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An Expanded Description of the CPR Algorithm

Prepared by Al Marshall
Sensis Corporation

SUMMARY
This paper is intended to become an informative Appendix on the CPR encoding and decoding algorithms. The algorithms are described with diagrams, text and equations in a manner that is easier to understand than the necessarily terse description in Appendix A. No new requirements or test procedures are proposed.

1 Purpose

The purpose of this appendix is to provide explanations and derivations of the Compact Position Reporting (CPR) equations given in Appendix A. CPR encoding and decoding can be implemented without using any of the information in this appendix but, if a CPR implementation has problems, the information in this appendix may be helpful in resolving the issue.

2 Motivation for Compact Position Reporting

CPR) was developed for ADS-B messages broadcast on the 1090 MHz Extended Squitter (ES) datalink to reduce the number of bits required to convey participant latitude and longitude. Position resolution for ES messages is approximately 5.1 meters for airborne participants and 1.3 meters for surface participants (see Section 3). The circumference of the earth is approximately 40 000 kilometers so 40 000 000 m/5.1 m = ~7 800 000 discrete position values. 7 800 000 position values would require 23 bits in a message. Longitude is expressed over a range of 360° so longitude would require the full 23 bits. Latitude is expressed over a range of 180° so only 3 900 000 discrete position values or 22 bits would be required. Following similar reasoning, surface position would require 25 bits for longitude and 24 bits for latitude. CPR conveys position with 17 bits each for latitude and longitude plus 1 “CPR format” bit.

Table 2-1 Message bits required for position encoding with and without CPR

		Without CPR	With CPR	Bits Saved with CPR
Airborne Position	Latitude	22	17	
	Longitude	23	17	
	CPR Fmt	0	1	
	Total	45	35	10
Surface Position	Latitude	24	17	
	Longitude	25	17	
	CPR Fmt	0	1	
	Total	49	35	14

CPR saves 10 bits per position message for airborne participants and 14 bits per position message for surface participants. Position messages are broadcast twice per second under most conditions so CPR saves 20 bits/second for airborne participants and 28 bits/second for surface participants. The maximum message transmission rate allowed for each 1090ES ADS-B participant is 6.2 messages/sec. Of the 112 bits in each ES message, only 56 are available for the ADS-B payload. The first 5 ADS-B payload bits are reserved for the message type so 51 bits from each message are available for data. 51 bits/message multiplied by 6.2 messages/sec is 316 bits/second. CPR saves 6% - 9% of the available bits for other uses.

3 CPR Coordinate System

CPR can be thought of as a coordinate system and a set of coordinate transformation algorithms. The coordinate system is spherical and comparable to the latitude/longitude reference system commonly used for navigation. The coordinate transformation algorithms convert between latitude/longitude and CPR coordinates. The coordinate transformation algorithms are commonly called “CPR encoding” and “CPR decoding.”

In the CPR coordinate system, the globe is divided into zones. “Latitude zones” start at the equator and go to both poles. “Longitude zones” start at the Prime Meridian and proceed eastward around the globe. Latitude zones are approximately 360 nautical miles (NM) in height measured in the north-south direction. Longitude zones are approximately 360 NM in width measured in the east-west direction. The number of longitude zones is reduced as one moves from the equator to the poles to maintain approximately constant zone width.

There are two sets of slightly different sized zones in both latitude and longitude. One set of zones is called “even” and the other is called “odd.” Figure 3-1 and Figure 3-2 depict latitude and longitude zones on a global scale where the red lines represent even zone boundaries and the blue lines represent odd.

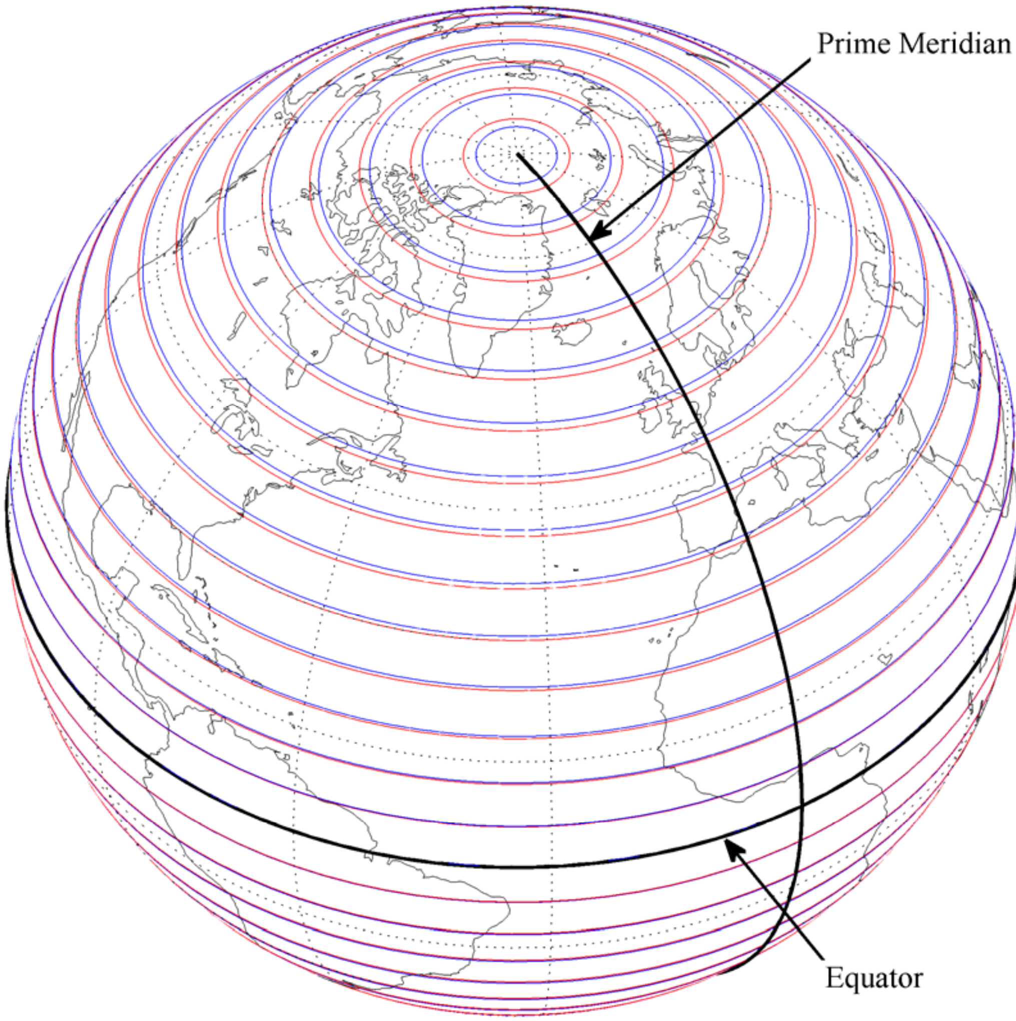


Figure 3-1 Latitude Zone Boundaries (Red is Even; Blue is Odd)

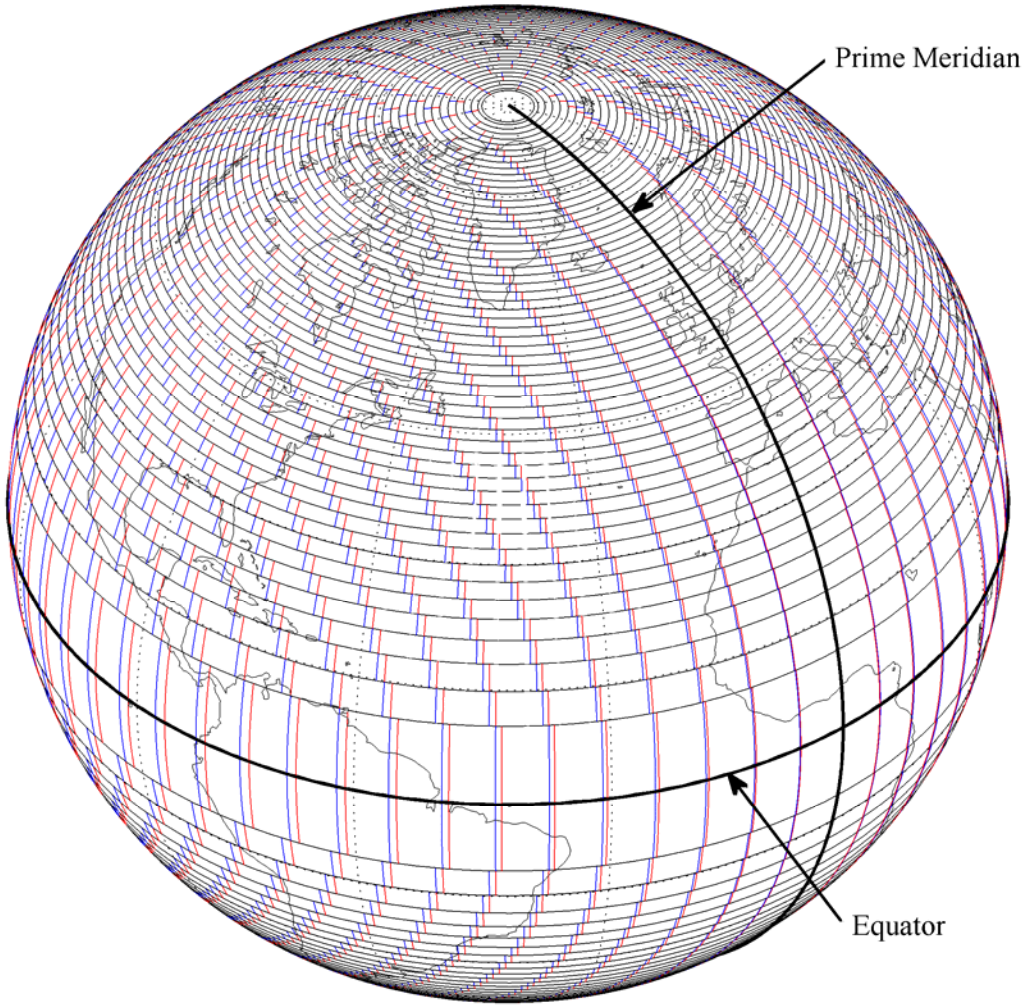


Figure 3-2 Longitude Zone Boundaries (Red is Even; Blue is Odd)

Each zone is identified with a zone index number. Imagine a tailor's tape measure marked with even and odd latitude zones as shown in the left side of Figure 3-3. The tape measure has $4NZ = 60$ even zones and $4NZ\text{-}1 = 59$ odd zones numbered beginning with zone index 0. The zone boundaries will line up at the beginning and end of the tape measure but nowhere else. The tape measure is wrapped around the globe starting with zone index 0 extending north from the equator. The tape passes over the north and south poles and returns to the equator as shown on the right side of Figure 3-3.

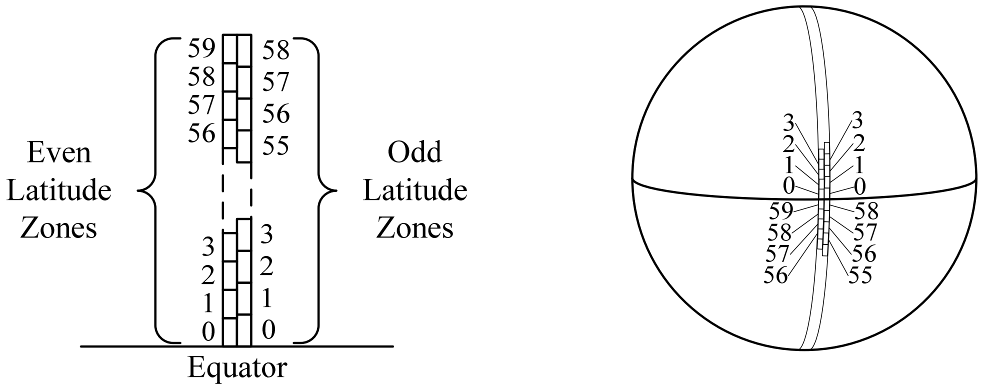


Figure 3-3 Latitude Zone Indexing

Longitude zone indexing is the same as latitude zone indexing except zone index 0 is just east of the Prime Meridian and the zone numbers increase in the eastward direction. As mentioned above, the number of longitude zones around the globe varies with latitude and this is reflected in the zone index numbers.

Latitude and longitude zones are divided into bins. Each zone contains 2^{Nb} equal sized bins. The value of *Nb* varies with the type of position being encoded. Bins are numbered starting with 0 at the southern edge of latitude zones and the western edge of longitude zones. More details on sizing are provided in the following sections.

Every point on the globe is identified in the CPR coordinate system with a latitude zone index, latitude bin number, longitude zone index, longitude bin number and CPR format (even or odd zone size).

3.1 Latitude Zones

Latitude zones are symmetrical about the equator. The height of a latitude zone is called $Dlat_i$. The subscript i has a value of 0 to indicate the height of an even zone or a value of 1 to indicate the height of an odd zone. $Dlat_i$ is defined in terms of the constant NZ. NZ is the number of even latitude zones in one quadrant of the globe and has a value of 15. The latitude zone size, $Dlat_i$, is determined with Eq 1.

$$Dlat_i = \frac{360°}{4NZ - i}$$ Eq 1

$NZ = 15$ [A.1.7.3 a]
$i = 0$ for even encoding
$i = 1$ for odd encoding

Since there are 4 quadrants around the globe, there are 60 even latitude zones and 59 odd zones. Even latitude zones are approximately 360 ~~nautical miles (nmi)~~ NM high and odd latitude zones are approximately 366 NM high measured in the north-south direction.

The definition of $Dlat_i$ is depicted in Figure 3-4.

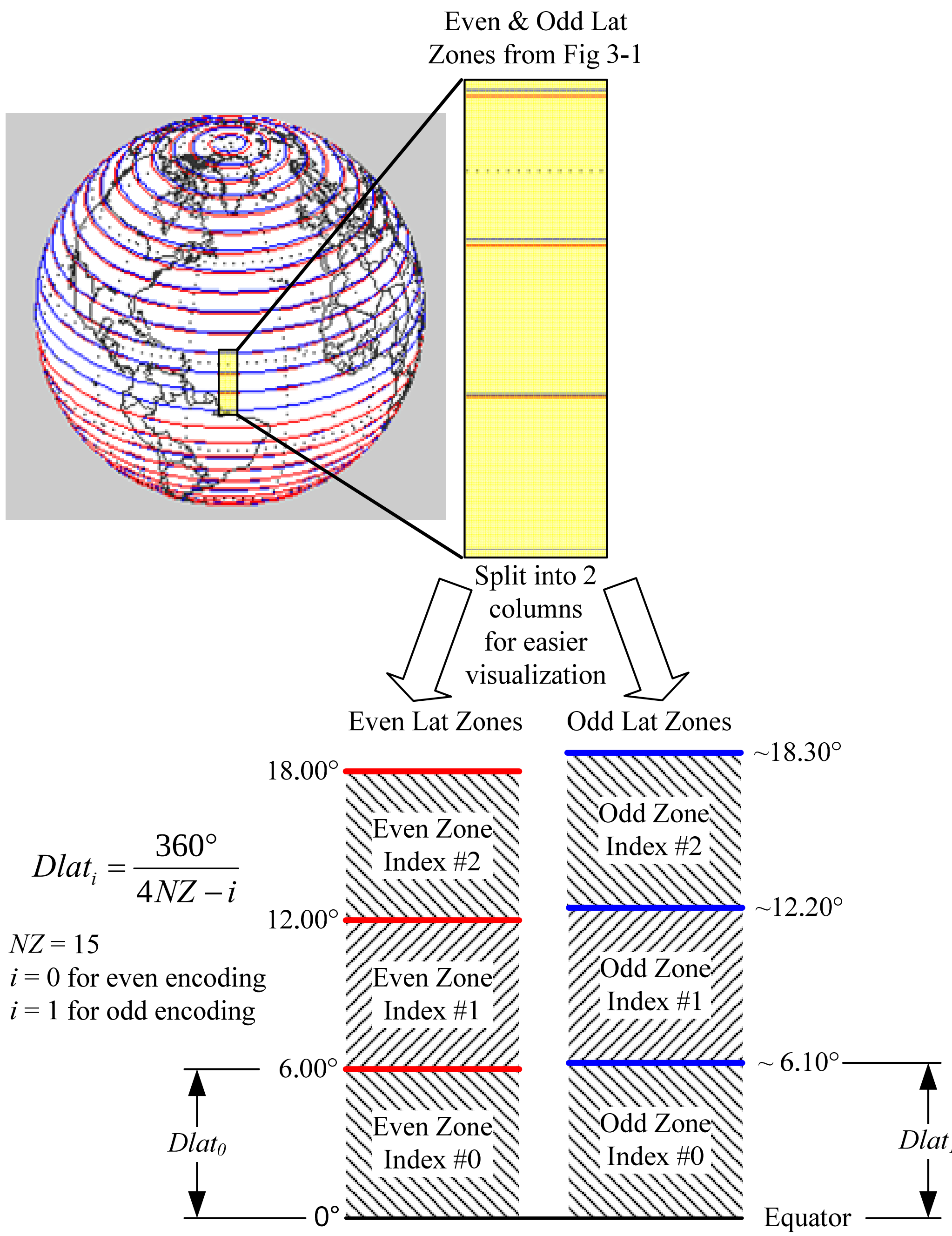


Figure 3-4 Definition of Latitude Zone Sizes

Latitude zones are divided into bins. There are 2^{Nb} bins in each latitude zone. Each latitude bin is identified by the integer bin number YZ_i. YZ_i is the bin number relative to the southern edge of the latitude zone (in both the northern and southern hemispheres). The subscript i indicates whether the value of YZ is relative to an even zone (i=0) or an odd zone (i=1). The CPR decoding algorithms produce a latitude value (a real number) from YZ_i which is the latitude at the centerline of the bin. This value is called the bin centerline latitude.

Figure 3-5 shows the relationship between latitude bins and zones.

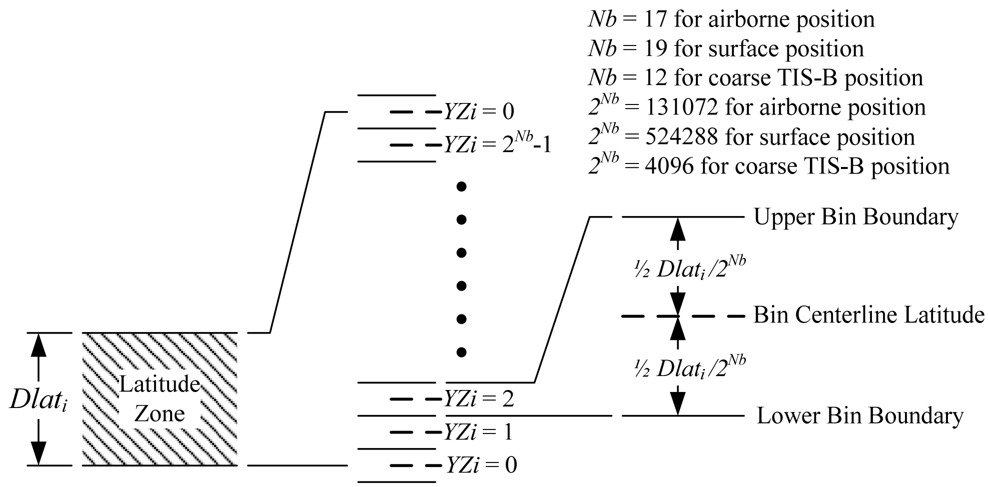


Figure 3-5 Latitude Zones and Bins

The bin height, which is equal to the encoding resolution, is the latitude zone height divided by the number of bins per zone. Section §A.1.7.2 defines the number of bits used for encoding to be 17 for airborne position, 19 for surface position and 12 for Coarse TIS-B position. The resulting bin sizes are shown in Table 3-1.

