International Council of the Aeronautical Sciences

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"UAV-Airworthiness, certification and access to the airspace"

ICAS Workshop
Seville, Spain – 24th September, 2007

Summary Report
2007

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REFERENCES/PRESENTATIONS

The following presentations from the workshop will be available on the ICAS Web-site:

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Bruce Tarbert, FAA NAS Integration Lead, UAPO

REF 2: NATO Developments in UAS Airworthiness and Sense/Avoid Functional requirements
Dave Seagle US HoD, NATO FINAS

REF 3: Responding to standardisation challenges of the future air transport system
Dewar Donnithorne-Tait Secretary WG-73 UAS

REF 4: Unmanned Aircraft Systems Pan-European ATM Network Integration
Holger Matthiesen, EUROCONTROL

REF 5: Autonomous Systems Technology Related Airborne Evaluation and Assessment (ASTRAEA) – UK access to airspace programme
Lambert-Dopping Hepenstal, BAE SYSTEMS, UK

REF 6: OUTCAST - Operation of UAVs: Transition to Civil Air Space and Traffic environments
Michiel Selier, NLR, NL

REF 7: Swedish industry efforts to increase UAV usability by progressing traffic insertion of UAVs
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REF 8: Flapless Air Vehicle Integrated Interdisciplinary Research (FLAVIIR)
Dr. Clyde Warsop, BAE SYSTEMS, UK

REF 9: HADA (Helicopter Adaptive Aircraft)
Rafael Pax, Technical Director of ARIES COMPLEX and Manuel Mulero, INTA, Spain

June 2007

Workshop on
"UAV-Airworthiness, certification and access to the airspace".
Seville, Spain, 24th September, 2007

The ICAS Programme Committee, comprising over 50 representatives from the world-wide aeronautical community, will hold a planning meeting in September 2007 in Seville, Spain for the ICAS 2008 Congress in Anchorage, Alaska. Taking advantage of the gathering of this unique group of experienced people, it has been decided to arrange a one-day workshop on the above theme.

The workshop will include presentations by invited speakers as listed below:

Autonomous Systems Technology Related Airborne Evaluation and Assessment (ASTRAEA) –
UK access to airspace programme
Lambert.Dopping-Hepenstal, BAE Systems

Flapless Airvehicle Integrated Interdisciplinary Research (FLAVIIR)
Phil John, Cranfield, UK

FAA View
K. D. Davis, FAA Unmanned Aircraft Program Office, USA

NATO FINAS Working Group,
Dave Seagle, DOD USA, Head of the US Delegation to FINAS

EUROCAE WG 73 progress report (to be confirmed)
Dewar Donnithorn-Tait, AUVSI (UK)

UAS integration in the pan-European ATM Network
Holger Matthiesen, Eurocontrol

Swedish industry efforts to increase UAV usability by progressing traffic insertion of UAVs
Gunnar Holmberg, Saab, Sweden

OUTCAST - Operation of UAVs: Transition to Civil Air Space and Traffic environments
Michiel Selier, NLR, Netherlands

HADA (Helicopter Adaptive Aircraft) - presentation
Rafael Pax, Technical Director of ARIES COMPLEX and Manuel Mulero, INTA, Spain

It is our intention and hope that this workshop will generate creative ideas regarding this key challenge. We plan to document the main findings and conclusions from this event and will make the documentation publicly available on the ICAS Web-site.

It is our pleasure to invite you to take part in this special event. The venue for this event will be Hotel Tryp Macarena, Seville - Spain. More information about the venue, accommodation booking and transportation details will be provided by the ICAS Secretariat.

With best regards

Fred Abbink
ICAS President

Ian Poll
Chairman Programme Committee

Anders Gustafsson
Executive Secretary

Workshop Agenda (Final version)

09:15 Welcome and introductions (Fred Abbink and Ian Poll)

09.30 – 13.00 Morning presentations

09:30 FAA View,
Bruce Tarbert, FAA Unmanned Aircraft Program Office, USA

10:15 NATO Flight in Non-Segregated Airspace (FINAS),
David Seagle, Head of US Delegation to FINAS, DOD, USA

11:00 Coffee

11:30 EUROCAE WG 73 progress report,
Dewar Donnithorn-Tate, AUVSI

12:15 UAS integration in the pan-European ATM Network,
Holger Matthiesen, Eurocontrol

13:00 Lunch

14.00 – 17.00 Afternoon presentations

14:00 Autonomous Systems Technology Related Airborne Evaluation and Assessment (ASTRAEA) - UK access to airspace programme,
Lambert Dopping-Heppenstal, BAE Systems, UK

14:30 OUTCAST - Operation of UAVs: Transition to Civil Air Space and Traffic environments,
Michiel Selier, NLR, NL

15:00 Swedish industry efforts to increase UAV usability by progressing traffic insertion of UAVs, Dr. Gunnar Holmberg, Saab, SE

15:30 Coffee

16:00 Flapless Air Vehicle Integrated Interdisciplinary Research (FLAVIIR),
Dr. Clyde Warsop, BAE Systems, UK

16:30 HADA (Helicopter Adaptive Aircraft)
Rafael Pax, Technical Director of ARIES COMPLEX and Manuel Mulero, INTA, Spain

17:00 Discussion and wrap up (Ian Poll)

17:30 Close

1. UAS Airworthiness, certification and access to the airspace
Bruce Tarbert, FAA NAS Integration Lead, UAPO

Nick Sabitini, Associate Administrator for Aviation Safety,:
"… UAs are part of the future of aviation, and that future is on our doorstep right now. The system is in place today to accommodate the entry of new aircraft into the National Airspace System; this is nothing new for the FAA. It is our day-to-day business."… "The FAA, working closely with the aviation industry, will develop safety standards and operating procedures to ensure their safe integration into the NAS."

