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Proposal to Transmit NAC_V as part of DO-260B Surface Messages

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Summary

It is recommended that the NAC_V parameter is added to the DO-260B surface message transmission.

NAC_V (Navigation Accuracy Category for Velocity) is the parameter used by ADS-B / TIS-B/ ADS-R to characterize the accuracy of the reported geometric velocity. DO-260 and DO-260A transponders (1090 MHz) transmit an indication of NAC_V when the airborne message set is transmitted; however, they do not transmit NAC_V when the surface message set is transmitted. Note that UAT transponders compliant with DO-282 or DO-282A transmit NAC_V regardless of whether the aircraft/vehicle is airborne or on the ground.

The NAC_V parameter characterizes the accuracy of the reported horizontal velocity and vertical rate. When transmitting surface message set, the NAC_Vparameter should indicate the quality of the reported horizontal velocity (i.e., ground speed), since vertical rate is not transmitted. This characterization is needed to support surface applications like ASSA, FAROA, ATSA-SURF, SURF-IA, as well as ground surveillance applications.

This recommendation to transmit NAC_V while on the surface is consistent with DO-242A and DO-289, and does not require any changes to those documents to accommodate adding NAC_V to the surface messages.

1. Introduction

This paper recommends that the Navigation Accuracy Category for Velocity (NAC_V) parameter is added to the DO-260B surface message transmission. The rationale for adding NAC_V to the surface message set is to characterize the quality of the ground speed to support surface applications like ASSA, FAROA, ATSA-SURF, SURF-IA, as well as other ground surveillance applications.

This proposal is consistent with DO-242A and DO-289. Incorporating this recommendation does not require any changes to DO-242A or DO-289 documents to accommodate adding NACv to be transmitted as part of the surface message set.

2. Background

This background section is intended to illustrate that adding NAC_V to the DO-260B surface message set is consistent with DO-242A whereby the NAC_V on the surface would characterize the accuracy of the reported horizontal velocity (i.e., ground speed).

2.1. NAC_V Definition

The definition of NAC_V [per DO-242A (section 2.1.2.14)] is given in Figure 1 below. NAC_V is intended to characterize the horizontal velocity accuracy (95%) as well as the vertical geometric velocity accuracy (95%). Of relevance for the DO-260B surface message set is the characterization of the reported horizontal velocity, since vertical velocity is not reported when on the surface. This interpretation is consistent with note 2 below Table 2-4 in DO-242A (reproduced below in Fig. 1).

2.1.2.14 Navigation Accuracy Category for Velocity (NAC_V)

The velocity accuracy category of the least accurate velocity component being supplied by the reporting A/V's source of velocity data **shall** (R2.33) be as indicated in Table 2-4.

Notes:

1. *NAC_V is another name for the parameter that was called NUC_R in the initial (DO-242) version of this MASPS.*
2. *Navigation sources, such as GNSS and inertial navigation systems, provide a direct measure of velocity which can be significantly better than that which could be obtained by position differences.*
3. *NAC_V does not apply to barometric velocity accuracy.*
4. *Refer to Appendix R for guidance material on determination of NAC_V.*

Table 2-4: Navigation Accuracy Categories for Velocity (NAC_V).

NAC_V	Horizontal Velocity Error (95%)	Vertical Geometric Velocity Error (95%)
0	Unknown or ≥ 10 m/s	Unknown or ≥ 50 feet (15.24 m) per second
1	< 10 m/s	< 50 feet (15.24 m) per second
2	< 3 m/s	< 15 feet (4.57 m) per second
3	< 1 m/s	< 5 feet (1.52 m) per second
4	< 0.3 m/s	< 1.5 feet (0.46 m) per second

Notes for Table 2-4:

1. *When an inertial navigation system is used as the source of velocity information, error in velocity with respect to the earth (or to the WGS-84 ellipsoid used to represent the earth) is reflected in the NAC_V value.*
2. *When any component of velocity is flagged as not available the value of NAC_V will apply to the other components that are supplied.*

Figure 1: NAC_V Definition

2.2. NAC_V was Intended to Support Surface Applications

Per Table 2-8 in DO-242A, it was intended that NAC_V be broadcast to support surface applications. See the last column of the table for "Airport Surface" and notice the entry in the "expected NAC_V" row. Clearly, it was intended that NAC_V be available to characterize the accuracy of horizontal velocity for surface applications.

