ENCLOSURE 3
(WG II Report)

(This working paper reflects the results of the discussions held during the UAV TF WGII meetings held throughout 2003 until its last meeting held on November 18& 19, 2003)

AIRWORTHINESS, CONTINUED AIRWORTHINESS AND ENVIRONMENT

3 AIRWORTHINESS, CONTINUED AIRWORTHINESS AND ENVIRONMENT

3.1 SCOPE / INTRODUCTION

This Working Paper summarizes the discussion, consensual findings and recommendations established by the designated Working Group II of the JAA-Euro Control Taskforce. In line with the agreed Terms of Reference for the entire taskforce, the scope of this document is to define a **concept** of future EASA UAV regulations related to airworthiness, continued airworthiness and environment.
It primarily deals with major topics as identified by the Working Group and proposes outlines and guiding principles in the following areas:

- Section 2 presents most important definitions used in the rest of the document
- Section 3 describes the organizations and official bodies that would be normally involved in UAV Airworthiness Certification, Continued Airworthiness and Environment Certification.
- Section 4 identifies the UAV "product and parts" to be certified, including proposed relevant UAV classification, a review of concerned UAV System Elements and a minimum certification level
- Section 5 performs a critical survey of existing UAV regulatory (airworthiness related) materials, as currently proliferating throughout the world, draws conclusions and identifies expected trends.
- Section 6 discusses and proposes the different certification levels together with the conditions (including the criteria to define such conditions) to be subsequently applied for different types of UAVs. It takes into account the future context of EASA regulatory context as well as ICAO recommendations.
- Section 7 presents the guiding principles to be applied for Continued Airworthiness Issues where relevant to UAV applications.
- Section 8 presents the guiding principles for Environment Certification (noise & emission, frequency spectrum [ATM related]) where relevant to UAV applications.
- Section 9 reviews major technical issues to be dealt with under future UAV airworthiness certification process and proposes guiding principles for establishing regulatory criteria, namely:
    - System Safety Objectives and Criteria
    - Wherever required, a methodology to use and tailor existing manned aircraft requirements
    - Flight Termination and possible credit of such a function in the overall safety assessment
    - Communication Data Link
    - Control Station / Human Machine Interface Aspects

Section 10 at last provides conclusions of the entire work and proposes recommendations for further steps and actions to be undertaken by EASA in initiating UAV rule making process.

3.2 DEFINITIONS

3.2.1 SCOPE

The scope is to cover all the necessary definitions used specifically within the WG II work area of interest (Airworthiness)
The discussion text presented here is a summary of the arguments in favour and against the approach presented in the 'Recommended Text' section, and where possible the reasons for the decisions made by the Working Group II members.

3.2.2 DISCUSSION OF THE ISSUES

3.2.2.1 Definition of UAV

There have been a large number of discussions on this topic with the WG II, and agreement has been reached. This consensual view is presented in the 'Recommended Text' section. However, the definition that WG II agreed on is not consistent with that agreed by WG I. The reason for adopting the simple version presented here is that, within WG II, it was felt constructive to use as much of the regulatory material that relates to manned flight as is possible. In all these documents, the subject of the regulations is referred to as an 'Aircraft' even if it would normally be considered an Airship, Balloon, Glider, or whatever in normal conversation. It was felt important and relevant to allow a UAV to be covered by this same broad descriptor. Thus the definition focuses on what is different about a UAV, that differentiates it from other 'Aircraft' types, namely the absence of a human pilot.
The definition has also been phrased such that it includes, or does not specifically exclude, a passenger carrying UAV. Although outside the scope of the current task force work definition, it is hoped that the definition will be adequately robust as to be usable when such systems are considered at some future date.
The WG I definition is much more elaborate, and possibly technically more accurate, but in practice is less useful when viewed in the context of interpretation of existing regulations for UAV use.

3.2.2.2 Definition of Airworthiness

There is currently no accepted definition of airworthiness. Authorities often adopt a working definition that considers an aircraft is airworthy if it is in compliance with all applicable airworthiness requirements as specified by the State of Registration.
The State of Registration will issue an airworthiness approval, including an International Certificate of Airworthiness if compliance with the minimum standards defined in ICAO Annex 8 have been demonstrated, if it is satisfied that an aircraft is fit to fly having regard to its design, construction, workmanship, materials a equipment and such flying qualities which are considered necessary for the airworthiness of the aircraft.
The airworthiness standards applied by individual States will often exceed the minimum levels set by ICAO and will reflect individual experiences and the safety culture adopted. In terms of design, for example, the airworthiness standards would normally comprise the Type Certification standards applied by the State of Design but can, and often does, include additional national design requirements specific to the State of Registration. Airworthiness is therefore not a fixed concept, but the levels will vary from state to state.
The working definition is not particularly helpful in terms of providing clear guidance and co-ordination. It is also beyond the scope of this activity to define a term that seems to have eluded the aviation industry for decades.

