COMMENT RESPONSE DOCUMENT (CRD) TO NOTICE of PROPOSED AMENDMENT (NPA) 2007-12

for amending the Decision No 2003/13/RM of the Executive Director of the European Aviation Safety Agency of 14 November 2003 on certification specifications including airworthiness codes and acceptable means of compliance for sailplanes and powered sailplanes (« CS-22 »)

"Cockpit crashworthiness"

Explanatory Note

I. General

1. The purpose of the Notice of Proposed Amendment (NPA) is to envisage amending Decision 2003/13/RM of the Executive Director of the Agency of 14 November 2003 on certification specifications, including airworthiness codes and acceptable means of compliance for sailplanes and powered sailplanes.

II. Consultation

2. The draft Executive Director Decision amending Decision 2003/13/RM was published on the web site (http://www.easa.europa.eu) on 31 August 2007.

   By the closing date of 1 December 2007, the European Aviation Safety Agency ("the Agency") had received 33 comments from 15 National Aviation Authorities, professional organisations and private companies.

III. Publication of the CRD

3. All comments received have been acknowledged and incorporated into this Comment Response Document (CRD) with the responses of the Agency.

4. In responding to comments, a standard terminology has been applied to attest the Agency's acceptance of the comment. This terminology is as follows:

   - **Accepted** – The comment is agreed by the Agency and any proposed amendment is wholly transferred to the revised text.
   - **Partially Accepted** – Either the comment is only agreed in part by the Agency, or the comment is agreed by the Agency but any proposed amendment is partially transferred to the revised text.
   - **Noted** – The comment is acknowledged by the Agency but no change to the existing text is considered necessary.
   - **Not Accepted** - The comment or proposed amendment is not shared by the Agency

   The resulting text highlights the changes as compared to the current rule.

5. The Agency's Decision will be issued at least two months after the publication of this CRD to allow for any possible reactions of stakeholders regarding possible misunderstandings of the comments received and answers provided.

6. Such reactions should be received by the Agency not later than **03 June 2008** and should be submitted using the Comment-Response Tool at http://hub.easa.europa.eu/crt.

IV. CRD table of comments, responses and resulting text

(General Comments)	-

comment	*3* comment by: *Francis Fagegaltier Services* General The whole concept behind this NPA is, of course, supported. However, it must be noted that the real safety objective is only hidden in the AMC 22.561 and cannot be easily determined from either the new wording of CS-22.561 or the explanation of the NPA. It would appear that this safety objective is similar to what has been done for cars : « the main part of the cockpit … should constitute a cage strong enough » to protect the passengers. Indeed, this concept has proven its efficiency for saving lives. Why is this requirement not clearly imposed in CS-22.561 and why is it only suggested in the AMC 22.561 ? A suggestion for re-writing of the package is made in another comment.
response	*Noted* The concept of this NPA is introduced within the current principle of CS-22, using the existing requirement based on compliance showing to static loads. The first development in this concept is therefore the change of the load factors of the cockpit that provides a safety cell. The requirement for occupant protection and means to absorb energy in an emergency landing are currently captured in the existing CS 22.561(a). Supporting information to this is provided through new AMC. More specific and explicit AMC is not available at this time, however based on accident data evaluation it is considered necessary to introduce the safety cell requirement and in addition share insight and available data in this AMC.

comment	*9* comment by: *CAA CZ* The CAA CZ generally agrees with the idea of the NPA in question. We would like to use this opportunity to express few following general comments: 1) The requirements of the NPA will lead to the improvement of the impact resistance; however, they will probably not lead to more elaborate design solutions such as for example use of controlled destruction methods 2) Similar approach should be implemented in other Certification Specifications considering the same type of structures, e.g. CS-VLA 3) It is not clear from the proposal whether the requirements set forth by the NPA are applicable also to powered sailplanes
response	*Noted* 1) Refer to the response to comment 3. 2) If applicable and substantiated, similar crashworthiness requirements for these types of structures used for aeroplanes certified to other airworthiness

codes will be considered in future rulemaking tasks.
3) CS-22 is applicable to powered sailplanes unless specifically mentioned otherwise. This is also true for the NPA although it was not specifically mentioned.

comment

10 comment by: *CAA-NL*

CAA-NL has no comment on this NPA.

response

Noted

comment

19 comment by: *Allstar PZL Glider*

Idea of increasing safety of soaring, especially in crash-landing conditions, is right and worth to be promoted, but we think that those aims can be realized by other means.
Focusing on problem of sharpening regulations only, which forces to design more and more ‘armored' cockpits, today's proposals can be found insufficient tomorrow by their Authors. But currently used gliders can be in use next few dozens of years.
Increasing load factors we can reach the point, where in unbreakable (safe) cockpit pilot will suffer fatal inner injuries or fatal spinal injuries, caused by deceleration loads.
Assuming that, we think the philosophy of ‘safe cockpit' should be based on determining of maximum acceptable for pilot load factor, and minimum ‘undamaged cockpit volume', necessary for occupants safety. For those parameters cockpit should be designed for absorb energy during its progressively destruction, according to above assumption. By other words - base cockpit design on philosophy of undercarriage shock absorbtion.
Quantity determining for those assumptions will require further research, so applying it in CS 22 rules should concerns only gliders, which are in the first stage of design. Similarly, if decision of changes according to NPA 2007-12 will be taken, we think it should concerns only new projects.
In NPA 2007-12 p.IV.9 Authors has mentioned insufficient carbon-reinforced composites properties for carry dynamic loads. Paying attention for that, change of load coefficients could be connected to the material used in foremost part of fuselage.
And so:
1. For glass-epoxy structures, impact-absorbing and resisting to brittle cracking, leave load factors like they are now defined in CS 22.561(b)(1).
2. Consider excluding carbon-only reinforced composite structures for foremost part of fuselage, and introduce hybrid -glass-carbon or kevlar-carbon structures.

response

Noted

Current cockpit designs are far away from 'armoured cockpits', which can be clearly seen when looking to accident data that was gathered during the research work of TÜV Rheinland. (Please refer to NPA AMC 22.561 No. 10). The goal of the NPA is to require a 'safety cell' and to prevent collapsing of the cockpit, to improve the pilot's chance to survive a crash landing.