Table 3-1 - CPR Latitude Encoding Resolution

			Zone size (degrees)		Bin size (degrees)		Bin Size (meters)	
Position Type	Nb	bins/zone	Even	Odd	Even	Odd	Even	Odd
Airborne	17	131072	6.000	6.102	4.6E-05	4.7E-05	5.10	5.18
Surface	19	524288	6.000	6.102	1.1E-05	1.2E-05	1.27	1.30
Coarse TIS-B	12	4096	6.000	6.102	0.00146	0.00149	163.07	165.83

The CPR encoding algorithm transforms latitude into even and odd bin numbers. Figure 3-6 is an example showing even and odd bin numbers for airborne position at 43.054°N. Red lines delimit the even zone and blue lines delimit the odd zone. The point of interest, colored magenta, is in even bin number 23035 and odd bin number 7349.

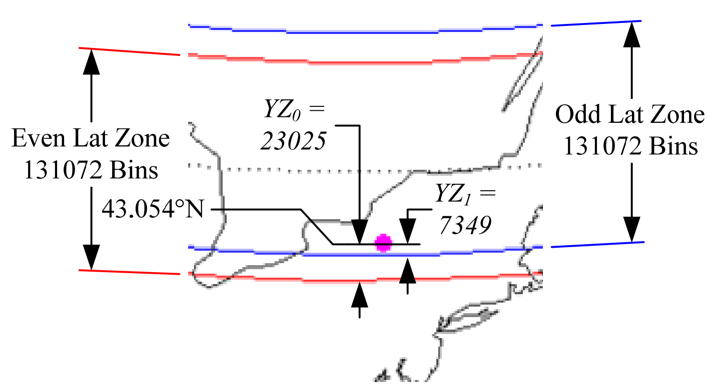


Figure 3-6 YZ for Even and Odd Latitude Zones at 43.054N

Although not produced by the encoding algorithm, the zone index number for both the even and odd zones at the latitude in Figure 3-6 is 7.

3.2 Longitude Zones and Bins

Longitude zones and bins are similar to latitude zones and bins. For a given position type (i.e. airborne, surface, coarse TIS-B), the number of bins per longitude zone is equal to the number of bins per latitude zone. The main difference between latitude and longitude zones is that the number of longitude zones circling the globe is a function of latitude. The CPR coordinate system keeps the encoding resolution (i.e. bin width in meters) as close to a constant as possible everywhere on the globe. Since the number of bins per zone is fixed, the zone width (in NM) must also remain close to constant. The distance around the globe along lines of constant latitude is smaller near the poles than near the equator. The CPR algorithm keeps the longitude bin and zone width approximately constant by reducing the number of zones as latitude increases.

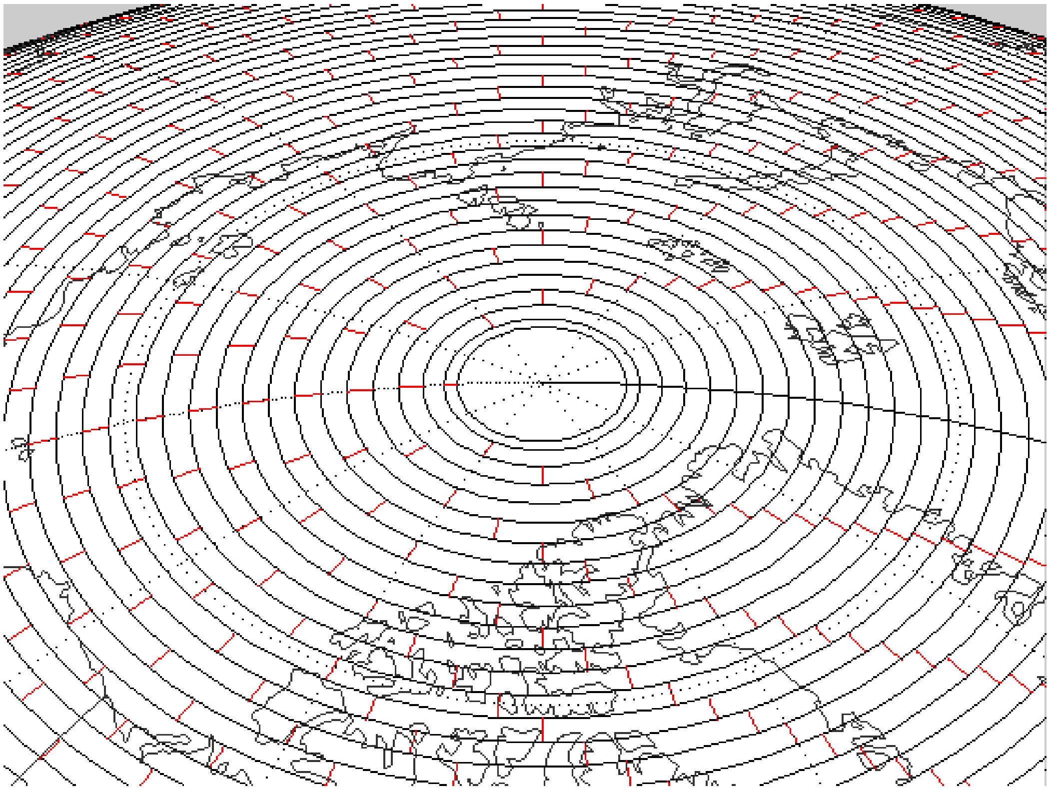


Figure 3-7 Reduction in Number of Longitude Zones at High Latitudes

Note that the linear (not angular) widths of the longitude zones in Figure 3-7 are all approximately equal and that the number of zones around the globe decreases as the magnitude of latitude increases. The number of even longitude zones at a latitude is called *NL*. The latitudes at which the number of longitude zones changes are called "NL Transition Latitudes." These are represented by black lines of constant latitude in Figure 3-2 and Figure 3-7. NL Transition Latitudes generally do not coincide with latitude zone boundaries.

For all CPR computations, NL is calculated using the "recovered latitude" $Rlat_i$. $Rlat_i$ is obtained by converting a bin number to a bin centerline latitude. The rationale for this is discussed in Section 4. The equation for the number of longitude zones (*NL*) as a function of latitude is specified in Eq 2:

For $Rlat_i = 0°$ (the Equator), $NL = 59$
For $Rlat_i = +87°$ or $lat = -87°$, $NL = 2$
For $Rlat_i > +87°$ or $lat < -87°$, $NL = 1$
For all other latitudes ($-87° < Rlat_i < 0°$ and $0° < Rlat_i < +87°$):

$$NL(Rlat_i) = floor\left(2\pi\left[\arccos\left(1-\frac{1-\cos\left(\frac{\pi}{2NZ}\right)}{\cos^2\left(\frac{\pi}{180°}\bullet\left|Rlat_i\right|\right)}\right)\right]^{-1}\right)$$

Eq 2
[A.1.7.2.d]

Note in Eq 2 that NL is inversely proportional to the magnitude of the recovered latitude and that the result of the computation on the right hand side is quantized by the floor function. As the magnitude of the recovered latitude increases (i.e. from the equator to the poles), NL changes *after* the recovered latitude crosses the NL Transition Latitude. This is illustrated in Figure 3-8.

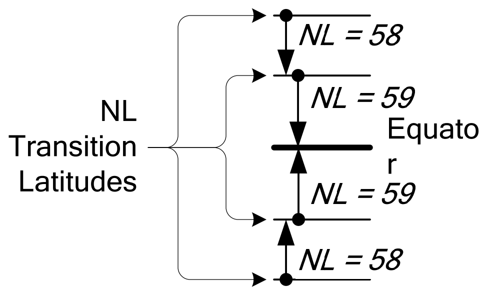


Figure 3-8 NL Values and Transition Latitudes

A rearranged version of Eq 2 gives NL Transition Latitudes as a function of the number of longitude zones. The rearranged equation is presented in Eq 3:

$$lat_{NL\ Transition} = \frac{180°}{\pi}\bullet\arccos\left(\sqrt{\frac{1-\cos\left(\frac{\pi}{2NZ}\right)}{1-\cos\left(\frac{2\pi}{NL}\right)}}\right) \quad for\ NL=2\ to\ 4NZ-1$$

Eq 3
[A1.7.2.d, note 5]

The longitude angular zone width, $Dlon_i$ (in degrees of longitude) depends on the value of NL and is given by Eq 4:

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

Eq 4
[A.1.7.3.d]

A visual representation of these equations is shown in Figure 3-9. Red lines are even longitude zone boundaries and blue lines are odd longitude zone boundaries. Black lines of constant latitude are the transition latitudes defined by Eq 3.

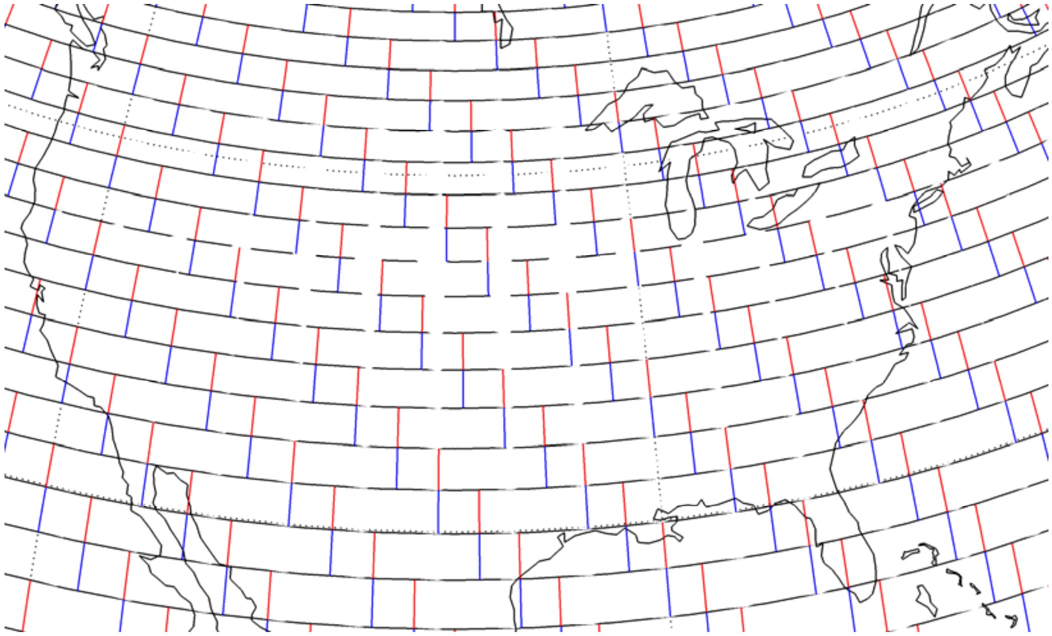


Figure 3-9 Even and Odd Longitude Zones With Transition Latitudes

Zone indexing for longitude is similar to latitude except that zone index 0 extends east from the Prime Meridian and the "tape measure" continues eastward around the globe, returning to the Prime Meridian. The number of zones on the "tape measure" varies with recovered latitude as described above.

Longitude zones are divided into bins in the same manner as latitude zones except that bin number zero is located at the western edge of each zone and bin numbers increase to the east. Even bin numbers are represented by the variable XZ_0 and odd bin numbers are represented by the variable XZ_1.

Figure 3-10 is an example showing even and odd bin numbers for airborne position at 76.06°W. Red lines delimit the even zone boundary and blue lines delimit the odd zone boundary. The point of interest, colored magenta, is in even bin number 119938 and odd bin number 16559.

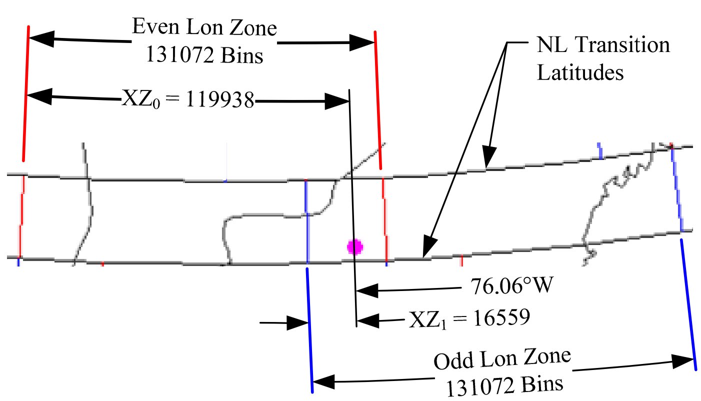


Figure 3-10 XZ for Even and Odd Longitude Zones at 76.06°W

The longitude zone index number for both the even and odd zones at the longitude shown in Figure 3-10 is 33.

4 CPR Encoding

The first step of the encoding process is to determine the latitude zone size $Dlat_i$. $Dlat_i$ is calculated with Eq 1.

The second step of the encoding process converts the input latitude into an output bin number YZ_i. The input latitude can be any real number between -90° and +90°. YZ_i is limited to a finite set of integers (0 to 131072) which represent bin numbers. Eq 5 converts input latitude *lat* into a bin number YZ_i.

$$YZ_i = floor\left(2^{Nb} \bullet \frac{MOD(lat, Dlat_i)}{Dlat_i} + \frac{1}{2}\right)$$

Eq 5
[A.1.7.3.b]

The modulus function returns the number of degrees between the southern edge of the zone containing *lat* and *lat*. Dividing this by the latitude zone size $Dlat_i$ produces the "fraction into the zone" or "zone fraction" of the input latitude. The product of the zone fraction and the number of bins in the zone (i.e., 2^{Nb}) is approximately the bin number of the input latitude. The product is not necessarily an integer so it is rounded to the nearest integer by adding ½ and taking the floor of the sum.

The third step in the encoding process is to recover the bin centerline latitude of YZ_i. Because Eq 5 performs rounding, the bin centerline latitude of YZ_i will not equal the input latitude in most cases.

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

Eq 6
[A.1.7.3.c]

$YZ_i / 2^{Nb}$ is the zone fraction of YZ_i. floor($lat/Dlat_i$) is the zone index number. The first latitude zone north of the equator is index number 0. The sum of the terms inside the parentheses is the number of whole zones plus the zone fraction of YZ_i. The product of this sum and $Dlat_i$, the number of degrees per zone, is the bin centerline latitude of YZ_i.

In the fourth step, $Rlat_i$ from Eq 6 is used to determine *NL* from Eq 2 or from a lookup table based on Eq 3. Then, $Dlon_i$ is calculated with Eq 4. Using $Rlat_i$ in the determination of *NL* ensures that the transmitted value of YZ_i is consistent with the value of *NL* used for longitude encoding. The step also ensures that only one value of *NL* is used for any latitude within a single latitude bin. The receiver only knows the latitude that is recovered from YZ_i and must determine *NL* based on this value alone. If more than one value of *NL* were used for latitudes in the same bin, the receiver would have no reliable way to determine which value of *NL* was appropriate.

The next step is to encode the longitude. This is done with Eq 7.

$$XZ_i = floor\left(2^{Nb} \bullet \frac{MOD(lon, Dlon_i)}{Dlon_i} + \frac{1}{2}\right)$$

Eq 7
[A.1.7.3.e]

Eq 7 works in the same manner as Eq 5 except that the inputs and results are longitude values.

The final step trims YZ_i and XZ_i to the number of bits available in the position message. For surface position, this fits a 19 bit number into a 17 bit space by discarding the 2 most significant bits. For airborne and coarse TIS-B position, this step takes care of the case where the latitude or longitude falls within the most northern or most eastern ½ bin in a zone. YZ_i or XZ_i calculated from Eqs 5 or 7 would equal 2^{Nb} in these cases which is too large be encoded in the respective position messages. This step drops the most significant bit leaving only a string of zero bits for transmission. See Figure 4-1 for an example with latitude.

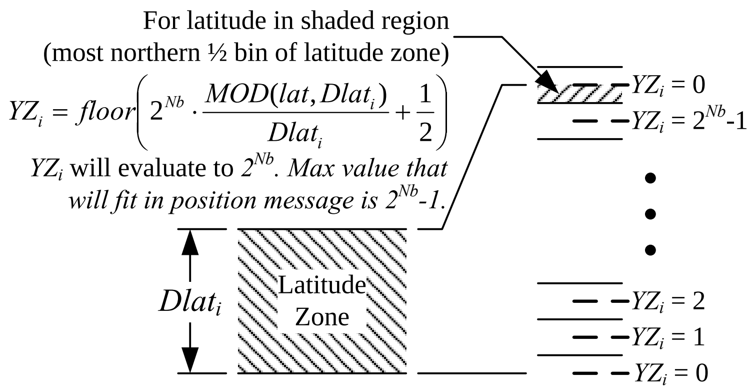


Figure 4-1 YZ_i When Latitude is in Northernmost 1/2 Bin of Latitude Zone

The following equations from section A.1.7.3f trim YZ_i and XZ_i to the appropriate number of bits:

$$\left.\begin{aligned} YZ_i &= MOD(YZ_i, 2^{17}) \\ XZ_i &= MOD(XZ_i, 2^{17}) \end{aligned}\right\} \text{ for Airborne encoding}$$

$$\left.\begin{aligned} YZ_i &= MOD(YZ_i, 2^{17}) \\ XZ_i &= MOD(XZ_i, 2^{17}) \end{aligned}\right\} \text{ for Surface encoding}$$

$$\left.\begin{aligned} YZ_i &= MOD(YZ_i, 2^{12}) \\ XZ_i &= MOD(XZ_i, 2^{12}) \end{aligned}\right\} \text{ for Coarse TIS} - \text{B encoding}$$

5 CPR Decoding

Every latitude and longitude can be mapped to a unique triple of zone index, bin number and CPR Format. However, only the bin number and CPR Format are transmitted in position messages. Receivers must recover the latitude and longitude using only the transmitted bin numbers and CPR Format. Remember that any latitude bin number YZ_i will exist in each latitude zone and that there are 15 even and 14 ¾ odd latitude zones in both the northern and southern hemispheres. The ambiguity in longitude is similar except the number of longitude zones varies from 1 to 59 depending on latitude. The MOPS provides two methods for recovering the zone and determining the position of a target in section A.1.7. One method is called Globally Unambiguous CPR Decoding and the other is called Locally Unambiguous CPR Decoding. These methods are commonly called “global decoding” and “local decoding.”

Most implementations use global decoding to determine position when a target is first acquired and then switch to local decoding for ongoing position updates. Global decoding can determine the location of a target anywhere on the globe but must have one even CPR format position message and one odd CPR format position message received within 10 seconds of each other to perform a valid decode. Local decoding is limited to a range of ±½ zone in latitude and longitude from the last position update but can use an encoded position of either format with no time limit between updates.

5.1 Global Decoding for Airborne and TIS-B Position

Global decoding uses the bin numbers from one even position message and one odd position message to determine which zones contain the target and to recover the latitude and longitude. The target could be anywhere on the globe and global decoding will still work correctly.

5.1.1 Airborne and TIS-B Latitude Global Decoding

A receiver needs to determine the zone index of the target because the zone index is not transmitted in position messages. Global decoding works on the idea that the zone index is related to the offset between the southern edges of the even and odd zones that contain the latitude bin numbers transmitted in the two position messages. The principle is illustrated for latitude in Figure 5-1.

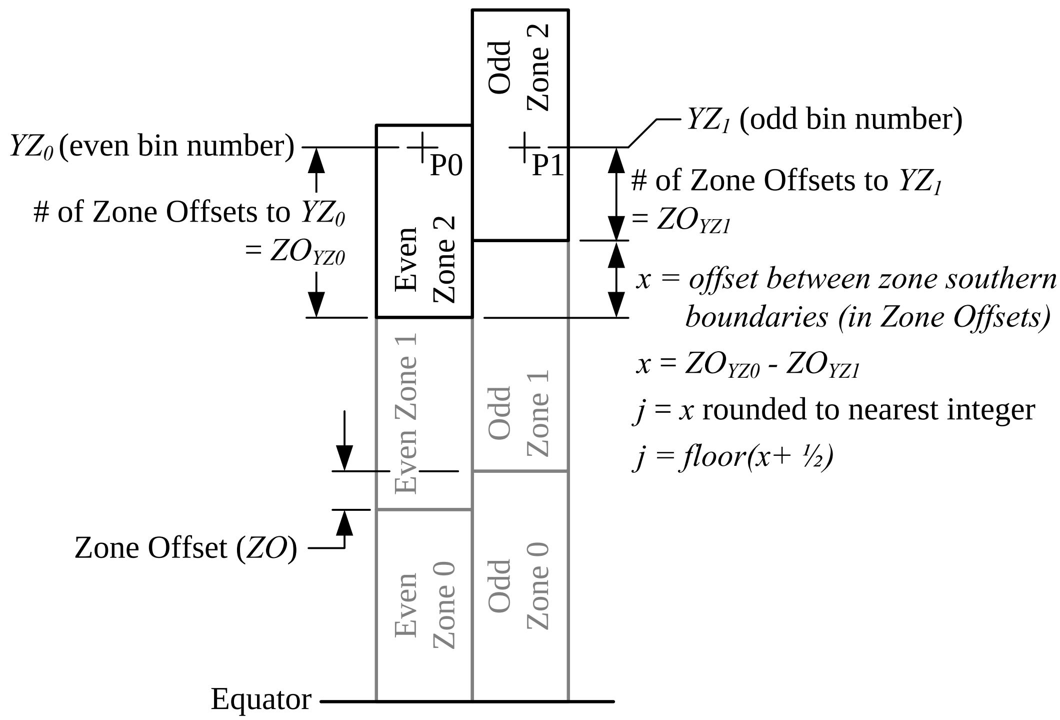


Figure 5-1 Principle of Global Decoding

Figure 5-1 is a magnified view of the first three zones north of the equator in Figure 3-3. The latitude bin numbers YZ_0 and YZ_1, which are received in separate even and odd position messages, are also shown.