In order to provide the needed co-ordination, it is therefore the intent of this Paper to specifically identify aspects of regulation that are considered to be within the scope of "airworthiness" and those regulatory functions which are not. This is provided in the 'Recommended Text' section below, in place of a true definition.

3.2.2.3 Definition of "UAV Continued Airworthiness"

The members of WG II could not identify any aspect of the UAV system that made the understanding of Continued Airworthiness differ from that for a manned aircraft. Therefore, no UAV-specific definition is provided in this Paper

3.2.2.4 Definition of "UAV Environment (Noise & Emission)"

The members of WG II could not identify any aspect of the UAV system that made the understanding of Environment, with regard to Noise and Emissions, differ from that for a manned aircraft. Therefore, no UAV-specific definition is provided in this Paper

3.2.2.5 UAV System Elements to be Included in Future Airworthiness Certification

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. One such definition, provided by the UK CAA in their guidance paper (CAP 722, Chapter 4), follows:

"Where any function of a UAV System is essential to, or can prejudice, continued safe flight and 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 aircraft for the purposes of the validity of the certificate of airworthiness of the UAV and, as such will have to comply with the applicable airworthiness requirements."

This covers all of the major points, although perhaps take-off should be included, but it implies that the same airworthiness requirement will be applied no matter where the equipment is located. This can result in an unnecessarily onerous requirement for ground based equipment. An addition to the above statement that limits the airworthiness requirements to those appropriate to location does not appear to be unreasonable.

By implication, the airworthiness requirements of any future JAR-UAV will then need to allow for the fact that some equipment is ground based or carried in another air vehicle and operating in a very different environment from that experienced in the UAV.

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, which is good, 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.

3.2.3 RECOMMENDED DEFINITIONS

3.2.3.1 UAV means an aircraft which is designed to operate with no human pilot aboard.
3.2.3.2 UAV System is comprised of all dedicated elements and subsystems necessary to enable the flight of the one or more UAV's. "Flight" also includes taxiing, takeoff and recovery and/or landing.

Note : Above paragraphs to be merged with 2.2.4

3.2.3.3 UAV Airworthiness

<u>Items deemed to be part of an "Airworthiness" approval typically include</u>:

- 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.
- UAV Control
- 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

<u>Note</u>
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. (refer to section 4.3)

<u>Items not covered under "Airworthiness"</u>:

- 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).
- Frequency spectrum allocation.
- Noise & Emission certification.
- Launch/recovery equipment not part of the UAV System.
- Operation of the payload (other than its potential to hazard the aircraft)

3.2.3.4 Systems Elements to be included in the scope of the Type Certification basis

Where any function of a UAV System 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 system for the purposes of the validity of the Type Certificate of the UAV system and, as such will have to comply with the applicable airworthiness requirements as stated in the Type Certification Basis. The airworthiness requirements shall be appropriate to the equipment location and the criticality of its function within the UAV System.

Identification of UAV System Elements to be included in the Type Certification shall normally be supported by a functional hazard assessment to be performed by the applicant.

3.3 INVOLVED ORGANIZATIONS

Refer to 1.1.2

3.4 UAV SYSTEM COMPONENTS TO BE CERTIFIED

3.4.1 UAV CATEGORIES

A review and analysis of UAV system types, addressing physical properties, purpose and maturity has been supplied by EURO-UVS and is contained in Appendix 3-1.

3.4.2 UAV KIND OF OPERATIONS / AIRWORTHINESS IMPACT

In most of the cases, for manned aircraft, airworthiness requirements are normally independent of the operational conditions under which the aircraft will fly. There are however some exceptions, for instance, JAR All Weather Operations Airworthiness Requirements (JAR AWO Subparts) which provide different levels of requirements as a function of Decision Height / Runway Visual Range (RVR).

In addition, as per the provisions of EASA Regulation EC1592/2002, Article 5 (as further reviewed under section 6) the nature of certification process (e.g. "full" or restricted Type Certificates / Certificate of Airworthiness) and the subsequent conditions to be applied in the granting of the relevant certificates may vary as a function of operational restrictions that may be applied.

For UAV Systems, operational restrictions or conditions are most likely to include preventing overflight of certain areas, particularly where people or property are located. Restrictions may also include time of day, weather conditions and classification of airspace. Those operational restrictions or conditions may also have an impact on the level of airworthiness requirements to be applied.