Prescription of energy absorption is not a primary goal of this requirement. A stronger cockpit structure is a prerequisite to improve the survivability of crash

landings.

There is no direct link between the increased structural strength of a safety cell and the injuries of the occupant.

The proposal to differentiate between materials and construction methods used in types of designs is not accepted and too prescriptive.

The change to CS-22 proposed by this NPA will only become applicable for applications for TC from the day it is introduced to the CS-22. (See Part 21A.17) Retroactive implementation is not considered for this NPA.

comment *20* comment by: *Austro Control GmbH*

General:
ACG in general highly supports any regulation activity for improvement of crashworthiness on gliders. It is obvious if you look at the picture of glider accidents that the cockpit structure of current designs does not protect the pilot/pax related to the size of impact. Formula One racing car designs have clearly shown, that with moderate impact to the industry (cost and weight) an "Safety Cockpit" can be achieved.

Comments:
The NPA does not contain the technical justification, that the new values can meet the intent. It is more important that the g-loads have been raised by an factor of 2 !

Proposal:
The sailplane development shall also be in future an simple and low end aviation field, without any complex analysis using very simple methods. It was understood by the AMC 22.561 that an dynamic set test is not required, but on the other hands an analysis of the structure may be also an complex task.
There is a good chance that an simple test may be more cost and time effective and may give better results than any test. It is cheaper and faster for small companies to builds a test structure than to carry out complex analysis.
It is proposed to add an simple test method, that can be achieved with a simple test jig should be adds to the AMC. This test should include one point and direction for measuring a g-load. This minimum g- load must be achieved by the test. If the structure is capable to withstand this, than, 22.561 (b) is completely complied with.

response *Noted*

The values contained in the NPA are an outcome of accident investigation, research work and compromise from discussions with stakeholders, regarding realization of increased load factors in the requirements.
Examples for simple static load tests as well as dynamic tests are contained in the research report of TÜV Rheinland. (Please refer to NPA AMC 22.561 No. 10). Nevertheless, the requirement defines only static loads.
To avoid confusion, the first sentence "To show compliance with CS 22.561 (b) no dynamic tests are mandatory." in the AMC is removed. The AMC has been restructured to provide better understanding of the AMC.

comment 33 comment by: *Armageddon Associates*

Having read through your document I feel that option 2 is the only acceptable course in view of the number of accidents in this area of general aviation in the last few years.

I apologise for my delay in responding due to pressure of other work in aviation matters. Nationally and internationally.

response *Noted*

A. Explanatory Note - I. General p. 3

comment 17 comment by: *DGAC France*

This proposal does not seem consistent with the new EASA approach on non complex aircraft. At a time when EASA is trying to find alternative certification requirements for aircraft up to 2000kg, we do not understand how gliders can be considered more drastically than CS23 aircraft, and than CS25 aircraft.

Ultimate Load Factors

	CS22	NPA	CS23	CS25
Upward	4,5	7,5	3 4,5 (Aerobatics)	3
Forward	9	15	9	9
Sideward	3	6	1,5	3
Downward	4,5	9	6	6

response *Noted*

The EASA approach on non-complex aircraft is aiming for simplified certification procedures; they do not address changing the airworthiness requirements, like CS-22.
Proposed increase of load factors is based on experimental results and human body resistance.

A. Explanatory Note - IV. Content of the draft decision p. 4-5

comment 13 comment by: *Walter Gessky*

Generally Austria will support any regulatory activity for improvement of crashworthiness on gliders. It is obvious if you look at the glider accident rate, that the cockpit structure of current designs does not protect the pilot/pax in relation to the kind of impact.
Formula One racing car designs have clearly shows, that with a moderate impact with regard to cost and weigh to the industry a "Safer Cockpit" can be achieved.

response *Noted*

comment	*16* comment by: *Walter Gessky* The NPA does not contain a technical justification, that the new values can meet the intent. It is more important that the g-loads have been raised by a factor of 2!
response	*Noted* The values contained in the NPA are an outcome of accident investigation, research work and compromise from discussions with stakeholders, regarding realisation of increased load factors in the requirements.

comment	*23* comment by: *European Sailplane Manufacturers* The comments from the sailplane manufacturers have been collected and forwarded to EASA centrally. Most European sailplane manufacturers used this discussion period to provide comments and to find wordings acceptable for all manufacturers. Nevertheless some different ideas about answering NPA 2007-12 remained. Therefore it was decided to include all answers acceptable to all manufacturer into the comments – this may include some overlapping answers. The common opinions of all manufacturers were: a) Occupant safety is an important topic – no manufacturer wants to risk health or life of pilots as they are also the customers which should buy new sailplanes in the future. b) Cockpit crashworthiness is a very complex business which cannot be handled by the manufacturers alone; research and supporting discussion by several institutions (like the authors and organisations listed in the proposed AMC material) has been fundamentally important in the ongoing development of occupant safety. c) Even without a change of regulation over a long time the safety level has been improved steadily and considerably; this is a result not of regulation but of information offered by these research programs which therefore have to be continued (hopefully now on an European level). d) It makes no sense to simply increase required loads when the resulting economical effort for the single manufacturer makes development of a new design not longer feasible. e) The reasoning for rulemaking activity 22.004 leading to NPA 2007-12 (long time without change in regulation plus increased speeds and masses) is not accepted as sufficient for the proposed change of regulation – neither EASA nor other authorities supplied ample proof that the actual safety level of current products (incorporating the "lessons learned" from the cited research projects) is low or even lower than older designs; quite contrary the manufacturer claim to have indications that the level of safety has been improved and therefore no reason for tighter regulation exists. Further comments by the manufacturers are supplied at the relevant locations within the NPA – if more than one opinion was given separate comments have been edited in the Comment Response Tool of EASA.
response	*Noted* The start of the issue of this rulemaking activity was an accident investigation that showed urgency to change the existing situation. The cockpit with the pilot seemed to be the energy absorbing zone of the gliders - due to the fact that

the cockpits collapsed. This fact had to be changed. Aim of this NPA is to improve safety issues, not to prevent a decrease of the level of safety. It is noted that design changes have been made for improvement of crashworthiness.
The NPA addresses the concerns derived from the accident investigations, and enhances a level playing field for all designers for Type Certification.

comment

24 comment by: *European Sailplane Manufacturers*

The sailplane manufacturer appreciate the effort by EASA to increase the level of safety of occupants in sailplane cockpits.
It is furthermore appreciated that existing research work conducted by several organisations including the manufacturers is been included into this rulemaking activity.

