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Improved CPR Encoding Tests

Martin Gray
Trig Avionics Limited

Al Marshall
Sensis

Summary
This Working Paper proposes a change in the way that CPR Encoding tests are performed at the NL Latitude Transition Points to improve test coverage in an area where there have been encoding errors seen in the field.

Purpose/Introduction

CPR is a bit-efficient method of communicating a Lat/Long position. In return for this coding efficiency, CPR adds complexity by requiring a series of calculations to be performed to calculate the encoded position.

A number of errors in the reported position have been seen in the field and vendors have addressed issues with implementations that pass the required DO260A/B tests, but report the incorrect position under certain conditions.

Al Marshall submitted an analysis of error conditions in 2006 and has written “A description of the CPR Algorithm” for inclusion as an Appendix in DO260B, which is a welcome addition to the MOPS.

Trig have performed testing triggered by Al’s papers and have determined that it is possible to report incorrect positions, primarily through incorrect zone calculations, whilst passing the tests in the MOPS. The identified issues have been errors in using INTEGER rather than FLOATING values and rounding errors in FLOATING point calculations.

It is possible that future CPR implementers may only run the required tests in the MOPS and not the tests implied by Al’s paper. We therefore propose some clarification notes and an additional test to exercise the CPR encoder.

An important point to identify is that the error conditions are quite dependent on the resolution and implementation of floating point in the encoding system. It is therefore not possible to prescribe universal test values. The tests require that the minimum system resolution is used in the testing. The system resolution is the position resolution based on GPS input position resolution, internal representation of the position and floating point math resolution.

Proposed Change

Change – section 2.4.3.2.4.7.1.1

2.4.3.2.4.7.1.1 Verification of Latitude Transition Points (§2.2.3.2.4.6, §2.2.3.2.4.7, §2.2.3.2.4.7.1, §2.2.5.1.7, §2.2.5.1.13, Appendix A.1.7)

Purpose/Introduction:

This test procedure verifies that the latitude transition points used in CPR encoding are properly computed or established to satisfy the equations provided in Appendix A,§A.1.7.2.d.

Measurement Procedure:

Step 1: Encode Lower Values

a. Set the input longitude value to 45.00 degrees East and keep it at that value for the duration of this test procedure.

b. For each line item in Table 2-130, set the input latitude value to the value provided in the lat_{low} column provided in Table 2-130.

c. Verify that the Even Surface Position latitude encoding agrees with the value provided in the "lower latitude" column of Table 2-130.

   If the latitude encoding does not agree with the Table 2-130 value, then proceed to subparagraph d.

   Otherwise, verify that the Even Surface Position longitude encoding agrees with the value provided in the "lower longitude" column of Table 2-130.

   If the Even Surface Position latitude and longitude encoding values agree with the values provided in the "lower latitude" and "lower longitude" columns of Table 2-130, then this portion of the test **shall** be considered as PASSED, $lat_{low\text{-}actual}$ shall be set to the input latitude used for this step for use in Step 3, and testing **shall** proceed with Step 2 below.

d. Increase or decrease, as appropriate, the input latitude value until the Surface Position latitude encoding agrees with the value provided in the "lower latitude" column of Table 2-130.

   Verify that the difference between the input latitude value and the lat_{low} value provided in Table 2-130 does not exceed 2^{-19} * 10 degrees.

   Verify that the Even Surface Position longitude encoding agrees with the value provided in the "lower longitude" column of Table 2-130.

   If the Even Surface Position latitude and longitude encoding values agree with the values provided in the "lower latitude" and "lower longitude" columns of Table 2-130, then this portion of the test **shall** be considered as

PASSED, $lat_{low\text{-}actual}$ shall be set to the input latitude used for this step for use in Step 3, and testing **shall** proceed with Step 2 below.

Step 2: Encode Upper Values

a. Set the input longitude value to 45.00 degrees East and keep it at that value for the duration of this test procedure.

b. For each line item in Table 2-130, set the input latitude value to the value provided in the lat_{up} column provided in Table 2-130.

c. Verify that the Even Surface Position latitude encoding agrees with the value provided in the "upper latitude" column of Table 2-130.

   If the latitude encoding does not agree with the Table 2-130 value, then proceed to subparagraph d.

   Otherwise, verify that the Even Surface Position longitude encoding agrees with the value provided in the "upper longitude" column of Table 2-130.

   If the Even Surface Position latitude and longitude encoding values agree with the values provided in the "upper latitude" and "upper longitude" columns of Table 2-130, then this portion of the test **shall** be considered as PASSED and $lat_{upper\text{-}actual}$ shall be set to the input latitude used for this step for use in Step 3, and testing shall proceed with Step 3 below.

d. Increase or decrease, as appropriate, the input latitude value until the Surface Position latitude encoding agrees with the value provided in the "upper latitude" column of Table 2-130.

   Verify that the difference between the input latitude value and the lat_{up} value provided in Table 2-130 does not exceed 2^{-19} * 10 degrees.

   Verify that the Even Surface Position longitude encoding agrees with the value provided in the "upper longitude" column of Table 2-130.

   If the Even Surface Position latitude and longitude encoding values agree with the values provided in the "upper latitude" and "upper longitude" columns of Table 2-130, then this portion of the test **shall** be considered as PASSED, $lat_{upper\text{-}actual}$ shall be set to the input latitude used for this step for use in Step 3, and testing shall proceed with Step 3 below.
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Step 3: Cross Transition Latitude

Note:
The transition latitude test table (Table 2-130) is presented in millionths of a degree and AWB format. Since other implementations with other resolution is are possible and allowed by this standard, the following test allows the input co-ordinates to be adjusted to correspond to the co-ordinate system used in the implementation under test.

The system position resolution is the minimum change in position due based on GPS input position resolution, internal representation of the position and floating point math resolution. This must be calculated for the implementation under test.

a. Set the input longitude value to 45.00 degrees East and keep it at that value for the duration of this test procedure.

b. For each lat_{low} in Table 2-130, perform the following action c) below.

c. Starting at $lat_{low\text{-}actual}$, increase the latitude in increments of the GPS input position resolution until $lat_{upper\text{-}actual}$ is reached. The test shall be considered PASS if the encoded latitude and longitude pair change from the lower values to the upper values only once and the latitude and longitude values change at the same change of GPS input position.