Interim Report of the Preliminary Impact Assessment on the Safety of Communications for Unmanned Aircraft Systems (UAS)

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QinetiQ

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Record of changes

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0.1	26 June 09	First draft
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Executive Summary

Introduction

This report constitutes the second formal deliverable of the Preliminary Impact Assessment of communications architectures for UAS contract number EASA.2008.C20 (procedure OP.08). The report details the work that has been undertaken since the publication of the Inception report.

Objectives

Much debate has taken place within the industry (including standardisation groups such as EUROCAE WG-73 and RTCA SC-203) about the architecture of the communications systems that will support the operation of UAVs in non-segregated airspace. Although these groups have produced some useful technical work, their role is not to endorse or promote a particular architecture, and consequently there is no consensus on what the architecture should look like.

In creating this project, EASA has initiated a process that will lead to the implementation of a regulatory policy to permit the use of UAS in non-segregated airspace. The objective of this study is to provide an initial input and guidance for the Regulatory Impact Assessment (RIA) process. This will be achieved through a Preliminary Impact Assessment on the safety and other factors that will be affected by the architecture(s) used for UAS communication systems. In the end the regulations, while protecting safety, should not over-constrain technical and business choices.

Scope of the Study

The scope of this impact assessment is limited to the following communications links:

- An air-ground link between the Ground Control Station (GCS) and the UAV for command and control;
- An air-ground link between ATS/C and the UAV for traffic surveillance (and/or communication) purposes, if assessed as necessary;
- Communication link(s) between the UAS crew and ATS/ATC.

The way these links are implemented may have a considerable impact on aspects of the UAS marketplace. This study is therefore assessing the impact of various communications architectures on the topics of Safety, Economy, Social, Spectrum, Global interoperability and European regulation.

Approach

There are four main steps to the approach adopted in this study.

Step 1 – Creation of Bounded Architectures and Impact analysis

Clearly, there are many different means of implementing Command and Control (C2) and ATC communications links for UAS. Whilst there will always need to be a radio link between the UA and the GCS for C2 elements, this could be achieved using either terrestrial or satellite based systems. Furthermore, the communications systems used might be limited to the coverage provided by a single ground station, or alternatively may consist of a network of ground stations or satellites. For the communications link with ATC, be it voice or data, the communications path can be either relayed via the UA, or non-relayed using either ground-to-ground radio links or some form of wired connection to the ATC network. Similarly, options exist with regard to the use of additional networks to provide communications with ATC, and whether such networks use wired or radio-based connections to the ATC system.

From an initial set of 20 candidate architectures, a functional hazard analysis was used to elicit a set of four bounded architectures. Impact analysis was conducted on each of the bounded architectures, and this identified areas to be explored through stakeholder engagement.

It is important to stress that whilst not intended to be de-facto solutions, the bounded architectures contain elements that are potentially suitable be for UAS communications, and more importantly, allow stakeholders to address associated issues, whether related to safety, performance, interoperability, spectrum, regulation or cost.

Step 2 - Stakeholder Engagement

There are two distinct groups of stakeholders. Group 1 represent the regulatory and safety community. Their role is to review the architectures and provide comment on a range of safety and performance related issues, as well as consider impact from a regulatory perspective. A series of interviews was held with a cross-section of Group 1 stakeholders in order gain a detailed understanding as to which aspects of the four bounded architectures are acceptable from a safety, regulatory and interoperability perspective.

Group 2 comprises UAS and associated payload manufacturers, anyone involved in the operations of UAS or other areas of the UAS industry. The role of Group 2 is to provide feedback on a range of related issues in order to highlight what issues are important for UAS operation. This is to be achieved using an on-line survey. The survey asks Group 2 stakeholders to comment on the importance of issues that have been identified (e.g. coverage requirements, operating costs, size and weight of equipment etc), and according to the answers given, will indicate which of the bounded architectures best meet the industry's requirements and highlight issues or benefits related to these architectures.

Step 3 - Analysis and Correlation

The information obtained from Group 1 stakeholder interviews will be analysed to identify common issues. Where there is consensus of opinion (e.g. latency can be a critical issue for ATC voice communications in certain airspace) this will influence the weighting that is applied to architectures that are known to introduce latency issues for ATC voice communications.

As already mentioned, the Group 2 responses from the on-line survey will be used to indicate the importance of issues that have been identified. Group 2 stakeholder's responses will first be weighted by their role, (e.g. an ANSP response to questions about the physical size of communications equipment to be installed on a UA will be weighted lower than a manufacturers' response and the opposite for the ATC procedures).

A figure of merit for each architecture will then be derived by multiplying the Group 1 derived weightings with the weighted results of the Group 2 survey. This process will indicate which of the bounded architectures best satisfy the expectations of regulators, and the needs of the UAS industry.

Finally a sensitivity analysis will be conducted to ensure that the weightings being applied are not having a disproportionate impact on the results obtained.

Step 4 - Prepare final report

The final report will be a pedagogic summary of the process and the results obtained. The report data will be made available to ensure transparency in the process, the results and the conclusions reached. Recommendations where appropriate will be made.

Scope of this report

This report contains a summary of the potential issues identified in the initial impact assessment and the results from the seven Group 1 stakeholder interviews already carried out, in order to provide stakeholders interim information on progress achieved so far. As the engagement process with both Group 1 and Group 2 stakeholders is still on-going, the complete analysis of their replies and any conclusions will be presented in the final report to be issued by end of 2009.

Contents

1 Introduction

This report constitutes the second formal deliverable of the Preliminary Impact Assessment of communications architectures for UAS contract number EASA.2008.C20 (procedure OP.08). This Interim Report contains further details of the impact analysis undertaken and the initial results obtained from Group 1 stakeholder interviews that have taken place to date. However, it should be noted that the Group 2 on-line survey has yet to be completed, and therefore any analysis of these results will be provided in the final report to be issued by end of 2009.

1.1 Background

In recent years considerable interest and effort has been expended world-wide into the development of technologies, procedures and standards that will allow Unmanned Aircraft Systems (UAS) to become fully integrated into the Air Traffic Management (ATM) environment. This work is essential to satisfy the safety criteria required for UAS to be operated in non-segregated airspace.

The mission of the European Aviation Safety Agency (EASA) is to promote and maintain the highest common standards of safety and environmental protection for civil aviation in Europe and worldwide. In the near future the Agency will also be responsible for safety regulation of airports and air traffic management systems.

The Agency needs to prepare itself to progressively develop implementing rules, certification specifications (CS), acceptable means of compliance (AMC) and guidance material (GM) as appropriate, for the UAS, their crews and their operations, including their interaction with aerodromes, other airspace users and the Air Traffic Management (ATM)/Air Navigation Services (ANS) infrastructure that exists both now and in the future.

The communications architectures required to operate UAS will form the foundation upon which many technologies, systems and operational procedures will be based. There are many architecture options available and no single, obvious solution. It is essential that these options are properly assessed and refined to enable the pace of development to be maintained.

1.2 Objectives

Much debate has taken place within the industry (including standardisation groups such as EUROCAE WG-73 and RTCA SC-203) about the architecture of the communications systems that will support the operation of UAVs in non-segregated airspace. Although these groups have produced some useful technical work, their role is not to endorse or promote a particular architecture, and consequently there is no consensus on what the architecture should look like.

In creating this project, EASA has initiated a process that will lead to the implementation of a regulatory policy to permit the use of UAS in non-segregated airspace. The objective of this study is to provide an initial input and guidance for the Regulatory Impact Assessment (RIA) process. This will be achieved through a Preliminary Impact Assessment on the safety and other factors that will be affected by the architecture(s) used for UAS communication systems. The purpose though is not to define, endorse or mandate any particular architecture. The purpose of the defined bounded architectures is to provide a platform for investigation and discussion of the issues and impacts that various architectural features will have on the impact topics being investigated in this study.

In the end the regulations, while protecting safety, should not over-constrain technical and business choices.

1.3 Scope

The scope of this preliminary impact assessment is limited to the following communications links:

- An air-ground link between the Ground Control Station (GCS) and the UAV for command and control;
- An air-ground link between ATS/ ATC and the UAV for traffic surveillance (and/or communication) purposes, if assessed as necessary;
- Communication link(s) between the UAS crew and ATS/ ATC.

The way these links are implemented may have a considerable impact on safety and other aspects of the UAS marketplace. This study will therefore assess the impact of various communications architectures on the following topics:

- Safety - including taking into account the availability, integrity and latency of transmitted data
- Economy - including the cost and weight of avionics and of modifying ATC systems
- Social - including the speed of development of the market and its effect on jobs and market penetration
- Electromagnetic Spectrum - including the amount of spectrum required, candidate frequency bands and issues associated with protection of existing users (within the candidate bands)
- Global interoperability – the ability for UAS to be safely operated in different States, and to conduct flights that transit FIR boundaries from one State to another
- EU Regulation – the compatibility of architectures with SES regulations and future operating concepts and system architectures identified by SESAR.

A requirement of the impact assessment is to cover adequately all 27 countries in the EU and to provide possible international comparisons. QinetiQ will conduct the main stakeholder engagement primarily through the use of an on-line survey tool. This is to be made available to a world wide stakeholder group to ensure that the international input as well as the EU input is as comprehensive as possible.

This report contains a summary of the potential issues identified in the initial impact assessment and the results from the seven Group 1 stakeholder interviews already carried out, in order to provide stakeholders interim information on progress achieved so far. As the engagement process with both Group 1 and Group 2 stakeholders is still on-going, the complete analysis of their replies and any conclusions will be presented in the final report to be issued by end of 2009.

1.4 Structure of the Interim Report

Section 1 – Introduction to the Requirement provides a statement of the customer need and objectives.

Section 2 – Provides a reprise of the work done to date as reported in the Inception Report.

Section 3 – Provides a brief summary of the work undertaken to derive the stakeholder questionnaires.

Section 4 – Collates the responses of the Group 1 stakeholder interviews.

Section 5 – Outlines the work to be undertaken to complete the study.

Appendix A - The briefing note produced to introduce the purpose of the study.

Appendix B - Description of the bounded architectures.

Appendix C - Provides the questionnaire to be answered by the Group 2 stakeholders.

2 The story so far

This section provides a short summary of the work undertaken and reported in the first deliverable, the Inception Report. The purpose of this section is to acquaint readers with sufficient understanding of the project without having recourse to the previous report (the Inception Report).

A brief outline of the methodology is presented followed by a description of how the candidate architectures were derived and finally how the Risk analysis that derived the 4 bounded architectures was undertaken. The detail can be found in the Inception report available on the EASA web site:

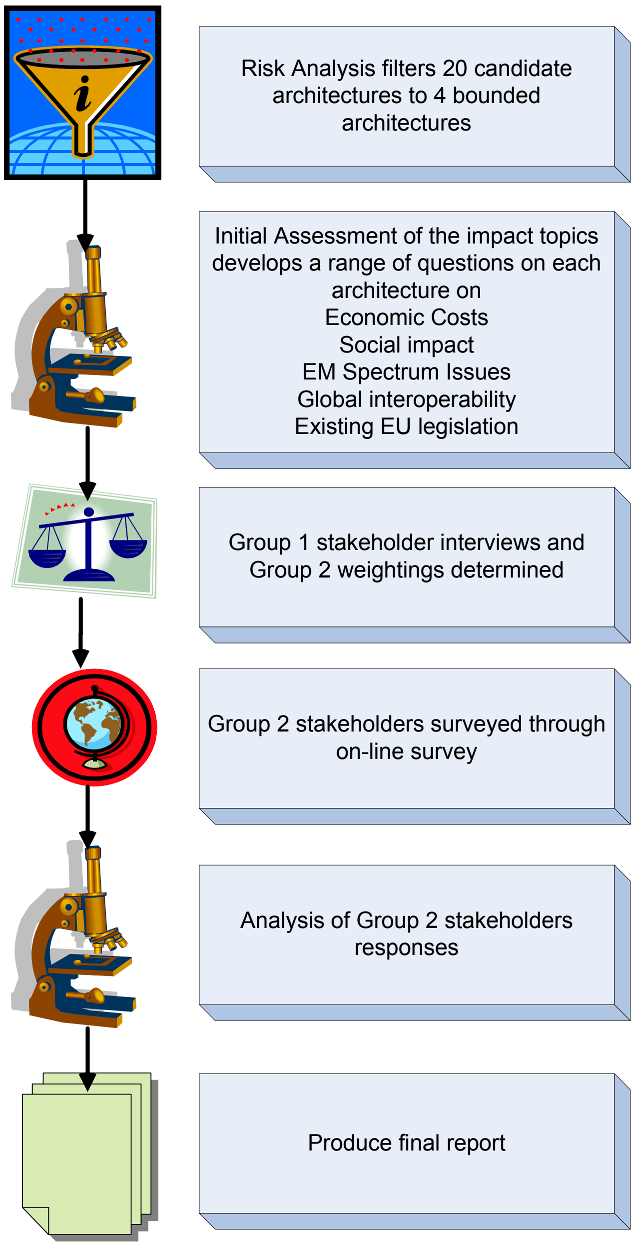
http://www.easa.europa.eu/ws_prod/r/doc/research/UAS_COMMS_Impact%20_asessment_inception_report_v1.02deid.pdf.

