

**RTCA SC-159
DO-229C**

**Minimum Operational Performance Standards for Global Positioning System/Wide
Area Augmentation System Airborne Equipment**

(RTCA Paper No. 193-01/SC159-876)

**FINAL COMMENTS MUST BE RECEIVED BY RTCA NOT LATER THAN
4:30 P.M. (EST) August 22, 2001**

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(see comment sheet and letter attached)

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Comment #	Comment Author	Section	Page	Comment	Suggested Resolution
1		1.1	2	Require PVT, accuracy, integrity, and time as standard outputs for all WAAS equipment classes. Rational: Needed to support surveillance applications.	“.... Appendix H is a recommended output standard for all WAAS equipment classes. ”
2	Tom Foster	2.1.1.13.1	42	Require Gamma and Delta equipment to output HPL. Rational: Needed to support surveillance applications.	“...3) Class Gamma and Delta equipment are required to compute the HPL, but are not and are required to output them to an external device(s).”
3	Tom Foster	2.1.4.12.1	59	Require Gamma and Delta equipment to output HPL _{WAAS} and VPL _{WAAS} values. Rational: Needed to support surveillance applications.	“...3) Class Gamma and Delta equipment are required to compute the HPL _{WAAS} and VPL _{WAAS} , but are not and are required to output them as HPL and VPL to an external device(s) when operating in WAAS mode. ”
4	Tom Foster	General		Require WAAS PVT, WAAS accuracy, and WAAS integrity outputs for all WAAS equipment classes. Rational: Needed to support surveillance applications.	All equipment classes to output WAAS PVT, WAAS accuracy, and WAAS integrity to external equipment when operating in WAAS mode.
5	Tom Foster	General		Other related changes may result from addressing the above items.	Make other changes as necessary to maintain consistency with the above changes.

To: RTCA SC159 GNSS

Date: August 3, 2001

From: Tom Foster, RTCA SC186 WG-6 Chairman

Subject: RTCA DO-229C WAAS MOPS PVT Output Requirements to Support Surveillance

Introduction

The proposed Final Draft of the revised RTCA DO-229C, Minimum Operational Performance Standards for Global Positioning System/Wide Area Augmentation System Airborne Equipment, is currently being circulated to committee members for review and approval. This DO-229 revision is to be presented for final approval at the August 30, 2001 SC-159 Plenary meeting. During review of this draft, issues have been identified with DO-229 with respect to WAAS equipment providing suitable PVT to support surveillance operations. The surveillance community is providing inputs to RTCA SC-159 on the WAAS MOPS regarding these issues, so that they may consider the readiness of the proposed draft revised DO-229 document for approval in its current form.

Background

The ADS-B surveillance systems require PVT inputs from on-board sensors or systems that are utilized in the broadcast messages to other ADS-B equipped aircraft or by ground receivers as a reliable position surveillance alternative for traditional surveillance methodologies, e.g. Primary and secondary radar. Since these ADS-B surveillance systems are intended to provide surveillance services to manage airspace operations in both VMC and IMC conditions, the ADS-B position data is required to meet suitable accuracy and integrity requirements. For receiving users, the accuracy and integrity of the position data for a target of concern is assessed via the message data that is broadcast. For the operational benefits to be obtained by airborne and ground users of ADS-B, the airborne ADS-B systems must be able to report the accuracy and integrity of the position sources being broadcast. GNSS sensors and systems are viewed as a primary source of airborne PVT for ADS-B.

The important GNSS sensor PVT output requirements from a surveillance perspective are:

- Best available PVT, i.e. WAAS or LAAS accuracy augmented when the sensor is operating in these modes
- Accuracy values based on 95% accuracy levels for the augmentations in effect
- Integrity values based on integrity assessment methods in effect (WAAS or LAAS when sensor is operating in these modes)

WAAS MOPS Concerns

In review of the WAAS MOPS draft, it is not clear that the document, in its current form, recognizes the role of WAAS capable airborne equipment in support of ADS-B. The primary concern is with the appropriate output of PVT to an external ADS-B device from WAAS capable GNSS equipment. In addition to access to PVT data, ADS-B needs the current assessed accuracy and integrity data from GNSS equipment to appropriately report NIC/NAC values in broadcast ADS-B messages. The following text excerpts illustrate the concerns with the draft WAAS

MOPS document. There may, however, be other sections of the document that will need to be changed to address the surveillance needs from WAAS equipment.