It is outside the scope of this workgroup to be more specific. It is recommended that the possible adaptation of airworthiness requirements to be applied as a function of those UAV operational restrictions or conditions be reviewed on a case-by-case basis.

3.4.3 UAV MINIMUM CERTIFICATION LEVEL

There are a number of significant technical problems to be resolved before UAVs can achieve parity with manned aircraft in respect of freedom of operation, (e.g. the provision of an adequate "Sense & Avoid" capability). Until the solutions to such problems are available, any routine operations of civil UAVs will remain segregated from manned aircraft and confined to flight above sparsely populated areas.

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 with no or limited airworthiness requirements in place. Based on the principles of "equality", this chapter together with Appendix 3-2, proposes regulatory guidance to enable UAVs that have no greater capability than existing model aircraft, to operate without obtaining airworthiness certification, subject to the UAV system complying with similar limitations and conditions to those applied to model aircraft. This will ensure that UAVs introduce no greater risk to persons or property than that presented by existing model aircraft.

The need for regulatory guidance for this category of UAV has been highlighted following a review of the worldwide UAV fleet (see Appendix 3-1). 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

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

continue for the foreseeable future with 65% of those UAV types either entering service, market ready or being developed, also under 150kg.

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. It is therefore recommended that these guidelines be considered for adoption by National Aviation Authorities in order to form a harmonised approach for the regulation of Light UAV systems throughout the EU and beyond.

Appendix 3-2 contains the regulatory guidance for light UAV systems. This guidance has been derived from FAR Part 103 (Ultralight Vehicles), but extensively developed and expanded to ensure "equivalent" safety standards to model aircraft are provided. In essence, the guidance material allows a UAV system falling outside the regulatory scope of EASA, which has an impact kinetic energy that does not exceed 95KJ and a maximum level speed that does not exceed 70kts, to operate without formal airworthiness certification, provided the design and construction standards, pilot competence and initial flight testing is overseen by an approved body or national authority. Adequate safety is maintained by stipulating additional operational constraints to limit the area of operation and provide protection to 3rd parties and property.

The regulatory guidance is intended to facilitate the development of the civil UAV market, to enable this category of UAV to operate routinely with the minimum of regulatory oversight or special provisions. However, it also provides a cautious approach that is considered to be both reasonable and defendable. It is expected that the limitations imposed will be reviewed when several years of successful light UAV operational experience has been gained.

3.5 SURVEY OF EXISTING UAV REGULATORY MATERIAL

There is currently a worldwide proliferation of UAV regulatory materials draft relating to proposed ways to handle UAV Airworthiness and Operations.

The following table aims at providing a summary indication of some of the most significant (airworthiness oriented) materials - mostly under draft form - that are available and are currently discussed in European Countries, in the USA and or in some other countries.

It considers primarily materials that may be viewed as an input to the JAA Taskforce, more particulary the Airworthiness Aspects discussed in the Airworthiness Working Group WGII.

The table contains the following information:

- Country
- Title / Subject / Reference
- Nature:
    - Leg.: Legislation / Law
    - Pol. : Policy
    - Prog. : Program / Specific Project Oriented
    - Req.: Requirement
    - Pap. : Conference paper
    - D : Draft
    - F: Formally Released
- Civil./ Mil. : C for Civilian, M for Military Materials
- UAV def./char. : Addresses (+) UAV definition or is related to peculiar UAV characteristics
- Airspace Consider.: Provides (+) some Airspace Considerations
- UAV Category: Provides / proposes (+) some UAV categorization
- Safety Objectives: Provides (+) some form of Safety Objectives
- JAR/FAR tailoring: Addresses (+) some kind of tailoring of existing FAR/JAR manned

requirements.

