A300-600R - AAL587
PUBLIC HEARING

History of Gust requirements

Draft - Issue 1.0- 23/09/2002

History of gust requirements

Content:

- **Certification basis for A300-600 R**
- **Means of Compliance**
  - Pratt Formula for Vertical Tailplane
  - Discrete gust
  - Discrete Tuned gust
  - Continuous Turbulence
- **Recent requirements**
  - Discrete Tuned gust
  - Continuous Turbulence
- **Summary**

History of gust requirements

Certification basis for A300-600 R

The applicable Certification Basis for the A300-600 R is based on FAR 25.

Therefore FAR 25.351 (b) applies for Lateral Gusts.

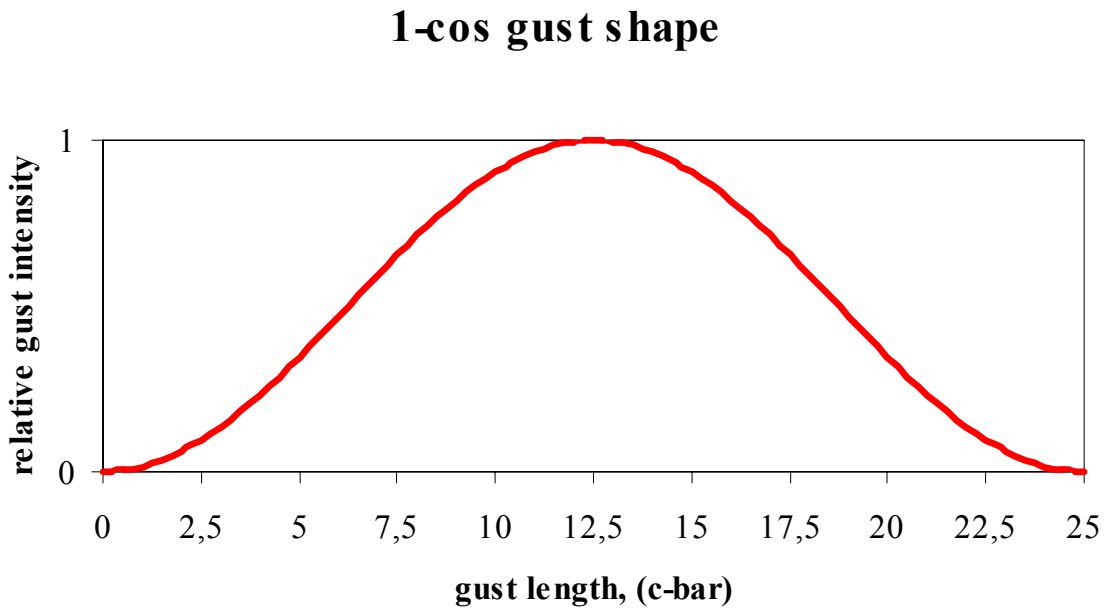
Additionally Complementary Condition CC6 introduces the following changes:

- an analysis with a full flexible dynamic aircraft model (structural flexible modes)
- 100% of the derived gust velocity Ude
- a tuned gust with a wavelength of the gust S_0 varying between 7c and 18c.
- study for the behavior of the aircraft in Continuous Turbulence

History of gust requirements

Means of Compliance: Pratt Formula for Vertical tailplane

In absence of a more rational analysis FAR 25 allowed up to 1996 to use so-called Pratt Formula. This formula was derived from a simple model based on the 1-cos gust shape with a fixed length of 12.5 times the geometric mean chord of the Vertical Tailplane for the half wave (gust gradient).



History of gust requirements

Means of Compliance: Pratt Formula for Vertical tailplane (cont.)

This formula for Vertical Tailplane Load is given as:

$$Q_Y = \frac{\rho_0}{2} K_g U_{de} V_e C_{Y_\beta} S_{VTP}$$

with: $$K_g = \frac{0.88\,\mu_g}{5.3 + \mu_g}$$

and: $$\mu_g = \frac{2W}{\rho\,\bar{c}_{VTP}\,g\,C_{Y_\beta}\,S_{VTP}}\left(\frac{K}{l_t}\right)^2$$

Flexibility can be introduced in a quasi-flexible manner by using a modified C_{Y_β}

History of gust requirements

Means of Compliance: Discrete Gust

Also more advanced simulations taking into account mathematical description of the aircraft behaviour uses the 1-cos gust shape.

