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Additional NIC values in ES Surface Position Format

Revision 2

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SUMMARY

The current format used for surface position squitters limit the ability to transmit four values of measurement integrity (of up to at maximum 0.1NM containment radius) plus one value to indicate unknown integrity (or larger than 0.1NM containment radius). Therefore, today many ADS-B systems are reporting unknown integrity while they actually have a sufficient integrity to support some applications. This Working Paper presents the preferred approach recommended by Eurocae WG51 SG1 and RTCA SC186 WG3, to extend the capability of reporting more NIC values in the ES surface position messages.

1. Introduction

In total, there are currently five NIC values that have been defined for the ES surface position version 1 format. NIC values of 8/9/10/11 represent a measurement integrity of better than 0.1NM (185.2m). A NIC value of 0 represents a horizontal position containment radius of more than 0.1NM or unknown. As a consequence, the current NIC encoding capability in the ES surface message does not allow to differentiate between horizontal position reports with a measurement integrity of more than 0.1NM and messages with very bad or actually unknown measurement integrity.

The Eurocontrol CASCADE ADS-B Monitoring Project, in conjunction with the Pioneer Airlines Project, has established statistics of the reported horizontal position containment radius Rc showing the following distribution of **Version 0** transponder and GPS SA ON[1] based NUC_P values:

47.1% of NUC_P=7 (Rc<0.1NM),

49.6% of NUC_P=6 (Rc<0.2NM),

3.2% of NUC_P=5 (Rc<0.5NM), and

0.1% of NUC_P=5 (Rc<1.0NM).

As a consequence, with the current ES surface message formats more than 50% of the NUC_P is forced to report an unknown measurement integrity. This corresponds with similar statistics reported by Australia in ASP01-21.

FAA proposed in ASP TSG WP5-23 two different possibilities for extending the NIC encoding capability in the ES surface position messages.

These different options have been analyzed during recent EUROCAE WG51 SG1 and RTCA SC186 WG3 meetings.

This working paper presents the justification for extending the NIC encoding capability in the ES surface position messages and details the preferred option for review and approval by the ICAO TSG.

[1] GPS Selective Availability ON, including receiver autonomous integrity monitoring (RAIM), refers to the most basic compliant ADS-B position source in support of ATC services. It can be found on the vast majority of today's aircraft installations.

2. Current NIC encoding for Surface position message

The following table is an extract of Doc 9871 Appendix B which describes ES version 1 format:

TYPE Code	Subtype Code	NIC Supplement	Format (Message Type)	Horizontal Containment Radius Limit (R_C)	Navigation Integrity Category (NIC)	Altitude Type	Notes
0							
5	Not Present	0	Surface Position (§B.2.3.3)	$R_C < 7.5$ m	NIC = 11	No Altitude Information	
6		0		$R_C < 25$ m	NIC = 10		
7		1		$R_C < 75$ m	NIC = 9		6
		0		$R_C < 0.1$ NM (185.2 m)	NIC = 8		
8		0		$R_C \geq 0.1$ NM (185.2 m) or unknown	NIC = 0		

3. Justification

Introducing the ability to report NIC values on the surface of lower than NIC=8 and also lower than NIC=7 provide operational benefits for the near- and mid-term implementations in regards to the:

- Bridging between surface and airborne ADS-B In applications (e.g. ATSA-SURF, ATSA-VSA and ATSA-AIRB) with respect to their operational overlap and related traffic display;

- Provision of a higher availability of an indication of horizontal position measurement integrity when aircraft are on the surface. This would allow for:

  - An indication of GPS being used as the horizontal position source as well as some indication of a “healthy” satellite constellation;

  - The observation of relative changes in horizontal position measurement integrity providing a means to detect a deterioration of the horizontal position quality;

  - An advanced indication of the capability of supporting ATC separation services by departing aircraft. For instance, the Safety, Performance and Interoperability Requirements document for ADS-B-RAD (Enhanced ATS in radar areas using ADS-B surveillance) specifies the following NIC requirements:
    - NIC equal to or greater than 5 ($R_C < 1$ NM) for 5NM separation
    - NIC equal to or greater than 6 ($R_C < 0.6$ NM) for 3NM separation.