COUNTRY	TITLE / SUBJECT/REF.	Nature	Civill / Mil.	UAV def. / char.	UAV Categor y	Safety objectives	JAR/FAR tailoring
AUSTRALIA	CAR 1998 – Part 101 – Unmanned Aircraft and Rocket Operations in Australia – Subpart F – UAVs	Leg, F	C	+	+		
BELGIUM	Belgium decrees : Arrêté Royal 18995 / 10 Octobre 1978, Arrêté Ministériel 45708 / 17 Février 1983	Leg,. F	M				
	B-Hunter Airworthiness Certification Programme (Sonaca/IAI/Thales)	Prog.,	M	+		+	+
EUROPE	JAA-EuroControl UAV Task Force	Pol., D	C	+	+	+	+
FRANCE	Arrêté Ministériel du 25 Août 1986 relatif aux conditions d'emploi des aéronefs civils qui ne transportent aucune personne à bord	Leg., F	C	+	+		
	French DGA study - Applicability to the HALE UAV's of the civil airworthiness regulations	Pol., D	M	+			+
	French DGA study - Applicability to the MALE UAV's of the civil airworthiness regulations	Pol., D	M	+		+	+
	France - Nav Droc study performed by Euro UVS, SAGEM, Dassault Aviation, Thales	Pol., D	C	+			+
	French DGA Flight Test Center UAV Flight Test Safety Criteria ITC 202-001	Pol., F	M			+	
GERMANY	Special Regulations for the Airworthiness Verification of Bundeswehr Unmanned Aerial Vehicles, LTF1550-01	Leg., D	M	+	+	+	
ITALY	State UAV draft law	Leg., D	M				
	Airworthiness for UAVs, a discussion paper by Filippo De Florio	Pap.	C			+	
	JAR VLA adapted to UAV (draft RAI-UAV)	Req., D	C	+	+	+	+
	Predator certification programme in Italy	Prog.	M	+			
JAPAN	Civil UAV Applications and related Safety & Certification by Akira Sato, Yamaha Motors, paper presented at Euro UVS meeting, Paris, June 12, 2002	Pap.	C	+	+	+	
NATO	NATO / CEAC Guidance for unmanned aerial vehicles (UAV) operations, design specification, maintenance and training of human resources (1998, under updating process)	Pol., D	M	+		+	
NETHERLANDS	Royal Netherlands airforce Sperwer certification Documents based on JAR´s	Prog,	M	+		+	+
SWEDEN	UAV-Policy, Issue 2	Pol., D	M	+	+	+	
UK	CAP 722 – Unmanned aerial vehicle operations in UK airspace – Guidance May 2003	Pol, F	C, M	+	+	+	
	CAA Aircraft Airworthiness Standards for Civil UAVS, by D. Haddon & C. Whittaker, paper presented at Euro UVS Conference, Paris, June 11, 2002	Pap	C	+	+	+	+
	JSP 553 Regulation of Aircraft (including Annex B on UAVs)	Leg., F	M	+		+	
	UK MOD DEF STAN 00-970-1 PART 9 Design and Airworthiness requirements for service Aircraft, Part 9 : UAV (2002)	Pol, F	M	+		+	
USA	FAA- AC Unmanned Vehicle Design Criteria (1996)	Pol., D	C	+		+	+
USA	NASA/ERAST HALE UAV Certification & Regulatory Roadmap (2002)	Prog.,	C	+			+
USA	Unmanned Aerial Vehicles Roadmap 2002 –	Prog, /Pol.	M	+	+	+	+

COUNTRY	TITLE / SUBJECT/REF.	Nature	Civill / Mil.	UAV def. / char.	UAV Category	Safety objectives	JAR/FAR tailoring
	2027 Office of the secretary of the Defense						
USA	Certificate of Authorisation Process 7711-1	Pol,	C	+		+	

3.6 TYPE OF REGULATORY APPROACH & CERTIFICATION LEVEL

3.6.1 A CONCEPT FOR AIRWORTHINESS CERTIFICATION

The globally adopted approach to the civil certification of manned aircraft is to apply defined codes of airworthiness requirements 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 preferred by some military operators is to adopt a "safety target" approach of setting an overall safety target for the aircraft within the context of a defined 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.

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.

3.6.1.1 Commercial Competition

The Safety Target approach favoured by the military is greatly facilitated by the fact that military UAV operators are all under the direct control of the Government, 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.

3.6.1.2 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.

3.6.1.3 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.

3.6.1.4 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.

3.6.1.5 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.

3.6.1.6 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.

3.6.1.7 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.

3.6.1.8 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, 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. 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 4.4.

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 a derogation from the requirement for an aircraft to hold a Type Certificate and Certificate of Airworthiness provided the aircraft is operationally constrained and the design conforms to specific airworthiness specifications that ensure adequate safety with regard to the purpose. So, for example, approval of a UAV designed and operated specifically for artic surveys and constrained to operate entirely over a very remote area where the risk to third parties on the ground is small, could be undertaken by special procedures, and this may be based on the safety target approach.

3.6.2 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. However, due to the specific characteristics of UAV systems they may not readily be amenable to such procedures and this section attempts to highlight specific issues.

3.6.2.1 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 must be considered as part of the aircraft for the purposes of design, manufacture and maintenance.

3.6.2.2 Remote Control Station

The WG considered whether approval of the remote control station should be sought as part of the UAV system or whether the control station could be approved in its own right and hold a Type Certificate similar to existing practice with Engines and Propellers. In developing these proposals, the WG gave consideration to future civil UAV system developments, and 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 air vehicle, the WG 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 system Type Certificate approval to ensure compatibility with the remote control station and the overall safety of the UAV system.

