
EASA	European Union Aviation Safety Agency
eSIM	Embedded SIM
FAA	Federal aviation authority
GM	Guidance material
GNSS	Global navigation satellite service
GSMA	Global system for mobile communications association
GUTMA	Global UTM Association
ICAO	International Civil Aviation Organization
IoT	Internet of things
JARUS	Joint authorities for rule making on unmanned systems
LDACS	L-band Digital Aeronautical Communications System

Abbreviations	
LoRaWAN	Low power radio wide area network
LTE	Long term evolution (4G)
LTE-M	Long-Term Evolution for Machines
MNO	Mobile network operator
MOC	Means of compliance
MSS	Mobile satellite service
MVNO	Mobile virtual network operator
NB IoT	Narrow band IoT
OSO	Operational safety objective
PSTN	Public switched network
RF	Radio frequency
RLoS	Radio line of sight
RLP	Required link performance
RPAS	Remotely piloted aircraft system
RTCA	Radio Technical Commission for Aeronautics
SAIL	Specific assurance and integrity level
Satcom	Satellite communications
SIM	Subscriber identity module
SORA	Specific operational risk assessment
TSO	Technical standard order
UA	Unmanned aircraft
UAS	Unmanned aircraft system
UK	United Kingdom
UKCA Mark	UK conformity assessed
VHF	Very high frequency