2.1 Methodology

The QinetiQ approach recognises the need to evaluate architectures that best satisfy the needs of the UAS industry at large, without compromising on safety performance. This is essentially a 2-part process. The first part identified 4 architectures that will meet safety performance requirements and lists the associated impact issues. In the second part, engagement with a broad cross-section of UAS stakeholders is taking place to understand the importance of the impacts associated with the architectures identified. The stakeholder survey is being performed using an on-line survey tool. Participation has been sought throughout the EU and world wide to selected countries with active UAS programmes. An expert body of stakeholders comprising EASA, other regulators and ANSPs have provided input into determining the weightings to be applied to the stakeholder responses. This has been undertaken through direct interviews. Furthermore, by asking stakeholders to rate the importance of such issues, it is possible to apply a Multi Criteria Analysis to provide a quantitative assessment of each of the architectures. Finally a sensitivity analysis will be performed to gauge the variation in impact against the weighting applied.

The methodology being used for this preliminary assessment is outlined by 6 key steps below:

- Identify potential candidate architectures
- Apply risk analysis to identify set of bounded (safe) architectures
- Impact assessment
- Stakeholder engagement (questionnaire/interviews)
- Analysis and Correlation
- Prepare draft final report



2.2 Candidate Architectures

The scope of the study is limited to the following communications links:

- An air-ground link between the GCS and the UAV for command and control;
- An air-ground link between ATS/C and the UAV for traffic surveillance (and/or communication) purposes, if assessed as necessary;
- Communication link(s) between the UAS crew and ATS/ATC.

Furthermore, for any architecture to be eligible for consideration it must satisfy certain core tenets to ensure transparency, equivalence and interoperability. Some of these are as follows:

- ATC communications with a UAV pilot should be no different to that for pilots of manned aviation. Fundamentally, voice channels should have good intelligibility, low latency and high reliability.
- Controller-Pilot communications should be available at all times, from the time the aircraft starts moving to the time it comes to a halt at the end of the flight. Even if the UAV/S is fully autonomous, there is a requirement for the UAV pilot to monitor ATC frequencies, and comply with any ATC instructions that are issued whenever operating inside controlled airspace, or accepting a separation service from ATC in other airspace.
- There is a need for accurate UAV position information to be available via the air-ground surveillance link at all times. Furthermore, surveillance systems on the UAV should be standardised to ensure interoperability with other systems (e.g. ATC surveillance and airborne collision avoidance systems).
- Similarly, the UAV pilot is legally responsible for the UAV. There is a requirement to monitor the position and status of the UAV at all times, as there is a duty to comply with aviation law and avoid harm or injury to people, air vehicles or structures through negligence or in the event of a system failure/emergency.

Up to 20 architectures capable of satisfying these core tenets were identified. A review of WG-73 and SC-203 was conducted to ensure that architectures being considered by these expert groups were included.

2.3 Functional Hazard Analysis

It is essential that only the architectures identified in Step 1 that are capable of meeting safety requirements for ATC communications and surveillance should be considered for more detailed impact assessment. QinetiQ organised an internal workshop with communication systems architects and operational experts who performed a Functional Hazard Analysis on all the 20 architectures.

Whilst a failure or interruption of any element of the architecture may not constitute a direct safety hazard, such problems can contribute to an operational incident (the so called chain of events). For example, loss of voice communications with a UAV pilot could increase ATC workload, which could lead to a more serious incident (i.e. loss of separation).

When considering the generic safety performance of candidate architectures the following events were considered to be hazardous:

- Loss of voice communications between UAV/S pilot and ATC
- Interruptions to voice communications between UAV pilot and ATC
- Intelligibility and latency of voice communications between UAV pilot and ATC
- Loss of command and control link between UAV and GCS
- Interruption of command and control link between UAV and ATC (due to system reliability or coverage)
- Loss of surveillance information feed to ATC

- Interruption of surveillance information feed to ATC (due to system reliability or coverage)
- Loss of surveillance information to other airspace users
- Interruption of surveillance information to other airspace users (due to system reliability or coverage).

For each of the above categories, a tolerable safety level was proposed. Once the tolerable levels were agreed, risk analysis was conducted on each of the proposed architectures. The architectures that best met or exceeded the tolerable safety level in all event categories were considered eligible. Out of these, 4 architectures were identified that contained attributes or system elements that are likely to have some impact on the UAS industry, ANSPs and safety regulatory authorities. These are referred to as bounded architectures.

The preliminary set of 4 bounded (safe) architectures were identified for detailed impact assessment. The project kick off meeting reviewed the total architecture set and approved the selection of the bounded architectures. These were provided in the Briefing document for the Group 1 stakeholders and are provided in Appendix A (Briefing Note) and Appendix B (Description of the Architectures).

It is important to stress that the bounded architectures are not intended to be de-facto solutions. They are simply architectures with particular attributes to allow stakeholders to consider what associated issues might exist, whether related to safety, performance, interoperability, spectrum, regulation or cost.

3 Initial Assessment of Impact Topics

This section covers the initial assessment of potential impact undertaken on the 4 bounded architectures. The aim of this assessment was to identify broad areas of impact, and use this to focus on the issues that need to be addressed in the Group 1 stakeholder interviews and the Group 2 on-line survey.

3.1 Scope

The initial impact assessment identified the issues that are likely to be contentious or high risk, be it for UAV/S manufacturers, UAV/S operators, Air Navigation Service Providers (ANSP) or safety regulators. It covered a wide range of issues including:

- Investment Costs (to develop suitable avionics equipment and associated ground/space infrastructure)
- Practical limitations (size and weight of equipment)
- Operational Costs
- Operational Limitations.

To achieve this, the impact of each of the bounded architectures was assessed in detail in the following five areas:

- Economic (cost and weight of the avionics and/or cost of modifications to ATS/ATC systems)
- Social Impact (slower or faster development of EU UAS industry), with a benchmark prediction as to the size of the industry by 2020.
- Use of Electromagnetic Spectrum (estimated total requirement)
- Global Interoperability (ability to operate in different States, and to transit FIR boundaries)
- Impact on other existing EU rules (i.e. compatibility with SESAR regulations and ESARRs).

The purpose of the initial assessment process is to culminate in a list of topics to be investigated further through the stakeholder engagement. Both positive and negative attributes associated with each topic were summarised. However, to ensure that only the issues likely to have significant impact were addressed by stakeholders, judgement was applied during this stage to ensure that issues of little impact were not included in the questions presented to stakeholders.

3.2 Approach

All the bounded architectures were analysed against each of the topics above. To perform this analysis a series of questions were developed, the purpose of which was to identify assumptions and issues relevant to the implementation of the architecture. It was not the intention at this stage to provide definitive answers, more to 'tease out' the questions that need to be asked of the stakeholder community in general. The answers to these questions should not be seen as definitive or representing anything other than an initial view from a range of experts.

The full details of the analysis performed will be provided as part of the final report. However, for the purpose of this report it is only necessary to summarise the main issues identified in each area, as they emerged from the first set of interviews.

3.3 Economic

The economic impact assessment concentrated on the cost and other implications of implementing the architectures both on the UAS and for ANSPs to provide the support infrastructure. The findings of the economic assessment can be summarised as follows:

- Regardless of architecture, UAS datalink will require significant spectrum and communications infrastructure

- Implementation of dedicated ground/radio networks will provide maximum user flexibility and minimise total spectrum requirement
- Users must be prepared to pay for spectrum licences and where relevant, the use of networks.
- Mobile phone networks and satellite-based mobile networks such as Inmarsat provide good indication of charges for voice and data services. Their historical development shows that charges tend to progressively decrease in parallel with technological evolution.
- Public and industry investment has focused on research and development of UAS technology, and the drafting of technical standards and regulations.
- To date, there is no evidence of any public investment into suitable infrastructure or services to support UAS operation in non-segregated airspace.

3.4 Social

Results from the social impact assessment concluded that:

- Published market forecasts vary wildly. Although all predict growth to some extent, it is not clear when this is likely to occur, and which aspects of UAS operation will see most growth (and hence what type of communications architecture and infrastructure will be required, and when).
- There are many candidate applications for UAS technology. However, viability will largely depend on enabling infrastructure and the regulatory environment that is put in place. In turn the regulatory environment may delay or contribute to allow market development.
- It is not clear how many UAS applications will need to operate in the airspace as GAT (General Air Traffic) amongst other (manned) traffic.
- Spectrum requirements can be reduced and quality/reliability of voice/data communications with ATC could be improved by using non-ATC relay architectures.
- Use of communication service providers is key to many of the potential architectures, but this may raise social issues.
- Wired architectures are attractive as they offer high bandwidth, high integrity and high reliability connections with minimal need for spectrum, or for UA to carry ATC radio equipment. This solution is unconventional and needs to be explored in detail with safety regulators, industry and ANSPs.
- Similarly, whilst offering potential benefits, the use of ground-based ATC radio equipment in some of the bounded architectures is also unconventional, and needs to be explored in detail with safety regulators and ANSPs.
- In the future, many UA are expected to be highly autonomous. It is not clear what regulatory expectations will be for the performance of command, control and ATC communications links for such UAS. This topic needs to be discussed in detail with safety regulators, industry and ANSPs.

3.5 Electromagnetic Spectrum

Results from the Electromagnetic Spectrum impact assessment concluded that:

- Harmonised UAS spectrum allocations do not exist at present. Existing allocations are either ad hoc or assigned at a national level.
- The total requirements for UAS spectrum (C2/C3 datalink, Detect and Avoid and payload) are still to be defined (although work is on-going within ITU-WP5B to estimate the C3 requirement).
- The market split between local (short range UAS operation) and wide area operation (using satellites or networked terrestrial ground stations) is not clear, but it is likely that different user needs will emerge.

- New spectrum allocations are difficult to acquire and the UAS industry will have to compete with other applicants or find a way to co-exist with existing aeronautical services.
- Almost the totality of present aeronautical frequency bands are already congested, and it is not obvious where capacity will be found for new (UAS) allocations.
- Some modern communications technologies are very spectrum efficient, but these methods are not necessarily as reliable as more traditional (less spectrally efficient techniques) due to the need for substantial amounts of signal processing.

3.6 Global Interoperability

Results from the interoperability impact assessment concluded that:

- Party line is still recognised as being important for ATC voice communications
- It is not clear how important party line communications will be in the SESAR concept, given that the expected predominance of data link communications.
- Additional latency is likely to be introduced for communications via geostationary satellite or digital switching networks. The potential impact of latency on ATC communications (voice or data) and C2 needs to be explored in detail with safety regulators and ANSPs.
- In networked architectures, interoperability standards will be required to allow users to access networks in different geographical regions
- Wired architectures may not be fully interoperable with all ATC ground infrastructure and this may lead to operational limitations
- 'Detect and Avoid' could provide greater levels of safety than 'see & avoid' for today's manned aviation community
- The need for ATC surveillance, situational awareness and collision avoidance necessitates the carriage of transponders or position squittering devices (i.e. ADS-B concept) by all UA (other than those operating within visual line-of-sight of the pilot). This is the only safe and fully interoperable means of providing surveillance data.
- It is not clear what percentage of UAS will operate (i) outside the coverage footprint of a single terrestrial ground station or (ii) perform longer flights that transit across national or regional boundaries. This will impact on the type of communications infrastructure required.
- Given that full capability 'detect and avoid' technology is unlikely to be certified for some time, there is an expectation that some UAS will seek to be approved to operate under IFR only in controlled airspace, with ATC providing a separation service (with appropriate separation minima to be defined) . This issue needs to be explored with regulatory authorities, as if it is deemed to be acceptable, it could lead to greater demand for UAS communications infrastructure in the short-medium term.