3.6.2.2 Launch & Recovery Equipment

Approval of essential equipment for the launch and recovery of the air vehicle was also discussed by the WG. The consensus view was that launch and recovery would normally be controlled through operational restrictions that provided a secure launch and recovery area which was free from any persons or property. However, it was envisaged that this provision may 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 system.

3.6.2.4 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. Additionally, replacement parts must be manufactured by approved organisations, and appropriately licensed engineers 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. The WG also considered the acceptance of alternate procedures for organisation approval other than a DOA issued in accordance with Part 21. The issue discussed by the WG 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 WG concluded that, for the short term, UAV Systems should not be considered of "simple design" because of the novelty of the systems, but that this position could change as experience is gained in the certification and operation of civil UAV Systems.

3.6.2.5 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 Section 3.6.4)

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 were fulfilled. However, in recognition of the current restriction imposed by ICAO Article 8, an operational restriction to limit its freedom to operate internationally could be imposed.

3.6.3 EASA ESSENTIAL REQUIREMENTS

A review was undertaken of the EASA Essential Requirements to determine their applicability to UAV systems. The Essential Requirements were, in the main, found to be equally applicable to manned aircraft and UAV systems. The most significant amendment considered necessary was to include an assessment of all system equipment as part of the certification process. Appendix 3-3 contains draft proposal to amend EC 1592/2002 to facilitate the certification of UAV systems.

A similar review will be necessary in respect of Part 21, certification procedures. This was unavailable for review since it was still in draft form during the course of developing this regulatory concept.

3.6.4 SETTING THE CERTIFICATION BASIS

Codes of airworthiness requirements provide basic aircraft design standards for the protection of passengers, crew and 3rd parties on the ground. (The avoidance of aerial collisions will also have an airworthiness input, although this is limited to ensuring that equipment performs its intended function). 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 advance 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 will change 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.

Codes of airworthiness requirements were originally derived from ICAO standards. The primary aim of ICAO is to aid international air transport and to facilitate flight of aircraft from one contracting states into or over the territory of another contracting state. The primary focus was therefore the protection of other aircraft, third parties and property, the exact same factors that are now applicable to UAVs. However, as the regulations developed, aircraft constructors and regulators had to ensure that those on-board the aircraft were sufficiently protected and the emphasis changed over the years to focus on protection of the occupants. While the hazard to third parties still remained, it could be argued that any such hazard is addressed at source by ensuring that the aircraft is airworthy and operated safely and is therefore consistent with the objectives of the Chicago Convention.

Historically, codes of airworthiness requirements have been developed using a scaled approach to increase the applicable standards as a function of aircraft weight, performance and occupancy (number of passengers). The weight criterion is used as a rough guide to an aircraft's complexity, energy level and fuel load while the performance criterion indicates energy level, number of engines, flight characteristics and structural implications. The use of occupancy as a defining criterion has arisen directly from public opinion and has lead to the standards for cabin design and impact survivability being developed. Occupancy also has a bearing on the standards required to avoid failures which would lead to high energy impacts. These varying standards are implicit in the different codes of airworthiness requirements applied within national, JAA or EASA regulatory systems.

The existing codes of airworthiness requirements for manned aircraft can therefore 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. 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 for suitable requirements for UAV system 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 which the public accepts. Most UAV system certification activities undertaken to-date, both military and civil, have started with this premise. However, with the knowledge that 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 Appendices 3-4 and 3-5. The approach contained in Appendix 3-4 is applicable to all UAV systems and defines safety levels and the capability to harm people in terms of impact kinetic energy of the air vehicle. 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. **Comments on the acceptance of these techniques are particularly welcome.**

Once the relevant airworthiness code(s) has/have been chosen which represents the approrpriate safety level, the type certification basis is constructed by tailoring the selected airworthiness code(s) (see Section 9.2) 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.

3.7 CONTINUED AIRWORTHINESS ISSUES

The main concept is that the same Continuing Airworthiness requirements and procedures used for the manned aircrafts are applicable to the UAVs, therefore this section of the report takes into consideration all the reference material on this subject to identify and clarify specificities of the UAV systems.

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 the aircraft during its service life. The applicability of such requirements shall be defined for all the UAV System elements that contribute to the UAV airworthiness concept.

JAR 21 endorses the ICAO recommendations on the Continuing Airworthiness and is applicable to the products, parts and appliances, therefore the applicability shall be reviewed in light of the UAV system definition.

The following recommendations are proposed, with regard to the way the requirements should be handled concerning UAV System Continuing airworthiness issues.