What is an Unmanned Air System (UAS)? A UAS is an aircraft. An *Aircraft* means a device that is used or intended to be used for flight in the air (14 CFR § 1.1). 14 CFR § 91.203 requires all civil aircraft to have a current airworthiness certificate. A UAS is not just an airframe – it's a system, including ground control station and communications and control. It must comply with 14 CFR § 91.

Federal Register Notice Feb 13, 2007, describes the current ways to fly in the National Airspace System (NAS). It officially defines UAS an "Aircraft". It provides issuance of a Certificate of Waiver/Authorization and an Experimental Airworthiness Certificate. It clarifies what AC 91-57 is and isn't (Circa 1981), for example model aircraft are for recreational and hobbyist and flown under AMA established guidance. Revising Interim UAS Guidance Reflect 'lessons learned'

The approach to integration of UAS into national airspace is based on "Do no Harm" policy. There must visual observers, either on the ground or in a chase plane, or the UAS must have segregate operations from manned aircraft, for example operations contained to active restrictive, prohibited or warning areas or positive control airspace. ATM concerns must be addressed to ensure that capacity and efficiency is not impacted. Radar is not a sole means of mitigation.

The Cerificate of Authorisation/Waiver (COA) is for public aircraft only. Airworthiness basis is the responsibility of the Public entity. Instrument of Authorisation/Waiver (IAW) established standards and policy (MIL Handbook 516). The application process is managed by Air Traffic and is done online. Aviation Safety reviews application to determine appropriateness of operational mitigations. Approximately 100 COA's were issued last year.

Approval basis for civil aircraft is based on Special Airworthiness Certificate (Experimental). It defines operational limitations and must not be used for compensation or hire (14 CFR § 21.191,193,195). It authorizes use for market share, crew training and R&D.

The policy has been proto-typed in 2007 (Draft Order 8130.UAS). It is now very mature and close to finalizing. 14 certificates have been issued to date with more than eight applications in the queue. The applications are for all types of UAVs with all shapes and sizes.
To determine the feasibility of law enforcements operations in metropolitan areas, experimental tests are conducted in the City of Houston and Miami Dade Police Department. The objective of the test plan is to identify risks associated with non-rural areas, RFI and EMI issues, etc. It is a collaborative effort between operator, manufacturer, and the FAA. The initial operations will most likely be restrictive.

The FAA works in collaboration with Department of Defense, Department of Homeland Security, National Oceanographic & Atmospheric Administration, NASA, Many other US Government Agencies, EUROCAE, EUROCONTROL, RTCA and ICAO.

In the future, the FAA is pursuing a small UAS strategy for which a new policy is needed. A safety analysis is being completed on potential size, speed and location of operation. It will potentially follow a nontraditional certification approach. It will be a collaborative FAA/Industry approach with the establishment of an Aviation Rule Making Committee and various rulemaking activities.

Detect, See and Avoid (DSA) should provide separation assurance, should have a single layer approach, it should involve both cooperative and non-cooperative traffic. The applicable standards are yet to be determined.

With regard to command, control and communications, standards and a regulatory framework has to be developed that includes: communication security, latency concerns, lost link (must be able to integrate with other NAS users), ATC communications, spectrum management, such as bandwidth requirements and allocation and RFI, particularly in metropolitan areas.

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2. NATO Developments in UAS Airworthiness and Sense/Avoid Functional requirements
Dave SeagleUS HoD, NATO FINAS

Missing statement: “To recommend and document NATO-wide guidelines to allow the cross-border operation of unmanned aerial vehicles (UAVs) in non-segregated airspace”

Designated UAV Operator (DUO) requirements: there must be a designated UAV operator with skills listed as subject knowledge areas, task knowledge and task performance. It is tailored to UAV type and role. If the majority ratifies it, it is then promulgated as STANAG 4670.

UAV Systems Airworthiness Requirements (USAR). It applies to fixed wing UAVs with weight between 150 to 20,000 kg. It is based on CS-23 and must comply with minimum airworthiness standards, key component of national standards and ratification ends 1 Nov 07. If the majority agrees it is promulgated as STANAG 4671. The information is in the public domain.

STANAG 4671 is the key to UAV airspace integration. International rules to integrate an aircraft in the airspace. Integration of Military Airworthiness Requirements (e.g MIL-HDBK-516B, JSSGs, STANAG 4671, etc.), Flight Crew Licenses (STANAG 4670 DUO Training Qualifications) and operational requirements “rules of the air” (NATO/Military/FAA/Eurocontrol SAA Requirements).

