ADVANCE -NOTICE OF PROPOSED AMENDMENT (NPA) No 16/2005

Policy for Unmanned Aerial Vehicle (UAV) certification.

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A. EXPLANATORY NOTE

I. General

1. The purpose of this Advance-Notice of Proposed Amendment (A-NPA) is to propose a policy for the certification of UAV (Unmanned Aerial Vehicle) Systems (the Policy) and is a first step towards more comprehensive UAV regulation. The scope of this rulemaking activity is described in more detail below.

2. The Agency is directly involved in the rule-shaping process. It assists the Commission in its executive tasks by preparing draft regulations, and amendments thereof, for the implementation of Regulation (EC) No 1592/2002 of the European parliament and the Council of 15 July 2002 on common rules in the field of civil aviation and establishing a European Aviation Safety Agency [1](hereinafter referred to as “the Basic Regulation”) which are adopted as “Opinions” (Article 14.1). It also adopts Certification Specifications, including Airworthiness Codes and Acceptable Means of Compliance and Guidance Material to be used in the certification process (Article 14.2).

3. When preparing its rulemaking decision the Agency is required to follow a structured process as described in the EASA rulemaking procedure[2]. Such process may include preliminary consultation in those cases where the Executive Director concludes that additional consultation is required prior to embarking on the drafting/NPA/consultation procedure. This may be the case for rulemaking in new areas. The A-NPA will allow for the publication of consultation papers seeking opinions and input on, for example, a choice of different rulemaking options to address a specific need

4. This rulemaking activity is included in the Agency’s rulemaking programme for 2005. It implements the rulemaking task 21.034.

5. The text of this A-NPA has been developed by the Agency. It is submitted for consultation of all interested parties in accordance with Article 43 of the Basic Regulation and Articles 5(3), and 14 of the EASA rulemaking procedure.

II. Consultation

1. To achieve optimal consultation, the Agency is publishing the draft decision of the Executive Director on its internet site. Comments should be provided within 3 months in accordance with Article 14 of the EASA rulemaking procedure. Article 14 states that the duration of the consultation period is determined by the Executive Director: the standard period for NPA has been chosen in that case.

[1] Regulation (EC) No 1592/2002. OJ L 240, 7.9.2002, p.1.
[2] Decision of the Management Board concerning the procedure to be applied by the Agency for the issuing of opinions, certification specifications and guidance material (“rulemaking procedure”): EASA MB/7/03, 17.6.2003.

2. Comments on this proposal may be forwarded *(preferably by e-mail)*, using the attached comment form, to:

By e-mail: **NPA@easa.eu.int**

By Fax: **+49(221) 89990 5508**

By correspondence: Process Support Unit
Rulemaking Directorate
EASA
Ref: A-NPA 16-2005
Postfach 10 12 53
D-50452 Köln
Germany

Comments should be received by the Agency **before 07-02-2005**. If received after this deadline they might not be treated. Comments may not be considered if the form provided for this purpose is not used.

III. Comment response document:

1. All comments received in time will be responded to and incorporated in a comment response document (CRD). This may contain a list of all persons and/or organisations that have provided comments. The CRD will be widely available on the Agency's website.

IV. The A-NPA: background, purpose and specific issues:

1. EASA and National Authorities remits:

a. EASA remit:
The EASA remit, as defined by EC Regulation 1592/2002, covers the airworthiness and environmental regulation of UAVs with a maximum take-off mass of 150 kg or above, which are not excluded by Article 1(2) or Article 4(2) and Annex II of that document. Regulation of excluded UAVs is then the responsibility of National Authorities.

b. National Authorities' remit:
National Authorities retain responsibility for the airworthiness and environmental regulation of UAVs not within the scope of EASA. This includes:
a) UAVs with a maximum take-off mass below 150kg
b) UAVs of any mass specifically designed for research, experimental or scientific purposes and likely to be produced in small numbers.
c) UAVs engaged in military, customs, police or similar services (However, National Authorities shall undertake to ensure that such services have due regard as far as is practical to the EASA regulations).

National Authorities also currently remain responsible for operational regulations pertaining to UAVs.

2. JAA initiative:

To aid National Authorities in the regulation of Light UAV Systems, some guidelines have been developed by the task-force set up as a joint initiative of the JAA and EUROCONTROL before the entry into force of Regulation 1592/2002. While National Authorities were not obliged to adopt these guidelines, they were intended to identify an acceptable level of safety and to promote harmonised standards within Europe.

3. Other initiatives World-wide:

An outline of such initiatives is provided in attachment 3 to this explanatory note. It is quite obvious from this attachment that there are multiple initiatives that need to be taken into account. It also shows that UAV are getting growing attention from regulatory authorities.

4. The A-NPA :purpose and the rationale to use the A-NPA procedure:

a. Purpose of the A-NPA:

The purpose of the A-NPA is to propose a general policy for the certification for UAV systems. Such policy may be seen as guidance material to paragraph 21A.17. The intention is to use such policy in the short term when applicants request EASA certification for an UAV

Comments are requested on the Policy and also on the following specific issues:

- The method to select the relevant certification code applicable to a similar manned aircraft (See paragraph IV c iv of the explanatory note; paragraph d of the policy and paragraph 1 of attachment 2 to the Policy).
- The issue of certificates of airworthiness in relation with the control station (See paragraph IV c v of the explanatory note and paragraph d of the Policy).
- The issue of noise certification requirements for UAV (See paragraph h of the Policy).
- The content of the regulatory impact assessment in particular on its environmental and social aspects (See paragraph 4 a iv and v of the regulatory impact assessment).
- The next steps for EASA after adoption of the Policy (See paragraph IV d of the explanatory note).

b. Why an A-NPA:

Article 14 from the EASA rulemaking procedure specifically requires that explanations are provided why an A-NPA procedure was chosen. In the present case, there are three main reasons that are developed hereunder:

- Ideally the UAV issue should be treated using a Total System Approach;
  Airworthiness and environmental protection are just two elements of the problem. Ideally comprehensive UAV regulations should address not only airworthiness and environmental protection but also UAV operations, crew licensing, ATM and airport operations. Today EASA is only responsible for airworthiness, environmental protection at source and maintenance. Therefore this A-NPA is an appropriate tool as it is aimed at contributing and stimulating further debate into how a comprehensive regulation for UAVs should be developed, while allowing EASA to respond positively to UAVs certification requests.

- Multiple initiatives world-wide
  As described in attachment 3 to this explanatory note, there are many initiatives worldwide dealing with UAV safety regulation. This A-NPA allows EASA to present ideas for debate and at the same time does not impose regulations that may be inappropriate or found not to be easily adaptable to UAVs.

- Some issues need specific comments:
  Several questions as described in paragraph 3 a above are not yet completely answered and specific comments are requested.

c. Selected issues:

i. General principles underlying the Policy

The JAA/EUROCONTROL Task-force developed general guiding principles to be used in achieving its goal of developing a concept of regulation for UAVs They are further developed in attachment 1 of this explanatory note.

These principles are: fairness, equivalence (equivalent risks, equivalent operations), responsibility/accountability and transparency.

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.

ii. UAV system:

The Policy is applicable to the UAV system. An UAV system is defined as follows in the policy:

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

Certifying the UAV system is essential for safety. The issue is that there are parts of the systems that are obviously not attached to the vehicle (e.g. ground control station) and therefore the question of compatibility with the Basic Regulation needs to be raised. A review of Articles 1(1)(a); 3(c); 4(2) of the Basic Regulation and letter (g) of its Annex II leads to concluding that ground control stations and other remote equipment, which performs the same functions and consequently replace parts and appliance located on board manned aircraft, should be certified as part of the UAV system.

iii. UAV airworthiness and certification

a) Two possible approaches for UAV that are in the EASA remit:

The Conventional approach:

The Conventional approach for the civil certification of manned aircraft is to apply defined airworthiness codes (Certification Specifications in the EASA system), 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 certification specifications, sometimes supplemented by special conditions, address all aspects of the design which may affect the airworthiness of the aircraft. Up to now, it is a common philosophy of these certification specifications that, as far as is practicable, they avoid any presumption of the purposes for which the aircraft will be used in service.