3.7.1 The State of Design is the State having jurisdiction over the organization responsible for the type design of the UAV System. This definition has been derived by the ICAO Annex 8 and it has been reworded to explicitly refer to the UAV System, as it has been defined in Chapter 2 of the UAV T-F WG II Final Report, that is to say that the type design will include the aircraft and the required flight control and operating system, which include the control station(s), communication links, data terminals, launch and recovery systems, ground support equipment and the communication system.

3.7.2 The State of Registry is the State on whose register the UAV System is entered.

3.7.3 ICAO Annex 8 is referred to aircrafts, but in the case of the UAVs the applicability shall be extended to the UAV System, therefore Continuing Airworthiness requirements shall ensure that the UAV System continues to comply with the appropriate airworthiness requirements after a modification, a repair or the installation of a replacement part and is maintained in an airworthy condition.

3.7.4 ICAO Annex 8 recommendations are endorsed in the JAR 21.3 “Failures, malfunctions and defects” that defines all the obligations for the holder of a Type Certificate, Supplemental Type Certificate, JTSO Authorisation, JPA Authorisation or a major design approval. The JAR 21 can be considered applicable to a UAV System while we assume that a UAV system is defined as a product. The obligations for the design holder shall include:

- System for collection, investigation of data;
- Reporting to the Authority;
- Investigation of reported occurrences;
- Airworthiness Directives (mandatory continuing airworthiness information).

3.7.5 Any set of UAV Airworthiness Requirements has to address the issue of Continuing Airworthiness in a manner and level of details comparable to those existing within the context of manned aircraft airworthiness requirements (typically JAR XX.1529 and related Appendix A).

3.8 ENVIRONMENT

3.8.1 NOISE & EMISSION:

The EASA basic regulation (EC1592/2002) specifies ICAO Annex 16 as the essential environmental protection requirements within the EU. This Annex contains detailed design compliance requirements and guidance material that is both mature and comprehensive and has found worldwide acceptance.

A review of Annex 16 has identified that there is nothing within this Annex which specifically excludes the application of the recommended standards to UAV systems. Although the situation has yet to be confirmed, it could reasonably be expected that UAVs falling within the scope of the various chapters would therefore be required to comply with the standards. From a regulatory standpoint, this would ensure equality of application, which is one of the underlying principles demanded by the UAV community.

3.8.1.1 Noise Regulation

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, who’s 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 the 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.

3.8.1.2 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 is determined by the ECAC environment committee known as ANCAT (Abatement of Nuisances Caused by Air Transport). Technical advice to ANCAT is provided by JAA SGs, although in the future it is likely that the Commission in consultation with EU member states, and possibly ECAC, will determine policy.

3.8.2 FREQUENCY SPECTRUM

3.8.2.1 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.

3.8.2.2 Discussion Elements & Rationale

The bandwidth will vary highly depending on the datalink type C^2 datalinks may only use a small spectrum (bandwidth requirement) Though the payload may have to use for intelligence a very broadband to transmit information. The military world has this spectrums 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 UAV in airspace will raise immediately a bandwidth problem if they have to be operated in one band.

3.8.2.3 Recommendation

Refer to and consult ITCU.

Note:(ITCU 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)
As long as no guarantee of non interference can be provided, Airworthiness requirements should address the need to mitigate the effects of possible interferences.

3.9 MAJOR TECHNICAL ISSUES

3.9.1 UAV SYSTEM SAFETY OBJECTIVES AND CRITERIA

3.9.1.1 Statement of Issue

Any set of UAV Airworthiness Requirements has to address System Safety Issues by providing safety objectives and criteria for safety assessment in a manner and level of details comparable to those existing within the context of manned aircraft airworthiness requirements (typically, JAR VLA/23/25.1309 and related Advisory Materials).

Manned airworthiness requirements related to safety may not be fully reconducted as such in the frame of a future UAV airworthiness certification, considering that potential UAV safety hazards are different (no crew / passengers on board) and that UAV system contain specific and unusual design features that have a direct impact on safety.

A regulatory concept to handle the definition of UAV System Safety Requirements and Criteria is to be established in consideration of the above.

3.9.1.2 Recommended regulatory approach and concept regarding System Safety

The following recommendations are proposed, with regard to the way airworthiness requirements should be handled concerning UAV System Safety.
(1) The level of requirements should be tailored according to UAV agreed airworthiness certification categories *See section 3.6.4*
(2) As for manned aircraft requirements, 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 & interpretive materials related to UAV system safety that would parallel (and replace) relevant sections of JAR 1309" & corresponding interpretive materials.
(4) The following inputs are proposed in establishing such special condition

- (4.1) The worst UAV Hazard Event designated hereafter as Catastrophic or Severity I Event may be defined as the UAV 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 death fatalities or severe damage on the ground.
- (4.2) 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."
- (4.3) Quantitative safety objective – where found required according to UAV Airworthiness category (see 3.1) - for the individual UAV 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 JAA AMJ25.1309 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" with regard to subsequent ground fatalities.