Zone Offset (*ZO*) is the difference in size between an even zone and an odd zone. This difference, in degrees, is defined by Eq 8.

$$ZO = Dlat_1 - Dlat_0 = \frac{360°}{4NZ-1} - \frac{360°}{4NZ} = \frac{360°}{4NZ(4NZ-1)}$$

$$ZO = \frac{360°}{(59)(60)} \qquad \text{Eq 8}$$

Observe in Figure 5-1 that as the zone index number increases, the offset between zone southern boundaries also increases by the value of *ZO*. The difference in latitude between the southern edges of the even and odd zones with index 1 is *ZO* and the difference in latitude between the southern edges of zones with index 2 is 2*ZO*. The zone index number and offset between zone southern boundaries are linearly related. Therefore, the offset between zone southern boundaries can be used to determine the zone index number.

Global decoding is easier to see if the following two assumptions are made:

> Assumption 1. P0 and P1 have the same latitude (e.g. stationary target or one moving due east or due west).
>
> Assumption 2. P0 and P1 are in zones with the same index number.

Figure 5-1 incorporates these assumptions. The offset between zone southern boundaries (x) of the zones with index number 2 (measured in Zone Offsets) is the number of Zone Offsets from the southern edge of the even zone to YZ_0 (ZO_{YZ0}) minus the number of Zone Offsets from the southern edge of the odd zone to YZ_1 (ZO_{YZ1}). The result will be a number that is very close to an integer, which is the expected answer, because zones are always offset by an integer multiple of the Zone Offset. If the result (x) is rounded to the nearest integer (j), the zone index number of the even or odd zone containing P0 or P1 will be equal to the number of Zone Offsets (j) between the zone southern boundaries.

The number of Zone Offsets from the southern boundary of the zone to YZ_0 (ZO_{YZ0}) or YZ_1 (ZO_{YZ1}) is the product of the number of Zone Offsets per zone (ZO_i) and the zone fraction of YZ_0 or YZ_1. The number of Zone Offsets per zone is determined with Eq 9.

$$ZO_i = \left\{\frac{Dlat_i}{ZO}\right\} = \left\{\frac{\left(\frac{360°}{4NZ-i}\right)}{\left(\frac{360°}{4NZ(4NZ-1)}\right)}\right\} \qquad \text{Eq 9}$$

$$ZO_i = \frac{4NZ(4NZ-1)}{4NZ-i} = \begin{cases} 4NZ-1 = 59 \ \ when\ i=0\ (even) \\ 4NZ = 60 \ \ when\ i=1\ (odd) \end{cases}$$

The zone fraction is the bin number of P0 or P1 divided by the number of bins in the zone ($YZ_i/2^{Nb}$).

Eqs 10 & 11 define the number of zone offsets from the southern edge of a latitude zone to a bin with coordinate YZ_i.

$$ZO_{YZ0} = 59\left(\frac{YZ_0}{2^{Nb}}\right) \ for\ even\ zones \qquad \text{Eq 10}$$

$$ZO_{YZ1} = 60\left(\frac{YZ_1}{2^{Nb}}\right) \ for\ odd\ zones \qquad \text{Eq 11}$$

Subtracting Eq 11 from Eq 10 produces the number of Zone Offsets between the southern boundaries of the zones containing P0 and P1.

$$x = ZO_{YZ0} - ZO_{YZ1} = 59\left(\frac{YZ_0}{2^{Nb}}\right) - 60\left(\frac{YZ_1}{2^{Nb}}\right)$$

$$x = \frac{59YZ_0 - 60YZ_1}{2^{Nb}} \qquad \text{Eq 12}$$

The number of Zone Offsets between zone southern boundaries must be an integer because of the way zones are defined. P0 and P1 will not have exactly the same latitude in most cases because, even if the input latitudes are equal, the CPR encoding process will result in the centerline of the even bin being a slightly different latitude than the centerline of the odd bin. Therefore, x must be rounded to the nearest integer to determine the true (i.e. integer) number of Zone Offsets between zone southern boundaries. Eq 13 rounds the result of Eq 12 to the nearest integer. The result is the equation given in A.1.7.7b.

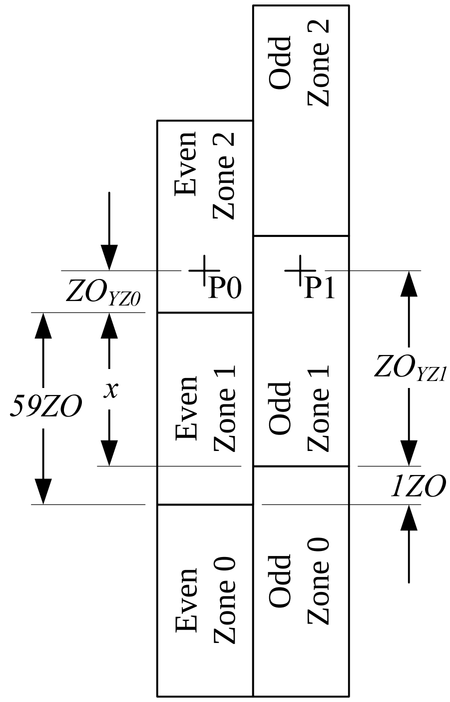
$$j = floor\left(x + \frac{1}{2}\right) \qquad \text{Eq 13}$$

$$j = floor\left(\frac{59YZ_0 - 60YZ_1}{2^{Nb}} + \frac{1}{2}\right) \qquad \text{[A.1.7.7b]}$$

Assumption 1 is not practical for real applications because aircraft and ground vehicles move during the period between position messages. The rounding performed by Eq 13 will accommodate up to ½ Zone Offset between P0 and P1. Assumption 1 can be relaxed to allow up to ½ Zone Offset between P0 and P1 including vehicle movement, position errors and CPR quantization errors.

Note: *Appendix A, Section §A.1.7.7, Note 2 states that airborne position global decodes cannot be performed with even-odd position message pairs received more than 10 seconds apart because the distance between the reports for a target moving at 1000 knots ~~could move more~~ must be less than 3 NM ~~in a 10 second period~~. The 3 NM limit comes from the requirement that the latitude (or longitude) change between P0 and P1 not exceed ½ ZO. From Eq 8, ZO ≅ 0.10169°. ½ ZO ≅ 0.05085° ≅ 3.051 NM.*

Assumption 2 is also impractical because P0 and P1 could end up in zones with different zone index numbers. An example is shown in Figure 5-2.



$x = ZO_{YZ0} - ZO_{YZ1} \approx -59ZO + 1ZO = -58ZO$
$j = floor(x+½) = floor(ZO_{YZ0} - ZO_{YZ1} + ½)$
$j = -59ZO + 1ZO = -58ZO$

Figure 5-2 - Points in Zones With Different Zone Index Numbers

In Figure 5-2, P0 is in a zone with index number 2 while P1 is in a zone with index number 1. The value of *j* in Figure 5-2 will be -58 because Even Zone 1 is 59 Zone Offsets tall and the bottom of Odd Zone 1 is 1 Zone Offset above the bottom of Even Zone 1. The Modulus function defined in Appendix A can be used to recover the zone index number when the offset between zone southern boundaries is negative. The Modulus function is repeated in Eq 14.

$$MOD(x, y) = x - y \bullet floor\left(\frac{x}{y}\right) \; where \; y \neq 0$$

Eq 14
[A.1.7.2.c]

The value of *y* is chosen to produce the zone index number from *j*. Figure 5-3 depicts the relationship between *j* and the index number of each zone.

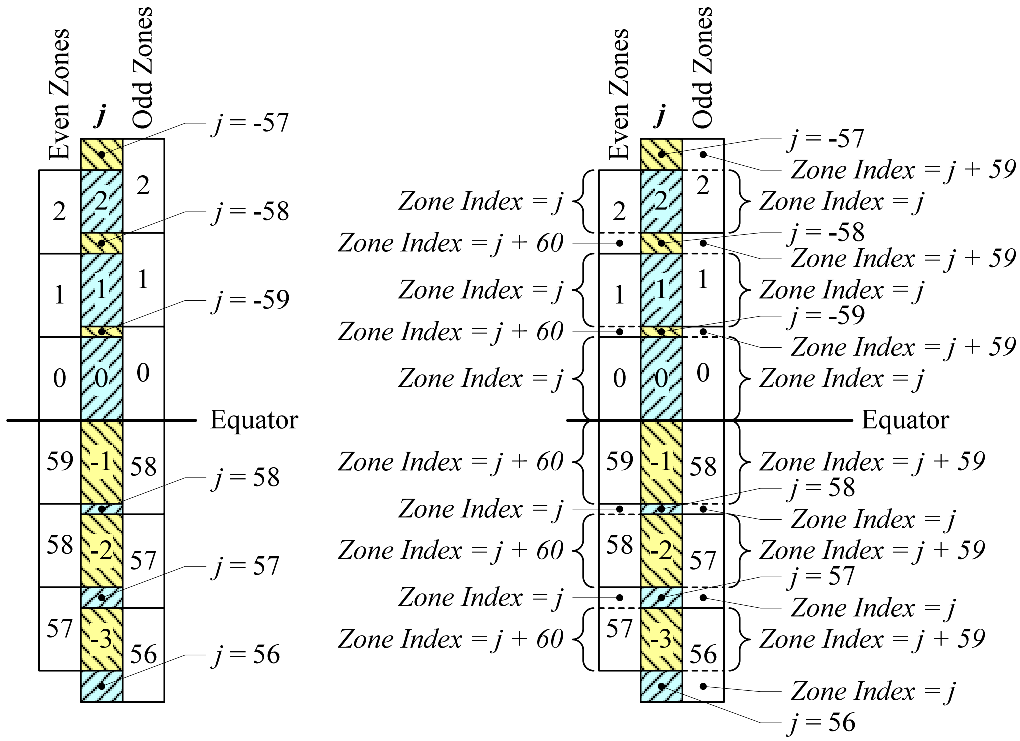


Figure 5-3 Relationship Between *j* and Zone Index

If *y* in Eq 14 is replaced with the number of even (60) or odd (59) zones around the globe (refer to the "tape measure" in Figure 3-3) and if *x* is replaced with *j*, Eq 14 becomes:

$$MOD(j,4NZ-i) = j-(4NZ-i)\bullet floor\left(\frac{j}{4NZ-i}\right) \quad \text{Eq 15}$$

The range of *j* is -59 to +58. The quantity *4NZ-i* is either 59 or 60. *floor(j/(4NZ-i))* will be 0 when *j* is positive and -1 when *j* is negative. When j is positive, the second term of Eq 14 is zero and the zone index equals *j*. When j is negative, the sign in front of the second term is positive and the value of the term is *4NZ-i*. These forms of the equation match the forms shown in Figure 5-3. The zone index can be determined from *j* using Eq 16.

$$\begin{aligned} Zone\ Index &= MOD(j,4NZ-i) \\ Zone\ Index &= MOD(j,60-i) \end{aligned} \quad \text{Eq 16}$$

The latitude is recovered using the zone index and bin number (YZ_i). The bin number divided by the number of bins in a zone equals the zone fraction of the bin number. Multiplying the height of a zone by the sum of the zone index and the zone fraction will produce the bin centerline latitude of YZ_i.

$$Rlat_i = Dlat_i\left(MOD(j,60-i)+\frac{YZ_i}{2^{Nb}}\right) \quad \text{Eq 17 [A.1.7.7.c]}$$

$Rlat_0$ is the latitude of the even position message used in the global decode and $Rlat_1$ is the latitude of the odd position message. Recalling the tape measure of Figure 3-3, the northern hemisphere will have zone index numbers between 0 and 14 and latitude values between 0° and 90°. The southern hemisphere will have zone index numbers between 45 and 59 and latitude values between 270° and 360°. Latitudes between 90° and 270° are invalid. Southern hemisphere latitude values can be put in the range of 0° to -90° by subtracting 360° from the result of Eq 17 or by using Eq 18.

$$Rlat_i = MOD(Rlat_i + 180°, 360°) - 180° \qquad \text{Eq 18}$$

5.1.2 Airborne and TIS-B Longitude Global Decoding

Longitude global decoding is similar to latitude global decoding in that even and odd messages are used to count zone offsets and determine the zone index. The concept of offset between zone southern boundaries is replaced with the idea of offset between zone western boundaries. The measured offset is rounded to the nearest integer, which is named *m* instead of *j*, and the Modulus function is used to get the zone index from positive or negative values of *m*. The rule that the even and odd positions must be within ½ Zone Offset of each other also applies to longitude global decoding.

The main difference between longitude global decoding and latitude global decoding is that the number of longitude zones around the globe varies with latitude. There are always 60 even zones and 59 odd zones around the globe in latitude global decoding. In longitude global decoding, there are between 1 and 59 longitude zones, as depicted in Figure 3-2.

The first step in longitude global decoding is to ensure that the values of NL for the even and odd positions are the same. If they are different, the Zone Offset sizes will be different and the equation to compute the number of Zone Offsets will produce erroneous results. Eqs 17 and 18 will produce one latitude for each bin number used in the latitude global decode (i.e. $Rlat_0$ and $Rlat_1$). *NL* for each of these latitudes is computed with Eq 2. If the *NL* values are different, the receiver must wait until a pair of even and odd messages arrive that produce the same value for *NL*.

If the *NL* values are the same, longitude global decoding proceeds using the same logic as latitude global decoding. In Eqs 8 and 9, the factor *4NZ*, the number of even latitude zones around the globe, is replaced with *NL*, the number of even longitude zones around the globe at $Rlat_0$ and $Rlat_1$. Eq 8 for the size of the Zone Offset becomes Eq 19.

$$ZO = Dlon_1 - Dlon_0 = \frac{360°}{NL-1} - \frac{360°}{NL} \; for\; NL > 1$$
$$ZO = \frac{360°}{NL(NL-1)} \; for\; NL > 1 \qquad \text{Eq 19}$$

Eq 9 for the number of Zone Offsets in a zone becomes Eq 20

$$ZO_i = \left\{\frac{Dlon_i}{ZO}\right\} = \left\{\frac{\left(\frac{360°}{NL-i}\right)}{\left(\frac{360°}{NL(NL-1)}\right)}\right\} \; for\; NL > 1$$
$$ZO_i = \frac{NL(NL-1)}{NL-i} = \begin{cases} NL-1 \;\; when\; i = 0\; (even) \\ NL \;\; when\; i = 1\; (odd) \end{cases} for\; NL > 1 \qquad \text{Eq 20}$$

Eq 10 for the number of Zone Offsets to an even bin becomes Eq 21.

$$ZO_{XZ0} = (NL-1)\left(\frac{XZ_0}{2^{Nb}}\right) \; for\; even\; zones \qquad \text{Eq 21}$$

Eq 11 for the number of Zone Offsets to an odd bin becomes Eq 22.

$$ZO_{XZ1} = (NL)\left(\frac{XZ_1}{2^{Nb}}\right) \; for\, even\;\, zones \qquad \text{Eq 22}$$

Subtracting Eq 22 from Eq 21 produces the number of Zone Offsets between the western boundaries of the zones containing P0 and P1.

$$x = ZO_{XZ0} - ZO_{XZ1} = (NL-1)\left(\frac{XZ_0}{2^{Nb}}\right) - (NL)\left(\frac{XZ_1}{2^{Nb}}\right)$$

$$x = \frac{(NL-1)XZ_0 - (NL)XZ_1}{2^{Nb}} \qquad \text{Eq 23}$$

The result of Eq 23 must be rounded to the nearest integer. Instead of assigning the result to *j*, as is done for latitude in Eq 13, the result is assigned to *m*.

$$m = floor\left(x + \frac{1}{2}\right) \qquad \text{Eq 24}$$

$$m = floor\left(\frac{(NL-1)XZ_0 - (NL)XZ_1}{2^{Nb}} + \frac{1}{2}\right) \qquad \text{[A.1.7.7.f]}$$

As was the case with Eq 13, the rounding performed by Eq 24 will accommodate up to ½ Zone Offset between P0 and P1 including vehicle movement, position errors and CPR quantization errors.

m will behave the same as *j* in that the value of *m* will be negative when the even and odd longitude zones containing P0 and P1 have different Zone Index numbers. The Zone Index is recovered from *m* in the same manner that it is from *j*. Again, the term *4NZ* is replaced with *NL* and *j* is replaced with *m* in Eq 15 to form Eq 25.

$$MOD(m, NL-i) = m - (NL-i) \bullet floor\left(\frac{m}{NL-i}\right) \; NL > 1 \qquad \text{Eq 25}$$

Eq 16 becomes Eq 26.

$$Zone\ Index = MOD(m, NL-i) \;\; for\ NL > 1 \qquad \text{Eq 26}$$

The recovered longitude $Rlon_i$ is determined in the same manner as the recovered latitude $Rlat_i$.

$$Rlon_i = Dlon_i\left(MOD(m, NL-i) + \frac{XZ_i}{2^{Nb}}\right) \; for\ NL > 1 \qquad \text{Eq 27}$$

$Rlon_i$ will be a value between 0° and 360°. It can be placed in the range of -180° to +180° with Eq 28.

$$Rlon_i = MOD(Rlon_i + 180°, 360°) - 180° \qquad \text{Eq 28}$$

Eqs 19, 20, 25, 26 and 27 will be indeterminate when *NL*=1. From Eq 2, *NL* will be 1 at latitudes greater than 87°N or less than -87°S. When *NL* = 1, $Dlon_i$, the longitude zone width, equals 360° (ref Eq 4) for both even and odd encoding. With one zone, there is no need to determine the zone index. Longitude can be recovered by multiplying the zone width ($Dlon_i$) by the zone fraction ($XZ_i/2^{Nb}$). While this is a straightforward approach, the algorithm description in Appendix A does not handle *NL*=1 this way.

When *NL* is 1, Eq 24 (A.1.7.7f) for *m* reduces to either 0 or -1 for all values of XZ_i and *Nb*. Section A.1.7.7g defines a variable n_i.

n_i = greater of [NL($Rlat_i$) – *i*] and 1 Eq 29

Section A.1.7.7g also defines a formula for $Rlon_i$ in terms of *m* and n_i.

$$Rlon_i = Dlon_i\left(MOD(m, n_i) + \frac{XZ_i}{2^{17}}\right)$$ Eq 30 [A.1.7.7g]

When *m* = 0 and n_i = 1, $MOD(m, n_i)$ equals 0. When m = -1, $MOD(m, n_i)$ also evaluates to 0. In either case, Eq 30 for $Rlon_i$ reduces to the zone width ($Dlon_i$) multiplied by the zone fraction ($XZ_i/2^{17}$). This is the expected result.

For values of *NL* > 1, n_i will equal *(NL – i)* and Eqs 27 and 30 will be equivalent.