With a fixed gust gradient of 12.5 times the mean geometrical chord this analysis is known as the Discrete Gust.

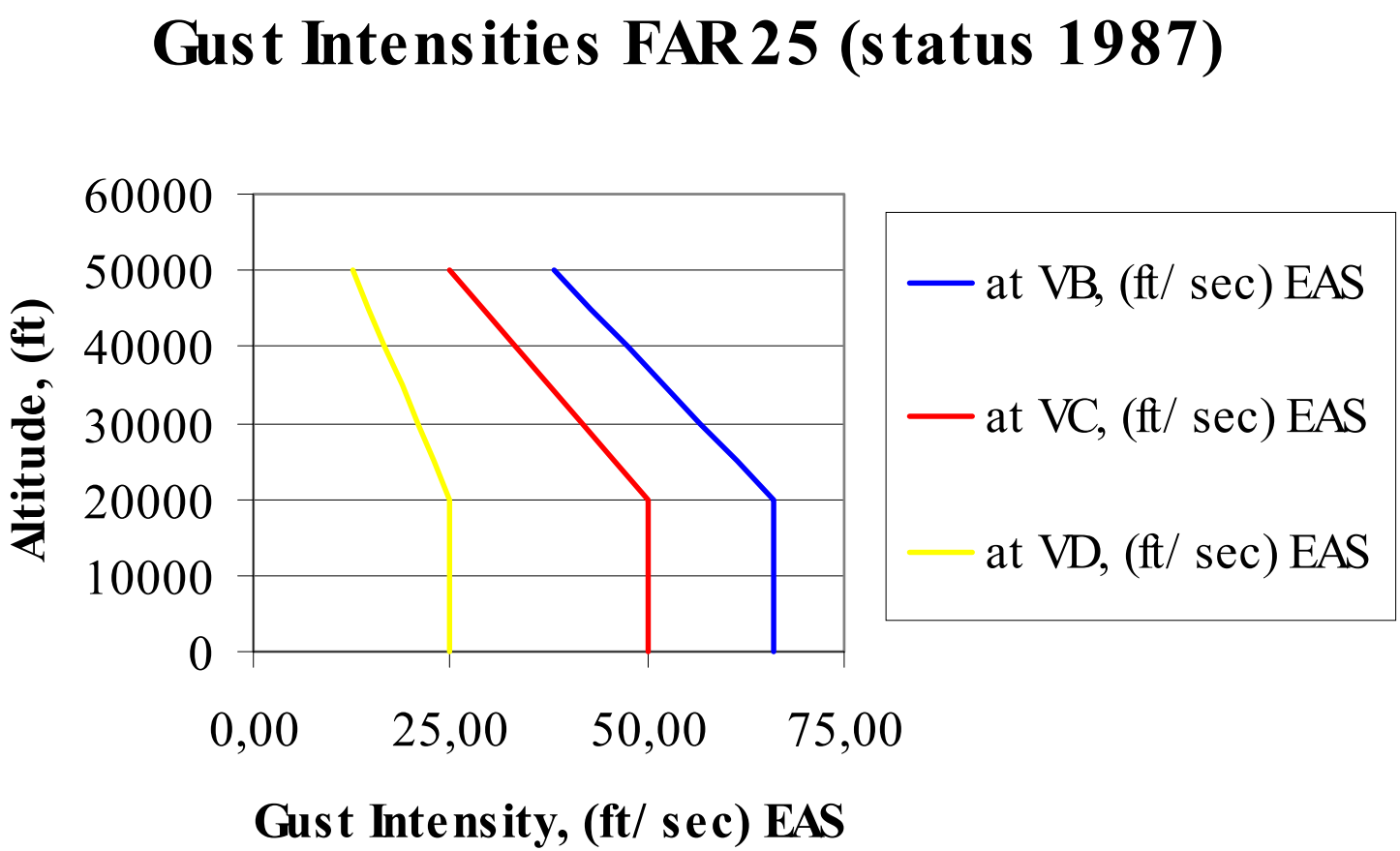
Depending on the aircraft model used a further seperation can be made between:

- **Discrete Gust (quasi-flexible)**
- **Discrete Gust (full flexible)**

In AIRBUS the full flexible model has been used to show compliance with this requirement using the gust intensities given at next page.