Table 2-8: Summary of A/V-to-A/V Performance Assumptions for Support of Indicated Applications

Information ↓	Operational Capability						
	Aid To Visual Acquisition	Conflict Avoidance and Collision Avoidance		Separation Assurance and Sequencing	Flight Path Deconfliction Planning	Simultaneous Approach	Airport Surface (Blind Taxi and Runway Incursion) (Note 8)
		Future Collision Avoidance	Terminal Station Keeping	Free Flight/ Cooperative Separation in Overflight	Cooperative Separation in Oceanic/ Low Density En route		
Initial Acquisition of Required Information Elements (NM)	10	20	20	40 (50 desired) (Note 7 & 9)	90 (120 desired) (Note 7)	10	5
Operational Traffic Densities # A/V (within range) (Note 4)	21 (< 10 NM)	24 (< 5 NM); 80 (< 10 NM); 250 (< 20 NM)	6 (< 20 NM)	120 (< 40 NM)	30 (< 90 NM)	32 landing; 3 outside extended runway; 5 beyond runway	25 within 500 ft 150 within 5 NM
Alert Time (Note 3)	n/a	1 min	2 min	2 min	4.5 min (6 min)	15 sec	10 s (Blind Taxi) 5 s (Runway Incursion)
Expected NAC_P	n/a	10	10	10	6	10	10
Expected NAC_V	n/a	3	3	3	3	3	4
Service Availability % (Note 5)	95	99.9	99.9	99.9	99.9	99.9	99.9

Figure 2: NAC_V was Intended to Support Surface Ops. [ref. DO-242A, Table 2-8]

2.3. Receive Side State Vector Report Defines Horizontal Velocity to Include Ground Speed on the Surface

Per section 3.4.3 in DO-242A, the State Vector Report defines "Horizontal Velocity" as North and East Velocities (when airborne) and Ground Speed (when on the surface). The NAC_V parameter is intended to characterize the "horizontal velocity" accuracy, which thus includes ground speed when on the surface.

3.4.3 State Vector Report

Table 3-6 lists the report elements that comprise the state vector (SV) report. The SV report contains information about an aircraft or vehicle's current kinematic state. Measures of the state vector quality are contained in the NIC element of the SV report and in the NAC_P, NAC_V, NIC_{baro} and SIL elements of the Mode Status Report (§3.4.4 below).

Table 3-6: State Vector Report Definition.

	SV Elem. #	Contents	[Resolution or # of bits]	Required from surface participants	Required from airborne participants	Reference Section	Notes
ID	1	Participant Address	[24 bits]	•	•	2.1.2.2.2.1	
	2	Address Qualifier	[1 bit]	•	•	2.1.2.2.2.2	1
TOA	3	Time Of Applicability	[0.2 s]	•	•	3.4.3.3	
Geometric Position	4a	Latitude (WGS-84)		•	•	3.4.3.4	2, 3
	4b	Longitude (WGS-84)		•	•		
	4c	Horizontal Position Valid	[1 bit]	•	•	3.4.3.5	
	5a	Geometric Altitude		•		3.4.3.6	3, 4
	5b	Geometric Altitude Valid	[1 bit]	•		3.4.3.7	
Horizontal Velocity	6a	North Velocity while airborne		•		3.4.3.8	3
	6b	East Velocity while airborne		•			3
	6c	Airborne Horizontal Velocity Valid	[1 bit]	•		3.4.3.9	
	7a	Ground Speed while on the surface	[1 knot]		•	3.4.3.10	
	7b	Surface Ground Speed Valid	[1 bit]		•	3.4.3.11	
Heading	8a	Heading while on the Surface	[6° or better (6 bits)]		•	3.4.3.12	
	8b	Heading Valid	[1 bit]		•	3.4.3.13	
Baro Altitude	9a	Pressure Altitude		•		3.4.3.14	3, 4
	9b	Pressure Altitude Valid	[1 bit]	•		3.4.3.15	
Vertical Rate	10a	Vertical Rate (Baro/Geo)		•		3.4.3.16	3
	10b	Vertical Rate Valid	[1 bit]	•		3.4.3.17	
NIC	11	Navigation Integrity Category	[4 bits]	•	•	3.4.3.18	
Report Mode	12	SV Report Mode	[2 bits]			3.4.3.19	

