JAA
Joint Aviation Authorities

The Joint
JAA/EUROCONTROL
Initiative on UAVs

EUROCONTROL

UAV TASK-FORCE
Final Report

A CONCEPT FOR EUROPEAN REGULATIONS FOR CIVIL UNMANNED AERIAL VEHICLES (UAVs)

11 May 2004

INTENTIONALLY LEFT BLANK

TABLE OF CONTENTS

ENCLOSURES:

0 FOREWORD/EXECUTIVE/ SUMMARY

This document represents the final report of the UAV Task-Force established to address a development of an concept for the regulation of civil unmanned aerial vehicles (UAVs), with respect to safety, security, airworthiness (including continued airworthiness), operational approval, maintenance and licensing. The UAV Task Force was established as a result of a joint initiative of the Joint Aviation Authorities (JAA) and the European Organisation for the Safety of Air Navigation (EUROCONTROL) in September 2002.

Broad participation from representatives of the European aerospace industry in the work of the UAV Task-Force provided a major contribution to the development of the contents of this final report. Participation also included representation from a number of State civil aviation authorities, JAA, and EUROCONTROL. Authorities with direct interest in areas of UAV regulations, such as NATO, were kept informed of the progress of the UAV Task- Force work.

Although this concept does not address military UAVs directly, it is considered that the information could also be of value to military certification authorities.

The scope of the final report does not include the development of a concept for the regulation of civil UAVs with respect to air traffic management (ATM). The UAV Task- Force acknowledged that the responsibility for a future development of an ATM unified concept for the operation of civil UAVs outside of reserved airspace would continue to reside with international ATM organisations such as ICAO and EUROCONTROL. However, implications of UAV operations for ATM were considered to the extent this pertains to airworthiness certification, and the report contains some recommendations (see 8.5) for future work on ATM provisions for UAV operations outside restricted areas.

This document has been the subject of a wide external consultation process with relevant bodies and their views/comments have been fully considered and incorporated where possible.

The UAV Task-Force plans to present its report early June 2004 to the JAA Committee (JAAC: Management Committee of the JAA). The JAAC should be invited to endorse the report and agree to the recommendations it contains.

The UAV Task-Force also plans to present its report to the EUROCONTROL Safety Regulation Commission (SRC) around the same period of time. The SRC should be invited to support the report and the recommendations it contains.

When these two steps are done, it is the intention of the UAV Task-Force to submit its report for the consideration of:

- The ICAO EUR/NAT Office in support of future ICAO initiatives in this area.

- The European Aviation Safety Agency (EASA) in support of EASA's possible future development of airworthiness regulations pertaining to civil UAVs.

This document consists of a main body, two Annexes and five enclosures.
The main body represents the consensus achieved by the UAV Task-Force.
The Enclosure 1 sets up the scene with introductory information on the international and national regulatory framework for UAVs, describes the current and foreseen UAV applications and provides some details on the establishment of the UAV Task-Force.
The enclosures 2-5 represent the output of the 3 Working Groups created within the Task-Force (General, Safety and Security; Airworthiness & Certification; Operations, Maintenance and Licensing) and EUROCONTROL for ATM issues.
The enclosures provided further information on the issues discussed and the key points raised by each of the Working Groups. Cross-references to enclosures were introduced into the main body to assist further understanding of the issues.

The main body first reminds the Terms of Reference of the Task-Force, its composition and the objective of the document and states the proposed regulatory applicability. Main definitions of UAV related terms used in this document are provided.

Guiding principles for the development of a regulatory concept, based upon fairness, equivalence, responsibility/ accountability and transparency are proposed. An overall concept of regulations is then proposed around the five pillars of Safety and Security to be envisaged when dealing with regulations for UAVs: Airworthiness & Certification, Security, Operations & Maintenance & Licensing, Air Traffic management and Airports. Emphasis has been put, at least at this stage, on the use of existing manned regulations while recognizing the need to tailor than and/or complement them considering the specific character of UAV operations.

A number of discussion topics that have been considered by the Task Force and are also reviewed in this document, covering significant issues related airworthiness & certification, security, operations and Air Traffic management. While the list of these topics may have to be completed at a further stage, they were viewed significant attention items.
For each topic, a statement of issue is provided, the discussions which took place at the Task-Force are summarised and recommendations are outlined together with relevant institutions to which they are addressed with an indication of proposed timeframe and priority.

Those recommendations are summarized in the last part of the main body of this document and mostly concern proposals for the relevant institution to initiate rule-making changes or policy making process to adjust the existing manned regulatory framework and address relevant technical issues.

1 INTRODUCTION

1.1 BACKGROUND

The Joint JAA/EUROCONTROL initiative on UAVs (hereinafter addressed by "UAV Task-Force" or "UAV T-F") was established in September 2002 on the basis of a joint decision of the JAA and EUROCONTROL governing bodies. This decision was taken in reaction to the growing European UAV Industry and their recognised need for the authorities to commence work leading to European regulations for civil Unmanned Aerial Vehicles (UAV). The non-existence of such regulations is seen as a major obstacle for a further development of the European UAV applications.

The report is limited to civil UAVs as JAA regulates only civil aircraft. However it is recognised that ATM requirements can also apply to military aircraft.

1.2 TERMS OF REFERENCE

The Terms of Reference for the UAV Task –Force, as agreed by the JAA and EUROCONTROL governing bodies (see Appendix 1-3 to Enclosure 1 to this report), have requested the UAV T-F to develop and deliver in the Final Report a CONCEPT for European regulations for civil UAVs, its justification and recommendation for a future regulatory work. The areas covered by the agreed Terms of Reference include –

- Safety and Security
- Airworthiness, Continued airworthiness and Environment
- Operations, Maintenance and Licensing
- Air Traffic Management

1.3 COMPOSITION

The JAA (National Authorities and the Central JAA), EUROCONTROL, FAA and key representatives from the UAV Industry participated in the work of the UAV T-F. The first three bullets of the Terms of Reference were covered by three Working Groups while ATM would be handled by EUROCONTROL//ICAO as a function of validated airspace requirements. Plenary sessions were organised where the three Working Groups and EUROCONTROL reported on progress made. More details on the composition of the UAV T-F and the working methods can be found in the Enclosure 1 and its appendices.

1.4 OBJECTIVE OF THE DOCUMENT

The objective of this document is to articulate the results of the UAVT-F's analysis into future European UAV operations, to identify impediments to free operations and to indicate where changes are required to the regulatory framework. This work therefore sets forth a concept for civil UAV regulations that would allow, when implemented, the safe integration of UAVs into the European airspace.
The concept will address the safety of the people on the ground and the safety of the people in flight

This document is primarily intended to address UAV systems engaged, or intended to be engaged, in aerial work activities. The concepts outlined are considered to be the starting basis for commercial transport operations, including the transportation of passengers. However this deserves further research.

2 BACKGROUND TO UAV SYSTEMS

2.1 UAV PERSPECTIVES

For many decades UAVs have been widely used for military missions mainly in the area of tactical and strategic reconnaissance. More than 30 nations are developing or manufacturing more than 250 models of UAVs. More than 40 countries operate more than 80 types of UAVs showing a wide range of system performance concerning speed, altitude, mission duration, and payload capability. The entire spectrum of aviation companies and research institutes, both small and large, are developing and operating UAVs as well as forwarding their related technologies.

For the next years the development and operations of European UAVs – either military or civilian - is one of the most important challenges and at the same time one of the biggest opportunities of the European Community and its industries to stay at the technological and commercial frontier of aerospace industry.

In 2000 the world market for UAV systems reached the order of one billion € in terms of annual revenues, with a continued compound annual growth rate forecast of approximately 7 percent for the next years. To date approximately 90+ percent of all funding for UAV systems are a direct result of national government requirements channelled through their military and defence program elements. With few exceptions this is a world wide trend and one which will likely continue until national airspace issues are resolved. Therefore the rest of this decade will be greatly influenced by this funding trend and technology developments will follow mainly national requirements.

2.2 CIVIL APPLICATIONS

Although the military UAV market has been steadily growing, civil UAVs applications have been slow to take advantage of potential applications due, at least in part, to the lack of a regulatory framework. Civil missions such as global monitoring of environment and security (GMES), for example, can only be achieved if UAVs are able to fly seamlessly amongst other air traffic within national or international airspace. Where it has been identified that existing regulations cannot accommodate civil UAVs, the regulatory framework needs to be developed to determine what technologies or procedures are essential and a demonstration at an early stage to show the safe introduction of UAV civil applications should be an objective. Where it is identified that civil UAV applications can already be accommodated within existing regulatory arrangements it is expected that operators would be able to identify and exploit UAV technologies, if UAVs can commercially compete with similar applications based on manned aircraft.

For market introduction of civil UAV services three promising categories of market entry candidates for civil applications are found (see Fig. 2-1):

- **Technology induced applications**
  focusing on local range applications in the area of visual inspection and earth observations based on light UAVs (see Annex 1 for definition of light UAVs) and highly miniaturised payloads. Future applications will be heavily driven by the technological improvement (miniaturisation, performance enhancement, reduction in power consumption) of platform and payload.

  In this business field mainly research centres, universities, small and medium sized enterprises will be involved. The offered services will be dedicated to the very specific request of the users.

- **Platform induced applications**
  based on existing medium altitude military platforms to perform governmental and scientific missions (e.g. GMES) as well as dedicated infrastructure monitoring tasks for pipeline and power line monitoring.

  In this business segment the well established military UAV manufacturer and system integrator will play a dominant role. Typical customers are institutional organisations (government, national research centres).

- **Service induced applications**
  to use high altitude geostationary UAVs as new infrastructure elements for future telecommunication system or Earth observation services to extend the capabilities of satellite systems.

  This business segment will be dominated by telecommunication or earth observation service providers, infrastructure manufacturers and system integrators with a background in aeronautics and space.

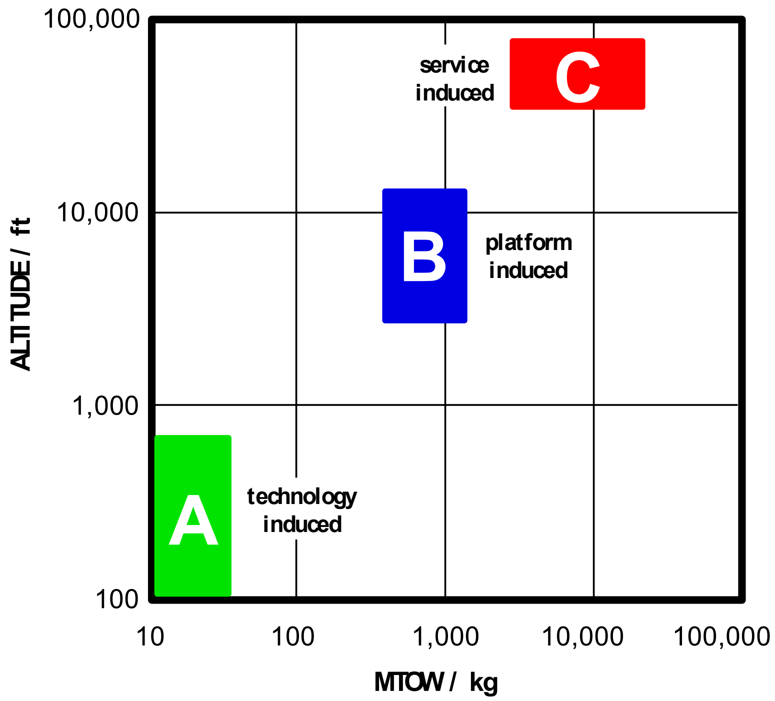

Fig. 2-1 Civil UAV trends

To open the market for civil UAVs it is important to see clearly their strengths and weakness.

Major market drivers for civil UAVs are:
- unique flight performance (high altitude, long endurance)
- suitability of use in “dull, dirty and dangerous” missions

Major market restraints against civil UAVs are
- lack of appropriate airspace regulations for UAVs

- insurance for civil operation is expensive and difficult to obtain
- lack of secure communication frequencies
- some kind of operations may be cheaper with manned aircraft

Although the majority of demonstrations of UAVs have been for military evaluation, the frequency of such demonstrations has led to increased interest from new civil user groups. The primary mission profiles are quite similar both on military and civil side, that are mainly earth observation (military: reconnaissance) and communications.
A ranking of the most important near, medium and long term applications for the defined reference cases of civil / commercial use of UAVs are shown in Fig. 2-2.

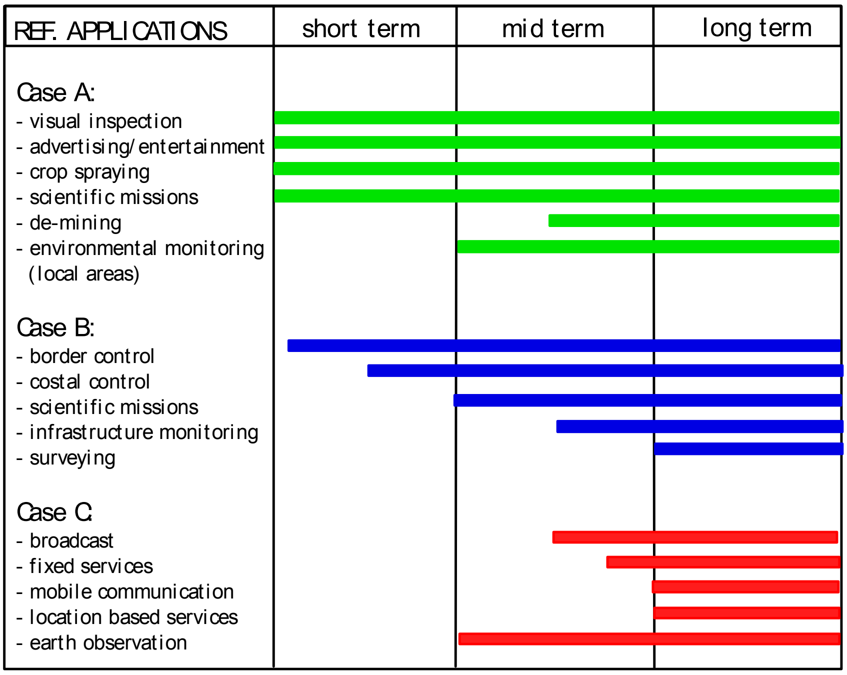

Figure 2-2:

Timeline of introduction of civil / commercial applications for UAVs (short term 1-2 yrs, midterm 3-5 yrs, long term 6-7yrs).

2.3 CURRENT REGULATORY CONTEXT

2.3.1 AVIATION SAFETY PRINCIPLES

Aviation and specifically aviation safety have been highly regulated right from the beginning. This may be explained as follows:

- Flying is not a natural activity for mankind. Public confidence in that mode of transport must be established.
- Aviation is also a powerful weapon of war. There are numerous examples in the past of bombers and transport airplanes developed from the same design.
- Sovereignty of States over their airspace is a fundamental principle.

The basic principle regulating the safety of flight can be expressed as follows:

> An aircraft is only allowed to fly if it has been designed, manufactured, operated and maintained in accordance with relevant regulation and if its crew is also

qualified in accordance with relevant regulations. Such principle is usually incorporated in high level regulations. It is also necessary to develop safety regulations for Air Transport Infrastructure (airports, navigation aids) and for Air Navigation Services.

It should be well understood that aviation safety is a shared responsibility between Authorities, Operators, Manufacturers, and Crews…. The Authorities are responsible for Aviation Safety Regulations (i.e. developing, adopting, and enforcing regulations); the others have primary responsibility to comply with Aviation Safety Regulations.

Due to this shared responsibility, development of Aviation Safety Regulations should involve interested parties (manufacturers, operators, crews, maintenance organisations….).”

Lessons learned from experience are a very important element of aviation safety. Accidents and serious incidents are analysed by independent investigation boards with the objective to define the causes and propose safety recommendations. These recommendations, together with the information obtained through incident reporting systems (mandatory and voluntary) are used to improve requirements

Historically, the purpose of aviation safety regulations was to protect people on the ground. Due to the development of Commercial Air Transportation and social legislation, the purpose is now to protect people on the ground, crews and passengers.

2.3.2 INTERNATIONAL REGULATORY ENVIRONMENT FOR UAV'S

Aviation by its nature is borderless and thus international in scope, especially in Europe. International aviation conventions were convened in the 1920's (CINA; Warsaw Convention…).

In 1944, in view that international relations will re-start after the war, one of the most significant conventions was held in Chicago. The Chicago Convention was signed and had as its purpose the following objective:

The "governments agreed on certain principles and arrangements in order that international civil aviation may be developed in a safe and orderly manner and that international air transport services may be established on the bases of equality of opportunity and operated soundly and economically".

It should be born in mind that UAV's are regarded aircraft. Moreover UAV's may be engaged in international aviation. Consequently international rules pertaining to the safety and operation of aircraft may apply. Apart from the Chicago Convention, other instruments of international law may apply as well to UAV, such as the Montreal Convention (Convention for the suppression of unlawful acts against the safety of civil aviation signed in Montreal on 23 September 1971) and Cape Town Convention (Convention on international interest in mobile equipment signed at Cape Town on 16 November 2001). These and other instruments will not be further addressed in this report.

As UAV's are regarded aircraft within the meaning of the Chicago Convention, some provisions should be explicitly mentioned. These provisions deal mainly with the nationality, registration and marking of a UAV, as well as its airworthiness (including certification) and operation. The international standards laid down in related Annexes to the Chicago Convention, are applicable as well. Some relevant articles of the Convention are highlighted below:

- The notion of pilot-less aircraft is specifically mentioned in *Article 8* of the Chicago Convention.
- *Article 3* stipulates that the Chicago Convention applies only to civil aircraft, and is not applicable to state aircraft. UAV's, when used in military, customs and police

services are regarded state aircraft. These aircraft require authorisation by special agreement before they can fly over the territory of another State.

- *Article 8* requires special authorisation by the State over flown by a UAV.

- *Article 20* requires UAV's to bear its registration and nationality marks.

- With regard to airworthiness, *Article 31* stipulates that UAV's must have a certificate of airworthiness, while *Article 33* addresses the recognition by ICAO states of such certificates.

2.3.3 NATIONAL REGULATORY ENVIRONMENT

A questionnaire was sent to 40 National Authorities requesting information on their present or future legislation for UAVs; UAVs activities in their Country; etc. Salient points from the survey can be found in Enclosure 1, paragraph 1.1.3.

2.4 JAA/EUROCONTROL RESPONSE

The growth of the UAV Industry and the lack of cohesion amongst national authorities in addressing the issues have been identified by the JAA/EUROCONTROL. The UAV Task-Force was a response to address this and its findings and recommendations are put forward in this report.

The following chapters propose a concept for European regulations for civil UAVs. Concept means a set of principles and guidelines for the development of such regulations but does not include the regulations themselves. The objective of the concept is to protect people on the ground and in flight.

3 THE PROPOSED REGULATORY APPLICABILITY

This document sets out a concept for regulation of civil certification and operation of Unmanned Aerial Vehicle (UAV) systems, of all types and categories, which fall within the jurisdiction of EASA. However, it does not apply to the following air vehicles:

- Rockets, missiles and aerial weapons.
- UAV Systems that are engaged in military, customs, police or similar services and are exempt from EASA regulation under EC1592/2002 Article 1(2).