The Safety Target approach:

Another possibility would be to adopt a "Safety Target" approach of setting an overall safety objective for the aircraft within the context of a defined mission 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 volumes from which third 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 for missions that are not envisaged. Compliance with the Essential Requirements included in the EASA basic regulation may however be difficult to achieve and this may limit the use of such an approach to the issue of restricted certificates of airworthiness or permits to fly.

b) Comparison of the two approaches:
A comparison of these two methodologies has identified a number of issues, which need to be considered in developing the Policy. Attachment 2 to this explanatory note provides more details on this comparison and provides a discussion of the benefits and constraints of each approach. The comparison addresses the following issues: commercial competition, commonality of standards, exploiting the civil market potential, ease of modification, import and export, effect on civil design practices, the ICAO Convention and the EASA Basic Regulation.

c) Conclusion:
In conclusion, it has been determined that 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 depart from the established system 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 and EASA Basic regulation. Following due consideration of the pertinent issues, the Policy is based on 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 UAV when compliance with the approved type design has been shown. It is clearly workable for the short and medium terms as it is based on known documents. Therefore its confidence level should be high.
While the comparison has dealt with the concept of regulation for routine certification of UAV Systems, there may be, on an occasional basis, UAV Systems that fall outside of the considerations given above, which may benefit of the safety target approach in conjunction with the issue of restricted certificates of airworthiness.
Such an option is provided for in Article 5 Paragraph 3 of EASA Basic Regulation and detailed in Part 21 subpart H. This permits the issuance of a Restricted certificate of Airworthiness by derogation to 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 negligible, could be approved under a restricted certificate of airworthiness, and this may be based on the safety target approach.

iv. Selection of the applicable manned certification specification:
The Policy for establishing the UAV type-certification basis envisages that the starting basis is the selection of the applicable manned certification specification. Two alternatives have been presented for consultation purpose in appendix 1 to

attachment 2 of the Policy. However the Agency intends to keep only one method. These two alternatives may be summed-up as follows:

- One method is based on kinetic energy considerations
- One method relies on the definition of safety objectives

Attachment 4 to the explanatory note provide background on the two alternatives
Comments are specifically requested relative to the method to be used.

v. <u>Issue of certificate of airworthiness:</u>
The Policy envisages that certificates of airworthiness would be issued to the individual UAV in accordance with Part-21 subpart H and renewed in accordance to Part M subpart I. This looks rather straightforward. However the UAV System includes in particular the flying vehicle and the control station. When one or several control stations control one UAV this is not a problem, as the certificate of airworthiness can cover several identical control stations for one flying vehicule. The situation is different when only one control station controls two or more UAV. In such case, should the control station be included in the two certificate of airworthiness or should a specific certificate of airworthiness be created for the control station? The latter seems difficult to achieve under the EASA Basic regulation as it currently stands.
Comments and suggestions are requested on this specific issue.

vi. <u>Sense and avoid:</u>
The airworthiness certification is considered to address the intrinsic safety of the UAV. ‘Sense and avoid’ is there for anti-collision purposes and its operating criteria is dependent on the airspace being used and the aircraft flying into it (e.g. cooperative targets and non-cooperative targets). It is also good airmanship to avoid noise sensitive areas and objects when flying at low level. UAV pilots should have all information, capabilities and resources needed to be able to achieve the same level of avoidance of noise sensitive areas and objects.
Such criteria should be defined by the authorities responsible for air navigation services. Once the operating criteria have been established, the design, production, installation and operation of the equipment to ensure it functions correctly would be subject to the type design approval, similar to other installed avionic systems and equipment.
This explains why the safety and environmental objectives of the Policy are limited to people on the ground and to the design of the UAV system. The objective is to provide for an intrinsic level of safety and environmental protection that would be complemented by the ‘Sense and Avoid’ criteria mentioned above. This will allow preventing collision with other aircraft and minimize annoyance.
The view described above reflects the EASA view on where the responsibility boundaries should be put. It should not be interpreted that EASA views the collision avoidance of lesser importance than the protection of people on the ground. On the contrary EASA agrees that the definition of appropriate criteria for ‘Sense and Avoid’ is a key issue to the introduction of UAV in non-segregated airspace.
The fact that the type-certification does not address ‘Sense and Avoid’ should be reflected by a statement in the aircraft flight manual.

vii. <u>Environmental protection</u>
From an environmental protection point of view there is very little difference between a manned and an unmanned aircraft. The essential requirements for environmental protection (ICAO Annex 16, Volumes I and II) make no distinction

between manned or unmanned aircraft. Thus, in principle the normal environmental protection requirements are applicable.

For jet aircraft however, no requirements exist for aeroplanes with takeoff distances below 610 meters. The justification for this was that on major airports, aircraft with short take off distances would quickly reach an altitude where noise would no longer be a problem. The option was kept open to set more stringent limits for Short Take-Off and Landing (STOL) aircraft if they would be developed and if subsequently many airports close to cities would emerge. But this never happened. As UAV are likely to operate from small or dedicated airports or launching sites that may be located much closer to noise sensitive areas it may be necessary to develop noise certification requirements for jet UAV with shorter take-off distances. This would also be the case if the normal operation of certain jet powered UAV would have a different character and/or would include sustained low level flight[3].

Comments and suggestions are requested on this specific issue.

d. Perspective:

The next step will be the publication on the Agency's web-site of the Policy proposed in Part B of this A-NPA taking into account comments received

The ultimate objective should be to achieve in Europe a comprehensive set of UAV regulations allowing UAV operations in non-segregated airspace.

A multi-disciplinary task (MDM.030) has been included in the EASA advance rulemaking planning for 2007-2009. Its schedule and actual contents are not yet defined and will depend on the results of this consultation.

The Agency recalls however that it has no mandate to act as a co-ordinator of the various organisations potentially involved in the regulation of this type of activity. It also wants to insist that operational use of UAV is a political decision that goes well beyond the Agency's role and responsibilities. It suggests therefore that an appropriate co-ordinating body be put in place. In such context the Agency would be ready to go beyond its role if requested and if supported by the EU, Member States and Industry.

V. Regulatory Impact Assessment:

1. Purpose and intended effect:

a. Issue which the A-NPA is intended to address:

This A-NPA is a contribution to the development of appropriate regulations to cater for UAVs. It is intended to identify regulatory changes necessary to enable UAVs to gain regulatory acceptance and to remove some barriers that may be preventing the development of UAVs and their use in a non-segregated airspace.

b. Scale of the issue:

Although there are not many civil UAVs flying today in Europe, this number is expected to increase considerably in the future. There are today around 130 UAV types/models in production or under development worldwide that have a maximum take-off mass above 150kg. While these are predominantly aimed at military operations, data supplied by UVS International suggests that around a quarter of these (32) could also fulfil civil or dual role missions. As these UAVs would then have to comply with EASA regulations,

[3] Comments are specifically requested on the to develop noise certification requirements for jet UAV with shorter take-off distances

there is a pressing need to develop the regulatory framework to meet these new challenges and to remove some barriers preventing the UAV Industry from growing.

c. Brief statement of the objectives of the A-NPA:
The purpose of the A-NPA is to propose a general policy for the certification of UAV Systems.

2. Options:

a. The options identified for EASA action:
Three options could be identified:
Option 1: Do nothing: UAVs will continue to fly in segregated airspace and their development will be limited. As a consequence they will not introduce new safety risk. Considering this option is requested by the EASA procedure for RIA. However, in this case, it is not really an option because the basic regulation envisage that civilian UAVs with a maximum take-off mass above 150kg and that do not belong to annex II of the basic regulation are clearly within the remit of EASA.
Option 2: Propose a policy for the -certification of UAVs: this has the advantage of allowing to reply positively to certification requests and to contribute to the development of a comprehensive regulatory framework for UAVs allowing for future cooperation with other initiatives on UAVs.
Option 3: Develop a comprehensive regulatory framework for UAVs: this would be ideal. However it is a very ambitious task as mature drafts are not yet available. Furthermore the Agency currently has no remit to address issues outside of its direct control.

b. The preferred option selected:
Please see paragraph V-5 below.

3. Sectors concerned:

The sector directly concerned is manufacturers of UAVs for which EASA rules would be applicable. Their number may be estimated to around 60 worldwide. They range from small organisations to large manufacturers.
The use of UAVs in non-segregated airspace will affect the whole aviation system.