Why STANAG 4671? *"If a National Certifying Authority states that a UAV System airworthiness is compliant with STANAG 4671 . . . that UAV System should have streamlined approval to fly in the airspace of other NATO countries, if those countries have also ratified this STANAG.” – excerpt.* For US UAVs this streamlines access to NATO non-segregated airspace by clearly defining UAV airworthiness requirements, it provides PMA guidance on minimum airworthiness spec requirements and it provides design guidance to industry and enhances FMS potential. For NATO UAVs to fly in US, it provides minimum airworthiness standard in support of diplomatic clearances and FAA approvals for NATO partner UAVs.

The following issues are not addressed by STANAG 4671 and are subject to other forms of approval by the Certifying Authority:

- Control station security
- Security of the command and control data link from unlawful interference
- Airspace integration and segregation of aircraft
- The competence, training and licensing of UAV crew, maintenance and other staff
- Approval of operating, maintenance and design organizations
- Frequency spectrum allocation
- Noise, emission, and other environmental certification
- Operation of the useful payload (other than its potential to hazard the aircraft),
- Non-deterministic flight (e.g. neural net)
- Sea basing, Supersonic Flight, and carriage/release of stores
- Remote piloting (i.e. direct control of flt surfaces) from an external or internal control box

Sense and Avoid is a key enabling issue for UAS operations; however, derivation of 'sense and avoid' requirements is primarily an operational issue and hence outside the scope of this STANAG. Once the SAA requirements have been clarified, any system designed and installed to achieve these objectives is subject to "installed equipment" requirements.

Why should NATO write SAA Functional Requirements:

"The CAA considers that, until such time as research and development work has been carried out to define potential system concepts and architectures, the parameters that will govern the performance characteristics of a sense and avoid system cannot be identified with any certainty, (and so cannot be agreed)". UK CAP 722, Chap 9.

FINAS view:

- *Access difficult without common SAA standard*
- *"Peg in the ground"*
- *Exploit ATM principles*

ATM Principles for Conflict Management *(Re: ICAO ATM Operational Concept Doc - AN-Conf/11 -WP/4 App.* Conflict management 3 layers:

- Strategic: airspace organisation & management e.g charts, routes, traffic synchronisation.
- Separation provision: tactical process of keeping aircraft apart at (occasionally) prescribed minima (e.g 5 miles, 2000ft), but who is the "separator"? ATC or Aircraft Cdr(UAV Cdr)? Depends on class of airspace and flight rules in force
- Collision avoidance: must activate when separation provision has failed. Last ditch manoeuvre necessary for survival. Applies at all times, in any class of airspace under any flight rules. Independent from separation provision (e.g. TCAS II).

Sense & Avoid System <u>must consider</u> both the separation and collision avoidance function. A common misperception is that a SAA system is an Airborne Collision Avoidance System (ACAS). It is not - the ACAS function is but one element of a SAA system.

FINAS SAA considerations are:

- Separation provision ≡ "*don't scare others"*
  - not all losses of separation result in a MAC
  - separation minima not defined for VFR flight
  - FINAS suggest 500ft vertical & 0.5nm lateral

- Collision Avoidance ≡ "*don't scrape paint"*
  - must be less than separation minima
  - FINAS suggest 350ft vertical & 500ft lateral

To determine the probability of Mid-Air Collision (PMAC) consider the following sequence of events:

- 2 a/c on collision course
- Failure of separation provision function by ATC, or UAV pilot (DUO)
- Failure of collision avoidance function in UAV *and*
- Simultaneous failure of collision avoidance function in other a/c, since both a/c are responsible for collision avoidance

The Probability of Mid-Air Collision ,$P_{MAC} = P_{collision\ course} \times P_{separation\ fail} \times P_{UAV\ Collision\ Avoid\ fail} \times P_{Conflicting\ A/C\ Collision\ Avoidance\ fail}$

This relationship lead us to the Target Levels of Safety (TLOS) and PMAC: TLOS= $P_{collision\ course} \times P_{separation\ fail} \times P_{UAV\ Collision\ Avoid\ fail} \times P_{Conflicting\ A/C\ Collision\ Avoidance\ fail}$

Empirical Data (1995-2004, UK registered GA a/c): average MAC rate = 1.47 collisions/million flt hrs. However, FINAS suggest UAV and CAT collision so undesirable that the TLOS should be 1 x 10-9 collisions/flight hr, primarily to overcome a public concern that UAVs are unreliable and unsafe. Hence, a higher safety target must be set.

Seek And Avoid issues:

- What happens if we assign UAV a finite size?
- Does CPA minima (350ft & 500ft) have an affect
- PMAC expression - *are terms truly independent?*
- MAC rate 10-9 = TLOS - *is this realistic?*
- Ambient probability of collision - 4 x 10-5 – *valid?*
- UAV's concept of operations - *critical*
- VMC and/or IMC operation - *both or just VMC?*
- Where next? ………….*modelling*!

3. Responding to standardisation challenges of the future air transport system
Dewar Donnithorne-Tait Secretary WG-73 UAS

In 1999, following a EUROCONTROL/ NATO workshop, the JAA was requested to consider certification and operational issues for civilian unmanned aircraft. A JAA/EUROCONTROL task force was created leading to the publication of a report in May 2004. Following discussions between the JAA, EASA and EUROCAE, WG-73 was launched in April 2006. EASA is to propose WG-73 as the European UAS expert group that will assist development of airworthiness criteria and Special Conditions to supplement *Policy for Unmanned Aerial Vehicle (UAV) certification* (EASA A-NPA-16/2005).