The inclusion of the OSTIV sailplane development panel into the rulemaking activity leading to NPA 2007-12 has assured that all research work done in this important field until now could be regarded and most of it has been included in the proposed AMC material.
Due to this research documentation literature already published by OSTIV and inclusion of modified wording in the OSTIV airworthiness requirements (OSTIVAS) many sailplane manufacturers were already able to improve their products and thereby increase occupant safety.

Nevertheless it has to be pointed out that the EASA rulemaking process leading to NPA 2007-12 is now different to the approach taken within the OSTIVAS:

The NPA 2007-12 basically increases the loads which will lead towards reinforced cockpit structures which may still fail completely after reaching the (now increased) breaking load. This may also lead to higher deceleration forces upon the occupant(s) if actual loads do not go beyond the specified breaking loads.
(Admittedly experience with modern designs shows that the deceleration levels with designs complying with existing rules are below tolerable g-levels and that the highest injury probability is due to structural failure and not due to exceeding deceleration forces.)

The OSTIVAS approach was to find a wording in the relevant requirements which will insure that failure will at first not be complete but that starting from the nose of the glider. The goal of this approach is to maximise the level of energy absorption until full failure thus minimizing deceleration forces upon the occupant(s).

The NPA 2007-12 approach will increase structural strength and keep the level of effort for showing compliance at a minimum required level.
The OSTIVAS approach is nearer the physics of the crash dynamics which have to be considered but leads toward increased certification effort.

Perhaps the NPA 2007-12 should include clearer wording to not impede more detailed showing of compliance (i.e. by using a more detailed approach like the one proposed by OSTIVAS).

response

Noted

It is the intention of the NPA to avoid a too far deviation from the existing CS-22 wording. Nevertheless, all relevant information, also available from OSTIV

AS, is enclosed. The safety cell philosophy is introduced into CS 22.561 requirements and the energy absorption concept is captured within the AMC material.

comment

25 comment by: *European Sailplane Manufacturers*

"The increased loads in the revised CS 22.561 also take into account the introduction of Sailplane Parachute Rescue Systems (SPRS), which after activation brings the sailplane or its damaged body to the ground at a vertical speed of maximum 8 m/s and approximately 45° negative pitch."

It has to be stated that up to now there are no regulations within CS-22 that define SPRS on board of sailplanes. Since these conditions are not defined, it is not possible to define cockpit standards on the base of assumed SPRS characteristics.

Nevertheless several studies concerning possible use and safety impact of SPRS have already been conducted (Röger, Fachhochschule Aachen et.al.) and the results have been published.
These documents point more towards a maximum sink speed of 6 m/s which would be acceptable in combination with cockpits fulfilling the existing requirements (i.e. 6g under 45° in 22.561 (b)(2)).

response

Noted

It is accepted that the SPRS are not a part of the NPA. It is only mentioned in the Summary to supply background information.

A. Explanatory Note - V. Regulatory Impact Assessment p. 5-7

comment

12 comment by: *UK CAA*

Paragraph:
A v "Regulatory Impact Assessment"

Comment:
The RIA does not provide justification for the 15g value that is chosen. The RIA appears to rely upon the technical references identified in the NPA document. A number of these references are identified in the German language only and some of the references cannot be readily accessed by readers of the NPA and/or by users of the proposed AMC material.

Justification:
The RIA needs to provide all necessary justification for the regulatory change it identifies, providing an analysis of the references that may be used, rather than relying on the reader to review each of the references and come to their own conclusion.

response

Noted

The values contained in the NPA are not an outcome of the information in the references but of accident investigation, research work and compromise from discussions with stakeholders, regarding realization of increased load factors in the requirements.
The 15 g requirement is already existing for the retractable engine (CS 22.561

(e)) and the NPA brings the requirements in line by introducing it into CS 22.561 (b)(1) and CS 22.787.

comment

14 comment by: *Walter Gessky*

The RIA does not reflect the retroactivity issue.
To increase the safety of the future fleet retroactive measures should be imposed.
I propose the following measures:
a. the new emergency landing condition requirements has to be applied for all derivatives and significant major changes of the gliders after the new CS becomes effective,
b. all gliders manufactured five years after the new CS becomes effective, has to comply with the new standards for emergency landing conditions.

Justification:
It is obvious from the glider accident rate, that the cockpit structure of current designs does not protect the pilot/pax in relation to the kind of impact. To improve emergency landing conditions in CS-22 will only be effective for new designed products.
Existing products which remain in production, new derivatives to existing models can be designed based on the old emergency landing conditions, because 21A.101 which might require compliance with the requirements effective on the date of application is not effective for gliders.
Since to show compliance with this requirement will create higher costs for the TC holder with regard to design and production, the improvements will not be incorporated in existing type designs.
When no retroactivity measures are in force, no new gliders will be designed.
The new design requirements will only be used on a volountary basis.

response

Noted

This comment is considered outside of the scope of this NPA. The NPA addresses a change to the Airworthiness Requirements only.

comment

15 comment by: *Walter Gessky*

It is proposed to add a simple test method to the AMC, that can be achieved with a simple test rig. This test should include one point and direction for measuring a g-load. This minimum g- load must be achieved by the test. If the structure is capable to withstand this, than, 22.561 (b) is completely complied with.
Justification:
The sailplane development shall also be in future a simple process for the low end aviation field. Complex analysis should not be required to show compliance with the requirement, very simple methods should be offered in the AMC. As far as we understand the AMC 22.561 a dynamic test is not required, but on the other side a structural analysis may be also a very complex task. The AMC should include the description of a very simple test set up to show compliance with the requirement, which could be easily be performed by the industry.
There is a good chance that this simple test may be more cost and time effective and may give better and more reliable results than a complex analysis. It is cheaper and faster for small companies to builds a test bed, than to carry out complex analysis.

