Deviation request #100 for an ETSO approval for CS-ETSO applicable to Stand-alone Airborne Navigation Equipment using GPS Augmented by the Satellite Based Augmentation System (ETSO-C146a) & (ETSO-C146c) Consultation Paper

1. Introductory note

The hereby presented deviation requests shall be subject to public consultation, in accordance with EASA Management Board Decision No 7-2004 as amended by EASA Management Board Decision No 12-2007[1] products certification procedure dated 11th September 2007, Article 3 (2.) of which states:

"2. Deviations from the applicable airworthiness codes, environmental protection certification specifications and/or acceptable means of compliance with Part 21, as well as important special conditions and equivalent safety findings, shall be submitted to the panel of experts and be subject to a public consultation of at least 3 weeks, except if they have been previously agreed and published in the Official Publication of the Agency. The final decision shall be published in the Official Publication of the Agency."

2. ETSO-C146#23 & ETSO-C146c#10 – Stand-alone Airborne Navigation Equipment using GPS Augmented by the Satellite Based Augmentation System

Deviate from RTCA/DO-229D section 2.2.4.4.2.2, RTCA/DO-229D section 2.2.4.4.2.3 and RTCA/DO-229C section 2.2.4.4.2 and RTCA/DO-229C section 2.2.5.4.2 for all calculations of lateral FSD and lateral scale transition points that are based on the distance from the aircraft to the GARP in the above requirements, to replace that distance with the difference of the distance from the aircraft to the GARP and the distance from the LTP/FTP to the MAWP and to exclude approaches LPV and underlying LNAV/VNAV approaches from the database of the equipment where the FSD change to 0.3 nm occurs prior to the decision point, which is a point where the glide path intercepts the decision altitude. The fact that the deflection might be not ILS look alike after the decision point has to be documented in the DDP.

Requirement:

RTCA/DO-229D, section 2.2.4.4.2.2

> If a VTF has not been selected and a FAS data block is available, the lateral deviation shall be as follows:
>
> a) …….
>
> b) Between the FAWP and the LTP/FTP, the deviation shall be the final approach segment lateral deviation;
>
> c) Between the LTP/FTP and a point that is prior to the GARP by a distance equal to either 305 m plus the ΔLength Offset (if the ΔLength Offset parameter is provided) or 305 m (if the ΔLength Offset parameter is not provided), the deviation shall be either the final approach segment lateral deviation or linear (i.e., proportional to distance from the aircraft center of navigation to the closest

[1] Cf. EASA Web: http://easa.europa.eu/management-board/docs/management-board-meetings/2007/04/MB%20Decision%2012-2007%20amending%20the%20certification%20procedure.pdf

point on the lateral deviation reference plane) with FSD for a cross-track error of +/-(Course Width at LTP/FTP).

d) Beyond this point, the deviation shall be linear with FSD for a cross-track displacement of +/- 0.3 NM.

RTCA/DO-229D, section 2.2.4.4.2.3

If a VTF has been selected and a FAS data block is available, the lateral deviation shall be as follows:

a) On the approach side of the LTP/FTP, the deviation shall be either:

i) ……

ii) The deviation shall be the final approach segment lateral deviation (Figure 2-15).

b) Between the LTP/FTP and a point that is prior to the GARP by a distance equal to 305 m plus the ΔLength Offset (if the ΔLength Offset parameter is provided) or 305 m (if the ΔLength Offset parameter is not provided), the deviation shall be either the final approach segment lateral deviation or linear with FSD for a crosstrack error of +/- (Course Width at LTP/FTP);

c) Beyond this point, the deviation shall be linear with FSD for a cross-track displacement of +/- 0.3 nm.

RTCA/DO-229C section 2.2.4.4.2

2.2.4.4.2 Non-Numeric Lateral Cross-Track Deviation

Final approach segment lateral deviations (see Figure 2-16) are defined from the following:

- lateral deviation reference plane: the plane that contains the LTP/FTP vertical direction vector and the flight path alignment point (FPAP).
- vertical direction vector: the vector that passes through the LTP/FTP and is normal to the WGS-84 ellipsoid at the LTP/FTP.
- GNSS Azimuth Reference Point (GARP): the point that lies in the horizontal plane containing the LTP/FTP and is 305 m beyond the point where the vertical projection of the FPAP intersects this plane.

