Deviation request #82 for an ETSO approval for CS-ETSO applicable to Airborne Navigation Sensors Using the Global Positioning System Augmented by the Satellite Based Augmentation System (CS-ETSO C146c) Consultation Paper

Introductory note

The hereby presented deviation request shall be subject to public consultation, in accordance with EASA Management Board Decision No 7-2004[1] products certification procedure dated 30 March 2004, 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."

ETSO-C146c#2 (Airborne Navigation Sensors Using The Global Positioning System Augmented By The Satellite Based Augmentation System)

Deviate from ETSO-C146c and RTCA/DO-229D section 2 and not implement LP capability.

Requirement:

As LPV capability includes LP performance there are very little differences in the failure annunciation between both modes otherwise the LP performance requirements are included in the LPV requirements.

Industry:

Industry requests a deviation to RTCA/DO-229D, Section 2.1 to not implement LP approach capability. Operational Classes are defined in section 1.4.2. *"Class 3. Equipment that supports oceanic and domestic en route, terminal, approach (LNAV, LNAV/VNAV, LP and LPV) and departure operation."* Table 1-1 repeats this information in a tabular format. When the equipment was developed and certified in 2007 initially, LP approaches were not available, and the practical equipment performance could not be evaluated, and there was no customer demand for this feature, therefore industry choose not to implement LP approach capability.

Equivalent Level of Safety:

LP Approach types are removed from the navigation databases at every cycle, and therefore, cannot be added to a flight plan directly in the FMS or using the off-line flight planning software. No safety hazards have been identified with the lack of LP approach support.

EASA: We accept the industry approach to not certify the LP function without addressing the specific needs of that function. LPV and LP approaches are identified differently and are having different requirements. LPV approaches including the missed approach procedure can be performed without having LP capability. Therefore we can accept to

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[1] Cf. EASA Web: http://www.easa.europa.eu/ws_prod/g/doc/About_EASA/Manag_Board/2004/mb_decision_0704.pdf

implement only the LPV functionality without having the required LP functionality as well. The resulting limitation, that no LP approach functionality is implemented, needs to be clearly communicated in the Declaration of Design and Performance, and the installation and operation manual as meanwhile LP procedures have been published.

ETSO-C146c#3 (Airborne Navigation Sensors Using The Global Positioning System Augmented By The Satellite Based Augmentation System)
Deviate from ETSO-C146c and RTCA/DO-229D section 2.1.3.2.2.3 and remove a satellite not only from the Fault Detection availability prediction tool but from the navigation as well.

Requirement:
RTCA/DO-229D
2.1.3.2.2.3 – **FD Prediction**
… A means to manually identify a satellite that is expected to be unavailable at the destination (for scheduled maintenance as identified in an FAA Notice to Airmen) may be provided. Identification of each satellite for FD prediction purposes shall not affect the satellite selection process or deselect that satellite for use in the navigation solution."

Industry:
Industry seeks to continue to remove satellites from the position solution when deselected. by the pilot. This protocol is used in previous ETSO-C129a approved GPS sensors as well as throughout our FMS product line. Industry position is that this feature is a valuable aid in demonstrating compliance to the MPS accuracy and integrity requirements, both in the lab and flight testing.

Equivalent Level of Safety:
Removal of a satellite from the position solution does not significantly affect the accuracy of the system. If sufficient satellites are removed from the navigation solution to affect accuracy, the equipment provides an indication of the effects of de-selection on the Sensor Status pages of the FMS CDU as well as providing a GPS Integrity message if the number of satellites tracked drops below the integrity threshold. The pilot may reselect the satellites at any time.

EASA:
De-selecting satellites from the navigation solution is addressed in 2.1.1.6 and considered an optional, not recommended feature.
RTCA/DO-229D 2.1.1.6 **Satellite Selection**
… It is recommended that the equipment does not provide manual de-selection of satellites to avoid situations where the pilot in correctly de-selects satellites or fails to re-select them. In a GPS/SBAS environment, it is highly unlikely that the pilot is aware of a satellite failure that the GPS/SBAS system has not flagged. If manual de-selection is implemented, the manufacturer shall address the issues. Consideration should be given to: 1) annunciations to remind the pilot that satellites have been de-selected; 2) the capability to readily re-select satellites; and 3) the appropriate training to ensure proper equipment operation. The equipment shall clear all previous manual de-selections at power up.

Manual selection of satellites that have been designated SBAS UNHEALTHY or GPS UNHEALTHY shall be prohibited.

The removal of satellites for the FD prediction as addressed in 2.1.3.2.2.3 is optional as well but may be useful for detailed analysis of the situation expected at specific airport

having e.g. a specific shading of satellites due to mountains or approach flights in a valley or other local potential specifics.