3.7 Regulation

Results from the regulatory impact assessment concluded that:

- SES regulations mandate carriage of 8.33 kHz communications[1] and VDL M2[2] for aircraft operating in controlled airspace (or a known environment). In addition ECAC States require carriage of Mode S airborne transponders. Many UAS may be too physically small or not have sufficient electrical power to support such systems. Regulators have to assess whether alternative means exist to provide equivalent functionality (e.g. non-ATC relay).
- ATS Providers must comply with ESARRs as transposed in SES legislation (governing the design, maintenance and operation of ATM systems).

[1] Commission Regulation (EC) No 1265/2007 of 26 October 2007
[2] Commission Regulation (EC) No 29/2009 of 16 January 2009

- Are new regulations required to support the operation of UAS? UAS are not specifically mentioned in current regulations and are currently outside the scope of SESAR. Despite this, the ICAO UAS Study Group and EASA[3] is progressing the development of policy to formally recognise UAS, and ensure that appropriate regulations are put in place.

[3] http://www.easa.europa.eu/ws_prod/r/doc/Explanatory%20Note%20to%20CRD-16-2005.pdf on the policy for airworthiness of UAS and rulemaking task MDM.030 in the rulemaking programme: http://www.easa.europa.eu/ws_prod/g/doc/Agency_Mesures/Agency_Decisions/2009/Annex%20to%20ED%20Decision%202009_002_R%20(4-y%20RMP).pdf

4 Stakeholder Engagement

This section provides a brief analysis of the responses from the engagement with the Group 1 stakeholders to date. A more detailed analysis will be undertaken in producing the final report.

Interviews have been held with the following stakeholders to date:

- European Commission (DG-TREN)
- European Aviation Safety Agency (EASA)
- EUROCONTROL
- European Defence Agency (EDA)
- SESAR Joint Undertaking (SJU)
- French Civil Aviation Authority (DSNA)
- UK Civil aviation Authority (CAA)

The following sections summarise the responses to the questions that were asked (derived from the potential impact analysis described in the previous section), and classifies them according to the level of consensus.

The following definitions have been used in analysing the responses

- Strong consensus - where the same response was given by nearly all stakeholders, and there were no opposing views
- General consensus: Where the same response was given by the majority of stakeholders
- Other responses: where issues were raised by one or two stakeholders. These responses may complement or oppose the general consensus.

It should be noted that the bullet points summarise the views of different stakeholders, and therefore can appear to be inconsistent when grouped together. This is intentional in order to give readers the full picture of the responses given.

4.1 Responses to Economic Questions

Q1. Do you believe there is a market for UAS, and if so, what type of applications do you expect to emerge initially?

Strong Consensus

- There is potentially a large market for state sponsored civil applications (i.e. governmental nature, but non military) such as State services (police, fire etc), border patrol, search and rescue etc
- Significant growth in military UAS applications driven by operational requirements and lower operating costs
- Other civil applications will be market driven (i.e. where unmanned operation is more cost effective than manned).

General Consensus

- Peace Keeping – the need to provide surveillance of ground activity in remote/hostile territory
- Maritime Surveillance – already UA are being procured to replace existing manned platforms
- Cargo – urgent delivery of high value goods (i.e. delivery of transplant organs from one hospital to another).

Other Responses

- Humanitarian Missions/Disaster Relief. For example, organisations like Medicine sans Frontier could use UAS to deliver food and medical supplies in areas where ground transportation (road/rail etc) was either impractical, non-existent or too dangerous
- Environmental and spectrum monitoring
- High altitude communications relays – less expensive and easier to put in place than traditional communications satellite
- Reduced crew manning is likely to be viable for long haul cargo operations, as GCS crew will not be subject to jet lag, and assuming on-board crew only accrue hours during take-off and landing phase of each flight. If shown to be safe, this could significantly reduce the total number of crew required to operate a long haul freighter. From the regulatory point of view this means that the UAS domain and manned aviation have to be considered in a total system approach.

Q2. Do you have any investment plans to provide infrastructure and services specific to support the operation of UAS?

Strong Consensus

(none)

General Consensus

- Most stakeholders have no specific plans for investment to provide dedicated UAS infrastructure or services at this time
- Most national regulatory authorities provide support to the UAS industry through attendance at standardisation groups (i.e. EUROCAE WG-73) and by providing temporary segregated airspace within which UAS may be operated. Other activities include providing regulatory advice and guidance to the UAS community, and supporting activities for new spectrum allocations through CEPT, ITU and ICAO meetings.

Other Responses

- The EC and EDA are funding large research and development programmes (INUOI, MIDCAS, SIGAT etc) with the aim of providing enabling technology for UAS operation in non-segregated airspace
- Any new development of ATM infrastructure must be compatible with that being developed within the SESAR programme and dedicated additional infrastructures for UAS, if necessary, must be funded by the UAS industry
- The EC will increase the awareness of the benefits of UAS and assist in building political consensus on integrating UAS into the European framework over the next few years.

Q3. If so, what infrastructure or services are planned, and when will they be available?

Strong Consensus

(none)

General Consensus

- No planned new infrastructure or services at this time.

Other Responses

(none)

Q4. If you have no direct investment plans at present, what would be required to justify such investment (e.g. legal certainty; public incentives; business plan; etc.)? Could there be any

synergism with infrastructure or services stemming from SESAR (e.g. for C, N and S)? And/or which part of the infrastructure should be directly provided by the UAS operators?

Strong Consensus

(none)

General Consensus

- The need to maintain safety is generally what drives investment by aviation safety regulators.

Other Responses

- The situation today, with UAS only operating inside segregated airspace means that there are no additional ATM safety issues to be managed, and hence there is no justification for investment by safety regulators
- NAA's are largely funded by the manned aviation community, so it could be difficult to justify a disproportionate level of investment to support a minority group
- From the EC perspective, sufficient interest from industry has been demonstrated to initiate new activity. In addition synergies with the SESAR programme are being explored.

Q5. Should the development of UAS communications infrastructure to permit voice/data communications with ATC have a cost implication for ANSPs?

Strong Consensus

(none)

General Consensus

- There should be no cost implications for ANSPs.
- Aside from the military, most ANSPs are commercial organisations and are unlikely to invest in dedicated infrastructure to enable UAS communications without a compelling business case.

Other Responses

- UAS must be included within the SESAR architectures, which will minimise additional cost.

Q6. How do you believe the cost of UAS regulation (rulemaking plus certification and oversight) should be funded?

Strong Consensus

- In line with other areas of the industry, the cost of certification should be paid for by those being regulated.

General Consensus

- Within Europe, the cost of rule making activity is generally centrally funded and charged on the totality of the population (i.e. by the European Commission).

Other Responses

(none)

Q7. Overall, how critical is the need for economic investment to facilitate the development of necessary communications infrastructure to permit UAS operation outside segregated airspace?

Strong Consensus

(none)

General Consensus

- The need for infrastructure is generally seen as critical for UAS that need to operate beyond line-of-sight (BLOS)
- The need for UAS infrastructure (and certified detect and avoid technology) is seen as critical in the long term to overcome the need for segregated airspace which is inefficient and places a burden on other airspace users.

Other Responses

- EASA recognises that for all but very short range UAS operating in Class F and G airspace, the need for appropriate infrastructure will be essential in order to reduce demand on the electromagnetic spectrum. It is possible that up to 90% of UAS platforms might depend on such infrastructure
- Economic investment is critical in order to develop appropriate infrastructure to permit GAT operation of military UAS, both in European airspace, and in other regions.

4.2 Responses to Social Questions

Q8. How important is datalink reliability and continuity for fully autonomous UA?

Strong Consensus

(none)

General Consensus

- Some level of autonomy will be needed in case of communication failures
- Any datalink would need to be reliable and have good continuity to allow continuous monitoring and override of the autonomous system by the human operator as and when required
- The link between GCS and ATC is less critical than the C2 link between the GCS and the UA. Loss of communications with ATC occurs today, and there are established procedures for handling such eventualities
- The performance requirement for the C2 link will be determined according to the UA's kinetic energy, using established certification methods (i.e. similar to CS-25/1309). This is driven by the need to protect people (on the ground or in other aircraft) from an out of control UA.

Other Responses

- There is an important social dimension to the issue of the public acceptability of autonomous UAs, and there have already been concerns expressed on the adequate control of UAs.

Q9. What percentage of GAT flights (i.e. by civilian operators, by military services under GAT or by non military governmental organisations in controlled airspace or a known traffic environment) do you believe will be unmanned by (a) 2015, (b) 2020 and (c) 2030?

Strong Consensus

- All stakeholders believe that percentage will be around 1% by 2015
- All stakeholders recognise that it is extremely difficult to predict the percentage for 2030, but that it could be as much as 20%.

General Consensus

- Most stakeholders believe that percentage will start to rise sometime from 2020 onwards when more experience and acceptance of UAS operations has been achieved.

Other Responses

(none)

Q10. Some of the architectures identified utilise ground-based radio equipment located close to ATC ground radio equipment, and linked to UAS ground control stations via a wired network. Are there any reasons why voice/data communications could not be provided via a ground-based radio system?

Strong Consensus

(none)

General Consensus

- This type of architecture should be acceptable as long as equivalence with the current method of operation can be demonstrated.
- Ground-based equipment must be carefully sited to ensure that (i) it does not overload ATC receivers and (ii) it can provide similar coverage to ATC transmitters (in order to maintain party line for voice communications).

Other Responses

- The use of fixed ground-based equipment may not be permitted by ITU as part of aeronautical mobile (route) service
- Airborne radio equipment will generally provide the UAS pilot with better situational awareness
- There is an increased risk of 'step-on' if the transmissions from the ground-based equipment cannot be heard by other aircraft on the frequency
- In some countries, there might be public opposition to the establishment of new radio masts (where necessary to correctly site the additional ground-based equipment).

Q11. Some of the architectures identified have a wired connection to the ATC voice/data communications system. Are there any reasons why, subject to equipment meeting safety and reliability requirements, a wired connection could not be provided?

Strong Consensus

- This type of architecture should be OK as long as transparency can be maintained.

General Consensus

- It was noted that although it might be difficult to achieve connectivity with all ATC units today, it should be much easier in the future infrastructure being considered within the SESAR programme.

Other Responses

- This architecture will be limited to national ATC infrastructure, ATC centres or major airports with the capability for a 'wired' connection. The value of such architectures was questioned if the UAS still has to carry an ATC radio in order to communicate with ATC infrastructure without a wired interface (e.g. small airfields or military sites)
- The availability of Voice over IP (VoIP) technology may be able to more easily facilitate a wired connection
- It is important to take a total system approach and not to decouple ATC and C2 communication requirements

- It will be important to ensure that ATC are aware of any malfunction of the wired system.

Q12. If a wired connection is acceptable, would there be any constraints on the number of connections that could be made?

Strong Consensus

- No, as long as safety, interoperability and performance are not compromised.

General Consensus

(none)

Other Responses

(none)

Q13. Some of the architectures are only likely to be economically viable using a communication service provider. Do you see any issues associated with the use of a service provider to provide UAS voice/data communications?

Strong Consensus

(none)

General Consensus

- No, as long as safety and interoperability is not compromised.

Other Responses

- The use of commercial communications service providers raises some interesting issues for military UAS
- For safety critical applications, the design of equipment and software used must be approved. This might make it difficult to use extant infrastructure (i.e. existing mobile telcoms networks)
- Equipment maintenance staff will be subject to personnel licensing regime (to ensure technical competency through training and recency requirements)
- Service Level Agreements must be put in place to ensure that performance requirements are met. Commercial incentives should be used to help guarantee the performance of the service.