response

Not accepted

Examples for simple static load tests as well as dynamic tests are contained in the research report of TÜV Rheinland. (Please refer to NPA AMC 22.561 No. 10). Nevertheless, the requirement defines only static loads.
To avoid confusion, the first sentence "To show compliance with CS 22.561 (b) no dynamic tests are mandatory." in the AMC is removed.

comment

26 comment by: *European Sailplane Manufacturers*

„Option 2 could have only a moderate negative impact. Costs for achieving increased protection of occupants and showing the compliance with new requirements would moderately rise with the necessary design effort. No further research is necessary, published results of accomplished research programmes are sufficient. The new models of sailplanes with improved cockpit design show, that the extra costs are negligible. The results are achieved with the application of standard materials (composites) but with an intelligent structural design, providing the necessary strength in the main part of the cockpit and energy absorption capability in the front part. The weight penalty remains limited. The costs for showing compliance are not increased, thanks to the development of computerised modelling programmes, considered as acceptable means of compliance."

It is accepted that test cockpit structures have been built showing compliance with the new requirements.

Nevertheless it must be pointed out that

- only single-seater cockpit test fuselages have been built and tested (with double seaters the cockpit is much longer which necessitates probably additional structural reinforcements not yet described)
- the single seater cockpit in the cited tests (which fulfil the new requirements) had in some versions unacceptable high (over 20 kg) weight penalty
- the main financial impact for the manufacturers would be the necessity to modify the mold lines which causes considerable costs due to the needed new tools – it is not clear from the outset if the new requirements will cause such a fundamental modification.

Therefore it cannot be stated that only a "moderate negative (economical) impact" has to be expected. It is simply not yet foreseeable if this impact would be moderate or unacceptable.
The manufacturers do not accept such a "downsizing" of possible impacts on basis of pure speculation.

response

Noted

The economic impact is only substantiated based on single seater designs that have been used for research. The expectations are however expressed that the negative economic impact is justified when balanced against the increased safety level.
The weight penalty has already been addressed in the research report, showing that additional strength may be achieved by negligible additional weight.

B. DRAFT DECISION CS-22 p. 8

comment 8 comment by: *Francis Fagegaltier Services*

General
It is suggested a change to the package as described below. Of course, to find the more appropriate wording would require a significant amount of additional re-writing but it is believed this would end up in a more easily understandable set of certification specifications.

In particular, it should also avoid making reference to factors which are out of the competence of the aircraft designer: individual conditions / chances of survivability for each passenger.

This would also result in a more controlled, uniform application of these texts by eliminating the subjective assessments. This counter-proposal is consistent with the currently proposed wording of AMC 22.561 :
« the objective of this requirement is to design a cockpit structure that in survivable emergency landing conditions shall provide:

- Maximum energy absorption, and
- Occupant protection against serious injuries, namely injuries of head and spine.
- For maximum protection of the foremost part of legs during the front part deformation, the feet should have adequate space to move slightly backwards together, without twisting or rocking »
-

  Counter-proposal
  A new 22.561 (b) based on the following concept :
- 22.561 (b) The cockpit structure must be capable of supporting the crash landing conditions of 22.561 (xx) without deformation or failure leading to parts entering the "life" volume of each passenger and pilot.

  Notes
  1 - of course, this "life" volume must be defined somewhere in CS-22, and should be uniquely based on geometrical considerations, like margins around the seat dimensions.
  2 - The new 22.561 (xx) should contain the crash conditions to be used for the aircraft design.

  A new 22.561 (yy) based on the following concept:
  22.561 (yy) The aircraft and seat structures must be designed so that in case of crash landing in the conditions of 22.561 (xx) the maximum accelerations to which the centre of gravity of a seated passenger would be submitted are limited to TBD.

  22.561 (d) and 22.787 (b) must be modified to impose that the "potentially becoming loose items" or baggage must not enter the "life" volume under the crash conditions of 22.561 (xx).

  22.561 (e) must be similarly modified to impose that the engine and propeller (note: propeller is not addressed in current CS-22) must not enter the "life" volume under the conditions of 22.561 (xx).

22.785 must be similarly modified to impose that the seat must stay attached to the aircraft structure under the conditions of 22.561 (xx). The harnesses

must not break with a passenger mass of XX kg submitted to the crash conditions of TBD.

response *Not accepted*

Defining a life volume is difficult to apply within the sailplane cockpit design with limited space and variety of configurations. Introduction of energy absorption and maximum accelerations will lead to mandatory dynamic testing which is not the goal of this NPA.
The rulemaking task is based on an existing wording that is in place for almost 3 decades and is accepted by designers and authorities, being used to the methods of showing proof of compliance. The aim of the NPA is to adjust the required values to actual experience with minimum change of wording, not to change procedure of showing proof of compliance.

B. Draft Decision CS-22 - Book 1 / Subpart C-Structure p. 8

comment *4* comment by: *Francis Fagegaltier Services*

22.561 (e)
This paragraph is not modified by this NPA.

However, to consider only a forward force is not consistent with the explanation given on "Sailplane Parachute Rescue Systems (SPRS), which after activation brings the sailplane or its damaged body to the ground at a vertical speed of maximum 8 m/sec and approximately 45° negative pitch". This is very likely to result in both forward and downward forces acting on the engine attachments. This is important when 22.561 (e) refers to an "engine located behind and above the pilot's seat".

It is suggested adapting 22.561 (e) to the new crash conditions.

response *Not accepted*

The reason for this requirement is protection of the pilot. The important component to protect the pilot is the forward component. For this reason, only the forward component is regarded in this paragraph.
However, SPRS are not a part of the NPA. It is only mentioned in the Summary to supply background information.

comment *6* comment by: *Francis Fagegaltier Services*

22.561 (d)
This paragraph is not modified by this NPA.

However, the cross reference to the new values in 22.561 (b)(1) is questionable when the subject is only items of mass becoming loose in case of "minor crash landing".

