European Aviation Safety Agency	Airbus A350 CERTIFICATION REVIEW ITEM	Ref.:	**B-06**
		Issue:	2
		Status:	Closed
		Date:	30.07.2010
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Subject:	**Normal Load Factor limiting System**
Category:	**Special Condition**
Requirements:	**CS 25.143**
Advisory Material:	
Primary Panel:	**Flight**
Secondary Panels:	**Performance**

Statement of Issue

Traditional aircraft are limited in the pitch axis regarding load factor capability only by aerodynamic capability of the wings and of the elevator surface. Thus traditional aircraft may have a flight domain (high speed, low altitude, low weight, aft Cg) wherein maneuverability in excess of the structural load factor limits defined by CS 25.333 is possible, but have also a flight domain where maneuverability is well below the structural load factor limits as defined by CS 25.333 (low speed, high altitude, high weight, forward Cg).

The load factor capability required for conventional aircraft is not explicitly addressed in the CS 25, and the need to define it was not found necessary as considered indirectly addressed through several handling qualities requirements regarding maneuverability in the CS 25.

As the A320, A330/A340 and A380, the A350 has a normal load factor limiting feature implemented in the flight control laws within the whole flight domain, which limits the load factor capability within or well inside the structural load factor range defined by CS 25.333 for negative load factors. At high speed the load factor in the negative sense can be limited to values less than -1g due to high speed protections. At low speed, the load factor in the negative sense can also be limited to values less than -1g, as for a conventional aircraft, but due to pitch and stall protections for instance. Nevertheless, the CS 25 has not been amended to reflect the use of normal load factor limiting features, and therefore a special condition needs to be issued in accordance with Part 21A.16B(a)(1) to address this unusual design feature, and to correctly adapt the requirement at high and low speed in a consistent level of standard with the maneuverability that could be expected from a conventional aircraft.

Similar special conditions have already been proposed for previous Airbus aircraft (A320, A330/A340 and A380) but the positive and negative limiting load factors have always been defined in accordance with the flight manoeuvring envelope as defined by JAR/CS 25.333(b). Nevertheless, the experience from recent certification projects (A380) has shown that the maximum reachable negative load factor may be further limited by flight control system characteristics or flight envelope protections other than the load factor limitation as it would be for a conventional aircraft at low speed due to the aerodynamic capability of the horizontal tail plane.

For the A350 special condition on normal load factor limiting system further clarification shall be provided under which conditions a further reduction of the normal load factor limits by flight envelope protections (other than load factor limitation) is acceptable, and under which criteria the resulting maneuverability is deemed to remain acceptable.

EASA Position (dated 21 January 2009):

For A350 Type Certification, the following Special Condition is proposed.

Special Condition

Add a new paragraph CS 25.143 (o) to read as follows:

CS 25.143 General
(o) In the absence of aerodynamic limitation (lift capability at AoA max):

1) The positive limiting load factor must not be less than:
   a) 2.5 g for the EFCS normal state with high lift devices retracted.
   b) 2.0 g for the EFCS normal state with the high lift devices extended.
2) The negative limiting load factor must be equal to or more negative than:
   a) minus 1.0 g for the EFCS normal state with high lift devices retracted.
   b) 0 g for the EFCS normal state with high lift devices extended.

Maximum reachable positive load factor wings level may be limited by flight control system characteristics or flight envelope protections (other than load factor limitation) provided

- That the required values are readily achievable in turn and
- that wings level pitch up responsiveness is satisfactory

Maximum reachable negative load factor may be limited by flight control system characteristics or flight envelope protections (other than load factor limitation) provided:

- pitch down responsiveness is satisfactory
- From level flight, 0g is readily achievable or at least a trajectory change of 5°/s is readily achievable at operational speeds (From Vls, to Max speed -20kt)

Compliance demonstration with the above requirements may be performed without ice accretion on the airframe.

