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Surface Movement Clarifications to Support ATSA SURF and RFG APT Applications

In Response to Action Item 27-09

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Summary

The ATSA SURF and the RFG APT applications would like to know when the aircraft is stopped as soon as possible. The existing 30 second criteria for dropping to the low rate squitter is not ideal for use as a determining factor. This Working Paper proposes to use a cutoff velocity for declaring that the aircraft is stopped.

1. Introduction

The ATSA SURF and RFG APT applications would like to know when the aircraft is stopped as soon as possible. The existing surface movement field does not currently have an encoding to communicate stopped. The existing 30 second criteria for dropping to the low rate squitter is not ideal for use as a determining factor. This Working Paper proposes to use a cutoff velocity for declaring that the aircraft is stopped.

2. Discussion

RTCA SC-186 WG-1 and the RFG APT Subgroup has requested that there be an indication that the aircraft has stopped. They are concerned that the existing definition of the movement field allows for positive ground speeds to be reported because the noise of the measurements can be greater than the 0.125 knots given in the table. One of their initial proposals was to use the 30 second criteria for low squitter rate to trigger this indication. This is not ideal as it requires a considerable amount of time to indicate during which the receive application may extrapolate the aircraft inappropriately. Some of this can be solved on the receive side by choosing how to use the surface movement field. However, a few minor adjustments to the transmit side should accommodate the WG-1 request with relatively little impact to DO-260B.

One of the more problematic issues that WG-1 is dealing with regards stopping at hold lines while facing an active runway. The geometry of this situation is such that a non-zero velocity extrapolated over a few seconds results in a false alert because the extrapolated traffic appears to be on the runway. Given that problem, it seems prudent to explore a cutoff velocity below which the aircraft is considered stopped that is greater than that in the existing definition.

When on the surface, it is desirable for the aircraft to report heading. A consideration here is that many light aircraft do not have a heading source available. Those aircraft will report GPS track angle. Since the extrapolation of their position by a receiver is based on the ground speed and track angle, it is useful to consider the limitations. Although the GPS N/S E/W Velocity can be accurate to less than a knot, many GPS receivers' track angle becomes unusable below 7 knots. For inertials, the track angle typically is marked invalid below 20 knots. Without a valid track angle, the ground speed isn't of much use to a receive application. For these types of installations, it is a useful approximation to consider the aircraft stopped below a ground speed that provides a valid track angle. At those speeds, it will cover very little distance in the time between squitter updates even in high interference environments. This will delay an alert in the event that the aircraft does not actually stop and enters an active runway. The risk should be quantified and validated by WG-1. Alerting algorithms are always a compromise between missed alerts and time-to-alert/false alerts. Qualitatively, this approach should significantly reduce false alerts at the cost of a few seconds of time-to-alert and a small risk of a missed alert, presuming that the link is behaving reliably.

For installations that do report heading, the situation is a little different. It may be possible to use the N/S E/W Velocity to establish that the aircraft is stopped at values closer to zero. The time-to-alert benefit you would gain from this over the larger value is probably small. However, the proposed language should not prohibit this.

For reference the definition of the Movement field from DO-260A appears here.

2.2.3.2.4.2 "Movement" Subfield in ADS-B Surface Position Messages

The "Movement " subfield is a 7-bit ("ME" bits 6 through 12, Message bits 38 through 44) field that **shall** be used to encode information regarding the status of "Movement" of the ADS-B Transmitting Subsystem in accordance with the coding provided in Table 2- 18.

Table 2-18: "Movement" Subfield Code Definitions

Coding (Decimal)	**Meaning**	**Quantization**
0	No Movement Information Available	
1	Aircraft Stopped (Ground Speed < 0.2315 km/h (0.125 knots))	
2 – 8	0.2315 km/h (0.125 kt) < Ground Speed < 1.852 km/h (1 kt)	0.2315 km/h (0.125 kt) steps
9 – 12	1.852 km/h (1 kt) < Ground Speed < 3.704 km/h (2 kt)	0.463 km /h (0.25 kt) steps
13 – 38	3.704 km/h (2 kt) < Ground Speed < 27.78 km/h (15 kt)	0.926 km/h (0.50 kt) steps
39 – 93	27.78 km/h (15 kt) < Ground Speed < 129.64 km/h (70 kt)	1.852 km/h (1.00 kt) steps
94 – 108	129.64 km/h (70 kt) < Ground Speed < 185.2 km/h (100 kt)	3.704 km/h (2.00 kt) steps
109 – 123	185.2 km/h (100 kt) < Ground Speed < 324.1 km/h (175 kt)	9.26 km/h (5.00 kt) steps
124	324.1 km/h (175 kt) < Ground Speed	
125	Reserved for Aircraft Decelerating	
126	Reserved for Aircraft Accelerating	
127	Reserved for Aircraft Backing-Up	

Notes:

1. *The data encoding represented in Table 2-18 represents a non-linear encoding:therefore, encoding is performed exactly as specified in the table.*
2. *The last three movement encodings (125, 126, 127) are reserved to indicate high levels of ground speed change, etc. The precedence of the codes is not defined yet as inputs that would be required are not currently available.*

I do not propose changing this table as that will affect backwards compatibility. Instead, I propose some clarification for how to set this field based on the velocity source on the aircraft.