1. The following is found in the introduction defining applicability of Appendices as normative or requirements. This, in addition to the other following items, make the output requirements for PVT unclear.

Section 1.1 Introduction [pg. 2]

*“Appendices H, I, K and L contain example algorithms for implementing functions that are required by this MOPS. **In other words, the GPS/WAAS equipment need not realize these algorithms. Appendix H is a recommended output standard.**”*

2. The following is found in the requirements applicable to Beta, Gamma, and Delta class WAAS equipment. [Note: Beta class equipment is stand-alone GPS sensors. Gamma class is integrated GPS and LNAV/VNAV equipment, e.g. ARINC 756 GNLU. Delta class is integrated GPS and precision approach equipment, e.g. ARINC 755 MMR.]

Section 2.1.1.13.1 Protection Level [pg. 42]

“Class Beta equipment shall output the Horizontal Protection Level (HPL_{WAAS} or HPL_{FD}) as described in Sections 2.1.2.2.2, 2.1.3.2.2, and 2.1.4.2.2). The latency of the WAAS-based protection levels shall not exceed 4.8 seconds, from the arrival at the antenna port of the last bit of a message which affects the horizontal protection level. The GPS/WAAS equipment shall indicate if the HPL cannot be calculated (insufficient number of WAAS HEALTHY satellites and fault detection is not available).

Notes:

- 1) In addition to the HPL, the equipment may output the HUL.
- 2) When no HPL can be calculated, integrity monitoring is not provided.
- 3) Class Gamma and Delta equipment requirements can be found in Sections 2.2.1.6 and 2.3.6. **Class Gamma and Delta equipment are required to compute the HPL, but are not required to output them to an external device.**

3. The following is found in the requirements for LNAV/VNAV operations using WAAS.

2.1.4.12.1 Protection Level [pg. 59]

“Class Beta-2 and 3 equipment shall output WAAS-based protection levels (HPL_{WAAS} and VPL_{WAAS}) once per second. The latency of the output of the WAAS-based protection levels shall not exceed 0.6 seconds, from the arrival at the antenna port of the last bit of a message, which affects the horizontal or vertical protection levels to output of the last bit of a message containing the protection levels. The GPS/WAAS equipment shall indicate if the HPL_{WAAS} and VPL_{WAAS} cannot be calculated (insufficient number of WAAS HEALTHY satellites). Note that when the HPL_{WAAS} and VPL_{WAAS} cannot be calculated, LNAV/VNAV or precision approach mode are not available.

*Note: The equipment that determines deviation data from the Beta-2 and 3 position has been allocated a latency of 0.2 seconds. Class Gamma and Delta equipment requirements can be found in Sections 2.2.1.6 and 2.3.6. **Class Gamma and Delta equipment are required to compute the HPL_{WAAS} and VPL_{WAAS} , but are not required to output them to an external device.**”*

Recommendation

The current draft revision to DO-229 WAAS MOPS should be changed to recognize the PVT output requirements for on-board ADS-B systems. PVT outputs should be required for all classes of DO-229C WAAS compliant equipment and should reflect WAAS accuracy augmentations when WAAS mode is in effect. These outputs should also include $HFOM_{WAAS}$, $VFOM_{WAAS}$, HPL_{WAAS} , and VPL_{WAAS} computed values when the WAAS augmentation mode is in effect. Time of applicability of the position measurements that can be correlated to UTC EPOCH is also needed.

It is critical that these changes be incorporated now to ensure that subsequent fielded WAAS equipment can support ADS-B needs. The time required to equip airborne users with ADS-B capabilities to allow needed user benefits and airspace improvements to be obtained is driven by the timely availability of adequate industry standards. Changes to the WAAS MOPS to require appropriate PVT outputs for use by external systems is critical to this objective.

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