  Notes:

  EASA Member States shall undertake to ensure that such services have due regard, as far as is practicable, to the objectives of the EASA basic Regulation 1592/2002 (see Article 1, paragraph 2) and that consideration has been given to the concept for UAV systems regulation contained in this document.

  In ICAO context, according to the Chicago Convention military aircraft can operate as State Aircraft, which are therefore exempted from "civil regulations", and can operate both as GAT (General Air Traffic) and as OAT (Operational Air Traffic). It is also recognised that the responsibility for the airworthiness certification of military UAVs will reside within the appropriate military authorities. This does not hinder the national military authorities to use the report and to adopt its different recommendations as far as possible, so that the introduction of flights of civil and military UAVs into non-segregated airspace can be as harmonised as possible.

- Light UAV Systems (UAVs with an operating mass of less than 150kg), which fall within the scope of EC1592/2002 Annex 2 and are exempt from regulation by EASA. However, it is recommended that the guidelines for the regulation of Light UAV Systems contained in Annex 1 of this report are considered by National Aviation Authorities. Light UAVs do not contain model aircraft. Model aircraft are defined and regulated nationally.

- UAVs specifically designed or modified for research, experimental or scientific purposes, and likely to be produced in very limited numbers.

This document is primarily intended to address UAV systems engaged, or intended to be engaged, in aerial work activities. The concepts outlined are considered to be the starting basis for commercial transport operations, including the transportation of passengers. However this deserves further research.

4 DEFINITIONS

The following definitions shall be used for interpretation of this document. Where used in this document, the words defined below will be identified by initial capital letters. All definitions applicable to manned flight are considered to be extant except where modified here.

Airworthiness

An aircraft is deemed to be airworthy within EU if it meets or exceeds the essential requirements as defined in the EASA basic Regulation (EC1592/2002 Annex 1)
Note: see 7.2 for further interpretation.

Autonomy

The ability to execute processes or missions using on-board decision capabilities.

Control Station (CS)

A facility or device(s) from which a UAV is controlled for all phases of flight. There may be more than one control station as part of a UAV system.

Emergency Recovery Procedures

Emergency Recovery Procedures are those that are implemented through UAV pilot command or through autonomous design means in order to mitigate the effects of certain failures with the intent of minimizing the risk to third parties. This may include automatic pre-programmed course of action to reach safe landing or crash area.

Flight Termination

Flight Termination is a system, procedure or function that aims to immediately end the flight.

Remotely Piloted Vehicle (RPV)

An RPV is an UAV that is continuously under control of a pilot.

ROA (Remotely Operated Aircraft)

The US acronym for a UAV.

UAV (Unmanned Air Vehicle, Unmanned Aerial Vehicle)

An aircraft which is designed to operate with no human pilot onboard.

UAV Communication Link

The means to transfer command and control information between the elements of a UAV System, or between the system and any external location. (e.g. Transfer of command and response data between control stations and vehicles and between the UAV System and Air Traffic Control).

UAV Commander

A suitably qualified person responsible for the safe operation of a UAV System during a particular flight and who has the authority to direct a flight under her/his command.

UAV Launch and Recovery Element

A facility or device(s) from which a UAV is controlled during launch and/or recovery. There may be more than one launch and recovery element as part of a UAV system.

UAV Operator

The legal entity operating a UAV system.

UAV Pilot

The person in direct control of the UAV.

UAV System

A ***UAV*** System comprises individual UAV System elements consisting of the flight vehicle (***UAV***), the "***Control Station***" and any other UAV System Elements necessary to enable flight, such as a "**Communication link**" and "***Launch and Recovery Element***". There may be multiple UAVs, Control Stations, or Launch and Recovery Elements within a UAV System.

("Flight" is defined as also including taxiing, takeoff and recovery/landing)

5 GUIDING PRINCIPLES FOR THE DEVELOPMENT OF A REGULATORY CONCEPT

In developing a concept of regulation for UAV Systems, certain guiding principles have been established. These principles are identified in the following paragraphs.

5.1 FAIRNESS

Any regulatory system must provide fair, consistent and equitable treatment of all those it seeks to regulate.

Developing concepts specifically targeted at one sector of the aviation community (i.e. UAVs) would be open to criticism that the spirit of this principle has been breached. A concept of regulation for UAV Systems should therefore start from the basis that existing regulations and procedures developed for and applicable to manned aircraft should be applied wherever practicable and not simply discarded in favour of a regulatory framework tailored specifically for UAV Systems.

5.2 EQUIVALENCE

Regulatory standards should be set to be no less demanding than those currently applied to comparable manned aircraft nor should they penalise UAV Systems by requiring compliance with higher standards simply because technology permits.

Equivalence can be broken down into specific sub-sets as detailed below:

5.2.1 Equivalent Risk

UAV Operations shall not increase the risk to other airspace users or third parties

Any detrimental change in aviation safety or levels of risk would be contrary to the prime objective of Civil Aviation Authorities. . ICAO Global Aviation Safety Plan (GASP) introduced with Resolution A33-16, should be applicable to UAV Operations.

The service record of the existing UAV fleet, primarily operating in military service, has not proved yet that the reliability and safety standards of such systems are assured to the same level demanded by civil regulatory authorities for manned aircraft. With this background, it is reasonably foreseeable that the widespread introduction of civil UAV Systems, based on similar technology, will cause some unease amongst the general public and existing airspace users regarding the safety standards of such aircraft. If civil UAV Systems are to become a reality the industry must gain the acceptance and confidence of these people, and this could be achieved by demonstrating a level of safety at least as demanding as the standards applied to manned aircraft.

5.2.2 Equivalent Operations

UAV operators should seek to operate within existing arrangements.

Existing arrangements can be at a local, national or regional level and are those arrangements that are currently in place and used by manned aircraft. However it is recognised that the introduction of UAV Systems may bring with it special circumstances where these arrangements may not be able to be complied with and that changes to these arrangements will be sought. Arrangements may be in place specifically for reasons of safety and/or security.

UAV operators should recognize the expectations of other airspace users. This means ensuring that equivalent behaviour and responses are made so that Air Traffic Units and other airspace users can determine courses of action as they would for any other airspace user.

5.3 RESPONSIBILITY/ACCOUNTABILITY

The legal basis should be clearly defined in a similar manner as for manned aircraft.

This is valid for design and manufacture (including control of suppliers), operation and maintenance of UAV Systems. However, provisions must be made for transfer of command and maybe even for transfer of operator responsibility during a global flight.

In particular, for UAV operations the sharing of responsibilities between the Operator (i.e. the organisation operating the UAV) and the UAV Commander should be defined in a comparable manner to JAR-OPS.

5.4 TRANSPARENCY

The provision of an Air Traffic Service (ATS) to a UAV must be transparent to the Air Traffic Control (ATC) controller and other airspace users.

An ATC controller must not be expected to do anything different using Radio Telephony or landlines than he would for other aircraft under his control. Nor should he have to apply different rules or work to different criteria. UAVs must be able to comply with ATC instructions and with equipment requirements applicable to the class of airspace within which they intend to operate.

These guiding principles are of great value when comparing manned and unmanned systems, both in the determination of airworthiness and in the operation of the air vehicle

6 OVERALL CONCEPT OF REGULATIONS

6.1 SYSTEMS APPROACH TO REGULATIONS

There are differences today between the regulatory approach for the certification of aircraft, the approach for certification of Air operators and that adopted for the regulation of Aerodrome and Ground Aids (AGA) and other Air Navigation Services (ANS). In addressing the issue of the regulatory framework for UAV Systems, aspects of all environments must be addressed.

The current aircraft certification process seeks compliance with a set of well defined standards known as the Joint Aviation Requirements (JAR) and/or EASA Certification Specifications (CS). The air traffic environment is regulated by tasking the service providers to make available Safety Cases to demonstrate their safe operations.

Certification of Aerodrome and Ground Aids (AGA) is the responsibility of the National States of Europe.

A Total aviation system approach for the regulation of Aviation is not currently in place. Each component within the system i.e. aircraft, airports, air traffic control centres, personnel etc are administered and regulated independently.

The evolution of UAV Systems should be facilitated by the introduction of a terminology that put focus on a Total aviation system approach, in a life cycle perspective. This is in line with the road map for EUROCONTROL in developing "system of systems" within the area of CNS/ATM.

The development of future UAV Systems requires a higher degree of integration to different functions of the aviation system than for manned aircraft. The term “system of systems” may also be applicable to advanced UAV Systems. The evolution of UAV Systems will in addition to the aircraft, put focus on the need for minimum requirements for and certification of generic UAV Control Stations involved and may require the identification of the role of an UAV System Integrator.

The basic approach in this report is to bring into focus the various elements that exist for the total regulatory framework of EASA and EUROCONTROL. In doing this care has been taken to ensure that all existing processes, standards and documents are accommodated and that there is a common way that each issue can be addressed. This approach is illustrated in figure 6-1 showing the relationship between the major areas covered by the UAV Task-Force’s work.

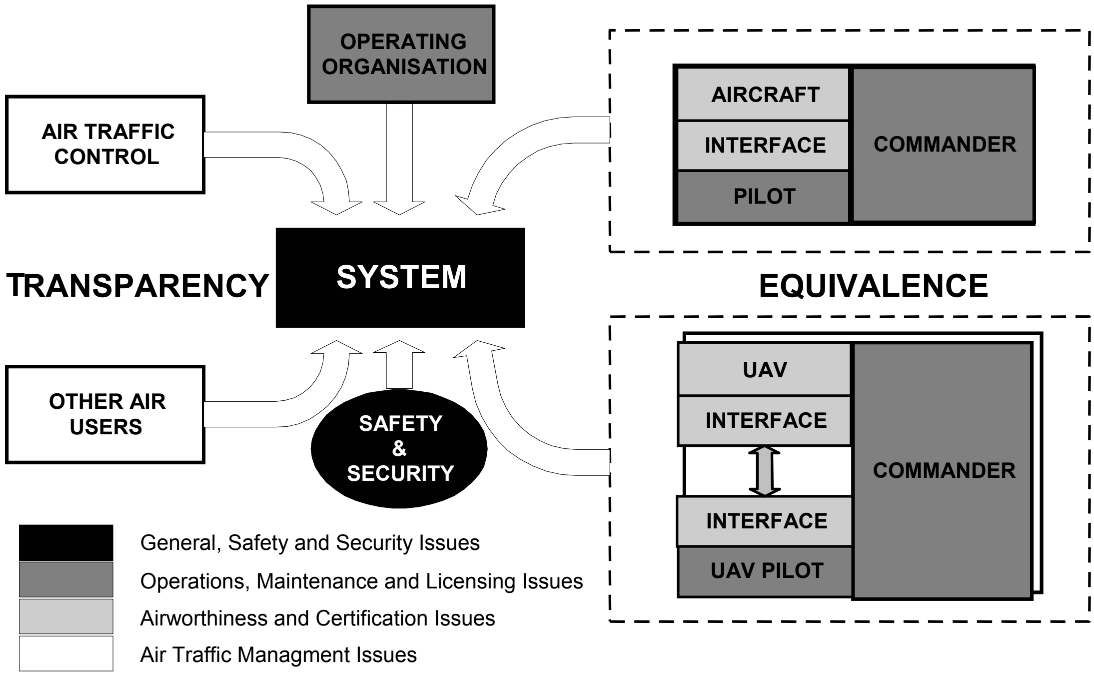

Figure 6-1 – Systems Approach to regulatory determination

The diagram illustrates how manned and unmanned systems are equivalent except for the data link between the Pilot and the Air Vehicle and for the Control Station where the aircraft control mechanism is extended beyond the physical air vehicle. Also an equivalent of a Commander who bears ultimate responsibility for the system is easily identified. The Commander may not be the actual pilot of the aircraft where actual direct control may reside with another person.

Moving away from the system itself to the organisational and operational issues there is no reason to expect major regulatory differences as the fundamental operational and maintenance issues of UAV Systems should be equivalent to manned aircraft systems.

It is in the realm of actual flight operations and the interaction with other airspace users where transparency is necessary as they should not be required to operate differently because of the UAV. However seeking equivalence to the issue of the Rules of the Air will prove more challenging and an equivalent to see and avoid is at present considered to be a necessity.

6.2 SAFETY PRIORITY AND SUPPORTING CONCEPTS

The key system issue is Safety and is the priority aim of Regulation. Due to the nature of a UAV System, the safety aspects cover concepts that in some areas have yet to be defined and this leads to issues not normally considered for manned systems. This also brings into sharp contrast the different approaches between the way aircraft and their operating environments are regulated.

The five key areas underpinning Safety for UAVs as shown in Figure 6-2 and indeed for all aircraft are:

- Security
- Airworthiness and Certification
- Operations, maintenance and licensing
- Air Traffic Management
- Airports & Ground Aids

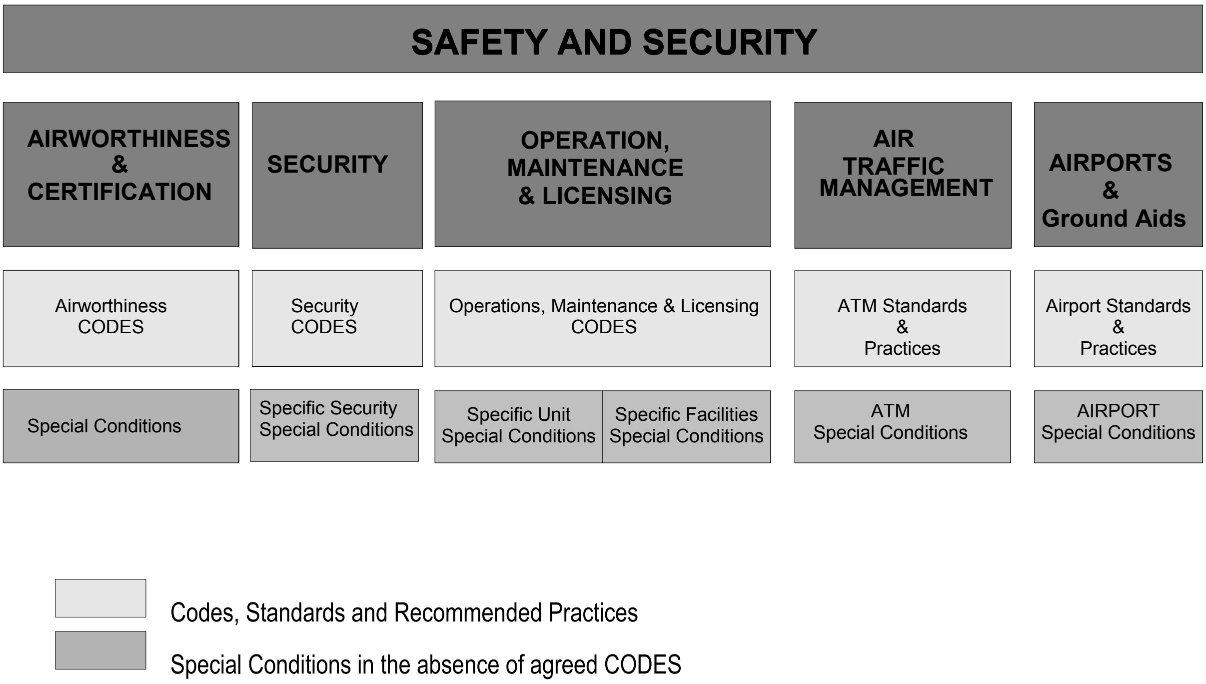

Figure 6-2 - Safety Priority, Supporting concepts and implementation aspects

These areas are addressed in the first instance through a combination of adherence to agreed Codes, Standards and Recommended Practices. Many of these have been developed over a number of years.

In the absence of such codes or when such codes are not fully adopted, the second approach is to adopt a risk based approach in which structured arguments are used to articulate why certain special conditions contribute to the safety of a particular system. These arguments are usually encapsulated in what is termed safety. Figure 6-2 shows that the overall justification for the safety of a UAV System is built from both approaches and neither is exclusive. More comprehensive discussion of the merits of the two approaches for the airworthiness certification is contained in paragraph 6.3.1 and Enclosure 3. The setting of the certification basis, including an explanation when Special Conditions are likely, is described in 7.4.

Although airworthiness and operation regulations contain requirements related to security it is felt that security deserves to be considered as a separate area because there are a significant number of issues that are not covered (see paragraph 6.3.2 and 7. 15 for more details.

The overall safety objective is to protect third parties both on the ground and in the air. This objective is has been apportioned to the five pillars described above. In line with the philosophy adopted for manned aircraft, airworthiness requirements do not address the risk of mid-air collision (see 7.2). Collision avoidance is seen as part of the operational rules and as an ATM issue (see 7.16). However the UAV T-F fully recognises that if systems are installed to comply with airspace requirements, such systems must be shown to be airworthy and certified.

6.3 SUMMARY OF ADOPTED CONCEPTS

6.3.1 AIRWORTHINESS & CERTIFICATION

6.3.1.1 Two possible approaches for UAV Airworthiness Certification

The globally adopted approach to the civil certification of manned aircraft is to apply defined codes of airworthiness requirements, based on long lasting experience, to the design of any aircraft. Recognition of compliance with those requirements is given by the granting of a Type Certificate for the approved design and Certificates of Airworthiness to individual aircraft. The codes of airworthiness requirements used, sometimes supplemented by Special Conditions, address all aspects of the design which may affect the airworthiness of the aircraft.

It is a common philosophy of these codes of airworthiness requirements that, as far as is practicable, they avoid any presumption of the purposes for which the aircraft will be used in service.

An alternate approach is to adopt a “safety target” approach of setting an overall safety objective for the aircraft within the context of a defined mission role and operating environment. The “Safety Target” methodology is a top-down approach which focuses on safety critical issues which could affect achievement of the safety target, and allows potential hazards to be addressed by a combination of design and operational requirements. For example, uncertainties over the airworthiness of an aircraft may be addressed by restricting operations to defined areas from which 3rd parties are excluded. Claimed advantages of the Safety Target approach are that it facilitates concentration on the key risks and is not constrained by the need to compile and comply with a comprehensive code of airworthiness requirements covering all aspects of the design.

However, it should be noticed that typical codes of airworthiness requirements such as JAR/CS 25, do also include one prominent safety objective oriented requirement “1309”, whereby, in particular, it is required to show that there is an inverse relationship between the probability of a failure condition and its consequences. This latter “1309 approach” has often been useful to assess new technologies or novel design features (such as Fly by Wire) not covered by existing requirements. Guidelines to solve possible conflicts between “1309” and other specific airworthiness requirements may be proposed e.g. as in the core of CS 25.1309 latest amendments or on a case by case basis through Special Conditions

In the context of a “global” assessment of a complete UAV System, (including consideration of all contributory factors, such as operational role, sphere of operations, and aircraft airworthiness), it is likely that some form of safety target will have to be established. However, the specific issue discussed in this Section is whether the “airworthiness” contribution to the overall safety target will be to a fixed standard defined by a code of airworthiness requirements, or will be variable dependent upon the operational restrictions imposed in parallel.

A comparison of these two methodologies has identified the following issues which need to be considered in developing this regulatory concept, and provides a discussion of the benefits and constraints of each approach.