UAV - Unmanned Aerial Vehicle: Is it or is it not an aircraft?
UA - Unmanned Aircraft. It is clearly an aircraft, hence subject to aircraft regulations and standards.
UAS - Unmanned Aircraft Systems. This terminology adds the control station and other system elements such as Communications Links and Launch and Recovery Elements. WG-73 elected to change its name from UAV to UAS to show that the whole system was being addressed.

More than 600 models of UA are being developed or are in service, many of these are military UAS. Civil and commercial UAS applications include:

- Surveillance. Weather, terrain, maritime, railways, disaster, search & rescue, pipelines, power grids, traffic, sports, crowds, environmental, agriculture, prospecting, wildlife, law enforcement, facility inspection, mapping
- Communications. Broadcasting, signal relay
- Security. Safeguarding of important people, sites, infrastructure
- Cargo and Transport. Mail and packages, hazardous material, animals and, maybe in the future, passengers.

The objectives of WG-73 are:

- Develop a requirements framework that will support civilian UAS airworthiness certification and operational approvals.
- Allows safe operation within non-segregated airspace in a manner compatible with other airspace users.
- Assures compatibility with the existing ATM regulatory framework, existing ATM infrastructures, existing procedures, and without degrading ATM efficiency.

The deliverables requested from the WG-73 are:

- ***Deliverable 1. UAS related elements regarding the Operational Concept***.
  - Provides a preliminary inventory of airworthiness certification and operational approval items to be addressed (Jan 07).
- ***Deliverable 2. Work Plan.***
  - Identifies work packages and timescales to guide the future activities of WG-73. (May 07)
- ***Deliverable 3. A Concept for UAS Airworthiness Certification and Operational Approval in the Context of Non-segregated Airspace.***
  - Will assist development of recommendations and a requirements framework for civilian UAS such that they will operate safely within non-segregated airspace.

- ***Deliverable 4. UAS Command, Control and Communication Systems.***
  - Will define the requirements for command, control and communication systems including autonomous operation.
- ***Deliverable 5. UAS Sense and Avoid Systems.***
  - Will define the functional requirements for sense and avoid systems.
- ***Deliverable 6. Catalogue of UAS ATM Incompatibility Issues.***
  - Will identify those aspects of UAS normal and abnormal operations that would require special ATM consideration.
  - Will identify potential technical and operational solutions that could assist ATM compatibility development.

In January 2007, WG-73 completed its first deliverable, a report entitled ***UAS related elements regarding the Operational Concept***. The report provides a preliminary inventory of airworthiness certification and operational approval items which need to be addressed. The inventory was derived from a review of the *JAA/EUROCONTROL UAV Task-Force Final Report*, May 2004, other existing and relevant documents, and taking account of the current regulatory context.

Some of the main issues reported are:

- An ITU allocation of radio spectrum is needed to support safe civilian UAS operation in non-segregated airspace.
- For this purpose, information needs to be obtained about civilian UAS communication characteristics which involve command, control, UA flight and system monitoring, and relay of air traffic communications.
- WG-73 is supporting ICAO, EUROCONTROL, FAA and RTCA in a team effort to develop a technical case to support a bid for UAS spectrum allocation at the 2011 World Radio Conference. **This bid will require concerted international support if it is to succeed.**
- Many types of UAS could be available with a large variation in weight, size, performance, and means of control.
- UAS Type Certification categories and safety targets need to be defined with related certification requirements.
- Generic Special Conditions & Interpretive materials to be recommended for specific issues: e.g. UAS Safety Assessment, Command and Control, Control Station, Automatic Take-off & Landing.
- Applications from potential UAS operators are likely to be received by the responsible authority of the State of the operator.
- Many different types of operation can be expected.
- Operational categories will need to be defined for which related conditions for operating approval can be published.
- UAS operating certificates can be granted to operators that demonstrate ability to comply with the operating conditions.
- There can be a trade-off between the autonomous capability of the UA and the capacity of the flight control data link.
- Issues include:
  - the degree of autonomy of the UA
  - compatibility with the evolving ATM
  - the capacity, integrity, redundancy and security of flight control data links
  - application of EUROCAE ED-78A and the means of compliance for certification
  - control station human-machine interface
  - data synchronisation at control station handover (normal and abnormal conditions)
  - support tools for mission planning
  - and personnel training and qualification

