UAS INSERTION INTO AIRSPACE and RADIO FREQUENCIES
AN INDUSTRIAL PERSPECTIVE

An Inevitable Requirement

Contributions to the first Workshop on ‘UAS Industry and Market Issues’, highlighted the enormous economic potential and growth opportunities that this new class of air vehicle could bring to citizens, industries, and organisations of the EU. The market could be seen as one of the next major catalysts for economic growth at a time when such growth is urgently needed. The European defence and aerospace manufacturing industry has an enviable record in delivering products, services and capabilities that exploit the substantial investment in research and development both from national government and European funded support over recent decades. This investment has created the potential for the successful development of civil and military UAS programmes that could make Europe a leading player in this global market.

However, it has become clear that, to take advantage of technologies already in place, UAS must be available to the wider civilian and commercial markets. Because military activity is today restricted to operational air traffic environments, there is no ready route to inserting UAS into the wider general air traffic environment. Although useful for specific missions or phases of the mission, there is little incentive for defence ministries to fund works on UAS Air Traffic Insertion. The careful and protracted negotiations preceding each military UAS flight transiting civil airspace, en-route to the security of segregated airspace for its operation, are far too inhibiting for commercial activities. More importantly, non-military state actors, e.g. police, customs, coastguard, etc will need to comply with civilian regulations, but will also want the freedom to act quickly and independently to meet operational needs. It is therefore quite clear that there is an economic market, but that there are fundamental obstacles to its realisation. Without the ability to operate in civil airspace, it is the ASD’s view that there are few prospects for further developing the UAS market.

For UAS to truly realise their potential, and for the market to grow, it is vital that they have full, un-restricted access to non-segregated airspace and tap into the potential commercial demand.

This paper sets out, from an industrial perspective, the 5 broad issues that need to be addressed to enable the European Aerospace and Defence industries to kick start growth in the commercial sector while, preserving a cost-effective route to producing world-beating defence solutions. These issues are:

- The need for regulation.
- The role of standards.
- The implications of international regulation.
- The evolution of Air Traffic Management systems.
- Radio-Frequency Management

Each of these issues is discussed to explain the implications; describe what has been, and is being done; and offer recommendations for future work under the Commission’s guidance.
The Need for Regulation

All regulatory authorities addressing the problem of inserting UAS into civil air traffic have been quite clear in that UAS must comply with the same procedures and infrastructure requirements that apply to manned aviation. There will be no concessions because of the peculiarities of UAS technology. What does this mean in practice for the industries that will design and build the systems and platforms?

It is widely recognised that 3 pertinent issues bind the manufacturing industry in this field:

- **Certification of Airworthiness.** A certification of airworthiness is a fundamental basis of aviation safety. All manned aircraft are certified to internationally recognised Certification Specifications (CS) that define overall safety targets.
  
  o Such CS do not yet exist for UAS, particularly for civil UAS. CS standards must be implemented from the outset in aircraft and systems design and so, facing the lack of a regulatory framework, manufacturers have already incurred risk in seeking to compete globally.
  
  o It is clear that future use of UAS must not reduce the overall safety of Aviation, but adequate targets and methods must be defined in the CS in order not to jeopardize the UAS market development. More importantly, by implication there is no coherence with standards emerging in other parts of the World; European Industry is not able to compete on a level playing field.
  
  o Although certification will be addressed in detail in workshop 3, as an integral part of the regulatory framework, it is essential that the need for common global standards is recognised. However, as the airworthiness safety objectives are for UAS to protect the over-flown populations, insertion operational rules should consider such safety objectives and request them for all UAS operating in European airspace whatever their national registration. This means that these safety objectives will have to be harmonized between Europe and USA, and later consolidated and agreed at ICAO level.

- **Authorisation to operate.** To be authorised to fly and operate, industry must demonstrate that their UAS comply with international regulation.
  
  o The ICAO Convention, and annexes, rules on all aspects of civil aviation, but does not yet include UAS. Although study groups have been formed, urgent action is needed to progress this work. For example, the new ICAO concept of ‘detect and avoid’ has been recently defined as: ‘the capability to see, sense, or detect conflicting traffic or other hazards and take appropriate action.’ Only when this has been precisely defined in an unmanned aircraft context can new technology be developed to meet the requirement.
  
  o The International Telecommunications Union regulates radio-communications exchanges. The introduction of UAS with remote piloting stations will demand substantial, secure communications to assure safe and effective operation, all of which must comply with clearly defined regulations, none of which yet exists, and is addressed further in this paper.
  
  o Finally, the introduction of new ATM systems such as Europe’s SESAR and NextGen in the USA, will bring new concepts and technologies that must account for UAS. This topic, too, is addressed further in this paper.