4. Impacts:

a. All identified impacts

i. Safety
The service record of the existing UAV fleet, primarily operating in military service, has yet to prove that the reliability and safety standards of such systems can achieve the same level as the one demanded by civil regulatory authorities for manned aircraft.
Any detrimental change in civil aviation safety and level of risks would be contrary to the prime objective of EASA.
Option 1 would have no/limited effect on safety as UAV operations would remain very limited.
Options 2 and 3 should ensure that there is no detrimental change in civil aviation safety level with the introduction of UAVs because they contain provisions to mitigate the risks (e.g. system safety analysis) to the extent that equivalent safety standards are applied to the same category as manned aircraft. Option 3 would be better than option 2 in that respect because it would cover the whole regulatory framework.

ii. Economic:

Present civil use of UAVs is very limited. The UAV Task-Force report has tried to develop some forecast for the possible UAV operations. It started first to classify the UAV in three broad categories for market entry that are summed-up by figure 2.1 below

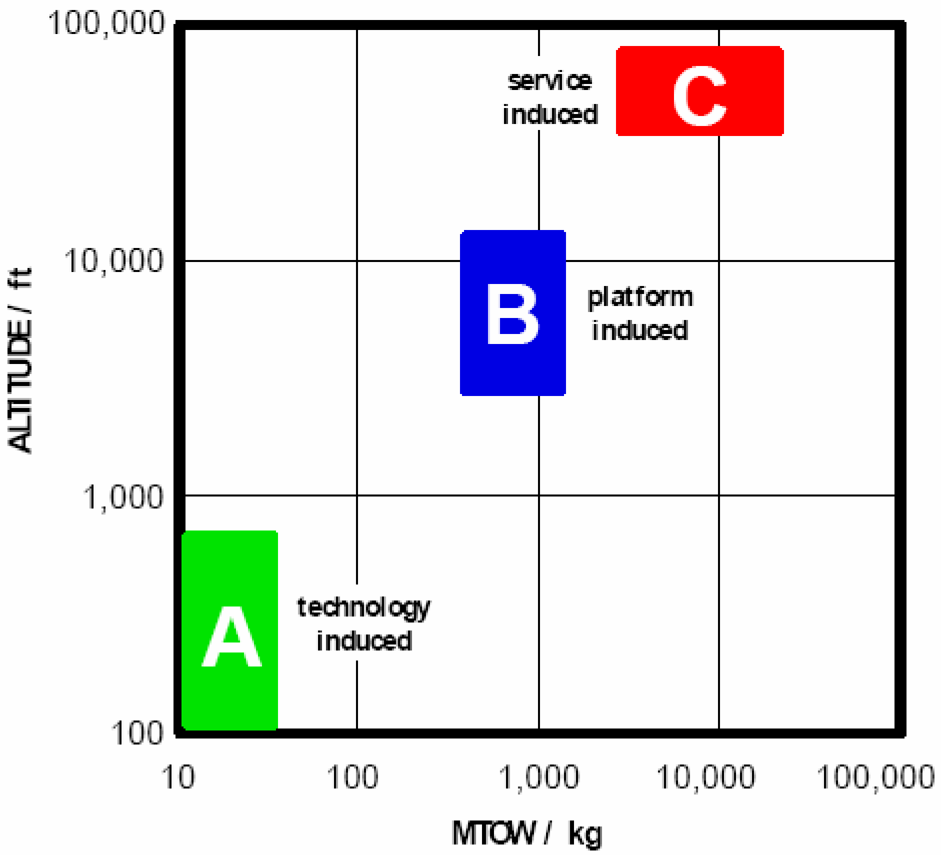


Fig. 2-1 Civil UAV trends

Technology induced applications

They focus on local range applications in the area of visual inspection and earth observations based on 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

They are 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 manufacturers and system integrators will play a dominant role. Typical customers are institutional organisations (government, national research centres).

Service induced applications

They would use high altitude geo-stationary 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.

Figure 2.2 below present a forecast for the introduction of civil UAV application corresponding to the 3 cases described above.

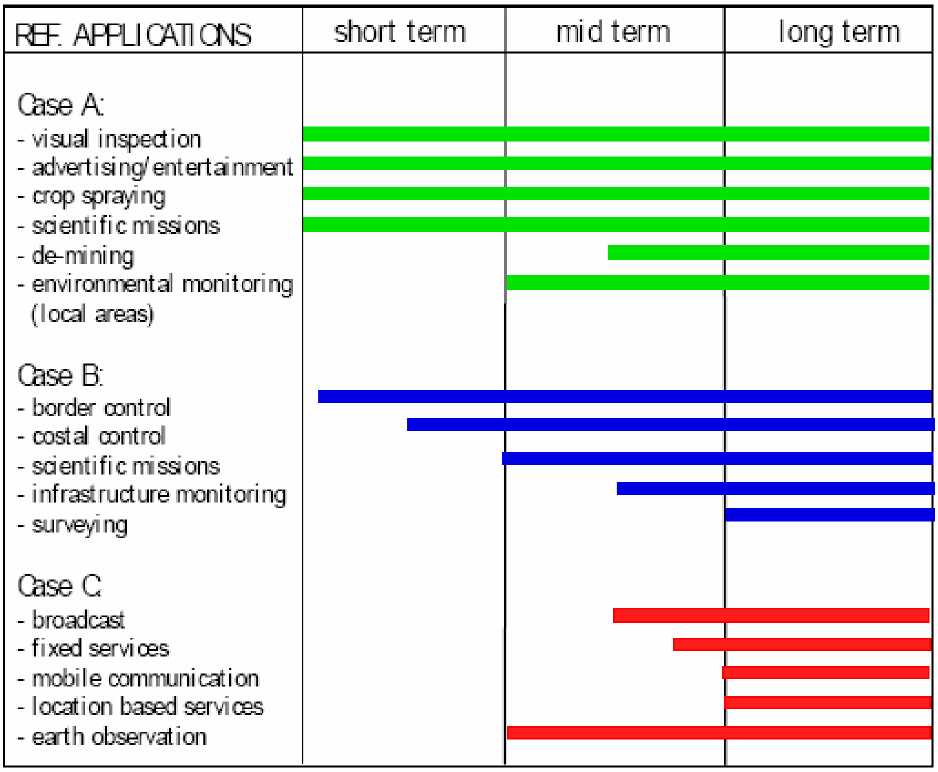


Figure 2-2:

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

This forecast is just an example: there are others that may be different but they all foresee a growth of civil UAVs in the coming years.
Option 1 would not allow such development.
Options 2 and 3 would allow it. If the UAV market is allowed to develop to reach its full potential, then it is expected that there will be huge economic benefit for industry and society as a whole. The absence of regulation has been mentioned regularly as a hindrance to UAV development. It should be noted that there will be certification costs in these two options. In particular the need to obtain a design organisation approval must be pointed out, in particular relative to small organisations.
The development of option 3 (a comprehensive set of UAV regulations) will be in itself quite a significant effort (e.g. use of groups, need for further research)
Options 2 and 3, depending of the alternative retained after consultation to identify the appropriate manned certification specification, could increase the remit of CS-

VLA and CS-23 in the case of UAV and therefore create an un-equal treatment with manned aircraft of comparable mass. If indeed, as described in attachment 4 of the explanatory note, the alternative based on the definition of safety objectives is retained at the end of the consultation, the maximum take-off mass for certification using CS-VLA could be increased from 750 kg to 1500 kg in the case of UAV and the maximum take-off mass for certification using CS-23 could be increased from 8600kg to 35000kg. If we concentrate on the latter case, using CS-23 to certify a UAV system of a maximum take–off weight of 35000 kg will certainly advantage the UAV compared to an aeroplane of a similar maximum take-off mass that will have to use CS-25.

Such un-equal treatment will not exist if the method based on kinetic energy considerations is retained at the end of the consultation.

iii. Environmental

Most UAVs use fossil fuels for propulsion. A very limited number of them use other sources of energy (electrical, solar, fuel cells) for propulsion.

Option 1 would have no/limited effect on the environment as the development of UAVs will remain limited in such case.

Options 2 and 3 allow the development of UAVs, and this in turn will have an effect on environment but Option 2 contains provisions in relation with Noise and emissions which follow existing practice. Option 3 would also contain such provisions, but could be more environmentally friendly as it could also contain a so-called "balanced approach" between source control, land-use planning, operational measures and operating restrictions. However, it is not clear at this stage in their development, how the UAV civil market will grow and whether UAVs will replace existing manned aircraft or create their own niche roles

Specific comments are requested on these environmental impacts.

iv. Social:

Public acceptance of UAVs flying in non-segregated airspace is an issue still to be resolved, which has the potential to limit UAV development. Another social issue is that UAVs may replace manned aircraft as regards for example agricultural work or power line surveillance, and this could be expected to trigger a negative reaction from the pilot community

Option 1 will have no/limited effect as the development of UAVs will be limited in such a case.

Option 2 and 3 will have an effect on both issues.

Option 3 is likely to be supported by safety cases and will envisage the necessary qualifications for operators and their staff.

Option 2 and 3 by allowing the development of UAVs are likely to create jobs and therefore should provide some alleviation to expected negative reactions mentioned above.

Specific comments are requested on these social impacts.

v. Other aviation requirements outside EASA scope:

Before an UAV can actually fly in non-segregated airspace, not only will certification issues need to be addressed, but also operations and licensing, air navigation services and aerodromes issues.

The issue of harmonisation with other initiatives should also be considered.

Option 1 has no effect because UAV development will be limited in such case.

Option 3 would need the cooperation of several regulatory bodies in Europe.

