RTCA SC-186 WG3

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Position Offset Adjustment Performance

Revision 1

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Summary

The requirement for the Position Offset Adjustment in DO-260A does not include a performance requirement. This paper proposes that if POA is implemented, it should be accurate to within 3 meters including the effects of the internal calculation and the rounding of the True Heading to the transmitted resolution of 2.8125 degrees. This 3 meters is intended to be additional error budget over the transmitted NAC_P value. Thus a receiving application wishing to know the entire transmit system error would need to add an additional 3 meters to the NAC_P quantization value when the POA bit is set.

1. Introduction

The requirement for the Position Offset Adjustment in DO-260A does not include a performance requirement. The preliminary Surface Alert work that Honeywell and other companies are involved in suggests that the Position Offset Adjustment is necessary in order to perform this application. Honeywell is proposing to add a performance requirement to DO-260A so that vendors know what accuracy to design to when implementing the Position Offset Adjustment.

This version of the paper includes requirements changes and test paragraphs.

2. Discussion

Honeywell is currently working with FAA on initial requirements for the SURF ALERT application. The preliminary work suggests that the Position Offset Adjustment is necessary for large aircraft in order for the application to work more effectively.

If manufacturers are going to implement the Position Offset Adjustment, there should be a performance requirement so the users of the position data know what accuracy they can expect and the performance is consistent across implementations.

In order to do the position offset adjustment, you need to have the following data: extrapolated latitude, extrapolated longitude, aircraft True Heading, GPS Antenna Distance from Nose, and Aircraft Length/Width Code. It is important that the True Heading be rounded to the resolution of the transmitted message (2.8125 deg LSB) before doing the offset calculation. This minimizes the error on the receive side if they attempt to compute the position of the nose of the aircraft. It turns out that this rounding of the heading is the largest contribution of calculation error. If you use the worst case Aircraft Length (200 m), the cross-track error introduced by a lever arm of L/2 (100 m) and half of the True Heading LSB (1.40625 deg) is 100*sin(1.40625 deg) = 2.454 meters.

I propose that the GPS Antenna Position from the nose of the aircraft be specified as +/- 1 meter. This can be realized on the existing ARINC 718A connector for federated air transport aircraft with a table of 2 meter increments. The actual antenna position is rounded to the nearest 2 meter quantization.

If you root sum square 2.454 meters with 1 meter, you get 2.65 meters. This is the error due to the max cross-track and along track resolution issues.

I propose that the calculation error be allowed an additional 0.35 meters. To validate this I have implemented a 32 bit fixed point calculation at Honeywell that performs well below this bound. This limits the error due to resolution and calculation to 3 meters.

I do not propose any requirement on the heading accuracy at this point. The heading error is subject to many local effects so in practice would be difficult to maintain. I propose that any certified digital heading source that can provide True Heading is adequate for the purposes of this calculation.

The following paragraph is the existing text from DO-260A with proposed changes marked.

2.2.3.2.7.2.3.7 "Position Offset Applied" CC Code Subfield in Surface Aircraft Operational Status Messages

The "Position Offset Applied" (POA) subfield of the CC Code subfield of the "surface" format Aircraft Operational Status Message (TYPE=31, Subtype=1) is a one-bit Boolean flag that the ADS-B Transmitting Subsystem shall set to ONE as specified in Table 2-67 if the position that it is transmitted in the ADS-B Surface Position Message (§2.2.3.2.4) is known to be the position of the ADS-B participant's ADS-B Position Reference Point (RTCA DO-242A, §3.4.4.9.7) rather than, for example, the position of the antenna of the navigation receiver. Otherwise, the ADS-B Transmitting Subsystem shall set this flag to ZERO.

Table 2-67: Position Offset Applied (POA) Encoding

Coding	Meaning
0	The position transmitted in the Surface Position Message is not known to be referenced to the ADS-B Position Reference Point of the A/V
1	The position transmitted in the Surface Position Message is known to be referenced to the ADS-B Position Reference Point of the A/V

If the POA subfield is set, True Heading shall be used to compute the ADS-B Position Reference Point. The True Heading shall be rounded to the Surface Squitter field resolution prior to computing the ADS-B Position Reference Point. If the POA subfield is set, the error due to resolution and calculation effects shall not exceed 3 meters.

Note: Rounding True Heading prior to computing the ADS-B Reference Point minimizes the error on the receive side when the position of the aircraft nose is computed. Magnetic Heading is not permitted to perform this calculation due to additional error induced by the local Magnetic Variation. True Track is not permitted to perform this calculation due to poor availability and accuracy when the aircraft is stopped.