- *'See and avoid'* is a **principle** (ICAO Annex 2) whereas separation assurance (with traffic or with terrain) and collision avoidance (with traffic or with terrain) are **functions**.
- The separation assurance function is, in some cases, the responsibility of ATC (IFR/IFR in class A to E for example), in others, the responsibility of the pilot using the *‘see and avoid’* **principle** and applying the right-of-way **rules.**
- These functions are presently achieved in manned aviation through the sensing by pilot's eyes and through other sensors not referred to in the *'see and avoid'* principle (ATC radar and ADS-B for traffic separation, ACAS for traffic collision avoidance, E-GPWS for terrain avoidance, weather radar for bad weather avoidance).
- The issue is how to define the functional perimeter of a UAS physical **system** that is equivalent to the manned aircraft *‘see & avoid’* **principle** and its **rules**.
- Recognising that different notions are involved (principles, functions, rules, physical systems), the initial intent is to remain as far as possible at the functional level and to issue functional requirements or recommendations.
- A so-called ‘sense & avoid’ **system** could implement most of the sub-functions of the separation provision responsibility of the UA controlling operator, and of the collision avoidance function. This **system** could still include a human in the loop.
- ‘What needs to be detected and avoided’ has to be considered.
    - Does it include airport ground traffic, the 'congested areas of cities..' or 'open-air assemblies of persons' as stated in Annex 2?
    - Will it determine the minimum over-flight height and decide to fly around an area if a minimum height cannot be achieved?
- WG-73 is discussing with RTCA SC-203 how the required functionality, safety, performance, and interoperability requirements could be developed jointly with the objective of achieving a common technical standard.
- The *sense and avoid* function of a UAS is recognised as being critical for safe UAS operations in non-segregated airspace. A reliable solution will be of benefit also to manned aviation.
- WG-73 will address the security, physical and electronic, of the UAS, the pilots, the ground control stations, and the launch and recovery aspects.
- Security of communications between the UA and the controlling operator will also be addressed.
- The intent is to propose policy, guidance, and requirements, as appropriate, to ensure an adequate level of security so that unmanned aircraft might be safely operated only by authorised personnel with a minimal risk of accidental or deliberate intrusion and disturbance.
- EASA position is that UA with a mass of less than 150kg are subject to national certification and regulation
- WG73 focus is on UA >150kg
- UA <150kg can have significant capabilities and trans-national operating ranges. Issue of international interoperability
- Possible that standards developed for UV >150kg could be appropriate for some lighter UA (subject to national regulation)
- International ATM system must cater for aircraft of all masses
- EUROCONTROL to explore UAS issues using simulation, including UA <150kg
- WG73 has established a ‘Small UAS Focus Group’ and is developing a work package to address the issues

The WG-73 current status is:

- Deliverable 1 (Inventory of Issues): Agreed January 2007
- Deliverable 2 (Work Plan): First Version agreed 31 May 2007
- Deliverable 3 (Concept Document): 1st iteration due early 2008
- Deliverable 4 (Command & Control) and Deliverable 5 (Sense & Avoid): In accordance with Work Plan and discussions with SC-203.
- Deliverable 6 (ATM Incompatibility Issues): Ongoing activity
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4. Unmanned Aircraft Systems Pan-European ATM Network Integration
Holger Matthiesen, EUROCONTROL

EUROCONTROL is "The European Organisation for the Safety of Air Navigation" covering both civil and military users, with 38 member states. Its activities are divided into "4 Pillars:

1. Regional ATC Services, with the Maastricht UAC providing upper airspace control for 1.6 million flights annually in Germany, Belgium, the Netherlands and Luxembourg.
2. Pan-European Functions, such as the Central Flow Management Unit (CFMU) and Central Route Charges Office (CRCO).
3. Support to Regulation, including the Single European Sky (SES) and Safety Regulation (encompassing UAS required Levels of Safety).
4. ATM Network Design, which is a cooperative stakeholder process developing strategies, concepts and roadmaps, backed up by the EUROCONTROL Experimental Centre.

Integration of UAS into the pan-European ATM network is taking into account safety, security, environment, airspace capacity, flight efficiencies and airspace access.UAS integration cannot be allowed to disrupt civil aviation, which is experiencing a period of massive growth estimated to be 240% over the period 2005 to 2025. However, the role of EUROCONTROL is to ensure that ATM meets the requirements of all legitimate users, which includes UAS, with UAS certification currently being the missing element.

Further segregation is not an option, there is already too much, so more flexible use of airspace is essential. The EUROCONTROL Airspace and Navigation Team (ANT) is looking at ATM requirements for UAS as civil and military "General Air Traffic" (GAT), the key requirement being that UAS as GAT shall perform at least as well as manned aircraft. Achievement of the principle of ATM Transparency is being pursued through UAS certification.

Civil UAS certification is being addressed through EUROCAE Working Group 73 with EUROCONTROL involvement at many levels, and WG-37 is coordinating with RTCA. WG-73 acts as the European UAS Expert Group within the European Aviation Safety Agency (EASA), working on a phased UAS integration approach. EUROCONTROL is also working with the International Civil Aviation Organization (ICAO). EUROCONTROL is working through a plan of UAS "next steps" covering the short, medium and long term.

ATM will continue to evolve, and UAS are seen as significant drivers for change. These changes should benefit all air users in areas such as sense & avoid, improved air/ground communications links and autonomous flight. Provision of adequate communications bandwidth is expected to be a key issue, and further human factors studies are required. UAS have arrived, and EUROCONTROL will remain fully engaged in addressing this "turning point" in aviation.

Question 1: Has EUROCONTROL has investigated the market outlook for UAS?

Answer 1: Yes, covering Europe, the USA and Global markets. Exponential growth is expected in military UAS, and the biggest growth area in the civil market is expected to be for small UAS. This is because manned aircraft are likely to remain competitive for larger vehicles.
Question 2: Is SESAR (Single European Sky ATM Research) taking any notice?