6.3.1.2. <u>Comparison of the two approaches</u>

6.3.1.2.1 Commercial Competition

The Safety Target approach is greatly facilitated when UAV operators are all under the direct control of the single Entity, which has ultimate responsibility for safety, and is also the sole “customer”. This direct control of operations is a significant advantage when accepting a safety case which relies upon the restriction of operations to compensate for uncertainties over airworthiness. In the civil environment, EASA/NAAs are not the ultimate beneficiary of UAV operations and do not have an equivalent governing control over the operators. It is to be expected that in the future there will be occasions when civil UAVs from different operators will be undertaking the same missions simultaneously for competing commercial organisations; the civil regulatory system must be capable of dealing with such scenarios.

6.3.1.2.2 Commonality of Standards

Under a Safety Target philosophy constructed on the basis of an assessment of 3rd party risks, the acceptability of a UAV would have a dependency on the frequency and duration of missions. Under such a system, limitations on the frequency and duration of missions may be part of the justification of acceptable airworthiness. The use of such a philosophy could place EASA/NAAs in the position of giving permission for one commercial Operator to fly his UAVs in preference to a competitor on the basis of an assessment of the relative airworthiness of the competing fleets. The complexity of that task would be compounded by the prospect of the various operators using markedly different philosophies to compile their safety cases. Such a system would be very difficult to administer in the transparently equitable manner required of EASA/NAAs. In contrast, certification of the UAV System based on defined codes of airworthiness requirements provides for common standards which are not dependent upon mission frequency and length, and so avoids a direct and contrary dependency between airworthiness and utilisation for commercial gain. Also, the application of defined airworthiness standards to UAVs would build upon past experience and existing knowledge which has delivered for manned aircraft a level of safety for 3rd parties which is acceptable to the general public.

6.3.1.2.3 Exploiting Civil Market Potential

Military UAVs are normally designed to fulfil a particular mission and operating scenario. This aids the use of the Safety Target approach, as the UAV System can be designed and optimised to the customer’s tightly defined specification. In contrast, civil aircraft developments are normally initiated by the aircraft companies in response to their perception of marketing opportunities. The viability of a civil aircraft project commonly depends upon it being readily adaptable to the diverse specifications of many potential customers.

6.3.1.2.4 Ease of Modification

The certification task involved in switching existing civil aircraft between diverse roles is greatly eased by the basic aircraft design having previously complied with a comprehensive code of airworthiness requirements that were not inter-linked with a specific kind of operation. When an aircraft is modified in service to meet a new role, it must be demonstrated that the modified aircraft continues to comply with the certification requirements. In doing so it is usual to confine the new justification of airworthiness to the modification and its effects on the aircraft. It is not normally necessary to re-assess the whole aircraft as reliance can be placed upon the prior certification of the basic aircraft. With the safety case approach a complete reassessment of the aircraft and its operating environment may be required for every change of role.

6.3.1.2.5 Import and Export

The choice of regulatory system will have an impact on the ability and ease of exporting a UAV from one State and importing it into another. By the 1970's most States with civil aircraft manufacturing industries had compiled their own comprehensive codes of airworthiness requirements for civil aircraft. The marked differences between these requirements became a significant impediment to the transfer of aircraft between the civil registers of the different States. It was generally necessary to modify the design of aircraft built for export in order to comply with the unique requirements of each State. Over the last 25 years great effort has been expended, primarily through the JAA and FAA, on the harmonization of requirements to eliminate national differences and thereby facilitate the import and export of aircraft. If UAV Systems are certificated to codes of airworthiness requirements derived from the existing civil aircraft requirements, their manufacturers may benefit from the widespread understanding and acceptance of those standards brought about by the harmonization process. Conversely, if the "safety target" approach were to be adopted, we may be faced with the task of international harmonization of safety case regulations.

6.3.1.2.6 Effect on Existing Civil Design Practice

It is noteworthy that the conventional approach of applying a code of airworthiness requirements gives the aircraft designer the advantage of knowledge from the outset of the minimum acceptable standards applicable to all aspects of the design. This approach is well understood by the civil aerospace industry and is compatible with their existing infrastructure. This may not be so if the Safety Target approach was adopted.

6.3.1.2.7 International Convention

A further aspect that must be considered for UAV certification is where these aircraft will fit into the current legal framework for civil aviation. Adoption of a Safety Target philosophy for UAVS, which does not include a code of airworthiness requirements to impose a minimum airworthiness standard, would raise a number of issues. For example, the ICAO Convention on International Civil Aviation (the "Chicago convention") obliges each contracting State to collaborate in the development and application of uniform standards. Annex 8 to the Convention defines the essential standards for Certificates of Airworthiness.

6.3.1.3 Conclusion and Recommendation

In conclusion, the existing civil regulatory system has delivered continually improving safety levels whilst being flexible enough to cope with the relentless evolution and development in aircraft design over the last half-century. Any proposal to allow the established system to be set aside in favour of a Safety Target approach will be hard to justify today, especially where the new approach is not consistent with the ICAO Convention. Following due consideration of the pertinent issues, this concept of regulation recommends retention of the existing civil certification procedures for the routine certification of UAV Systems, using defined codes of airworthiness requirements to gain Type Certification and the

granting of Certificates of Airworthiness to individual UAVs when compliance with the Type Design has been shown. This approach is further defined in sections 7.4, 7.5 and 7.6. Such proposal is clearly workable for the short and mid-terms as it is based on known documents. Therefore its confidence level should be high.
The only general exception to this basic concept is for light UAV Systems intended for operation in confined, remote areas, where parallels can be drawn with model aircraft and considerations such as international flight are not valid. Guidance material for the regulation of light UAV Systems, which fall outside the scope of EASA under EC 1592/2002 Article 4(2) and Annex II, is discussed in Section Annex 1 of this report.

While this chapter has dealt with the concept of regulation for routine certification of UAV Systems, there may, on an occasional basis, be UAV Systems that fall outside of the considerations given above and which demand special procedures. Such a procedure is provided for in Article 5 Paragraph 3 of EASA Regulation 1592/2002, which permits the issuance of a Restricted Certificate of Airworthiness and a derogation from the requirement for an aircraft to hold a Type Certificate provided the aircraft is operationally constrained and the design conforms to a specific Airworthiness Specification that ensures adequate safety with regard to its purpose. So, for example, approval of a UAV designed and operated specifically for arctic surveys and constrained to operate entirely over a very remote area where the risk to third parties on the ground is small, could be approved under a Restricted Certificate of Airworthiness, and this may be based on the safety target approach.

In addition it is recommended that further research and development (in particular in relation with ICAO Annex 8) should be done on the "safety target" approach especially in the light of future development of UAVs.

6.3.1. 4 CERTIFICATION PROCEDURES

Having determined that the basis for airworthiness certification should follow the principles applied to manned aircraft, it follows that existing certification procedures should also be applied to UAV Systems wherever applicable.

6.3.1. 4.1 Type Certificates and Certificates of Airworthiness.

In accordance with Article 5 of EASA Regulation EC1592/2002 (as amended by Appendix 3-3), a product will be issued with a Type Certificate when the applicant has shown that the product complies with the type certification basis. The type certification basis is established between the applicant and EASA and will be based on the existing airworthiness standards derived for manned aircraft together with special conditions to address any novel features of the design. (See Section7.4)

Article 5 also provides for 3 types of airworthiness approval to be issued:

- A Certificate of Airworthiness when the Essential Requirements set out by the European Commission are met and the aircraft conforms to the type design and is in a condition for safe operation,
- A Restricted Certificate of Airworthiness where a deviation from the Essential Requirements has been mitigated by an operational restriction, and the aircraft is safe for its intended purpose, or

- A Permit to Fly if it can be shown that the aircraft is capable of performing a basic flight.

Insufficient guidance was available at the time of writing as to how these forms of airworthiness approval would be interpreted for manned aircraft. However, based on existing certification principles, the expectation is that issuance of a Permit To Fly for commercial operations is inappropriate, and is inconsistent with the notion of a "basic flight". UAV Systems designed with the intention of undertaking Aerial Work tasks would therefore not qualify for a Permit to Fly. It is also noted that under Article 8 of the Chicago Convention, UAVs would not gain automatic rights to operate into and over other ICAO contracting states and furthermore that UAVs would not be eligible for complete freedom to operate unless the dangers to other aircraft were obviated. It is expected therefore, that, as with manned aircraft, UAV Systems would qualify for a standard CofA if compliance with the EASA Essential Requirements are fulfilled or a restricted Certificate of Airworthiness if the Essential Requirements are not met but it can be demonstrated that the UAV is safe for its intended operation. However, in recognition of the current restriction imposed by ICAO Article 8, an operational restriction to limit there freedom to operate internationally could be imposed.

[Note: In the case of a Restricted Certificate of Airworthiness, a UAV would not be required to hold a Type Certificate, but to comply with an Airworthiness Specification that may or may not be based on an existing code of airworthiness requirements. A Restricted Type Certificate may be issued if the number of UAVs so justify.]

6.3.1.4.2 Organisation Approval

In the civil regulatory environment, compliance with the appropriate design requirements alone is not sufficient to ensure the validity of a certificate of airworthiness. It must also be demonstrated that each individual aircraft is in conformity with the certificated design throughout its operational life. Conformity with the approved design is assured by requiring that organisations that design and/or build aircraft hold appropriate organisation approvals (ref.: EASA basic Regulation 1592/2002, Annex 1, paragraph 3). Additionally, replacement parts must be manufactured by approved organisations, and appropriately licensed personnel must carry out maintenance. Organisation approvals and personnel licences are granted on the basis of compliance with the appropriate requirements. For example, an organisation undertaking design activities may be granted a DOA approval through compliance with Part 21 Subpart J. On the basis that UAVs are to be issued with certificates of airworthiness, their design, manufacture, and maintenance will be subject to the same requirements that are applied to these activities in respect of manned aircraft. Consideration was also given to the acceptance of alternate procedures for organisation approval other than a DOA issued in accordance with Part 21. The issue discussed was primarily whether a UAV System that was covered under EASA regulations could be considered to be of "simple design" due to the necessity to incorporate complex and integrated avionic systems. The conclusion reached was that, for the short-term, UAV Systems should not be considered of "simple design" because of the novelty of the type, but that this position could change as experience is gained in the certification and operation of civil UAV Systems.

6.3.2 SECURITY

Unlike many areas that are being addressed within the UAV Task-Force where a direct mapping of the regulation and approaches associated with the manned world can be made, the un-manned world introduces issues of security that did not previously exist.
Security measures need to be incorporated into a design in order to provide a measure of confidence that the UAV System will be used for its intended and authorised purpose. However the level of security measures necessary need to be assessed from a "Systems" level balancing the Threats and Weaknesses of the system and its intended operational profile. This will then lead to defining "System Vulnerability" and determines the level of security measures that should be taken.

Figure 6-3 illustrates that the balance between Threats and Weaknesses provides a measure of System Vulnerabilities. Examples of factors that are used to assess threats and weaknesses are provided in ENCLOSURE 2 Section 2.4. Of note here is that the "desirability" for an adversary to target the UAV is an important factor in these assessments. If a system cannot provide any gain then it is unlikely that it will experience an attack whereas a UAV with a high potential for damage or commercial advantage may attract considerably more attention and therefore the security measures necessary should reflect this.

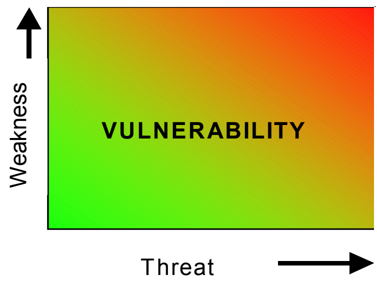

Figure 6-3

The top level issues to be considered in any proposed security framework designed to meet the requirements of a Threat Analysis are:

- Physical Security
- Communication Links
- Data Networks
- Software
- Malicious(terrorist) intentions for the use of civil UAVs
- Market Control

The security measures that can be applied to the Physical UAV Pilot (UAVp), Communication Link, Data Network, Processing Unit vary considerably dependant upon the Threats that could be posed by and to the UAV System. It is therefore imperative that the market for UAV Systems is not constrained by security measures that are not appropriate to the specific characteristics of the air vehicle, system or mission. It is equally important that the security measures are sufficient to support the required safety levels and that security is not reduced creating an unsafe environment. The use of Vulnerability analysis emphasises that there is not a prescriptive set of security measures that apply to a particular air vehicle in a particular airspace.

If a UAV is to operate in all classes of airspace it is important that a range of security measures be defined that allows the many and varied vulnerabilities to be managed. Examples of the issues to be addressed are:

- The availability of the pilot on the ground,
- The need for defendable occurrence investigation data,
- The access to UAV control data by a third party,
- The impersonation of the UAVp by a third party,
- Intentional data link disruption,
- Correctness of data transmission
- UAVp ground station access control.

It is recognised that civil UAVs could represent a significant level of concern as regards national security issues in connection with the increased opportunity for malicious intentions and therefore the need for sufficient security measures, as discussed in detail in ENCLOSURE 2 Section 2.4, must be addressed in order to mitigate the Threat.

Effectively the European Community has included the UAVs with *"capability of autonomous flight control and navigation or capability of controlled flight out of the direct vision range involving a human operator"* in the so called "dual use items and technologies", which are subject to a specific regime for the control of exports, set up in the Council Regulation No 1334/2000 of 22 June 2000, which was further amended by Council Regulation No 149/2003 of 27 January 2003.

"Dual use goods" are also treated in the Wassenaar Arrangement, established among 33 worldwide countries to contribute to regional and international security and stability by promoting transparency and greater responsibility in transfers of these goods.

UAVs capable of carrying a payload of 500 kg or more to 300 km range or more will also be subject to Missile Technology Control Regime (MTCR), a voluntary arrangement among 27 countries consisting of common export policies applied to a common list of controlled items.

As is the case for military airborne systems, States will have to assess possible requirements for market controls related to civil UAVs. Such assessments, which would need to quantify terrorist advantages which could be derived from the "unmanned" nature of UAV Systems, are fundamental and pre-requisite to concluding discussions and acceptance that civil UAVs do not represent intolerable State security risks.

The security measures considered in ENCLOSURE 2 Section 2.4 examine the core differences between manned and unmanned aircraft flight and explores the range of security measures that can be utilised to mitigate the unique risk posed by the UAV System.

6.3.3 OPERATIONS, MAINTENANCE, LICENSING

6.3.3.1 Approach
Three ways to identify significant issues for UAVs on operations, maintenance and licensing that might need further action before drafting regulations were used:

1. Brainstorm about particularities of UAVs that might not yet have been sufficiently addressed in existing regulations for manned aircraft.
2. A review of existing regulations on operations, maintenance and licensing, notably the JAR-OPS, JAR-66, JAR-145, JAR 147 and JAR-FCL. As well as the applicable ICAO Annexes
3. If available, a review of EASA regulatory material.

When reviewing the existing regulations it appeared that these could not always be applied to UAVs because these regulations were established for other purposes. For example, the JAR-OPS 1 prescribes requirements applicable to the operation of civil airplanes for the purpose of commercial air transportation. General aviation is not commercial and hence not addressed in the JAR-OPS 1. Also excluded are customs and police services and aerial work. The majority of the UAV operations may be "aerial work" and would hence not fall under the commercial air transportation for which the JAR-OPS 1 is intended.
For these reasons the JAR-OPS 1 is not applicable for UAV operations. It may, however, be the best source with requirements for aircraft operations and hence a useful means (but not the only means) to quickly identify issues that should be considered for UAV operations.

Another thing is that UAVs have very specific characteristics that are not found with manned aircraft. To name a few, secure data link requirement, the possibility to control multiple UAVs by one Pilot, handling over the control of a UAV to another Control Station etc.

6.3.3.2 Basic principles
The goal is to stay as close to existing rules as possible. As long as equivalence with existing manned operations can be fulfilled, no deviating concepts are proposed.
Only UAVs to be operated for civilian purposes are dealt with in the concept. As the regulations will be developed by JAA or EASA as appropriate they will be international. It has been decided that the international regulations will be applicable for UAVs with a take-off mass in excess of 150 kg. This means that for a take-off mass below 150 kg, national regulations apply which are not covered by the UAV Task-Force.

6.3.3.3 Licensing
It is recognized that -like with manned aircraft- persons and organizations working with UAVs may need a formal approval or license to do so.

Persons involved in the operations and maintenance of UAVs are:

- UAV crew
- UAV technicians.

Organizations involved in UAV operations and maintenance are:

- UAV Operators
- UAV Maintenance organizations

For UAVs, as much as possible, use should be made of the experience that already has been gained and translated into different kinds of licenses, regulations, training means and methods, training schools and so on; these should be used as far as appropriate and adopted to special

UAV needs. As much as possible, the licenses for UAV personnel shall be compatible with those for manned aircraft. For AOC holders and maintenance organisations, this could imply adding the UAV type as an additional aircraft type in the scope of approval. For pilots and maintenance personnel this could imply the adding the UAV type as an aircraft type rating in the existing pilot's flight crew license and aircraft maintenance personnel license

6.3.3.4 Operations

Considering the equivalence principle a UAV Operator intending to operate UAVs should also be in the possession of a license or approval for UAV operation.
In the current situation the existing JAR-OPS 1 requirements do not include UAV operations; however the certification of UAV operators should include similar requirements and practices as those for manned aviation in order to be equivalent.
There is a broad scope of different kind of operations with UAVs comparable to Aerial Work activities in manned aviation. By lack of applicable JAA requirements for aerial work other available regulatory material can be used as a starting point. The following types of aerial work are distinguished: Aerial filming, agriculture, construction, emergency and medical services, fire fighting, law enforcement, observation and patrol, stock mustering and survey.
The JAR-OPS 1 was assessed on a requirement by requirement basis for their possible applicability to the operations of an UAV.

6.3.3.5 Maintenance

For manned aircraft the requirements for maintenance organisations have been laid down in JAR 145. The requirements for maintenance training organisations can be found in JAR 147 while the requirements for maintenance technicians are stated in JAR 66.
As UAVs are required to meet the airworthiness certification standards, maintenance requirements in order to ensure the continued airworthiness of the UAV have to be applicable as well.
As UAVs will primarily be used in aerial work applications, the maintenance requirements applicable for aerial work operators will provide the best fit. A problem is that until now no European (JAA or EASA) regulations for aerial work operators exist. However it is expected that EASA Part M (Annex 1 to Commission Regulation (EC) No. 2042/2003) to will be applicable for aerial work operators by the time UAV regulatory material will be developed.
For light UAV Systems (to be excluded from this document) it is not required to meet the airworthiness certification standards. Therefore maintenance requirements in order to ensure the continued airworthiness of the UAVs do not apply either.

6.3.3.6 Conclusions

In order to be able to operate and maintain civil UAVs with a take-off mass in excess of 150 kg, international regulations have to be developed. For UAVs below 150 kg, national regulations will apply and these are not covered by this document.
These recommendations serve as a guideline to identify which specific items related to UAVs need to addressed for operations and licensing.

The general philosophy should be to stay as close to existing regulations as possible and use the equivalence principle whenever possible.

6.3.4 ATM

The safety regulatory structure within ECAC ATM environment is defined by the EUROCONTROL Safety Regulatory Requirements, referred next as ESARR.

The objectives of those developing safety regulatory requirements are formulated as follows:

- Development of ATM safety regulatory requirements across ECAC region;
- Co-ordination of requirements implementation across the ECAC region
- Establishment of a process to measure the safety performance and identify the key risk areas

The principles listed above provide that the regulatory framework is not isolated but provides for feed back to be improved.