Suggestion : either the old values of 22.561(b)(1) are retained for these "minor" crash conditions or the word "minor" is deleted from 22.561 (d).

response *Accepted*

The word "minor" will be deleted from 22.561 (d).

comment	*18* comment by: *FAA* Paragraph CS 22.561(b)(1) provides proposed static ultimate inertial loads factors to which the occupant must be protected. The intent of these proposed load factors is to provide enhanced strength of the occupant restraint system in the event of an emergency landing. The FAA agrees that increasing these static load factors will likely increase the strength of the passenger restraint system. However, increased passenger restraint static strength will not necessarily increase the energy absorption capability of this system. We suggest EASA consider adding a rule to CS 22 similar to 14 CFR 23.562 to allow for the installation of an energy absorbing seat. Energy absorbing seats are tested in a dynamic environment (reference 14 CFR 23.562). Increased static structural strength may not equate easily to the ability of a seat to absorb a dynamic impact.
response	*Noted* It was intention of the authors of the NPA to avoid a too far deviation from existing CS-22 wording. Nevertheless, all relevant information, also available from OSTIV AS, is enclosed. The safety cell philosophy is introduced into CS 22.561 requirements and the energy absorption concept is captured within the AMC material. Introduction of energy absorption requirements is not considered in the scope of this NPA.

comment	*21* comment by: *Howard Torode* Has consideration been given to the feasibility of achieving these strength reserves using traditional, conventional sailplane materials such as wood? While clearly these reserves are desirable and achievable in more sophisticated materials, such as composites and metals, it appears conceivable that by mandating this rule EASA could be effectively precluding the future construction of sailplanes by rendering the traditional material for glider construction unacceptable. Not only the strength but the convenience of location of the necessary structural members to meet this requirement need to be considered.
response	*Noted* The requirements of CS-22 are objectives to be met, independent from design details such as choices of materials or constructions.

comment	*27* comment by: *European Sailplane Manufacturers* *(2) An ultimate load of ~~6~~ 9 times the maximum weight of the sailplane acting rearwards and upwards at an angle of 45° to the longitudinal axis of the sailplane and sideward at an angle of 5° acts on the forward portion of the fuselage at ~~the foremost point(s) suitable for the application of such a load~~ a suitable point not behind the pedals.* It is accepted, that for the limited scope of single seater glider cockpits the above draft requirements can possibly generate additional safety. The studies of TÜV Rheinland et. al. gave insight into the complex relations of dynamic

impact. The parameters impact speed and attitude, soil condition and dynamic deformation and failure behaviour of the cockpit structure are condensed and simplified into a static requirement.
In the spirit of CS-22 this is a suitable procedure. However it is necessary to define an additional required compliance of the cockpit section. Otherwise it is possible that due to the increased loads designers are forced to create structures with a stiffness exceeding the undefined stiffness of the TÜV test cockpits and therefore leading to higher g-loads during impact. The proposed draft can therefore generate a severe additional risk for the pilot.

With double seater cockpits the situation is even more critical: Up to now there are no detailed tests available. Structural design methods for this case are not state of the art. The influence of the dynamic impact parameters on double seater cockpits has to be analyzed in the same depth as it was done for single seater. There is no evidence up to now, that a simplified static requirement can be found. It is very well possible that dynamic impact parameters have to be defined within CS-22, to give designers additional freedom for the cockpit design (*).

Especially the energy absorption characteristics of the fuselage can be optimized in different ways. Within the scope of TÜV analysis only the principle of a stiff cockpit section with a crash zone in the fuselage nose section up to the rudder pedals was taken into account. The above draft does not allow the designer to decrease the load during dynamic impact with optimized dynamic deformation behaviour of the front fuselage structure, because these dynamic parameters are not defined.

The development of suitable structural design principles for double seater cockpits is therefore limited. Optimization for the static load case will not lead to the best compromise of safety, performance and economical standards.

It is therefore of utmost importance that either:

1. Additional investigation with double seater cockpits are performed, leading to simplified requirements as it was done for single seater
2. Or the dynamic load state (impact energy) is defined within CS-22, to give the designer freedom to find an optimized cockpit structure.

(*) Nota bene: Even if such additional data regarding the dynamic load state are to be included within CS-22 it must be noted that mandatory dynamic testing of sailplane cockpits must not be included as such type of testing is by far exceeding the typical economical possibilities of the sailplane manufacturers.

response

Noted

It is accepted that sufficient research work for double seater sailplanes- as it has been performed for single seater sailplanes - is not available right now. EASA supports very much the idea to perform research work on this field. Nevertheless, the lack of research data on double seater sailplanes is not considered to be sufficient reason to question or postpone the NPA, as accident data is also available for double seater sailplanes and shows the need for improvement of the crashworthiness of cockpits.

comment

28 comment by: *European Sailplane Manufacturers*

(2) An ultimate load of ~~6~~ 9 times the maximum weight of the sailplane acting rearwards and upwards at an angle of 45° to the longitudinal axis of the sailplane and sideward at an angle of 5° acts on the forward portion of the

fuselage at ~~the foremost point(s) suitable for the application of such a load~~ a suitable point not behind the pedals.

It has to be noted that a main statement of the research projects cited in the proposed AMC material (i.e. reports from TÜV Rheinland about occupant safety) has been that the existing 22.561 requirement already represents a quite high safety level. The cited reports have not indicated that this existing regulation system is insufficient – the main purpose of the research was to show that static testing and/or structural proof by numerical methods is sufficient in comparison the (much more complex and expensive) dynamic testing of test fuselages.

The proposed increase of the ultimate force by a factor of 1.5 is not warranted on basis of the tests conducted within the cited reports.
Merely one single test fuselage was tested up to a static load of 9g (for an assumed MTOW of 525 kg) but this test sample had considerable weight penalty.

The conclusions drawn from this research work only are valid for single seater cockpits – double seater cockpits have not been tested and it is not yet clear if the new proposed ultimate forces can be sustained by such cockpits without major redesigns.