Answer 2: SESAR is reluctant to consider anything beyond commercial airspace use, but pressure from other users has put UAS in its first deliverables. We need to keep up the pressure.

Question 3: What kind of R&D infrastructure is required to do validation and transition?

Answer 3: Validation requires a simulation/evaluation suite covering ATM and human factors to explore alternative concepts and modes of use. The existing EUROCONTROL facilities in Paris need to be updated. A permanent EUROCONTROL facility is required to support integrated simulation for distributed control.

Question 4: Is there really a market for unmanned civil aviation? Aren't pilots actually quite cheap?

Answer 4: Yes, there will be a market, especially for small aircraft. (Comment from the audience – it took the Wright brothers eight years to sell an aircraft!).

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5. Autonomous Systems Technology Related Airborne Evaluation and Assessment (ASTRAEA) – UK access to airspace programme
Lambert-Dopping Hepenstal, BAE SYSTEMS, UK

ASTRAEA is a UK collaborative research and validation programme aimed at enabling the opening up of the UK and European airspace in general (not just commercial/military) to the routine use of autonomous UAS, without the need for special restrictive conditions of operation. It covers the development and demonstration of technologies and operating procedures, guided by the principle that it is pointless to develop technologies if they cannot achieve certification.

ASTRAEA is a £32M partnership, jointly funded by industry and the public sector (Department for Business, Enterprise and Regulatory Reform / Technology Strategy Board and various regional development agencies), involving more than forty small/medium enterprises and universities. Larger industry participants include BAE SYSTEMS, EADS, Flight Refuelling, QinetiQ, Rolls Royce and Thales. The Civil Aviation Authority (CAA) is also involved. "Hard" technical drivers include dependable/secure communications (especially spectrum allocation), sense & avoid and emergency flight termination. "Soft" drivers include regulatory acceptance that visual signals are unnecessary and ground handling/maintenance.

Autonomy is a key issue, which can be applied to both manned and unmanned platforms. For UAS to be routinely used in place of manned aircraft, the current regulatory framework requires reinterpretation. The approach adopted is to look at where ATM is going to be in the future and work towards that, rather than trying to fit into where ATM has come from. However, UAS are already a reality, so they need to work with systems which are already in place in the short term. This requires engagement with the complex wider picture of stakeholders across the world, including regulation authorities.

The ASTRAEA programme is driving capability developments in areas such as ground operations/human system interface, adaptive routeing, prognostics & health management and decision making in accordance with an overall integration and demonstration plan. A common operating environment is provided by the synthetic environment facility at Parc Aberporth in Wales. More information is available on the ASTRAEA website at www.ASTRAEA.aero, including details of the first ASTRAEA Conference in Bristol on October 17th 2007.

Question 1: Is ASTRAEA just looking at UAS, or wider?
Answer 1: Autonomous systems don't have to be unmanned. The aim is to feed validated information on how to handle autonomous systems into the regulatory areas. For UAS, the advice is not to set standards beyond what manned aircraft are capable of, i.e. set realistic targets.

Question 2: What are the critical issues?
Answer 2: Communications spectrum availability. Any requirement for continuous live video is a non-starter from this point of view. However, some bandwidth allocation for command and control is essential. Lobbying support for this in each country would be very helpful.

Question 3: Will UAS require more spectrum than current aircraft allocations?
Answer 3: Yes.

Question 4: Taking the command & control/ATC view of optimum airspace, the weak link is the controllers. Can we change the idea of controlling to one of management? Is what we have today making best use of available technology?
Answer 4: Management is a better way of expressing it.

Question 5: Is a change of philosophy required in going from control to management?
Answer 5: Yes, the human/machine interface is a very important aspect.

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6. OUTCAST - Operation of UAVs: Transition to Civil Air Space and Traffic environments
Michiel Selier, NLR, NL

The Dutch National Aerospace Laboratory (NLR) conduct the National Technology Program OUTCAST (Operation of UAVs - Transition to Civil Air Space and Traffic environment) in the time period of 2004 to 2007 to answer the question if unmanned aerial vehicles can fly safely in Dutch airspace, without risking collision with other aircraft. A series of tests on behalf of the Dutch Ministry of Defense has been performed aimed on the vision to ensure the safe integration and operation of UAVs in Dutch civilian airspace in 2010 - 2012.

In total, 33 test flights have being conducted with NLR's own laboratory aircraft, a Cessna Citation. There is a pilot on board, to ensure flight safety, but the aircraft has been equipped with a test rig that includes the same anti-collision system used in civilian aircraft (TCAS), as well as a camera system that replicates pilot vision (EO: electro-optical / IR: infrared camera system). A UAV crew, seated in the rear of the aircraft, uses information from both systems to detect and avoid air traffic. The Royal Netherlands Air Force has contributed to the project by providing aircraft that simulate other air traffic by flying in the vicinity of the Citation. The intruder aircraft include a Pilatus PC7 (general aviation), a Fokker 50 (transport a/c) and a F-16 (fighter a/c). Also, 9 flights were carried out through regular NL airspace.