ATM issues have stemmed from the users request to operate within specific portions of airspace and as such they have to fulfil specific requirements. This is the case now with UAV operations outside restricted airspace. Today operations are considered within restricted airspace for which arrangements and clear requirements are formulated. The range of operation for civil UAVs concerns for the time being only aerial work. Transport of passengers within UAVs is not considered within the next future.

A total system approach is considered also by the safety regulatory framework described by ESARRs. That is to say that there is a clear relationship between all ESARRs and also they are looking to the element of ATM: People, Equipment and Procedures within the ATM organisation addressing safety from the perspective of airborne and ground components of the ATM system.

UAV operations outside restricted airspace will have to consider the ATM safety regulatory framework and also the principles listed above. Further implications within the ATM environment for UAV operations outside restricted airspace shall take into consideration the airspace development mentioned within the EUROCONTROL airspace strategy for ECAC States and navigation standards specified within Navigation Strategy for ECAC States.

6.3.5 AERODROMES

Safety regulations for aerodromes are based on ICAO Annex 14. In Europe, the Group of Airport Safety Regulators (GASR) has been set-up by 14 countries to develop on a voluntary basis harmonised safety regulation standards for aerodromes and ground aids.
GASR are developing a JAR-AGA for aerodromes and heliports which address issues such as Aerodrome Licensing, data, physical characteristics, markings, etc.
GASR is also considering issues such as surface movement management and safety management systems.

In the future UAVs should use aerodromes that are used for Commercial Air Transportation and General Aviation. They should also use dedicated platforms that may be temporary.

Aerodrome issues have not been looked at in this report. However this does not mean that there are no UAV issues in relation with aerodromes. One obvious risk is the one of runways incursions. It is not specific to UAV. In the present manned aircraft context there may be one runway incursion every three to four days, causing a quasi-collision every 2 or 3 months within Europe. Circulation on the ground of UAVs may cause specific problems for UAV as there is no one on board to identify red signal for example.

The UAV-TF recommends that GASR review aerodrome regulation to identify possible changes in the light of UAV operations

7 DISCUSSION TOPICS

7.1 to 7.11 deal with airworthiness issues, 7.12 with noise and emissions, 7.13 with frequency spectrum, 7.14 with responsibilities and handover, 7.15 with security and 7.16 to 7.21 with operations, licensing and ATM issues.
The following present a number of discussion topics that have been considered by the Task Force. While the list of these topics may have to be completed at a further stage, they were viewed significant attention items. For each topic, a statement of issue is provided, the discussions which took place at the Task-Force are summarised and recommendations are outlined together with relevant institutions to which they are addressed with an indication of proposed timeframe and priority

7.1 LEGAL FRAMEWORK FOR UAV AIRWORTHINESS CERTIFICATION

Statement of Issue

EASA Regulation EC 1592/2002 provides a legal framework for the regulation of airworthiness standards and certification procedures within Europe. However, no consideration was given during the drafting of the Regulation as to the unique characteristics of UAV Systems. A review of the Regulation has been undertaken with the view to adapting it to cover the specific case of UAV Systems.

Summary of the discussion

A review was undertaken of the EASA Regulation EC 1592/2002 and its Annex 1 (Essential Airworthiness Requirements) to determine their applicability to UAV Systems. It was found, in the main, to be equally applicable to manned aircraft and UAV Systems. However, some changes are found necessary; the most significant amendment considered necessary was to extend the definition of a “product” to include an assessment of the complete UAV System as part of the certification process. In the current regulation, "product" means an aircraft, engine or propeller. In the case of an Unmanned Aerial Vehicle (UAV) system, the aircraft “product” will have to include any remote equipment forming part of the UAV System that could prejudice safe flight and safe recovery, including launch equipment, the Control Station and any Communication Link essential for control of the aircraft. A UAV System Element, e.g., typically, the Control Station may be certified in its own right as a product, in which case the aircraft product needs to consider its safe integration.

Recommendations

It is recommended to initiate a regulation change of the EASA EC1592/2002 to facilitate the certification of UAV System. Appendix 3-3 contains the recommended changes to the regulation and its Annex 1 on Essential Airworthiness Requirements.

The relevant institution(s) identified to continue the work on this issue

It is recommended that EASA to express an opinion to the European Commission to initiate the proposed change. This could be undertaken together with already identified required changes to clarify compliance for small aircraft.

Timeframe & priority proposed

2 years. Medium priority.

7.2 INTERPRETATION OF UAV AIRWORTHINESS DEFINITION

Statement of Issue

The definition of "airworthiness" stated in Section 4 is "*an aircraft is deemed to be airworthy within the EU if it meets or exceeds the essential requirements as defined in the EASA basic requirement EC1592/2002 Annex 1*". While providing an accurate statement, in the context of developing airworthiness requirements for UAV Systems, a need was identified to expand on this definition and to provide clear guidance on what should and what should not be addressed within the scope of airworthiness requirements.

Summary of the discussion

Prior to EASA, there was no accepted definition of airworthiness and Authorities often adopted a working definition that considered an aircraft as airworthy if it was in compliance with all applicable airworthiness requirements as specified by the State of Registration. As different states applied their own airworthiness requirements to reflect their individual experiences and safety culture, airworthiness was not a fixed concept and the level of requirements demanded would vary from State to State.
With the introduction of EASA Essential Requirements, the concept of airworthiness is now better defined and with the adoption of implementing rules and certification specifications, provides the basis for a harmonised and common interpretation. However, until such time as these requirements are fully developed and due to the unique features of UAV Systems, further clarity is provided to establish the scope of airworthiness requirements.

Recommendations

Items deemed to be part of an "Airworthiness" approval typically include:

- Safety related aspects of aircraft performance & flight characteristics.
- Design and production of aircraft structure (including launch and recovery loads).
- Design and production of mechanical/hydraulic/pneumatic/ electrical systems.
- Design and production of aircraft propulsion systems and APUs.
- Design and production of avionic systems and equipment (including software) in so far as ensuring they perform their intended function to the expected safety level.
- The instructions for continued airworthiness.
- Flight Manual, including emergency procedures and limitations
- Safety assessment of the UAV Communication Link including its susceptibility to environmental effects (HIRF, Lightning, Interference)
- The design and production of any element of the Control Station the failure of which could prejudice safe control of the aircraft.
- Human Factors aspects of the Control Station where relevant to the safe control of the UAV.
- Design and production of any Flight Termination system

Items not covered under "Airworthiness":

- Control station security.
- Security of the Flight Control link from wilful interference.
- Segregation of Aircraft.
- The competence/training of UAV pilots & operating personnel.
- The type of operation (other than to define flight envelope limitations and other aircraft limitations).
- Frequency spectrum allocation.
- Noise & Emission certification.
- Launch/recovery equipment that is not safety critical and which does not form part of

the type certification basis.
- Operation of the payload (other than its potential to hazard the aircraft)

Note. Items not covered under "airworthiness" may be subject to other forms of approval.

The relevant institution(s) identified to continue the work on this issue

See global action under 8.3.

Timeframe & Priority proposed

See global action under 8.3.

7.3 UAV SYSTEM ELEMENTS TO BE INCLUDED IN TYPE CERTIFICATION BASIS

Statement of Issue:

In order to certify a UAV System it is necessary to identify from the outset the boundaries of that system. There are intrinsic aspects of UAV design, its control, support, and interface with its Pilot and other air traffic, that may require different or unique types of approvals and certifications which fall outside of the traditional aircraft methods of type certificates or TSO's.

The identification of the system is necessary since the traditional aircraft design certification process doesn't clearly lend itself to a UAV System. For example, the cockpit of a traditional aircraft design is approved as part of the aircraft airworthiness certification. However, when a cockpit is remotely located (which is the case of a UAV System) the Control Station could require multiple approvals, including: airworthiness certification, health & safety, security, etc.

***Summary of Discussion*:**

There are a number of definitions of the elements that should be regulated in existing published data. The most useful of these are those based on the functionality of the equipment, rather than its location, as this allows for varying degrees of UAV automation. The nature of general statements also removes any specific list of functions, or equipment that are included or excluded from the regulation. Although this makes the overall intention clear, it leaves applicability for some specific systems rather ambiguous and could lead to later confusion. As an addition to a statement of this nature, there would therefore be merit in including guidance as to typical systems that are considered to be within, or outside, the boundary of regulation. Such a list will never be exhaustive, but may at least remove the majority of questions and give guidance for other unlisted functions that arise in future.

To illustrate the problem, an example would the flight planning system. If the flight plan were prepared in advance then the system used to create it is of little importance, what matters is that the plan has integrity. However, if the plan is to be updated as the means of UAV control in flight, then the system used becomes vital to UAV control, and should be within scope of regulation.

One difficult issue is that of ground-based test equipment, used in final preparation and readiness for flight of the UAV. In many ways, failure of this equipment to detect faults could be very serious, yet this is no different to the situation with many items of equipment for manned aircraft that are outside of the current regulation. At present, this is not included in the scope (adopting the principal of equivalence) though discussion may result in its later inclusion.

Some specific issues that have been identified and an approach adopted are discussed in the following sub-sections.

1 Flight Control/Flight Management Systems

The flying controls, flight guidance and flight management systems for existing manned aircraft are subject to regulation to the extent necessary to ensure that system failures do not give rise to unacceptable hazards. These systems are included in the aircraft design standard for certification and their compliance with the design requirements is essential to the validity of the Certificate of Airworthiness. With UAV Systems it is probable that at least part of the flight management or flight guidance systems will be contained in a Control Station remote from the air vehicle.

Applying to UAV Systems the same logic of assuring the validity of the Certificate of Airworthiness as for manned aircraft, it follows that the relevant remote equipment (e.g. UAV Communication Link) must be considered as part of the aircraft for the purposes of design, manufacture and maintenance.

2 Control Station

Consideration was given as to whether approval of the remote Control Station should be sought as part of the UAV or whether the Control Station could be approved in its own right and hold a separate Type Certificate similar to the existing practice with Engines and Propellers. In developing these proposals, future civil UAV System developments were considered, including the likelihood that generic Control Stations able to control more than one type of air vehicle, would emerge. Provided interface protocols were developed to ensure the correct functioning of the UAV, it was concluded that both approaches were equally valid. Where the Control Station was granted a separate Type Certificate, it would be the responsibility of the applicant for UAV Type Certificate approval to ensure compatibility with the remote Control Station and the overall safety of the UAV System.

3 Launch & Recovery Equipment

Essential equipment for the launch and recovery of a UAV could be safety critical if it failed in a manner that prevented flight control from being maintained. To prevent such a condition, it was envisaged that launch and recovery would normally be controlled through operational restrictions that provided a secure launch and recovery area free from any persons or property. However, it was also envisaged that this provision might not be practicable in certain types of operations, e.g. vertical launch from the top of a building situated in a populated area. For this and other type of operation, the launch and/or recovery equipment would be safety critical and must therefore be included within the type design configuration and certified as part of the UAV.

Recommendations:

For an aircraft product certification (UAV), any function of the UAV System that can prejudice safe take-off, continued safe flight or safe landing of the UAV, that function, and the equipment performing that function, (including equipment remote from the UAV), shall be considered as part of the UAV for the purposes of the validity of the Type Certificate and as such will have to comply with the applicable airworthiness requirements as stated in the Type Certification Basis. If a UAV System Element, e.g., typically, the Control Station is certified in its own right as a product, the aircraft product (UAV) need only consider its safe integration.
Identification of UAV System Elements included as part of the aircraft product should normally be supported by a functional hazard assessment performed by the applicant.

The relevant institution(s) identified to continue the work on this issue

See global action under 8.3.

Timeframe and priority proposed

See global action under 8.3.

7.4 SETTING THE TYPE CERTIFICATION BASIS

Statement of Issue

Codes of airworthiness requirements provide basic aircraft design standards primarily aimed at the protection of passengers, crew and 3rd parties on the ground. The codes of airworthiness requirements for manned aircraft have been developed over the past 50 years by taking account of evidence from accidents, in-service experience and advances in technology and have been paramount in achieving a high level of safety acceptable to the public. With the introduction of UAV Systems with no persons on-board, the protection of passenger and crew is no longer a consideration and the safety emphasis changes to the protection of third parties and property. The question then arises as to how an appropriate certification basis for UAV Systems can be established which builds on this experience and provides an "equivalent" level of safety to manned aircraft.

Summary of the discussion

The existing codes of airworthiness requirements for manned aircraft have been developed using a scaled approach to increase the applicable standards as a function of aircraft all-up weight, performance and occupancy (number of passengers). They can be interpreted as being derived from a set of ICAO Standards imposed primarily with the protection of 3rd parties and property in mind, plus cabin safety requirements aimed specifically at assuring adequate protection for passengers and crew. In the recent years more emphasis was put on protection of people on board. Clearly, if an aircraft is unmanned, the use of occupancy as a major criterion is inappropriate. It could therefore be argued that an acceptable starting point in determining suitable requirements for UAV Systems could be reached by taking the existing requirements for manned aircraft and deleting the paragraphs which address the cabin environment and the protection of occupants. This would build upon existing knowledge and evidence that such requirements have delivered a level of safety for manned aircraft that the public accepts. Most UAV System certification activities undertaken to-date, both military and civil, have started from this premise. However, as the occupant criterion has had a strong influence on the standards developed, can we be sure this assumption is valid and that the inherent standards contained within the codes of airworthiness requirements still reflect the appropriate level of safety?

Two techniques for establishing an initial type certification basis, which have been developed independently and take no account of existing criteria, are presented in Enclosure 3 Appendices 3-4 and 3-5. The approach contained in Appendix 3-4 is applicable to all UAV Systems and defines safety levels in terms of impact kinetic energy of the air vehicle, thereby creating a direct correlation with the capability of the UAV to cause injury and damage. Identifying elements of existing codes of airworthiness requirements that provide "equivalent" energy (safety) levels to manned aircraft is used to set an initial Type Certification basis. The second technique contained in Appendix 3-5, attempts to redefine the boundaries of the existing manned aircraft codes of airworthiness requirements by orientating the safety objectives to the protection of people on the ground. This proposal uses a number of parameters including: an acceptable ground victim criterion, kinetic energy, lethal surface area and population density. Both of these techniques were discussed in depth during the development of this concept but without reaching any consensus on a way forward.

Once the relevant airworthiness code(s) has/have been chosen which represent(s) the appropriate safety level, the type certification basis is constructed by tailoring the selected airworthiness code(s) (see Section 7.6) and by adding special conditions to cater for novel elements of the UAV System. The extent of such special conditions should be comparable with the general level of airworthiness identified. Agreement to the type certification basis will be an iterative process between the Authority and the applicant.

Recommendations

1. The Type Certification basis should be adapted from the existing codes of requirements developed for manned aircraft. –

2. The methodology for selecting the appropriate code or codes has yet to be established. Two possible approaches are detailed in Enclosure 3 Appendix 3-4 and Appendix 3-5.

3. A typical Type Certification Basis is likely to include:

    a. Existing manned airworthiness requirements duly tailored to UAV Systems using the recommended method stated in 7.6

    b. System Safety Objectives and Criteria, applying the "1309" approach to UAV System as a whole, as recommended in 7.5

    c. Special condition & Interpretative Materials related to UAV specifics, such as:
        - Emergency Recovery Capability (See 7.7)
        - Communication Link (See 7.8)
        - Level of Autonomy (See 7.9)
        - Human Machine Interface (See 7.10)
        - Other Special Conditions as appropriate considering the envisaged kinds of operations (e.g. IFR operations certification in case of JAR/CS-VLA code application)

    Note: Technical Issues when defining the Type Certification basis as may arise from the tailoring of existing manned requirements or from specific UAV topics may typically be handled through Certification Review Items between the applicant and the authority (as per JAA Administrative Guidance Material, Section 3, Part 2, Appendix 55 or EASA equivalent).

4. Where application is made for a restricted certificate of airworthiness under the provisions of Article 5 paragraph 3 of EASA regulation 1592/2002, the airworthiness specification should be set commensurate with the level of imposed operational restrictions.

Note:
In the case of a small UAV operating in a remote area, airworthiness requirements may be reduced, provided equivalent safety can be maintained through imposing more stringent operating constraints. (See Annex 1 and Enclosure 3 Appendix 3-2)

The relevant institution(s) identified to continue the work on this issue

EASA will need to determine the criteria for selecting the appropriate airworthiness code to be used as the basis for type certification approval, and develop generic special conditions to approve UAV novel features.
See also global action in section 8.3

Timeframe & Priority proposed

Timeframe immediate, Priority Medium to High.

7.5 UAV SYSTEM SAFETY OBJECTIVES AND CRITERIA

Statement of Issue

To accord with the UAV Guiding Principles, UAV Airworthiness Requirements have to include safety objectives and criteria in a manner comparable to those which exist for manned aircraft (typically, CS-VLA/23/25.1309 and related Advisory Materials). However, airworthiness requirements and safety criteria developed for manned aircraft may not be fully applicable in the framework of a future UAV airworthiness certification, considering, for example, that UAVs have no crew / passengers on board and that UAV Systems contain specific and unusual design features that have a direct impact on safety.
This section discusses System Safety objectives and how the traditional manned aircraft approach may be tailored to address the specific characteristics of UAV Systems.

Summary of the discussion

- Current airworthiness safety criteria for manned aircraft range from very broadly stated ones, like CS-VLA 1309 (with no quantitative criteria) to more detailed ones such as CS-25.1309 and related AMC 25.1309 which define general safety objectives and require an inverse (quantitative) relationship between the probability of failure and its severity. For example, AMC 25.1309 recommends that "Catastrophic failure conditions must be "Extremely Improbable", where "Catastrophic" is the effect associated with loss of the aircraft and multiple deaths of aircraft occupants.
- UAV Airworthiness safety criteria should aim at providing an equivalent safety level based on rationale similar to the one adopted for manned airworthiness requirements, but consider the particular characteristics of UAV System design viewed as a whole and not only confined to the Air Vehicle.
- From the airworthiness point of view, the risk to third parties on the ground would become the most severe risk to be minimized and manned aircraft severity definitions related to death or injury of on board passengers are to be subsequently readjusted. For instance, UAV System failure conditions leading to a controlled crash over unpopulated areas should obviously be considered less severe than those leading to uncontrolled crash over populated areas.
- Quantitative UAV Safety Objectives and criteria may use similar rationale to the one used for different manned aircraft categories (see in particular AMC 25.1309 or FAA AC 23.1309-1C) and vary depending on the UAV category. (See potential approaches discussed under 7.4)
- According to the nature of the certification requested (as per provisions of Article 5 of the EC 1592/2002), the "hit" probability on the ground (that is a function of population density and UAV lethal area) may or may not be considered, which could then lead to some operational limitations with regard to the over flown zones
- The tailoring of quantitative probability criteria according to operational restrictions was also discussed. When and if applying such method, attention was drawn on elements such as public trust and the possibility to have imposed realistic operational restrictions (e.g. emergency landing on actually unpopulated area)

Recommendations

The following recommendations are proposed, with regard to the way airworthiness requirements related to UAV System Safety should be handled:

1. The level of requirements should be tailored according to and compatible with the agreed selected airworthiness code as discussed under 7.4
2. There should be a distinction between qualitative safety requirements and quantitative criteria to be set forth as acceptable means of compliance and advisory materials.