- **Crew licensing.** Does a UAV pilot need a licence different from that for a manned aircraft? The question is clearly fundamental to the design of equipment, as the UAV pilot may have no direct physical connection to the controls. Training for such a role is therefore potentially very different as the UAV pilot, rather than being trained in the physical skills of flying, will need to demonstrate competence in understanding displayed information, especially if there is no feedback from the aircraft. His systems could also be quite different, eg coping with the potential lag in datalinks. In the ‘File and Fly’ context, the difference between manned and unmanned flying could be expressed as:
'The traditional pilot must learn how to fly; the UAV pilot must learn how to let the machine fly'.

Such legislation clearly applies to other crew members, eg is there a need to licence ground maintainers to rectify faults on a ground control system that is in use, but which has suffered a failure? Would this be an equivalent to the flight engineer, and require different licensing?

Progress to date.

Air Traffic Insertion studies have been commissioned to define general concepts, in particular EDA studies Air4All, Air4All extension, the E4U study by European Research Centres, and FAS4Europe. The UK has also commissioned ASTRAEA, NATO is developing airworthiness STANAGs 4671 (fixed wing UAS), 4702 (rotary wing UAS), and 4703 (light UAS), and European nations are preparing specifications (eg UK, France, Germany, etc). However, there is presently no usable civil CS. EASA has produced a policy paper (EY-101, 2009), JARUS EASA and FAA are holding discussions at government level, and EUROCAE WG 73 progress is slow because of limited and not funded resources. None of this constitutes a code for certification. Regarding the authorisation to operate and the sense and avoid issue, both EDA’s MIDCAS and UK’s ASTRAEA are ongoing, EUROCAE WG-73 has a focus team and NATO is exploring the issue from a defence perspective. The EDA SIGAT project has addressed radio-frequency management. Finally, there is some crew licensing work through DUO STANAG 4670, WG-73 and JARUS. The main studies conducted by European industry are summarised at Appendix 1.

There is, of course much work in other parts of the World, particularly the USA. The following list is not exhaustive:

- The FAA has mandated the RTCA to form a specific group on the UAS (SC-203)
- The FAA has defined a Roadmap for Civil/Public UAS in the 2010-2020 timeframe identifying all issues related to the introduction of UAS both into the current US National Air Space (NAS) and into the future NAS fitted with Next Gen
- The FAA is organizing specific workshops on the Sense And Avoid (SAA) issue
- The US DoD has been conducting many R&D studies and demonstrations on the concept of SAA using airborne EO/IR, radar sensors and T-CAS
- The FAA is experimenting with a concept of Ground Based Sense And Avoid (GBSAA) based on the use of ground radars
- The FAA is experimenting with the use of a certified Flight Management System in a medium size UAS

Recommendations for Air Traffic Insertion in Europe

European industry already supports actions as a way forward for Air Traffic Insertion of UAS in Europe and strongly recommends the following:

- Urgently establish a pan-European, joint civil and military schedule of funded activities to capture and define a single, common framework of defence, security and commercial legislation. The Commission, charged with responsibility for defining the framework against which individual products will be assessed, must drive this work forward with utmost urgency, supported by stakeholders from industry, national institutions, regulators, research and academia, as appropriate.
- Develop a step by step strategic plan of studies and demonstrators, as defined in the Air4All report and consistent with the FAS4Europe and E4U studies, to underpin the preparation of standards. Studies will define requirements. Proofs of concept will be validated by demonstrators. Standards must be defined through the support of demonstrations.
• Promote a schedule of work under the Framework Programme to develop new UAS technologies, meeting critical needs. This programme should capitalise on projects like MIDCAS for detect and avoid in all classes of airspace and for all sizes of UAS. It should also experiment with new technologies and standards such as: GBSAA, Advanced Flight Management and Navigation, Communications, VLOS and BLOS data links …

• The above work must be aligned with SESAR (see below).
The Role of Standards

Civil aviation, and particularly the manufacturing community supporting the industry, are well used to working within a set of standards. In Europe, these are developed by EUROCAE, under EC mandate, and in the USA by RTCA under FAA direction. The standards are broadly grouped as MOPS and MASPS, defining performance and functional requirements, and TSO/ETSO, which define equipment interoperability and airworthiness standards for certification. Military standards are typically defined by nations and harmonised through NATO as STANAGS for interoperability. Some nations tend to lead the definition of military standards.

There is clearly a need to develop new standards for UAS to cope with the emerging specific requirements for such matters as: concept of operation, flight envelopes, safety objectives, system architecture, introduction of new systems and equipment. These could all diverge from the needs of manned aircraft and their support systems. To mitigate the effects of individual European nations each developing their own standards, Industry needs European leadership and support to quickly put such standards in place and allow competitive product development.

Progress to date.

EUROCAE WG-73 and RTCA SC-203 are developing MPS and MASPS, with first deliveries expected in 2013. However, progress is slow as it is based on voluntary attendance and work by both industry and the Authorities. Of greater concern is the lack of participation by users. They cannot see the potential market applications or products emerging in the near term because the market is closed. There is therefore no market pressure to proactively develop the required standards, even though many users recognise the significant benefits they could gain from UAS, if they were available.