Section A.1.7.7e redefines $Dlon_i$ in terms of n_i. Eqs 4 and 31 are equivalent. The reason for the redefinition is not clear.

$$Dlon_i = \frac{360°}{n_i}$$ Eq 31 [A.1.7.7.e]

5.2 Surface Global Decoding

Surface global decoding is the same as airborne and TIS-B local decoding except that the latitude and longitude zone widths $Dlat_i$ and $Dlon_i$ are reduced by a factor of 4. Surface position encoding is performed with 19 bits of resolution (reference Table 3-1) but only the 17 least significant bits are transmitted in the surface position message (A.1.7.3f). Dropping the two most significant bits reduces the number of bins per zone by a factor of 4 but the width of the bins must remain the same for both encoding and decoding. Therefore, the latitude and longitude zone widths $Dlat_i$ and $Dlon_i$ used in decoding must also be smaller by a factor of 4. *Nb* for surface decoding is equal to 17 rather than 19 because the number of bins in each of the reduced size zones is 2^{17} instead of 2^{19}.

The smaller zone width means that the length of the "tailor's tape measure" described in Figure 3-3 will be ¼ of the distance around the globe. Calculations for recovered latitude and longitude $Rlat_i$ and $Rlon_i$ will be in the range of 0° to 90° (i.e. northern hemisphere and 0° to 90° east longitude). Additional solutions will exist at 90°, 180° and 270° from the calculated latitude and longitude. The receiver must choose the appropriate solution and that solution may be in a different quadrant of the globe than the receiver. Latitude solutions between 90° and 270° are discarded. If there were targets broadcasting surface position messages near either of the poles, longitude ambiguity could be a problem. This is an unlikely scenario.

For surface global and local decoding, the latitude zone width is given by Eq 32 (reference Eq 1).

$$Dlat_i = \frac{1}{4}\left(\frac{360°}{4NZ - i}\right) = \frac{90°}{4NZ - i}$$ Eq 32 [A.1.7.8a]

NZ = 15
i = 0 for even encoding
i = 1 for odd encoding

Latitude Zone Offset defined in Eq 8 will also be smaller by a factor of 4. Eqs 9 through 18 are valid for surface global decoding as long as the correct values of $Dlat_i$, Nb and ZO are used.

$Rlat_i$ from Eq 17 will be between 0° and 90°. An additional solution in the southern hemisphere will be located at $Rlat_i - 90°$. The receiver must choose the closer of the two.

NL is calculated using Eq 2 and $Rlat_i$ but the result is the number of longitude zones in one quadrant of the globe rather than the number of zones around the globe.

Before proceeding with longitude global decoding, the receiver must verify that $NL(Rlat_0) = NL(Rlat_1)$. If not, the decode is aborted and the process is restarted with a new pair of even and odd position messages.

For surface global and local decoding, the longitude zone width is obtained by dividing Eq 4 by 4. This results in Eq 33:

$$Dlon_i = \begin{cases} \dfrac{90°}{NL(Rlat_i) - i}, & when\ NL(Rlat_i) - i > 0 \\ 90°, & when\ NL(Rlat_i) - i = 0 \end{cases}$$

Eq 33
[A.1.7.8e]

Longitude Zone Offset defined in Eq 19 will also be smaller by a factor of 4. Eqs 20 through 27 are valid for surface global decoding as long as the correct values of $Dlon_i$ and ZO are used.

$Rlon_i$ will be between 0° and 90°. Additional solutions will exist at longitudes of 90°, 180° and 270° to the east of $Rlon_i$. The receiver must choose the appropriate longitude which will be, in most cases, the closest longitude.

5.3 Airborne and TIS-B Locally Unambiguous Decoding

Local decoding uses a “reference position” and the contents of one position message to recover the latitude and longitude of the target. The difference between the target position and the reference position must be less than ½ of a zone in both latitude and longitude. The reference position is usually the last successfully decoded position received from the target. Since ½ of a zone is approximately 180 nautical miles for airborne position and 45 nautical miles for surface position, the position change between two successfully decoded position messages is unlikely to exceed the ½ zone limit.

The effect of the local decoding algorithm is to create a sliding region 1 zone wide in latitude and longitude, centered on the reference position. Because the region is 1 zone wide, each bin number occurs only once in the region, ensuring a unique result for each encoded latitude and longitude. Figure 5-4 illustrates the behavior of the sliding region for latitude. The number of bins per latitude zone has been reduced to 8 (i.e. $Nb = 3$) to simplify the figure. Behavior of the sliding region is the same for longitude except the figure is rotated 90° clockwise and references to latitude are replaced with longitude.

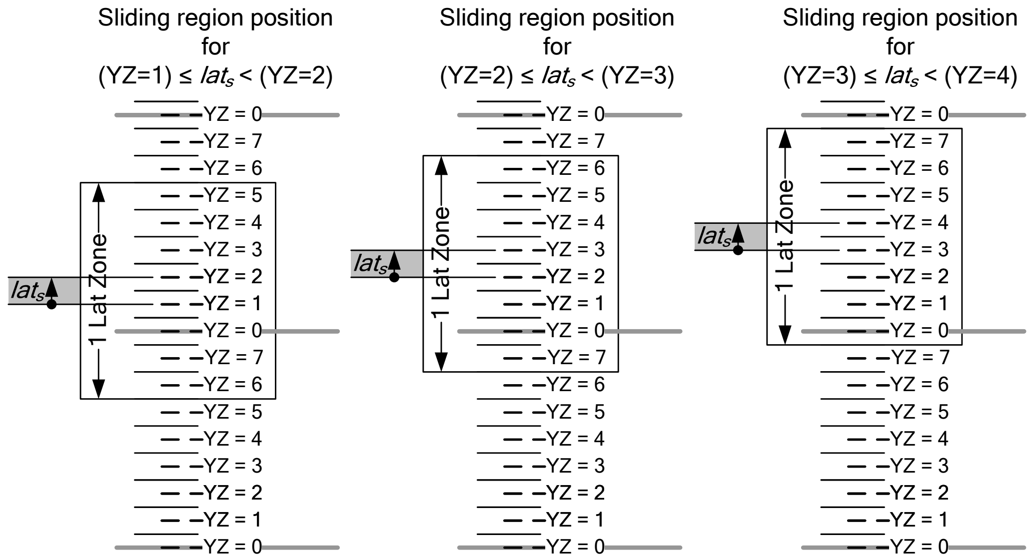


Figure 5-4 Local Decoding Sliding Region Behavior

The sliding region position changes when lat_s moves from one grey region to another.

In the unlikely event that the target position is more than ½ zone from the reference position, the target position will appear to "wrap around" the other side of the ±½ zone region. For example, if the target was in bin 7 (YZ=7) in the upper zone with the reference position between YZ=1 and YZ=2 (see left side of Figure 5-4), the recovered latitude would be for YZ=7 in the lower zone. This wrap around behavior occurs because the algorithm assumes the target is within ½ zone of the reference position and the only bin number 7 is in the lower zone. In effect, the recovered position is shifted one zone from the actual position in the direction of the reference position. Some older implementations used the receiver position as the reference position instead of the last target position. Surface targets more than ½ zone away (45 nautical miles) would decode incorrectly as described above.

The local decoding algorithm may be easier to visualize with a simplified example. Imagine a road with a marker at each kilometer stating the number of kilometers from the beginning of the road. A person walking along the road toward the end, who is known to be within ½ km of the 22 km marker, announces they are 0.2 km past the last marker. What is their location relative to the beginning of the road? Since they are within ½ km of marker 22 and they are 0.2 km past the last marker, they are 22.2 km from the beginning of the road. Suppose they had announced their position as 0.7 km past the last marker. Their location would be 21.7 km from the beginning of the road because this is the only location that is both 0.7 km past the last marker and within ½ km of 22 km marker. This is the logic embodied in the local decoding algorithm.

5.3.1 Airborne and TIS-B Latitude Local Decoding

Local decoding determines latitude first in order to compute *NL* and then determines longitude. Latitude is calculated from the bin number and CPR format transmitted in the position message, and the zone index, which is computed from the last known target position. The algorithm sums the Zone Index of the reference position (RP) and the difference between the Zone Indices of the reference position and the encoded position (EP) to obtain the Zone Index of the encoded position.

$$ZI_{EP} = ZI_{RP} + \Delta ZI_{RP \to EP} \quad \text{Eq 34}$$

Because the encoded position is assumed to be within ½ zone of the reference position, the difference in zone indices $\Delta ZI_{RP \to EP}$ is limited to -1, 0 or +1.

The Zone Index of the reference position ZI_{RP} is determined with Eq 35.

$$ZI_{RP} = floor\left(\frac{lat_s}{Dlat_i}\right) \quad \text{Eq 35}$$

lat_s is the reference latitude. $Dlat_i$ is the latitude zone width from Eq 1. The first zone north of the equator has an index number of zero. Latitude Zone Index numbers south of the equator start at -1 and increase in magnitude toward the South Pole. Note that southern hemisphere latitude zone indices for local decoding are numbered differently than the zone indices for global decoding.

The difference between the latitude zone indices of the reference position and of the encoded position $(\Delta ZI_{RP \to EP})$ is the difference between the latitude zone fractions of the reference position and the encoded position $(f_{RP} - f_{EP})$, rounded to the nearest integer. This is shown for $f_{RP} > ½$ in Figure 5-5.

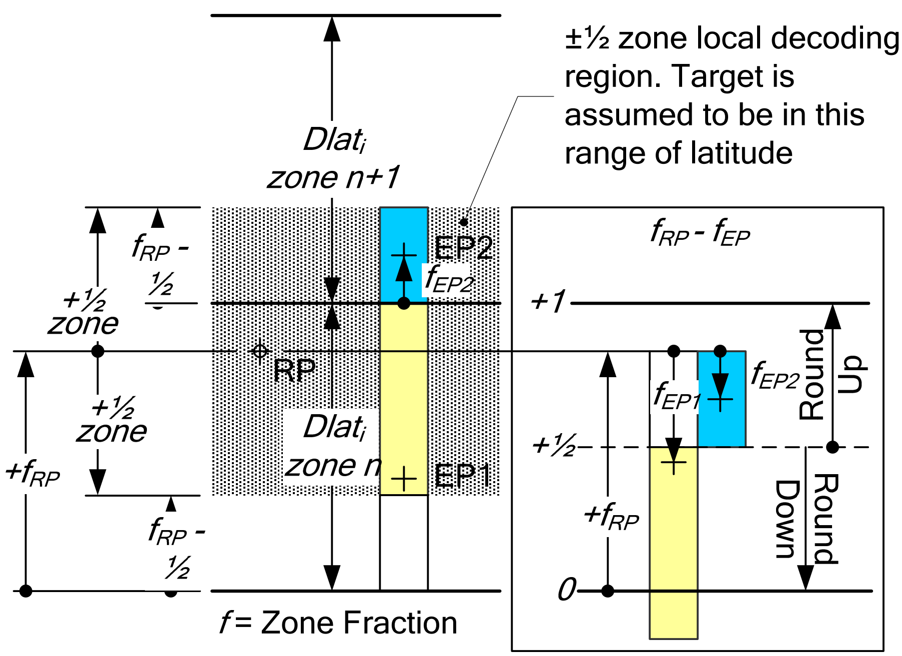


Figure 5-5 Local Decoding Zone Index Determination when f_{RP} > 1/2

f_{RP} is given by Eq 36.

$$f_{RP} = \frac{MOD(lat_s, Dlat_i)}{Dlat_i} \quad \text{Eq 36}$$

f_{EP} is given by Eq 37.

$$f_{EP} = \frac{YZ_i}{2^{Nb}} \quad \text{Eq 37}$$

The RP and EP are assumed to lie within the ±½ zone local decoding region (the shaded area in Figure 5-5), but the RP and EP may be in different latitude zones (e.g. RP and EP2). The difference in zone fractions is used to determine whether the EP is in the same zone as the RP, one zone to the north or one zone to the south.

The conversion from the difference in zone fractions $(f_{RP} - f_{EP})$ to the difference in zone indices $(\Delta ZI_{RP\rightarrow EP})$ is done by rounding as shown in Eq 38.

$$\Delta ZI_{RP\rightarrow EP} = floor\left(f_{RP} - f_{EP} + \frac{1}{2}\right) \qquad \text{Eq 38}$$

If the two positions are in the same zone, the difference in zone fractions will always be between -½ and +½. Eq 38 will produce a difference in Zone Indices $(\Delta ZI_{RP\rightarrow EP})$ of 0.

If EP is in the zone to the north of RP (e.g. EP2 in Figure 5-5), the difference in zone indices $\Delta ZI_{RP\rightarrow EP}$ is expected to be +1. f_{EP} will be less than f_{RP} – ½ and therefore $(f_{RP} - f_{EP})$ will be greater than +½. Applying Eq 38 for $\Delta ZI_{RP\rightarrow EP}$ to $(f_{RP} - f_{EP})$ will produce the expected value of +1. This value is added to the zone index of RP to get the zone index of EP (n+1).

The case where f_{RP} < ½ is shown in Figure 5-6.

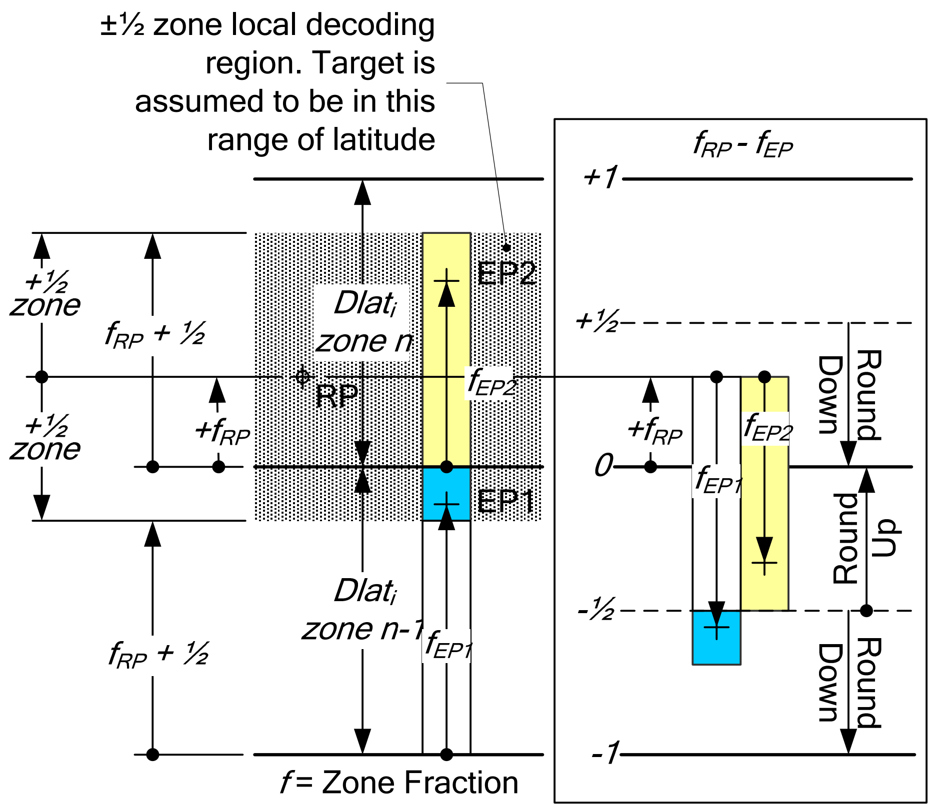


Figure 5-6 Local Decoding Zone Index Determination when f_{RP} <1/2

If EP is in the zone to the south of RP (e.g. EP1 in Figure 5-6), the difference in zone indices $\Delta ZI_{RP\rightarrow EP}$ is expected to be -1. f_{EP} will be greater than f_{RP} + ½ and therefore $(f_{RP} - f_{EP})$ will be less than -½. Applying Eq 38 for $\Delta ZI_{RP\rightarrow EP}$ to $(f_{RP} - f_{EP})$ will produce the expected value of -1. This value is added to the zone index of RP to get the zone index of EP (n-1).

Eq 38 produces the correct difference in zone indices for any two reference position and encoded position zone fractions. Substituting Eqs 35 through 38 into Eq 34 and rearranging results in Eq 39.

$$ZI_{EP} = ZI_{RP} + \Delta ZI_{RP \rightarrow EP}$$

$$ZI_{EP} = floor\left(\frac{lat_s}{Dlat_i}\right) + floor\left(f_{RP} - f_{EP} + \frac{1}{2}\right)$$

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

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

Eq 39

[A.1.7.5b]

The latitude of the encoded position is the latitude zone width, $Dlat_i$, multiplied by the sum of the encoded position zone index j and the encoded position zone fraction.

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

Eq 40

[A.1.7.5c]

5.3.2 Airborne and TIS-B Longitude Local Decoding

Local decoding of longitude is similar to local decoding of latitude. Longitude Zone Width is calculated with Eq 4, which is repeated in [A.1.7.5d]. Then, the longitude zone index is computed using Eq 41.

$$ZI_{EP} = ZI_{RP} + \Delta ZI_{RP \rightarrow EP}$$

$$ZI_{EP} = floor\left(\frac{lon_s}{Dlon_i}\right) + floor\left(f_{RP} - f_{EP} + \frac{1}{2}\right)$$

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

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

Eq 41

[A.1.7.5e]

Eq 41 is the same as Eq 39 except the following variable substitutions have been made:

- RP latitude lat_s replaced with RP latitude lon_s
- Latitude Zone Width $Dlat_i$ replaced with Longitude Zone Width $Dlon_i$
- Latitude bin number YZ_i replaced with Longitude bin number XZ_i
- EP latitude zone index j replaced longitude zone index m

ZI and f in Eq 41 refer to longitude zone indices and zone fractions whereas the same variables in Eq 39 refer to latitude zone indices and zone fractions.

Longitude zone indices start at zero on the east side of the prime meridian and increase with increasing east longitude. If RP longitude is between 0° and 360°, the longitude zone indices will range from 0 to 59 and the recovered longitude $Rlon_i$ will be in the range of 0° to 360°. If RP longitude is between -180° and +180°, the longitude zone indices will range from -30 to +29 and the recovered longitude $Rlon_i$ will be in the range of -180° to +180°.

The longitude of the encoded position is the longitude zone width, $Dlon_i$, multiplied by the sum of the encoded position zone index m and the encoded position zone fraction.

$$Rlon_i = Dlon_i\left(m + \frac{XZ_i}{2^{Nb}}\right)$$ Eq 42 [A.1.7.5f]

5.4 Surface Local Decoding

Surface local decoding is the same as airborne and TIS-B local decoding except that the latitude and longitude zone widths $Dlat_i$ and $Dlon_i$ are reduced by a factor of 4. Surface position encoding is performed with 19 bits of resolution (reference Table 3-1) but only the 17 least significant bits are transmitted in the surface position message (A.1.7.3f). Dropping the two most significant bits reduces the number of bins per zone by a factor of 4 but the width of the bins must remain the same for both encoding and decoding. Therefore, the zone widths for decoding must also be smaller by a factor of 4. *Nb* for surface decoding is equal to 17 rather than 19 because the number of bins in each of the reduced size zones is 2^{17} instead of 2^{19}.

The ±½ zone sliding region is applicable for surface local decoding, but since the zone width is smaller by a factor of 4, the sliding region width will be smaller by a factor of 4 also. This means that instead of a surface target needing to be within approximately ±180 nautical miles of the reference position, the surface target must be within approximately ±45 nautical miles.

Eqs 34 through 40 are applicable for surface latitude local decoding as long as the reduced latitude zone width $Dlat_i$ from Eq 32 and the correct value for Nb are ~~is~~ used in the calculations.

NL is calculated using Eq 2 and $Rlat_i$ but the result is the number of longitude zones in one quadrant of the globe rather than the number of zones around the globe.

Eqs 41 through 42 are applicable for surface longitude local decoding as long as the reduced longitude zone width $Dlon_i$ from Eq 33 is used in the calculations.

6 Additional Information

The preceding sections describe how the CPR algorithms should work..This section describes specific issues that have arisen in terms of the concepts described above.