The sense-and-avoid (S&A) procedure is essential for UAV airspace integration. This process was intensively analyzed in the project based on the so called OODA (Observe-Orient-Decide-Act) loop. It is an iterative process with both aircraft responsible, i.e. 1) to detect aircraft (observe), 2) to track and assess conflict (orient), 3) to select maneuver (decide), which must be compatible with manned aircraft operations and TCAS, and 4) to execute maneuver until "clear of conflict" and after "clear of conflict". The process is strongly dependent on EO/IR camera capabilities.

Main results of the OUTCAST program are requirements for sense and avoid procedures to obtain an "equivalent safety level" and a concept promising for workable and pragmatic solution.

Question 1: How is the intruding aircraft recognized ?
Answer 1: IR is very useful in finding the aircraft, the type of the aircraft is better recognized with the EO camera. The combination of IR and EO is definitely useful.

Question 2: Is there a problem with video monitoring of a number of UAVs ?
Answer 2: There is no problem with a lot of UAVs.

Question 3: Is the camera operated by hand ?
Answer 3: Yes, the camera was operated by hand, but some automatic procedure is possible.

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7. Swedish industry efforts to increase UAV usability by progressing traffic insertion of UAVs
Dr. Gunnar Holmberg, Saab, SE

This presentation deals with UAV traffic insertion which will increase the flexibility of UAV usage. Traffic insertion is essentially necessary for the civil UAV market to reach volume and to set up a technology basis that could contribute to more efficient use of air space (e.g. within the frame of SESAR - Single European Sky ATM Research). Regulatory, technological and acceptance issues need to be addressed in an integrated manner.

A broad variety of security tasks and services demonstrate the strong need for UAV usage which is potentially more cost-effective compared to manned vehicles and will have also technology spin-off for Commercial Air Transport Systems. Especially, the risk to send human beings in hazardous areas is reduced.
<u>Security:</u>
- Surveillance / reconnaissance (e.g. borders, movements, maritime, etc.)
- Support of police actions / prevention of crime and terrorist actions
- Survey and inspection of pipelines, power lines, etc.
- Tracking, detection, photography

<u>Services:</u>
- Search and rescue
- Fire fighting and monitoring
- Environmental surveillance (oil spill, pipeline inspection, fishing restrictions, mineral exploration, agricultural spraying, etc.)
- Cartography, photography and mapping
- Disaster relief
- Communication
- Research (atmospheric, oceanographic, geophysical, etc.),

Activities that involve all stakeholders are important to achieve traffic insertion. A stepwise approach is proposed to set up regulatory procedures for certification and qualification. Considering the time period 2006 – 2015, this stepwise process starts with non-type certificated UAVs (experimental UAVs) flying in segregated airspace (step 1) and non-segregated airspace (step 2) within national borders, progressing to type certificated UAVs (state and civil vehicles) in non-segregated airspace within national borders up to type certificated UAVs flying worldwide under ICAO rules (step 5).

Main technological aspects include methods and systems for aircraft separation, sensing and collision avoidance (Auto ACAS) linked to mixed initiative (pilot, operator, ATC) and autonomous decision making.

Swedish industry is prepared for the next step to demonstrate in-flight capabilities regarding national and international solutions. It is now the time for the market to introduce UAV in air traffic.

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8. Flapless Air Vehicle Integrated Interdisciplinary Research (FLAVIIR)
Dr. Clyde Warsop, BAE SYSTEMS, UK

FLAVIIR is a partnership between ten UK universities (Cranfield, Imperial, Leicester, Liverpool, Manchester, Nottingham, Southampton, Swansea, Warwick and York) funded at £6.5M from 2004 to 2009 by BAE SYSTEMS and the Engineering and Physical Sciences Research Council. The objective is to support the development of competitive products, processes and capabilities for future UAS markets by assembling the best university skills to address the challenges of this changing market through research, staff education & training and the creation of a skilled recruitment pool.

FLAVIIR has been given two "Grand Challenges":

1. A maintenance-free Uninhabited Combat Air Vehicle (UCAV) without conventional control surfaces and no cost or performance penalties.
2. Significant research impact through effective academic/industry management of large-scale, integrated academic research.

The research addresses high-risk technologies with potential for significant advances in capability and future business growth. Topic areas include aerodynamics, electromagnetics, numerical simulation, control systems, materials & structures, manufacturing and integration & demonstration. Two approaches to fluidic flight control are being investigated: fluidic thrust vectoring and circulation control. Control systems work includes non-linear adaptive control and adaptive real-time navigation. Materials work covers virtual testing of composite structure failure aimed at reducing the cost and time for testing. Manufacturing topics include direct-write technologies, reconfigurable tooling and resin infusion moulding.

The process being followed is to proceed from an understanding of the physics to ground test demonstration, then development and validation of system models, leading to demonstrations of increasing complexity on flight vehicles. Flight vehicle masses were less than 6kg in the first two years of the programme, with less than 20kg this year, leading to less than 70kg in 2008/9. The large-scale flight demonstrations take the research work to higher Technology Readiness Levels (TRLs) than is normally the case for universities, providing more realistic feedback on how the various technologies interact and affect air vehicle configuration and operation.

Apart from the challenges of collaboration between academics and industry, the new technologies being investigated pose serious questions for UAS clearance and certification, especially in terms of coupled propulsion/fluidic flight control and adaptive flight control algorithms.