We accept the deviation. The considerations and requirements form 2.1.1.6 still apply. We are clearly not recommending that other applicants implement the same functionality based on the facts as already stated in DO-229D. The satellite de-selection from navigation during planning can have negative performance impact especially when having a less good constellation.

It has to be stated clearly in the operation instruction that removing a satellite during FD planning will immediately remove that satellite from the current navigation solution as well.

ETSO-C146c#4 (Airborne Navigation Sensors Using The Global Positioning System Augmented By The Satellite Based Augmentation System)
Deviate from DO-229D 2.2.1.1.4.5 and name waypoints only with their associated name and not in addition with their function in the procedure (IAW, FAWP, MAWP or Missed Approach Holding Fix)

Requirement:
Paragraph 2.2.1.1.4.5 **Alphanumerics**
"…*Except on map displays, the initial approach, final approach, missed approach and missed approach holding waypoints shall be labeled clearly when used as part of an approach procedure. If space limitations require the use of abbreviations, see Section 2.2.1.1.7.*"

Industry:
Each waypoint is identified as per the charted procedure. The waypoints are not specifically labeled as IAW, FAWP, MAWP or Missed Approach Holding Fix. The FAWP is readily identifiable to the crew by the corresponding approach label "GPS 08" or "ILS 27". MAWP is identified by the runway identifier, waypoint name when applicable, and the End of Approach label *EOA*. The missed approach holding fix is identified by the waypoint name and holding pattern annunciation.

Equivalent Level of Safety
Our family of Flight Management Systems is designed as an upgrade to the present FMS systems that are approved to ETSO C115b. They retain all of the functionality and capabilities of the previous certified systems with the added ability to conduct LPV approaches.
The alphanumerics used by the FMS allow the crew to understand and execute any approach in the navigation database using the same procedures as the previous FMSs with a minimum of training. Industry believes that changing the currently approved alphanumerics, as presented to the flight crew, would have adverse human factors and training transfer affects.
EASA:
We agree that a waypoint is primarily identified through its 5 letter waypoint identifier as published in the official Aeronautical Information Publication (AIP). For unnamed turn points, intersections and bearing/distance waypoints the ARINC 424 navigation data base standard provides guidance how to assign such identifier. Often but not always a link between the waypoint identifier and the function of the waypoint in a procedure can be established.

In addition to the 5 letter identifier there is a provision for a longer name associated to the waypoint in the ARINC 424 data standard. That field could in theory be used to transport

the required information but we agree that there is not necessary in all cases a one to one relationship between waypoint name and its use in various procedures.

We accept the deviation and consider the pilot being able performing the translation between the waypoint identifier and the waypoint function in a given procedure but encourage industry investigating possibilities to implement the function as intended, as having both information available for a given procedure could reduce work load and potential confusion. The required information to implement the function is available through the waypoint description identifier in the procedure sequence.

ETSO-C146c#5 (Airborne Navigation Sensors Using The Global Positioning System Augmented By The Satellite Based Augmentation System)
Deviate from RTCA/DO-229D 2.2.1.16 and implement a different naming convention and operational sequence to achieve similar functionality.

Requirement:
RTCA/DO-229D Paragraph 2.2.1.1.6 – **Set of Standard Function Labels**
"Table 2-6 lists potential functions and indications, and provides the associated label or message. Not all of these functions are required. If a function is implemented as a discrete action, the equipment shall use the labels or messages in the Table. If several of the following functions are accomplished as a discrete action, one of the applicable labels in Table 2-6 shall be used (e.g., suspend automatic sequencing and accessing the ability to select a course to or from a waypoint would be labeled "DCRS"). Except for waypoint identifiers, these abbreviations shall not be used to represent a different term."

Industry:
The applicant consistently employs the same set of labels and messages across the entire FMS product line including the non-SBAS capable units. It was chosen to retain the human interface currently in use throughout the product line and operated by thousands of flight crews today. The modified Minimum Performance Standard (MPS) Table 2-6 shown below identifies labels and messages where deviations are requested.

Table 2-6 Labels and Messages (Modified)		
Function	**Label/Message**	**Alternate Implementation**
CDU Keys		
Suspend / unsuspend automatic waypoint sequencing	Suspend (SUSP)	We do not support the suspend/unsuspend function as it is unnecessary in our family of FMSs. The suspend functionality may be accomplished at any point on the flight plan by entering the FMS heading mode. This allows maneuvering off the flight plan or onto subsequent leg via the intercept mode The pilot may also enter a GAP into the active flight plan. This functionality is accessed from the flight plan pages. When a GAP has been inserted, the flight plan will not auto-sequence to the next leg. Rather, the aircraft will fly an extension of the last leg. The pilot can then enter into a heading mode and vector as required. To re-establish waypoint sequencing to the original flight plan, the pilot may go "Direct To" or edit the gap out of the flight plan.
Access to selecting a	OBS, CRS	FMS uses a well-established "PVOR" function for this procedure, which allows the creation of