For the military, NATO has already issued standards on interoperability (STANAG 4586), on data links (STANAG 4660) and on Air Traffic Insertion.

Recommendations For Standards

Industry has already started working towards strategies for preparing standards, but needs a central focus in Europe:

- Develop Air Traffic Management CONOPS for UAS, based on a strategy of incremental access to non-segregated airspace, ie develop CONOPS for the simplest case (Class A, B and C airspace) and progressively expand that to full Class G airspace as experience and technology progresses.

- Fund the joint definition of standards by industry and stakeholders. For military and state UAS, this could adopt the MIDCAS approach, ie define functional and performance standards through study, followed by a technology demonstrator to validate the standard. For civil UAS standards, industry should be funded to support EUROCAE WG-73, with mandated and funded participation of EASA and Eurocontrol and with some form of motivation to engage users in the process.

- Harmonise civil and military standards to avoid duplication, discrepancies and fractionising of the market between different market users (e.g. civil and military).
**Evolving International Regulation**

The regulations and standards covering all aspects of international civil aviation are defined in annexes to the Chicago Convention as Standards and Recommended Practices (SARPs) and Procedures for Air Navigation Services (PANS). Without these SARPs and PANS, national and regional authorities, eg the FAA, EASA and Eurocontrol, cannot define their own regulation set. The existing guidance, defined for manned aircraft, will need interpretation and change to address the unique characteristics of UAS before they are allowed to fly in civil airspace. Furthermore, although the ICAO Annexes are valid only for civil aircraft and state aircraft are exempted, state aircraft need to comply to the ICAO rules in order to get unlimited access to European airspace.

**Progress to date**

ICAO formed the Unmanned Aircraft System Study Group (UASSG) in November 2007 to provide suitable guidance, and issued Circular 328 formally in early 2011 as the first deliverable. Further subgroups were established to adapt existing guidance in a number of areas, including: airworthiness, operations, personnel licensing, special authorisations, detect and avoid, and communications.

ICAO has set the ambitious target of publishing a complete set of documents by 2015 and has already published some proposals (eg for for Annexes 2 and 7). However, there is still much to do and, to meet the proposed deadline, ICAO has requested support from other organisations. Industry has already offered some support. Any delay in the publication of this guidance will result in a delay for UAS ATI. The work of the ICAO UASSG is fundamental to progressing UAS air traffic insertion and must be given the highest priority. This is therefore one of the most important tasks to be considered.

**Recommendations**

Industry recommends that the Commission explores options to fund support to ICAO from stakeholder organisations in Europe, i.e. EASA, the national Civil Aviation Authorities, and Eurocontrol. Given that the standards are affected by current and evolving technologies, the Commission should make provision for those authorities to acquire industrial technical support from industry.
Evolving Air Traffic Management Systems

Both European and North American airspace operating authorities recognise that there is a need for significant change in Air Traffic Management in the next 10 to 15 years. This change will be delivered by SESAR in Europe and NextGen in the USA. Although different, both programmes are driven by similar objectives to cater for the rapidly increasing volume of traffic (threefold), the need for increased levels of safety (a factor of 10), and an imperative to reduce both costs (by 50%) and environmental impact (by 10%).

These targets will be met through a variety of innovative concepts including: 4D trajectory management, collaborative planning and decision making, optimised civil/military cooperation and communications standards (e.g. datalinks), increased situation awareness, flexible voice and data communications, networked aircraft using SWIM (System-Wide Information Management), ADSB-IN and OUT, ASAS self-separation modes, T-CAS for all aircraft, etc.

The programmes are aimed primarily at commercial air transport operations but do include other airspace users such as general aviation, commercial helicopters, and military aircraft. Inevitably the characteristics of manned aircraft will be considered as these concepts are delivered, and arguably, the same prominence should be given to UAS, which will already be operating in the airspace when the programmes are introduced. NextGen included UAS from the outset, while SESAR is considering UAS as future potential users of the airspace.

Progress to date

Progress to date has been limited to an EC Framework Programme research contract called INOUi that ran from 2007 to 2010 and explored UAS ATM concepts and architectures, common operating picture, certification and safety, and new aerodrome concepts. However, it is clear that there is a lack of information exchange between SESAR and the UAS industry. UAS are presently focussed on military applications, with limited connections with SESAR, and SESAR concepts focus on the manned platform, with limited interest in UAS. There is very limited engagement between the 2 communities.