Q14. Do you believe that the number of service providers should be limited?

Strong Consensus

- No, as long as safety is not compromised.

General Consensus

(none)

Other Responses

- More service providers encourages competition and could reduce costs.

Q15. Overall, do you believe UAS will represent a significant proportion of traffic in the European ATM system (a) before 2020 and (b) after 2020?

Strong Consensus

(none)

General Consensus

- No, the proportion of UAS traffic in the ATM is expected to remain low both before and increase steadily at some point after 2020.

Other Responses

(none)

Q16. Do you believe that it is acceptable to use innovative/novel communications architectures, potentially involving new service providers to achieve safe and effective communications with UAS?

Strong Consensus

- Yes, as long as safety and interoperability can be maintained.

General Consensus

(none)

Other Responses

(none)

4.3 Responses to Spectrum Questions

Q17. A standardised networked C2 datalink will provide greatest flexibility for UAS operators that need to operate over a wide area, but this is likely to require significantly more spectrum than would be required for individual operation of proprietary systems over a local area. How important is it to secure sufficient spectrum to establish one or more standardised C2 networks across Europe?

Strong Consensus

(none)

General Consensus

- The amount of spectrum required should be commensurate with the operational requirement
- The ICAO position for UAS spectrum allocations must be supported in preparation for WRC11. This currently includes 49 MHz for the operation of satellite based services for BLOS operation (which is expected to be networked) and 35MHz for terrestrial LOS operation.

Other Responses

- The ability to maintain control of the UA and know where it is will require a high integrity, high availability radio link. Any single radio link is unlikely to achieve the same availability as onboard avionics systems, so back-up communications systems (and associated spectrum) will be required if the continued safe operation of a UA is not to be hindered by the radio link
- To fully achieve the goals of SESAR, aviation will require more spectrum in general and that any additional spectrum needed for UAS technology should be seen as part of a common pool for use by all aviation users including manned aircraft.

Q18. How important do you believe it is to secure, through ITU World Radio Conferences, a common spectrum allocation for UAS C2 datalink? And it is the same for mission/payload data?

Strong Consensus

- A common spectrum allocation is key to global operability.

General Consensus

- Either global allocations or recognised region allocations within common global allocations could be suitable.

Other Responses

- It is not possible to standardise spectrum for the payload as the requirements are so different for the wide range of applications. However, there are benefits in the C2/C3 link operating in nearby band as this could allow reuse of common avionic components
- Solutions operating in different bands using software-defined radios could also be possible.

Q19. How important do you believe it is for UAS C2 datalink communications to be wholly contained within aeronautical frequency bands AM(R)S or AMS(R)S?

Strong Consensus

- For civil UAS this is essential. However, it is not essential for military aircraft to operate in AM(R)S or AMS(R)S bands (as long as protected spectrum is used)
- Civil users must obtain allocations in civil bands.

General Consensus

(none)

Other Responses

- As it is predicted that most of the initial operations will be military UAV flights in GAT (~85% of UAV flights), the allocation could be from within the existing military allocations. A portion of military bands could be converted to protected spectrum for military UAS operations in GAT.

Q20. How important is it to have a single harmonised global spectrum allocation for UAS C2 datalink communications?

Strong Consensus

(none)

General Consensus

- This is both important from a regulatory perspective, and also for manufacturers as it will minimise the number of systems that have to be developed and certified. Unmanned aircraft that need to cross national or operate in different regions should not have to be equipped with entirely separate communications equipment.

Other Responses

- A lack of harmonised bands would make operation and management difficult.

Q21. How important is it to adopt architectures that minimise the amount of spectrum required?

Strong Consensus

- Yes, it is important that the need for spectrum is kept low as ultimately there will be a cost of ownership including the cost of using spectrum.

General Consensus

(none)

Other Responses

- The cost of providing alternative infrastructure (i.e. wired networks) should not be overlooked when trying to reduce the need for spectrum.

***Q22.* How important is it to use spectrally efficient techniques?**

Strong Consensus

- Spectrally efficient techniques should be used as long as they do not have an adverse impact on performance (integrity, continuity or latency).

General Consensus

(none)

Other Responses

- The aeronautical community needs to show that it is doing everything possible to encourage efficient use of spectrum to Radio Regulators.

4.4 Responses to Interoperability Questions

Q23. Which of the 4 bounded architectures are acceptable in terms of the provision of party line voice communications? (i.e. in today's pre-SESAR environment).

Strong Consensus

(none)

General Consensus

- All 4 architectures are considered acceptable as long as quality of 'party line' communications is no worse than today's environment.

Other Responses

- The delay associated with use of geostationary satellites for C2 poses a potential problem.

Q24. How important will it be to continue to provide voice party line to pilots in the SESAR environment, where trajectory management via data link and improved situational awareness in the cockpit may be available?

Strong Consensus

- Wherever it is important to provide party line to manned aviation, the requirement should exist for unmanned aircraft.

General Consensus

- In general, the need for party line communications is expected to be less in future ATM concepts e.g. the SESAR target concept where data link will be become more widespread and applications such as TIS-B will provide pilots with greater situational awareness.

Other Responses

- The need for, and benefit of, party-line may be over emphasised. Full party line may not be achieved today in mixed VHF/UHF environment or when pilots speak different languages on the same channel
- The on-going need for voice communication and party line in the SESAR target concept is not clear. This is currently being studied.

Q25. Is it acceptable for a UAS to only have voice/data communications capability with the relevant ATC sectors and units whose area of responsibility the flight is planned to enter/transit?

Strong Consensus

(none)

General Consensus

- Yes, as long as operation (including emergency situations) can be managed safely.

Other Responses

- A system without the ability to communicate with all ATC sectors (either wired or radio-based) could be acceptable if it can be shown to be acceptably safe

- The UAS communications capability must be able to cope with the need for ATC to unexpectedly divert a UAS on an unplanned route. Basically a UAS needs to have the same capability as manned aircraft to cater for all contingencies.

Q26. Latency is potentially an issue both for ATC communications and C2, particularly where geostationary satellites are used. How much latency can be tolerated?

Strong Consensus

- The amount of latency that can be tolerated for ATC communications will depend on the operational environment (i.e. type of airspace and traffic density).

General Consensus

- System latency (introduced by satellite communications or switching networks) is generally not significant given the reaction/thinking time where there is a human-in-the-loop
- The latency of for C2 link may not be an issue if autonomous collision avoidance systems were used to overcome the need for pilot intervention.

Other Responses

- The latency of data over existing airline data link systems can be as much as 30 to 40 seconds, and this amount of latency is considered unacceptable for C2 in any circumstances
- A system approach must be adopted and it is the combination of systems that is important. The communication requirements depend on type of communication system e.g. aircraft spacing and density, operational environment, etc.

Q27. Is it acceptable, in case of 'wired' voice communications exchanges between ATC and the UAS pilot, that such communications be broadcast by the ATC transmitters, so as to provide a party line to other aircraft in the same sector? Do you see technical or operational issues connected to this possibility?

Strong Consensus

- Yes, as this already happens today when ATC voice channels are cross-coupled.

General Consensus

(none)

Other Responses

(none)

Q28. In the case of a communication service provider that provides C2/C3 link to several UAS operators, how might this be acceptable?

Strong Consensus

(none)

General Consensus

- This is entirely acceptable as long as the service provider is under appropriate safety oversight.

Other Responses

- This is entirely acceptable as long as the service provider is under an appropriate service level agreement, the limitations of which are accounted for in the operator's safety case
- A single service provider does not mean a single point of failure.

Q29. Do you recognise the potential for "detect and avoid" technology on UAS for supplementing/replacing current "see and avoid" concept?

Strong Consensus

- Yes, if it can be shown to provide real safety benefits.

General Consensus

(none)

Other Responses

- Yes indeed. The accident rate for aircraft operating in non-controlled airspace is unacceptably high. TCAS has already demonstrated how similar technology can bring safety benefits to larger (commercial) operations in controlled airspace.

Q30. In the short term do you support UAS operating as IFR in controlled airspace with limited "detect and avoid" capability?

Strong Consensus

(none)

General Consensus

- Yes, detect and avoid is not required for IFR GAT operation, and this makes UAS operation potentially feasible
- Yes, this is very much how military UAS are expected to operate in the ATM system initially.

Other Responses

- No, this could set a precedent that could reduce the overall level of aviation safety and place greater responsibility on the controller which would be unacceptable. All aircraft currently have a legal responsibility to maintain separation and collision avoidance. ATC can only provide separation from other known traffic, and aircrew are responsible for separation from other objects. Aircraft operating IFR in CAS still have a 'last-ditch' capability to detect visually and avoid conflicting objects.

4.5 Responses to Regulation Questions

Q31. Overall, how essential is it for UAS to be fully compliant with SES regulations?

Strong Consensus

- UAS must be fully compliant with SES regulations applicable to their area of operation
- Every effort must be made to treat UAS, from the legal and regulatory point of view, in exactly the same way as other aircraft.

General Consensus

(none)

Other Responses

- In the medium term, ICAO plans to modify Annexes to make them applicable for UAS operation
- Regulations must be put in context. For example, there is no sense in a UA being compliant with the 8.33kHz Implementing Rule if it does not operate with ATC radios i.e. it uses a wired ATC service.

Q32. If necessary, do you support the drafting of new SES regulations specifically for UAS to ensure that they can be accommodated in future ATM environment?

Strong Consensus

- Yes, where aspects of UAS operation that are not covered by existing SES regulations (e.g. detect and avoid or C2 datalink performance requirements)
- As well as implementing rules governing the operation of UAS, it is likely that a new airworthiness standard (CS-UAS) will be developed. There will also be rules for UAS operators and competency requirements for UAS,flight crews and strict operating procedures to ensure that UAS are not vulnerable to hijack or misuse.

General Consensus

(none)

Other Responses

- Such regulations should not be reserved exclusively for UAS. Instead, they should be equally applicable to manned aircraft (i.e. to allow carriage of detect and avoid technology, or to use datalink for reduced crew operation etc)
- Additional SES regulations should permit military UAS operation in non-segregated airspace.

5 Next Steps

This section provides a summary of the steps following the Group 1 stakeholder interviews that are required to complete the study. It is not the intention here to detail the work to be done. This can be found in the Inception Report of this study which can be found on the EASA web site: http://www.easa.europa.eu/ws_prod/r/doc/research/UAS_COMMS_Impact%20_asessment_inception_report_v1.02deid.pdf.

5.1 Group 2 On-Line survey

The on line survey went live on 2 June when a number of groups/ organisations were contacted with a request to participate in the survey. This initial list is shown below.

- EASA Advisory Group of National Authorities (AGNA)
- EASA Safety Standards Consultative Committee (SSCC)
- SES Industry Consultation Body (ICB)
- CANSO (relevant WG's)
- UVS International members
- AUVSI members
- EUROCAE WG-73
- RTCA SC-203
- European Aviation Research Partnership Group
- UAVS
- SIGAT
- INNOUI
- SITA
- ARINC
- INMARSAT

Although a number of responses have been received it is too early to draw any conclusions.

Readers of this report who have not been contacted are welcome to participate by filling in the on-line survey which can be accessed through the web link below. The survey will close on 11 September 2009.

5.1.1 Email participation Request

The following is a reproduction of the email sent to request participation.

'EASA ATM/Airport department plans to conduct a Regulatory Impact Assessment (RIA) on Unmanned Aircraft Systems (UAS) communications. In preparation for this, EASA has tasked QinetiQ to perform a Preliminary Impact Assessment (PIA) on a range of UAS Communication Architectures - please see attached accreditation letter outlining the need for this study. EASA are very keen to elicit as many and varied participants as possible from the UAS Stakeholder community, so please pass this survey on to any appropriate stakeholders.

<u>Our request to participants</u>

EASA kindly requests your support to complete this on-line survey. The results of the survey will inform future activity for the development of regulation for UAS and is therefore very important for all the UAS community to provide their viewpoint.

This email is being distributed through a wide variety of routes and it is likely that you may receive this email several times. Please accept our apologies if this is the case, and you have already performed the survey.