Option 2 is an action that EASA can do by itself: it nevertheless needs to be complemented by other actions such as for air navigation services to develop criteria for see and avoid.

vi. Security:

The main security issues for UAVs are:

- Physical security
- Communication links
- Data networks
- Software
- Malicious intentions for the use of civil UAVs
- Market control

Option 1 will have no/limited effect because the development of UAVs will be limited in such case.
Options 2 and 3 will have an effect on security issues.
Option 3 being a comprehensive approach, it should be possible to address those issues effectively.
Option 2 does not contain specific security provisions but the intended special condition relative to data-link should provide some mitigating factors. However, the other security issues would need to be addressed by the appropriate authority prior to UAV operations being permitted.

b. Equity and fairness in terms of distribution of positive and negative impacts among concerned sectors:
UAV development will benefit their designers and manufacturers. The other sectors of the aviation system are affected by this development without direct benefit. The main issues here are in maintaining present levels of safety and in ensuring that existing airspace users are not unduly penalised by the introduction of UAVs.

5. Summary and Final Assessment:

a. Comparison of the positive and negative impacts for each option:
Option 1 has no effect but will not allow for the development of UAVs. However, UAV are included into the EASA remit except those described in paragraph IV 1 of the explanatory note. This means that option 1 is not a realistic option for the Agency. The Agency must be able to certify UAV and must have the appropriate tools to do so.
Therefore this assessment will concentrate on choosing between Option 2 and Option 3.
Option 2 can be defined as a pragmatic step towards the certification of UAV. It is fully within the remit of the agency. As it does not address the sense and avoid issue, it does not allow UAV to fly in non-segregated airspace but it provides a starting basis for them to do so.
Option 3 would provide comprehensive regulations addressing all aspect of UAV activities and would allow UAV to fly in non-segregated airspace
Options 2 and 3 allow for the development of UAVs and contain provisions that should maintain the level of safety and of environmental protection.
Options 2 and 3 will have the social and security impact described in paragraphs 4.iv and v of this RIA. One uncertainty when addressing such impacts is how much UAV will replace manned aircraft in specific roles.
Option 3 is the ultimate goal but it will require a very intense development effort.
Option 2 requires a much limited effort and provides for a short term solution to UAV certification while leaving open all options for regulating issues related to flying in non-

segregated airspace. Also because it is a contribution towards a comprehensive regulatory framework for UAVs, option 2 would allow, better than option 3, other initiatives on UAV to be taken into account.

b. Summary describing who would be affected by these impacts and analysing issues of equity and fairness:
UAV manufacturers are directly affected. The whole aviation system is also affected. UAV development will benefit to their designers and manufacturers. The other sectors of the aviation system are affected by this development without direct benefit.

c. Final assessment and recommendation of a preferred option:
On balance option 2 has been chosen because it provides a realistic short term objective with limited resources and effort. It provides a basis to stimulate the development of UAV even if it does not allow for UAVs to fly directly into non-segregated airspace but provides a starting basis for them to do so.

Attachment 1 to the explanatory note

Guiding principles for UAV airworthiness regulation

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. UAV) 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.

Equivalence

Regulatory airworthiness 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.

a) 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 yet to prove that the reliability and safety standards of such systems can achieve the same level as the one 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 must be achieved by demonstrating a level of safety at least as demanding as the standards applied to manned aircraft.

b) 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 comply with and that change 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 Service Providers and other airspace users can determine courses of action as they would for any other airspace user.

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 long flight where they would be transfers between ground control stations.

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 manned aircraft operational rules (e.g. JAR-OPS)

Transparency

The provision of an Air Traffic Service (ATS) to a UAV must be transparent to the air traffic controllers and other airspace users.

A 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. UAV must be able to comply with ATC instructions and with equipment requirements applicable to the class of airspace within which they intend to operate.

Attachment 2 to the explanatory note

Comparison of the Target Safety and the Conventional approaches to certification

General

The two approaches ('Safety Target' and 'Conventional') have been described in paragraph IV 3 c iii a of the explanatory note. It should be noted that the two methods are not fully excluding each other.

Indeed, typical airworthiness codes such as JAR/CS 25, 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. The present version of CS-25.1309 contains criteria relative to the respective applicability of paragraph 1309 and other paragraphs. In the context of a "global" assessment of a complete UAV System, it is likely that some form of safety target will have to be established. However, the specific issue at stake here is whether the "airworthiness" contribution to the overall safety target will be to a fixed standard defined by an airworthiness code, or will be dependent upon the operational restrictions imposed in parallel.

Commercial Competition

The 'Safety Target' approach is greatly facilitated when UAV operators are all under the direct control of a 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 is not the ultimate customer 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.

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 depend 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 in the position of giving permission for one commercial Operator to fly his UAV 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 transparent equitable manner required of EASA. 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 UAV 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.

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 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.

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 Target' approach a complete reassessment of the aircraft and its operating environment may be required for every change of role.

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 would be faced with the task of international harmonization of safety case regulations.

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, providing therefore also for better certainty on the behaviour of the certificating authority. 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, as each case would have to be examined on the basis of its own merit, increasing therefore uncertainties on the conditions of certification for the presented UAV.

Legal framework

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 UAV, which does not include a code of airworthiness requirements to impose a minimum airworthiness standard, would raise a number of issues.

The ICAO Convention on International Civil Aviation (the "Chicago convention") obliges indeed through its Annex 8 that each State of Design certifies aircraft against standard airworthiness codes. (Certification Specifications in the EASA context)

Moreover a pure 'Safety Target' approach would not be in line with the Basic Regulation which requires the use of Certification Specifications as a starting basis to provide an assumption of compliance with the essential requirements.

Attachment 3 to the explanatory note

Other initiatives on UAV

1. European activities:
Joint JAA/EUROCONTROL initiative on UAVs (UAV-TF):
Its report is attached to this A-NPA as providing justification and further explanations. The report was adopted by JAA in June 2004.
EASA rulemaking programme for 2005 envisages publication of A-NPA as a follow-up.

EUROCONTROL military activities:
A task force has been set-up by EUROCONTROL military unit to address the issue of UAVs in Operational Air Traffic (UAV-OAT Task Force). The military unit of EUROCONTROL was involved in the UAV-TF.

EUROCAE:
EUROCAE (European Civil Aviation Equipments) is a standardisation body and it plans to develop an activity on UAVs.

EU research programmes:
The EU has launched several studies on UAVs, in particular the USICO study has produced a report on UAV airworthiness that recommends to follow-up the work done by the UAV-TF. Other examples of EU research programmes are CAPEON (Civil UAV designs project), UAVNET (the new European civil UAV roadmap) and studies on UAVs in the framework of GARTEUR (UAV autonomy)

EU Member States activities:
Several Member States are quite active. For example the French Flight Test Centre (CEV) recently adopted a tailoring of CS-23 to UAVs (USAR: UAV Systems Airworthiness Requirements). Sweden has also developed a total system approach in the framework of a vision for UAV operation in non-segregated airspace. (November 2004)
UK-CAA have produced general guidance on UAV (Civil Aviation Publication 722: Unmanned Aerial Vehicle Operations in UK Airspace – Guidance)

2. US activities:
UNITE/ ACCESS 5:
The aim of this activity is to allow within 5 years UAVs to fly in the US airspace by just filing a flight plan like manned aircraft do. They concentrate initially on High Altitude Long Endurance UAVs. Membership of UNITE consist of the main manufacturers of High Altitude Long Endurance UAVs, NASA, DOD and FAA. The objective is to have a type-certification basis available in 2008.

Standardisation bodies activities:
At least three US Standardisation Bodies are working on UAVs: the Society of Automotive Engineers (SAE); Radio technical Committee for Aeronautics (RTCA) and American Society for Testing and Material (ASTM).
The report of the UAV-TF has been sent to the three for information

FAA activities
The FAA policy is to allow any public UAV to fly using the authorizing document, the certificate of waiver and authorisation. The FAA has published a policy memorandum relative to issue of

experimental certificates to unmanned aircraft system and is also preparing a memorandum outlining requirements for UAV to fly in the National Airspace System. An experimental airworthiness certificate in the research and development category was issued to General Atomic in August 2005.
The FAA has also created a working group on UAVs.

US Department of Defence (US DOD) activities
The US DOD published a new edition of the UAV roadmap for years 2005-2030.

<u>3. International:</u>
ICAO:
ICAO has sent on 27.05.2005 a questionnaire to Member States and international organisations on the subject of UAVs and the priority to be given to the development of ICAO provisions and guidance material. EASA has recommended that such ICAO activity should proceed with moderate to high priority.

NATO activities:
NATO has launched a working Group (FINAS) to address the topic of flight in non-segregated airspace for larger UAVs. The work of the UAV-TF was presented late 2003 to FINAS.

UVS international activities
UVS International (One association representing the UAV community) has set-up a group to act as an interface with Regulatory Bodies.

<u>4. Other Authorities:</u>
Several authorities have developed or are considering developing UAV regulations.