The above reasoning is also in line with the likely requirements of situational awareness surface applications assessed today (ATSA-SURF, ATSA-SURF IA, ADS-B-APT). Future surface applications might require a horizontal position containment radius that is in line with the actual surface dimensions (e.g., NIC=10). This, however, would require a very costly fleet-wide upgrade to high-end GNSS installations.

For the above reasons, it is recommended to add NIC = 5, 6 and 7 reporting capability in the ES surface position message by use of the NIC supplement.

4. Proposed changes

First alternative

The current preferred RTCA/EUROCAE proposal for extending Containment Radius categories in Extended Squitter Surface Position messages is as follows:

TYPE Code	Subtype Code	NIC Supplement	Format (Message Type)	Horizontal Containment Radius Limit (R_C)	Navigation Integrity Category (NIC)	Altitude Type	Notes
0							
5	Not Present	0	Surface Position (§B.2.3.3)	R_C < 7.5 m	NIC = 11	No Altitude Information	
		1		R_C < 0.2 NM (370.4m)	NIC = 7		
6		0		R_C < 25 m	NIC = 10		
		1		R_C < 0.5 NM (926m)	NIC = 6		
7		1		R_C < 75 m	NIC = 9		6
		0		R_C < 0.1 NM (185.2 m)	NIC = 8		
8		1		R_C<1.0 NM (1852m)	NIC = 5		
		0		$R_C \geq$ 1 NM (1852 m) or unknown	NIC = 0		

This should also be reflected in the NIC supplement table (future section equivalent to B.2.3.10.6).

NAVIGATION INTEGRITY CATEGORY (NIC) *SUPPLEMENT*

This 1-bit (ME bit 44, message bit 76) subfield shall be used with the TYPE Code to encode the navigation integrity category (NIC) of the transmitting ADS-B participant to allow surveillance applications to determine whether the reported geometric position has an acceptable integrity containment region for the intended use. Encoding of the NIC Supplement subfield shall be as specified in the following table. If an update has not been received from an on-board data source for the NIC Supplement subfield within the past 5 seconds, then the NIC Supplement subfield shall be encoded to indicate that R_C is "Unknown."

NIC Value	Containment Radius (R_C) and Vertical Protection Limit (VPL)	Airborne		Surface	
		Airborne Position TYPE Code	NIC Supplement Code	Surface Position TYPE Code	NIC Supplement Code
0	R_C unknown	0, 18 or 22	0	0, 8	0
1	R_C < 20 NM (37.04 km)	17	0	N/A	N/A
2	R_C < 8 NM (14.816 km)	16	0	N/A	N/A
3	R_C < 4 NM (7.408 km)	16	1	N/A	N/A
4	R_C < 2 NM (3.704 km)	15	0	N/A	N/A
5	R_C < 1 NM (1852 m)	14	0	8	1
6	R_C < 0.6 NM (1111.2 m)	13	1	N/A	N/A
	R_C < 0.5 NM (926 m)	13	0	6	1
7	R_C < 0.2 NM (370.4 m)	12	0	5	1
8	R_C < 0.1 NM (185.2 m)	11	0	7	0
9	R_C < 75m *and* VPL < 112 m	11	1	7	1
10	R_C < 25m *and* VPL < 37.5 m	10 or 21	0	6	0
11	R_C < 7.5m *and* VPL < 11 m	9 or 20	0	5	0

Note 1.— "N/A" means "This NIC value is not available in the ADS-B surface position message formats."

Note 2.— The NIC parameter is broadcast partly in the TYPE subfield of airborne position and surface position messages, and partly in the NIC Supplement subfield of the aircraft operational status message. ~~*The NIC integrity containment region is described horizontally and vertically using the two parameters, R_C and VPL.*~~

Note that the last sentence of Note 2 has been removed as there is another change proposal proposing to remove the vertical dimension from the NIC establishment.

Issues:

- There are backwards compatibility issues between this new version and the previous version of ES. In particular, receivers disregarding the NIC supplement (compatible with version 1) could interpret:

  a Type code =5 with NIC supplement= 1 encoding NIC=7 (R_C < 0.2 NM (370.4m))

  as

  a Type code = 5 version 0 which corresponds to a NIC=11 (R_C < 7.5 m).