Airbus Position (dated 20 October 2009):

With the letter ref. V02M09045251 dated 20 October 2009 Airbus provided the following position to A350 CRI B-06 "*Normal Load Factor limiting System*" at issue 1, dated 27 May 2009:

Airbus concurs provided that the following request is taken into account:

For load aspects, the maximum load factor reduction above V_{MO}/M_{MO} is allowed by CS 25.337(d) if the aeroplane has design features that make impossible to exceed these values in flight.
Current SC B-06 wording does not allow nor forbid a load factor reduction above V_{MO}/M_{MO} as the applicability limits of the limiting load factor are not explicitly defined. Therefore, in order to take benefit of CS 25.337(d), Airbus proposes to modify SC B-06 to allow a gradual reduction of the load factor up to 2.25g above VFC/MFC.

EASA Position (dated 30 July 2010):

In response to the above Airbus position, the EASA team confirms that the current wording of Special Condition B-06 does neither allow nor forbid a load factor reduction above V_{MO}/M_{MO}.
We also confirm that CS 25.337(d) is applicable and may be used by Airbus to request EASA agreement on a gradual reduction of the manoeuvring load factor above V_{MO}/M_{MO}.
The EASA Flight Panel is ready to accept a gradual reduction of the load factor as proposed in the above Airbus position, provided it has been agreed with EASA Structures Panel before. Nevertheless, the EASA team wants to highlight that such reduction of the manoeuvring load factor based on CS 25.337(d) needs to be agreed with EASA Structures Panel.
The Special Condition in the appendix of this CRI has been updated in order to allow a gradual reduction of the load factor up to 2.25g above V_{MO}/M_{MO}, and to highlight the potential impact of CS 25.337(d) on the limits defined in the requirements of CS 25.143. The EASA Structure Panel also confirmed acceptance of this updated Special Condition.
In order to take into account FAA remarks, the special condition has also been updated with a Vls definition. With this definition, it clarifies why Vls is the minimum speed relevant for the purpose of verifying adequate longitudinal pitch down maneuverability at operational speeds as required by SC B-06, and changing the maximum speed considered with associated rational.

Conclusion (dated 30 July 2010):

Agreement has been reached. The agreed special condition to be used for the A350 Type Certification is defined in the appendix to this CRI.
The CRI is closed at Issue 2.
As the subject special condition has been extended compared to special conditions that have been used on previous programmes (as e.g. A380 SC B-6), a public consultation process will be initiated by EASA.

Heiko Honert
A350 Project Certification Manager

A350 Special Condition B-06

Add a new paragraph CS 25.143 (o) to read as follows:

CS 25.143 General
(o) In the absence of aerodynamic limitation (lift capability at AoA max):

1) The positive limiting load factor must not be less than:
   a) 2.5g for the EFCS normal state with the high lift devices retracted up to VMO/MMO. The positive limiting load factor may be gradually reduced down to 2.25g above VMO/MMO.
   b) 2.0 g for the EFCS normal state with the high lift devices extended.
2) The negative limiting load factor must be equal to or more negative than:
   a) minus 1.0 g for the EFCS normal state with high lift devices retracted.
   b) 0 g for the EFCS normal state with high lift devices extended.

Maximum reachable positive load factor wings level may be limited by flight control system characteristics or flight envelope protections (other than load factor limitation) provided

- That the required values are readily achievable in turn and
- that wings level pitch up responsiveness is satisfactory

Maximum reachable negative load factor may be limited by flight control system characteristics or flight envelope protections (other than load factor limitation) provided:

- pitch down responsiveness is satisfactory
- From level flight, 0g is readily achievable or at least a trajectory change of 5°/s is readily achievable at operational speeds (From Vls*, to Max speed-10kt**)

Compliance with CS 25.337(d) should be established for positive limiting load factor gradually reduced down to 2.25g above VMO/MMO.

Compliance demonstration with the above requirements may be performed without ice accretion on the airframe.

* Vls is the lowest speed that the crew may fly with auto thrust or auto pilot engaged. It is displayed on primary flight displays as the top of the low speed amber band, and is the lower end of the normal flight envelope.
**Max speed-10kt is proposed to cover typical margin from VMO/MMO to cruise speeds and typical margin from VFE to standard speed in high lift configurations