3. Special condition and/or advisory & interpretative materials related to UAV System airworthiness safety requirements and criteria should be established in the spirit of the "1309" approach for manned aircraft.
4. In establishing such special condition and advisory materials, the following may be considered:
    - The worst UAV Hazard Event designated hereafter as "Catastrophic" or Severity I Event may be defined as the UAV's inability to continue controlled flight and reach any predefined landing site, i.e. an UAV uncontrolled flight followed by an uncontrolled crash, potentially leading to fatalities or severe damage on the ground.
    - The overall (qualitative) Safety Objective for UAV System may subsequently be e.g. "to reduce the risk of UAV Catastrophic Event (as above defined) to a level comparable to the risk existing with manned aircraft of equivalent category."
    - Quantitative safety objective for the individual UAV "Catastrophic" or "Severity I" conditions and/or for the sum of all failure conditions leading to a UAV Severity I Event should be set, per UAV category, based upon a rationale similar to the one used in AMC 25.1309 and FAA AC 23.1309-1C considering:
        - The probability level for catastrophic failure conditions that is considered as acceptable by the airworthiness requirements applicable to manned aircraft of "equivalent class or category"
        - The historical evidence and statistics related to manned aircraft "equivalent class or category", including, where relevant, consideration of subsequent ground fatalities.
    - Severity categories lower than "I" as determined above may be defined as follows, as "parallel" the JAR/AMJ.25.1309 categories of Hazardous, Major, Minor and No Safety Effect.
        - Severity "II" would correspond to failure conditions leading to the controlled loss of the UAV over an unpopulated emergency site, using Emergency Recovery procedures where required.
        - Severity "III" would correspond to failure conditions leading to significant reduction in safety margins (e.g., total loss of communication with autonomous flight and landing on a predefined emergency site)
        - Severity IV would correspond to failure conditions leading to slight reduction in safety margins (e.g. loss of redundancy)
        - Severity V would correspond to failure conditions leading to no Safety Effect.
    - As per Advisory Materials such as FAA AC 23.1309 1C or AMC.25. 1309, the quantitative probability ranges required for lower severities should be derived from the quantitative required objective for the worst severity
    - In addition, the following ground rules and system safety criteria may be added:
        - Emergency landing sites (unpopulated areas) should be defined as follows:
            - These sites shall be unpopulated areas
            - Their location be such that :
                - the UAV will be able to reach them, considering e.g. UAV gliding capability and emergency electrical power capacity (e.g. in case of loss of thrust)
                - One of them will be selected to cope with failure conditions other than loss of thrust, e.g. total loss of Communication Link that would prevent the UAV from landing on normal site.

- The method used to reach those emergency sites shall be determined and assessed, should any credit be requested in the system safety assessment.
- When assessing the total probability of UAV Catastrophic Event, failure to reach those emergency sites should be taken into consideration.

The relevant institution(s) identified to continue the work on this issue

Refer to global action under section 8.3

Timeframe & priority proposed

Refer to global action under section 8.3

7.6 TAILORING OF EXISTING MANNED REQUIREMENTS

Statement of Issue

Section 7.4 discusses the setting of a UAV Type Certification basis based upon the tailoring of existing airworthiness requirements of a selected airworthiness code. Once this airworthiness code has been selected, a method on how to tailor the corresponding requirements for UAV application has to be defined.

Summary of the Discussion

When using and tailoring EASA Certification Specifications (CS) as an element of the applicable UAV Type Certification Basis, one should keep in mind that the related requirements have been established for manned aircraft, assuming crew and passengers on board.

While the tailoring of EASA CSs may be a useful tool to assess the airworthiness of the Air Vehicle, and possibly identify the required display of flight parameters within the Control Station, it should be used in conjunction with other airworthiness requirements covering additional areas such as:

- System Safety Objectives and Criteria (as discussed under 7.5)
- Emergency Recovery Procedures (as discussed under 7.7)
- Communication Link (as discussed under 7.8)
- Control Station / Human Machine Interface (as discussed under 7.10)

There are requirements that are obviously not relevant for consideration in UAV applications, namely those dealing with the comfort and safety of crew or passengers on board.

On the other hand, for some other requirements, there may be no immediate reason not to use them. However, “blind” application of such requirement to UAVs may lead to hazardous flight demonstration, excessive design or weight penalties, for example, that would present an unnecessary economic burden for the industry. The rationale for such requirements should be then carefully reviewed and potential alternative criteria providing an equivalent level of safety could be suggested on a case-by-case basis.

Recommendations

The following recommendations are proposed, with regard to the way airworthiness requirements should be tailored when establishing the Type Certification basis as discussed under 7.4, after a relevant airworthiness code has been selected.

1. The applicant should provide the Certifying Authority with a tailoring proposal of the requirements using the following type of categorization for each requirements:

   - F: Requirement as is may be Fully applied
   - I: “Intent” of the requirement may be applied but not as exactly worded (interpretation / slight change required in order to make it suitable to UAV application).
   - N/A: Requirement Not Applicable as obviously not relevant to UAV applications “per se” (e.g. no crew or passengers on board)
   - N/A-C: Requirement Not Applicable due to assumed UAV Configuration
   - P: Requirement may be only *partially* applied (e.g. part of it may be “N/A”)
   - A: *Alternative* criteria may be proposed

2. Rationale for above categorization shall be presented and justified for each requirement.

3. Wherever found necessary, Certification Review Items shall be raised to address specific issues, in particular where the category “A” has been proposed. These CRIs may subsequent lead to Special Conditions or Interpretative Materials to provide an equivalent level of safety with the original intent of the requirement.
4. Criteria set forth under UAV System Safety Objectives [see 7.5] may be considered when assessing specific sections of the EASA Certification Specifications that contain specific and possibly conflicting safety design requirements; these possible conflicts should be resolved using e.g. as guidelines related wording of current CS 25.1309 or on a case by case basis through Special Conditions.

The relevant institution(s) identified to continue the work on this issue

Refer to global action under section 8.3

Timeframe & priority proposed

Refer to global action under section 8.3

7.7 EMERGENCY RECOVERY

Statement of Issue

UAV System design may incorporate some emergency recovery capability. Various terminologies are currently being used, such as “flight termination system”, “emergency recovery systems” and the way these capabilities are implemented, their exact definition or function may however vary from one application to another. Any UAV airworthiness regulation concept should propose a way to handle the following issues:

- Definition of emergency recovery capability, broad enough to be applied to most UAV applications, without imposing a particular type of design solutions.
- Corresponding Airworthiness Criteria (at least highlights) covering:
    - the need or not to make this emergency recovery capability mandatory
    - the conditions to be met, including those under which credit may be granted to such a capability in the UAV System airworthiness assessment

Summary of the discussion

- In most of the current UAV draft materials, Flight Termination Capability or System is defined as “a controllable parachute or automatic pre-programmed course of action used with UAV Systems to terminate flight in case of a critical failure”. This latter definition seems to be currently the broadest one, compared to other ones that dictate the type of technologies and design solutions to be implemented.
- Flight Termination terminology may be somewhat misleading since it may sometimes range from dedicated systems such as a parachute to the implementation of emergency procedures (in the case of UAV, through autonomous design means).
- The very purpose of an UAV System Safety Assessment (in line with 7.5) is to verify that the UAV System complies with safety objectives – e.g. the probability level for the risk of uncontrolled UAV crash is less than an agreed figure and the severity of various potential failure conditions is compatible with their agreed probability of occurrence. Hence, an UAV manufacturer should be entitled to show, through means of compliance to be approved by the certifying authority, that it complies with these safety objectives, taking into account the existence of UAV emergency recovery capability, provided the use of Emergency Recovery Procedures are not used as a “catch-all” for every failure case and their potential use is judged not to be excessive. An example of failure conditions that would be analysed considering the existence of the emergency recovery capability would be the loss of thrust and the critical malfunction of the flight management system.
- Typically, a failure condition which would lead to the activation of Emergency Recovery Procedures would not be classified as Severity I (i.e. leading to an uncontrolled UAV crash) but rather of a lesser severity. Alternatively, for an UAV System which would not incorporate Emergency Recovery Procedures, it would have to show that, either those failure conditions do not lead to a Severity I effect or if so that the Safety Objectives (including single failure criteria) related to uncontrolled UAV crash are met.

Recommendations

1. Flight Termination terminology should be exclusively devoted to systems, procedures or functions that aim at immediately ending the flight.

2. Emergency Recovery Procedures, which could be implemented through UAV Pilot command or through autonomous design means, may be used to mitigate the effects of certain failures. This may include automatic pre-programmed course of action to reach safe landing or crash area.

3. UAV System Safety Assessment should be performed to show that the UAV System complies with safety objectives - e.g. the probability level for the risk of uncontrolled UAV crash is less than an agreed figure and the severity of various potential failure conditions is compatible with their agreed probability of occurrence (see also 7.5). Hence, a UAV manufacturer should be entitled to show, through means of compliance to be approved by the certifying authority, that it complies with these safety objectives, taking into account the existence of the UAV Flight Termination Capability or/and Emergency Recovery Procedures, provided the use of Emergency Recovery Procedures are not used as a "catch-all" for every failure case or every non-compliance to requirements and their potential use is judged not to be excessive.

The relevant institution(s) identified to continue the work on this issue:

Refer to global action proposed under 8.3

Timeframe & Priority proposed

Refer to global action proposed under 8.3

7.8 COMMUNICATION LINK

***Statement of Issue*:**

Communication Link represents one of the specific features of an UAV System and is not currently addressed by manned airworthiness requirements. Specific airworthiness criteria may thus have to be established and included in the UAV System Type Certification basis.

Summary of the Discussion

UAV System Safety Assessment should cover the Communication Link failures that are to be assessed according to agreed System Safety Objectives and Criteria (refer to 7.5).

However additional and specific criteria should also be established. No detailed discussions could take place at this stage within the UAV T-F and reference was made to criteria such as those existing in the draft NATO guidelines on UAV design. Topics to be covered include:

- UAV frequency approval (see also 7.13)
- Link monitoring
- Single failure criteria
- EMI susceptibility
- Contingencies for lapse times and intermittent failures

Recommendations

Airworthiness criteria to be included in the UAV System Type Certification basis should be based upon the following considerations:

1. Approval for all frequencies used in UAV operations must be obtained from national authorities.
2. Communication Link signal strength shall be continuously monitored and appropriate maximum Communication Link range cues should be provided to the Pilot in command.
3. Any single failure of the communications system (uplink or downlink) should not affect normal control of the UAV.
4. Uplink/downlinks are sensitive to electromagnetic interference (EMI) and should be adequately protected from this hazard.
5. Contingencies for lapse times, intermittent failures, alternate modes of Communication Links and total loss of Communication Link needs to be evaluated as part of the airworthiness certification.

(Provisions for direct communications between the pilot in command and the appropriate ATC via two way radio to be incorporated in the system design plus lapse time consideration to be added should be derived from operational requirements)

The relevant institution(s) identified to continue the work on this issue

Refer to global action 8.3

Timeframe and priority proposed

Refer to global action 8.3

7.9 AUTONOMY

Statement of Issue

Levels of UAV Autonomy may considerably vary. At one extreme, the UAV Pilot may have direct control of the UAV (RPV) similar to existing model aircraft, whereas ultimately, there may be the fully autonomous UAVs where there is no need for a permanent control link and where the UAV Commander will only in special cases intervene in the management of the UAV flight. However, with the possible exception of light UAVs, most types are expected to have some limited Autonomy capability where the UAV Pilot is still given the possibility to monitor and intervene, for example, to perform corrective actions in case of failure. Yet, fully autonomous functions could be undertaken in the case of total loss of control link.
There is a need to review the impact of these various levels of Autonomy on UAV System airworthiness criteria.

Summary of the discussion

Various documents refer in details to possible UAV Autonomy levels (see e.g. NATO SG 75, US UAV Roadmap 2002-2027 etc…) and may be used as reference materials to understand various possible categories.

The impact of UAV Autonomy levels on UAV regulations is likely to cover the following areas and issues:

- Human Machine Interface (trading Autonomy level versus possibility of UAV Pilot intervention),
- Compliance with ATC instructions
- Communication link integrity
- Handling of UAV System failure and compliance with safety objectives
- Specific autonomy techniques (e.g. non deterministtic algorithms) but which have to prove safe behaviour
- Collision Avoidance
- Type of airspace

Recommendations

1. Autonomy issues are to be covered when establishing the Type Certification basis and are likely to lead to Special Conditions, according to the detailed type of UAV design (as discussed under 7.4)

2. It is recommended that certification experience be gained on lower levels of Autonomy whereby the possibility of monitoring and intervention by the UAV Pilot is left before certifying UAVs with a full level of Autonomy.

The relevant institution(s) identified to continue the work on this issue

Refer to global action proposed under 8.3

Timeframe &Priority proposed

Refer to global action proposed under 8.3

7.10 HUMAN MACHINE INTERFACE

Statement of Issue

The remote location of the UAV Pilot with respect to the air vehicle creates an operation that must be shown to be safe as for manned aircraft operations. The UAV operations concept implicitly requires that a specific Human Machine interface design can adequately and safely control the vehicle, be cognizant of the environment and air traffic around the vehicle, and respond to emergency conditions and situations in order for continued safe flight and landing of the vehicle.
The following main issues can be identified on this topic:

- the lack of physical (and particularly visual) cues that allow the pilot on board to recognize some failure scenarios and to decide the suitable decisions and actions to take,
- the lack of experience in the civil UAV System operations, and the impossibility to access in-service-experience data bases of military UAV Systems,
- the impossibility to define in a quantitative way the level of safety of the man machine interface design and related procedures.

A policy concept is to be established in order to address Human Machine Interface issues, when establishing the UAV System Type Certification basis (as per 7.4).

Summary of the discussion

The existing airworthiness codes (JAR/CS) address some basic man machine interface requirements that may be tailored to UAV Systems (as discussed under 7.6); but additional requirements specific for UAVs shall be identified and included in the proposed Type Certification Basis under the form of special conditions or interpretative materials.

Basic Airworthiness requirements related to Human Machine Interface may also have to take into consideration the kind of envisaged UAV operations, e.g. IFR operations as stated in Enclosure 4.

Other HMI topics to be discussed and reviewed should typically include:

- Number, type and layout of display versus minimization of human errors criteria
- Color coding and relevancy of existing manned criteria
- Nature of flight safety related parameters to be displayed, including those related to specific UAV System features such as Communication Link.
- Warning indications, including the handling of emergency procedures
- Minimum number of UAV Pilots required for flight safety
- the effect of a bandwidth limitation on HMI
- the effect of bandwidth latency time
- the potentially limited situational awareness of the UAV pilot on systems status

Guiding principles when defining airworthiness criteria related to above topics should refer to the minimization of human error, the need to keep the workload to an acceptable level when coping with normal and adverse operating conditions, considering the “average skill” of an UAV Pilot.

The notion of “average skill” for UAV Pilot will have to be defined, based upon in service experience data. This may not be an easy task, since those in service experience data are essentially military and thus are not readily accessible.

Recommendations

1. The Type Certification Basis discussed under 7.4 shall specifically include requirements relating to UAV System specific Human Machine Interface characteristics.

2. These requirements that may be under the form of Interpretative materials or Special Conditions should typically consider:
   - The tailoring of existing airworthiness manned requirements (as per 7.6)
   - Number, type and layout of display versus minimization of human errors criteria
   - Colour coding and relevancy of existing manned criteria
   - Nature of flight safety related parameters to be displayed
   - Warning indications, including handling of emergency procedures
   - Minimum number of UAV operators required for flight safety
   - Level of autonomy

3. The Special Conditions or Interpretative materials should also take into account the applicable Essential Requirements (EASA Regulation 1592/2002 Annex 12.a.2 and 2.c.3)

<u>The relevant institution(s) identified to continue the work on this issue</u>

Refer to global action 8.3

<u>Timeframe & priority proposed</u>

Refer to global action 8.3

7.11 CONTINUED AIRWORTHINESS

Statement of Issue

Legal and regulatory procedures for the control of continued airworthiness are well established for manned aircraft and there is an assumption that these same concepts can be applied to the continued airworthiness control of all aircraft.

In the case of UAVs, requirements for continued airworthiness are applicable not only to the UAV itself but also to any UAV System Element covered by the Certificate of Airworthiness. The issue therefore arises as to whether existing requirements for continued airworthiness and associated procedures used for manned aircraft are valid or whether the existing legal or regulatory framework needs to be modified to take account of UAV Systems.

Summary of the discussion

ICAO Annex 8 Part II Chapter 4 "Continuing Airworthiness of aircraft" establishes the obligation and responsibility of the State of Registry and of the State of Design to develop and adopt requirements to ensure the continued airworthiness of aircraft throughout their service life. These principles are adopted by individual ICAO contracting states and are endorsed within PART 21.

If during the service life of an aircraft any design feature is determined to be unsafe or potentially unsafe, the principles adopted by ICAO will ensure that responsibilities are assigned to correct the unsafe design feature and that corrective action is promulgated and applied by those affected, thus ensuring the continued validity of the Certificate of Airworthiness. In the case of UAVs these overriding principles need to be retained if UAVs are to operate in an equivalently safe manner as manned aircraft. Knowing that UAV System Elements could have an impact on the safe operation of a UAV, it follows that the requirements for continued airworthiness should be extended to include all UAV System Elements that are covered by the Certificate of Airworthiness.

The State of Design is defined as the State having jurisdiction over the TC Holder (for UAV, UAV System or the Control Station as appropriate). The State of Registry is the State on whose register the UAV is entered.

Recommendations

1. The existing requirements for continuing airworthiness contained in ICAO Annex 8 and referring to aircraft, should be amended to include safety critical elements of a UAV System
2. Under a proposed amendment to the EASA Essential requirements (see 7.1) a UAV product will include any safety critical UAV System Element. To reflect this change in applicability, PART 21 will require review and amendment.
3. Each applicant shall include in the proposed UAV Type Certification Basis the Continuing Airworthiness requirement, based upon the provisions of EASA Regulation 1592/2002, Annex 1, paragraph 1.d. and shall ensure the Continuing Airworthiness obligations defined in PART 21 are met.

The relevant institution(s) identified to continue the work on this issue

ICAO, EASA. See also global action under 8.3

Timeframe & priority proposed

Timeframe EASA appropriate, priority Medium.

7.12 NOISE & EMISSIONS

Statement of Issue

The review of noise and emission certification issues for UAVs is necessary to establish whether UAVs present a unique case from traditional aircraft.

Summary of Discussion

a. Noise

Aircraft noise standards are defined in ICAO Annex 16 Volume I. The scope of this standard is limited to aircraft issued with a Certificate of Airworthiness and which are engaged in international air navigation. Permit to Fly aircraft, which are exempt from these requirements, are not expected to be relevant to civil UAV Systems, whose objective is to undertake commercial aerial work activities and would not qualify for a Permit to Fly (see 6.2). Under EASA, noise certification will be part of the aircraft Type Certification process.

To determine compliance with the ICAO standards, tests are made which simulate the noise levels close to an airport. With UAV Systems capable of operating off-runway, it could be questioned whether the same standards are appropriate, or do people remote from an airport expect a lower level of aircraft noise pollution. One answer is that if noise levels are acceptable to people situated close to an airport where the frequency of operations is high, it should be acceptable elsewhere. However, the appropriateness of these standards to UAVs is a matter for EU and national government.