Note: 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 overflown zones.

(4.4) 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 a unpopulated emergency site, using emergency 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.

(4.5) As per Advisory Materials such as AC 23.1309 1C or AMJ.25. 1309, the quantitative probability ranges required for lower severities should be derived from the quantitative required objective for the worst severity

(4.6) 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 data 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.

3.9.2 TAILORING OF EXISTING MANNED REQUIREMENTS

3.9.2.1 Statement of Issue

Assuming that it has been established that the UAV Airworthiness Certification Basis shall include a given JAR code normally applicable to manned aircraft airworthiness certification (depending on UAV category and as defined in 6.4), there are still specific requirements within this code that are not relevant or that cannot be used as is, concerning UAV specificity.

A regulatory concept to handle the tailoring of JAR code when applied to UAVs shall be defined.

3.9.2.2 Discussion Elements & Rationale

When using and tailoring JAR Airworthiness Code such as JAR 25, JAR 23, JAR 27 or JAR VLA as an element of the applicable UAV Airworthiness 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 this JAR Code may be a useful tool to assess the airworthiness of the Air Vehicle, and possibly identify the required display of flight parameters in the Ground 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 9.1)
- Flight Termination (as discussed under 9.3)
- Data Link (as discussed under 9.4)
- Ground Control Station / Human Machine Interface (as discussed under 9.4)

There are requirements that are obviously not relevant to considered 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 no immediate reason not to use them. However, “blind” application of such requirement to UAVs may lead to e.g. hazardous flight demonstration, excessive design or weight penalties 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 bas

3.9.2.3 Recommended regulatory approach regarding the tailoring of JAR existing codes for UAVs

Considering above discussion elements, the following recommendations are proposed, with regard to the way airworthiness requirements should be handled concerning UAV System Safety.
Once it has been established that a given existing JAR airworthiness code should be used as an element of the applicable UAV Airworthiness Certification Basis, 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 **F**ully applied
- **I :** “**I**ntent” 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 **N**ot **A**pplicable as obviously not relevant to UAV

applications "per se" (e.g. no crew or passengers on board)

- **N/A-C:** Requirement **N**ot **A**pplicable due to assumed UAV **C**onfiguration
- **P:** Requirement may be only *partially* applied (e.g. part of it may be "N/A")
- **A:** *Alternative* criteria may be proposed

Rationale for above categorization shall be presented and justified for each requirement. 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 Interpretive Materials to provide an equivalent level of safety with the original intent of the requirement. Criteria set forth under UAV System Safety Objectives [WP task 9.1] may be considered when assessing specific sections of the JAR Code that contain specific and possibly conflicting safety design requirements.

3.9.3 FLIGHT TERMINATION CAPABILITY

3.9.3.1 Statement of Issue

UAV System design would normally incorporate some Flight Termination Capability. The way this Flight Termination capability is implemented, its 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 Flight Termination, 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 Flight Termination capability mandatory
    - the conditions to be met, including those under which credit may be granted to such a Flight Termination capability in the UAV system airworthiness assessment

3.9.3.2 Discussion Elements & Rationale

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.

The main purpose of Flight Termination Capability should be to provide a means to interrupt the flight in order to prevent any hazard to other airspace users and/or to persons / property on the ground following an unrecoverable failure of the UAV system.

Flight Termination terminology may be somewhat misleading since it may sometimes range from dedicated systems such as parachute till the implementation of emergency procedures (in the case of UAV, through autonomous design means).

The very purpose of an UAV System Safety Assessment (see 9.1) is to verify that the UAV system comply 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 the UAV Flight Termination Capability.

Typically, a failure condition which would lead to the activation of the Flight Termination Capability would not classified as Severity I (i.e. leading to an uncontrolled UAV crash) but rather of a lesser severity II or possibly III or IV (see proposed definition under 9.1)Alternatively, for an UAV system which would not incorporate Flight Termination Capability, 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.

Typical failure conditions that would be analysed considering the existence of the Flight Termination capability would be the loss of thrust and the loss of communication (see example of handling in attachment)

3.9.3.3 Recommended regulatory approach regarding Flight Termination

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

Emergency recovery procedures, that could be implemented through operator 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.