Question 1: If the virtual structural tests went well, how do you know?
Answer 1: For delamination, test pieces of typical structural components were fabricated and subjected to destructive testing. Results were then compared to the models, giving results within 3% to 5%.

Question 2: What are the target benefits for the flapless control?
Answer 2: Mainly Radar Cross-Section (RCS) and no moving parts, leading to reduced maintenance costs due to elimination of wear. However, a control valve is still needed, as well as ducting for large volumes of air. Even so, cost reductions are expected. Cost/benefit analysis will be carried out in the final two years of the programme.

Question 3: Is the fluidic thrust vectoring an on/off system?
Answer 3: A segmented circular nozzle does the work. This is a linear, zero hysteresis, fast-reacting device.

Question 4: Is the work relevant to manned aircraft.
Answer 4: Yes, but the driving requirements are from UAS.

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9. HADA (Helicopter Adaptive Aircraft)
Rafael Pax, Technical Director of ARIES COMPLEX and Manuel Mulero, INTA, Spain

The HADA (Helicopter ADaptive Aircraft) program focuses on the development of a combination of helicopter and fixed wing aircraft to improve operational capabilities for a wide variety of applications. The project is scheduled for four years (2007 – 2010) and is funded by the Ministry of Education and Science and the Ministry of Defence with a budget of about 22 M€. The consortium includes 18 partners in the start-up phase belonging to industry, research establishments and academia. The R&D leader is INTA (National Institute for Aerospace Technology) and the industrial leader is the Aries Complex, a group of companies specialized in design and manufacturing of high technology composite aero-structures.

The HADA concept is part of the programme PLATINO (Light Aerial Platform for Innovative Technologies) addressing five technological areas, namely morphing aircraft, UAV, on-board communication, automatic landing system and mini synthetic radar.
The HADA is aimed on VTOL operations providing also high efficiency in cruise flight. The design is a morphing aircraft configuration based on a conventional helicopter. The inno-vations concern the two tiltable half span wings included in the belly fairing and a pusher propeller at the rear end of the fuselage. When changing from hover mode (take-off and landing) to cruise mode, after reaching operational altitude and transition speed, the wings are turned out of the belly fairing and fully deployed while the rotary wings are folded together in rearward position. Power is transferred from the main rotor engine to the pusher propeller, at the same time decoupling gears of main rotor and tail rotor.
The preliminary design for this UAV system includes a main rotor diameter of 6 m, a wing span of 6 m and a wing area of 4 m^2. The mass is 380 kg and the required power is 130 kW. Transition speed is approximately 50 m/s and optimum L/D is about 10 at 110 m/s.

In comparison to other combined rotary-wing and fixed-wing configurations, considering both manned and unmanned vehicles, the HADA is thought to produce an effective operational aircraft using state-of-the-art technologies. Particularly, light composite materials, micro-electronics and advanced flight control system are addressed. The short term goal associated with the HADA-UAV version is to fullfil missions in context of requirements of Navies and Civil agencies, i.e. payload of 40 to 90 kilograms, ranges of 100 – 200 miles, and flight duration of about 5 hours.

The HADA project is divided into two parts, namely a feasibility study and proof of concept at reduced scale called ”Colibri” conducted in 2007 (phase A) and a full scale UAV prototype development called ”Libélula” in 2008 – 2010 (phase B).
International partners are invited to join the HADA project from 2008 and beyond.

Question 1: How big is the budget of the project ?
Answer 1: The budget is split over the four years period as follows: 2007: 2 M€; 2008: 6 – 8 M€, prototype development in 2009 – 2010: 12 M€.

Question 2: Which type of engine will be installed ?
Answer 2: A conventional engine will be used, either a single gas turbine or a piston engine.

Question 3: How much power is needed and how is the electrical power provided ?
Answer 3: The power is about 130 kW and electrical power is provided via the main engine.
Question 4: What is about stability problems, especially during the transition phase, the complexity of the system and weight penalties ?
Answer 4: Stability characteristics are still under analysis. The part of the flight control system associated with the transition phase is under development. Flight dynamics problems are expected in pitch. The tilt mechanism of the wings and the folding mechanism of the main rotor will create some additional weight.

List of Abbreviations

ACAS	Airborne Collision Avoidance System
ATM	Aircraft Traffic Management
ASTRAEA	Autonomous Systems Technology Related Airborne and Assessment
EO	Electro-Optical
EUROCAE	European Organization for Civil Aviation Equipment (regulatory agency for certifying aviation equipment in Europe)
FAA	Federal Aviation Administration
FINAS	Flight In Non-Segregated Airspace
FLAVIR	Flapless Air Vehicle Integrated Interdisciplinary Research
MALE	Medium Altitude Long Endurance
HADA	Helicopter Adaptive Aircraft
HALE	High Altitude Long Endurance
ICAO	International Civil Aviation Organization
IR	Infrared
R&T	Research and Technology
S&A	Sense and Avoid
SESAR	Single European Sky ATM Research
TCAS	Traffic Alert and Collision Avoidance System
UAS	Unmanned Aircraft System
UAV	Unmanned (uninhabited) Aerial Vehicle
VTOL	Vertical Take-Off and Landing