Instructions on how to access and complete the survey

The survey will run until 11th September 2009 and is available to all through the link below:

http://www.surveymonkey.com/s.aspx?sm=S8hzIC3QRjwGLm38go_2bB1Q_3d_3d

We kindly ask you to enter the code word – Oscar – which identifies the route of the email for security reasons. We would also request your name and contact details if you would be willing to discuss your answers should the need arise. You may fill out the survey multiple times if the UAS applications you envisage require different answers to the questions.

The survey will take about 15 minutes to complete; consisting of 9 pages with 2-4 multiple choice questions per page. If you have any problems accessing the site / any technical difficulties please send details of error and your contact information to: ATMsupport-mail@QinetiQ.com. Further guidance and help is provided on–line.

Data Protection

Please note as mentioned in the attached letter that any information will be treated with the strictest confidence and shall only be used for the purposes of this study. The survey uses an online surveying tool called SurveyMonkey to collect the results which adheres to privacy conditions.

Thank you in advance for participating in the survey. Your responses will form a valuable resource with which to influence the future regulation of UAS in non segregated airspace.'

5.2 Remaining steps

The following table lists the remaining steps to be undertaken and the expected timescales.

Task	Description	Completion Date
Group 1 Weightings Analysis	The Group 1 responses will be analysed to provide a weighting which will be applied to the Group 2 responses.	11 September 2009
Closure of the Group 2 survey	The survey goes off line	11 September 2009
Analysis of Group 2 results	The Group 2 results will be analysed in conjunction with the weightings determined by the Group 1 stakeholders	8 October 2009
Final Report	Publication of the final report	17 November 2009

A Group 1 Stakeholder Briefing Note

Introduction

This document provides a brief outline and background to the areas that will be discussed during the face to face meeting with QinetiQ as part of the EASA Preliminary impact assessment on the communications for UAS. This briefing is intended solely for what has been designated as Group 1 stakeholders. That is, those stakeholders who perform some form of regulatory and/ or safety related function in the air transport industry. The intention is to conduct face to face interviews to investigate the issues and potential impacts arising from a selected set of communications architectures.

General Context

Much debate has taken place within the industry (including standardisation groups such as EUROCAE WG-73 and RTCA SC-203) about the architecture of the communications systems that will support the operation of UAVs in non-segregated airspace. Although these groups have produced some useful technical work, their role is not to endorse or promote a particular architecture, and consequently there is no consensus on what the architecture should look like.

In creating this project, EASA has initiated a process that will lead to the implementation of policy to permit the use of UAS in non-segregated airspace. As part of this process, QinetiQ has been contracted to carry out a study to provide an initial input and guidance for the Regulatory Impact Assessment (RIA) process. This will be achieved through a Preliminary Impact Assessment on the safety and other factors that will be affected by the architecture(s) used for UAS communication systems.

Scope

The scope of this preliminary impact assessment is limited to the following communications links:

- An air-ground link between the Ground Control Station (GCS) and the UAV for command and control;
- An air-ground link between ATS/C and the UAV for traffic surveillance (and/or communication) purposes, if assessed as necessary;
- Communication link(s) between the UAS crew and ATS/ATC.

The way these links are implemented may have a considerable impact on aspects of the UAS marketplace. This study will therefore assess the impact of various communications architectures on the important impact topics outlined below:

- Safety - including taking into account the availability, integrity and latency of transmitted data
- Economy - including the cost and weight of avionics and of modifying ATC systems
- Social - including the speed of development of the market and its effect on jobs, market penetration
- Electromagnetic Spectrum - including the amount of spectrum required, candidate frequency bands and issues associated with protection of existing users (within the candidate bands)
- Global interoperability – the ability for UAS to be safely operated in different States, and to conduct flights that transit FIR boundaries from one State to another.
- EU Regulation – the compatibility of architectures with SES regulations and future operating concepts and system architectures identified by SESAR

Methodology

A six step methodology to perform the study has been adopted that is compatible with the Eurocontrol Safety Assessment Methodology (SAM) and ESSAR 4 principles:

- Identify potential candidate architectures
- Apply risk analysis to identify set of bounded (safe) architectures

- Impact assessment – on the remaining topics
- Stakeholder engagement (questionnaire/interviews)
- Analysis and Correlation
- Prepare final report

To date the first three steps have been carried out and now consultation with stakeholders is underway. The aim of the consultation process is to gain a wider understanding of potential areas of importance and this stage is vitally important to this initial assessment. The 4 architectures chosen for further review of the impact topics outlined above are shown in Appendix A.

Bounded Architectures

The methodology provided the rationale for the selection of bounded architectures. The following architectures were selected and agreed at the project kick off meeting as the 4 bounded architectures to take forward to assess the remaining impact topics.

AR2 - ATC relay using a networked ground station

This had the lowest overall risk score, required no modification to present day ATC infrastructure and was seen as a logical solution as long as sufficient spectrum was available to permit ATC voice/data to be carried over the C2 datalink.

NR1 - ATC via terrestrial ground station and datalink via non-networked ground station

This had the lowest risk score of the non-ATC relay architectures, and was seen as being a practical and cost effective solution for small UAS operating within a confined geographical area (e.g. radio line of sight).

NR3 - ATC via terrestrial Ground Station and datalink via geostationary satellite

This is the lowest scoring architecture with a satellite communications element and is seen as being cost effective and practical for medium/large UAS that need to operate over longer distances, or where there is no terrestrial C2 ground station coverage. By studying this architecture in more detail it will be possible to explore issues to do with the use of Satellite communications for C2, and the use of a Communication Service provider (CSP) to provide voice/data communications with ATC using ground-based radio equipment.

NR12 - ATC via CSP wired interface and datalink via networked ground station

Although this architecture does not have a particularly low score, it is considered to be a practical solution in the context of the SESAR 2020 timeframe. By studying this architecture in more detail it will be possible to explore issues associated with the use of a CSP managed wired interface to the ATC voice/data network.

Next steps

Stakeholder Engagement

There are two distinct groups of stakeholders. Group 1 represent the regulatory and safety community to review the architectures and draft questions and produce a weighting for the questions. As a Group 1 stakeholder the areas of interest will focus discussions on the impact topics outlined previously.

Group 2 stakeholders represent the wider community and consist of UAS manufacturers and operators, as well as ANSPs. Group 2 stakeholders will be surveyed through the use of an on-line survey to ensure as wide a sample as possible.

Analysis and Correlation

The Group 2 stakeholder's responses will be analysed in conjunction with the weightings determined by the Group 1 stakeholders. Group 2 stakeholder's responses will first be weighted by their role, e.g. an ANSP response to questions about the weight of avionics will have less weight than the manufacturer's response. Finally a sensitivity analysis will be conducted. All results will be provided in a final report delivered to EASA.

It is important that key Stakeholders involved in UAS development, regulation or operation are sought and incorporated in this important preliminary impact assessment study.

B Bounded Architectures

The following architectures were selected and agreed at the project kick off meeting as the 4 bounded architectures to take forward to assess the remaining impact topics.

AR2 - ATC relay using a networked ground station

NR1 - ATC via terrestrial ground station and datalink via non-networked ground station

NR3 - ATC via terrestrial Ground Station and datalink via geostationary satellite

NR12 - ATC via CSP wired interface and datalink via networked ground station

B.1 Candidate architectures Diagrams

The following diagrams represent the 20 candidate architectures and their equivalent schematic diagrams

B.2 Definitions

The following definitions are used in the functional and schematic diagrams.

UA	Unmanned Aircraft
UAS	Unmanned Aircraft System (comprises the UA the GCS and the radio link for command and control between the two).
ATC Relay	An architecture where the ATC voice and/or data communications path is relayed via the UA.
Non-ATC Relay	An architecture where the ATC voice and/or data communications path is not relayed via the UA.
DL	Datalink (used for either ATC voice/data, and/or UA command and control)
GS	(radio) Ground Station (facility used to support either ATC voice/data, and/or UA command and control communications equipment)
GCS	Ground Control Station (from where the UAS pilot governs the flight of the UAV) and associated UAV monitoring/control systems
CSP	Communications Service Provider (used to provide voice/data communications between two specified points – independent of national ATC system).
DLSP	Datalink Service Provider (used to provide aeronautical data communications between ATC and aircraft)
SCSP	Satellite Communications Service Provider. This includes routing signals to/from satellite earth stations, along satellite feeder links and transmission/reception of signals by satellites.
Direct Communications	Where there is a direct communications path between the UA or GCS with ATC (i.e. not routed via a third party voice or data communications network).
Non-Direct Communications	Where the communications path between the UA or GCS with ATC is routed via third party voice or data communications network.
ATC-N	Air Traffic Control – part of a national networked ATC system.
ATC-I	Air Traffic Control – independent service provider without connection to the national networked ATC system.

B.3 Conventions

The following conventions apply to all candidate architectures in this paper:

Colour coding on functional diagrams

- RF links are denoted by dashed lines
- Wired links are denoted by solid lines
- Single line = half duplex channel
- Parallel line = full duplex channel
- Colour shading (on schematic diagrams):
- Light blue denotes systems physically installed on the unmanned aircraft
- Orange shapes are current and future ATC systems
- Magenta lines represent ATC voice/data
- Blue lines represent telecommand links
- Green lines represent telemetry links
- Black lines represent a combined ATC communications, telecommand and telemetry

A mnemonic is used to reference each of the architectures.

- The first letter categorises the architecture in terms of having ATC relay (R) or non-ATC relay (N).
- The second letter defines whether the architecture has a dedicated (D) or networked (N) communications path to ATC.
- The third letter defines whether the architecture has radio (R) or wired (W) connection to ATC.
- Where there is more than one path in the architecture, a second mnemonic block is used.

B.4 Functional Diagram

The purpose of the functional diagram is to show the signal path(s) for ATC voice/data, telecommand and telemetry components, which constitute the command and control or C2 link. To aid clarity, the functional diagram does not show other aircraft or UAS. Similarly, it does not show the system elements or institutional aspects of each architecture.

B.5 Schematic Diagram

The schematic diagram provides a more detailed breakdown of the communications paths used for ATC voice/data, telecommand and telemetry. It identifies the systems used, the means of connectivity between systems, and in broad terms, who has responsibility for each system element.

To maintain clarity and to enable maximum flexibility in the functional risk analysis process, the attributes of each system (i.e. availability, integrity, likelihood of failure etc) are not specified.

Key to Schematic diagram

T – Potential to result in total failure of UAS communications

M – Potential for a fault to result in communications being misheard by ATC or the UAV pilot

P – Potential to result in a partial failure of UAS communications

D – Potential for communications to be misdirected (to the wrong aircraft, ground station or ATC unit)

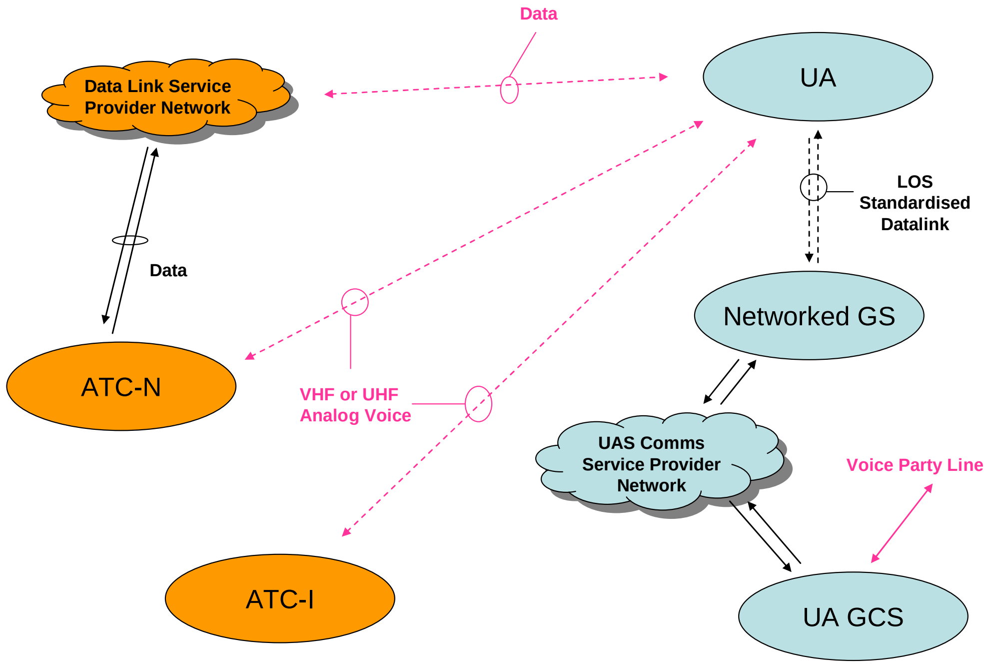
L – Potential for system element to introduce significant latency