Attachment 4 to the explanatory note

Further explanations on the two proposed alternative for selecting the appropriate manned certification specification

Introduction:
Two methods have been proposed for consultation purposes. The two methods were proposed by the report of the joint JAA/EUROCONTROL initiative on UAV and no consensus was found at the time.
However it is the Agency's intention to keep only one. Comments are specifically requested relative to the method to be used.
These two methods are:
Alternative I is based on kinetic energy considerations: it 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. This method will called below the 'Kinetic Energy' method

Alternative II relies on the definition of safety objectives: it attempts to redefine the boundaries of the existing manned aircraft certification specifications 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. This method will be called below the 'safety objectives' method.

The two alternatives may not give equivalent results when applied to the same UAV. The second method takes into account the safety levels of military aircraft which has not yet been done in civil certification.

Further information on the 'Kinetic Energy' method
Several worked examples can be provided:

Application to Global Hawk

Global Hawk is a High Altitude Long Endurance (HALE) UAV produced by Northrop Grumman in the USA with a primary role of reconnaissance/surveillance. Global Hawk is powered by a single turbofan engine. Its estimated characteristics are: a gross weight of 25,600lbs (11,600kg), a maximum operating speed (V_{MO}) of 345kts and a stall speed (V_S) of 95kts. Using these parameters gives energy levels of 0.177 (unpremeditated descent scenario) and 3.53 (Loss of control). These are illustrated in Figures 1 & 2 of appendix 1 to attachment 2 to the policy and indicate that CS-25 standards are applicable throughout.

Application to Predator

The RQ-1A Predator UAV from General Atomics is a Medium Altitude Long Endurance (MALE) UAV which has seen extensive operational experience within the military. Powered by a single piston-engine, the estimated parameters for Predator are: MTOW of 1,900lbs (855kg), Vmo of 120kts and Vs in the region of 56kts. For the "unpremeditated descent" scenario, this equates to energy levels of 0.0046 (CS-23 single-engine) and for the "loss of control" scenario 0.024 (CS-23 single-engine). The certification basis for the Predator would therefore be CS-23.

Application to Hunter

Hunter from IAI is a short range UAV which was/is operated by the armies of USA, Israel, Belgium and France. The Hunter comes in both standard and endurance versions and is powered by 2 Motto-Guzzi engines. The two versions of the aircraft have gross weights of 726 kg and 952 kg respectively. The values for each version and each scenario are shown in Figures 1 and 2 of appendix 1 to attachment 2 to the policy. Although there is a small overlap with CS-VLA in one case, it can be seen that the guideline standard is CS-23 for both versions of the aircraft.

Application to StratSat
StratSat is an unmanned communications airship intended for long duration missions stationed above population centres. For this aircraft the "unpremeditated descent" analysis indicates that a standard equivalent to CS-23 as applied to single-engine aeroplanes would be appropriate. The "loss of control descent" analysis indicates that standards equivalent to a combination of CS-25 and CS-23 Commuter Category should be applied to reduce the probability of such an event. Thus the basis for civil certification of this aircraft should be the airship equivalent of CS-23 supplemented as necessary by requirements from CS-25 and CS-23 Commuter.

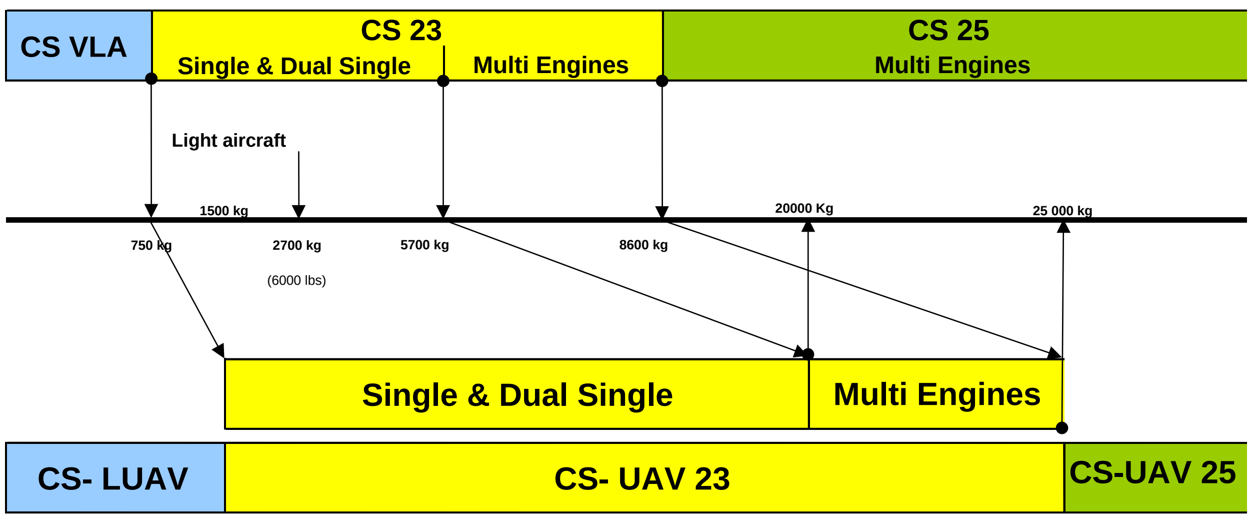
It is appreciated that no simple method can give a complete answer to the definition of the certification basis, and the conventional processes using judgement and debate will still be required. However, the method presented provides a useful tool in anticipating the general level of airworthiness requirements to be set. Its application is also rather straightforward.

Further information on the 'Safety Objectives' method:
Alternative two is based on a study conducted at the request of the French Civil Aviation Authority (NAVDROC study)
This alternative proposes that UAV safety objectives should take into account:

- The protection of populations and he today risk encountered by the populations
- The economics reality to allow a smooth development of the UAV
- The safety objectives must be consistent with the safety objectives of all today flying machines not only the objectives of transport civil aircraft but also the objectives of military aircraft as combat aircraft or helicopters.

It also propose to use Certification Specifications (CS) as a guide to define UAV type certification basis but advocates that based on safety objectives the mass categories for the CS would have to be redefined as suggested by the graph below.

CIVIL AIRCRAFT REGULATIONS



UAV REGULATIONS

Policy for UAV systems certification (Airworthiness and Environmental protection)

a) Scope
The proposed policy is applicable to UAV systems with a maximum take-off mass of 150 kg or more; which are not excluded by Article 1(2) or Article 4(2) and Annex II of EC Regulation 1592/2002.

b) Objectives:
Airworthiness Safety objectives
The airworthiness safety objectives are the protection of people and property on the ground. (See also discussion on 'sense and avoid')

Environmental protection objectives
A level of protection of people on the ground that is equal or equivalent to ICAO Annex 16 to the Chicago Convention as issued in March 2002 for Volume I and November 1999 for Volume II, from the viewpoint of technical feasibility, economic reasonableness and environmental benefit

c) Definitions and acronyms
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 applicable except where modified here:

UAV System: A ***UAV System*** comprises individual UAV System elements consisting of the flying 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.
UAV (Unmanned Air Vehicle, Unmanned Aerial Vehicle): An aircraft which is designed to operate with no human pilot onboard
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. "Flight" is defined as also including taxiing, takeoff and recovery/landing.
Remotely Piloted Vehicle (RPV): An RPV is an UAV that is continuously under control of a pilot.
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 and environmentally compatible 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 Operater: The legal entity operating a UAV System.
UAV Pilot: The person in direct control of the UAV.

d) <u>Procedure for UAV systems Certification</u>

The general principle is that Part-21 is applicable to the UAV System. The definition of the applicable requirements is done using paragraph 21A.17, in particular the provisions 21.17(a)1.("unless otherwise agreed by the Agency") and 21.17(a)2. (special conditions).

The type-certification basis is established according to paragraph 21A.17. It will consist of requirements based on the reference certification specifications developed for manned aircraft (if relevant), which are selected and tailored in accordance with the method detailed in appendix 1 to attachment 2 of this policy[4]. Where the existing requirements do not contain adequate or appropriate safety standards, Special Conditions will be added in accordance with 21A.16B. Type-certificates are issued in accordance with paragraph 21A.21

In order to obtain a TC, a Design Organisation Approval issued as required by 21A.14 and Sub-part J must be obtained. UAV categories and types covered by the EASA regulations are considered to be complex systems and do not qualify for the use of alternative procedures under 21A.14 (b).

Certificate of Airworthiness are issued to the individual UAV systems in accordance with Part 21 subpart H and renewed in accordance to part M subpart I.[5]

Noise certificates are issued to the individual UAV systems in accordance with part 21 Subpart I.

Issuance of a Restricted C of A will be considered for remote operations. Where application is made for a restricted certificate of airworthiness under the provisions of Article 5 paragraph 3 of EASA regulation 1592/2002 and detailed in Part-21 subpart H, the Agency will set the airworthiness specifications commensurate with safety objectives and the level of imposed operational restrictions.