Under these aspects the sailplane manufacturers see further research efforts warranted. As long as such research results are not available the ultimate force for double seaters should not be raised above the existing 6g level.

response *Not accepted*

Actual requirement do not distinguish between single and double seater sailplanes. It is not considered acceptable to make a different approach and to have a different safety level for the two "categories".

comment *29* comment by: *European Sailplane Manufacturers*

With the changed wording of NPA 2007-12 it will now be required to show compliance with 22.561 (2) b assuming a force equivalent to "*9 times the maximum weight of the sailplane*" instead of "*6 times the weight of the sailplane*".

While some increase of the value may be accepted (at least for single seat types) it is not accepted to include the word "maximum".

With designs having a substantial weight in he front of the cockpit (e.g. powered sailplanes of the touring motor glider variety) the force acting upon the cockpit structure might be much lower as with typical sailplane configuration with the pilot sitting in the front.
Additionally some masses of the sailplane might separate before the maximum specified force is reached which also decreases load upon the cockpit structure. Such effects must be possible to include into the showing of compliance.

Therefore the sailplane manufacturers propose to omit the word "maximum".

response *Accepted*

The wording does not take into account different design philosophies and seems too be too strict. Therefore, deletion of the word "maximum" in 22.561

(b)(2) is accepted.

comment

30 comment by: *European Sailplane Manufacturers*

With the changed wording of NPA 2007-12 it will now be required to show compliance with 22.561 (2)(b) assuming a force acting " …. *and sideward at an angle of 5°"*.

It is accepted to have this additional requirement to include some additional safety margin against forces not acting in the plane of symmetry due to yaw angle etc..
Nevertheless it must be pointed out that all AMC material stated within the NPA 2007-12 describes analysis and testing within the plane of symmetry.
Therefore the assumption that sufficient data is herewith existing to show suitable ways for designing structures able to withstand the now 1.5 times higher loads is wrong.

Therefore it is proposed that either the additional 5° direction side wards is dropped and/or additional research work is been conducted to describe the additional effects of this part of the requirement.

response

Not accepted

Research work of the TÜV has pointed out that side loads are part of the accident scenarios. "Load case 3" with side loads applicable show a share within 15% - 20% of the total number of accidents.

comment

31 comment by: *European Sailplane Manufacturers*

The work of the rulemaking group responsible for NPA 2007-12 was based on research projects which are reflected in the extensive literature list of the proposed AMC material.

One very important cornerstone is the research of TÜV Rheinland "Insassensicherheit in Segelflugzeugen und Motorseglern" (Occupant safety in sailplanes and motor gliders) from 1993-98 which was supported by German aviation authorities and several sailplane manufacturers (see also literature source no. 6 in the proposed AMC).

Contact with TÜV Rheinland during the rulemaking activity leading to NPA 2007-12 and also very recent communication indicates that in the near future the results of a subsequent research project will be finalised and published.
Preliminary analysis already indicates that if an increase in ultimate force levels of 22.561 (2)(b) is envisaged then it should be discussed to change the direction of such a force towards the main direction of deceleration which is typically about parallel to the longitudinal axis.

Such a change or amendment in the regulation would

a) reflect better the physical mechanisms during the actual dynamic crash event
b) lessen the effects of the different cockpit geometry of single and double seater
c) open the possibility to introduce force-limiting crash absorbing elements which could lessen the deceleration forces upon the occupants.

The manufacturer propose to delay any proposed rulemaking activity in regard to 22.561 (2)(b) until this research project has been published due to the

fundamental implications of the possible results in regard to occupant safety.

response *Noted*

EASA is aware of the newest research work of the TÜV Rheinland.
Nevertheless, it is not regarded to be sufficient reason to question or postpone the NPA, as accident data is also available for double seater sailplanes and shows the need for improvement of the crashworthiness of cockpits.
Furthermore, the energy absorption is not part of the proposed change of the requirement itself, but of the AMC material given in book 2.

B. Draft Decision CS-22 - Book 1 / Subpart D-Design and Construction p. 8

comment *5* comment by: *Francis Fagegaltier Services*

22.787 (b)
The comment made against 22.561 (e) would also be valid here : why only forward forces ?

response *Noted*

In general, this requirement covers the usual design of sailplanes and powered sailplanes. Unusual designs will be covered by special conditions.

comment *32* comment by: *Swiss Federal Office of Civil Aviation (FOCA)*

Attachment #1

Proposed change:
Include following change and guidance material for CS 22.785(d) to clarify that the combinaison has to be covered.

Book 1/CS22.785 (d)
The strength of the safety harness and supporting structure must not be less than that following from the ultimate loads for the flight and ground load conditions and for the emergency landing conditions according to CS 22.561(b) taking into account the geometry of the harness and seat arrangement and the relevant fuselage deformation.

Book 2/AMC 22.785(f)
Fuselage deformation is considered relevant only for emergency landing conditions for the front seat of two seats sailplane.
The strenght of the shoulder harness supporting structure for the front seat of two seats sailplane has to consider the combinaison of the occupant ultimate inertia forces corresponding to a forward acceleration from CS 22.561(b)(1) combined with fuselage side deformation resulting from the ultimate load defined under CS 22.561(b)(2).

Justification: Following an accident on a 2 seater sailplane, it was observed that the shoulder harness supporting structure for the front occupant failed.
See attached picture: <<P4180032.JPG>>
On 2 seaters, the front seat shoulder harness are fixed to a crossbeam which joints the two sides of the fuselage just below the canopy.
During a crash when loads are applied on the nose the forward part of the fuselage, both sides of the fuselage deform to the outside increasing the width of the cockpit area.

The maximum deformation is in the area of the middle of the cockpit area where the crossbeam supporting the front seat shoulder harness is fitted.
This deformation introduce tension loads in the crossbeam and its joint in addition to the load directly applied by the shoulder harness.
Note that this combinaison is critical only for the front seat of 2 seaters as the fuselage deformation is negligible for the other cases.
Reviewing the current CS 22.561 and 22.785 and the proposed NPA, it is not clear whether the aforementionned combinaison is required for certification. Contact with the LBA (H. Fendt, R. Blume) suggests that the combinaison is not considered and we were then advised to bring this input within the consultation period of NPA 2007-12.
Therefore, we think this combinaison should be required as:

- this relevant to the purpose of this NPA,
- it results from a realistic crash scenario,
- the additionnal burden for the certification is assumed to be negligible.

response

Not accepted

EASA regarded the case as relevant. The proposed change to CS 22.785(d) is however not accepted because CS 22.785(d) is intended for the safety harness only; not the safety harness installation. The issue highlighted by this comment is already taken into account in the NPA change to CS 22 785(f) by adding that also the condition of CS 22.561(b)(2) must be considered.

resulting text

Book 1
SUBPART C- STRUCTURE

EMERGENCY LANDING CONDITIONS

CS 22.561 General (See AMC 22.561)

……

(b)…….