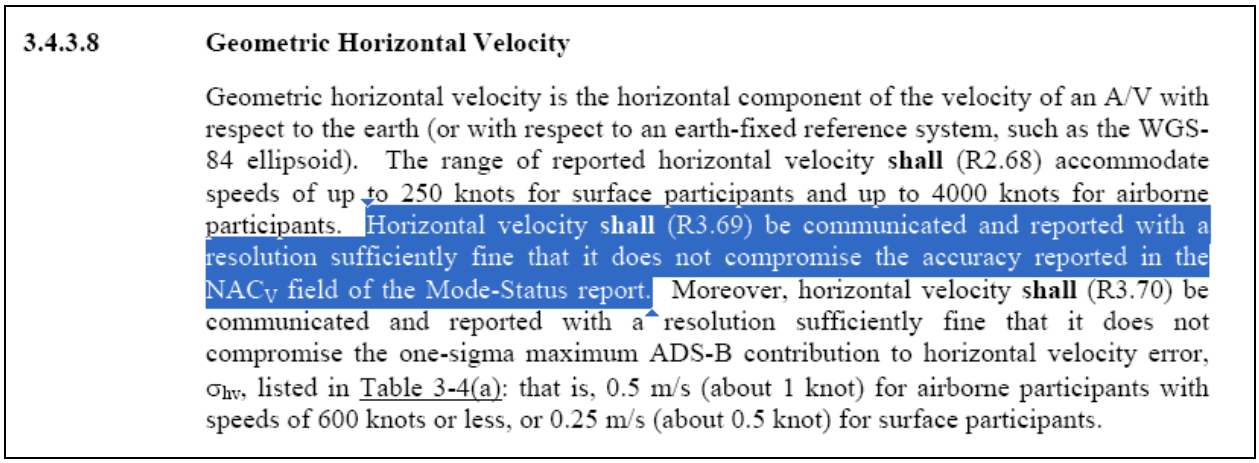
Figure 3: State Vector Report (Ref. section 3.4.4 in DO-242A)

Horizontal Velocity is defined to be "Ground Speed" when on the surface, whereby the NAC_V characterizes the accuracy of "Horizontal Velocity"

2.4. Receive Side Horizontal Velocity Report Resolution must be Consistent with NAC_V

Per sections 3.4.3.8 and 3.4.3.10 in DO-242A, the Horizontal Velocity and Ground Speed must be communicated and reported with a resolution that does not compromise the accuracy of the NAC_V field.

Thus, it was intended that the Receive Side have a means to establish NAC_V, even for surface vehicles.