Production organisation approvals are issued to the manufacturer in accordance with Part 21 Subpart G.

e) <u>General considerations</u>

i. UAV System elements to be included in the type-certification basis

For certification, any function of the UAV System that can prejudice safe take-off, continued safe flight, safe landing or environmental compatibility of the UAV, 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 and as such will have to comply with the applicable airworthiness and environmental requirements as stated in the type-certification basis. Identification of UAV System Elements included as part of the aircraft product shall normally be

[4] For the purpose of consultation, two methods are presented in the appendix 1 to attachment 2. Comments are specifically requested relative to the method to be used. It is the Agency's intention to keep only one method.

[5] Comments are specifically requested on the issue of certificates of airworthiness in relation with the control station.

supported by a functional hazard assessment performed by the applicant. (See attachment 1 for further guidance)

f) Type-certification basis:

1. The type-certification basis will be adapted from the existing certification specifications developed for manned aircraft.

2. The methodology for selecting the appropriate certification specification is detailed in Appendix 1 to attachment 2[6].

3. A typical type-certification basis is likely to include:

   a. Existing manned aircraft certification specification duly tailored to UAV Systems,
   b. System Safety Objectives and Criteria, applying the "1309" approach to UAV System elements that could effect aircraft safety,
   c. Special Conditions & interpretative materials related to UAV specifics, such as:
      - Emergency Recovery Capability
      - Communication Link
      - Level of Autonomy
      - Human Machine Interface
      - Other Special Conditions as appropriate considering the envisaged kinds of operations (e.g. IFR operations certification in case of JAR/CS-VLA code application.)

Attachment 2 provides more guidance on how to establish the type-certification basis

g) Continuing Airworthiness

Annex I (Part M) of Regulation 2042/2003 is applicable.

h) Environmental protection:

Noise

For propeller driven aeroplanes up to 8618 kg there are the requirements of Annex 16, Vol I, Chapter 10. For heavier aeroplanes, the requirements of Chapter 3 or 4 are applicable (subject to possible additional requirements for jet aircraft with take of distances below 610 meters).
For Helicopters the normal requirements of Chapter 8 and/or 11 are applicable.

Gaseous Emissions and fuel venting

For Turbojet and turbofan engines the normal requirements of Annex 16, Volume II are applicable. Currently no requirements for engines with other propulsion principles (such as piston driven) exist.

[6] For the purpose of consultation, two methods are presented in the appendix 1 to attachment 2. Comments are specifically requested relative to the method to be used. It is the Agency's intention to keep only one method

Attachment 1

Detailed guidance relative to the UAV airworthiness definition

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 Control and 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
- Integration of payload

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.

Attachment 2

Detailed guidance relative to the development of the type-certification basis

1. **Selecting reference manned airworthiness code**:
For consultation purposes, two techniques for establishing an initial type-certification basis, which have been developed independently and take no account of existing criteria, are presented in Appendix 1 to this attachment[7].
The alternative 1 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.
The alternative 2 attempts to redefine the boundaries of the existing manned aircraft certification specifications 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.

2. **Tailoring reference manned certification specification**
The following guidelines are proposed, with regard to the way certification specifications should be tailored when establishing the type-certification basis after a relevant certification specification has been selected.

The applicant should provide the Agency with a tailoring proposal of the certification specification using the following type of categorization for each specification:

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

Rationale for above categorization should be presented and justified for each specification
Wherever found necessary, Certification Review Items should be raised to address specific issues. This is in particular valid where the category "A" has been proposed. These CRIs may subsequently lead to special conditions or interpretative materials to provide an equivalent level of safety with the original intent of the specification
Criteria set forth under paragraph 3 below may be considered when assessing specific sections of the EASA Certification Specifications to assist resolving difficult cases.

3. **UAV System Safety Objectives and Criteria:**
The following guidelines are proposed, with regard to the way certification specifications related to UAV System Safety should be handled:

The level of specification should be tailored according to and compatible with the agreed selected certification specification.

[7] For the purpose of consultation, two methods are presented in the appendix 1 to attachment 2. Comments are specifically requested relative to the method to be used. It is the Agency's intention to keep only one method.

There should be a distinction between qualitative safety requirements and quantitative criteria to be set forth as acceptable means of compliance and advisory materials.
The worst UAV hazard event designated hereafter as “Catastrophic” or Severity I Event may be defined as the UAVs 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 for example “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 for a catastrophic failure 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” may be defined as follows, as “parallel” the AMC.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 is added because some of the mitigation measures for failures could be to rely on emergency sites:
Emergency landing sites (unpopulated areas) should be defined as follows:
These sites shall be unpopulated areas
Their location shall 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 assumption made relative to the selection of the emergency sites should be made available to operators so that they can select their actual emergency sites. Appropriate limitations could be introduced in the flight manuals.

4. Special Conditions and interpretative material:

The special conditions or interpretative materials shall comply with Part 21A.16.

4.1 Emergency recovery Capability

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

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.

UAV System Safety Assessment shall 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 paragraph 3 above). 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.

4.2 Communications link:

Airworthiness criteria to be included in the UAV System type-certification basis shall be based upon the following considerations:

Communication Link signal strength shall be continuously monitored and appropriate maximum Communication Link range cues should be provided to the Pilot in command.

Any single failure of the communications system (uplink or downlink) shall not affect normal control of the UAV.

Uplink/downlinks are sensitive to electromagnetic interference (EMI) and shall be adequately protected from this hazard.

Contingencies for lapse times, intermittent failures, alternate modes of Communication Links and total loss of Communication Link need 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)

Note: It is reminded that approval for all frequencies used in UAV operations must be obtained from national authorities. This is not part of an airworthiness approval.

4.3 Level of autonomy

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 deterministic algorithms) but which have to prove safe behaviour
- Collision avoidance
- Type of airspace
- Avoidance of noise sensitive areas and objects.

4.4 Human machine interface:

The type-certification basis shall specifically include criteria relating to UAV System specific human machine interface characteristics.

These criteria that may be under the form of Interpretative materials or Special Conditions shall typically consider:

- The tailoring of existing airworthiness manned requirements 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

Appendix 1 to Attachment 2

The method to select the manned airworthiness codes

Alternative I: IMPACT ENERGY METHOD FOR ESTABLISHING THE DESIGN STANDARDS FOR UAV SYSTEMS[8]

This Appendix describes a method for obtaining a first outline of the certification specifications which should be applied to UAV Systems. The method compares the hazard presented by a UAV with that of existing conventional aircraft to obtain an indication of the appropriate level of requirements which should be applied. The most significant feature of this proposal is that it relies on a comparison with existing conventional aircraft design requirements which contribute to a currently accepted level of safety, and avoids controversial assumptions about future contributions to that level of safety from operational, environmental or design factors.

1. COMPARISON CRITERIA

The capability of a vehicle to harm any third parties is broadly proportional to its kinetic energy on impact. For the purposes of the comparison method it is assumed that there are only two kinds of impact; either the impact arises as a result of an attempted emergency landing under control, or it results from complete loss of control. More precisely, the two impact scenarios are defined as:

a. *Unpremeditated Descent Scenario* - A failure (or a combination of failures) occurs which results in the inability to maintain a safe altitude above the surface. (e.g. loss of power, WAT limits etc).

b. *Loss of control scenario* - A failure (or a combination of failures) which results in loss of control and may lead to an impact at high velocity.

Unpremeditated Descent Scenario:
For many air vehicles the likelihood of the unpremeditated descent will be dominated by the reliability of the propulsion systems. For the calculation of kinetic energy at impact the mass is the maximum take-off mass and the velocity used is the (engine-off) approach velocity. i.e.

For aeroplanes	V =	1.3 X Stalling Speed (Landing configuration, MTOW)
For Rotorcraft	V =	Scalar value of the auto-rotation velocity vector,
For Airships/Balloons	V =	The combination of the terminal velocity resulting from the static heaviness, and the probable wind velocity.

Loss of Control Scenario:
For the calculation of kinetic energy at impact for the loss of control case the mass is the maximum take-off mass and the velocity used is the probable terminal velocity. i.e.

For aeroplanes	V =	1.4 X Vmo (the maximum operating speed)
For Rotorcraft	V =	Terminal velocity with rotors stationary.
For Airships/Balloons	V =	Terminal velocity with the envelope ruptured/deflated to

[8] For the purpose of consultation, two methods are presented in the appendix 1 to attachment 2. Comments are specifically requested relative to the method to be used. It is the Agency's intention to keep only one method.

the extent that no lifting medium remains.

For each scenario the kinetic energy has been calculated for a selection of 28 different civil aircraft; (21 aeroplanes, and 7 rotorcraft). The results are shown in Figures 1 and 2. On each Figure the "applicability region" for each of the existing aeroplane and rotorcraft codes is shown. These regions have been established using practical constraints based upon the sample of the existing fleet, plus any weight and speed limitations specified in the applicability criteria of the codes of airworthiness requirements.