Positive lateral deviation shall correspond to aircraft positions to the left of the lateral deviation reference plane, as observed from the LTP/FTP facing toward the FPAP.

The final approach segment lateral deviations are referenced to the lateral deviation reference plane and are defined to be proportional to the angle (α_{lat}) measured at the GARP between the aircraft and the lateral deviation reference plane, with full-scale deflection (FSD) at a lateral cross-track error of:

$$\alpha_{lat,FS} = \pm \tan^{-1}\left(\frac{\text{FAS Course Width at LTP/FTP (m)}}{\text{Distance from LTP/FTP to GARP (m)}}\right)$$

If in LNAV/VNAV and a VTF has not been selected, the lateral deviation shall be as follows:

a) ….

b) Between the FAWP and the LTP/FTP, the deviation shall be the final approach segment lateral deviation with FSD for a cross-track error of $\alpha_{lat,FS}$;

c) Between the LTP/FTP and the length offset distance to the FPAP, the deviation shall be either the final approach segment lateral deviation or linear with FSD for a crosstrack error of ± (Course Width at LTP/FTP).

If in LNAV IVNAV and a VTF has been selected, the lateral deviation shall be as follows:

a) Prior to the LTP/FTP, the deviation shall be either:
   i. At a distance greater than $\frac{1}{\tan(\alpha_{lat,FS})}$ nm to the GARP, the deviation shall be linear with FSD for a cross-track error of ± 1 nm. Between $\frac{1}{\tan(\alpha_{lat,FS})}$ nm to the GARP and the LTP/FTP, the deviation shall be the final approach segment lateral deviation (Figure 2-16a); or
   ii. The deviation shall be the final approach segment lateral deviation with FSD for a cross-track error of $\alpha_{lat,FS}$ (Figure 2-16b).

b) Between the LTP/FTP and a point that is prior to the GARP by a distance equal to either 305 m plus the length offset distance (if the length offset parameter is provided) or 305 m (if the length offset parameter is not provided) to the FPAP, the deviation shall be either the final approach segment lateral deviation or linear with FSD for a cross-track error of ± (Course Width at LTP/FTP);

c) Beyond the length offset distance to the FPAP, the deviation shall be linear with FSD for a cross-track displacement of ± 0.3 nm.

When a missed approach is initiated, the deviation shall be linear with FSD for a cross-track error of ± 0.3 nm.

Notes:

1. Compatibility with ILS display systems can be achieved by converting the lateral deviation to µA (DDM) based upon a FSD at 150 µA (0.155 DDM).

2. The final approach path for standalone LNAVIVNAV approaches is defined by the intersection of the non-precision approach lateral path (as defined in Section 2.2.3.3.1) with the vertical path defined by the threshold location, threshold crossing height, and glide path angle

RTCA/DO-229C section 2.2.5.4.2

2.2.5.4.2 Non-Numeric Lateral Cross-Track Deviation

Final approach segment lateral deviations (see Figure 2-16) are defined from the following:

- lateral deviation reference plane: the plane that contains the LTP/FTP vertical direction vector and the flight path alignment point (FPAP).
- vertical direction vector: the vector that passes through the LTP/FTP and is normal to the WGS-84 ellipsoid at the LTP/FTP.
- GNSS Azimuth Reference Point (GARP): the point that lies in the horizontal plane containing the LTP/FTP and is 305 m beyond the point where the vertical projection of the FPAP intersects this plane.

Positive lateral deviation shall correspond to aircraft positions to the left of the lateral deviation reference plane, as observed from the LTP/FTP facing toward the FPAP.