The following section of DO-260A covers how to set the movement field. I have marked up this paragraph with proposed changes highlighted.

2.2.5.1.9 Ground Speed Data

a. The ADS-B Transmitting Subsystem **shall** accept own vehicle Ground Speed information via an appropriate variable data input interface and use such data to establish the "Movement" subfield (see §2.2.3.2.4.2) in the Surface Position Message as specified in §2.2.3.2.4.2.

For each source of Ground Speed, establish a cutoff value below which the movement field shall be encoded as 1 (aircraft stopped).

The aircraft stopped cutoff value shall be less than or equal to 7 knots for GNSS equipment.

The aircraft stopped cutoff value shall be less than or equal to 20 knots for other equipment.

***Note**: The cutoff value should be chosen such that the noise of the measurement does not cause the movement field to indicate a stopped aircraft is moving.*

b. If Ground Speed data is not available to the ADS-B Transmitting Subsystem, then the device **shall** enter ALL ZEROs into the Movement subfield specified in §2.2.3.2.4.2.

c. Ground Speed may be used in conjunction with Ground Track data to arithmetically establish East/West Velocity Data (see §2.2.5.1.2) and North/South Velocity Data (see §2.2.5.1.3) if East/West and/or North/South Velocity Data is not available.

(1). When Ground Speed data is used as provided in subparagraph "c," the NAC_V (see §2.2.5.1.20) data reported by the ADS-B Transmitting Subsystem **shall** be consistent with the accuracy, range, and resolution that can be obtained by using Ground Speed data as the input data to the arithmetic computations necessary.

(2). When Ground Speed data is used as provided in subparagraph "c," but Ground Speed Data is not available to the ADS-B Transmitting Subsystem, then the device **shall** enter ALL ZEROs into all transmitted subfields that are computed based on Ground Speed data.

The following section of DO-260A covers how to set the track angle field. This section already addresses the issues with track angle at low speed. I propose no changes to this section.

2.2.5.1.10 Heading/Ground Track Data

The ADS-B Transmitting Subsystem **shall** accept own vehicle Heading/Ground Track information via an appropriate variable data input interface and use such data to establish subfields in transmitted ADS-B Messages as follows:

a. The "Status Bit for Heading/Ground Track" subfield in the Surface Position Message (See §2.2.3.2.4) as specified in §2.2.3.2.4.3,

b. The "Heading/Ground Track" subfield in the Surface Position Message (see §2.2.3.2.4.2) as specified in §2.2.3.2.4.4,

c. If Heading/Ground Track data is not available to the ADS-B Transmitting Subsystem, then the device shall enter ALL ZEROs into the "Status Bit for Heading/Ground Track" and "Heading" subfields specified in §2.2.3.2.4.3 and §2.2.3.2.4.4 respectively,

d. Heading/Ground Track may be used in conjunction with Ground Speed data to arithmetically establish East/West Velocity Data (see §2.2.5.1.2) and North/South Velocity Data (see §2.2.5.1.3) if East/West and/or North/South Velocity Data is not available.

(1). When Heading/Ground Track data is used, the NAC_V (see §2.2.5.1.20) data reported by the ADS-B Transmitting Subsystem **shall** be consistent with the accuracy, range, and resolution that can be obtained by using Heading data as the input data to the arithmetic computations necessary.

(2). When Heading/Ground Track data is used, but Heading/Ground Track Data is not available to the ADS-B Transmitting Subsystem, then the device **shall** enter ALL ZEROs into all transmitted subfields that are computed based on Heading/Ground Track data.

Notes:

1. *Ground Track data may be unreliable at low ground speeds. At very low ground speeds, the best estimate of an aircraft's or ground vehicle's ground track angle may be from a heading source rather than from the "track angle" output of a GNSS receiver.*

2. *If a source of A/V Heading **is not** available to the ADS-B Transmitting Subsystem, but a source of Ground Track angle **is** available, then Ground Track angle may be used instead of Heading, provided that the "Status Bit for Heading/Ground Track" subfield is set to ZERO whenever the Ground Track angle is not a reliable indication of the A/V's heading. (The Ground Track angle is not a reliable indication of the A/V's heading when the A/V's ground speed is close to ZERO.)*

3. Recommendations

The Working Group is requested to consider the proposals in section 2 for inclusion in DO-260B.

If accepted, test procedure section text will be provided in an update to this Working Paper.