6.1 NL Transition Latitudes

This section defines the 32 bit Angular Weighted Binary (32bAWB) input latitudes at which the value of *NL* changes. In 2006, Airservices Australia reported anomalies in encoded longitude reported by certain aircraft. The root cause of the longitude jumps was inconsistency between the encoded latitude and the value of *NL* used to encode the longitude. SC-186 WG3 added the position reasonableness tests in sections §2.2.10.3.1, §2.2.10.3.2 and §2.2.10.6 to detect the erroneous longitudes caused by incorrect *NL* values as well as erroneous positions caused by undetected bit errors and other mechanisms. During the review of this appendix, SC-186 WG3 requested that a table be added showing the 32bAWB input latitudes at which the value of *NL* changes.

The CPR encoding process is described in Section 4. The relevant steps leading to the selection of NL are:

1. Determine the latitude zone width $Dlat_i$ (Eq 1)

2. Determine the bin number YZ_i (Eq 5)

3. Determine the bin centerline latitude $Rlat_i$ (Eq 6)

4. Determine *NL* using $Rlat_i$ (Eq 2 or Eq 3)

A crucial and commonly misunderstood point is that the value of *NL* selected during encoding is NOT based directly on the latitude input to the encoder. *NL* is determined from $Rlat_i$ and $Rlat_i$ is dependent on the input latitude. The reason for this is the decoder can determine only $Rlat_i$ and must use the value of $Rlat_i$ to determine *NL*. If the value of *NL* used during encoding is not consistent with the encoded latitude, the decoder will select a different value for NL and produce an incorrect longitude.

Figure 6-1 depicts the relationships between input latitude, bin centerline latitude and the NL transition latitude for even and odd airborne encoding at the 53/52 NL transition (approx 27.9° south latitude). Input latitudes at or above the bin boundary will have $Rlat_i$ values (i.e. bin centerline latitudes) above the *NL* transition latitude and an *NL* value of 53. Input latitudes below the bin boundary will have $Rlat_i$ values below the NL transition latitude and an *NL* value of 52. Note that latitudes above the bin boundaries but below the NL transition latitude still result in *NL*=53. An encoder that based *NL* directly on the input latitude, instead of $Rlat_i$, would incorrectly select NL=52 for these latitudes.

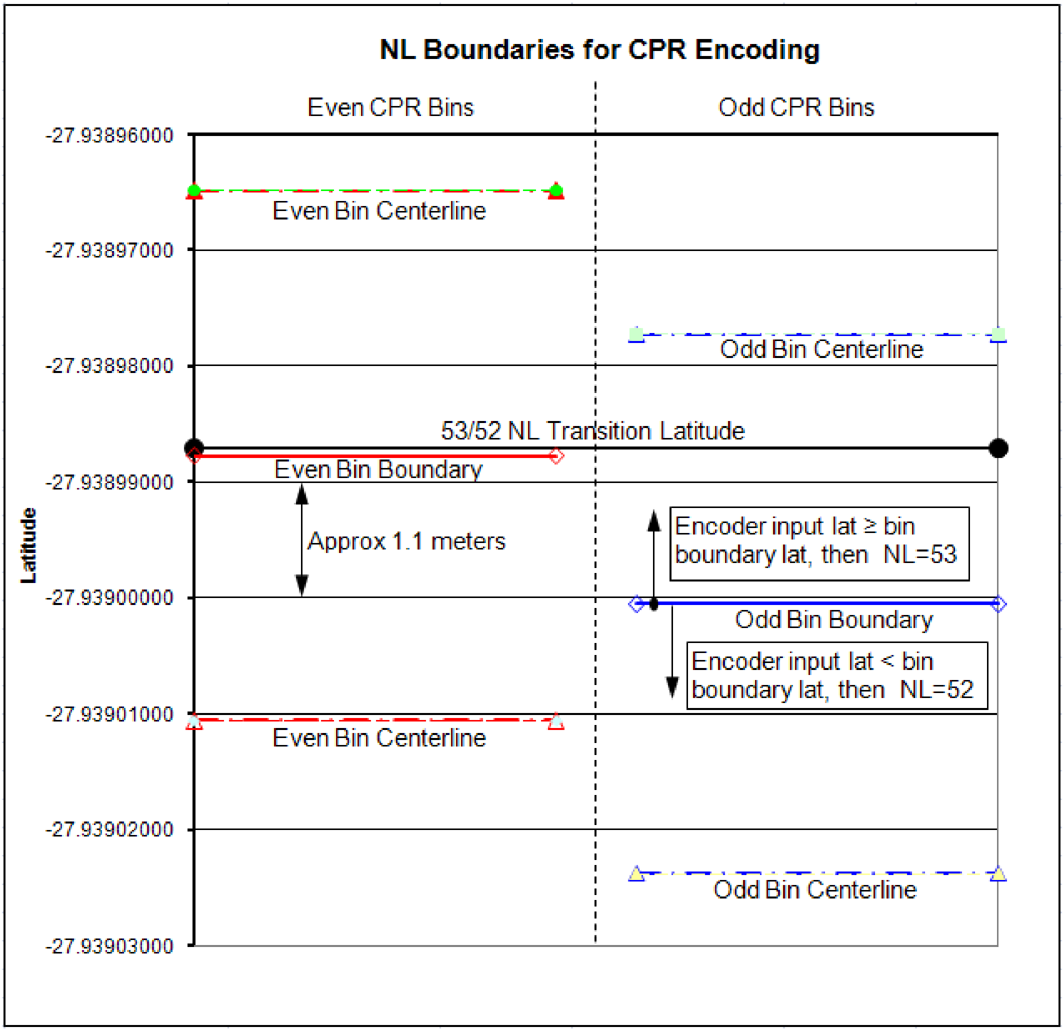


Figure 6-1 Example of relationships between input latitude, $Rlat_i$ and NL

Given the purpose of this section and the behavior described above, the 32bAWB latitudes of interest are the ones that straddle the latitude of the bin boundary closest to each NL transition latitude. The latitude of the closest bin boundary will depend on the CPR format (i.e. even or odd) and the number of bits used for encoding *Nb*. The process to determine the 32bAWB NL transition boundary latitudes is as follows:

1. Determine the NL transition latitudes using Eq 3.

2. Determine the bin numbers YZ_{north} and YZ_{south} of the bins that straddle each NL transition latitude

$$YZ_{north} = floor\left(2^{Nb} \bullet \frac{MOD(lat_{north}, Dlat_i)}{Dlat_i}\right) + 1 \qquad \text{Eq 43}$$

$$YZ_{south} = floor\left(2^{Nb} \bullet \frac{MOD(lat_{south}, Dlat_i)}{Dlat_i}\right) \qquad \text{Eq 44}$$

3. Determine the bin centerline latitude $Rlat_i$ of the straddling bins using Eq 6

4. Average the bin centerline latitudes to get the bin boundary latitude

5. Find the 32bAWB NL latitudes that straddle the bin boundary latitude

$$32bAWB_{north} = \left(\frac{360}{2^{32}}\right) ceiling\left(\frac{lat_{bin\ boundary}}{\left(\frac{360}{2^{32}}\right)}\right) \qquad \text{Eq 45}$$

$$32bAWB_{south} = \left(\frac{360}{2^{32}}\right)\left(ceiling\left(\frac{lat_{bin\ boundary}}{\left(\frac{360}{2^{32}}\right)}\right) - 1\right) \qquad \text{Eq 46}$$

6. Using Eq 7, verify that the encoded longitude changes between the 32bAWB latitudes when the input longitude remains constant. This is an indication that *NL* changed.

Eq 44 is the same as Eq 5 except the first bin with a bin centerline at or south of the NL transition latitude is selected. Eq 45 selects the bin just to the north of the bin selected in Eq 44. Special handling is required for the NL transition latitude at 87° south when even CPR format is used. Eq 43 will select the bin with a bin centerline that coincides with the 2/1 NL transition latitude at 87° south and Eq 44 will select the bin just to the north. Since NL is defined to be 2 at 87° south and 2 at the centerline of the next bin to the north, NL will not change at the bin boundary between these two bins. Therefore, the northern bin should be at 87° south and the southern bin should be the next bin to the south.

The ceiling function in Eq 46 produces the number of 32bAWB bins from the equator to the 32bAWB latitude just north of the bin boundary. The number of bins multiplied by the height of each bin ($360°/2^{32}$) is the north 32bAWB latitude. Eq 46 gives the next 32bAWB latitude to the south. The ceiling function is used instead of the floor function to address cases where the 32bAWB latitude coincides with the bin boundary. An input latitude on the bin boundary should "round up" to the next more northerly bin. The "ceiling/ceiling-1" approach provides a northern latitude on the bin boundary and a southern latitude on 32bAWB bin to the south.

Verification using Eq 7 is performed with constant input longitudes of 45° for surface encoding and 180° for airborne and TIS-B encoding. Any value could be used but these values create encoded longitude values that represent either the edge of a zone or the exact middle of a zone.

Table 6-1 through

Table 6-6 present the northern and southern 32bAWB boundary latitudes for each transition latitude with even and odd, surface, airborne and TIS-B encodings. The expected outputs in Table 6-1 are identical to those in Table 2-130. The input latitudes in Table 2-130 are the bin centerlines of the even format, surface encoded bins that straddle each NL transition latitude. The distance between the bin centerlines is approximately 127 cm for even format and 130 cm for odd. The distance between the 32bAWB boundary latitudes is approximately 0.93 cm. Even though the separation between the 32bAWB boundary latitudes is much smaller than the test latitudes in Table 2-130, both sets of latitudes are on opposite sides of the bin boundary and both will generate the same values of *NL* and the same encoded longitudes. Encoders that determine NL incorrectly from the input latitude rather than from Rlati will produce the expected outputs using the inputs from Table 2-130 but will not produce the expected outputs using the 32bAWB boundary latitudes presented in Table 6-1.

Table 6-1 32bAWB boundaries for NL Transition latitudes - surface even encoding

Input 32bAWB Boundary Latitudes (Input Longitude = 45°)				Expected Outputs			
South		North		South		North	
Decimal	32bAWB	Decimal	32bAWB	Enc Lat	Enc Lon	Enc Lat	Enc Lon
87.0000057108700	3DDDDE22	87.0000057946890	3DDDDE23	00000	00000	00001	10000
86.5353755280375	3D8948CC	86.5353756118565	3D8948CD	16168	10000	16169	00000
85.7554148789495	3CFB4BFF	85.7554149627685	3CFB4C00	0572E	00000	0572F	10000
84.8916606791317	3C5E0E22	84.8916607629507	3C5E0E23	1305A	10000	1305B	00000
83.9917316101491	3BBA3A66	83.9917316939681	3BBA3A67	1FD2D	00000	1FD2E	10000
83.0719928350299	3B12CB77	83.0719929188489	3B12CB78	0C33D	10000	0C33E	00000
82.1395740006119	3A690D99	82.1395740844309	3A690D9A	184F9	00000	184FA	10000
81.1980113480240	39BDA599	81.1980114318430	39BDA59A	04396	10000	04397	00000
80.2492275182157	3910ED11	80.2492276020348	3910ED12	0FFBC	00000	0FFBD	10000
79.2942866776138	38631599	79.2942867614328	3863159A	1B9C8	10000	1B9C9	00000
78.3337382599711	37B438CC	78.3337383437901	37B438CD	071EA	00000	071EB	10000
77.3678913060575	37046511	77.3678913898766	37046512	1283D	10000	1283E	00000
76.3968486618250	36539F33	76.3968487456440	36539F34	1DCCA	00000	1DCCB	10000
75.4205646459013	35A1E511	75.4205647297203	35A1E512	08F8D	10000	08F8E	00000
74.4389361608773	34EF31DD	74.4389362446963	34EF31DE	1407D	00000	1407E	10000
73.4517688304185	343B7C88	73.4517689142376	343B7C89	1EF89	10000	1EF8A	00000
72.4588450603187	3386BAEE	72.4588451441377	3386BAEF	09C9E	00000	09C9F	10000
71.4598674606531	32D0DF33	71.4598675444722	32D0DF34	147A2	10000	147A3	00000
70.4545154236257	3219DA66	70.4545155074447	3219DA67	1F079	00000	1F07A	10000
69.4424228277057	31619B77	69.4424229115247	31619B78	09703	10000	09704	00000
68.4232234675437	30A81155	68.4232235513627	30A81156	13B20	00000	13B21	10000
67.3964710067957	2FED2733	67.3964710906147	2FED2734	1DCA9	10000	1DCAA	00000
66.3617076259106	2F30C7BB	66.3617077097296	2F30C7BC	07B76	00000	07B77	10000
65.3184527903795	2E72DC88	65.3184528741985	2E72DC89	1175D	10000	1175E	00000
64.2661685496568	2DB34C88	64.2661686334758	2DB34C89	1B02F	00000	1B030	10000
63.2042712718248	2CF1FC88	63.2042713556438	2CF1FC89	045B9	10000	045BA	00000
62.1321658417582	2C2ED0CC	62.1321659255772	2C2ED0CD	0D7C7	00000	0D7C8	10000
61.0491770971566	2B69A9DD	61.0491771809756	2B69A9DE	1661E	10000	1661F	00000

Input 32bAWB Boundary Latitudes (Input Longitude = 45°)				Expected Outputs			
South		North		South		North	
Decimal	32bAWB	Decimal	32bAWB	Enc Lat	Enc Lon	Enc Lat	Enc Lon
59.9545955099165	2AA266AA	59.9545955937355	2AA266AB	1F080	00000	1F081	10000
58.8476428203284	29D8E2EE	58.8476429041475	29D8E2EF	076A9	10000	076AA	00000
57.7274722885340	290CF733	57.7274723723530	290CF734	0F84F	00000	0F850	10000
56.5931910742074	283E79DD	56.5931911580264	283E79DE	17524	10000	17525	00000
55.4437808599323	276D3B77	55.4437809437513	276D3B78	1ECCF	00000	1ECD0	10000
54.2781772278249	26990A66	54.2781773116439	26990A67	05EF3	10000	05EF4	00000
53.0951671488583	25C1AE22	53.0951672326773	25C1AE23	0CB26	00000	0CB27	10000
51.8934230133891	24E6E8CC	51.8934230972081	24E6E8CD	130F4	10000	130F5	00000
50.6715030502527	24087733	50.6715031340718	24087734	18FDF	00000	18FE0	10000
49.4277591258287	23260C88	49.4277592096477	23260C89	1E757	10000	1E758	00000
48.1603946629911	223F5511	48.1603947468101	223F5512	036BF	00000	036C0	10000
46.8673381581902	2153F044	46.8673382420092	2153F045	07D62	10000	07D63	00000
45.5462664831429	206371DD	45.5462665669620	206371DE	0BA75	00000	0BA76	10000
44.1945476364344	1F6D5F33	44.1945477202534	1F6D5F34	0ED12	10000	0ED13	00000
42.8091373108327	1E712A66	42.8091373946517	1E712A67	1142F	00000	11430	10000
41.3865222316235	1D6E2FBB	41.3865223154425	1D6E2FBC	12E99	10000	12E9A	00000
39.9225711263716	1C63AEAA	39.9225712101906	1C63AEAB	13AE7	00000	13AE8	10000
38.4124202281236	1B50C488	38.4124203119426	1B50C489	13770	10000	13771	00000
36.8502559326589	1A346266	36.8502560164779	1A346267	12238	00000	12239	10000
35.2289943583309	190D3E22	35.2289944421499	190D3E23	0F8D4	10000	0F8D5	00000
33.5399379394948	17D9C266	33.5399380233138	17D9C267	0B84C	00000	0B84D	10000
31.7721004318445	1697EF33	31.7721005156636	1697EF34	05CE0	10000	05CE1	00000
29.9113597534596	15453266	29.9113598372787	15453267	1E1BE	00000	1E1BF	10000
27.9389819316565	13DE22EE	27.9389820154756	13DE22EF	14081	10000	14082	00000
25.8292522095143	125E1266	25.8292522933334	125E1267	07062	00000	07063	10000
23.5450457967817	10BE3EAA	23.5450458806008	10BE3EAB	164B5	10000	164B6	00000
21.0293940827250	0EF448CC	21.0293941665440	0EF448CD	00A08	00000	00A09	10000
18.1862583104521	0CEEB511	18.1862583942711	0CEEB512	03F93	10000	03F94	00000
14.8281726054847	0A8B62EE	14.8281726893037	0A8B62EF	1C559	00000	1C55A	10000
10.4704685043543	07721733	10.4704685881733	07721734	1F5EB	10000	1F5EC	00000
-10.4704685881733	F88DE8CC	-10.4704685043543	F88DE8CD	00A14	00000	00A15	10000
-14.8281726893037	F5749D11	-14.8281726054847	F5749D12	03AA6	10000	03AA7	00000
-18.1862583942711	F3114AEE	-18.1862583104521	F3114AEF	1C06C	00000	1C06D	10000
-21.0293941665440	F10BB733	-21.0293940827250	F10BB734	1F5F7	10000	1F5F8	00000
-23.5450458806008	EF41C155	-23.5450457967817	EF41C156	09B4A	00000	09B4B	10000
-25.8292522933334	EDA1ED99	-25.8292522095143	EDA1ED9A	18F9D	10000	18F9E	00000
-27.9389820154756	EC21DD11	-27.9389819316565	EC21DD12	0BF7E	00000	0BF7F	10000
-29.9113598372787	EABACD99	-29.9113597534596	EABACD9A	01E41	10000	01E42	00000
-31.7721005156636	E96810CC	-31.7721004318445	E96810CD	1A31F	00000	1A320	10000
-33.5399380233138	E8263D99	-33.5399379394948	E8263D9A	147B3	10000	147B4	00000

Input 32bAWB Boundary Latitudes (Input Longitude = 45°)				Expected Outputs			
South		North		South		North	
Decimal	32bAWB	Decimal	32bAWB	Enc Lat	Enc Lon	Enc Lat	Enc Lon
-35.2289944421499	E6F2C1DD	-35.2289943583309	E6F2C1DE	1072B	00000	1072C	10000
-36.8502560164779	E5CB9D99	-36.8502559326589	E5CB9D9A	0DDC7	10000	0DDC8	00000
-38.4124203119426	E4AF3B77	-38.4124202281236	E4AF3B78	0C88F	00000	0C890	10000
-39.9225712101906	E39C5155	-39.9225711263716	E39C5156	0C518	10000	0C519	00000
-41.3865223154425	E291D044	-41.3865222316235	E291D045	0D166	00000	0D167	10000
-42.8091373946517	E18ED599	-42.8091373108327	E18ED59A	0EBD0	10000	0EBD1	00000
-44.1945477202534	E092A0CC	-44.1945476364344	E092A0CD	112ED	00000	112EE	10000
-45.5462665669620	DF9C8E22	-45.5462664831429	DF9C8E23	1458A	10000	1458B	00000
-46.8673382420092	DEAC0FBB	-46.8673381581902	DEAC0FBC	1829D	00000	1829E	10000
-48.1603947468101	DDC0AAEE	-48.1603946629911	DDC0AAEF	1C940	10000	1C941	00000
-49.4277592096477	DCD9F377	-49.4277591258287	DCD9F378	018A8	00000	018A9	10000
-50.6715031340718	DBF788CC	-50.6715030502527	DBF788CD	07020	10000	07021	00000
-51.8934230972081	DB191733	-51.8934230133891	DB191734	0CF0B	00000	0CF0C	10000
-53.0951672326773	DA3E51DD	-53.0951671488583	DA3E51DE	134D9	10000	134DA	00000
-54.2781773116439	D966F599	-54.2781772278249	D966F59A	1A10C	00000	1A10D	10000
-55.4437809437513	D892C488	-55.4437808599323	D892C489	01330	10000	01331	00000
-56.5931911580264	D7C18622	-56.5931910742074	D7C18623	08ADB	00000	08ADC	10000
-57.7274723723530	D6F308CC	-57.7274722885340	D6F308CD	107B0	10000	107B1	00000
-58.8476429041475	D6271D11	-58.8476428203284	D6271D12	18956	00000	18957	10000
-59.9545955937355	D55D9955	-59.9545955099165	D55D9956	00F7F	10000	00F80	00000
-61.0491771809756	D4965622	-61.0491770971566	D4965623	099E1	00000	099E2	10000
-62.1321659255772	D3D12F33	-62.1321658417582	D3D12F34	12838	10000	12839	00000
-63.2042713556438	D30E0377	-63.2042712718248	D30E0378	1BA46	00000	1BA47	10000
-64.2661686334758	D24CB377	-64.2661685496568	D24CB378	04FD0	10000	04FD1	00000
-65.3184528741985	D18D2377	-65.3184527903795	D18D2378	0E8A2	00000	0E8A3	10000
-66.3617077097296	D0CF3844	-66.3617076259106	D0CF3845	18489	10000	1848A	00000
-67.3964710906147	D012D8CC	-67.3964710067957	D012D8CD	02356	00000	02357	10000
-68.4232235513627	CF57EEAA	-68.4232234675437	CF57EEAB	0C4DF	10000	0C4E0	00000
-69.4424229115247	CE9E6488	-69.4424228277057	CE9E6489	168FC	00000	168FD	10000
-70.4545155074447	CDE62599	-70.4545154236257	CDE6259A	00F86	10000	00F87	00000
-71.4598675444722	CD2F20CC	-71.4598674606531	CD2F20CD	0B85D	00000	0B85E	10000
-72.4588451441377	CC794511	-72.4588450603187	CC794512	16361	10000	16362	00000
-73.4517689142376	CBC48377	-73.4517688304185	CBC48378	01076	00000	01077	10000
-74.4389362446963	CB10CE22	-74.4389361608773	CB10CE23	0BF82	10000	0BF83	00000
-75.4205647297203	CA5E1AEE	-75.4205646459013	CA5E1AEF	17072	00000	17073	10000
-76.3968487456440	C9AC60CC	-76.3968486618250	C9AC60CD	02335	10000	02336	00000
-77.3678913898766	C8FB9AEE	-77.3678913060575	C8FB9AEF	0D7C2	00000	0D7C3	10000
-78.3337383437901	C84BC733	-78.3337382599711	C84BC734	18E15	10000	18E16	00000
-79.2942867614328	C79CEA66	-79.2942866776138	C79CEA67	04637	00000	04638	10000
-80.2492276020348	C6EF12EE	-80.2492275182157	C6EF12EF	10043	10000	10044	00000