course to or from a waypoint		courses to or from any waypoint in the flight plan. The PVOR is accessed from either the NAV MENU page or the DTO mode key. The pilot then is given the option to enter a waypoint and select the desired track to or from the selected waypoint.
Clear previous entry, no, or delete	Clear (CLR)	FMS utilizes the "BACK" key. The back key is analogous to the Backspace key on a computer keyboard.
Access Direct-To function	Direct To (→ D)	FMS utilizes the "DTO" Key for this function.
Access to nearest airports or other fixes	Nearest (NRST)	FMS utilizes a "DIVERT" line select key on the DTO page for this function. The DIVERT page displays a list of up to 12 of the closest airports with associated bearing, range, and longest runway based on current present position. There is a prompt where the pilot can select the airport for automatic insertion into the flight plan.
Select Vectors-to- Final (Section 2.2.3.2.1)	Vectors-to-Final (VTF)	The flight crew can initiate this function by pressing the "ACT APPR" Line Select key any time the approach is armed. Once the approach is activated, the option to intercept the Final Approach course becomes available via FMS heading mode.
Annunciations		
Indication of loss of integrity monitoring	LOI "Loss of Integrity – Cross Check NAV."	FMS uses an amber "INTEG" annunciation on EFIS or a separate annunciator.
Indication of impending turn	WPT (flashing), or "Turn to [next heading] in [distance] nm"	FMS uses the message "WAYPOINT ALERT. The FMS provides a discrete that flashes at waypoint sequencing. In the demonstration certification aircraft, the waypoint name that is being sequenced flashes on the map display at lower left hand corner where the TO waypoint is displayed. The primary flight display also flashes the TO waypoint name in the lower left corner upon waypoint sequencing.

Equivalent Level of Safety:
The FMS family is functionally and operationally identical to the previously certified one's with the added functionality of using an SBAS GPS sensor to allow LPV approaches. The use of these function keys in the FMSs is equivalent to using them with an external SBAS Class Beta sensor, an approach which is acceptable under DO-229D. They also provide all the functionality necessary to support all SBAS based procedures.

EASA: We regret having missed the opportunity to implement one common set of Human Machine Interface for SBAS receivers across all equipment manufacturers but agree that providing an un-changed operational concept brings safety benefit as well.

We accept the proposed alternate means of implementation.

ETSO-C146c#6 (Airborne Navigation Sensors Using The Global Positioning System Augmented By The Satellite Based Augmentation System)

Deviate from RTCA/DO-229D 2.2.1.3.16 and provide navigation information (bearing, distance, time, and To/From) not in relation to the Parallel Offsets leg but to the original flight path.

Requirement:
Paragraph 2.2.1.3.16 **Parallel Offsets**
…*"When in offset mode, the equipment shall provide reference parameters (e.g., cross-track deviation, distance-to-go, time-to-go) relative to the offset path and offset reference points."* …

Industry:
The family of FMSs provide bearing, distance, time and To/From to the original flight plan waypoint to comply with SAE 4102/9, "*Flight Management Systems (FMS)*", paragraph 3.2.2.17.
The original waypoint(s) shall remain in the system while in parallel offset track operation and be available for display to the pilot. The cross-track deviation shall be zero when the aircraft is on the desired offset track. Parallel offset track operation shall be clearly annunciated. Return from parallel offset track shall be accomplished in a similar manner to the capture maneuver when initiated by the pilot or when designated by flight plan.

This statement implies that the guidance should reference the original waypoints. Industry's philosophy is that situational awareness is best served by referencing the original flight plan since the map display and ATC directions both reference the original flight plan path. Offset reference points are not named nor shown on any chart. It should also be noted that some map displays use bearing and distance to draw the TO waypoint. Subsequent waypoints are drawn using geo-referenced coordinates or other means independent of bearing and distance. With these displays, the effect of this requirement would be that the map display would show the TO waypoint as an offset, and subsequent waypoints on the original path.

Equivalent Level of Safety:
The requirement in paragraph 2.2.1.3.16 has been imported to DO-229D from DO-236A to comply with an RNP RNAV requirement for future implementation by Air Traffic Control, and is not currently in use. If the system displays and guides to the offset waypoints, the pilot has more confidence he is on the offset path. If on the other hand the system displays the original flight plan waypoints, the pilot has more awareness of his position relative to the base route from which ATC communication is referenced.