Annex 16 Volume I contains various chapters dealing with noise requirements for specific aircraft categories, including: subsonic jets, propeller driven aeroplanes and helicopters. The annex has however evolved with the introduction of new aircraft types and now includes additional categories such as supersonic aeroplanes and guidelines for tilt-rotors. The noise requirements specified for each category are derived based on the consideration of 3 factors; are the standards technically feasible, economically reasonable, and appropriate to type. The standard for each aircraft category will be initially set based on the first types investigated (i.e. what was technically feasible at the time). For UAV Systems that don't fall naturally within any of these chapters, new categories may be created (subject to the need for noise control being established) and the first examples will then set the initial standards for future generations.

b. Emissions

Emission standards are contained in Annex 16 Volume II. Applicability is currently limited to large Turbo-jet and Turbofan engines with compliance being demonstrated as part of the engine Type Certification process.

European policy on emissions was determined by the ECAC environment committee known as ANCAT (Abatement of Nuisances Caused by Air Transport). Technical advice to ANCAT is provided by JAA Steering Groups, although in the future it is likely that the Commission in consultation with EU member states, and possibly ECAC, will determine policy (See Articles 2, 6, and 15 of the basic Regulation 1592/2002).

Recommendations

1. Noise & Emission and Continued Airworthiness Issues (See Enclosure 3, sections 3.8 & 3.7) were reviewed and no impediments to the introduction of UAVs were identified. Therefore, the existing manned aircraft regulations should be applied to UAVs. Appropriate noise and emission standards should be applied to UAVs per EU policy and regulation.
2. Additionally, the standard for each aircraft category will be initially set based on the first types investigated (i.e. what was technically feasible at the time). For UAV Systems that

don't fall naturally within any of these chapters, new categories should be created (subject to the need for noise control being established) and the first examples will then set the initial standards for future technical standards.

The relevant institution(s) identified to continue the work on this issue

EASA

Timeframe and priority proposed

Medium priority, 2 years

7.13 FREQUENCY SPECTRUM

Statement of Issue

The UAV is connected to the Control Station via communication link. The link types can vary related to the operation and the Autonomy used by the UAV. Generally a control data link and a payload link will exist. Dedicated spectrums need to be defined and approved for use. Growth potential is needed for future generations of vehicles. Security requirements are essential for allotted frequencies. The Control Station may be subject to separate regulations (e.g. radio regulations) and therefore may require a separate approval.

Summary of the Discussion

The bandwidth will vary highly depending on the data being transmitted. C^2 data transmission systems may only use a small spectrum (bandwidth requirement). The military world has this spectrum already reserved for their purposes and even here frequencies are not sufficiently available.

The civil world will have their problems to get exclusive frequency for their use. Even digital technique might not solve this problem. It should be considered that the operation of several UAVs in airspace would raise immediately a bandwidth problem if they have to be operated in one band.

Recommendations:

1. Refer to and consult ITU (International Telecommunication Union).

(Note: ITU has put frequency allocation for UAV use on their agenda for their next meeting in June 2004 as result of lobbying by UAVS trade association)

2. As long as no guarantee of non-interference can be provided, airworthiness requirements should address the need to mitigate the effects of possible interferences.

3. Control Station needs an approval from a national authority competent for telecommunications.

The relevant institution(s) identified to continue the work on this issue:

ITU

Timeframe and priority proposed

Medium priority, 2 years

7.14 RESPONSIBILITY AND HANDOVER BETWEEN CONTROL STATIONS

Statement of the issue

Because the UAV Pilot is not present on board the aircraft it means that the situation can arise where the control of a UAV may be passed from a UAV pilot at one control station to another UAV pilot who may be at another control station. This requires examination of the regulatory and legal issues arising from transfer of control: handover. The identity of the UAV-pilot and the UAV Commander must be clear at all times during any UAV flight. The regulatory and legal consequences of this issue may be increased if the UAV pilot or UAV Commander are not located in the country that the UAV is operating over, particularly if there is an incident that requires regulatory action towards the UAV Pilot or the UAV Operator.

Summary of the discussion

The simplest way to bring out the areas related to this issue is to postulate a scenario.

The UAV is operating in country X, the UAV Pilot is controlling the aircraft from country Y and the UAV Operator is approved in country Z for operation of the UAV System.

There are a number of things that one would like to know about the aircraft in order to perform a handover including:

- What is the country of registration of the UAV System (UAV, Control Station etc.)?
- What is the nationality of the UAV System?
- What is the nationality of the UAV Pilot?
- Which country was the Pilot trained in and is his qualification acceptable?
- Who is the Operator of the UAV System?

The basis for the handover of this aircraft between control stations within one country or between one country and another will be based on the legal and regulatory framework that is adopted. To some extent there are issues that are outside the scope of the UAV Task-Force but a reasoned argument and base knowledge is required upon which to assist discussion.

Recommendations

It is recommended that the European Commission/ICAO should be made aware of the issues that might arise for UAV Systems operating within the European Union and that EASA should be used as the initial vehicle to highlight the issues that could potentially exist.

The relevant institution(s) identified to continue the work on this issue

EASA/ICAO

Timeframe & priority proposed

Timeframe immediate, priority high.

7.15 SECURITY

Statement of Issue

Although security issues since September 11th, 2001 have been high on the aviation agenda, the areas covered do not reflect some of the issues that the introduction of UAV Systems presents. Even within the Civil UAV community despite the strong military history of UAVs, Security is not given the high profile it deserves in relation to its essential underpinning for safety within the current regulatory framework.

Summary of the discussion

There are three major areas where UAV System fundamentally differs from manned aircraft systems from a security perspective. The first is that the UAV Pilot must communicate via a Communication Link with his aircraft; the second is that the UAV Pilot on the ground is more vulnerable to interference on the ground and the third is that the "unmanned" nature of the civil UAV is considered "attractive" for malicious terrorist intentions.
The first issue that arises is that the safety of the UAV System is dependent on the integrity of the Communication Link and its vulnerability to malicious interference. The second issue is that the UAV Pilot if he is on the ground can be subject to greater threats than might be the case for his airborne equivalent. The third issue requires attention and due consideration by State/International security authorities.

Recommendations

It is recommended that in the overall context of safety that EASA, ICAO and States be asked to look at appropriate requirements that could be recommended or adopted and that this be used as the basis for developing the support justification for safety. It is recommended that ICAO and/or other State legal authorities consider and conclude on the third issue.

The relevant institution(s) identified to continue the work on this issue

EASA, ICAO and States.

Timeframe & priority proposed

Immediate Timeframe and high priority

7.16 COLLISION AVOIDANCE

Statement of the issue

Operating UAVs equivalent to manned aircraft implies that they shall not be operated in a negligent manner so as to endanger life or property of others, e.g., by collisions with the surface (and people and property thereon) or with another aircraft.
To this effect, authorities have established a series of regulations (for manned aircraft) to avoid such collisions (See Enclosure 4).

Issue: are UAVs capable to comply with the existing regulations for collision avoidance such that they achieve a level of safety equivalent to that of manned aircraft?

Summary of the discussion

ICAO provides a set of rules to avoid collisions between aircraft in terms of "right of way" and evasive manoeuvring. There are additional rules for aircraft operations on or in the vicinity of an aerodrome, for the surface movement of aircraft, for water operations.

An aircraft that is obliged by the rules to keep out of the way of another shall avoid passing over, under or in front of the other, unless it passes well clear and takes into account the effect of aircraft wake turbulence.

The aircraft that has the right-of-way shall maintain its heading and speed, but the pilot-in-command of an aircraft shall always take such action as will best avert collision. "It is important that vigilance for the purpose of detecting potential collisions be not relaxed on board an aircraft in flight, regardless of the type of flight or the class of airspace in which the aircraft is operating, and while operating on the movement area of an aerodrome." Generally, this last resort is considered as separation by direct visual reference to other aircraft, obstacles and the surface.

ICAO Annex 2 requires that all aircraft in flight shall display anti-collision lights and navigation lights, from sunset to sunrise. If there is clear evidence that displaying these lights also during daytime enhances an aircraft's visibility significantly, then it shall be considered to require UAVs to carry these lights 24 hours a day.

Additional equipment may support the avoidance of collisions:

- Altitude alerting system
- Airborne Collision Avoidance System (ACAS)
- Ground Proximity Warning System (GPWS)
- Terrain Awareness and Warning System (TAWS)

UAVs, given suitable equipment and procedures, can be operated in full alignment with these regulations. There is one exception: separation by direct visual reference to other aircraft, obstacles and the surface, which may be the only means for collision avoidance.

For manned aircraft, avoiding collisions with UAVs may yield additional complications. If a crew separates by see and avoid, it may misread the distance to a UAV if its size differs significantly from that of a similarly shaped manned aircraft. If the crew can distinguish that it is a UAV at all. Such UAVs shall be visually distinguishable from manned aircraft, from any aspect angle. It may not be possible to achieve this by distinctive colour schemes (may not be visible from all angles) or distinctive lighting (the UAV may be too small to carry additional battery power). A UAV may need a method of indicating to a manned aircraft close by that the UAV is aware of the presence of the other aircraft (and taking appropriate action).

The US Aeronautical Information Manual section 7-6-3 defines a near mid-air collision as "the operation of an aircraft in which a possibility of collision occurs as a result of proximity of less than 500 feet to another aircraft". The possibility of collision, however, may be more complex than a 500 feet sphere and depend on aircraft size, flying speed, and geometry (vertical and horizontal miss distance, angle between the trajectories). Appropriate miss distance contours shall be established to facilitate proper evaluation of collision avoidance procedures and equipment.

Anti-collision systems will have to be certified and comply with airworthiness requirements

Recommendations

Identify (or if not existing: define) Minimum Performance Standards (MPS) for airborne ‘collision avoidance’ systems and develop Minimum Operational Performance Standards (MOPS) for the UAV Control Station which establish separation awareness and avoidance equivalent to that by direct visual reference.

Validate and implement these criteria into global regulations.

The relevant institution(s) to continue the work on this issue

The UAV industry shall define performance criteria to establish separation awareness and collision avoidance at least equivalent to that by direct visual reference.

The EASA, ICAO and EUROCONTROL should be invited to validate and implement these criteria into their regulations.

Timeframe & priority proposed

To be initiated immediately. Completion at short time. High priority.

7.17 EQUIPMENT

Statement of the issue

ICAO and JAA have set requirements for equipment for flight, navigation and communication during day-VFR, night-VFR and IFR operations.

Issue: are these requirements equally applicable to UAVs? If yes, can UAVs comply with these, and what should be done if they can not?

Summary of the discussion

Equipment requirements are derived from the type of flight:
- Day or night
- VFR or IFR.

The navigation equipment shall comply with the Required Navigation Performance (RNP) type for operation in the airspace concerned. The communication equipment shall comply with the requirements for the airspace concerned.
For flights in airspace where minimum navigation performance specifications (MNPS) are prescribed or where a reduced vertical separation minimum (RVSM) of 1000 ft is applied, aeroplanes shall be appropriately equipped and authorised.

Regulations may require the carriage of SSR Transponders to facilitate surveillance by ATC in specific airspace. This is equally applicable to UAVs. For some categories of UAVs and UAV operations it may be recommendable to extend this transponder requirement to other airspace, i.e., where transponders are not required for manned aircraft.

In addition, UAVs may carry additional equipment for communication relay, and data link. There are no specifications for this equipment.

UAVs may well be capable to meet all equipment requirements set by ICAO and JAA to the letter, but this may give no consideration for the possibilities of the technology on-board UAVs. Instead of meeting the ICAO and JAA requirements to the letter, there should be room for alternative solutions that offer an equivalent performance or better, and specified within future UAV certification criteria.

Collision avoidance and operational performance of the UAV Control Station are not included in this section 7.17 because these should be measured in terms of minimum functional performance instead of minimum equipment performance and are hence addressed in Section 7.16.

Equipments and systems mentioned here will have to be certified and comply with airworthiness requirements

Recommendations

Establish acceptable equipment requirements for UAVs, which consider the possibilities of state-of-the-art technology.

Establish Required Total System Performance (RTSP) standards for UAV operations. Such RTSP standards will include the navigation and communication performance standards. We have chosen to use the “RTSP” term because it is now being introduced by ICAO.

Establish specifications for UAV-specific equipment, e.g., for communication relay and data link.

The relevant institution(s) identified to continue the work on this issue

It is recommended that UAV industry to propose equipment requirements for UAVs which consider the possibilities of state-of-the-art technology, and to specify performance requirements for additional equipment.

It is recommended that EASA, EUROCONTROL, and ICAO to establish the applicable RTSP standards.

It is recommended that EASA to task an appropriate standardisation body for drafting of the corresponding ETSO for this.

Timeframe & priority proposed

To be initiated immediately. Completion time for UAV industry at the short term and for EASA at the medium term. High priority.

7.18 FLIGHT RULES

Statement of the issue

The ICAO Annex 2 “Rules of the Air” constitutes rules relating to the flight and manoeuvre of aircraft within the meaning of Article 12 of the Convention. Over the high seas these rules apply without exception. Annex 2 states that the operation of an aircraft either in flight or on the movement area of an aerodrome shall be in compliance with the general rules and, in addition, when in flight, either with the Visual Flight Rules (VFR), or the Instrument Flight Rules (IFR).

Issue: if UAVs wish to participate in the air traffic, then they shall comply with the rules of the air. But what to do if they can not?

Summary of the discussion

General rules address
- Protection of persons and property
- Avoidance of collisions
- Flight plans
- Signals
- Time
- Air traffic control service
- Unlawful interference
- Interception
- VMC visibility and distance from cloud minima.

VFR flights shall be conducted so that the aircraft is flown in conditions of visibility and distance from clouds equal to or greater than those specified. IFR flights require that the aircraft is equipped with suitable instruments and with navigation equipment appropriate to the route to be flown and with the required provisions when operated in controlled airspace.

For UAVs it may be difficult to comply with the rules for avoidance of collisions, signals, unlawful interference, and interception.
- Avoidance of collisions: see Section 7.16.
- Visual signals may be difficult to detect by UAVs. An observer on the airfield could see the visual signals on behalf of the UAV Pilot and communicate these to the UAV Pilot, maybe even intervene in the UAV's flight path by himself.
- It may be more difficult but not impossible to protect a Control Station against unlawful interference than the cockpit of an aircraft. Flight control and data communications systems shall be designed and operated such that the operation of the aircraft cannot be assumed by a 3rd-party for illegal purposes. Fully automated self-defence measures in the aircraft shall ensure that in the event of corrupt or interrupted ground instructions there will be an autonomous behaviour that will ensure a safe termination of the flight.
- It may be difficult for a UAV to detect that it is intercepted and to observe the visual signals from the intercepting aircraft.

It may also be difficult for a UAV crew to assess whether the visibility and distances from clouds are VMC and VFR is allowed.
VFR and IFR address the means for navigation. Except in airspace class A, both VFR and IFR are allowed. If an aircraft is unable to fly VFR, it could fly IFR if it is properly equipped. If unable to fly IFR, it could fly VFR if VMC criteria are met (except in airspace class A).

UAVs must be equipped to a level which allows full alignment and transparency with manned aircraft for all flight rules.

Recommendations

In addition to the recommendations for collision avoidance (7.16) and equipment, notably RTSP (7.17):

- Define Standard Operating Procedures (SOP) for UAV operations at airports to ensure that the inability to read, or make, visual signal does not have additional safety implications.
- Design and operate UAV navigation systems in a manner such that the flight profile of the aircraft cannot be unlawfully interfered with (see 7.15).

The relevant institution(s) identified to continue the work on this issue

UAV industry needs to define SOPs for UAV operations at airports to ensure that the inability to read, or make, visual signal does not have additional safety implications.
UAV industry shall design flight control and data communications systems such that they can be operated in order that the operation of the aircraft cannot be assumed by a 3rd-party for illegal purposes.
Actions for RTSP standards are already covered under equipment in section 7.17.

Timeframe& priority proposed

Short term, high priority.

7.19 LICENSING

Statement of the issue

To enable international UAV operations with privileges similar to those of manned aviation operations, the crewmembers that perform UAV operations shall accept responsibilities and obligations similar to those of the crew of manned aircraft.
At present, the responsibilities, privileges and obligations of crewmembers of manned aircraft are formalised by a license issued by the aviation authority. No licences currently exist for UAV crewmembers.
Issue: shall UAV crewmembers also be licensed?

Summary of the discussion

The JAR-FCL system guides individuals ab-initio to their license and up to a certain type specific rating: the JAR-FCL "delivers" a type rated pilot to an operator, whereupon the operator "only" has to adopt this pilot to his organisation in accordance with the requirements of the JAR-OPS 1.

During the discussion it was emphasised that, in the context of UAVs, issuing a license may or may not have impact on safety as long as certain minimum performance is met. As an example, reference was made to the ICAO requirements for licensing air traffic controllers (Annex 1, Section 4.3.1), that states that "unlicensed State employees may operate as air traffic controllers on condition that they meet the same requirements [as set out in 4.3.1 and 4.4]."
On the one hand, the issuing and re-issuing of licenses may merely create a bureaucratic overhead. On the other hand, the UAV community may ask for licensing because it insinuates the level of recognition of manned aviation.

Recommendations

Because of the varied UAV world, but the limited number of systems and operators, it is recommended to perform most of the skill and operational training within the operational requirements (JAR-OPS) and a theoretical examination and basic aviation and UAV generic system training within the JAR-FCL system. The licence for UAV pilots would then be issued if the applicant has received this training and successfully passed the examination. The subsequent operational training of UAV pilots could fall under the operator's approval (see chapter 7.20), as well as the skill tests and proficiency checks for validation, revalidation or renewal of licences and ratings therein. These checks shall include all operations for which the UAV system has been certified.

The following issues need further consideration: Medical fitness, Licenses and ratings, Synthetic flight instruction, Age, Experience, Training, Theoretical knowledge, skill and examination, Crew composition, Multiple type ratings.

The operation of UAVs suits the development of new concepts in Control Station set up. Due to the varied UAV world special emphasis should be paid to Human Factors on this development. Also the training of the UAV operators should pay due attention to the Human Factor aspects in order to make the UAV Pilot aware of human limitations when observing and controlling over an extended period of time.

The relevant institution(s) identified to continue the work on this issue

It is recommended that JAA/EASA in consultation with UAV industry to set licensing requirements for UAV crewmembers.

Timeframe & priority proposed

Mid term, medium priority. Shall be initiated immediately in consultation with 7.20

7.20 OPERATOR CERTIFICATION

Statement of the issue

When an operator wants to operate an aircraft for commercial use he shall comply with requirements for such operations set by the ICAO, JAA, and the EC (e.g. EC regulation 2407 on the licensing of air carriers). This is formalised by an Air Operator Certificate (AOC) issued by the national aviation authority.

Issue: should this also apply for operators of UAVs and -if yes- to which extent?

Summary of the discussion

In the world of manned aviation, the regulatory authority grants an AOC only after having established that the operator fulfils the requirements for the activities covered by that certificate:
1) Flight operations, 2) Maintenance system, 3) Crew training and 4) Ground operations.
The operator also must show to the regulatory authority that by means of a quality assurance system he will consistently fulfil the set requirements.