The very purpose of an UAV System Safety Assessment (see 9.1) is to verify that the UAV system comply 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 the UAV Flight Termination Capability or/and Emergency recovery procedures. Airworthiness Credit for Flight Termination would normally be granted only in specific cases e.g. if it is part of Emergency Recovery Procedures

Typically, a failure condition which would lead to the activation of Emergency Recovery Procedures would not classified as Severity I (i.e. leading to an uncontrolled UAV crash) but rather of a lesser severity II or possibly III or IV (see proposed definition under 9.1). 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.

3.9.4 COMMUNICATION LINK

Typical airworthiness criteria may include the following:

- Approval for all frequencies used in UAV operations must be obtained from national authorities.
- Data link signal strength shall be continuously monitored and appropriate maximum data link range cues should be provided to the pilot in command.

- Any single failure of the communications system (uplink or downlink) should not affect normal control of the UAV.
- Uplink/downlinks are sensitive to electromagnetic interference (EMI) and should be adequately protected from this hazard.
- (to be covered by WG3 : Provisions for direct communications between the pilot in command and the appropriate ATC via two way radio shall be incorporated in the system design plus lapse time consideration to be added]

3.9.5 AUTONOMY ISSUES

- Levels of UAV autonomy may considerably vary. There may be the "full autonmy case" where there is no need for a control link and where the UAV operator can never intervene in the management of the UAV flight. In other cases, the UAV operator is still given the possibility to monitor and intervene and e.g. perform corrective actions in case of failure; only in the case of total loss of control link, the UAV would actually enter into a fully autonomous mode.
- Various documents refer in details to these autonomy levels (see e.g. NATO SG 75, US UAV Roadmap 2002-2027 etc…)
- These levels of UAV autonomy will certainly have an impact on UAV Airworthiness Certification criteria and issues such as Human Machine Interface (trading autonomy level versu possiblity of operator intervention), compliance with ATC instructions, communication link integrity, handling of failure and compliance with safety objectives, specific autonomy techniques (e.g. non deterministic algorithms) will have to be duly addressed.
- It is recommended that certification experience be gained on lower levels of autonomy whereby the possibility of monitoring and intervention by the UAV operator is left before certifying UAVs with afull level of autonomy.

3.9.6 HUMAN MACHINE INTERFACE

To be completed

GT action

3.10 CONCLUSIONS & RECOMMENDATIONS

1. EASA Regulation EC1592/2002 was reviewed (3.6.3) to determine its 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 include an assessment of all system elements as part of the certification

process. Appendix 3-3 contains a draft recommendation to amend EC 1592/2002 to facilitate the certification of UAV systems.

2. Noise & Emission and Continued Airworthiness Issues (3.8 & 3.7) were reviewed and no impediments to the introduction of UAVs were identified. We conclude that the existing manned aircraft regulations are equally applicable to UAVs.
3. Guidance for the identification of UAV System Elements to be included within the Type Certification process is recommended (3.2.3).
4. In recognition of the likely growth of UAVs below the EASA EC Regulation 1592/2002 minimum mass limit lead to a recommendation for simplified certification and operating procedures for use by national authorities (Appendix 3-2) as a basis for harmonised regulation within EU.
5. The regulatory concept for Airworthiness approval, including both the "safety case" methodology and the "code of requirements" has been reviewed (3.6). It is recommended that the normal airworthiness certification approach for UAV systems should follow that of manned aircraft and be based on Part 21 and a code of requirements
6. It is recommended that, within the provisions of the existing legal framework (EASA regulation including above proposed changes) the UAV System TC applicant will have to propose and negotiate the dedicated Type Certification basis applicable to its product, within the guidelines described under this concept and summarized hereafter.
7. This Type Certification basis could vary with consideration of certification categories and operational restrictions
8. However, the Typical Airworthiness Certification Basis is likely to include:
    - System Safety Objectives and Criteria, applying the "1309" approach to UAV System as a whole) (3.9.1)
    - Existing manned airworthiness requirements duly tailored to UAVs as per recommended method (3.9.2)
    - Additional criteria related to UAV topics such as:
        - Communication Link (3.9.4)
        - Frequency Spectrum (3.8.2)
        - Emergency Recovery Capability (3.9.3)
        - Autonomy (3.9.5)
        - Human Machine Interface (3.9.6)
9. Possible Selection Criteria for the airworthiness reference code to be tailored will have to be agreed (3.6.4, see two potential approaches in Appendix 3-4 and Appendix 3-5)

Technical Issues when defining the Type Certification basis as may arise from the tailoring of existing manned requrements or from specific UAV topics should be handled through Certification Review Items between the applicant and the authority (3.9.2).