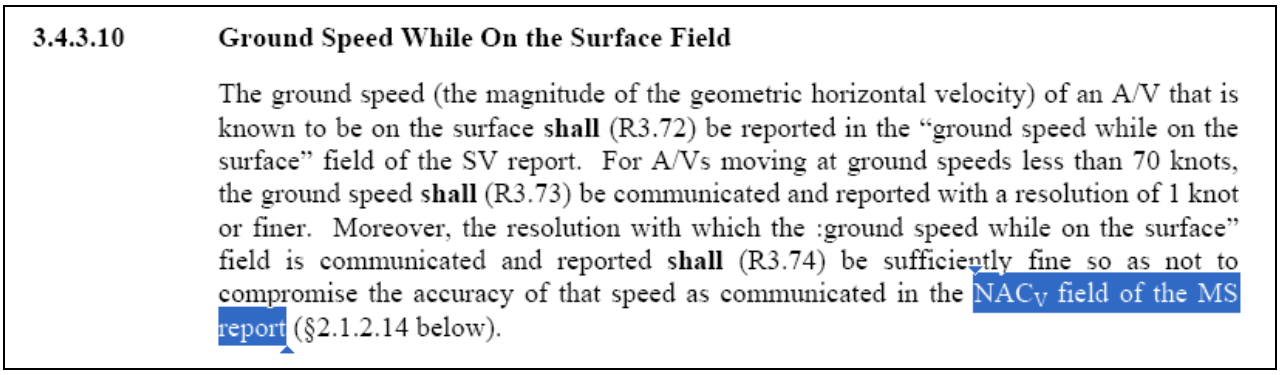


3.4.3.8 Geometric Horizontal Velocity

Geometric horizontal velocity is the horizontal component of the velocity of an A/V with respect to the earth (or with respect to an earth-fixed reference system, such as the WGS-84 ellipsoid). The range of reported horizontal velocity **shall** (R2.68) accommodate speeds of up to 250 knots for surface participants and up to 4000 knots for airborne participants. Horizontal velocity **shall** (R3.69) be communicated and reported with a resolution sufficiently fine that it does not compromise the accuracy reported in the NAC_V field of the Mode-Status report. Moreover, horizontal velocity **shall** (R3.70) be communicated and reported with a resolution sufficiently fine that it does not compromise the one-sigma maximum ADS-B contribution to horizontal velocity error, σ_{hv}, listed in Table 3-4(a): that is, 0.5 m/s (about 1 knot) for airborne participants with speeds of 600 knots or less, or 0.25 m/s (about 0.5 knot) for surface participants.

Figure 3: Horizontal Velocity Accuracy (e.g., North & East Velocities and Ground Speed) and Resolution must be Consistent with the Reported NAC_V

[Reference section 3.4.3.8 in DO-242A]



3.4.3.10 Ground Speed While On the Surface Field

The ground speed (the magnitude of the geometric horizontal velocity) of an A/V that is known to be on the surface **shall** (R3.72) be reported in the "ground speed while on the surface" field of the SV report. For A/Vs moving at ground speeds less than 70 knots, the ground speed **shall** (R3.73) be communicated and reported with a resolution of 1 knot or finer. Moreover, the resolution with which the :ground speed while on the surface" field is communicated and reported **shall** (R3.74) be sufficiently fine so as not to compromise the accuracy of that speed as communicated in the NAC_V field of the MS report (§2.1.2.14 below).

Figure 4: Ground Speed Resolution Must Be Consistent with NAC_V

[Reference section 3.4.3.10 in DO-242A]

3. Rationale for Need for NAC_V on the Surface

The Safety and Performance Requirements (SPR) for several surface applications intended to be supported by ADS-B have been and are under development. ASSA and FAROA are defined in DO-289 and DO-317. The safety and performance requirements for ATSA-SURF, SURF-IA, and ground surveillance surface applications are under development.

For traffic on the surface, it is expected that most if not all of these applications will typically latency compensate the received traffic positions using the reported ground speed and heading/track to a common time of applicability when the quality of the ground speed is sufficient. A characterization of velocity quality (i.e., NAC_V) is key to assessing whether the quality is sufficient. In addition, velocity (including velocity quality) will likely be used as part of developing appropriate indications and alerts.

Thus, NAC_V should be added to the DO-260B ADS-B surface message set, where it characterizes the quality (95% accuracy) of the transmitted ground speed.