I – Potential for system element to be intermittent

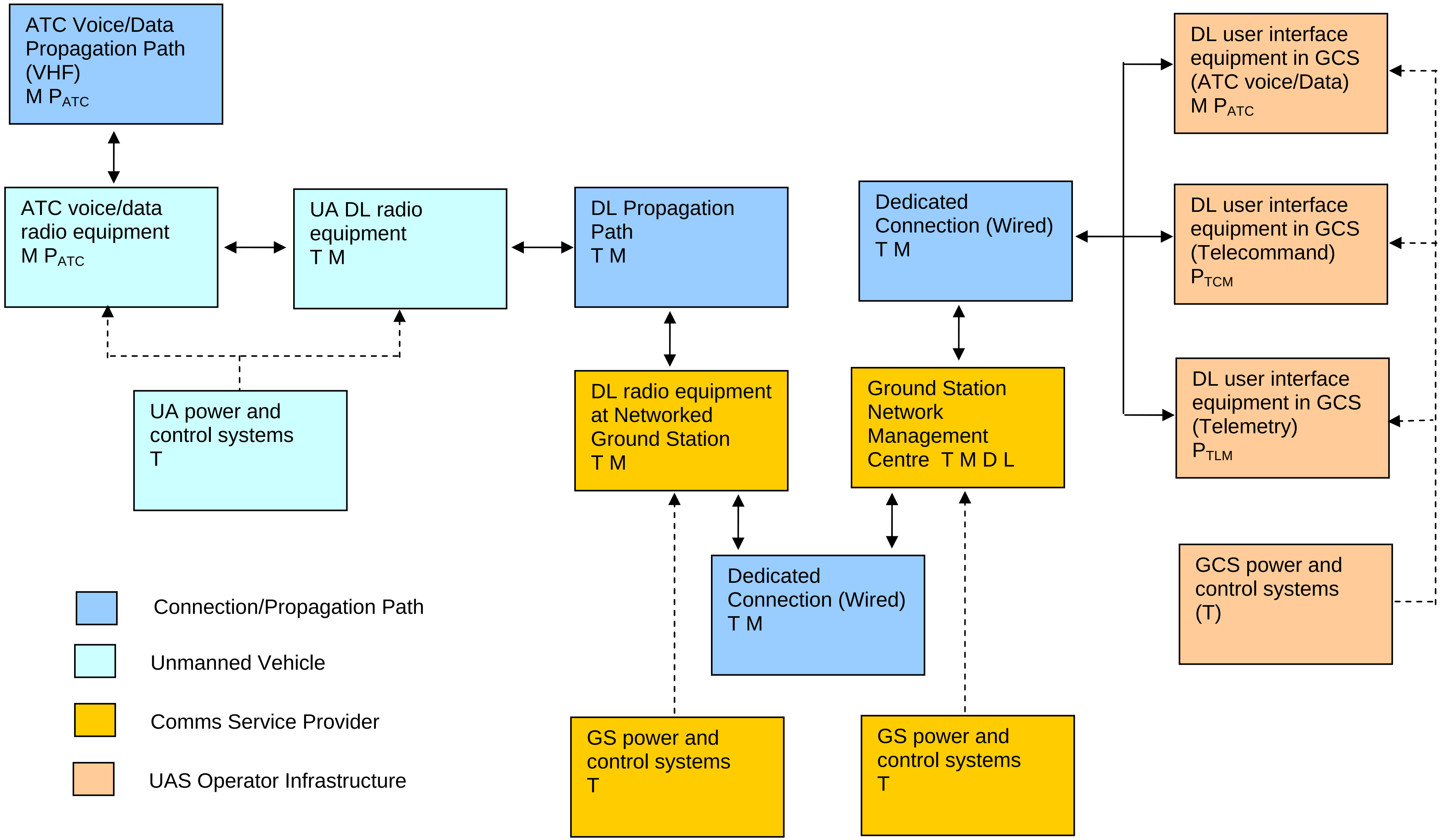
S – Potential for system element to fail through loss of synchronisation with other system elements

B.5.1 AR2 – ATC Voice/Data Communications, TLM & TCM via Networked Terrestrial Radio (ANTR)

AR2 – Functional Diagram

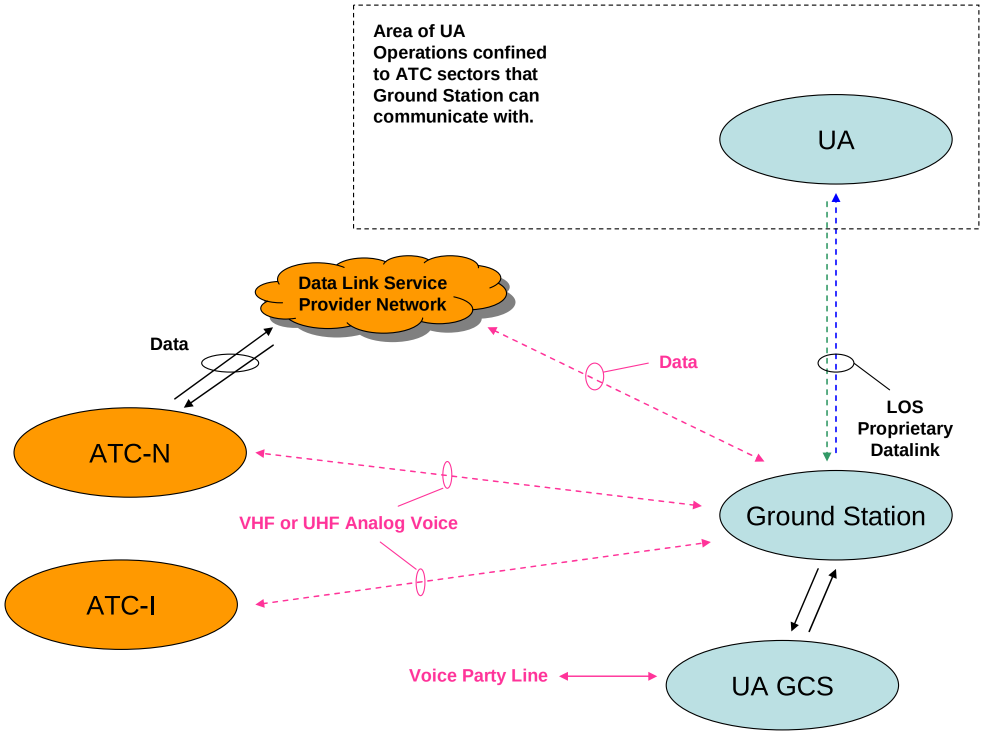


AR2 – Schematic Diagram

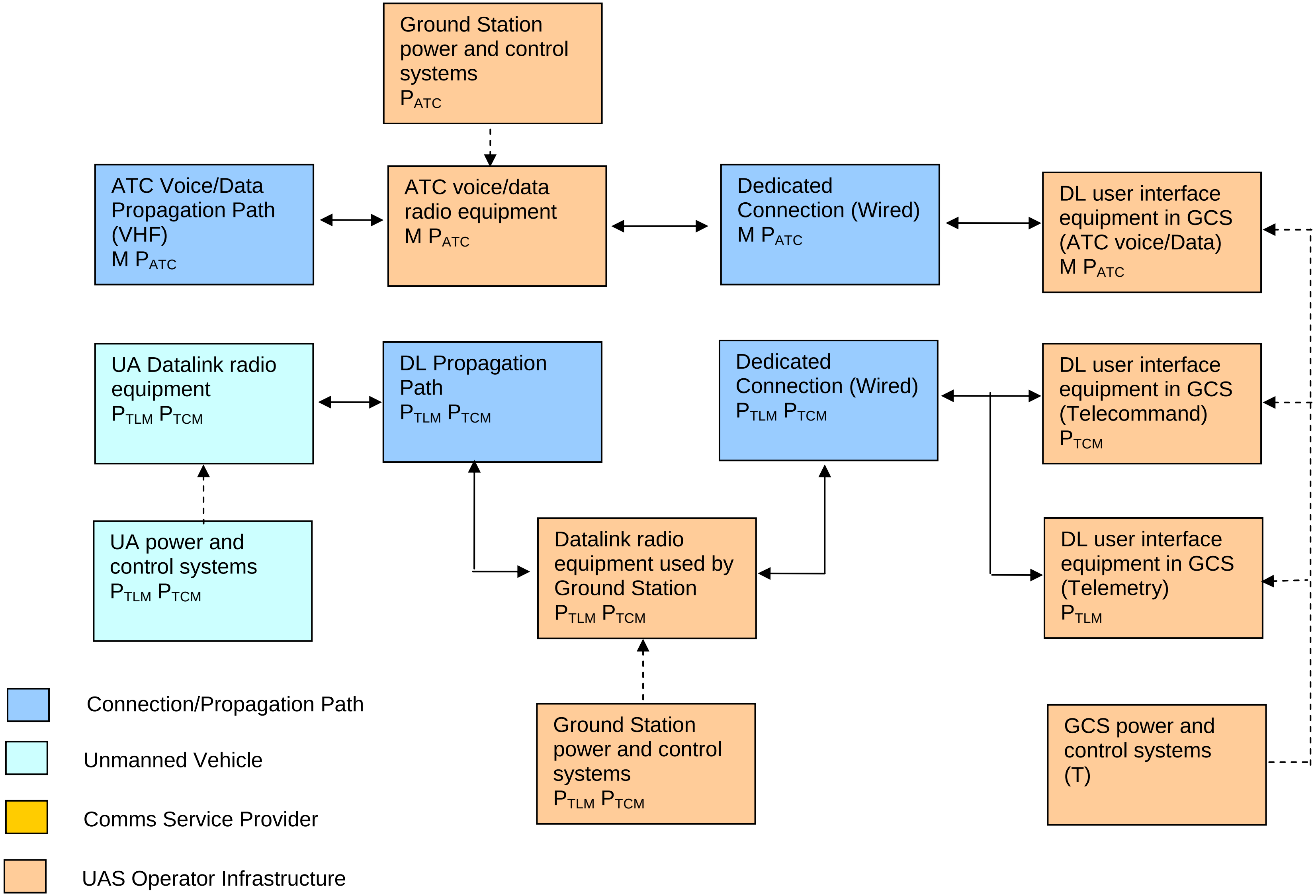


B.5.2 NR1 – ATC Voice/Data Communications via Dedicated Ground-based ATC Radio, TCM & TLM via Dedicated Terrestrial Datalink (NDGR-DTD)