Since the primary guidance cues (crosstrack deviation, desired track) function as intended by the MPS, the equivalent level of safety is satisfied. The remainder is a matter of pilot preference. Since it was considered safe before (reference the SAE 4102/9), it should still be considered safe, even when offset legs make up the bulk of the flight plan. Currently there is no hazard to which an Equivalent Level of Safety applies. Industry plans to address the parallel offset issue in a future software release.

EASA: We accept the deviation.

ETSO-C146c#7 (Airborne Navigation Sensors Using The Global Positioning System Augmented By The Satellite Based Augmentation System)
Deviate from RTCA/DO-229D 2.2.1.3.16 and not terminate Parallel Offsets at leg discontinuities.

Requirement:
Paragraph 2.2.1.3.16 **Parallel Offsets**
"An offset shall not be propagated through route discontinuities, unreasonable path geometries, or beyond the initial approach fix."

Industry:
The FMS offsets are not terminated at leg discontinuities. Guidance will be provided to an extension of the previous leg and the pilot is presented with a "Current Leg Extended" message.
Compliant: The FMS meets the requirement of not propagating through unreasonable path geometries.
Compliant: The FMS meets the requirement to not propagate the offset beyond the IAF. The parallel offset is terminated when the approach becomes active rather than at the IAF, avoiding an abrupt transition back to the original flight plan.

Equivalent Level of Safety:
The continuation of parallel offsets past a leg discontinuity is a carry-over from the legacy FMS design before the requirements of DO-236A and DO-229D were developed, and have been used without issue for many years. The pilot is presented with a "Current Leg Extended" message and the SXTK annunciator continues to be asserted past the leg discontinuity.

EASA:
We regret having missed the opportunity to implement one common set of Human Machine Interface for SBAS receivers across all equipment manufacturers but agree that providing an un-changed operational concept brings safety benefit as well.

We accept the deviation.

ETSO-C146c#8 (Airborne Navigation Sensors Using The Global Positioning System Augmented By The Satellite Based Augmentation System)
Deviate from RTCA/DO-229D 2.2.3.3.1 and provide the deviations relative to the first approach leg instead of the FAF.

Requirement:
RTCA DO-229D Paragraph 2.2.3.3.1 **Approach Path Definition**
> "*If the pilot has selected a VTF approach, deviations shall be provided relative to the inbound course to the FAWP. Full-scale deflection shall be angular or linear as shown in Figure 2-12. The active waypoint shall initially be the FAWP. The equipment should also account for short turns onto the final approach where the FAWP may not be crossed.*"

Industry:
The FMS's have had the capability for activating a VTF function throughout the product line. When an approach is manually activated by a line select key labeled "ACT APPR" all waypoints in the approach are sequenced and a CF leg is created to the FAF (FAWP) or the FACF if one is present in the approach coding. This allows the FMS Heading Mode (FHDG) to be entered and a heading to intercept the final approach course programmed. Regardless of heading, the deviations are always provided to the first approach leg according to the procedure. This MPS requirement does not allow conformance to the published procedure when a FACF is present.

Equivalent Level of Safety:
When an FACF is coded it is on the extended lateral path, and any vertical restriction is coded as "at or above". The FMS will guide to the extended lateral and vertical path, which is the same as if it were to guide to the FAF. The only difference is that the FACF will still appear on the moving map display, and bearing/distance will be to the FACF until passage, then to the FAF. Since the published procedure is safe, and the FMS guides to the published procedure, the safety requirement is satisfied.

EASA: We accept the deviation.

ETSO-C146c#9 (Airborne Navigation Sensors Using The Global Positioning System Augmented By The Satellite Based Augmentation System)
Allow a Direct-To action FAWP in case the difference between the desired track to the FAWP and the desired track to the final leg is 80° when the FAF is not designed as an "overfly" waypoint.

Requirement:
RTCA DO-229D Paragraph 2.2.3.3.1 **Approach Path Definition**
"*If the pilot has selected "Direct-To" the FAWP, and the difference between the desired track to the FAWP and the desired track of the final approach segment is greater than 45 degrees, the equipment shall indicate that the FAWP will not be sequenced (the intercept angle at the FAWP is too sharp). In this case, the equipment shall suspend automatic sequencing.*"

Industry:
Industry understands the inclusion of this requirement because of concerns with overshoot of the lateral approach path. However, industry is able to demonstrate acceptable performance up to 80 degrees course change at the FAF when it is not designated as "Overfly". Suspending sequencing means that if the pilot takes no action the aircraft will most certainly overshoot the approach course.

Equivalent Level of Safety:
When a Direct To is activated that results in a course change at the FAF of 45 degrees or more, the FMS will anticipate the turn in a way to minimize any path overshoot. Pilot awareness of the course change is provided in the conventional way. Industry believes this is safer than inhibiting the automatic turn.

EASA: We accept the deviation.