History of gust requirements

Means of Compliance: Discrete Gust



History of gust requirements

Means of Compliance: Discrete Tuned Gust (cont.)

In Europe especially the British Authority (CAA) asked for a so called „Tuning“ of the Discrete Gust (i.e. variation of gust length).

Furthermore CAA asked for a full flexible aircraft modelling.

Therefore in AIRBUS this type of analysis were carried out as:

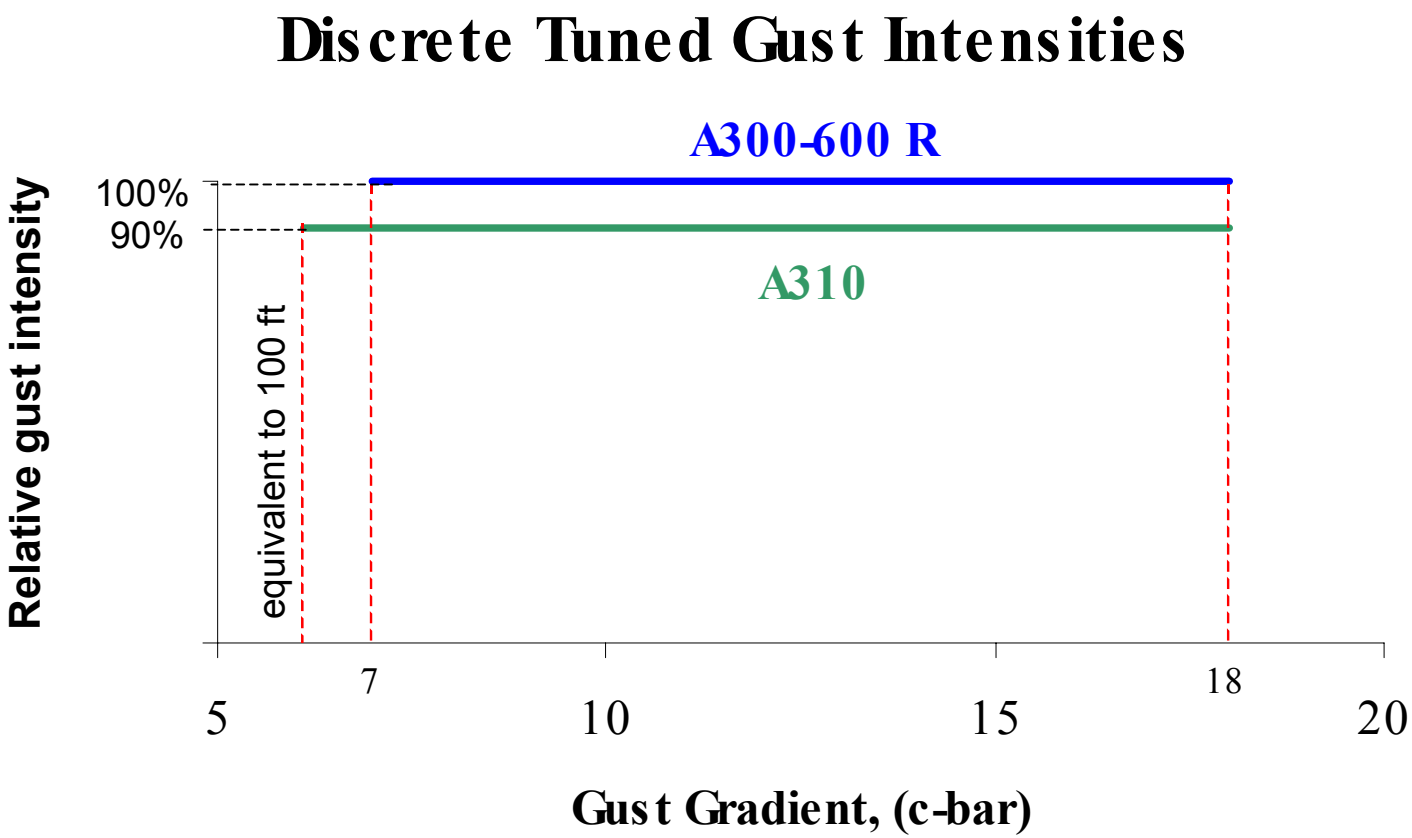
- **Discrete Tuned Gust (full flexible)**

For A300-600R the tuning has been varied in the limits of 7 and 18 times the mean geometrical chord using the gust intensities as prescibed in FAR 25.341 (100% Ude). These limits were agreed with CAA at that time.