The final approach segment lateral deviations are referenced to the lateral deviation reference plane and are defined to be proportional to the angle (α_{lat}) measured at the GARP between the aircraft and the lateral deviation reference plane, with full-scale deflection (FSD) at a lateral cross-track error of:

$$\alpha_{lat,FS} = \pm \tan^{-1}\left(\frac{\text{FAS Course Width at LTP/FTP (m)}}{\text{Distance from LTP/FTP to GARP (m)}}\right)$$

If in GLS or APV-II and a VTF has not been selected, the lateral deviation shall be as follows:

a) Prior to the FAWP, the deviation shall be either:
   i. Prior to 2 nm from the FAWP, the deviation shall be linear, with FSD for a cross-track error of ±1 nm. Between 2 nm from the FAWP and the FAWP, the deviation sensitivity shall gradually change to the final approach segment lateral deviation sensitivity (Figure 2-16a); or
   ii. The deviation shall be the final approach segment lateral deviation with FSD for a cross-track error of CXlat,FS (Figure 2-16b).
b) Between the FAWP and the LTPIFTP, the deviation shall be the final approach segment lateral deviation with FSD for a cross-track error of $\alpha_{lat,FS}$;
c) Between the LTPIFTP and the length offset distance to the FPAP, the deviation shall be either the final approach segment lateral deviation or linear with FSD for a cross-track error of ± (Course Width at LTP/FTP).

If in GLS or APV-II and a VTF has been selected, the lateral deviation shall be either:

a) Prior to the LTP/FTP, the deviation shall be either:
   i. At a distance greater than $\frac{1}{\tan(\alpha_{lat,FS})}$ nm to the GARP, the deviation shall be linear with FSD for a cross-track error of ± 1 nm. Between $\frac{1}{\tan(\alpha_{lat,FS})}$ nm to the GARP and the LTP/FTP, the deviation shall be the final approach segment lateral deviation (Figure 2-16a); or
   ii. The deviation shall be the final approach segment lateral deviation with FSD for a cross-track error of $\alpha_{lat,FS}$ (Figure 2-16b).
b) Between the LTP/FTP and a point that is prior to the GARP by a distance equal to either 305 m plus the length offset distance (if the length offset parameter is provided) or 305 m (if the length offset parameter is not provided) to the FPAP, the deviation shall be either the final approach segment lateral deviation or linear with FSD for a cross-track error of ± (Course Width at LTP/FTP);
c) Beyond the length offset distance to the FPAP, the deviation shall be linear with FSD for a cross-track displacement of ±0.3 nm.

When a missed approach is initiated, the deviation shall be linear with FSD for a cross-track error of ±0.3 nm.

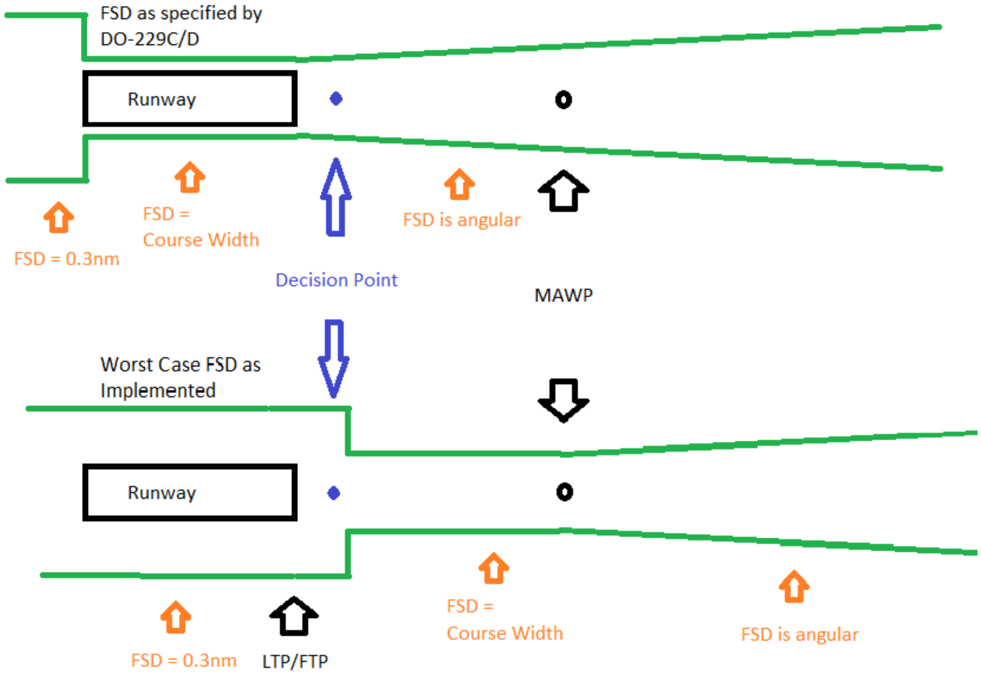
Note: Compatibility with ILS display systems can be achieved by converting the lateral deviation to µA (DDM) based upon a FSD at 150 µA (0.155 DDM).