(1)……

Upward	~~4,5g~~	7,5 g
Forward	~~9g~~	15 g
Sideward	~~3g~~	6 g
Downward	~~4,5g~~	9 g

(2) An ultimate load of ~~6~~ 9 times the weight of the sailplane acting rearwards and upwards at an angle of 45° to the longitudinal axis of the sailplane and sideward at an angle of 5° acts on the forward portion of the fuselage at ~~the foremost point(s) suitable for the application of such a load~~ a suitable point not behind the pedals. (See AMC 22.561(b)(2))

…….

(d) Except as provided in CS 22.787, the supporting structure must be designed to restrain, under loads up to those specified in sub-paragraph (b)(1) of this paragraph each item of mass that could injure an occupant if it came loose in a ~~minor~~ crash landing.

SUBPART D - DESIGN AND CONSTRUCTION

……

CS 22.785 Seats and safety harnesses

……
(f) Each seat and safety harness installation must be designed to give each occupant every reasonable chance of escaping serious injury under the conditions of CS 22.561 (b)(1) and (b)(2). (See AMC 22.785 (f)).

CS 22.787 Baggage Compartment

……
(b) Means must be provided to protect occupants from injuries by movement of the contents of baggage compartments under an ultimate forward acceleration of ~~9~~ 15 g

B. Draft Decision CS-22 - Book 2 / Subpart C-Structure p. 9-10

comment

1 comment by: *FFVV*

On behalf of Federation Française de vol a Voile, (French Gliding Union) General comment on this NPA:
As pilots safety can be increased, FFVV agree with this amendement.

response

Noted

comment

2 comment by: *François-Eric MASSIAS*

Energy-absorbing seats, seat cushions, **airbags,** *or seat mountings constitute another means of improving safety by reducing the load on the occupants head and spine in a crash (Reference (1), (4) and (11)) and /or landing with retracted wheels (CS 22.561(c)).*
Note: Compliance with the revised CS 22.561 requirements would also assure the adequate structural characteristics for safe ground impact when Sailplane Parachute Rescue System is applied. (Reference (5) and (13))
In particular, if using a SPRS, pitch angle should be calculated to minimize the impact of the crash on the crew.

response

Noted

SPRS are not a part of the requirement of this NPA. Introduction of airbags and other safety means is the task and freedom of designer's ideas.

comment

7 comment by: *Francis Fagegaltier Services*

AMC 22.561
It contains elements which would be worth moving to book 1 of CS-22 because they represent the real safety objective. For example : "during the front part deformation, the feet should have adequate space to move slightly backwards together, without twisting or rocking". Or else : "the main part of the cockpit … should constitute a cage strong enough to comply with paragraph CS 22.561 (b)(2) », or « the design should be such that the strength is not unduly sensitive to load direction in pitch or yaw ».

The whole AMC does not help much the designer in interpreting 22.561 with this kind of wording : "The wording „give every reasonable chance" should express the limited possibility to determine the quantitative probability of

injuries in the process, which is affected by many random inputs (e.g.: physical weight and height of the occupant, his age, influencing the spinal load resistance, specific characteristics of the particular accident etc.)".

This AMC should not introduce considerations which are not part of 22.561 and should not be a means to justify the new rules (this is the purpose of the NPA explanation part).

A suggestion for re-writing the proposals is made in another comment.

response

Partially accepted

The AMC will be reorganized for explanatory material to be more clearly separated from information addressing energy absorption.

comment

11 comment by: *UK CAA*

Paragraph:
AMC Material

Comment:
The AMC material, is verbose and subjective. Text such as:- "However the design should be such that the strength is not unduly sensitive to load direction in pitch or yaw" is not really helpful when trying to find compliance.

Justification:
The AMC material should not provide advice that is too vague to allow compliance to be found**.**

response

Partially accepted

There is a lot of information available on this issue. The AMC material offers to make use of this information to make it easier for the designer.

The AMC will be reorganized for explanatory material to be more clearly separated from information about energy absorption.

comment

22 comment by: *Howard Torode*

The attempt to quantify in AMC the phrase 'give every possible chance'... is necessary, but not wholly sufficient to the needs of regulation. I rather fear that the whole regulation in regard of detailed energy absorption design stands and falls by this definition. Considerable extra work on crashworthiness would be required for this aspect of the regulation be materially improved, to the point when it can be amenable to analytical or physical validation.

response

Noted

The requirement is only changed in respect of the safety cell principle, where information on energy absorption is added for a better understanding of the concept only.

resulting text

BOOK 2
CS-22

SUBPART C - STRUCTURE

…..

AMC 22.561
Emergency Landing Conditions
General

For maximum protection of the occupants in survivable crash landings, the main part of the cockpit, defined in AMC material, should constitute a safety cell strong enough to comply with paragraph CS 22.561 (b)(2).

The forward part should be sufficiently weaker for it to yield before the main part, but stiff enough for it to absorb considerable energy in doing so. (ref. 2, 5, 6, 10, 12)

Energy-absorbing seats, seat cushions or seat mountings constitute another means of improving safety by reducing the load on the occupants head and spine in a crash (ref. 1, 4, 11) and /or landing with retracted wheels (CS 22.561(c)).

The wording „give every reasonable chance" expresses the limited possibility to determine the quantitative probability of injuries in the process, which is affected by many random inputs (e.g.: physical weight and height of the occupant, his age, influencing the spinal load resistance, specific characteristics of the particular accident etc.).