Input 32bAWB Boundary Latitudes (Input Longitude = 45°)				Expected Outputs			
South		North		South		North	
Decimal	32bAWB	Decimal	32bAWB	Enc Lat	Enc Lon	Enc Lat	Enc Lon
-81.1980114318430	C6425A66	-81.1980113480240	C6425A67	1BC69	00000	1BC6A	10000
-82.1395740844309	C596F266	-82.1395740006119	C596F267	07B06	10000	07B07	00000
-83.0719929188489	C4ED3488	-83.0719928350299	C4ED3489	13CC2	00000	13CC3	10000
-83.9917316939681	C445C599	-83.9917316101491	C445C59A	002D2	10000	002D3	00000
-84.8916607629507	C3A1F1DD	-84.8916606791317	C3A1F1DE	0CFA5	00000	0CFA6	10000
-85.7554150465875	C304B3FF	-85.7554149627685	C304B400	1A8D1	10000	1A8D2	00000
-86.5353756118565	C276B733	-86.5353755280375	C276B734	09E97	00000	09E98	10000
-87.0000057946890	C22221DD	-87.0000057108700	C22221DE	1FFFF	10000	00000	00000

Table 6-2 32bAWB boundaries for NL Transition latitudes - surface odd encoding

Input 32bAWB Boundary Latitudes (Input Longitude = 45°)				Expected Outputs			
South		North		South		North	
Decimal	32bAWB	Decimal	32bAWB	Enc Lat	Enc Lon	Enc Lat	Enc Lon
87.0000050403177	3DDDDE1A	87.0000051241368	3DDDDE1B	01111	10000	01112	10000
86.5353671461343	3D894868	86.5353672299534	3D894869	1751D	00000	1751E	10000
85.7554193213582	3CFB4C34	85.7554194051772	3CFB4C35	06F54	10000	06F55	00000
84.8916657920926	3C5E0E5F	84.8916658759117	3C5E0E60	14D6A	00000	14D6B	10000
83.9917411655187	3BBA3AD8	83.9917412493377	3BBA3AD9	01F5C	10000	01F5D	00000
83.0719970259815	3B12CBA9	83.0719971098005	3B12CBAA	0EAA7	00000	0EAA8	10000
82.1395672950893	3A690D49	82.1395673789083	3A690D4A	1B1B0	10000	1B1B1	00000
81.1980133596807	39BDA5B1	81.1980134434998	39BDA5B2	075A9	00000	075AA	10000
80.2492322120815	3910ED49	80.2492322959005	3910ED4A	13735	10000	13736	00000
79.2942829057574	3863156C	79.2942829895764	3863156D	1F6AF	00000	1F6B0	10000
78.3337356615811	37B438AD	78.3337357454001	37B438AE	0B448	10000	0B449	00000
77.3678931500762	37046527	77.3678932338953	37046528	1701A	00000	1701B	10000
76.3968483265489	36539F2F	76.3968484103679	36539F30	02A2D	10000	02A2E	00000
75.4205664899200	35A1E527	75.4205665737390	35A1E528	0E27E	00000	0E27F	10000
74.4389310479164	34EF31A0	74.4389311317354	34EF31A1	19903	10000	19904	00000
73.4517792239785	343B7D04	73.4517793077975	343B7D05	04DAE	00000	04DAF	10000
72.4588432163000	3386BAD8	72.4588433001190	3386BAD9	10068	10000	10069	00000
71.4598671253770	32D0DF2F	71.4598672091960	32D0DF30	1B11B	00000	1B11C	10000
70.4545134119689	3219DA4E	70.4545134957879	3219DA4F	05FAA	10000	05FAB	00000
69.4424211513251	31619B63	69.4424212351441	31619B64	10BF6	00000	10BF7	10000
68.4232181031256	30A81115	68.4232181869447	30A81116	1B5DF	10000	1B5E0	00000
67.3964619543403	2FED26C7	67.3964620381593	2FED26C8	05D3F	00000	05D40	10000
66.3617104757577	2F30C7DD	66.3617105595767	2F30C7DE	101F0	10000	101F1	00000
65.3184515330940	2E72DC79	65.3184516169130	2E72DC7A	1A3C6	00000	1A3C7	10000
64.2661615088582	2DB34C34	64.2661615926772	2DB34C35	04294	10000	04295	00000
63.2042700145393	2CF1FC79	63.2042700983583	2CF1FC7A	0DE29	00000	0DE2A	10000
62.1321719605475	2C2ED115	62.1321720443665	2C2ED116	17651	10000	17652	00000
61.0491807013750	2B69AA08	61.0491807851940	2B69AA09	00AD1	00000	00AD2	10000
59.9545979406684	2AA266C7	59.9545980244874	2AA266C8	09B6D	10000	09B6E	00000
58.8476322591304	29D8E270	58.8476323429495	29D8E271	127E1	00000	127E2	10000

Input 32bAWB Boundary Latitudes (Input Longitude = 45°)				Expected Outputs			
South		North		South		North	
Decimal	32bAWB	Decimal	32bAWB	Enc Lat	Enc Lon	Enc Lat	Enc Lon
57.7274691034108	290CF70D	57.7274691872298	290CF70E	1AFE7	10000	1AFE8	00000
56.5931888949126	283E79C3	56.5931889787316	283E79C4	03330	00000	03331	10000
55.4437791835516	276D3B63	55.4437792673707	276D3B64	0B165	10000	0B166	00000
54.2781693488359	26990A08	54.2781694326549	26990A09	12A2A	00000	12A2B	10000
53.0951606109738	25C1ADD4	53.0951606947928	25C1ADD5	19D18	10000	19D19	00000
51.8934261985123	24E6E8F2	51.8934262823313	24E6E8F3	009BD	00000	009BE	10000
50.6714998651295	2408770D	50.6714999489486	2408770E	06F9B	10000	06F9C	00000
49.4277636520564	23260CBE	49.4277637358754	23260CBF	0CE27	00000	0CE28	10000
48.1603906396776	223F54E1	48.1603907234966	223F54E2	124C4	10000	124C5	00000
46.8673323746770	2153EFFF	46.8673324584960	2153F000	172C2	00000	172C3	10000
45.5462613701820	206371A0	45.5462614540010	206371A1	1B759	10000	1B75A	00000
44.1945473011583	1F6D5F2F	44.1945473849773	1F6D5F30	1F1A7	00000	1F1A8	10000
42.8091410826891	1E712A93	42.8091411665081	1E712A94	020A6	10000	020A7	00000
41.3865163642913	1D6E2F75	41.3865164481103	1D6E2F76	04327	00000	04328	10000
39.9225648399442	1C63AE5F	39.9225649237632	1C63AE60	057C9	10000	057CA	00000
38.4124219045042	1B50C49C	38.4124219883233	1B50C49D	05CEA	00000	05CEB	10000
36.8502567708492	1A346270	36.8502568546682	1A346271	05095	10000	05096	00000
35.2289936877787	190D3E1A	35.2289937715977	190D3E1B	0306A	00000	0306B	10000
33.5399387776851	17D9C270	33.5399388615041	17D9C271	1F97E	10000	1F97F	00000
31.7720943130552	1697EEEA	31.7720943968743	1697EEEB	1A820	00000	1A821	10000
29.9113548081368	1545322B	29.9113548919558	1545322C	13794	10000	13795	00000
27.9389830213040	13DE22FB	27.9389831051230	13DE22FC	0A190	00000	0A191	10000
25.8292472641915	125E122B	25.8292473480105	125E122C	1DD71	10000	1DD72	00000
23.5450452938675	10BE3EA4	23.5450453776866	10BE3EA5	0DEC3	00000	0DEC4	10000
21.0293972678482	0EF448F2	21.0293973516672	0EF448F3	19266	10000	19267	00000
18.1862659379839	0CEEB56C	18.1862660218030	0CEEB56D	1D81E	00000	1D81F	10000
14.8281736951321	0A8B62FB	14.8281737789511	0A8B62FC	170FE	10000	170FF	00000
10.4704768862575	07721797	10.4704769700765	07721798	1BA5B	00000	1BA5C	10000
-10.4704769700765	F88DE868	-10.4704768862575	F88DE869	045A4	10000	045A5	00000
-14.8281737789511	F5749D04	-14.8281736951321	F5749D05	08F01	00000	08F02	10000
-18.1862660218030	F3114A93	-18.1862659379839	F3114A94	027E1	10000	027E2	00000
-21.0293973516672	F10BB70D	-21.0293972678482	F10BB70E	06D99	00000	06D9A	10000
-23.5450453776866	EF41C15B	-23.5450452938675	EF41C15C	1213C	10000	1213D	00000
-25.8292473480105	EDA1EDD4	-25.8292472641915	EDA1EDD5	0228E	00000	0228F	10000
-27.9389831051230	EC21DD04	-27.9389830213040	EC21DD05	15E6F	10000	15E70	00000
-29.9113548919558	EABACDD4	-29.9113548081368	EABACDD5	0C86B	00000	0C86C	10000
-31.7720943968743	E9681115	-31.7720943130552	E9681116	057DF	10000	057E0	00000
-33.5399388615041	E8263D8F	-33.5399387776851	E8263D90	00681	00000	00682	10000
-35.2289937715977	E6F2C1E5	-35.2289936877787	E6F2C1E6	1CF95	10000	1CF96	00000
-36.8502568546682	E5CB9D8F	-36.8502567708492	E5CB9D90	1AF6A	00000	1AF6B	10000
-38.4124219883233	E4AF3B63	-38.4124219045042	E4AF3B64	1A315	10000	1A316	00000
-39.9225649237632	E39C51A0	-39.9225648399442	E39C51A1	1A836	00000	1A837	10000
-41.3865164481103	E291D08A	-41.3865163642913	E291D08B	1BCD8	10000	1BCD9	00000
-42.8091411665081	E18ED56C	-42.8091410826891	E18ED56D	1DF59	00000	1DF5A	10000
-44.1945473849773	E092A0D0	-44.1945473011583	E092A0D1	00E58	10000	00E59	00000
-45.5462614540010	DF9C8E5F	-45.5462613701820	DF9C8E60	048A6	00000	048A7	10000
-46.8673325423151	DEAC0FFF	-46.8673324584960	DEAC1000	08D3D	10000	08D3E	00000

Input 32bAWB Boundary Latitudes (Input Longitude = 45°)				Expected Outputs			
South		North		South		North	
Decimal	32bAWB	Decimal	32bAWB	Enc Lat	Enc Lon	Enc Lat	Enc Lon
-48.1603907234966	DDC0AB1E	-48.1603906396776	DDC0AB1F	0DB3B	00000	0DB3C	10000
-49.4277637358754	DCD9F341	-49.4277636520564	DCD9F342	131D8	10000	131D9	00000
-50.6714999489486	DBF788F2	-50.6714998651295	DBF788F3	19064	00000	19065	10000
-51.8934262823313	DB19170D	-51.8934261985123	DB19170E	1F642	10000	1F643	00000
-53.0951606947928	DA3E522B	-53.0951606109738	DA3E522C	062E7	00000	062E8	10000
-54.2781694326549	D966F5F7	-54.2781693488359	D966F5F8	0D5D5	10000	0D5D6	00000
-55.4437792673707	D892C49C	-55.4437791835516	D892C49D	14E9A	00000	14E9B	10000
-56.5931889787316	D7C1863C	-56.5931888949126	D7C1863D	1CCCF	10000	1CCD0	00000
-57.7274691872298	D6F308F2	-57.7274691034108	D6F308F3	05018	00000	05019	10000
-58.8476323429495	D6271D8F	-58.8476322591304	D6271D90	0D81E	10000	0D81F	00000
-59.9545980244874	D55D9938	-59.9545979406684	D55D9939	16492	00000	16493	10000
-61.0491807851940	D49655F7	-61.0491807013750	D49655F8	1F52E	10000	1F52F	00000
-62.1321720443665	D3D12EEA	-62.1321719605475	D3D12EEB	089AE	00000	089AF	10000
-63.2042700983583	D30E0386	-63.2042700145393	D30E0387	121D6	10000	121D7	00000
-64.2661615926772	D24CB3CB	-64.2661615088582	D24CB3CC	1BD6B	00000	1BD6C	10000
-65.3184516169130	D18D2386	-65.3184515330940	D18D2387	05C39	10000	05C3A	00000
-66.3617105595767	D0CF3822	-66.3617104757577	D0CF3823	0FE0F	00000	0FE10	10000
-67.3964620381593	D012D938	-67.3964619543403	D012D939	1A2C0	10000	1A2C1	00000
-68.4232181869447	CF57EEEA	-68.4232181031256	CF57EEEB	04A20	00000	04A21	10000
-69.4424212351441	CE9E649C	-69.4424211513251	CE9E649D	0F409	10000	0F40A	00000
-70.4545134957879	CDE625B1	-70.4545134119689	CDE625B2	1A055	00000	1A056	10000
-71.4598672091960	CD2F20D0	-71.4598671253770	CD2F20D1	04EE4	10000	04EE5	00000
-72.4588433001190	CC794527	-72.4588432163000	CC794528	0FF97	00000	0FF98	10000
-73.4517793077975	CBC482FB	-73.4517792239785	CBC482FC	1B251	10000	1B252	00000
-74.4389311317354	CB10CE5F	-74.4389310479164	CB10CE60	066FC	00000	066FD	10000
-75.4205665737390	CA5E1AD8	-75.4205664899200	CA5E1AD9	11D81	10000	11D82	00000
-76.3968484103679	C9AC60D0	-76.3968483265489	C9AC60D1	1D5D2	00000	1D5D3	10000
-77.3678932338953	C8FB9AD8	-77.3678931500762	C8FB9AD9	08FE5	10000	08FE6	00000
-78.3337357454001	C84BC752	-78.3337356615811	C84BC753	14BB7	00000	14BB8	10000
-79.2942829895764	C79CEA93	-79.2942829057574	C79CEA94	00950	10000	00951	00000
-80.2492322959005	C6EF12B6	-80.2492322120815	C6EF12B7	0C8CA	00000	0C8CB	10000
-81.1980134434998	C6425A4E	-81.1980133596807	C6425A4F	18A56	10000	18A57	00000
-82.1395673789083	C596F2B6	-82.1395672950893	C596F2B7	04E4F	00000	04E50	10000
-83.0719971098005	C4ED3456	-83.0719970259815	C4ED3457	11558	10000	11559	00000
-83.9917412493377	C445C527	-83.9917411655187	C445C528	1E0A3	00000	1E0A4	10000
-84.8916658759117	C3A1F1A0	-84.8916657920926	C3A1F1A1	0B295	10000	0B296	00000
-85.7554194051772	C304B3CB	-85.7554193213582	C304B3CC	190AB	00000	190AC	10000
-86.5353672299534	C276B797	-86.5353671461343	C276B798	08AE2	10000	08AE3	00000
-87.0000051241368	C22221E5	-87.0000050403177	C22221E6	1EEEE	10000	1EEEF	10000

Table 6-3 32bAWB boundaries for NL Transition latitudes - airborne even encoding

Input 32bAWB Boundary Latitudes (Input Longitude = 180°)				Expected Outputs			
South		North		South		North	
Decimal	32bAWB	Decimal	32bAWB	Enc Lat	Enc Lon	Enc Lat	Enc Lon
87.0000228099524	3DDDDEEE	87.0000228937715	3DDDDEEF	10000	00000	10001	10000

Input 32bAWB Boundary Latitudes (Input Longitude = 180°)				Expected Outputs			
South		North		South		North	
Decimal	32bAWB	Decimal	32bAWB	Enc Lat	Enc Lon	Enc Lat	Enc Lon
86.5353927109390	3D894999	86.5353927947580	3D89499A	0D85A	10000	0D85B	00000
85.7554091792553	3CFB4BBB	85.7554092630743	3CFB4BBC	095CB	00000	095CC	10000
84.8916548956185	3C5E0DDD	84.8916549794375	3C5E0DDE	04C16	10000	04C17	00000
83.9917373098433	3BBA3AAA	83.9917373936623	3BBA3AAB	1FF4B	00000	1FF4C	10000
83.0719985347241	3B12CBBB	83.0719986185431	3B12CBBC	1B0CF	10000	1B0D0	00000
82.1395797003060	3A690DDD	82.1395797841250	3A690DDE	1613E	00000	1613F	10000
81.1980056483298	39BDA555	81.1980057321488	39BDA556	110E5	10000	110E6	00000
80.2492446172982	3910EDDD	80.2492447011172	3910EDDE	0BFEF	00000	0BFF0	10000
79.2943038605153	38631666	79.2943039443343	38631667	06E72	10000	06E73	00000
78.3337325602769	37B43888	78.3337326440960	37B43889	01C7A	00000	01C7B	10000
77.3678970057517	37046555	77.3678970895707	37046556	1CA0F	10000	1CA10	00000
76.3968428783118	36539EEE	76.3968429621309	36539EEF	17732	00000	17733	10000
75.4205703455954	35A1E555	75.4205704294145	35A1E556	123E3	10000	123E4	00000
74.4389419443905	34EF3222	74.4389420282095	34EF3223	0D01F	00000	0D020	10000
73.4517745301127	343B7CCC	73.4517746139317	343B7CCD	07BE2	10000	07BE3	00000
72.4588393606245	3386BAAA	72.4588394444435	3386BAAB	02727	00000	02728	10000
71.4598616771399	32D0DEEE	71.4598617609590	32D0DEEF	1D1E8	10000	1D1E9	00000
70.4545211233198	3219DAAA	70.4545212071388	3219DAAB	17C1E	00000	17C1F	10000
69.4424056448042	31619AAA	69.4424057286232	31619AAB	125C0	10000	125C1	00000
68.4232406504452	30A81222	68.4232407342642	30A81223	0CEC8	00000	0CEC9	10000
67.3964767064899	2FED2777	67.3964767903089	2FED2778	0772A	10000	0772B	00000
66.3617019262164	2F30C777	66.3617020100355	2F30C778	01EDD	00000	01EDE	10000
65.3184584900736	2E72DCCC	65.3184585738927	2E72DCCD	1C5D7	10000	1C5D8	00000
64.2661513667553	2DB34BBB	64.2661514505743	2DB34BBC	16C0B	00000	16C0C	10000
63.2042769715189	2CF1FCCC	63.2042770553380	2CF1FCCD	1116E	10000	1116F	00000
62.1321486588567	2C2ECFFF	62.1321487426757	2C2ED000	0B5F1	00000	0B5F2	10000
61.0491713974624	2B69A999	61.0491714812815	2B69A99A	05987	10000	05988	00000
59.9546126928180	2AA26777	59.9546127766370	2AA26778	1FC20	00000	1FC21	10000
58.8476486038416	29D8E333	58.8476486876606	29D8E334	19DAA	10000	19DAB	00000
57.7274551056325	290CF666	57.7274551894515	290CF667	13E13	00000	13E14	10000
56.5932082571089	283E7AAA	56.5932083409279	283E7AAB	0DD49	10000	0DD4A	00000
55.4437636770308	276D3AAA	55.4437637608498	276D3AAB	07B33	00000	07B34	10000
54.2781600449234	26990999	54.2781601287424	2699099A	017BC	10000	017BD	00000
53.0951613653451	25C1ADDD	53.0951614491641	25C1ADDE	1B2C9	00000	1B2CA	10000
51.8934401962906	24E6E999	51.8934402801096	24E6E99A	14C3D	10000	14C3E	00000
50.6714858673512	24087666	50.6714859511703	24087667	0E3F7	00000	0E3F8	10000
49.4277419429272	23260BBB	49.4277420267462	23260BBC	079D5	10000	079D6	00000
48.1603774800896	223F5444	48.1603775639086	223F5445	00DAF	00000	00DB0	10000
46.8673323746770	2153EFFF	46.8673324584960	2153F000	19F58	10000	19F59	00000
45.5462722666561	20637222	45.5462723504751	20637223	12E9D	00000	12E9E	10000
44.1945418529212	1F6D5EEE	44.1945419367402	1F6D5EEF	0BB44	10000	0BB45	00000
42.8091201279312	1E712999	42.8091202117502	1E71299A	0450B	00000	0450C	10000
41.3865279313176	1D6E2FFF	41.3865280151367	1D6E3000	1CBA6	10000	1CBA7	00000
39.9225539434701	1C63ADDD	39.9225540272891	1C63ADDE	14EB9	00000	14EBA	10000
38.4124374110251	1B50C555	38.4124374948441	1B50C556	0CDDC	10000	0CDDD	00000
36.8502731155604	1A346333	36.8502731993794	1A346334	0488E	00000	0488F	10000
35.2290114574134	190D3EEE	35.2290115412324	190D3EEF	1BE35	10000	1BE36	00000