Recommendations

It is essential that the level of interchange between SESAR and the UAS community is increased significantly if UAS are not to be hampered by emerging regulations aimed at, and developed specifically for, manned platforms. Industry therefore recommends:

- That UAS should have equal priority with manned platforms when designing the future SESAR airspace likely to be used by both types of platform: a specific UAS CONOPS must be developed for SESAR.
- A programme of joint study activities, based on the output from INOUi, Air4All and MIDCAS, to bring UAS to the same standing as manned platforms in the future SESAR airspace. This programme should also identify the benefits for the Single Sky programme.
- A programme of joint studies and experiments to assess the benefits of new SESAR technology for UAS ATI. This might include developments in: navigation, communications and surveillance in non-segregated airspace; separation modes (self-separation using ADS-B and ASAS), conflict management and collision detection (both cooperative and non-cooperative); collaborative planning over the SESAR data link and airport operations.
Radio Frequency Management

UAS systems include a vehicle and a set of payloads, both controlled from the ground over a set of data-links. Safe and reliable communications are a key driver for UAS ATI, particularly in non-segregated airspace, and loss of a data-link is a critical failure for a UAS. This demands adequate redundancy and protection against jamming or spoofing in the system design. Two types of data-link are typically used, comprising:

- A Command & Control link for the vehicle (C2 data-link) with, typically, a medium data rate, in the order of 10 Kb/s. Loss of this link would directly affect vehicle safety.
- A Command & Control link for the payloads (mission or Payload data-link). This data-link typically operates at much higher data rates, in the order of 10 – 100 Mb/s for downloading large volumes of mission data. These much larger download rates are more demanding on frequency spectrum. Loss of this link would directly affect mission performance.

With UAS emerging onto a market that already faces critical pressures on the use of spectrum, they face severe pressure in finding sufficient spectrum for their activities. Access to this scarce resource has become a critical issue, especially for air operations, with their attendant safety concerns and reliance on available, reliable, high-integrity spectrum, free from harmful interference.

At an international level, radio-frequency (RF) allocation and spectrum management are regulated by the International Telecommunications Union (ITU) who holds a month-long conference every 3 ~ 4 years to control the allocation of spectrum. The next World Radiocommunications Conference (WRC) is in 2012 and one agenda item will be dedicated to spectrum required for UAS C2, Air Traffic exchanges, and Sense and Avoid systems. Access to suitable spectrum is of absolute importance for UAS operations, if no spectrum is available, UAS will simply not exist.

Progress to date

Preparation for WRC12 is taking place through a series of regional meetings that, for Europe, is led by the Conference Europeenne des Postes et des Telecommunications (CEPT). This will not include mission data link requirements for spectrum, which possibly will be addressed at a later conference. In the meantime, nations will allocate spectrum for this task from current allocation.

The most important contributor to this activity is the ITU-R process, but there are others: the convergence on military LOS solutions under STANAG 4660, the EDA SIGAT study, the EASA study on the safety of communications for UAS, the EDA/ESA study on SATCOM solutions for UAS, and the communications work within ASTRAEA. These studies and activities are described in more detail in Appendix 1.

Recommendations

Industry recommends that a European initiative:

- Supports preparation for future WRCs (2012 and beyond) on spectrum allocation.
- Funds technical studies/demonstrations for proof of concept and to provide solutions that reduce spectrum use and relax requirements on data links.
- Funds a ‘follow-on’ study to SIGAT to support future studies in spectrum allocation and optimisation and to support future European positions.
- Launches studies and demonstrations, as part of the EFC, on future SATCOM architectures, terrestrial end-to-end architectures, communication system integration, autonomy …
- Prepares provision of adequate SATCOM services at satellite and terrestrial level.
- Addresses the implications of potential new UAS technologies on spectrum use.
- Ensures that this work-strand is coherent with SESAR.
Conclusions

Air Traffic Insertion and Radio-Frequency Management are key issues for the development of the civil UAS market. This is particularly true in Europe, which is facing high air traffic densities both enroute and in TMAs. The development of adequate procedures, standards and technologies is essential and must take account of the evolving technical and regulatory environment generated by both UAS and future ATM systems in Europe (SESAR) and abroad (NextGen).

Solutions to these issues are complex and demand considerable effort. Even if some key work strands have been launched, there is much still to be done and European Industry is keen to contribute actively through technical studies, research and development, developing standards, and experimenting on demonstrators. Its main recommendations are the following:

- Organize a pan-European, Civil and Defence framework with adequate funding through a Joint UAS Programme covering the needs of Defence, Security and Commercial sectors.
- Develop a UAS roadmap of studies and demonstrators, as defined in the Air4All report and supported by the FAS4Europe and E4U studies.
- Develop and experiment with potential new technologies needed for UAS, while capitalizing on results from ongoing studies.
- Develop ATM CONOPS for UAS, based on incremental access to non-segregated airspace.
- Fund the development of Standards in a joint process between Industry and stakeholders.
- Harmonize research activities between military (NATO, EDA) and civil (EUROCAE, EASA, EUROCONTROL) authorities to avoid duplication or omission.
- Support the work of specific working groups: ICAO UASSG, EUROCAE WG 73 etc…
- Increase awareness and information exchange between SESAR and UAS experts through joint studies.
- Capitalize on INOUI, Air4All and MIDCAS conclusions to define how UAS operations can be integrated into SESAR airspace and identify their potential benefits to the Single Sky programme.
- Fund studies and experiments to assess the potential benefits of new technologies, being developed in SESAR, for UAS Air Traffic Insertion.
- Support the preparation of future WRCs (2012 and beyond) on spectrum allocation.
- Perform technical studies / demonstrations to provide solutions reducing spectrum requirements (spectrum will more an more become a scarce resource).
- Prepare implementation of future Satcom Services at satellite and terrestrial levels.
Appendix 1 – Synopsis of EDA Studies