2. METHOD OF COMPARISON

To obtain the indication of the level of requirements appropriate to a UAV System the following steps are carried out:

a. Calculate the kinetic energy of the UAV for each scenario.

b. Using these values and Figures 1 and 2 separately, determine the appropriate code to be applied with the intent of preventing the occurrence of each scenario. i.e:

   Figure 1 will provide an indication of the standards to be applied to any feature of the design whose failure would affect the ability to maintain safe altitude above the surface.

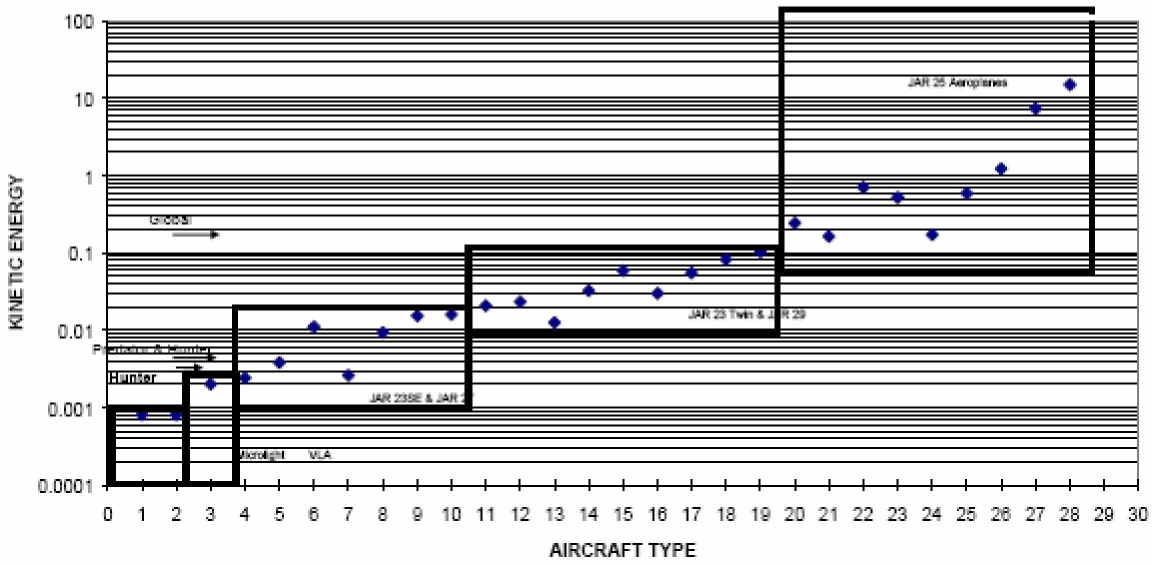
   Figure 2 will provide an indication of the standards to be applied to any feature of the design whose failure would affect the ability to maintain control, (particularly rate of descent). Clearly, this must include primary structure.

   If it is found that the aircraft fits within the region for more than one code, then this would indicate that it may be appropriate to apply a combination of standards. (e.g. CS-25 with reversions to CS-23 in some areas, or CS-23 with Special Conditions taken from CS-25).

c. Construct a certification basis which addresses the same aspects of the design as the existing codes and to the level indicated by the kinetic energy comparison. Clearly, Special Conditions will need to be considered for any novel features of the design not addressed by the existing codes. However, the extent of such special conditions should be comparable with the general level of airworthiness identified.

Note: In addition, operational requirements may dictate the inclusion of particular design features which may in-turn necessitate the inclusion of additional certification requirements. For example, the Rules of the Air specify that an aircraft operating over a congested area must be able to maintain a safe altitude following the failure of one power unit.

FIGURE 1 - UNPREMEDITATED DESCENT SCENARIO

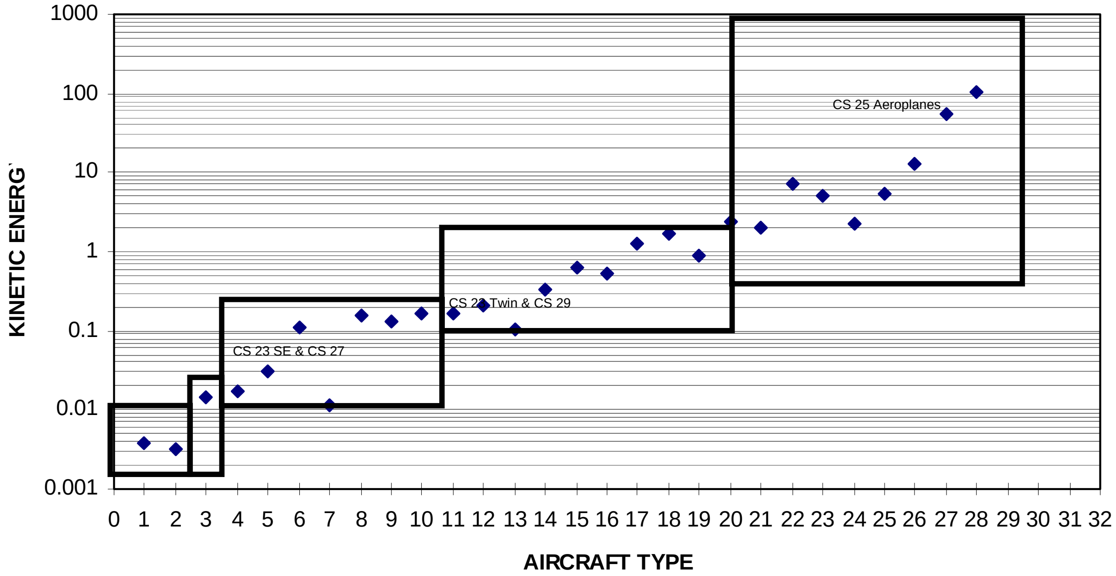


Kinetic Energy (as plotted) = (Mass (kg) X Velocity (kt)^2) / 10^9

Aircraft Key:	1. Flex wing microlight,	11. Piston twin	20. 50 seat Turboprop
	2. 3-axis microlight,	12. Piston twin,	21. 50 seat Turboprop
	3. Piston Single - JAR-VLA	13. Piston twin	22. 100 seat airliner
	4. Piston Single 2 seat,	14. Piston twin	23. Corporate Jet
	5. Piston Single 4 seat,	15. Light Corporate Jet	24. Corporate Jet
	6. Large Piston Single	16. Large Helicopter	25. 50 seat airliner

Note: in this figure please read CS instead of JAR

FIGURE 2 - LOSS OF CONTROL SCENARIO



Kinetic Energy (as plotted) = (Mass (kg) X Velocity (kt)^2) / 10^9

Aircraft Key:

1. Flex wing microlight,
2. 3-axis microlight,
3. Piston Single - CS-VLA
4. Piston Single 2 seat,
5. Piston Single 4 seat,
6. Large Piston Single
7. Helicopter 2 seat
8. Mid-size Helicopter
9. Mid-size Helicopter
10. Mid-size Helicopter
11. Piston twin
12. Piston twin,
13. Piston twin
14. Piston twin
15. Light Corporate Jet
16. Large Helicopter
17. Large Helicopter
18. Large Helicopter
19. Small Twin Turboprop
20. 50 seat Turboprop
21. 50 seat Turboprop
22. 100 seat airliner
23. Corporate Jet
24. Corporate Jet
25. 50 seat airliner
26. Single-aisle Airliner
27. Wide Body Airliner
28. Wide Body Airliner

Alternative II: METHOD BASED ON UAV SAFETY OBJECTIVES[9]

1. CONTEXT

Safety objectives have been used as a means to define and justify the civil aircraft characteristics.
These safety objectives are oriented to on board people protection and are defined by the FAR/CS 25/23 regulations.
As there are no people on board of UAV, safety objectives criteria for UAV must be redefined and oriented to on ground people protection.

2. ON GROUND VICTIM CRITERIA

A first step to define safety objectives is to select a figure corresponding to an "acceptable" probability for on ground victims per fatal UAV accident. This figure might be justified based on the today on ground victim due to the flying machines as light & transport aircraft, military aircraft or helicopters.
UAV must not be considered by civilian population as more risky that other flying machines. At the opposite the criteria must allow the development of UAV at an acceptable economic cost.
Most of the victim statistics published are relatives to on board people, and the few published statistics relatives to on ground victims are not reliable.
US Navy has published figures for "risk of aircraft flying overhead" and estimated the ground casualties at a rate of 1,8 victims per million flight hours (*).
It might be suggested to use for UAV the conservative criteria of:
One victim per million UAV flight hours.

Note: Air transport statistics for large aircraft provide figures of about 50 victims per million aircraft flight hour but they are passengers, they are aware of the risk.