Later there was the allowance to use 90% Ude in case of using a full flexible model. This was used for certification of A310-300.

History of gust requirements

Means of Compliance: Discrete Tuned Gust (cont.)

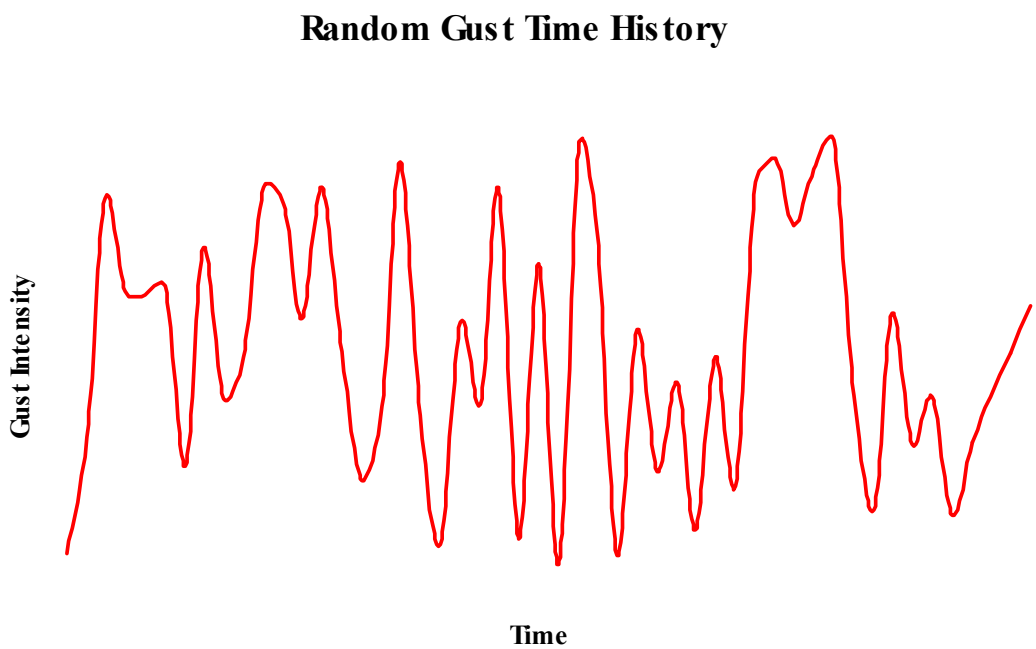


History of gust requirements

Means of Compliance: Continuous Turbulence

Furthermore a study for the behaviour of the Aircraft in continuous turbulence was requested.

This approach recognizes a time history of gust velocity as a random process. This means it has no apparent pattern or regularity.



History of gust requirements

Means of Compliance: Continuous Turbulence (cont.)

Nevertheless it can be described in terms of its statistical characteristics. One of this characteristics is for example the RMS (Root Mean Square).

In Appendix G of FAR 25 two methods for calculating design loads are given:

- Mission Analysis
- Design Envelope Analysis

For the study which was requested for A300-600 R the Design Envelope Criterion was used. The limit design loads for this type are determined by following equation:

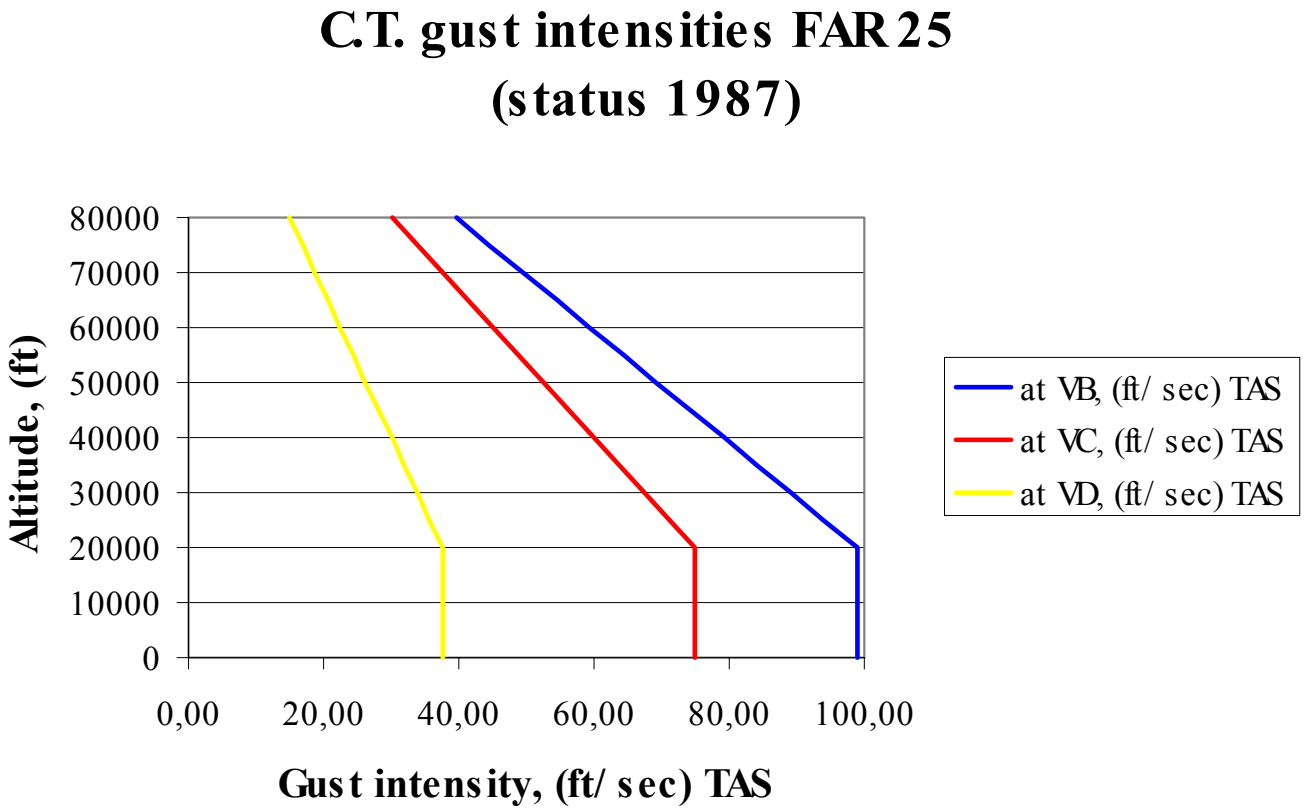
$$Y_{Design} = \overline{A} * U\sigma$$

$U\sigma$ is the RMS of the Design gust intensity and $\overline{A}$ is the result of a dynamic analysis with a full flexible model giving the ratio of RMS load to RMS gust intensity.

History of gust requirements

Means of Compliance: Continuous Turbulence (cont.)

Appendix G of FAR 25 defines an acceptable means of compliance for the Continuous Turbulence Requirement. AIRBUS has used this with the following gust intensities $U\sigma$:



History of gust requirements

Recent requirements:

Since mid 80's the gust requirements were subject of comprehensive discussions in the ARAC Loads & Dynamics Harmonization Working Group (L&DHWG).

As a first result the Discrete Tuned Gust Requirement was harmonized between FAR and JAR and result in a §25.341(a) published first time in FAR 25 admt. 86 and by amendment to JAR 25 Ch.13 (OP-91/1).

This status is still valid and includes as well vertical as also lateral gust, which were before separated in 25.341 and 25.351(b) respectively.

In addition also a harmonization of the Continuous Turbulence requirement is technically agreed inside L&DHWG and will lead to a NPRM modifying §25.341 by revising §25.341 (b) and adding a new paragraph §25.341 (c) .

Furthermore an Advisory Circular (AC) „Dynamic Gust Loads" has been proposed in conjunction with proposed revision of C.T.-requirement.