Note: Error induced by the sensor measurements provided to the ADS-B Transmit subsystem are not included in the 3 meters.

Note: The 3 meter error budget here is additional error over and above that reported in the NACp. So a receive application would need to add 3 meters to the reported NACp quantization value in order to know the total transmit system accuracy.

The following text is intended to replace section 2.4.3.2.7.2.3.7.

2.4.3.2.7.2.3.7 Verification of the "Position Offset Applied" CC Code Subfield in Surface Aircraft Operational Status Messages (§2.2.3.2.7.2.3.7)

Configure the ADS-B Transmitting Subsystem to transmit Aircraft Operational Status Messages by providing valid trajectory information at the nominal update rate. Provide the data externally at the interface to the ADS-B system and simulate a message coming from an aircraft that does not have a known position reference point that includes that position in an ADS-B Surface Position Message.

Verify that ME bit 11 is set to ZERO (0). Repeat this step simulating a message coming from an aircraft that has a known position reference point that includes that position in an ADS-B Surface Position Message and verify that ME bit 11 is set to ONE (1).

Provide the system with the information from the first row of Table 2-xxx. Set North/South Velocity and East/West Velocity to zero to prevent the system from extrapolating. Set the aircraft state to On-Ground. Validate that the Surface Squitter Encodings match the values given in the first row of Table 2-yyy plus or minus 1 LSB. Repeat this for all 48 rows of Table 2-xxx and Table 2-yyy.

Table 2-xxx - POA Input Parameters

Case	Latitude (deg)	Longitude (deg)	Heading (deg)	GPS Antenna Distance from Nose (meters)	Aircraft Length Quantization (meters)
1	0.0	0.0	0.0	2	200
2	0.0	0.0	45.0	2	200
3	0.0	0.0	90.0	2	200
4	0.0	0.0	135.0	2	200
5	0.0	0.0	-180.0	2	200
6	0.0	0.0	-135.0	2	200
7	0.0	0.0	-90.0	2	200
8	0.0	0.0	-45.0	2	200
9	0.0	-180.0	6.0	10	15
10	0.0	-180.0	51.0	10	15
11	0.0	-180.0	96.0	10	15
12	0.0	-180.0	141.0	10	15
13	0.0	-180.0	-174.0	10	15
14	0.0	-180.0	-129.0	10	15
15	0.0	-180.0	-84.0	10	15
16	0.0	-180.0	-39.0	10	15
17	87.0	90.0	12.0	42	75
18	87.0	90.0	57.0	42	75
19	87.0	90.0	102.0	42	75
20	87.0	90.0	147.0	42	75
21	87.0	90.0	-168.0	42	75
22	87.0	90.0	-123.0	42	75
23	87.0	90.0	-78.0	42	75
24	87.0	90.0	-33.0	42	75
25	-87.0	-90.0	18.0	13	35
26	-87.0	-90.0	63.0	13	35
27	-87.0	-90.0	108.0	13	35
28	-87.0	-90.0	153.0	13	35
29	-87.0	-90.0	-162.0	13	35
30	-87.0	-90.0	-117.0	13	35
31	-87.0	-90.0	-72.0	13	35
32	-87.0	-90.0	-27.0	13	35
33	36.0	-100.0	24.0	6	55
34	36.0	-100.0	69.0	6	55
35	36.0	-100.0	114.0	6	55
36	36.0	-100.0	159.0	6	55
37	36.0	-100.0	-156.0	6	55
38	36.0	-100.0	-111.0	6	55
39	36.0	-100.0	-68.0	6	55
40	36.0	-100.0	-21.0	6	55
41	-36.0	140.0	30.0	26	45
42	-36.0	140.0	75.0	26	45
43	-36.0	140.0	120.0	26	45
44	-36.0	140.0	165.0	26	45
45	-36.0	140.0	-150.0	26	45
46	-36.0	140.0	-105.0	26	45
47	-36.0	140.0	-60.0	26	45
48	-36.0	140.0	-15.0	26	45