Air4All & Air4All extension

As UAS have emerged as the next evolutionary step in aviation, it was widely recognised that the potential existed for this capability to contribute significantly to Europe’s security and Defence missions. However, whilst the military had been successfully using UAS for some time, it had not been possible to exploit state or indeed commercial operational requirements, mainly due to certification and qualification issues. The key barrier was the ability for UAS to integrate routinely with other airspace users, both at the national level and across international boundaries. EDA commissioned on EDA Operational Budget a series of studies to determine the key barriers and challenges to developing a regulatory framework thus enabling the insertion of UAS into non-segregated airspace. The Air4All consortium was formed from the major European defence aviation companies who developed a Roadmap and Implementation Plan 1. Further work was commissioned to supplement the findings of the original study and strengthen the support for the Roadmap concept with Member States (MS) 2.

Under both studies, key stakeholders were central to developing the material including regulators, government authorities, operators ATM providers and research agencies. It was widely agreed that for full exploitation of UAS into all sectors, operations at all flight levels in controlled and uncontrolled airspace were required. Therefore, a consolidated view of the priority barriers and challenges was obtained. In addition, the current rules for manned aviation were analysed for their impact on UAS; furthermore, the team determined that the regulatory framework needed to be compatible with managing the safety requirements between the system’s components. Four key barriers were identified: technical, rules and regulations, procedures and training and transversal issues. Against each barrier, a series of challenges were identified as specific enablers required to break through the barriers. From this analysis, a Roadmap was created on the understanding that not all challenges would be achieved in one step. Consequently, the route to traffic insertion was divided up into increasingly challenging steps based around different classes of airspace and the relative difficulty of operating in them.

The initial study also proposed an Implementation Plan for the Roadmap and included key milestones, a schedule of activities and capability demonstrations, together with some outline costs and a suggested management plan.

The Follow on Study specifically focussed on the likely missions and scenarios that MS

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<td>Fly experimental UAS within national borders in segregated airspace (regular, at short timescale) - overflown sparse population</td>
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<td>Fly a state UAS as IFR and VFR traffic across national borders, routinely in non-controlled airspace (airspace classes A, B, C, D, E, F, G)</td>
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Figure 1 - Air4All Roadmap

1 EDA Project “UAS Insertion into General Air Traffic”. Reference 07-ARM-001
2 EDA Project “UAS Insertion into General Air Traffic Follow On Contract, Reference 08-ARM005

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envisaged for UAS deployment and how these requirements could refine the Roadmap. In addition, the Air4All team looked more closely at some specific areas: Flight Crew Licensing, Human Factors in the development of the Ground Control Station, and Visual Flight Rule operations. The Study made a series of operational, regulatory and technical recommendations to EDA.

**MIDCAS**

The MIDCAS mission is to “demonstrate the baseline of solutions for the Unmanned Aircraft System Mid-air Collision Avoidance Function” acceptable by the manned aviation community and being compatible with UAS operations in non-segregated airspace by 2015 in all classes of airspace.

This EDA project led by Sweden and Saab has gathered the majority of European initiatives on sense and avoid into a joint effort to arrive at a standardized solution agreed throughout Europe. The project builds on sense, fusion and avoid technologies established e.g. within the partners organizations.

The 4 year, 50 M€ project includes research and demonstration in simulators, manned aircraft and finally in an UAS. The iterative approach of the project includes standardization support with contribution to standardization bodies, organization of workshops as well as a stakeholder group.