History of gust requirements

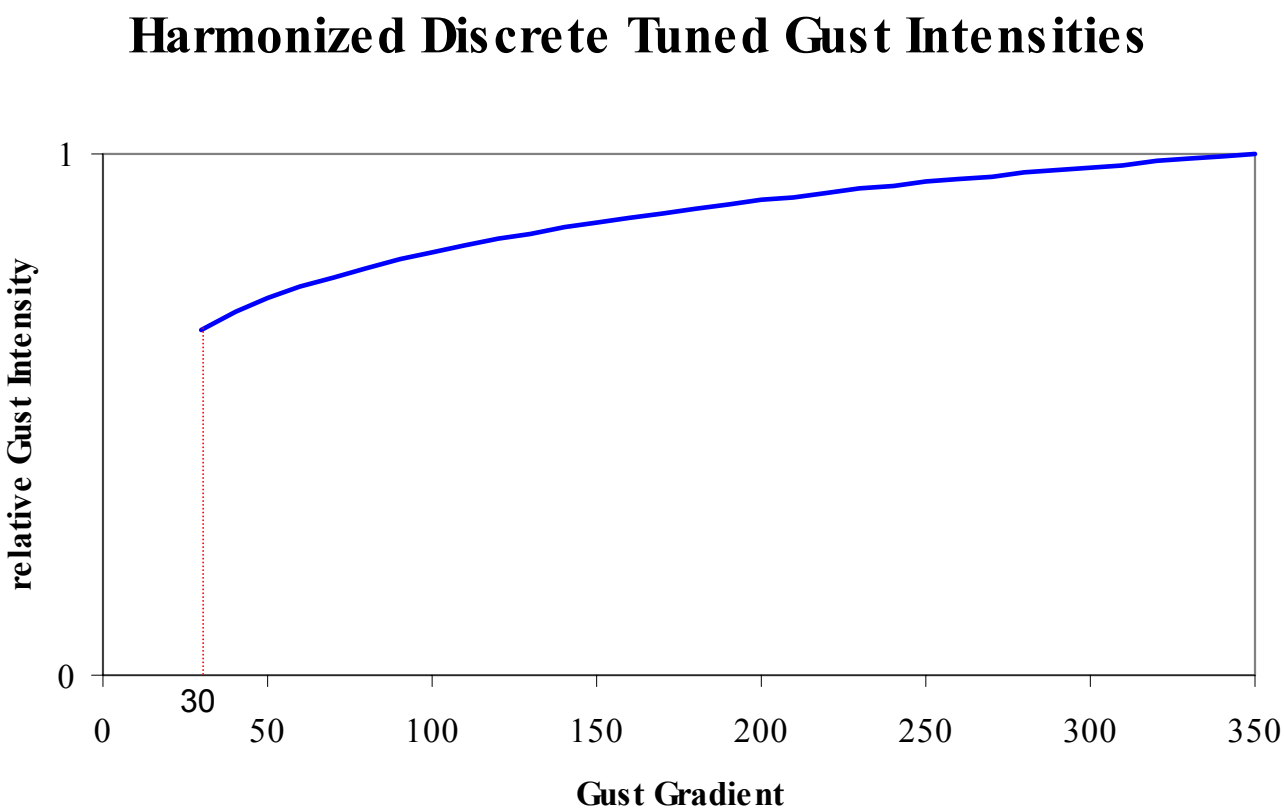
Recent requirements: Discrete Tuned Gust

The harmonized requirement for this paragraph §25.341(a) asks now for:

- a dynamic analysis using a full flexible model
- a (1-cos) gust shape
- gust gradients between 30 ft and 350 ft
- revised gust intensities (see next page)
- allowance for reduced gust intensities for gust gradients below 350 ft
- application of a flight profile factor to take into account aircraft usage