Table 1-yyy - POA Output Parameters

Case	Adjusted Latitude (deg)	Adjusted Longitude (deg)	Airborne Even Yz	Airborne Even Xz	Airborne Odd Yz	Airborne Odd Xz	Surface Even Yz	Surface Even Xz	Surface Odd Yz	Surface Odd Xz
1	-0.0008803143	0.0000000000	131053	0	131053	0	130995	0	130996	0
2	-0.0006224762	-0.0006224762	131058	131059	131059	131059	131018	131019	131019	131019
3	0.0000000000	-0.0008803143	0	131053	0	131053	0	130996	0	130998
4	0.0006224762	-0.0006224762	14	131059	13	131059	54	131019	53	131019
5	0.0008803143	0.0000000000	19	0	19	0	77	0	76	0
6	0.0006224762	0.0006224762	14	13	13	13	54	53	53	53
7	0.0000000000	0.0008803143	0	19	0	19	0	76	0	74
8	-0.0006224762	0.0006224762	131058	13	131059	13	131018	53	131019	53
9	0.0000223489	-179.9999977988	0	65536	0	0	2	0	2	0
10	0.0000142466	-179.9999826405	0	65536	0	0	1	1	1	1
11	-0.0000022012	-179.9999776511	0	65536	0	0	0	2	0	2
12	-0.0000173595	-179.9999857534	0	65536	0	0	131070	1	131071	1
13	-0.0000223489	-180.0000022012	0	65536	0	0	131070	0	131070	0
14	-0.0000142466	-180.0000173595	0	65536	0	0	131071	131071	131071	131071
15	0.0000022012	-180.0000223489	0	65536	0	0	0	131070	0	131070
16	0.0000173595	-180.0000142466	0	65536	0	0	2	131071	1	131071
17	87.0000396459	90.0001506814	65537	32768	33861	32768	3	0	4372	0
18	87.0000224576	90.0006422002	65536	65536	33861	32768	2	1	4371	1
19	86.9999921139	90.0007575268	65536	65537	33860	32768	131071	2	4368	1
20	86.9999663898	90.0004291044	65535	65536	33860	32768	131069	1	4366	1
21	86.9999603541	89.9998493186	65535	65536	33859	32768	131069	0	4366	0
22	86.9999775424	89.9993577998	65536	65536	33860	32768	131070	131070	4367	131071
23	87.0000078861	89.9992424732	65536	65535	33860	32768	1	131071	4370	131071
24	87.0000336102	89.9995708956	65537	32768	33861	32768	3	131071	4372	131071
25	-87.0000386820	-90.0002242065	65535	98304	97211	98304	131069	0	126700	0
26	-87.0000190551	-90.0006811674	65536	65536	97211	98304	131070	131071	126701	131071
27	-86.9999882659	-90.0007391097	65536	65535	97212	98304	1	131070	126704	131071
28	-86.9999643505	-90.0003640916	65537	65536	97212	98304	3	131071	126706	131071
29	-86.9999613180	-89.9997757935	65537	65536	97213	98304	3	1	126706	0
30	-86.9999809449	-89.9993188326	65536	65536	97212	98304	2	2	126705	1
31	-87.0000117341	-89.9992608903	65536	65537	97211	98304	131071	1	126702	1
32	-87.0000356495	-89.9996359084	65535	98304	97211	98304	131069	1	126700	1

Case	Adjusted Latitude (deg)	Adjusted Longitude (deg)	Airborne Even Yz	Airborne Even Xz	Airborne Odd Yz	Airborne Odd Xz	Surface Even Yz	Surface Even Xz	Surface Odd Yz	Surface Odd Xz
33	35.9998254124	-100.0001020668	131068	87380	117961	123788	131057	87374	78628	101938
34	35.9999349364	-100.0002247673	131071	87377	117963	123786	131066	87366	78638	101930
35	36.0000825738	-100.0002158022	2	87378	117967	123787	7	87366	78650	101930
36	36.0001818406	-100.0000804230	4	87380	117969	123789	16	87376	78659	101939
37	36.0001745876	-99.9998979332	4	87383	117969	123792	15	87388	78658	101952
38	36.0000650636	-99.9997752327	1	87385	117966	123794	6	87397	78649	101960
39	35.9999260923	-99.9997794496	131070	87385	117963	123794	131066	87397	78637	101960
40	35.9998181594	-99.9999195770	131068	87383	117961	123792	131056	87387	78628	101950
41	-35.9999730332	140.0000199789	1	87382	13108	36409	2	87383	52431	14565
42	-35.9999923608	140.0000376971	0	87382	13107	36410	1	87384	52429	14566
43	-36.0000161633	140.0000333328	0	87382	13107	36409	131071	87384	52427	14566
44	-36.0000304976	140.0000094426	131071	87381	13107	36409	131069	87382	52426	14564
45	-36.0000269668	139.9999800211	131071	87381	13107	36409	131070	87380	52426	14562
46	-36.0000076392	139.9999623029	0	87381	13107	36408	131071	87379	52428	14561
47	-35.9999838367	139.9999666672	0	87381	13108	36408	1	87379	52430	14561
48	-35.9999695024	139.9999905574	1	87381	13108	36409	3	87381	52431	14563

3. Recommendations

WG3 is requested to consider adding the performance requirements for the Position Offset Adjustment to DO-260B.