NR1 – Functional Diagram

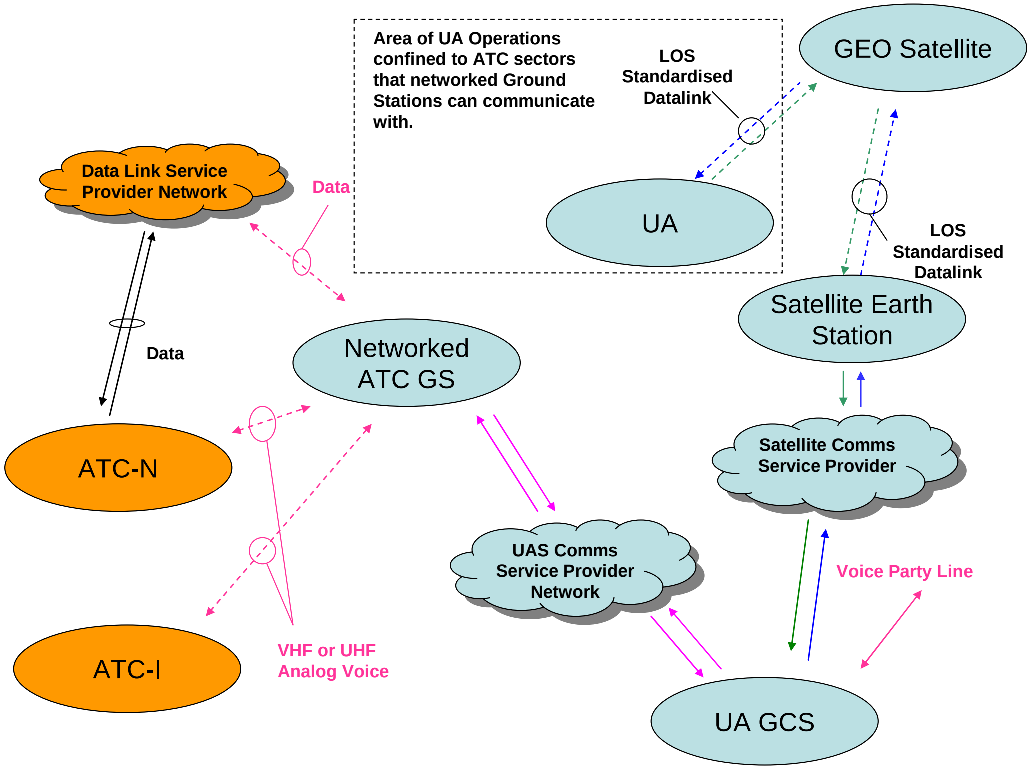


NR1 – Schematic Diagram

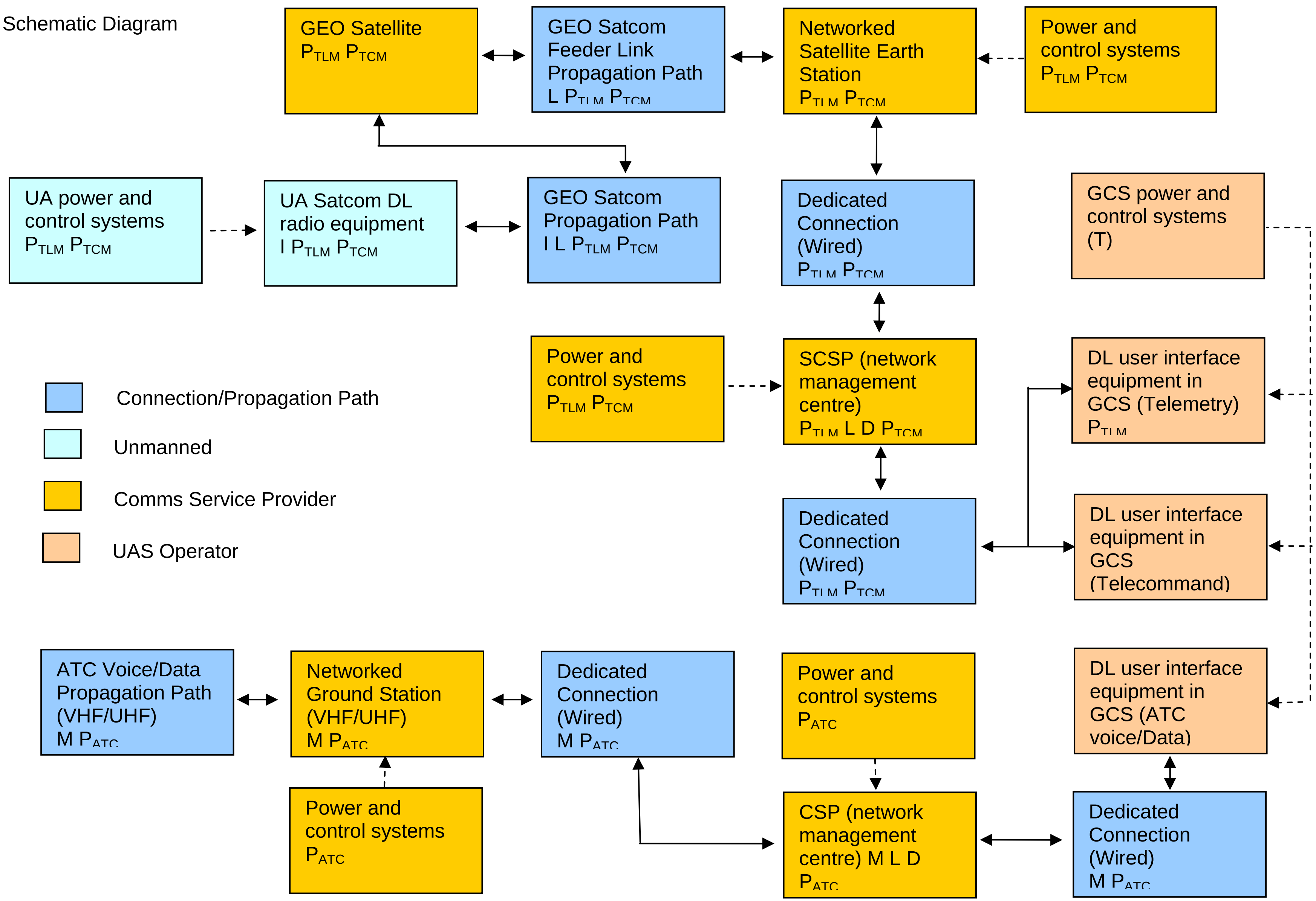


B.5.3 NR3 – ATC Voice/Data Communications via Networked Ground-based ATC Radio, TLM & TLC via Geostationary Satellite Datalink (NNGR-GSD)

NR3 – Functional Diagram

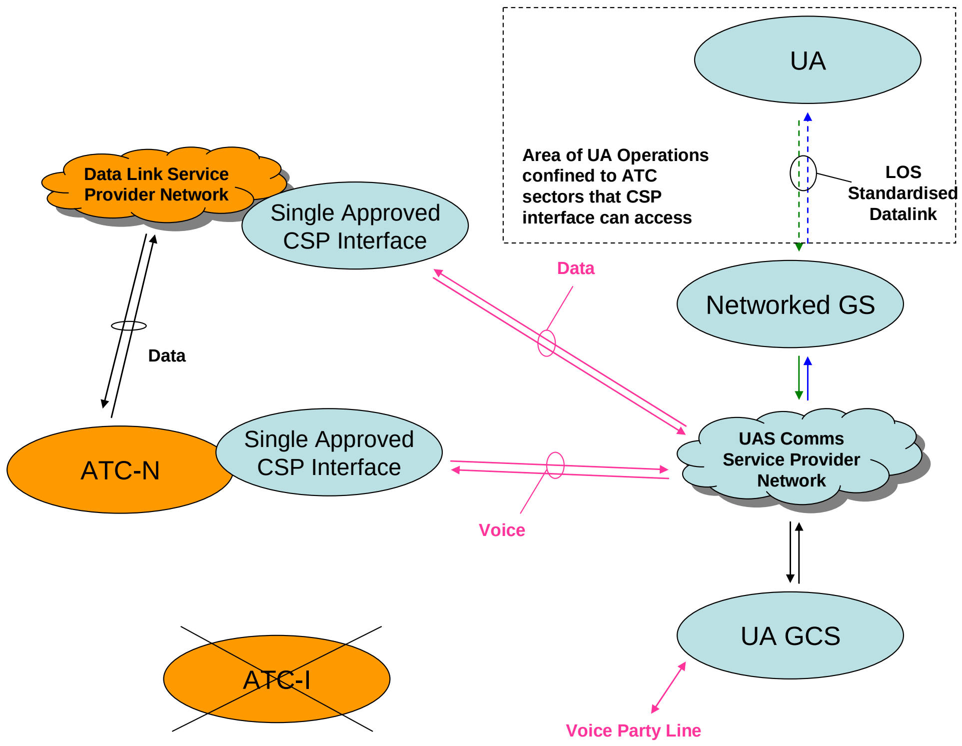


NR3 – Schematic Diagram



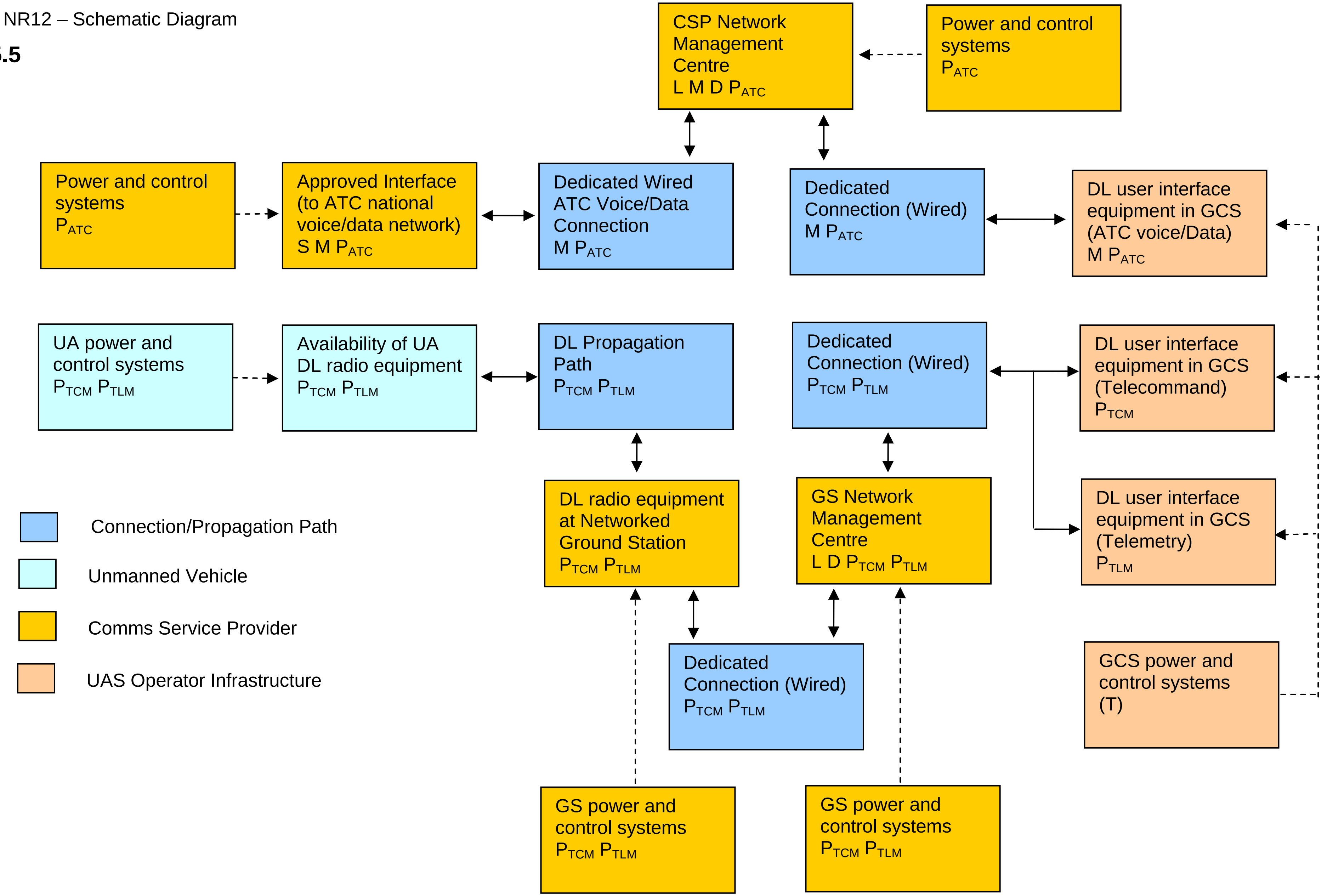
B.5.4 NR12 – ATC Voice/Data Communications via Networked Wired Interface, TLM & TLC via Networked Terrestrial Datalink (NNW-NTD)

NR12 – Functional Diagram



NR12 – Schematic Diagram

B.5.5



C Group 2 Stakeholder Questionnaire

Page 1: Information for Respondents

The purpose of this questionnaire is to gain a wide cross section of stakeholder opinion on communication infrastructures for Unmanned Aircraft Systems (UAS). The aim is to gain general opinion in the areas of UAS development, regulation and operation. Collection of the results is being performed by QinetiQ Ltd* in the UK on behalf of EASA.