Similar to the licensing of flight crewmembers, one can dispute whether the bureaucratic overhead of certification is reconcilable with the lack of any contribution to safety by a certificate. It was however felt that it shall be visually clear which of aspects of the wide diversity of operational options fall within the operator's approval, and that the general public may seek a visual evidence of the operator has the authority's consent. This may become more paramount if it were to be decided not to issue such formal documents for the UAV crewmembers (7.19).

Although aerial work is not regarded as commercial air transport for which JAR-OPS 1 or 3 are valid, it is commercial operation. UAV operation will mainly be executed as aerial work to be performed by a UAV Operator.

Enclosure 4 does not address flight and duty time limitations and rest requirements because these are not yet in the JAR-OPS 1. However, the lack of visual view for the UAV pilot, and fatigue and boredom may make this issue more pressing for pilots of unmanned aircraft than for those of manned aircraft.

Non-commercial operations for manned aircraft do not need formal certification, only approval. There is no reason why such a distinction would not be made for UAV operations as well: formal certification for commercial UAV operations, approval for non-commercial UAV operations.

Recommendations

All UAV operators shall be approved. Commercial UAV operators (performing aerial work) shall be licensed. For operators already possessing an AOC, this approval or licensing can be by adding the UAV as an additional aircraft to the scope of the existing approval or license. The present regulations only address commercial air transport, they shall be supplemented to also include UAV operations, which shall also address aerial work, and also address flight and duty time and rest requirements.

The relevant institution(s) to continue the work on this issue:

It is recommended that JAA/EASA to establish regulations for UAV operations.

Timeframe & priority proposed

Short term, medium priority. Shall be initiated immediately in consultation with 7.19.

7.21 EUROCONTROL SAFETY REGULATORY REQUIREMENTS - ESARR

Statement of the issue

Air Traffic Management is seen as the sum of Air Traffic Services (ATS), Air Traffic Flow Management (ATFM) and Airspace Management (ASM).

ATM issues with respect to military OAT operations are expected to be considered by the relevant military authorities on an "as required" basis. The interactions of eventual military UAV operations, outside reserved airspace, with civil ATM would be addressed as a function of such military concept for military UAV operations.

ATM provisions for civil UAVs already exist in the context of ASM. Where civil UAVs are being contemplated for domestic operations outside reserved airspace, this could only be undertaken within the frame of a national ATM regulatory framework. For international civil UAV operations outside reserved airspace, such ATM regulatory framework would require ICAO compliance, for which no possibility currently exists. Development of ATM regulations specific to civil UAVs, beyond those already existing, can only be expected on the basis of clear operational airspace requirements, stemming from civil/commercial UAV users, clearly indicating where existing ATM regulations cannot meet such airspace requirements.

ESARRs

EUROCONTROL member States shall implement the EUROCONTROL Safety Regulatory Requirements (ESARRs) as it is specified within Implementation section of each document (Section 6 from each ESARR document).

ECAC States which are non-EUROCONTROL members are encouraged to implement the provisions of EUROCONTROL Safety Regulatory Requirements in order to achieve harmonised levels of safety throughout the uniform implementation of safety regulatory requirements within ECAC.

ESARRs address only the Air Traffic Management organisations and not the entire aviation organisations. Therefore, EUROCONTROL encourages the other aviation entities to apply the same or similar principles as described within the EUROCONTROL Safety Regulatory Requirements.

Summary of discussions

The Ministers of the European Civil Aviation Conference (ECAC) decided in 1997 to establish a formal mechanism in Europe for the multilateral development and harmonisation of an ATM safety regulatory regime, separate from service provision, within a total aviation safety system approach.

EUROCONTROL Commission, under the early implementation of the EUROCONTROL Revised Convention, has established the Safety Regulation Commission (SRC) as an independent body to the EUROCONTROL Agency to provide advice in order to ensure consistent high levels of safety in air traffic management (ATM) within the ECAC area.

The EUROCONTROL Safety Regulation Commission (SRC) is responsible for the development and uniform implementation of harmonised safety regulatory objectives and requirements for the European Air Traffic Management, and ensuring their effectiveness through measurement of safety performance.

The objectives of the Safety Regulation Commission are:

- Development of ATM safety regulatory requirements across ECAC region;
- Co-ordination of requirements implementation across the ECAC region
- Establishment of a process to measure the safety performance and identify the key risk areas

The evolutions of flight operations, airspace systems, aerodromes and ground aids, aeronautical products, the integrated military and civil aviation system sets increasing requirements for integrated systems and harmonised regulations, standards and procedures. This calls for a Total Aviation System approach which has also to be considered for the operations of UAVs outside restricted airspace.

The framework established by the SRC follows a total system approach. As such, from this perspective an ATM system is defined as People, Equipment and Procedures within the environment of operations.

Each of ESARRs address one element of the framework as described below:

ESARR 2

The implementation of consistent high levels of aviation safety and the management of safety in ATM within the ECAC area require, as a priority, the successful implementation of harmonised occurrence reporting and assessment schemes. Such schemes will lead to more systematic visibility of safety occurrences and their causes, and will allow identification of appropriate corrective actions as well as areas where flight safety could be improved by changes to the ATM system.

Safety regulatory action is therefore considered necessary to promote more consistent and systematic reporting and assessment of safety occurrences within the ATM system. Such reporting and assessment, which must be in a non-punitive environment, has the potential to act as an effective contribution to accident and serious incident prevention.

The overall safety objectives are to ensure that, at national and ECAC levels, formal means exist to -

- Assess safety performance and related trends over time ;

- Identify key risk areas where the ATM system could contribute to safety improvement, and to take appropriate actions ;

- Investigate, assess and draw conclusions on the extent of the ATM system contribution to the cause of all types of safety occurrences and to take corrective measures, whether regulatory or not ;

- Draw conclusions on how the ATM system could improve safety even in areas where it is not involved in accidents or incidents ;

- Assess and monitor over time whether technical and operational changes introduced to the ATM system meet their predetermined safety requirements, and take appropriate actions.

ESARR 3

This safety regulatory requirement concerns the use of safety management systems (SMS) by providers of Air Traffic Management (ATM) services.

The prime responsibility for the safety of an ATM service rests with the service provider. Within the overall management of the service, the service provider has a responsibility to ensure that all relevant safety issues have been satisfactorily dealt with and to provide assurance that this has been done.

Safety management is that function of service provision, which ensures that all safety risks have been identified, assessed and satisfactorily mitigated. A formal and systematic approach to safety management will maximise safety benefits in a visible and traceable way.

The requirement shall apply to all providers of ATM services that fall within the jurisdiction of the national ATM safety regulatory body. Within the overall management of their ATM services, ATM service-providers shall have in place a safety management system (SMS) in accordance with this requirement.

The overall safety objective is to ensure that all safety issues within the provision of an ATM service have been addressed in a satisfactory manner, and to a satisfactory conclusion.

ESARR 4

This requirement concerns the use of Risk Assessment and Mitigation, including hazard identification, in Air Traffic Management when introducing and/or planning changes to the ATM System. In this requirement, Risk Assessment and Mitigation are being addressed adopting a total aviation system approach.

This requirement shall apply to all providers of ATM services in respect of those parts of the ATM System for which they have managerial control.

In addition, and in certain cases, the implementation of ESARR 3 (Use of Safety Management Systems by ATM Service Providers) also necessitates the provision of more specific requirements to be used. Within the requirements for Safety Achievement (Section 5.2.4) and Safety Assurance (Section 5.3.4) of ESARR 3 there are generic requirements for Risk assessment and Mitigation processes and Documentation. Therefore, ESARR 4 provides such detailed requirements, hence developing further sections 5.2.4 and 5.3.4 of ESARR 3

This requirement concerns the use of a quantitative risk based-approach in Air Traffic Management when introducing and/or planning changes to the ATM System (including the ground and airborne elements of the ATM system). It covers:

- the human, procedural and equipment (hardware, software) elements of the ATM System as well as its environment of operations.

- the complete life-cycle of the ATM System, and, in particular, of its constituent parts.

This requirement does not address the assessment of introducing and/or planning organisational or management changes to the ATM service provision (The implementation of Safety Management System through ESARR 3 is dealing with such aspects).

ESARR 5

This requirement sets out the general safety regulatory requirements for all ATM services' personnel responsible for safety related tasks within the provision of ATM services across the ECAC area, the safety regulatory requirements for air traffic controllers and the safety regulatory requirements for engineering and technical personnel undertaking operational safety related tasks

The overall safety objective is to ensure the competency and, where applicable, the satisfaction of medical requirements, of ATM services' personnel responsible for safety related tasks within the provision of ATM services.

The competence of ATM personnel and, where applicable, their satisfaction of medical requirements, are fundamental elements of safety achievement (see ESARR 3), and therefore of safety management, in the provision of ATM services. The application of EUROCONTROL safety regulatory requirements in this area aims to establish harmonised minimum levels of competency and proficiency for staff having specific ATM safety responsibilities.

Competence is taken to mean possession of the required level of knowledge, skills, experience and where required, proficiency in English, to permit the safe and efficient provision of ATM services.

Recommendations

1. Establish a robust and efficient safety management system of both ATM service providers and UAV operators in order to be able to address all interface issues when considering the UAV operations outside restricted airspace.

   Note: Currently aircraft operators and service providers have put in place quality management systems. The quality management systems for ATM service providers shall be seen as integrated part of the safety management system. As such, the quality management system of aircraft operators shall be seen as integrated part of the safety management system. Within this context, UAV operators shall make use of their quality management systems to set-up an efficient and harmonised safety management system.

2. Assess requirements for developing additional ATM provision to address the UAV operations outside restricted airspace based on operational airspace requirements.

3. Assess requirements for developing additional safety regulatory requirements addressing specifically the UAV operations outside restricted airspace based on operational airspace requirements.

4. Establish a common and harmonised reporting system of occurrences for both UAV operators and ATM service providers in order to be able to assess and categorise all possible occurrence, determine appropriate levels of safety and identify key risk areas when UAV operations will be integrated outside restricted airspace.

   Note: Current reporting systems used by aircraft operators can also be used by UAV operators and could be found as acceptable tools

5. Ensure that ATCOs awareness is addressed within initial and continuation training within the competence scheme applied for ATCOs when UAV operations will in place outside restricted airspace.

The relevant institution(s) identified to continue the work on this issue:

- EUROCONTROL together with ICAO - assessment of requirements for developing ATM provision for UAV operations outside restricted areas based on clear operational airspace requirements.

As a function of such assessment it is recommended:

- EUROCONTROL assessment of requirements for developing additional safety regulatory requirements addressing specifically the UAV operations outside restricted airspace.

- EUROCONTROL assessment of requirements for developing amendments to the initial and continuation training for ATCOs in order to incorporate the issues regarding UAV operations outside restricted airspace.

Timeframe & priority proposed

8 RECOMMENDATIONS FOR FUTURE REGULATORY WORK

8.1 JUSTIFICATION FOR FUTURE REGULATORY WORK

In accordance with its Terms of Reference the UAV Task-Force has developed and delivers in this Final Report a Concept for European Regulations for civil UAVs. Drafting the Concept has been understood as pre-regulatory work that will have hopefully a follow-up organised by the institutions having responsibility for aviation safety & security in Europe (EC/EASA/JAA/EUROCONTROL/) with interactions to ICAO, NATO or other international organisations.

The delivered Concept is assumed only to create a minimum necessary pre-regulatory basis that is supposed to be subject to a further evaluation by the above institutions and possibly amended when felt necessary. When accepted it is assumed to be further developed into detailed regulations for UAVs, covering all areas concerned, i.e. Security, airworthiness and environmental certification, continued airworthiness & maintenance, operations, personnel licensing, ATM and possibly other areas in the future (e.g. airports)

Under the discussion topics in sections 7.1 to 7.21, certain recommendations were formulated and relevant institutions were identified by the UAV Task-Force and recommended to continue the work on the identified issues. The sections below intend to summarize and sort these recommendations according to their timeframe and priority proposed, separately for each area covered.

8.2 SECURITY

The EASA, ICAO and States are recommended to look at appropriate security requirements to cover the three areas of main concern identified:

- Security of Communication Link
- Security of UAV Pilot on the ground
- Malicious use of civil UAVs by terrorist

The task was assigned with **High priority** and should start immediately.

8.3 AIRWORTHINESS RECOMMENDED ACTIONS

.

One GLOBAL ACTION and 6 specific actions in relation to future regulatory work were identified:

Relevant institution(s)	Action recommended	Timeframe	Priority
EASA	**GLOBAL ACTION**: Establish a policy paper (Temporary Guidance Leaflet or equivalent) to provide guidance to UAV manufacturers when proposing a Type Certification Basis as suggested under section 7.4. This policy paper may be largely based upon the detailed recommendations provided in this document throughout the sections 7.1 to 7.13 *(referred as "global action" under individual AW topics (7.1-7.13))*		
EASA	To initiate a regulation **change to the basic Regulation 1592/2002** to facilitate the certification of UAV Systems (see 7.1). The Appendix 3-3 contains the recommended changes.	2 years	Medium
EASA	To determine **criteria for selecting the appropriate airworthiness code** to be used as the basis for certification approval, and develop generic special conditions to approve UAV novel features (see 7.4).	Immediate	Medium to High
EASA	To set the (**noise**) standard for each UAV aircraft category based on the first types investigated. For UAV Systems that don't fall naturally within any of these chapters, new categories should be created (see 7.12)	2 years	Medium
ITU	Refer to and consult ITU in relation to **frequency spectrum** allocation for UAVs (see 7.13)	2 years	Medium
ICAO	To amend the existing **requirements for continuing airworthiness** contained in ICAO Annex 8 and referring to aircraft, to include safety critical elements of a UAV System (see recommendation No.1 in 7.11).	Appropriate	Medium
EASA	To review and **amend PART 21** to reflect the required change to the EASA Essential requirements (see 7.1) in applicability of the UAV product (see recommendation No.2 in 7.11).	Appropriate	Medium

8.4 OPERATIONS, MAINTENANCE AND LICENSING RECOMMENDED ACTIONS

Following specific actions in relation to future regulatory work were identified:

Relevant institution(s)	**Action recommended**	**Timeframe**	**Priority**
EASA/ICAO	EASA to make the European Commission/ICAO aware of the legal issues related to **Responsibility and Handover** that might arise for UAV Systems operating within the European Union. EASA should be used as the initial vehicle to highlight the issues that could potentially exist (see 7.14).	Immediate	**High**
UAV Industry EASA, ICAO EUROCONTROL	For UAV industry to define **collision avoidance** system performance criteria to establish separation awareness and avoidance equivalent to that by direct visual reference. EASA, ICAO and EUROCONTROL to validate and implement the above criteria into their regulations (see 7.16).	To be initiated immediately. Completion at short term.	**High**
UAV Industry EASA, ICAO EUROCONTROL	UAV industry to propose **equipment requirements** for UAVs which consider the possibilities of state-of-the-art technology, and to specify performance requirements for additional equipment. EASA, EUROCONTROL, ICAO to establish the applicable RTSP standards EASA to task an appropriate standardisation body for drafting corresponding ETSO (see 7.17).	To be initiated immediately. Short term completion for Industry. Medium term for EASA	**High**
UAV Industry	Concerning **Flight Rules, to** define Standard Operating Procedures (SOPs) for UAV operations at airports to ensure that the inability to read, or make, visual signal does not have additional safety implications. To design flight control and data communication systems such that they can be operated in order that the operation of the aircraft cannot be assumed by a 3rd-party for illegal purposes (see 7.18).	Short term	**High**
JAA/EASA	To establish regulations for **UAV operations (**see 7.20).	Short term.	Medium
JAA/EASA in consultation with UAV industry	To set **licensing requirements** for UAV crewmembers (see 7.19).	Mid term	Medium

8.5 ATM RECOMMENDED ACTIONS

Relevant institution(s)	Action recommended	Timeframe	Priority
EUROCONTROL/ICAO	To assess requirements for developing **ATM provision for UAV operations** outside restricted areas based on clear operational airspace requirements (see 7.21).		
EUROCONTROL	As a function of above, to assess requirements for developing additional safety regulatory requirements addressing specifically the **UAV operations outside restricted airspace** (see 7.21).		
EUROCONTROL	As a function of above, to assess requirements for developing amendments to the **initial and continuation training for ATCOs** in order to incorporate the issues regarding UAV operations outside restricted airspace (see 7.21).		

8.6 AERODROMES RECOMMENDED ACTIONS:

Relevant institution	Action recommended	Timeframe	Priority
Group of Airport Safety Regulators (GASR)	Review aerodrome regulation to identify possible changes in the light of UAV operations (see 6.3.5).	Appropriate	Medium

GUIDELINES FOR THE REGULATION OF LIGHT UAV SYSTEMS

1. INTRODUCTION

The routine operations of Civil UAV Systems are likely to be severely restricted in the short-term until a number of significant technical problems have been resolved (e.g. the provision of an adequate "Sense & Avoid" capability). Until the solutions to such problems are available and UAVs can achieve parity with manned aircraft in respect of freedom of operation, civil UAVs are likely to remain segregated from manned aircraft and be confined to flight above sparsely populated areas.

A review of the UAV Systems market has highlighted that UAV systems that are capable of operating under such constraints tend to be light UAVs and that this trend is likely to continue for the foreseeable future.

These operational constraints are not unique to UAVs. Pilotless aircraft in the form of "model aircraft" have been flying within these limitations for many years and have achieved an acceptable safety record. Most nations currently have provisions within their national legislation to allow model aircraft to operate with no or limited airworthiness requirements in place, provided operational constraints in terms of where and when the model aircraft is operated are enforced. Furthermore, in the past these model aircraft have, on a case-by-case basis, been allowed to operate commercially in performing aerial work tasks – effectively operating as UAVs.

With this background, the UAV-TF considered whether to produce guidelines for the regulation of light UAVs based on similar principles and restrictions to those applied to model aircraft and which, if adopted, would enable a harmonised approach for the routine operation of light UAV systems. Without such an initiative, it was anticipated that light UAV regulation and safety standards would evolve internationally in a diverse and regionalized manner. Furthermore, responses obtained from a questionnaire developed by the UAV-TF and sent to National Aviation Authorities, indicated that most nations had yet to address the regulation of light UAV systems and that National Aviation Authorities supported the development of such guidelines.

Consideration has therefore been given in this Annex as to whether UAVs that have no greater capability than existing model aircraft may be allowed to operate without obtaining airworthiness certification, subject to the UAV system complying with similar limitations and conditions to those applied to model aircraft.

Light UAVs covered by these guidelines are those with a maximum take-off mass below 150kg, and a maximum speed not exceeding 70kts, that are operated within 500 metres of the UAV-pilot and not more than 400 ft above ground level.

(Note - 500 metres is chosen as the maximum distance at which the UAV-pilot may reasonably be expected to maintain visual contact with a UAV capable of 70kts whilst also monitoring the sky around the UAV for conflicting traffic. The 400 ft limit is also intended to prevent conflict with other traffic).

UAVs under 150kg are excluded from the scope of Regulation (EC) 1592/2002 through the provisions of Annex II to that regulation. Consequently, responsibility for regulatory control of UAVs under 150 kg is vested with National Aviation Authorities and not with EASA. Some UAVs below 150kg mass may have maximum level speeds in excess of 70kts, and so cannot easily and reliably be operated without exceeding the 500 metres and 400 ft limitations. Such UAVs are not covered by these guidelines and National Aviation Authorities may still need to develop additional national policy and procedures for the appropriate regulation of such systems. However, it is recommended that such UAV systems abide by the basic regulatory concept developed within the main body of this document. It is expected that once sufficient experience of operating UAVs has been gained, these guidelines could be expanded to address all UAVs under 150 kg mass..

