RTCA Special Committee 186, Working Group 3

ADS-B 1090 MOPS, Revision A

Meeting #4

ACTION ITEM 3-10

Proposed Changes to Appendix A for TIS-B

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SUMMARY
Formats for TIS-B on 1090 MHz have been reviewed at previous WG-3 meetings. This working paper proposes material for subparagraphs A.7.3 and A.7.5 to accommodate the 12-bit CPR encoding for TIS-B.

1.0 Introduction

At the Phoenix meeting, the Working Group agreed to begin the documentation of TIS-B by assigning an action item to propose appendix material for this service. The intended approach was to add this material to Appendix A. However, on closer examination, it became evident that the TIS-B material should reside in its own appendix.

Because the fine TIS-B messages are closely related to the ADS-B messages, the TIS-B appendix will have numerous references to Appendix A. For this reason, it is desirable that the TIS-B appendix is physically close to Appendix A to make it easier to follow these references. To accomplish this purpose without renaming any existing appendices, it is proposed that the TIS-B appendix be labeled "A1." This proposed Appendix A1 is referenced in 1090-WP-4-08.

2.0 Proposed Changes to Appendix A.

A change is also required to paragraphs A.7.3 and A.7.5 to accommodate the 12-bit CPR encoding for TIS-B. A proposed change for these paragraphs is included in the following text.

A.7.3 CPR Encoding Process

The CPR encoding process shall calculate the encoded position values XZ_i and YZ_i for either airborne, surface, ~~or~~ TCP, TCP+1, or TIS latitude and longitude fields from the global position *lat* (latitude in degrees), *lon* (longitude in degrees), and the CPR encoding type *i* (0 for even format and 1 for odd format), by performing the following sequence of computations. The CPR encoding for TCP, TCP+1 always uses the even format (i = 0), whereas the airborne, ~~and~~ surface, and TIS encoding use both even (i = 0) and odd (i = 1) formats.

a. $Dlat_i$ (the latitude zone size in the N-S direction) is computed from the equation:

$$Dlat_i = \frac{360°}{4 \cdot NZ - i}$$

b. YZ_i (the Y-coordinate within the Zone) is then computed from $Dlat_i$ and *lat* using separate equations:

For airborne encoding:
$$YZ_i = \text{floor}\left(2^{17} \cdot \frac{\text{MOD}(lat, Dlat_i)}{Dlat_i} + \frac{1}{2} \right)$$

For surface encoding:
$$YZ_i = \text{floor}\left(2^{19} \cdot \frac{\text{MOD}(lat, Dlat_i)}{Dlat_i} + \frac{1}{2} \right)$$

For TCP, TCP+1 encoding:
$$YZ_0 = \text{floor}\left(2^{14} \cdot \frac{\text{MOD}(lat, Dlat_0)}{Dlat_0} + \frac{1}{2} \right)$$

For TIS encoding:
$$YZ_i = \text{floor}\left(2^{12} k \cdot \frac{\text{MOD}(lat, Dlat_i)}{Dlat_i} + \frac{1}{2} \right)$$

Where k=1 for airborne TIS and k=4 for surface TIS modes.

a. $Rlat_i$ (the latitude that a receiving ADS-B system will extract from the transmitted message) is then computed from *lat*, YZ_i, and $Dlat_i$ using separate equations:

For airborne encoding:
$$Rlat_i = Dlat_i \cdot \left(\frac{YZ_i}{2^{17}} + \text{floor}\left(\frac{lat}{Dlat_i} \right) \right)$$

For surface encoding:
$$Rlat_i = Dlat_i \cdot \left(\frac{YZ_i}{2^{19}} + \text{floor}\left(\frac{lat}{Dlat_i} \right) \right)$$

For TCP, TCP+1 encoding:
$$Rlat_0 = Dlat_0 \cdot \left(\frac{YZ_i}{2^{14}} + \text{floor}\left(\frac{lat}{Dlat_0} \right) \right)$$

a. $Dlon_i$ (the longitude zone size in the E-W direction) is then computed from $Rlat_i$ using the equation:

$$Dlon_i = \begin{cases} \dfrac{360°}{\mathrm{NL}(Rlat_i) - i}, & \text{when } \mathrm{NL}(Rlat_i) - i > 0 \\ 360°, & \text{when } \mathrm{NL}(Rlat_i) - i = 0 \end{cases}$$

b. XZ_i (the X-coordinate within the Zone) is then computed from *lon* and $Dlon_i$ using separate equations:

For airborne encoding:
$$XZ_i = \mathrm{floor}\left(2^{17} \cdot \frac{\mathrm{MOD}(lon, Dlon_i)}{Dlon_i} + \frac{1}{2}\right)$$

For surface encoding:
$$XZ_i = \mathrm{floor}\left(2^{19} \cdot \frac{\mathrm{MOD}(lon, Dlon_i)}{Dlon_i} + \frac{1}{2}\right)$$

For TCP, TCP+1 encoding:
$$XZ_0 = \mathrm{floor}\left(2^{14} \cdot \frac{\mathrm{MOD}(lon, Dlon_0)}{Dlon_0} + \frac{1}{2}\right)$$

For TIS encoding:
$$XZ_i = \mathrm{floor}\left(2^{12} k \cdot \frac{\mathrm{MOD}(lon, Dlon_i)}{Dlon_i} + \frac{1}{2}\right)$$

Where k=1 for airborne TIS and k=4 for surface TIS modes.

a. Finally, limit the values of XZ_i and YZ_i to fit in the 17-bit ~~or,~~ 14-bit or 12-bit field allotted to each coordinate:

For airborne encoding:
$$YZ_i = \mathrm{MOD}(YZ_i, 2^{17}),$$
$$XZ_i = \mathrm{MOD}(XZ_i, 2^{17})$$

For surface encoding:
$$YZ_i = \mathrm{MOD}(YZ_i, 2^{17}),$$
$$XZ_i = \mathrm{MOD}(XZ_i, 2^{17})$$

For TCP, TCP+1 encoding:
$$YZ_0 = \mathrm{MOD}(YZ_0, 2^{14}),$$
$$XZ_0 = \mathrm{MOD}(XZ_0, 2^{14})$$

For TIS encoding:
$$YZ_i = \mathrm{MOD}(YZ_i, 2^{12}),$$
$$XZ_i = \mathrm{MOD}(XZ_i, 2^{12})$$

A.7.5 Computations for the Airborne, ~~Message and~~ TCP, ~~TCP+1~~and TIS Messages

The following computations shall be performed to obtain the decoded lat/lon for the airborne, ~~and~~ TCP, TCP+1, and TIS message formats. For the TCP, TCP+1 format, *i* is always 0 (even encoding), whereas the airborne and TIS format~~s~~ use~~s~~ both even (*i* = 0) and odd (*i* = 1) encoding~~s~~. For the airborne format, *Nb* = 17, ~~and~~ for the TCP, TCP+1 format, *Nb* = 14, and for TIS *Nb* =12~~.~~

a. $Dlat_i$ is computed from the equation:

$$Dlat_i = \frac{360° / k}{4 \cdot NZ - i}$$

where *k=1* for all modes except TIS surface mode when *k=4.*

b. The latitude zone index number, *j*, is then computed from the values of lat_s, $Dlat_i$ and YZ_i using the equation:

$$j = \text{floor}\left(\frac{lat_s}{Dlat_i}\right) + \text{floor}\left(\frac{1}{2} + \frac{\text{MOD}(lat_s, Dlat_i)}{Dlat_i} - \frac{YZ_i}{2^{Nb}}\right)$$

c. The decoded position latitude, $Rlat_i$, is then computed from the values of *j*, $Dlat_i$, and YZ_i using the equation:

$$Rlat_i = Dlat_i \cdot \left(j + \frac{YZ_i}{2^{Nb}}\right)$$

d. $Dlon_i$ (the longitude zone size in the E-W direction) is then computed from $Rlat_i$ using the equation:

$$Dlon_i = \begin{cases} \dfrac{360° / k}{\text{NL}(Rlat_i) - i}, & \text{when } \text{NL}(Rlat_i) - i > 0 \\ 360° / k, & \text{when } \text{NL}(Rlat_i) - i = 0 \end{cases}$$

where *k=1* for all modes except TIS surface mode when *k=4.*

e. The longitude zone coordinate *m* is then computed from the values of lon_s, $Dlon_i$, and XZ_i using the equation:

$$m = \text{floor}\left(\frac{lon_s}{Dlon_i}\right) + \text{floor}\left(\frac{1}{2} + \frac{\text{MOD}(lon_s, Dlon_i)}{Dlon_i} - \frac{XZ_i}{2^{Nb}}\right)$$

f. The decoded position longitude, $Rlon_i$, is then computed from the values of *m*, XZ_i, and $Dlon_i$ using the equation:

$$Rlon_i = Dlon_i \cdot \left(m + \frac{XZ_i}{2^{Nb}}\right)$$

Figure 1 Special TIS-B Airborne Position Format

1	
2	
3	FORMAT TYPE CODE
4	(See A.4.1 and Note 1)
5	
6	SURVEILLANCE STATUS
7	
8	Reserved
9	
10	
11	ALTITUDE
12	Specified by the Format Type Code
13	
14	(1) the altitude code (AC) as specified
15	in section 2.2.13.1.2 of DO-181B but
16	with the M-bit removed
17	(Ref ARINC 429 Label 203), or
18	
19	(2) GNSS height (HAE)
20	(Ref. ARINC 429 Label 370)
21	Mode S = 0, ATCBS = 1
22	CPR FORMAT (F) (See A.4.2.1)
23	MSB
24	
25	
26	
27	
28	
29	
30	ENCODED LATITUDE
31	
32	(CPR Airborne Format
33	See A.7.1 to A.7.5)
34	
35	
36	
37	
38	
39	LSB
40	MSB
41	
42	
43	
44	
45	
46	
47	ENCODED LONGITUDE
48	
49	(CPR Airborne Format
50	See A.7.1 to A.7.4)
51	
52	
53	
54	
55	
56	LSB

Purpose: To provide accurate airborne position information

Surveillance Status coding
0 = no condition information
1 = permanent alert (emergency condition)
2 = temporary alert (change in Mode A identity code other than emergency condition) applies to Mode S Aircraft only
3 = SPI condition

Codes 1 and 2 take precedence over code 3.

Figure 2 Special TIS-B Surface Position Format

BDS 0,6

1	
2	
3	FORMAT TYPE CODE
4	(See A.4.1)
5	
6	
7	
8	
9	MOVEMENT
10	(See A.4.3.1)
11	
12	
13	STATUS for Gnd Tk (1 =valid, 0 = not valid)
14	MSB
15	
16	GROUND TRACK (7 bits)
17	(See A.4.3.2)
18	
19	**Resolution = 360/128 deg**
20	LSB
21	Mode S = 0, ATCBS = 1
22	CPR FORMAT (F) (See A.4.2.1)
23	MSB
24	
25	
26	
27	
28	
29	
30	ENCODED LATITUDE
31	
32	(CPR Surface Format
33	See A.7.1 to A.7.4 and 7.6)
34	
35	
36	
37	
38	
39	LSB
40	MSB
41	
42	
43	
44	
45	
46	
47	ENCODED LONGITUDE
48	
49	(CPR Surface Format
50	See A.7.1 to A.7.4)
51	
52	
53	
54	
55	
56	LSB

Purpose: To provide accurate surface position information.

Figure 3 Standard TIS-B Airborne Format

BDS 0,5

1	Mode S = 0, ATCBS = 1
2	No Emergency=0, Emergency=1
3	
4	**SITE II CODE**
5	
6	
7	MSB
8	
9	
10	
11	
12	VELOCITY
13	
14	
15	
16	
17	
18	
19	LSB
20	
21	ALTITUDE
22	Specified by the Format Type Code
23	
24	(1) the altitude code (AC) as specified
25	in section 2.2.13.1.2 of DO-181B but
26	with the M-bit removed
27	(Ref ARINC 429 Label 203), or
28	
29	(2) GNSS height (HAE)
30	(Ref. ARINC 429 Label 370)
31	
32	CPR FORMAT (F) (See A.4.2.1)
33	MSB
34	
35	
36	
37	ENCODED LATITUDE
38	
39	(CPR Airborne Format
40	See A.7.1 to A.7.5)
41	
42	
43	
44	LSB
45	MSB
46	
47	
48	
49	ENCODED LONGITUDE
50	
51	(CPR Airborne Format
52	See A.7.1 to A.7.4)
53	
54	
55	
56	LSB

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