Industry:

For all calculations of lateral FSD scale and lateral scale transition points that are based on the distance from the aircraft to the GARP in the above requirements, the applicant replaces that distance with the difference of the distance from the aircraft to the GARP and the distance from the LTP/FTP to the MAWP. Consequently, the FSD is affected as follows only for approaches when the LTP/FTP and MAWP are not co-located:

- From the FAWP (Final Approach Waypoint) to the MAWP, the FSD is angular but more restrictive than required by Section 2.2.4.4.2.2b and 2.2.4.4.2.3a.
- After the MAWP, the FSD is set to ±(Course Width)
- FSD will change to ±0.3 nm before the departure end of the runway
- FSD could in some limited cases switch to ±0.3 nm before the decision altitude when the distance between the LTP/FTP and MAWP is large.

The following diagram depicts the FSD for a typical approach as it is specified in 2.2.4.4.2.2 and 2.2.4.4.2.3 and as calculated by the applicants navigators:



Equivalent level of safety is provided by the following:

With the ICAO SBAS APV I/II criteria, the W, X, and Y surfaces in Figure III-3-5-5 (below) in ICAO Document 8168, Procedures for Air Navigation - Operations (PANS OPS) are based on the aircraft following the angular approach guidance to the Decision Altitude (DA).

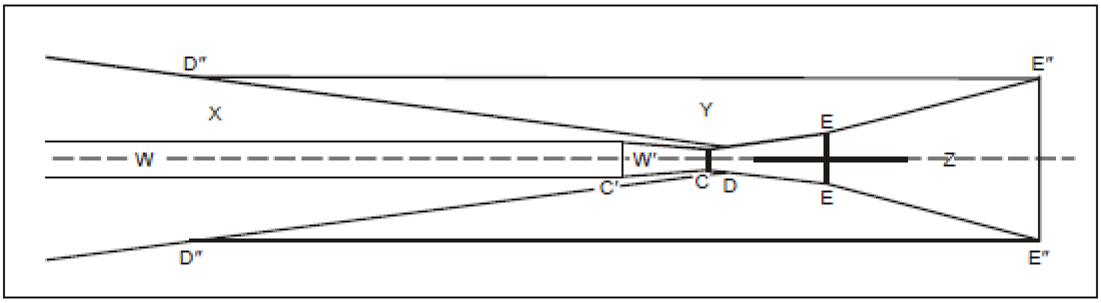


Figure III-3-5-5. Typical SBAS APV I OAS contours for standard size aircraft

After the DA, the W and X surfaces continue to the ground. The Y surface connects to the missed approach Z surface at E". The principle of the SBAS surfaces are based on the principle for Instrument Landing System surfaces, where there is no credit for missed approach guidance in the splay of the surfaces. So in Figure III-3-5-5, no credit for navigation guidance is used within the trapezoids defined by the line at C out to E and thence from E out to E". With SBAS, the missed approach guidance is accounted for in how far the Z surface splays out to the maximum width at E", which is 0.95 NM. The missed approach surface after E" remains at 0.95 NM width until the end of the missed approach if straight out, or, until a turn is encountered.

There are no reduced Obstacle Assessment areas in the vicinity of the runway that PANS OPS or TERPS takes credit for based on the RTCA DO-229 equipment scaling requirements depicted in DO-229 Figure 2-15; i.e., optional linear full-scale deflection (FSD) at course width.