2. REGULATORY CONCEPT

To provide a starting point for the development of guidelines for the regulation of light UAV systems, a proposal from Industry to base the concept on FAR Part 103 (Ultralight Vehicles) was accepted by the Working Group. Although at first sight it may appear that ultralight vehicles used for recreational purposes bear little relationship to light UAV systems, some parallels do exist and furthermore the stand alone nature of this document made it easily amenable to change and provided a complete regulatory concept in one simple document.

Historically there has been a trade-off between the level of airworthiness and operational standards. Recreational activities tend to have minimal airworthiness standards applied and are regulated more by operational requirements which dictate where and when they may fly. The converse is true for commercial activities and public transport. The rationale for this approach stems from the level of risk and cost that people are prepared to tolerate and their level of direct involvement in the activity. However, the level of risk for third parties should remain constant and independent of the type of operation being conducted.

To provide a measure of “equivalence”, the regulatory concept developed here uses impact kinetic energy as a basic criterion. Impact kinetic energy is directly linked to the ability of a UAV to cause damage and injury. It provides both an absolute measure for the showing of compliance and a relative standard for identifying “equivalence” with model aircraft. Kinetic energy is also an all-encompassing criterion applicable to all aircraft types, is easy to measure and can be readily estimated during the design process.

It is emphasized that there is no intent to change the regulatory environment for model aircraft in any way. The proposal detailed here is concerned with the regulatory environment for UAV systems performing Aerial Work tasks. The relevance of model aircraft to the matter at issue is their safety record and how this may be read-across to UAVs of equivalent capability.

3. DETAILED PROPOSALS FOR LIGHT UAV SYSTEMS

1 Applicability.

A light UAV system consists of an air vehicle that:

(a) Is used or intended to be used for unmanned operation in the air;

(b) Does not have any national or foreign airworthiness certificate;

(c) Has a maximum take-off mass of less than 150Kg;

(d) Is not capable of more than 70knots (CAS) at full power in level flight;

(e) Has an impact kinetic energy that does not exceed 95KJ when assessed against both a high speed and free-fall impact scenario, and calculated as follows:

(1) Kinetic energy = 0.5*Max. Operating Mass*(1.4 * Max. Level Speed)^2

(2) Kinetic energy resulting at impact from a free fall from a height of 400ft

3 Inspection requirements.

(a) Any person operating a light UAV system shall, upon request, allow the Authority to inspect the light UAV system to decide the applicability of these requirements.

(b) The pilot or operator of a light UAV system must, upon request of the Authority, furnish satisfactory evidence that the light UAV system is subject only to the provisions of these requirements.

5 Exemption.

No person may conduct operations that require a deviation from these requirements except under a written exemption issued by the Authority.

7 Certification and registration.

(a) A light UAV system is not required to meet the airworthiness certification standards specified for aircraft or to have a certificate of airworthiness. However, the design, construction and initial flight-testing of the light UAV system must be overseen by the responsible National Aviation Authority or by a body approved by the Authority to carry out such an oversight.

(b) The operator of a light UAV system is not required to meet any aeronautical knowledge requirements to operate the air vehicle or to have a pilot or medical certificate. However, every operator of a light UAV system must be identified and demonstrate a basic ability to control the air vehicle.

(c) A light UAV system is not required to be registered or bear markings of any type.

9 Hazardous operations.

(a) No person may operate a light UAV system in a manner that creates a hazard to other persons or property.

(b) No person may allow an object to be dropped from a light UAV if such action creates a hazard to other persons or property.

(c) A Light UAV is not permitted to perform aerobatic manoeuvres.

11 Daylight operations.

No person may operate a light UAV system except between the hours of sunrise and sunset and when environmental conditions are such that the UAV pilot can adequately perform his function of preventing aerial collisions.

13 <u>Operation near aircraft; right-of-way rules.</u>

(a) Each person operating a light UAV system shall maintain vigilance so as to see and avoid aircraft and shall yield the right of way to all aircraft.

(b) No person may operate a light UAV system in such a manner that the air vehicle creates a collision hazard with respect to any other aircraft.

(c) A light UAV shall not fly at a height exceeding 400ft a.g.l.

15 <u>Operations near people or property.</u>

(a) No person may operate a light UAV system such that the air vehicle approaches within 150m of any congested area of a city, town, or settlement.

(b) No person may operate a light UAV system such that the air vehicle approaches within 100m of any person, vehicle or structure not forming part of the operation.

(c) During take-off and landing a light UAV shall not fly within 50m of any person other than the UAV pilot.

(d) A light UAV is prohibited from operating within (TBD) metres of any object or installation that would present a risk to safety in the event of damage due to any impact of the said light UAV.

(e) No person may operate a light UAV system at any public flying display except with the prior permission in writing of the Authority.

17 <u>Operations in certain airspace.</u>

No person may operate a light UAV system within controlled airspace unless that person has prior authorization from the ATC facility having jurisdiction over that airspace.

19 <u>Operations in prohibited or restricted areas.</u>

No person may operate a light UAV system in prohibited or restricted areas unless that person has permission from the controlling agency.

20 <u>Flight restrictions in the proximity of certain areas designated by notice to airmen.</u>

No person may operate a light UAV system in airspace designated in a Notice to Airmen relating to temporary restricted airspace established for reasons of aviation safety or national security, unless authorized by ATC

21 <u>Visual reference with the light UAV.</u>

No person may operate a light UAV system except by visual reference with the air vehicle. The air vehicle shall remain visible to the operator without the aid of visual aids other than prescription corrective lenses.

24 <u>Flight Termination System</u>

A light UAV shall not fly unless it is equipped with a Flight Termination System that will immediately terminate its flight in the event of a failure of its control system, including the flight control data link, and which will limit the potential of the light UAV to cause damage or harm. The person in charge of a light UAV must satisfy himself/herself that the FTS is in working order prior to the flight commencing.

4. DISCUSSION OF PROPOSAL

1. Application

A light UAV system is described as consisting of an air vehicle used or intended to be used for unmanned operations in the air, with a mass of less than 150kg, is not capable of more than 70kts calibrated airspeed at full power in level flight and has a kinetic energy level on impact of less than 95KJ in both of two operating scenarios. The Light UAV must also not be subject to any national or foreign airworthiness certification.

The mass limit has been determined following a review of the worldwide UAV fleet (see Enclosure 3 Appendix WG II-1). This showed that 23 of the current 29 UAV types (79%) employed worldwide in purely civil, research or dual-purpose operations[1], have a mass of less than 150kg. A further analysis[2] also indicates that this trend is likely to continue for the foreseeable future with 65% of those UAV types entering service, market ready or being developed, also under 150kg. It was also noted that those UAVs with weights higher than 150kg tended to be designed for autonomous flight beyond the visual range of the operator, and were therefore outside the scope of these guidelines. By chance, (or by design), Annex II of EC Regulation 1592/2002 exempts UAVs with an operating mass of less than 150kg from the provisions of the regulation and places regulatory control of these types with National Aviation Authorities. In setting the boundary conditions for a light UAV to operate within a restricted operational area, it therefore seems appropriate to choose the 150kg mass limit. To ensure strict compliance with EC 1592/2002, the mass of any floats or safety equipment fitted to the air vehicle must be included within this limit.

The 70kts maximum speed limit has been applied based on a judgement of the capability of the existing model aircraft fleet, pilot workload, the ability of the pilot to retain control whilst possibly performing other operational tasks and the pilot reaction time necessary to ensure that the UAV does not hazard persons or property by passing through the buffer zone around the intended operating area. There is seen to be little benefit in higher speeds for aircraft that are restricted to operating within unassisted visual range of the pilot/operator. However, this is an area that would benefit from further discussion and could be broadened to include the experience of existing model operators and the advice of specialists in human factors, licensing, and operations. However, the imposition of this absolute speed limit at this time is seen as a prudent, precautionary position to take at this early stage of civil UAV operations.

Enclosure 3 Appendix WG II-4 of this report details an approach to setting UAV safety standards "equivalent" to manned aircraft using impact kinetic energy as the defining criterion. In developing these guidelines for the regulation of light UAV systems, a similar approach is taken, with equivalence being shown against the existing model aircraft fleet. Two scenarios are considered: i) a free-fall from 400ft (the maximum

---

[1] Analysis of "Application" CC+DP+RV and "Status" IS

[2] Analysis of "Application" CC+DP+RV and "Status" ES+MR+DC

altitude permitted), and ii) maximum impact speed (set as 1.4 x maximum operating speed for fixed wing aircraft, or the terminal velocity in the case of rotorcraft and lighter than air machines). These two scenarios represent the extremes of the operating envelope and compliance with the energy criteria derived from these scenarios will ensure that the ability of the UAV to cause damage or harm is constrained no matter what the circumstances of the crash or the characteristics of the UAV. In the maximum impact speed scenario, the factor of 1.4 has been added based on existing regulatory requirements for manned aircraft flutter prevention. Above this speed, it could be expected that the UAV would structurally fail and break-up. Note that the "free-fall" scenario is intended to address descent of the aircraft out of control, due to failures of primary structure or critical systems. Examples of such failures for a rotorcraft would be the unrecoverable loss of main rotor speed, or separation of a main rotor. For a lighter-than-air aircraft such failures could include the rupture or complete separation of the gas envelope.

A single kinetic energy limit is stipulated which a light UAV must not exceed when assessed against both impact scenarios. This limit has been established following a survey of existing model aircraft. The survey concluded that setting a mass limit of 75kg would be comparable with the majority of the existing model fleet. Note the difference here with the 150kg limit established from the UAV survey. As the intent is to provide "equivalent" regulation with model aircraft, the 75kg, 70kts limitations must take precedence in setting the energy level. The UAV worldwide survey was not detailed enough to identify exact weights in many cases, and so it is unknown how many UAVs may be disadvantaged through the setting of this limitation. However, the boundary has to be drawn somewhere, and this is seen as a defendable position given the level of maturity of civil UAV systems.

Combining the 70kts maximum level speed specified above, with a mass of 75kg, provides a kinetic energy limit of 95KJ. A UAV with a maximum speed below 70kts could have a correspondingly higher mass within the same kinetic energy limit as detailed in the following chart:

Mass of UAV (Kg)	Maximum achievable speed in level flight - (Vmax) – Kts	1.4 Vmax (m/s)	Kinetic Energy at 1.4 Vmax (KJ)
60	70	50	76
70	70	50	89
75	70	50	95
80	68	49	95
90	64	46	95
110	58	42	95
130	53	38	95
150	49	36	95

The impact velocity arising from the "free-fall" scenario will depend upon the aerodynamic drag characteristics of the falling object and so will be specific to the particular design of UAV. Assuming negligible aerodynamic drag, an object dropped from 400ft will hit the surface at 95kts and the kinetic energy at impact will be 95KJ if the mass of the object is 80Kg. Should the object in fact exhibit significant aerodynamic drag, (without reliance upon any onboard parachute deployment system), the impact velocity will be less and so a higher mass may be permissible. For illustrative purposes, the table below shows the relationship between the mass and cross-sectional area of a bluff-body, (with a non-dimensional drag coefficient of about 0.9), arising from the proposed 95 KJ limit.

Mass of body Kg	Cross-sectional area of bluff body Square Metres	Kinetic Energy at impact Kilo Joules
80	0 (Negligible drag)	95
115	0.5	95
130	1.0	95
150	1.5	95

Interpretation

UAV systems up to 80kg -

From the data presented above it can be seen that any UAV with a mass of less than 80kg will meet the "free-fall" criterion whatever its drag characteristics and so it need only be considered against the maximum impact speed scenario. If the mass is 80kg the maximum achievable level speed must not exceed 68kts. If the mass is less that 75kg the maximum achievable level speed must not exceed 70kts.

UAV systems above 80kg -

The data presented for the "free-fall" scenario shows that if the proposed UAV has a mass in excess of 80kg the constructor will have to provide a justification that the drag of the airframe, falling from a height above the surface of 400ft, will be sufficient to prevent the impact energy exceeding 95KJ.

The potential application of the "free fall" criterion is perhaps best illustrated by considering the example of an airship UAV with a total mass of 150kg.

A 150kg unmanned airship will be eligible under these provisions if it can be shown that:
- The maximum achievable level speed of the airship is less than 49kts,
- Any significant masses (with negligible drag) that might fall from it in the event of structural failure do not exceed 80kg, and
- The drag of the ruptured/deflated envelope is sufficient to limit the descent velocity of the complete airship falling from 400ft, to the same extent as a bluff body of $1.5m^2$ reference area.

No constraint has been placed here on the amount of fuel that can be carried. However, it is believed that the energy limit imposed and practical design constraints will in effect limit the fuel capacity available.

The approach adopted makes no assumption on the type of UAV and is intended to be all encompassing so that all types of UAVs are handled in the same way. While it is undoubtedly true that conventionally configured fixed wing UAVs will be limited to a somewhat lower mass than the maximum 150kg on account of their low drag, the full weight limit may be achievable by other types of light UAVs, e.g. an airship, when it can be demonstrated that the impact energy is no greater than that stipulated. The kinetic energy limit has been set based on experience with model aircraft. The aim is to limit, for the time being, the capability of this category of UAV to that already permitted for large model aircraft. It is expected that these limits will be reviewed once several years of experience with civil UAV operations has been gained. The current proposal is seen as a reasonable and defendable position to take based upon existing experience with model aircraft and represents a suitably cautious approach to take at this time.

3. <u>Inspection requirements.</u>

Standard clause

5. <u>Exemption.</u>

Standard clause

7 <u>Certification and registration.</u>

Under these provisions, a light UAV may overfly persons directly associated with the Aerial Work task. To protect these personnel, who have some degree of involvement in the activity (and presumably a good knowledge of the risks involved), yet who may not have direct control of the air vehicle, it is appropriate to set a safety level somewhat higher than that associated with recreational flyers. This proposal attempts to do so by applying some additional operational limitations beyond those of Part 103 and by imposing a degree of airworthiness approval.

The level of airworthiness approval is not intended to be onerous. However, to preserve equivalence with large model aircraft, it follows that regulation of light UAV systems by National Aviation Authorities should be no less demanding than that applied to large model aircraft. In this regulatory guidance, airworthiness is controlled by inspection of the design and construction, plus “function & reliability” flight testing of significant duration to ensure against the presence of poor stability, control and performance characteristics. Oversight of these functions could be undertaken either by the National Aviation Authority or by some other accredited body.

As Light UAVs will be operating over persons associated with the Aerial Work task, UAV pilots should be required to demonstrate a basic ability to control the air vehicle.

9 Hazardous operations.

It is prohibited to operate a light UAV system, or allow objects to be dropped from the air vehicle, in such a manner as to create a hazard to persons or property.

In addition, recognising that the flight assessment undertaken in the function & reliability flight tests must be essentially qualitative, it is considered prudent to supplement the assurance gained through such testing by prohibiting aerobatics when operating for aerial work purposes, thereby further guarding against the possible consequences of poor handling qualities and a high kinetic energy impact following loss of control.

11 Daylight operations.

A Light UAV system should only be operated in daylight hours and when the UAV pilot has the ability to "see and Avoid" effectively.

13 Operation near aircraft; right-of-way rules.

A light UAV will yield the right of way to all other aircraft. This is necessary as there are no requirements on the UAV pilot to have any knowledge of the Rules of the Air.

To minimise the potential for conflict, a light UAV will be segregated from other aircraft by limiting its maximum height above the ground to 400ft.

15 Operations over congested areas.

Restrictions are placed on a light UAV to ensure a safe separation distance from any person or property not involved in the aerial work activity.

These guidelines also prohibit an Aerial Work activity that involves aerial inspection of any object or installation that would present a risk to public safety in the event of damage due to any impact of the light UAV. (E.g. Chemical/gas storage areas).

17 Operations in certain airspace.

The use of controlled airspace is prohibited unless prior authorisation has been granted from the relevant ATC facility having jurisdiction over that airspace.

18 Operations in prohibited or restricted areas.

No person shall operate a light UAV system in prohibited or restricted airspace without permission.

20 <u>Flight restrictions in the proximity of certain areas designated by notice to airmen.</u>

The operator of a light UAV system must not operate in temporary restricted airspace.

21 <u>Visual reference with the light UAV.</u>

In the absence of any "Sense and Avoid" system, the UAV pilot must ensure safe separation between the UAV and any other air vehicle or ground based obstacle. In order to perform this task effectively, the UAV pilot must ensure that the light UAV remains visible at all times and the UAV pilot can see sufficiently beyond the air vehicle to observe any potential collision hazard and make any necessary flight path corrections in a timely manner.

24 <u>Flight Termination System</u>

In the absence of any formal airworthiness approval on which to place reliance on the integrity of the light UAV system's design and construction, the air vehicle must be fitted with a Flight Termination System (FTS) that will immediately terminate the flight and limit the light UAV's potential to cause damage or harm.

List of Acronyms

AC	Advisory Circular (FAA)
ACAS	Airborne Collision Avoidance System
AGA	Aerodrome and Ground Aids
AMC	Acceptable Means of Compliance
ANCAT	Abatement of Nuisance Caused by Air Transport
ANS	Air Navigation Services
AOC	Air Operator Certificate
APU	Auxiliary Power Unit
ASM	Airspace Management
ATC	Air Traffic Control
ATCO	Air Traffic Controller
ATFM	Air Traffic Flow Management
ATM	Air Traffic Management
ATS	Air Traffic Service
C of A	Certificate of Airworthiness
C^2	Command and Control
CNS	Communication, Navigation and Surveillance
CRI	Certification Review Item
CS	Certification Specification (EASA)
CS	Control Station
DOA	Design Organisation Approval
EASA	European Aviation Safety Agency
EC	European Communities / European Commission
ECAC	European Civil Aviation Conference
EMI	Electromagnetic Interference
ESARR	EUROCONTROL Safety Regulatory Requirements
ETSO	European Technical Standard Order
EU	European Union
FAA	Federal Aviation Administration
FHA	Functional Hazard Analysis
GAT	General Air Traffic
GMES	Global Monitoring of Environment and Security
GPWS	Ground Proximity Warning System
GSE	Ground Support Equipment
HIRF	High Intensity Radiated Fields
HMI	Human Machine Interface
ICAO	International Civil Aviation Organisation
IFR	Instrument Flight Rules
ITU	International Telecommunication Union
JAA	Joint Aviation Authorities
JAR	Joint Aviation Requirements (JAA)
MNPS	Minimum Navigation Performance Specifications
N/A	Not Applicable
NAA	National Aviation Authority (a member of the JAA)
OAT	Operational Air Traffic
RNP	Required Navigation Performance
ROA	Remotely Operated Vehicle
RPV	Remotely Piloted Vehicle

RTSP	Required Total System Performance
SAE	Society of Automotive Engineers
SMS	Safety Management System
SOP	Standard Operating Procedures
SRC	Safety Regulation Commission
TAWS	Terrain Awareness and Warning System
TC	Type Certificate
T-F	Task – Force
TSO	(FAA) Technical Standard Order
UAV	Unmanned Air/Aerial Vehicle
UAVp	UAV pilot
VFR	Visual Flight Rules
VMC	Visual Meteorological Conditions
VSM	Vertical Separation Minimum