History of gust requirements

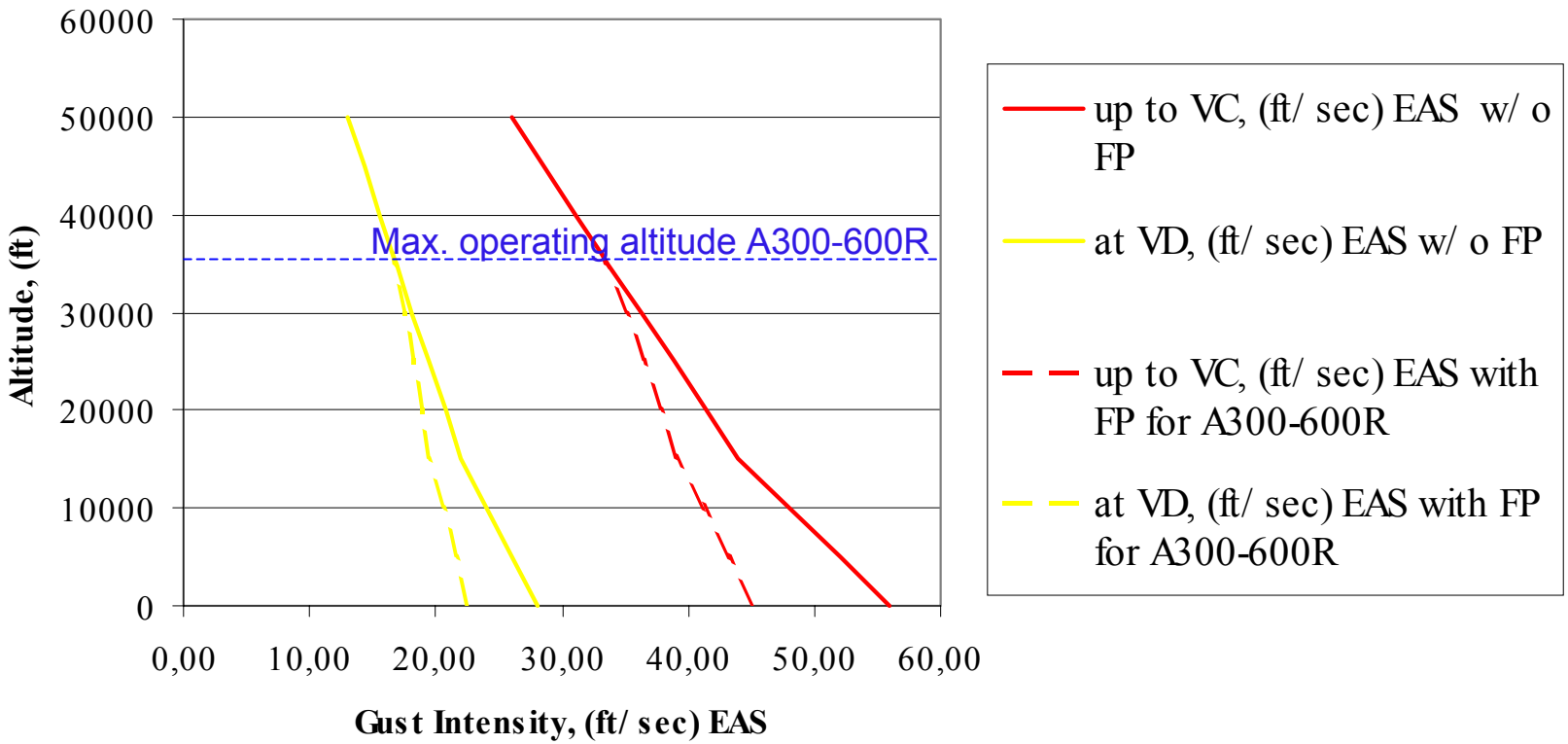
Recent requirements: Discrete Tuned Gust (cont.)



History of gust requirements

Recent requirements: Discrete Tuned Gust (cont.)

Harmonized Discrete Tuned Gust Intensities for A300-600R including Flight Profile Factor FP



History of gust requirements

Recent requirements: Continuous Turbulence

The harmonized proposal for this paragraph §25.341(b) asks now for:

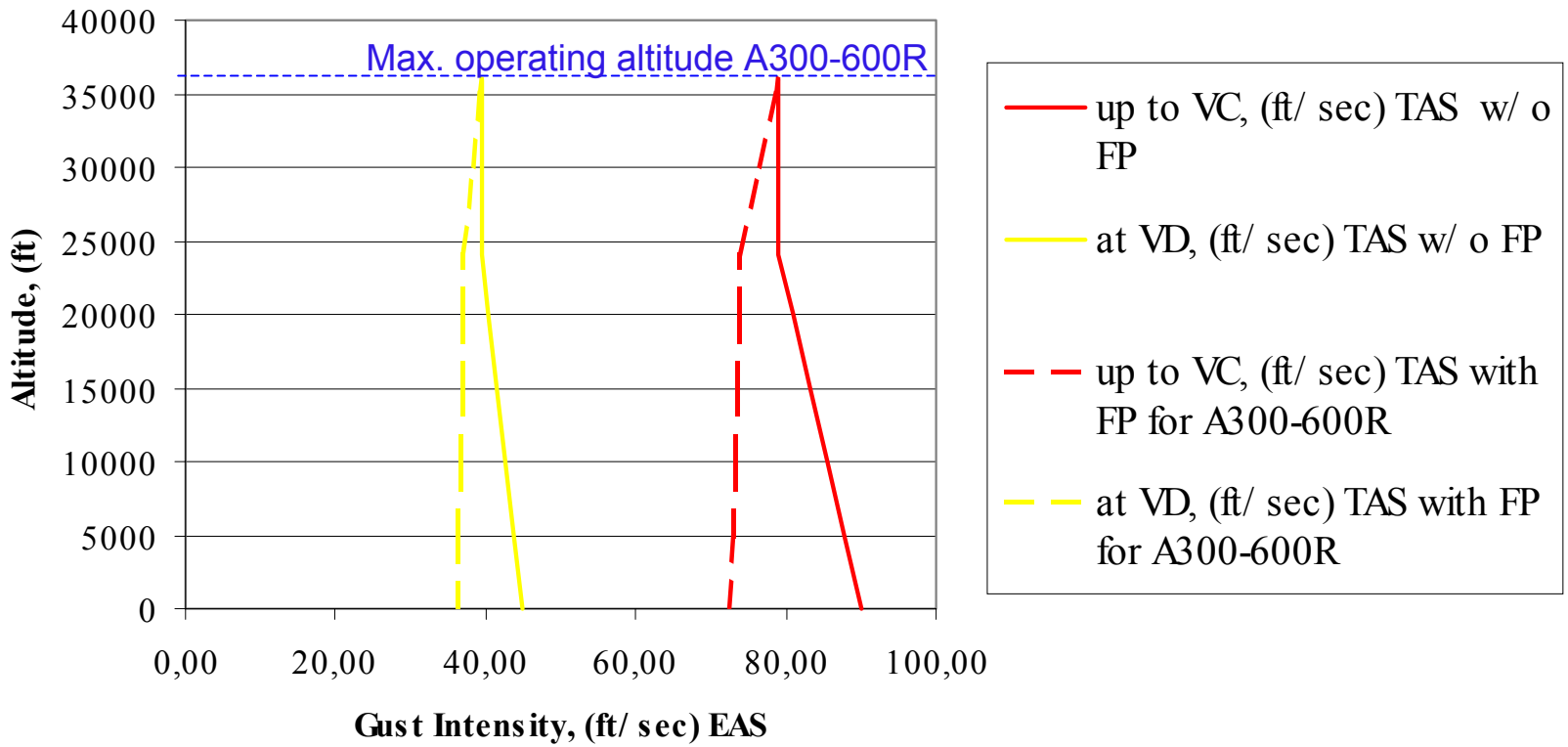
- a dynamic analysis using a full flexible model
- Design Envelope Analysis (Mission Analysis not allowed)
- revised gust intensities (see next page)
- application of a flight profile factor to take into account aircraft usage

The proposal adds a paragraph §25.341 (c), which requests for wing-mounted engine a supplementary gust condition (combination of vertical and lateral gust)

History of gust requirements

Recent requirements: Continuous Turbulence (cont.)

Harmonized Continuous Turbulence Gust Intensities for A300-600R including Flight Profile Factor FP



History of gust requirements

Summary:

	European Requirements (JAA)	FAA Requirements
	Pratt Formula or advanced calculations	Pratt Formula or advanced calculations
A300 -600R	Discrete Gust (12.5 c-bar) (full or quasi flexible) D.T.G. (full flex.) 100% Ude Continuous Turbulence Study (DEA or MA)	Pratt Formula or advanced calculations Continuous Turbulence Study (DEA or MA)
A310	Discrete Gust (12.5 c-bar) (full or quasi flexible) D.T.G. (full flex.) 90% Ude Continuous Turbulence Study (DEA or MA)	Pratt Formula or advanced calculations Continuous Turbulence (DEA or MA)
today	D.T.G. (full flex.) new Ude and Flight Profile Factor Continuous Turbulence (DEA or MA)	D.T.G. (full flex.) new Ude and Flight Profile Factor Continuous Turbulence (DEA or MA)
tech. agreed	D.T.G. (full flex.) new Ude and Flight Profile Factor Continuous Turbulence (DEA) new U_{σ} and Flight Profile Factor specific requirement for wing-mounted engine	D.T.G. (full flex.) new Ude and Flight Profile Factor Continuous Turbulence (DEA) new U_{σ} and Flight Profile Factor specific requirement for wing-mounted engine