The MidCAS project will deliver:

- A functional design for a future Sense & Avoid product
- A S&A simulator and a demonstrator
- Flight tests on manned and unmanned aircraft
- Support to progress Standardization

MidCAS is contracted by EDA as an “Ad Hoc” project funded by Sweden, France, Germany, Italy and Spain. The consortium is composed of the Industry and Research Institute partners from the five participating nations:

- For Sweden: SAAB (coordinator of the consortium)
- For Germany: Diehl BGT Defence GmbH & Co. KG, Deutsches Zentrum für Luft- und Raumfahrt e.V., Cassidian EADS Deutschland GmbH, ESG Elektroniksystem- und Logistik-GmbH
- For France: Sagem Défense Sécurité, THALES Systèmes Aéroportés S.A.
- For Spain: Indra Sistemas S.A

Current MIDCAS status include following typical considerations:

- **UAS Flight in classes A – C in IFR conditions**
  - Separation is ensured by ATC
  - Collision Avoidance can be achieved using detection from cooperative sensors
  - Compatibility with T-CAS if fitted on manned intruder

- **Flights in other classes, including uncontrolled airspace (F-G):**
  - Self-Separation using ATC information when available and/or using ADS-B and/or using fusion data from both cooperative and non cooperative sensors
Collision Avoidance using fusion data from both cooperative and non-cooperative sensors

Compatibility with T-CAS if fitted on manned intruder

EDA/ESA Satcom Study

UAS are crucial for the future of European military environment and are becoming increasingly important for global security and civil, commercial applications. The main drivers are reduced costs, improved safety, and more sustained/persistent surveillance.

In this context, satellite communications (Satcom) can provide a flexible infrastructure for UAS operations and even multi-missions capability (i.e. the same UAS could be used for a range of applications, customers and locations)

- Satellite communications enable an ‘always-on’ communications capability to all flight levels over a wide area.
- A Satcom C2 function allows the remote pilot to be based at a mission independent central location.
- A Satcom payload data return capability can provide nearly real-time access to mission data.
- In addition space-based navigation (i.e. GNSS) may be the only option for accurate navigation where terrestrial infrastructure is limited or non-existent.

In order to address this issue ESA&EDA have initiated two synchronized feasibility studies with the same statement of work, the EDA 09-ARM-007 (lead by EADS) and the ESA ITT-1-6118/09/NL/CLP (lead by INDRA), to investigate whether it is possible to demonstrate these technical challenges, as well providing insight to the viability of sustainable UAS services supported by space systems.

Two phases are foreseen:

- Phase 1: Feasibility Study
- Phase 2: Full scale Demonstration(s)

The main tasks performed within the Phase 1 studies have been the following:

- Review of military, state and civil Customer’s needs related to the use of Satcom for remote control of UASs within non-segregated airspace,
- Identification of candidate UAS Systems, infrastructure and associated Satcom services able to be demonstrated in Phase 2 – Demonstration
- Detailed description of potential Demonstration Mission(s),
- Battlelab simulations of the selected Mission,
- Demonstration Plan and evaluation Framework,
- Viability Analysis and Roadmap (beyond the Demonstration).

Phase 2 (Demonstration phase) is expected to be launched by EDA/ESA end of 2011-beginning of 2012.

**ESA (ARTES 1) "ESPRIT" study on emerging system concepts for UAS C2 via satellite**

As stated at the beginning of this paper, as of today, UAS are operated exclusively in so-called “segregated airspace” where they do not interfere with non-military aircraft. However, in the near future, both civil and military UAS applications will require UAS to fly “non-
segregated” airspace. Such flights will require their insertion into the air traffic with an equivalent level of safety to manned aircraft.

To achieve such high levels of safety, the UAS will have to rely on secure and redundant communication links with their control centers, to exchange C² data, as well as Sense & Avoid (S&A) data and Air Traffic Management (ATM) data. To implement these secured real-time data transfers, the UAS will have to get access to appropriate portions of the spectrum for both satellite and terrestrial communications. The allocation of bandwidth for such services will be discussed at the next World Radio Communications Conference (WRC12) on behalf of the International Telecommunications Union (ITU) in January/February 2012.

The ESA objective, through the ESPRIT study (the ESA-ITT/1-6553/10/NL/NR, lead by Thales Alenia Space) is to focus on the provision of communication capacity for Command & Control (C²) links to UAS flying through civilian airspace. The aim is to study solutions at both spectrum and system levels.

**FAS4Europe**

The objective for the EDA launched FAS4Europe (Future Air System for Europe) study is to identify the required key industrial capabilities (technologies, processes and skills) in order to enable Europe access to cost effective sovereign Air power solutions in strategic areas up to the 2035 timeframe. The study has also prepared an initial roadmap and proposed appropriate actions in order to start the implementation of the roadmap.

The position of the FAS4Europe study at this time, not yet finally reported, is that future European UAS programs (including VTOL, fixed wing, MALE and UCAS) are key components. The study also recognizes the importance of UAS traffic insertion as suggested by Air4All as an important enabler for the full utilization of UAS. The FAS4Europe study has been performed in parallel with the UAS panel initiative; hence it has assumed that the roadmap for implementation and corresponding initiatives will reside with the outcome of the UAS Panel.

The study is led by Saab and includes 40 European aerospace actors including major industries, institutes and universities.