Input 32bAWB Boundary Latitudes (Input Longitude = 180°)				Expected Outputs			
South		North		South		North	
Decimal	32bAWB	Decimal	32bAWB	Enc Lat	Enc Lon	Enc Lat	Enc Lon
33.5399551223963	17D9C333	33.5399552062153	17D9C334	12E13	00000	12E14	10000
31.7721175309270	1697EFFF	31.7721176147460	1697F000	09738	10000	09739	00000
29.9113540537655	15453222	29.9113541375845	15453223	1F86F	00000	1F870	10000
27.9389877151697	13DE2333	27.9389877989888	13DE2334	15020	10000	15021	00000
25.8292465098202	125E1222	25.8292465936392	125E1223	09C18	00000	09C19	10000
23.5450514964759	10BE3EEE	23.5450515802949	10BE3EEF	1D92D	10000	1D92E	00000
21.0294112656265	0EF44999	21.0294113494455	0EF4499A	10282	00000	10283	10000
18.1862411275506	0CEEB444	18.1862412113696	0CEEB445	00FE4	10000	00FE5	00000
14.8281783889979	0A8B6333	14.8281784728169	0A8B6334	0F156	00000	0F157	10000
10.4704513214528	07721666	10.4704514052718	07721667	17D7A	10000	17D7B	00000
-10.4704514052718	F88DE999	-10.4704513214528	F88DE99A	08285	00000	08286	10000
-14.8281784728169	F5749CCC	-14.8281783889979	F5749CCD	10EA9	10000	10EAA	00000
-18.1862412113696	F3114BBB	-18.1862411275506	F3114BBC	1F01B	00000	1F01C	10000
-21.0294113494455	F10BB666	-21.0294112656265	F10BB667	0FD7D	10000	0FD7E	00000
-23.5450515802949	EF41C111	-23.5450514964759	EF41C112	026D2	00000	026D3	10000
-25.8292465936392	EDA1EDDD	-25.8292465098202	EDA1EDDE	163E7	10000	163E8	00000
-27.9389877989888	EC21DCCC	-27.9389877151697	EC21DCCD	0AFDF	00000	0AFE0	10000
-29.9113541375845	EABACDDD	-29.9113540537655	EABACDDE	00790	10000	00791	00000
-31.7721176985651	E9680FFF	-31.7721176147460	E9681000	168C7	00000	168C8	10000
-33.5399552062153	E8263CCC	-33.5399551223963	E8263CCD	0D1EC	10000	0D1ED	00000
-35.2290115412324	E6F2C111	-35.2290114574134	E6F2C112	041CA	00000	041CB	10000
-36.8502731993794	E5CB9CCC	-36.8502731155604	E5CB9CCD	1B771	10000	1B772	00000
-38.4124374948441	E4AF3AAA	-38.4124374110251	E4AF3AAB	13223	00000	13224	10000
-39.9225540272891	E39C5222	-39.9225539434701	E39C5223	0B146	10000	0B147	00000
-41.3865280989557	E291CFFF	-41.3865280151367	E291D000	03459	00000	0345A	10000
-42.8091202117502	E18ED666	-42.8091201279312	E18ED667	1BAF4	10000	1BAF5	00000
-44.1945419367402	E092A111	-44.1945418529212	E092A112	144BB	00000	144BC	10000
-45.5462723504751	DF9C8DDD	-45.5462722666561	DF9C8DDE	0D162	10000	0D163	00000
-46.8673325423151	DEAC0FFF	-46.8673324584960	DEAC1000	060A7	00000	060A8	10000
-48.1603775639086	DDC0ABBB	-48.1603774800896	DDC0ABBC	1F250	10000	1F251	00000
-49.4277420267462	DCD9F444	-49.4277419429272	DCD9F445	1862A	00000	1862B	10000
-50.6714859511703	DBF78999	-50.6714858673512	DBF7899A	11C08	10000	11C09	00000
-51.8934402801096	DB191666	-51.8934401962906	DB191667	0B3C2	00000	0B3C3	10000
-53.0951614491641	DA3E5222	-53.0951613653451	DA3E5223	04D36	10000	04D37	00000
-54.2781601287424	D966F666	-54.2781600449234	D966F667	1E843	00000	1E844	10000
-55.4437637608498	D892C555	-55.4437636770308	D892C556	184CC	10000	184CD	00000
-56.5932083409279	D7C18555	-56.5932082571089	D7C18556	122B6	00000	122B7	10000
-57.7274551894515	D6F30999	-57.7274551056325	D6F3099A	0C1EC	10000	0C1ED	00000
-58.8476486876606	D6271CCC	-58.8476486038416	D6271CCD	06255	00000	06256	10000
-59.9546127766370	D55D9888	-59.9546126928180	D55D9889	003DF	10000	003E0	00000
-61.0491714812815	D4965666	-61.0491713974624	D4965667	1A678	00000	1A679	10000
-62.1321488264948	D3D12FFF	-62.1321487426757	D3D13000	14A0E	10000	14A0F	00000
-63.2042770553380	D30E0333	-63.2042769715189	D30E0334	0EE91	00000	0EE92	10000
-64.2661514505743	D24CB444	-64.2661513667553	D24CB445	093F4	10000	093F5	00000
-65.3184585738927	D18D2333	-65.3184584900736	D18D2334	03A28	00000	03A29	10000
-66.3617020100355	D0CF3888	-66.3617019262164	D0CF3889	1E122	10000	1E123	00000
-67.3964767903089	D012D888	-67.3964767064899	D012D889	188D5	00000	188D6	10000

Input 32bAWB Boundary Latitudes (Input Longitude = 180°)				Expected Outputs			
South		North		South		North	
Decimal	32bAWB	Decimal	32bAWB	Enc Lat	Enc Lon	Enc Lat	Enc Lon
-68.4232407342642	CF57EDDD	-68.4232406504452	CF57EDDE	13137	10000	13138	00000
-69.4424057286232	CE9E6555	-69.4424056448042	CE9E6556	0DA3F	00000	0DA40	10000
-70.4545212071388	CDE62555	-70.4545211233198	CDE62556	083E1	10000	083E2	00000
-71.4598617609590	CD2F2111	-71.4598616771399	CD2F2112	02E17	00000	02E18	10000
-72.4588394444435	CC794555	-72.4588393606245	CC794556	1D8D8	10000	1D8D9	00000
-73.4517746139317	CBC48333	-73.4517745301127	CBC48334	1841D	00000	1841E	10000
-74.4389420282095	CB10CDDD	-74.4389419443905	CB10CDDE	12FE0	10000	12FE1	00000
-75.4205704294145	CA5E1AAA	-75.4205703455954	CA5E1AAB	0DC1C	00000	0DC1D	10000
-76.3968429621309	C9AC6111	-76.3968428783118	C9AC6112	088CD	10000	088CE	00000
-77.3678970895707	C8FB9AAA	-77.3678970057517	C8FB9AAB	035F0	00000	035F1	10000
-78.3337326440960	C84BC777	-78.3337325602769	C84BC778	1E385	10000	1E386	00000
-79.2943039443343	C79CE999	-79.2943038605153	C79CE99A	1918D	00000	1918E	10000
-80.2492447011172	C6EF1222	-80.2492446172982	C6EF1223	14010	10000	14011	00000
-81.1980057321488	C6425AAA	-81.1980056483298	C6425AAB	0EF1A	00000	0EF1B	10000
-82.1395797841250	C596F222	-82.1395797003060	C596F223	09EC1	10000	09EC2	00000
-83.0719986185431	C4ED3444	-83.0719985347241	C4ED3445	04F30	00000	04F31	10000
-83.9917373936623	C445C555	-83.9917373098433	C445C556	000B4	10000	000B5	00000
-84.8916549794375	C3A1F222	-84.8916548956185	C3A1F223	1B3E9	00000	1B3EA	10000
-85.7554092630743	C304B444	-85.7554091792553	C304B445	16A34	10000	16A35	00000
-86.5353927947580	C276B666	-86.5353927109390	C276B667	127A5	00000	127A6	10000
-87.0000228937715	C2222111	-87.0000228099524	C2222112	0FFFF	10000	10000	00000

Table 6-4 32bAWB boundaries for NL Transition latitudes - airborne odd encoding

Input 32bAWB Boundary Latitudes (Input Longitude = 180°)				Expected Outputs			
South		North		South		North	
Decimal	32bAWB	Decimal	32bAWB	Enc Lat	Enc Lon	Enc Lat	Enc Lon
87.0000108238309	3DDDDE5F	87.0000109076499	3DDDDE60	08444	10000	08445	10000
86.5353729296475	3D8948AD	86.5353730134665	3D8948AE	05D47	00000	05D48	10000
85.7554367557168	3CFB4D04	85.7554368395358	3CFB4D05	01BD5	10000	01BD6	00000
84.8916600085794	3C5E0E1A	84.8916600923985	3C5E0E1B	1D35A	00000	1D35B	10000
83.9917586836963	3BBA3BA9	83.9917587675154	3BBA3BAA	187D7	10000	187D8	00000
83.0719795078039	3B12CAD8	83.0719795916229	3B12CAD9	13AA9	00000	13AAA	10000
82.1395848132669	3A690E1A	82.1395848970860	3A690E1B	0EC6C	10000	0EC6D	00000
81.1980192270129	39BDA5F7	81.1980193108320	39BDA5F8	09D6A	00000	09D6B	10000
80.2492380794137	3910ED8F	80.2492381632328	3910ED90	04DCD	10000	04DCE	00000
79.2942654713988	3863149C	79.2942655552178	3863149D	1FDAB	00000	1FDAC	10000
78.3337530959397	37B4397D	78.3337531797587	37B4397E	1AD12	10000	1AD13	00000
77.3678872827440	370464E1	77.3678873665630	370464E2	15C06	00000	15C07	10000
76.3968541938811	36539F75	76.3968542777001	36539F76	10A8B	10000	10A8C	00000
75.4205606225878	35A1E4E1	75.4205607064068	35A1E4E2	0B89F	00000	0B8A0	10000
74.4389136135578	34EF30D0	74.4389136973768	34EF30D1	06640	10000	06641	00000
73.4517733566462	343B7CBE	73.4517734404653	343B7CBF	0136B	00000	0136C	10000
72.4588607344776	3386BBA9	72.4588608182966	3386BBAA	1C01A	10000	1C01B	00000
71.4598496910184	32D0DE5F	71.4598497748374	32D0DE60	16C46	00000	16C47	10000
70.4545075446367	3219DA08	70.4545076284557	3219DA09	117EA	10000	117EB	00000

Input 32bAWB Boundary Latitudes (Input Longitude = 180°)				Expected Outputs			
South		North		South		North	
Decimal	32bAWB	Decimal	32bAWB	Enc Lat	Enc Lon	Enc Lat	Enc Lon
69.4424153678119	31619B1E	69.4424154516309	31619B1F	0C2FD	00000	0C2FE	10000
68.4232006687670	30A81045	68.4232007525861	30A81046	06D77	10000	06D78	00000
67.3964445199817	2FED25F7	67.3964446038007	2FED25F8	0174F	00000	01750	10000
66.3617279101163	2F30C8AD	66.3617279939353	2F30C8AE	1C07C	10000	1C07D	00000
65.3184457495808	2E72DC34	65.3184458333998	2E72DC35	168F1	00000	168F2	10000
64.2661789432168	2DB34D04	64.2661790270358	2DB34D05	110A5	10000	110A6	00000
63.2042757980525	2CF1FCBE	63.2042758818715	2CF1FCBF	0B78A	00000	0B78B	10000
62.1321778278797	2C2ED15B	62.1321779116988	2C2ED15C	05D94	10000	05D95	00000
61.0491865687072	2B69AA4E	61.0491866525262	2B69AA4F	002B4	00000	002B5	10000
59.9546038080006	2AA2670D	59.9546038918197	2AA2670E	1A6DB	10000	1A6DC	00000
58.8476381264626	29D8E2B6	58.8476382102817	29D8E2B7	149F8	00000	149F9	10000
57.7274515852332	290CF63C	57.7274516690522	290CF63D	0EBF9	10000	0EBFA	00000
56.5932063292711	283E7A93	56.5932064130902	283E7A94	08CCC	00000	08CCD	10000
55.4437850508838	276D3BA9	55.4437851347029	276D3BAA	02C59	10000	02C5A	00000
54.2781635653227	269909C3	54.2781636491417	269909C4	1CA8A	00000	1CA8B	10000
53.0951780453324	25C1AEA4	53.0951781291514	25C1AEA5	16746	10000	16747	00000
51.8934320658445	24E6E938	51.8934321496635	24E6E939	1026F	00000	10270	10000
50.6714823469519	2408763C	50.6714824307709	2408763D	09BE6	10000	09BE7	00000
49.4277462176978	23260BEE	49.4277463015168	23260BEF	03389	00000	0338A	10000
48.1604080740362	223F55B1	48.1604081578552	223F55B2	1C931	10000	1C932	00000
46.8673265911638	2153EFBA	46.8673266749829	2153EFBB	15CB0	00000	15CB1	10000
45.5462671536952	206371E5	45.5462672375142	206371E6	0EDD6	10000	0EDD7	00000
44.1945298667997	1F6D5E5F	44.1945299506187	1F6D5E60	07C69	00000	07C6A	10000
42.8091352991759	1E712A4E	42.8091353829950	1E712A4F	00829	10000	0082A	00000
41.3864988461136	1D6E2EA4	41.3864989299327	1D6E2EA5	190C9	00000	190CA	10000
39.9225706234574	1C63AEA4	39.9225707072764	1C63AEA5	115F2	10000	115F3	00000
38.4124160371720	1B50C456	38.4124161209911	1B50C457	0973A	00000	0973B	10000
36.8502626381814	1A3462B6	36.8502627220004	1A3462B7	01425	10000	01426	00000
35.2289878204464	190D3DD4	35.2289879042655	190D3DD5	18C1A	00000	18C1B	10000
33.5399329941719	17D9C22B	33.5399330779910	17D9C22C	0FE5F	10000	0FE60	00000
31.7721117474138	1697EFBA	31.7721118312329	1697EFBB	06A08	00000	06A09	10000
29.9113722424954	154532FB	29.9113723263144	154532FC	1CDE5	10000	1CDE6	00000
27.9390004556626	13DE23CB	27.9390005394816	13DE23CC	12864	00000	12865	10000
25.8292530477046	125E1270	25.8292531315237	125E1271	0775C	10000	0775D	00000
23.5450278595089	10BE3DD4	23.5450279433280	10BE3DD5	1B7B0	00000	1B7B1	10000
21.0293914843350	0EF448AD	21.0293915681540	0EF448AE	0E499	10000	0E49A	00000
18.1862601544708	0CEEB527	18.1862602382898	0CEEB528	1F607	00000	1F608	10000
14.8281679116189	0A8B62B6	14.8281679954379	0A8B62B7	0DC3F	10000	0DC40	00000
10.4704594518989	077216C7	10.4704595357179	077216C8	16E96	00000	16E97	10000
-10.4704595357179	F88DE938	-10.4704594518989	F88DE939	09169	10000	0916A	00000
-14.8281679954379	F5749D49	-14.8281679116189	F5749D4A	123C0	00000	123C1	10000
-18.1862602382898	F3114AD8	-18.1862601544708	F3114AD9	009F8	10000	009F9	00000
-21.0293915681540	F10BB752	-21.0293914843350	F10BB753	11B66	00000	11B67	10000
-23.5450279433280	EF41C22B	-23.5450278595089	EF41C22C	0484F	10000	04850	00000
-25.8292531315237	EDA1ED8F	-25.8292530477046	EDA1ED90	188A3	00000	188A4	10000
-27.9390005394816	EC21DC34	-27.9390004556626	EC21DC35	0D79B	10000	0D79C	00000
-29.9113723263144	EABACD04	-29.9113722424954	EABACD05	0321A	00000	0321B	10000

