CHANGE ISSUE – RTCA/DO-242

MASPS for ADS-B
Rev. A

Tracking Information (committee secretary only)	
Change Issue Number	57
Submission Date	2/08/02
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Short Title for Change Issue:	Deletion of NAC_V = 4 category

MASPS Document Reference:		Originator Information:	
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Table/Figure number(s)	Table 2.1.2.13	Other	

Proposed Rationale for Consideration (originator should check all that apply):	
	Item needed to support of near-term MASPS/MOPS development
?	DO-260/ED-102 1090 MHz Link MOPS Rev A
	ASA MASPS
	TIS-B MASPS
X	UAT MOPS
	Item needed to support applications that have well defined concept of operation
	Has complete application description
	Has initial validation via operational test/evaluation
	Has supporting analysis, if candidate stressing application
	Item needed for harmonization with international requirements
	Item identified during recent ADS-B development activities and operational evaluations
X	MASPS clarifications and correction item
X	Validation/modification of questioned MASPS requirement item
	Military use provision item
	New requirement item (must be associated with traffic surveillance to support ASAS)

Nature of Issue:		Editorial		Clarity		Performance	X	Functional

Issue Description:

The presence of NAC_V = 4 category requires 3 bits to encode NAC_V. Deletion of this category would allow NAC_V to be encoded with only 2 bits. The operational benefit of NAC_V = 4 has been questioned. If there is no operational benefit, the category should be deleted which would allow the extra bit to be used by other information subfields.

See Attachment A of this Issue Paper for further discussion.

Originator's proposed resolution if any:

The category NAC_V = 4 should be deleted, and the allowable range for NAC_V should be [0..3].

Working Group 6 Deliberations:

January 29, 2002: The topic of this Issue Paper was first discussed by WG6 at their January meeting in Seattle. It was agreed by all in attendance that – unless WG4 objected – NAC_V will only have a range from 0 to 3. An action item was given [AI 11-7] to produce this Issue Paper prior to the February, 2002 WG6 meeting so that it could be considered for revision A.

February 22: It was realized that a $NAC_V = 4$ or equivalent accuracy requirements are found in DO-242. Table 2-3 has an expected NUC_R of 4 for airport surface operations and Table 2-4(b)has a horizontal velocity error of 0.3 m/s for airport surface operations and parallel runway conformance monitoring. Given these existing entries in DO-242 and the insufficient time to analyze the validity of these requirements, it was agreed by WG6 to defer this Issue Paper from revision A.

During the January 2002 meeting of Working Group 6, a question was raised regarding the utility of the category $NAC_V = 4$. The presence of this category leads to a need to encode NAC_V with 3 bits instead of 2. If the extra bit does not lead to any operational benefit, the category should be deleted so that the bit could be applied to another data field.

NAC_V is referenced in Table 2.1.2.13, shown below for context. This table refers to the accuracy reported by the navigation source. The horizontal and vertical components will be addressed separately.

Table 2.1.2.13: 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 2.1.2.13:

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 NACV 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.*

Note:

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.

With regard to the horizontal component, it should be recognized that the ADS-B system is only required to report horizontal velocity to a resolution of 1 kt = 0.5 m/s, hence the one sigma error is 0.15 m/s and the 95% error due to the ADS-B system is 0.3 m/s. So even if the navigation source is reported to have an accuracy better than 0.3 m/s, the value applied at a receiving station cannot be trusted to this level (i.e., since the ADS-B system introduces its own error). The RSS combination of two errors each with 95% accuracy of 0.3 m/s is 0.42 m/s. This is the best that could be inferred at a receiving station with the current MASPS text. If $NAC_V = 4$ is deleted, the most accurate category for the navigation source would be 1 m/s (95%) which would lead to an inferred RSS error at a receiving station of 1.04 m/s ~ 1 m/s (effectively the same as the reported source accuracy category).

Is the extra bit operationally meaningful? Three cases may be considered to get an intuitive feel:

a) Air-to-air separation assurance. Here the intent is to keep aircraft far apart. Protection bubbles are large. The additional velocity error, between $NAC_V = 3$ and $NAC_V = 4$, amounts to only 30 meters after integrating for one minute. But long before a minute has elapsed, new position reports have been received. So the actual error in future projected position is much

smaller (since the starting point has been updated). The additional NAC_V category does not offer any benefit for this application.

b) Surface operations. Here one might be interested in the difference between no movement and slow movement. The aircraft reports either 0 kt or 1 kt. Position is reported with high resolution a 1Hz. An aircraft might be rolling at 0.4 kt and still report zero kt. It would move 0.2 m/s or 1 m every 5 seconds. Eventually this would be detected by observing a position deviation. Alternatively, the aircraft could be moving at 0.6 kt and report 1 kt. This might raise a flag in ground automation, but it would still take the aircraft 3 seconds to move 1 meter. Again, a position deviation will manifest over time. Now consider the operational benefit of the NAC_V datum. It does not allow the ground to conclude that an aircraft is truly stopped, since even with $NAC_V = 4$ (or infinity, implying a perfect velocity source), the aircraft could be rolling at 0.4 kt and report 0 kt. Alternatively if the reported velocity = 1 kt, the ground may have a slightly higher confidence that an aircraft is truly moving faster than 0.25 m/s if $NAC_V = 4$. But would the ground automation raise a flag to the controller prior to verifying the deviation with a change in the reported position? Probably not. With a 95% confidence level of 0.3 m/s, more than 5% of all reports from the nav source will indicate a velocity greater than 0.25 m/s, hence a reported velocity of 1 kt. This would be an unacceptably high false alarm rate. So again the position report will be key and the value of NAC_V is minimal.

c) Cooperative maneuvers and spacing control. Consider a simple case of in-trail spacing. Here the trailing aircraft must rely on the reported position and velocity of the lead aircraft. Knowledge of NAC_V does not affect the basic algorithm. At most, it allows an adjustment of the gain settings in the tracker (i.e., smoothing the reported velocity of the leading aircraft to a greater or lesser degree). Is it desirable to exert such fine control over an algorithm that must be shared across the NAS? Perhaps a small additional buffer in longitudinal spacing (5-10 meters) would be equivalent and a whole lot easier to certify.

Based on these thought experiments, the value of NAC_V with regard to its horizontal information component does not appear to be operationally significant.

Now consider the velocity component of NAC_V. What vertical accuracy is operationally meaningful? On the airport surface it is not needed at all. In the air, instantaneous changes due to updrafts and downdrafts will be large compared to a reporting resolution of 100 feet/minute. Aircraft typically climb and descend at much higher rates (this resolution of 100 feet/minute is “down in the noise” for vertical rates commanded by the pilot). As with the horizontal spacing issue considered above, receiving aircraft will place greatest emphasis on the reported vertical rate and the accuracy category will have secondary importance. This is particularly true if any averaging is taking place (a specific algorithm must be defined and placed in the MASPS so all manufacturers and application developers will understand the common meaning of the datum. We need to understand the meaning of the vertical rate datum before we can understand the accuracy level required.

At this time, there does not appear to be any defined operational reason to retain $NAC_V = 4$. If the group agrees with this assessment, the category should be deleted.