**ASTRAEA**

The UK Autonomous Systems Technology Related Airborne Evaluation and Assessment (ASTRAEA) programme was established in 2007 in recognition of the potential societal and industrial benefits that will accrue from the civil use of UAS. Funded jointly by government grants and Industry, it is taking a total systems approach to the problem of inserting UAS into non-segregated airspace. From the start it was recognised that there was a need for parallel activities on the maturation of technology and the development of UAS regulations which will come together in synthetic and practical demonstrations. The aim is for the regulator and industry stakeholders to explore the issues and to come to a common understanding of what is required to enable safe, routine flights of UAS and thereby open up a new market. The programme is adopting a novel virtual certification approach in which a generic architecture is developed by the partners together with operational assumptions and concepts which are then used as the basis for discussions with the regulator. Solutions for the on-board sense and avoid, autonomy, communications systems and human systems interfaces are then being developed taking into account this engagement. In addition, the programme is soliciting input from early and potential users of UAS to ensure that the operational concepts under study are consistent with the business models of the commercial entities who would take advantage of the opening of airspace to UAS. The output of the programme in 2013 will be a route to certification plan, a strategy of how to achieve this, suggested adaptations of regulations and potential technology solutions.

ASTRAEA is funded by the Industrial partners (AOS, BAE Systems, Cassidian, Cobham, QinetiQ, Rolls-Royce and Thales), the Technology Strategy Board, North West Development Agency, South East England Development Agency, Scottish Enterprise, South West Regional Development Agency and the Welsh Government.
ITU-R Process: Preparation of WRC-12 on harmonized frequency bands for UAS

The consideration of associated globally harmonized frequency bands for UAS is the scope of World Radio communication Conference 2012 (WRC-12) agenda item 1.3, the objective of which is “to consider spectrum requirements and possible regulatory actions, including allocations, in order to support the safe operation of unmanned aircraft systems (UAS), based on the results of ITU-R studies, in accordance with Resolution 421”. WRC-12 will take place in Geneva from 23 January to 17 February 2012.

Studies undertaken within ITU-R on WRC-12 agenda item 1.3

An important milestone on the path to WRC-12 was the Conference Preparatory Meeting (CPM), held in Geneva from 14 to 25 February 2011, which provided in its report an exhaustive overview of all technical and regulatory methods proposed internationally that can possibly answer the agenda item 1.3 problem. Main outcomes are recalled here.

- Spectrum requirements: deployment of UAV in non-segregated airspace will require access to both satellite and terrestrial spectrum, with a maximum estimated amount of 56 MHz for the satellite component and 34 MHz for the terrestrial component. These figures are based on an estimation of the number of UAV in 2030, on the detailed study of the data rate needed for a single UAV depending on its size (small, medium or large), and on specific terrestrial and satellite architectures. Regarding the Sense & Avoid function, studies have shown that existing allocations to the Aeronautical Radio navigation Service are sufficient to accommodate the spectrum needs.

- Type of spectrum needed: the integration of UAV in air traffic relates to “safety of flight”, and associated terrestrial and satellite communication links will have to comply with international aeronautical standards developed by the International Civil Aviation Organization (ICAO). Today’s ICAO position is to require the use of terrestrial and satellite frequency bands explicitly reserved for communications relating to safety of flight, i.e. allocated to the Aeronautical Mobile (Route) Service (AM(R)S) or to the Aeronautical Mobile Satellite (Route) Service (AMS(R)S). For the satellite component, others propose the use of generic Mobile Satellite Service (MSS), Aeronautical Mobile Satellite Service (AMSS) or Fixed Satellite Service (FSS) frequency bands, depending on the feasibility to extend to non-segregated airspace what is done today in segregated airspace while answering safety requirements.

- Method for the terrestrial component: the terrestrial component addresses the case of Line of Sight communications between the Vehicle and the Control Station. One method (ie Solution) has been identified by the CPM, which consists in a new AM(R)S allocation in all or portions of the band 5 000-5 150 MHz or/and 15.4-15.5 GHz. Sharing studies in the band 5 030-5 091 MHz are more mature than in other bands, with positive conclusions regarding the compatibility in this range with existing systems (MLS) and with the satellite component. Some countries have also identified the possibility to use part of the band 960-1164 MHz, which includes an AM(R)S allocation. This would be limited to certain countries/regions and to certain types of UAV.

- Methods for the satellite component: the case of the satellite component is more complex, due to the type of spectrum needed, and to the differentiation between the 2 links from the satellite. Five methods, named A1 to A5, have been identified by the CPM. They consider either AMS(R)S, MSS or FSS possibilities. Most of them propose the use of existing allocations, which is the most probable conclusion. The bands to be used will be discussed and could be agreed upon between the Regions during the Conference.