The required load level has been chosen partly on medical grounds and partly in consideration of what is currently practicable. The objective is to design a cockpit structure that does not collapse under survivable emergency landing conditions.

Furthermore the sailplane design should consider:

- Maximum energy absorption, and

- Occupant protection against serious injuries, namely injuries of head and spine.

For maximum protection of the foremost part of legs during the front part deformation, the feet should have adequate space to move slightly backwards together, without twisting or rocking.

The conditions specified in this paragraph are considered to be most representative of the wide envelope of possible crash loads and impact directions (ref.6, 10). However the design should be such that the strength is not unduly sensitive to load direction in pitch or yaw.

Further information about different aspects of the crashworthiness of small aircraft design has been accumulated for small airplanes (ref. 7). Published data and procedures are also applicable for sailplane designs.

Applicable information on dynamic computer modelling contained in (ref. 8) might be used to assess applicability of such methods for sailplanes crashworthiness tasks.

Note: Compliance with the revised CS 22.561 requirements would also assure the adequate structural characteristics for safe ground impact when Sailplane Parachute Rescue System is applied. (ref.5,13)

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AMC 22.561(b)(2)
Emergency Landing Conditions

Static tests or calculation methods are Acceptable Means of Compliance to show compliance with CS 22.561 (b)(2). If calculation methods are solely used for the proof of compliance, they shall be verified by re-calculation of static tests data of structures of similar design. Calculation methods should at least consider margins against material properties like tensile or compressive strength and margins against stability limits like e.g. buckling of canopy sill. The weight used showing compliance to CS 22.561(b)(2) needs to represent the maximum weight per CS 22.25(a)(2) as far as these weights contribute to the loading of the safety cell.

For conventional (semi-reclined) seating configurations it is sufficient to demonstrate, that the main part of the cockpit, extending at least from the front

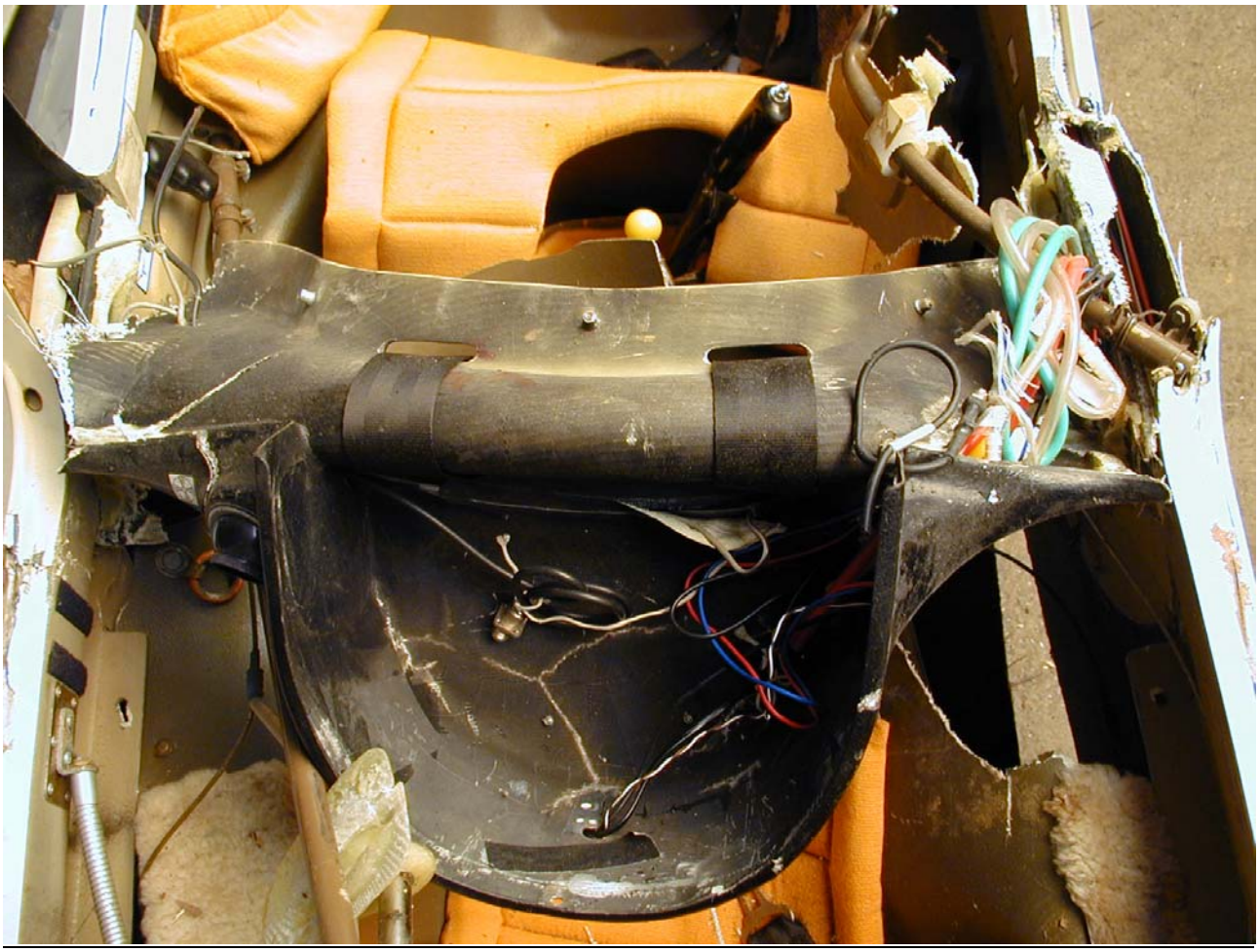
control pedals (adjusted to the intermediate longitudinal position) to the rearmost headrest mounting or the wing attachment section whichever is further aft, including the harness attachments, meets the requirements of CS 22.561(b).

AMC 22.785(f)
Seats and safety harnesses

….

(4) The design of the shoulder harness supporting structure has to consider the combination of the occupant ultimate inertia forces corresponding to a forward acceleration from CS 22.561(b)(1) combined with fuselage loads and possible side deformation resulting from the ultimate load defined under CS 22.561(b)(2).

Appendix A - Attachments



Attachment #1 to comment #32