(*): Range safety criteria for unmanned air vehicles. Rationale and methodology supplement to doc 323-99

3. METHOD TO ESTIMATE CRASH ENERGY & LETHAL AREA

This method of calculation is not limited to UAV but must be applied to all flying machines. Application of this method to the aircraft crashes (civil & military) and correlation of the figures with the statistics will allow the validation of the method.
The method consists of an estimation of the energy of the flying machine and an estimation of the lethal crash area. For an explosion energy is a cubic function of the radius ($E = d^3$) and lethal area a square function of the radius ($Ac = d^2$).

$Ac = k.E^{2/3}$ Ac = lethal area E = energy

3.1 Aircraft energy, Kinetic energy

Estimation of crash energy depends of variable parameters. There are two main sources of energy, the kinetic energy and the fuel energy. To simplify the fuel energy will be

[9] For the purpose of consultation, two methods are presented in the appendix 1 to attachment 2. Comments are specifically requested relative to the method to be used. It is the Agency's intention to keep only one method.

considered proportional to the air vehicle kinetic energy. Aircraft energy will be considered as proportional to kinetic energy.
Kinetic energy is a function of the mass & of the speed:

$Ec = \frac{1}{2}.M.V^2$ M = mass V = speed

Air vehicle mass vary from MTOW (Maximum Take Off Weight / Mass) to MW (Minimum Weight / Mass)

Air vehicle speed vary from VMO (Maximum Operating speed) to Vs (Stall speed).
To unify and simplify the determination of the average kinetic energy it might be useful to determine the energy at a given "lift coefficient" Cl (which is roughly the same on flying machines):

$M.g = \frac{1}{2}.\rho_0.Cl.Sref.V^2$ Cl: lift coef Sref: reference Wing surface

$V^2 = k1.M / Sref$ At a given Cl

$Ec = \frac{1}{2}.k1.M.M / Sref$

(0) $E = k2.MTOW^2 / Sref$

Energy is based on well identified characteristics published in the "aircraft data sheet" as MTOW and reference wing surface.

3.2 *Lethal crash area*

Lethal crash area can be determined as:

(1) $Ac = k.(MTOW^2 / Sref)^{2/3}$

Lethal crash area will have to be calibrated based on the experience of crashed aircraft. It might be suggested the following figures.

MTOW: 17 000 kg Sref: 42,5 m^2 Ac: 1 000 m^2

k is determined equal to 0,028

k = 0,028

(1a) $Ac = 0{,}028.(MTOW^2/Sref)^{2/3}$ Ac & Sref in m^2 MTOW in kg

3.3 *Applications*

Application of the "Ac" formula (1a) to different sizes of flying machines is provided in the following table:

AIRCRAFT TYPE		Mass kg	Sref m2	Wing loading kg/m2	Lethal Surface m2
Military	Combat aircraft	17000	42,5	400	**1000**
CS-25	Boeing 747	350000	520	673	**10627**
	Falcon 2000	20600	49	420	**1175**
CS-23	Commuters	6800	40	170	**307**
	M > 6000 lbs reciprocating	5700	38	150	**251**
	M < 6000lbs turbine	1800	15	120	**100**
	M < 6000lbs reciprocating	800	13	62	**37**
CS-VLA		750	15	50	**31**
		300	7,5	40	**15**
Ultra Light		100	2,5	40	**7**
		25	1,25	20	**2**

4. DETERMINATION OF ON GROUND VICTIMS

The determination of victim number is based on lethal crash area and on over flown population density.

N = Ac. D. Fc. P

N: **number of victims per million flying hours**
Ac: Lethal surface area (m^2)
D: standard population density (habitants per km^2)
Fc: Corrective density coefficient (>1 for higher density)
P: Crash probability per flying hour

(2) $N = k. D. Fc. P. (MTOW^2 / Sref)^{2/3}$

It might be suggested to used the following figures :
Standard population density: D 100 habitants per km^2
Density coef for civil aircraft: Fc 2 (high % of the flight over overpopulated area as terminal zones)
Density coef for military aircraft: Fc 0,3 (high percentage of the flight over low density reserved area)

(2a) $N = 0{,}028. D. Fc. P. (MTOW^2 / Sref)^{2/3}$

4.1 Applications

Fighter:
Ac = 1000 m^2 D = 100 H / km^2 Fc = 0,3 P = 5.10^{-5}
N = 1,5 victims per million hours which corresponds to US Navy figures

B747:
Ac = 10627 m^2 D = 100 H/ km^2 Fc = 2 P = 3.10^{-7}
N = 0,6 victims per million hours (correlation with statistics to be made).

5. SAFETY OBJECTIVES FOR UAV

Crash probability and so Safety Objectives can be determined using formula (2).

(3) $P = N. (Sref / MTOW^2)^{2/3} / (k. D. Fc)$

P:	**Crash probability per flying hour**	
N:	Number of victims per million flying hours	**N = 1**
Sref:	Reference Wing surface (m^2)	
K:	Coefficient	**k = 0,028**
MTOW:	Maximum Take off Weight (Mass in kg)	
D:	Standard population density (habitants per km^2)	**D = 100**
Fc:	Corrective density coefficient (>1 for higher density)	**Fc = 1**

(3a) $P = 0{,}36. (Sref / MTOW^2)^{2/3}$

5.1 Applications to large UAV

Application of (3a) equation to large UAV in the defined conditions allows determination of the crash probability.

UAV Type	**Mass** kg	**Wing Loading** kg/m2	**Sref** m2	**Lethal Area** m2	**Crash Probability Objective**
UCAV	**25000**	400	63	1293	**8,E-06**
HALE	**20000**	200	100	702	**1,E-05**
HALE	**8600**	200	43	400	**3,E-05**
MALE	**5700**	100	57	192	**5,E-05**
Fighter	**17000**	400	43	1000	**1,E-05**

Conditions: D = 100 h/km^2 Fc = 1 N =1 victim per million flight hours

6. AIRCRAFT SAFETY OBJECTIVES & CRASH PROBABILITY

By comparing today aircraft safety objectives (as they are defined in the regulations) to the UAV proposed safety objective, we will establish a correspondence between CS-23 categories and UAV categories.

Safety objectives for civil aircraft are defined by:
AMC 25-1309 for transport aircraft
FAA AC 23 –1309-1C for commuters, aerobatics & light aircraft

Three main figures have to be considered:

- Aircraft fatal loss which is a figure provided by the statistics. A value which takes into account all conditions of a fatal crash.
- Technical aircraft loss which correspond to the loss of aircraft due all technical errors. The figures are defined by the regulations. This figure vary from 10^{-7} for FAR/CS-25 to 5.10^{-5} for a FAR/CS-23 light single reciprocating engine aircraft of less than 6000 lbs.
- Catastrophic failure: which correspond to a technical multi failure combinations resulting in a catastrophic failure. It was estimated that on a large aircraft there was 100 of such failures, so the failure value was set as an initial target at 10^{-9}. On a smaller aircraft or UAV the number of such failures will certainly be less than 100.

The following tables provide either for CS-25, 23 aircraft, and military aircraft the values corresponding to the 3 types of figures.

AIRCRAFT TYPE		Catastrofic failure	Aircraft loss	
			Technical	Statistics
Military	Combat aircraft	1E-07	1E-05	**5E-05**
CS- 25	Transport a/c, business jets	**1E-09**	1E-07	**3E-07**
CS- 23	Commuters	1E-09	1E-07	**1E-06**
	M > 6000 lbs reciprocating	1E-08	1E-06	**5E-06**
	M < 6000 lbs turbine	1E-07	1E-06	**1E-05**
	M < 6000 lbs reciprocating	**1E-06**	5E-06	**2E-05**

Note: AC 23-1309-1C paragraph 6 t (4) (iii)
Hazardous failure def.: "serious or fatal injury to an occupant other than the flight crew" this means that a fatality is acceptable at 10^{-5}

6.1. UAV safety objectives versus CS-23 safety objectives

Based on the UAV crash probability objective the following table provides an equivalence between the UAV categories and the CS-23 aircraft categories.

UAV Type	**Mass** kg	**Sref** m2	**UAV Crash Probability Objective**	**Equivalent CS- 23 Category**	
UCAV	**25000**	63	**8,E-06**	**Commuters**	**1,E-06**
HALE	**20000**	100	**1,E-05**	**M > 6000 lbs Reciprocating**	**5,E-05**
HALE	**8600**	43	**3,E-05**	**M < 6000 lbs Turbine**	**1,E-05**
MALE	**5700**	57	**5,E-05**	**M < 6000 lbs Reciprocating**	**2,E-05**
Fighter	**17000**	43	**1,E-05**	**Today reality**	**5,E-05**

Remark: application of the method to the "combat aircraft" demonstrates that the method is too conservative.
The method applies an additional safety factor of "5" compared to the today design safety factor of the combat aircraft.
The combat aircraft crash probability is around 5.10^{-5}, using the method crash probability will have to be at 1.10^{-5}

APENDICES:

- The joint JAA/EUROCONTROL initiative on UAV: UAV task-force final report (See separate document)