The results of this questionnaire will not be publicly attributable to any individual and/or organisation and any such information is treated with strictest confidence. Information obtained will not be used for any other purpose or passed to any other organisation. An analysis of results will be included within the final EASA report for the project 'Preliminary Impact Assessment for UAS communication systems.' Your opinions are vital to the development of civil UAS and inclusion within the preliminary impact assessment; this is an important initial input to the Regulatory Impact Assessment (RIA) process.

Note: You may answer the questionnaire multiple times to reflect the needs of different UAS roles or applications.

In order to progress through this survey, please use the following navigation links:

- Click the Next >> button to continue to the next page.
- Click the Previous >> button to return to the previous page.
- Click the Submit >> button to submit your survey.

NOTE: If you do not have an opinion/answer on a particular question please leave the question blank.

*QinetiQ strictly adheres to a Third Party Information Policy which mandates the storage and management of data in accordance with the UK Data Protection Act 1998.

Page 2: Contact Information

What is your role within the Unmanned Aerial System (UAS) industry?

UA/S Manufacturer
UA/S Operator
Systems/Avionics manufacturer/supplier
Communication Service Provider
ANSP
Regulator
Support services – e.g. airport/ maintenance/ training – please specify
Other – please specify

Please fill in general information below:

Name
Company
Size of organisation (approximate no. of people employed)
Country
Email Address
Phone Number

Are you willing to be contacted by QinetiQ for clarification of answers if required?

Yes
No

Enter security code (from the invitation email)

PAGE 3: General Applications

In general it is recognised that UAS may require different communication links, such as:

- A command and control data link (C2) between the remote control station and the Unmanned Aircraft (UA);
- Voice/data communications (and the exchange of surveillance data) with Air Traffic Control (ATC) service providers;
- "Sense and avoid" in relation to neighbouring air traffic, severe weather, terrain;
- "Payload" data link (e.g. to downlink video images);
- C3 link which is defined as C2 and ATC commmunications relayed through the UA.

The primary aim of the following questions is to acquire stakeholders' opinions on the first two communication links listed above. The way in which the data links are implemented may have a considerable impact on aspects of the UAS marketplace including: economy, social, spectrum, global interoperability and EU regulation. Hence it is necessary as a first step to explore the various topics associated with UAS communications to see their importance to industry.

The aim of this section is to identify applications of relevance for civil UAS operations and identification of potential areas that you forsee future requirements of operation.

Q1. When do you foresee the following UAS applications commencing outside segregated airspace (answer all that you think are applicable)?

	Before 2020	After 2020
Aerial Imaging and Mapping		
Agricultural Applications		
Airborne Pollution Observation & Tracking		
Atmospheric Research		
Border Patrol		
Cargo		
Chemical & Petroleum Spill Monitoring		
Communications Relay		
Drug Surveillance and Interdiction		
Humanitarian Aid		
Law Enforcement		
Maritime Surveillance		
Natural Hazard Monitoring		
Other		
Port Security		
Search and Rescue		
Traffic Monitoring		
Utility Inspections		

Other please specify:

Page 4: UAV Operational Context

It is important that this questionnaire is answered with only one application in mind, various applications may have different communication requirements from a UAS. This section considers where the UAS may operate

Q2. Please specify the chosen application against which these questions will be answered.

Q3. For the application selected please specify the area of operation (from the ground station) Operating altitude (drop down box within the following range- below 400 ft to up to 40000ft)

Maximum operating range (drop down box within the range less than 24NM to beyond 500 NM)

Q4. For the altitude and range selected above what is your preferred C2/C3 datalink communications method (tick all that apply)

Satellite

Single ground station

Networked ground stations

N/A

Q5. Do you foresee any requirement to operate UAS over remote, maritime or polar regions devoid of infrastructure required for terrestrial based datalink ground stations?

a) Yes

b) No

Q6. How important is it to have the capability to operate UAS in different countries, and to cross international boundaries?

a) Not important

b) Desirable

c) Essential

Page 5: Infrastructure

Infrastructure on both the UAS and ground systems has an implication on the practicalities of operating a UAS in non-segregated airspace. The questions below aim to find out what sort of infrastructure you think is necessary to support the UAS application you foresee.

Q7. If globally standardised and approved C2/C3 datalink equipment were available, would you make use of it?

a) Yes

b) No

c) n/a or don't know

If No please explain:

Q8. What percentage of UAS operations do you expect to use the following C2/C3 communication infrastructures?

Single ground station

Networked ground stations

Satellite

Combination ground/ satellite

a) 0% to 20%
b) 21% to 40%
c) 41% to 60%
d) 61% to 80%
e) 81% to 100%

Q9. When do you require the following types of C2/C3 communications infrastructure to be available to support your business need?

Single ground station
Networked ground stations
Satellite
Combination ground/ satellite

a) 2010
b) 2012
c) 2014
d) 2016
e) 2018
f) 2020
g) n/a

Q10. How would you see the above infrastructure being provided?

In-house development of proprietary networks
Privately funded development of standardised networks
Publicly funded development of standardised networks

Q11. How do you intend to communicate with ATC?

	Before 2020	After 2020
Relay through UA using onboard COM equipment		
Ground based COM equipment		
Wired connection with ATC		
Via a Communications Service Provider		

Q12. What percentage of UAS platforms produced or operated by your organisation and intended for operation inside a controlled/known airspace environment will be capable of transponder <u>and</u> VHF (voice) transceiver carriage?

a) 0-20%

b) 21-40%
c) 41-60%
d) 61-80%
e) 81-100%

Q13. What percentage of UAS platforms produced or operated by your organisation and intended for operation inside a controlled/known airspace environment will be capable of transponder <u>and</u> VHF (voice) <u>and</u> VHF (data) transceiver carriage?

a) 0-20%
b) 21-40%
c) 41-60%
d) 61-80%
e) 81-100%

Page 6: Cost

Cost is a factor that is important to the development of the UAS industry. The questions below aim to capture the approximate range of cost and data requirements you would expect when operating an UAS.

Q14. What do you expect the cost per UA will be for the following communications standardised equipment (not including installation costs);

Terrestrial C2/C3 data link

Satellite C2/3 data link

a) Less than €10k

b) €10k to €49k

c) €50k to €99k

d) €100k to €250k

e) More than €250k

Q15. What are your expected data throughput requirements per UA?

Command and Control (C2)

Downlink of sense and avoid data

ATC voice communications

ATC data communications

a) 0 to 20kbps

b) 21 to 40

c) 41 to 60

d) 61 to 80

e) More than 80

Q16. Where communications are provided by a service provider, what costs would you expect per UA (€ per kbps)?

Command and Control (C2)

Downlink of sense and avoid data

ATC voice communications

ATC data communications

a) 0.1 to 0.5

b) 0.6 to 1.0

c) 1.1 to 2.0

d) 2.1 to 4.0

e) 4.1 to 6.0

f) More than 6.1

Page 7: Equipment

This section aims to gather information on the general equipage requirements for a UAS operating in non-segregated airspace.

Q17. What is an acceptable weight, power consumption, size and antenna gain of satellite communications equipment that a UA can support?

Supply Power Requirements (Watts)

1-49 Watts

50 to 99

100 to 199

200 to 299

300 to 499

Above 500

Weight (kg)

1- 4

5 to 9

10 to 14

15 to 19

20 to 24

Above 25

Size (Number of MCUs)

1 to 2

3 to 4

5 to 6

7 to 8

Above 8

Antenna Diameter (m)

Less than 0.5m

Less than 1m

Less than 2m

2m or more

Q18. What is an acceptable weight of terrestrial communications equipment that a UA can support?

Weight

1- 4 kgs

5 to 9

10 to 14

15 to 19

20 to 24

Above 25

Q19. The European Space Agency (ESA) is developing a new satellite system (i.e. Iris) to support air-ground communications for Air Traffic Management in the framework of SESAR. Iris should allow lighter avionics, smaller antennas on-board and cheaper service, when compared with today's technology. Do you think it would be worthwhile to explore the possibility of applying the Iris approach also to C2 datalink for UAS?

d) Yes

e) No

Page 8: Realization

This section aims to gain understanding of areas of importance for the realization of a UAS operating in non-segregated airspace. Understanding what areas you view as having a significant impact for advancement of the UAS industry.

Q20. On a scale of 1 to 5, (where 1=Not important and 5=Critical) how do you perceive the following areas to be constraining the development of the UAS industry in Europe?

- Regulation
- Global Standards
- Sense and Avoid
- Spectrum Availability
- Communications Infrastructure
- Environmental
- Social Acceptability
- Safety
- Availability of Trained Personnel (including internationally agreed competence requirements for them)
- Any other area to consider (if yes, please specify)

Other please specify:

Q21. Which of the following views do you most agree with on a scale of 1 (strongly disagree) to 5 (strongly agree)?

a) Sufficient spectrum should be sought to avoid UAS operations being constrained in any area, whatever the cost implications.

b) Operational limitations due to insufficient spectrum are inevitable, but will be overcome in time as the UAS industry grows.

c) It is acceptable to continue with the practice of seeking spectrum on a case-by-case basis, accepting that this could constrain the growth of UAS in many areas.

Q22. What are the constraining factors in using satellite communications for C2 and ATC (tick all that apply)

Available Spectrum

Communication cost

Equipment cost

Equipment Weight

Latency (signal delay)

Use of third party provider(s) for communication services

Reliability

Availability (service level/system coverage)

Security

Q23. The emerging Single European Sky (SES) Implementing Rule (IR) on Surveillance Performance and Interoperability (SPI), will require transponder carriage by UAVs operating in a controlled/known airspace environment. What percentage of UAS platforms produced or operated by your organisation and intended for operation inside a controlled/known airspace environment will be capable of transponder carriage?

a) 0-20%
b) 21-40%
c) 41-60%
d) 61-80%
e) 81-100%

Page 9: Standardisation

This section aims to find out your view on the importance of standardisation for the UAS industry.

Q24. How important is it for the UAS industry to have a standardised and interoperable set of standards for networked C2 datalink communications?

a. Not important

b. Desirable

c. Essential

Q25. How important is the need to achieve globally harmonised frequency allocation for UAS C2 datalink?

a. Not important

b. Desirable

c. Essential

Page 10 General

In general what will the impact be on your organisation over the coming years and is there any other important topics that have not been discussed within previous sections.

Q26. With the expansion UAS market what increase in manpower dedicated to UAS activity do you foresee over the following years

2010

2012

2014

2016

2018

2020

Beyond 2020

a) 0%

b) 1% to 20%

c) 21% to 40%

d) 41% to 60%

e) 61% to 80%

f) 81% to 100%

g) More than 100%

Q27. Do you see any other important issues to be considered in order to allow UAS operations in non-segregated airspace?

D Glossary

ACAS	Airborne Collision Avoidance System
AMC	Acceptable Means of Compliance
ANSP	Air Navigation Service Provider
ASAS	Airborne Separation Assistance System
ATC	Air Traffic Control
ATM	Air Traffic Management
ATS	Air Traffic Services
BLOS	Beyond Line of Sight
C2	Command and Control
C3	Command, Control and Communications
CATS	Combined Aerial Targets Service
CNS	Communication, Navigation and Surveillance
CS	Certification Specifications
CSP	Communications Service Provider
DL	Datalink
DME	Distance Measuring Equipment
EASA	European Aviation Safety Agency
EU	European Union
FANS	Future Air Navigation System
FOM	Figure of Merit
FIR	Flight Information Region
GAT	General Air Traffic
GCS	Ground Control Station
GS	(radio) Ground Station
HALE	High Altitude Long Endurance
ITT	Invitation to Tender
MCA	Multi Criteria Analysis
NCO	Network Centric Operation
NEC	Network Enabled Capability
PMP	Project Management Plan
SESAR	Single European Sky ATM Research Programme
SMART	Specific, Measurable, Achievable, Relevant, Timely
SSR	Secondary Surveillance Radar
SWIM	System Wide Information Management
UAS	Unmanned Aircraft System
UA (or UAV)	Unmanned Aircraft (Vehicle)
VHF	Very High Frequency