  However, this modification is proposed as part of a new version of the ES and can therefore correctly be handled by receivers using the ES version number (note that version number and NIC supplement are both in the Extended Squitter aircraft operational status message, Register 65_{16}).

- The order of the encoding of the containment radius is not natural and could be misinterpreted.
- It does not match with the recently agreed adaptation of the encoding of containment radius for the airborne position squitters.

2nd alternative for extending Containment Radius categories in Extended Squitter Surface Position messages as proposed by Kojo Owusu-Akyeampong.

This option allows a more natural encoding of the additional containment radius categories.

TYPE Code	Subtype Code	NIC Supplement	Format (Message Type)	Horizontal Containment Radius Limit (R_C)	Navigation Integrity Category (NIC)
5	Not Present	0	Surface Position (B.2.3.3)	R_C < 7.5 m	NIC = 11
6		0		R_C < 25 m	NIC = 10
7		1		R_C < 75 m	NIC = 9
		0		R_C < 0.1 NM (185.2 m)	NIC = 8
8		0		$R_C \geq$ 4.0 NM ((7.408 km) or unknown	NIC = 0
24	Not Present	1	Surface Position (B.2.3.3)	R_C < 0.2 NM (370.4 m)	NIC = 7
		0		R_C < 0.5 NM (926 m)	NIC = 6
25		1		R_C < 0.6 NM (1111.2 m)	NIC = 6
		0		R_C < 1.0 NM (1852 m)	NIC = 5
26		1		R_C < 2.0 NM (3.704 km)	NIC = 4
		0		R_C < 4.0 NM (7.408 km)	NIC = 3

Note: The highlighted text represents changes to Doc 9871 First Edition and DO-260A.

Issues:

- Type code 24 is now reserved for multilateration system.
- This option consumes all the remaining type codes prohibiting future extension.

3rd Alternative:

TYPE Code	Subtype Code	NIC Supplement	Format (Message Type)	Horizontal Containment Radius Limit (R_C)	Navigation Integrity Category (NIC)	Altitude Type	Notes
0							
5	Not Present	1	Surface Position (§B.2.3.3)	R_C < 7.5 m	NIC = 11	No Altitude Information	
		0		R_C < 25 m	NIC = 10		
6		1		R_C < 75 m	NIC=9		
		0		R_C < 0.1 NM (185.2 m)	NIC = 8		
7		1		R_C < 0.2 NM (370.4m)	NIC = 7		6
		0		R_C< 0.3 NM (555.6m)	NIC = 6		
8		1		R_C < 0.5 NM (926m)	NIC = 6		
		0		$R_C \geq$ 0.5 NM (926 m) or unknown	NIC = 0		

This option contains a natural list of increasing containment radius consistent with the containment radius defined for the airborne position messages.

The additional containment radius cover the great majority (99.9%) of integrity reported by current aircraft installations (see introduction).

Issues:

- Not backward compatible without using the version number.
- Limited to 0.5NM and not containing 0.6NM and 1NM as currently specified in the RDA document.

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4th Alternative:

TYPE Code	Subtype Code	NIC Supplement	Format (Message Type)	Horizontal Containment Radius Limit (R_C)	Navigation Integrity Category (NIC)	Altitude Type	Notes
0							
5	Not Present	1	Surface Position (§B.2.3.3)	R_C < 7.5 m	NIC = 11	No Altitude Information	
		0		R_C < 25 m	NIC = 10		
6		1		R_C < 75 m	NIC = 9		
		0		R_C < 0.1 NM (185.2 m)	NIC = 8		
7		1		R_C < 0.2 NM (370.4 m)	NIC = 7		
		0		R_C < 0.3 NM (555.6 m)	NIC = 6		
8		1		R_C < 0.6 NM (1111.2 m)	NIC = 6		
		0		$R_C \geq$ 0.6 NM (1111.2 m) or unknown	NIC = 0		

5. Action

The TSG is invited to review the different proposals for extending Containment Radius categories in Extended Squitter Surface Position messages and to decide whether the 3rd alternative is the most appropriate for the future version of ADS-B squitter.

6. Conclusion

During the Paris Meeting, the TSG discussed the alternatives and will recommend Alternative #4. There is a further TSG recommendation that the NIC table be completely renumbered.