- Alternative method for the terrestrial and satellite components: some countries were of the opinion that studies would not be completed in time for WRC-12 to take a decision, and that all studies in any given frequency band should be conducted before a decision. This might lead to postponing the issues to next WRC in 2015 or 2016.
European positions on WRC-12 agenda item 1.3

European positions to WRC-12 are defined in the framework of the Conference Europeenne des Postes et des Telecommunications (CEPT). The European Common Proposal on agenda item 1.3 will be finalised in November 2011, and submitted as input to WRC-12 on behalf of all 48 CEPT countries. Some aspects of the position still have to be refined at the light of certain studies, but its main points are the following:

- For the satellite component, CEPT supports method A2, and is of the view that there are enough frequency bands to accommodate the spectrum requirement, and that no change is required to the Radio Regulations. Indeed, studies have shown that the satellite spectrum requirement can be fulfilled in existing AMS(R)S allocations (L band for ATI early phase, and 5GHz for the longer term), and MSS/AMSS are also available in case ICAO eventually modifies its position.

- For the terrestrial component, CEPT supports the use of AM(R)S spectrum and considers that there is a lack of corresponding allocation. Due to intensive usage of the band 960-1164 MHz in Europe, it does not support this frequency band for the terrestrial component. The band 5030-5091 MHz is the main target for a new AM(R)S allocation, with regulatory and technical considerations related to the protection of existing services (including AMS(R)S). The band 5000-5010 MHz is also considered, but is allocated to the Radio Navigation Satellite Service and would require an agreement from Galileo. The range 15.4-15.5 GHz is also retained at this stage, but with little chance to be eventually retained.

NATO Stanag 4660

For the purpose of harmonization and interoperation, NATO is developing a STANAG 4660 related to the Command and Control data link of UAV when in visibility of the UACS (Line of Sight situation).

Studies undertaken within NATO

During the last few years, alongside STANAG 4660 effort, several NIAG studies have launched to make progress on waveform definition adapted to UAV control and command in LOS conditions.

The output of the NIAG SG 140 is a consensus involving 34 industrial companies to identify the lower layers of communication and the preferred frequency bands nation by nation

Frequency band

Among preferred frequency bands, the 4400-4990 MHz NATO type 1 band is of particular interest.

With such a situation, military UAV LOS C2 within 4400-4990 MHz and civil UAV air traffic insertion LOS C2 within 5 030-5 091 MHz which appears to be the most probable for a new AM(R)S allocation under the WRC-12 Agenda Item 1.3, a single airborne terminal can be used leading to an optimum technical solution.

In consequence, Nations are encouraged to adopt 4400-4990 MHz band for UAV LOS C2 under STANAG 4660.

SIGAT

This study was performed under EDA Contract from January 2009 to May 2010 by a large consortium of 23 companies from 9 countries led by Thales, set up in order to:

- Gather expertise in radio spectrum regulation and technologies, UAS System Architecture, integration and operations, UAS Data-Links, Airworthiness, Safety and Certification: Co-contractor (yellow) and Sub-contractors (green).
SIGAT objectives were to study, identify and synthesise European Military interests in frequency spectrum requirements needed for insertion of UAS in GAT within the framework of the next “World Radio-communication Conference” (WRC-2012).

After agreeing scenarios and taking airworthiness and security aspects into account, the SIGAT study concluded with the following spectrum requirements that can be partly compared to ITU-R:

<table>
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<tr>
<th>UAS in non segregated airspaces in 2020</th>
<th>Functions related to safety in non segregated airspace</th>
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<tr>
<td></td>
<td>C² LOS</td>
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<tr>
<td>SIGAT estimate</td>
<td>15 MHz</td>
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<tr>
<td>(Military UAS)</td>
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<tr>
<td>ITU-R estimate</td>
<td>34 MHz</td>
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<tr>
<td>(UAS including Military)</td>
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SIGAT proposed four possible options on frequency spectrum needs with associated levels of difficulty, performance and timeframe. The four options considered either existing civil aeronautic bands complying with ICAO safety of flight requirements (AM(R)S and AMS(R)S), or existing commercial bands (MSS).

SIGAT recommendations for WRC12 preparation were:

- To support WRC-12 in provisioning 34 MHz (LOS) and 56 MHz (SAT) of specific aeronautic bands complying with ICAO Safety of flight requirements
- To consider how to convince ICAO to potentially change its safety of flight requirements in order to use commercial bands
- To support Eurocontrol (and others) to harmonise efforts in order to fly military UAS in non segregated airspace as OAT in the short term (<2015) and GAT beyond, while civil UAS would have to fly as GAT

**EASA Study on the Safety of Communications for Unmanned Aircraft Systems (UAS)**

EASA has contracted a study in 2009 to identify potential solutions for data link communications
The communications architectures required to fully integrate UAS into the Air Traffic Management (ATM) environment will form the foundation upon which many technologies, systems and operational procedures will be based. There are many architecture options available and acceptable but no single, obvious solution. The objective of the study conducted by QinetiQ was to explore these options and provide an initial input and guidance for the Regulatory Impact Assessment (RIA) process. The analysis showed that two architectures were the most beneficial when considering factors such as safety, economy, social, electromagnetic spectrum, Global interoperability and EU Regulation.