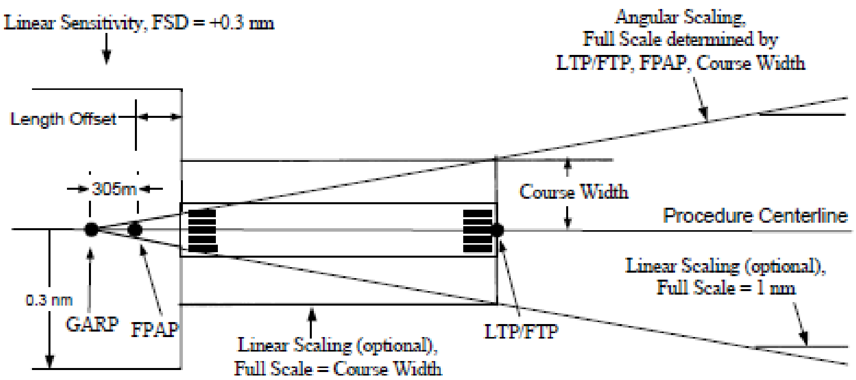


FIGURE 2-15 VTF FINAL APPROACH SEGMENT LATERAL DEVIATIONS WITH FAS DATA BLOCK

The RTCA/DO-229 requirement for optional linear +/- 350 ft (107m) or angular lateral deviation scaling between the LTP/FTP and runway departure end does not impact the PANS-OPS Obstacle Assessment Surfaces over the runway. The PANS-OPS surfaces, provide adequate protection relative to the 0.3 NM lateral deviation scaling and alerting in the deviation request except for those few cases where the 0.3 NM lateral deviation scaling occurs prior to the approach procedure decision altitude (DA).

LPV and underlying LNAV/VNAV approaches will be suppressed in aviation database where the CDI scale change to 0.3 nm FSD occurs prior to the decision point, which is a point where the glide path intercepts the decision altitude (DA). An example in the current database cycle is the LPV approach to Rome Italy, LIRA RNAV Runway 33.

FAA:

We have reviewed the deviation again in light of issues regarding autopilot use below the DA(H) for LPVs and MDA for LPs and we do not see this as an issue that affects the deviation request.

The SBAS signal is not certified for, and no operational approvals exist, for autoland, Category II, or Category III approach operations. The reason for this is because the signal-in-space error sources have not been evaluated for their effects below a 200 ft decision altitude, and no signal model exists to support those operations.

In the visual segment, the expectation is that pilots will land based solely on visual cues. There is no rule against pilots using electronic guidance or autopilot systems at their discretion when in the visual segment, but the visual cues take precedence. Any deviation from anomalous autopilot behaviour should be instantaneously noticed by a pilot in visual conditions who would then override the autopilot inputs.

However, the critical point is that autopilots receiving SBAS inputs are not approved for operations below a 200 ft DA(H). Pilots that choose to use an autopilot below that altitude do so with no guarantee of acceptable performance which is why visual cues in the visual segment take precedence.

Further, increasing scaling from angular guidance to 0.3 nm linear guidance should not have an impact on autopilots in the visual segment. That is, an autopilot that is on-course during LPV angular guidance will simply remain on-course when the scaling transitions to 0.3 nm linear. The autopilot gains will be de-sensitized regarding corrections, but this is inconsequential in the visual segment.

For these reasons, we believe autopilot use in the visual segment is not an issue regarding deviation request.

EASA:

We concur with FAA position on the use of autopilots possibly affected by this deviation insofar, as we should consider that below Decision Altitude, even in the very unlikely case of auto land with a GA aircraft, the pilot should have sufficient weather conditions to identify a deviation which could trigger the decision to start an aborted landing procedure.

If this deviation is used, the DDP has to state that the full scale deflections are not fully ILS look alike beyond the decision altitude/height. The reason for the inclusion in the DDP is that depending upon the system being ILS look alike or not, the performance demonstration of the autopilot has to be re-demonstrated or not. Without the information in the DDP, the installer will consider it is ILS look alike.

This deviation is considered to cover also units approved under ETSO-C146a, as the described computation is also performed by a large number of already installed units.

At this time, the behaviour of the unit described in this deviation is not considered to be an unsafe condition in already existing installation in aircraft that would warrant Airworthiness Directive (AD) action under EU 748/2012, Part 21.A.3B.

EASA accepts the deviation request.