Input 32bAWB Boundary Latitudes (Input Longitude = 180°)				Expected Outputs			
South		North		South		North	
Decimal	32bAWB	Decimal	32bAWB	Enc Lat	Enc Lon	Enc Lat	Enc Lon
-31.7721118312329	E9681045	-31.7721117474138	E9681046	195F7	10000	195F8	00000
-33.5399330779910	E8263DD4	-33.5399329941719	E8263DD5	101A0	00000	101A1	10000
-35.2289879042655	E6F2C22B	-35.2289878204464	E6F2C22C	073E5	10000	073E6	00000
-36.8502627220004	E5CB9D49	-36.8502626381814	E5CB9D4A	1EBDA	00000	1EBDB	10000
-38.4124161209911	E4AF3BA9	-38.4124160371720	E4AF3BAA	168C5	10000	168C6	00000
-39.9225707072764	E39C515B	-39.9225706234574	E39C515C	0EA0D	00000	0EA0E	10000
-41.3864989299327	E291D15B	-41.3864988461136	E291D15C	06F36	10000	06F37	00000
-42.8091353829950	E18ED5B1	-42.8091352991759	E18ED5B2	1F7D6	00000	1F7D7	10000
-44.1945299506187	E092A1A0	-44.1945298667997	E092A1A1	18396	10000	18397	00000
-45.5462672375142	DF9C8E1A	-45.5462671536952	DF9C8E1B	11229	00000	1122A	10000
-46.8673266749829	DEAC1045	-46.8673265911638	DEAC1046	0A34F	10000	0A350	00000
-48.1604081578552	DDC0AA4E	-48.1604080740362	DDC0AA4F	036CE	00000	036CF	10000
-49.4277463015168	DCD9F411	-49.4277462176978	DCD9F412	1CC76	10000	1CC77	00000
-50.6714824307709	DBF789C3	-50.6714823469519	DBF789C4	16419	00000	1641A	10000
-51.8934321496635	DB1916C7	-51.8934320658445	DB1916C8	0FD90	10000	0FD91	00000
-53.0951781291514	DA3E515B	-53.0951780453324	DA3E515C	098B9	00000	098BA	10000
-54.2781636491417	D966F63C	-54.2781635653227	D966F63D	03575	10000	03576	00000
-55.4437851347029	D892C456	-55.4437850508838	D892C457	1D3A6	00000	1D3A7	10000
-56.5932064130902	D7C1856C	-56.5932063292711	D7C1856D	17333	10000	17334	00000
-57.7274516690522	D6F309C3	-57.7274515852332	D6F309C4	11406	00000	11407	10000
-58.8476382102817	D6271D49	-58.8476381264626	D6271D4A	0B607	10000	0B608	00000
-59.9546038918197	D55D98F2	-59.9546038080006	D55D98F3	05924	00000	05925	10000
-61.0491866525262	D49655B1	-61.0491865687072	D49655B2	1FD4B	10000	1FD4C	00000
-62.1321779116988	D3D12EA4	-62.1321778278797	D3D12EA5	1A26B	00000	1A26C	10000
-63.2042758818715	D30E0341	-63.2042757980525	D30E0342	14875	10000	14876	00000
-64.2661790270358	D24CB2FB	-64.2661789432168	D24CB2FC	0EF5A	00000	0EF5B	10000
-65.3184458333998	D18D23CB	-65.3184457495808	D18D23CC	0970E	10000	0970F	00000
-66.3617279939353	D0CF3752	-66.3617279101163	D0CF3753	03F83	00000	03F84	10000
-67.3964446038007	D012DA08	-67.3964445199817	D012DA09	1E8B0	10000	1E8B1	00000
-68.4232007525861	CF57EFBA	-68.4232006687670	CF57EFBB	19288	00000	19289	10000
-69.4424154516309	CE9E64E1	-69.4424153678119	CE9E64E2	13D02	10000	13D03	00000
-70.4545076284557	CDE625F7	-70.4545075446367	CDE625F8	0E815	00000	0E816	10000
-71.4598497748374	CD2F21A0	-71.4598496910184	CD2F21A1	093B9	10000	093BA	00000
-72.4588608182966	CC794456	-72.4588607344776	CC794457	03FE5	00000	03FE6	10000
-73.4517734404653	CBC48341	-73.4517733566462	CBC48342	1EC94	10000	1EC95	00000
-74.4389136973768	CB10CF2F	-74.4389136135578	CB10CF30	199BF	00000	199C0	10000
-75.4205607064068	CA5E1B1E	-75.4205606225878	CA5E1B1F	14760	10000	14761	00000
-76.3968542777001	C9AC608A	-76.3968541938811	C9AC608B	0F574	00000	0F575	10000
-77.3678873665630	C8FB9B1E	-77.3678872827440	C8FB9B1F	0A3F9	10000	0A3FA	00000
-78.3337531797587	C84BC682	-78.3337530959397	C84BC683	052ED	00000	052EE	10000
-79.2942655552178	C79CEB63	-79.2942654713988	C79CEB64	00254	10000	00255	00000
-80.2492381632328	C6EF1270	-80.2492380794137	C6EF1271	1B232	00000	1B233	10000
-81.1980193108320	C6425A08	-81.1980192270129	C6425A09	16295	10000	16296	00000
-82.1395848970860	C596F1E5	-82.1395848132669	C596F1E6	11393	00000	11394	10000
-83.0719795916229	C4ED3527	-83.0719795078039	C4ED3528	0C556	10000	0C557	00000
-83.9917587675154	C445C456	-83.9917586836963	C445C457	07828	00000	07829	10000
-84.8916600923985	C3A1F1E5	-84.8916600085794	C3A1F1E6	02CA5	10000	02CA6	00000

Input 32bAWB Boundary Latitudes (Input Longitude = 180°)				Expected Outputs			
South		North		South		North	
Decimal	32bAWB	Decimal	32bAWB	Enc Lat	Enc Lon	Enc Lat	Enc Lon
-85.7554368395358	C304B2FB	-85.7554367557168	C304B2FC	1E42A	00000	1E42B	10000
-86.5353730134665	C276B752	-86.5353729296475	C276B753	1A2B8	10000	1A2B9	00000
-87.0000109076499	C22221A0	-87.0000108238309	C22221A1	17BBB	10000	17BBC	10000

Table 6-5 32bAWB boundaries for NL Transition latitudes - TIS-B even encoding

Input 32bAWB Boundary Latitudes (Input Longitude = 180°)				Expected Outputs			
South		North		South		North	
Decimal	32bAWB	Decimal	32bAWB	Enc Lat	Enc Lon	Enc Lat	Enc Lon
87.0007323380559	3DDDFFFF	87.0007324218750	3DDE0000	00800	00000	00801	00800
86.5349120926111	3D893333	86.5349121764302	3D893334	006C2	00800	006C3	00000
85.7556152064353	3CFB5555	85.7556152902543	3CFB5556	004AE	00000	004AF	00800
84.8913573380559	3C5DFFFF	84.8913574218750	3C5E0000	00260	00800	00261	00000
83.9919433370232	3BBA4444	83.9919434208422	3BBA4445	00FFA	00000	00FFB	00800
83.0720214173197	3B12CCCC	83.0720215011388	3B12CCCD	00D86	00800	00D87	00000
82.1389159373939	3A68EEEE	82.1389160212129	3A68EEEF	00B09	00000	00B0A	00800
81.1984862666577	39BDBBBB	81.1984863504767	39BDBBBC	00887	00800	00888	00000
80.2492674998939	3910EEEE	80.2492675837129	3910EEEF	005FF	00000	00600	00800
79.2941894475370	38631111	79.2941895313560	38631112	00373	00800	00374	00000
78.3332519419491	37B42222	78.3332520257681	37B42223	000E3	00000	000E4	00800
77.3679198883473	37046666	77.3679199721664	37046667	00E50	00800	00E51	00000
76.3967284653335	36539999	76.3967285491526	3653999A	00BB9	00000	00BBA	00800
75.4211424943059	35A1FFFF	75.4211425781250	35A20000	0091F	00800	00920	00000
74.4382324162870	34EF1111	74.4382325001060	34EF1112	00680	00000	00681	00800
73.4523925278335	343B9999	73.4523926116526	343B999A	003DF	00800	003E0	00000
72.4592284485697	3386CCCC	72.4592285323888	3386CCCD	00139	00000	0013A	00800
71.4602049998939	32D0EEEE	71.4602050837129	32D0EEEF	00E8F	00800	00E90	00000
70.4538573604077	3219BBBB	70.4538574442267	3219BBBC	00BE0	00000	00BE1	00800
69.4431151729077	3161BBBB	69.4431152567267	3161BBBC	0092E	00800	0092F	00000
68.4235839731991	30A82222	68.4235840570181	30A82223	00676	00000	00677	00800
67.3967284988611	2FED3333	67.3967285826802	2FED3334	003B9	00800	003BA	00000
66.3610839284956	2F30AAAA	66.3610840123146	2F30AAAB	000F6	00000	000F7	00800
65.3181151673197	2E72CCCC	65.3181152511388	2E72CCCD	00E2E	00800	00E2F	00000
64.2663573939353	2DB35555	64.2663574777543	2DB35556	00B60	00000	00B61	00800
63.2043456193059	2CF1FFFF	63.2043457031250	2CF20000	0088B	00800	0088C	00000
62.1320800110697	2C2ECCCC	62.1320800948888	2C2ECCCD	005AF	00000	005B0	00800
61.0495604854077	2B69BBBB	61.0495605692267	2B69BBBC	002CC	00800	002CD	00000
59.9553222209215	2AA28888	59.9553223047405	2AA28889	00FE1	00000	00FE2	00800
58.8479003123939	29D8EEEE	58.8479003962129	29D8EEEF	00CED	00800	00CEE	00000
57.7272948436439	290CEEEE	57.7272949274629	290CEEEF	009F0	00000	009F1	00800
56.5935058146715	283E8888	56.5935058984905	283E8889	006EA	00800	006EB	00000
55.4436034988611	276D3333	55.4436035826802	276D3334	003D9	00000	003DA	00800
54.2775878123939	2698EEEE	54.2775878962129	2698EEEF	000BD	00800	000BE	00000
53.0954589229077	25C1BBBB	53.0954590067267	25C1BBBC	00D96	00000	00D97	00800
51.8928221985697	24E6CCCC	51.8928222823888	24E6CCCD	00A61	00800	00A62	00000
50.6711425445973	24086666	50.6711426284164	24086667	0071F	00000	00720	00800
49.4274901505559	2325FFFF	49.4274902343750	23260000	003CE	00800	003CF	00000
48.1604003626853	223F5555	48.1604004465043	223F5556	0006D	00000	0006E	00800

Input 32bAWB Boundary Latitudes (Input Longitude = 180°)				Expected Outputs			
South		North		South		North	
Decimal	32bAWB	Decimal	32bAWB	Enc Lat	Enc Lon	Enc Lat	Enc Lon
46.8669432867318	2153DDDD	46.8669433705508	2153DDDE	00CFA	00800	00CFB	00000
45.5456542689353	20635555	45.5456543527543	20635556	00974	00000	00975	00800
44.1950683202594	1F6D7777	44.1950684040784	1F6D7778	005DA	00800	005DB	00000
42.8093261551111	1E713333	42.8093262389302	1E713334	00228	00000	00229	00800
41.3869628682732	1D6E4444	41.3869629520922	1D6E4445	00E5D	00800	00E5E	00000
39.9221190903335	1C639999	39.9221191741526	1C63999A	00A75	00000	00A76	00800
38.4118651784956	1B50AAAA	38.4118652623146	1B50AAAB	0066E	00800	0066F	00000
36.8503417633473	1A346666	36.8503418471664	1A346667	00244	00000	00245	00800
35.2287597488611	190D3333	35.2287598326802	190D3334	00DF1	00800	00DF2	00000
33.5397948604077	17D9BBBB	33.5397949442267	17D9BBBC	00970	00000	00971	00800
31.7717284429818	1697DDDD	31.7717285268008	1697DDDE	004B9	00800	004BA	00000
29.9113769363611	15453333	29.9113770201802	15453334	00FC3	00000	00FC4	00800
27.9396972432732	13DE4444	27.9396973270922	13DE4445	00A81	00800	00A82	00000
25.8288573380559	125DFFFF	25.8288574218750	125E0000	004E0	00000	004E1	00800
23.5451659932732	10BE4444	23.5451660770922	10BE4445	00EC9	00800	00ECA	00000
21.0300292633473	0EF46666	21.0300293471664	0EF46667	00814	00000	00815	00800
18.1867675110697	0CEECCCC	18.1867675948888	0CEECCCD	0007F	00800	00080	00000
14.8278808314353	0A8B5555	14.8278809152543	0A8B5556	0078A	00000	0078B	00800
10.4699706193059	0771FFFF	10.4699707031250	07720000	00BEB	00800	00BEC	00000
-10.4699707869440	F88DFFFF	-10.4699707031250	F88E0000	00414	00000	00415	00800
-14.8278809152543	F574AAAA	-14.8278808314353	F574AAAB	00875	00800	00876	00000
-18.1867675948888	F3113333	-18.1867675110697	F3113334	00F80	00000	00F81	00800
-21.0300293471664	F10B9999	-21.0300292633473	F10B999A	007EB	00800	007EC	00000
-23.5451660770922	EF41BBBB	-23.5451659932732	EF41BBBC	00136	00000	00137	00800
-25.8288575056940	EDA1FFFF	-25.8288574218750	EDA20000	00B1F	00800	00B20	00000
-27.9396973270922	EC21BBBB	-27.9396972432732	EC21BBBC	0057E	00000	0057F	00800
-29.9113770201802	EABACCCC	-29.9113769363611	EABACCCD	0003C	00800	0003D	00000
-31.7717285268008	E9682222	-31.7717284429818	E9682223	00B46	00000	00B47	00800
-33.5397949442267	E8264444	-33.5397948604077	E8264445	0068F	00800	00690	00000
-35.2287598326802	E6F2CCCC	-35.2287597488611	E6F2CCCD	0020E	00000	0020F	00800
-36.8503418471664	E5CB9999	-36.8503417633473	E5CB999A	00DBB	00800	00DBC	00000
-38.4118652623146	E4AF5555	-38.4118651784956	E4AF5556	00991	00000	00992	00800
-39.9221191741526	E39C6666	-39.9221190903335	E39C6667	0058A	00800	0058B	00000
-41.3869629520922	E291BBBB	-41.3869628682732	E291BBBC	001A2	00000	001A3	00800
-42.8093262389302	E18ECCCC	-42.8093261551111	E18ECCCD	00DD7	00800	00DD8	00000
-44.1950684040784	E0928888	-44.1950683202594	E0928889	00A25	00000	00A26	00800
-45.5456543527543	DF9CAAAA	-45.5456542689353	DF9CAAAB	0068B	00800	0068C	00000
-46.8669433705508	DEAC2222	-46.8669432867318	DEAC2223	00305	00000	00306	00800
-48.1604004465043	DDC0AAAA	-48.1604003626853	DDC0AAAB	00F92	00800	00F93	00000
-49.4274903181940	DCD9FFFF	-49.4274902343750	DCDA0000	00C31	00000	00C32	00800

Input 32bAWB Boundary Latitudes (Input Longitude = 180°)				Expected Outputs			
South		North		South		North	
Decimal	32bAWB	Decimal	32bAWB	Enc Lat	Enc Lon	Enc Lat	Enc Lon
-50.6711426284164	DBF79999	-50.6711425445973	DBF7999A	008E0	00800	008E1	00000
-51.8928222823888	DB193333	-51.8928221985697	DB193334	0059E	00000	0059F	00800
-53.0954590067267	DA3E4444	-53.0954589229077	DA3E4445	00269	00800	0026A	00000
-54.2775878962129	D9671111	-54.2775878123939	D9671112	00F42	00000	00F43	00800
-55.4436035826802	D892CCCC	-55.4436034988611	D892CCCD	00C26	00800	00C27	00000
-56.5935058984905	D7C17777	-56.5935058146715	D7C17778	00915	00000	00916	00800
-57.7272949274629	D6F31111	-57.7272948436439	D6F31112	0060F	00800	00610	00000
-58.8479003962129	D6271111	-58.8479003123939	D6271112	00312	00000	00313	00800
-59.9553223047405	D55D7777	-59.9553222209215	D55D7778	0001E	00800	0001F	00000
-61.0495605692267	D4964444	-61.0495604854077	D4964445	00D33	00000	00D34	00800
-62.1320800948888	D3D13333	-62.1320800110697	D3D13334	00A50	00800	00A51	00000
-63.2043457869440	D30DFFFF	-63.2043457031250	D30E0000	00774	00000	00775	00800
-64.2663574777543	D24CAAAA	-64.2663573939353	D24CAAAB	0049F	00800	004A0	00000
-65.3181152511388	D18D3333	-65.3181151673197	D18D3334	001D1	00000	001D2	00800
-66.3610840123146	D0CF5555	-66.3610839284956	D0CF5556	00F09	00800	00F0A	00000
-67.3967285826802	D012CCCC	-67.3967284988611	D012CCCD	00C46	00000	00C47	00800
-68.4235840570181	CF57DDDD	-68.4235839731991	CF57DDDE	00989	00800	0098A	00000
-69.4431152567267	CE9E4444	-69.4431151729077	CE9E4445	006D1	00000	006D2	00800
-70.4538574442267	CDE64444	-70.4538573604077	CDE64445	0041F	00800	00420	00000
-71.4602050837129	CD2F1111	-71.4602049998939	CD2F1112	00170	00000	00171	00800
-72.4592285323888	CC793333	-72.4592284485697	CC793334	00EC6	00800	00EC7	00000
-73.4523926116526	CBC46666	-73.4523925278335	CBC46667	00C20	00000	00C21	00800
-74.4382325001060	CB10EEEE	-74.4382324162870	CB10EEEF	0097F	00800	00980	00000
-75.4211426619440	CA5DFFFF	-75.4211425781250	CA5E0000	006E0	00000	006E1	00800
-76.3967285491526	C9AC6666	-76.3967284653335	C9AC6667	00446	00800	00447	00000
-77.3679199721664	C8FB9999	-77.3679198883473	C8FB999A	001AF	00000	001B0	00800
-78.3332520257681	C84BDDDD	-78.3332519419491	C84BDDDE	00F1C	00800	00F1D	00000
-79.2941895313560	C79CEEEE	-79.2941894475370	C79CEEEF	00C8C	00000	00C8D	00800
-80.2492675837129	C6EF1111	-80.2492674998939	C6EF1112	00A00	00800	00A01	00000
-81.1984863504767	C6424444	-81.1984862666577	C6424445	00778	00000	00779	00800
-82.1389160212129	C5971111	-82.1389159373939	C5971112	004F6	00800	004F7	00000
-83.0720215011388	C4ED3333	-83.0720214173197	C4ED3334	00279	00000	0027A	00800
-83.9919434208422	C445BBBB	-83.9919433370232	C445BBBC	00005	00800	00006	00000
-84.8913575056940	C3A1FFFF	-84.8913574218750	C3A20000	00D9F	00000	00DA0	00800
-85.7556152902543	C304AAAA	-85.7556152064353	C304AAAB	00B51	00800	00B52	00000
-86.5349121764302	C276CCCC	-86.5349120926111	C276CCCD	0093D	00000	0093E	00800
-87.0007325056940	C221FFFF	-87.0007324218750	C2220000	007FF	00800	00800	00000

Table 6-6 32bAWB boundaries for NL Transition latitudes - TIS-B odd encoding

Input 32bAWB Boundary Latitudes (Input Longitude = 180°)				Expected Outputs			
South		North		South		North	
Decimal	32bAWB	Decimal	32bAWB	Enc Lat	Enc Lon	Enc Lat	Enc Lon
87.0005461759865	3DDDF752	87.0005462598055	3DDDF753	00422	00800	00423	00800
86.5357686392962	3D895B1E	86.5357687231153	3D895B1F	002EA	00000	002EB	00800
85.7551806885749	3CFB4115	85.7551807723939	3CFB4116	000DE	00800	000DF	00000
84.8911711759865	3C5DF752	84.8911712598055	3C5DF753	00E9A	00000	00E9B	00800
83.9914094936102	3BBA2B63	83.9914095774292	3BBA2B64	00C3E	00800	00C3F	00000
83.0722820945084	3B12D8F2	83.0722821783274	3B12D8F3	009D5	00000	009D6	00800
82.1397476736456	3A6915B1	82.1397477574646	3A6915B2	00763	00800	00764	00000
81.1982752103358	39BDB1E5	81.1982752941548	39BDB1E6	004EB	00000	004EC	00800
80.2493544202297	3910F2FB	80.2493545040488	3910F2FC	0026E	00800	0026F	00000
79.2944749351590	38631E5F	79.2944750189781	38631E60	00FED	00000	00FEE	00800
78.3336367551237	37B43411	78.3336368389427	37B43412	00D68	00800	00D69	00000
77.3683295119553	3704797D	77.3683295957744	3704797E	00AE0	00000	00AE1	00800
76.3970636576414	3653A938	76.3970637414604	3653A939	00854	00800	00855	00000
75.4198391083627	35A1C341	75.4198391921818	35A1C342	005C4	00000	005C5	00800
74.4396351277828	34EF5270	74.4396352116018	34EF5271	00332	00800	00333	00000
73.4519829042255	343B8682	73.4519829880446	343B8683	0009B	00000	0009C	00800
72.4583719018846	3386A4E1	72.4583719857037	3386A4E2	00E00	00800	00E01	00000
71.4602919202297	32D0F2FB	71.4602920040488	32D0F2FC	00B62	00000	00B63	00800
70.4547636117786	3219E5F7	70.4547636955976	3219E5F8	008BF	00800	008C0	00000
69.4417868927121	31617DD4	69.4417869765311	31617DD5	00617	00000	00618	00800
68.4228514786809	30A7FFFF	68.4228515625000	30A80000	0036B	00800	0036C	00000
67.3964678216725	2FED270D	67.3964679054915	2FED270E	000BA	00000	000BB	00800
66.3611460383981	2F30AD8F	66.3611461222171	2F30AD90	00E03	00800	00E04	00000
65.3183758445084	2E72D8F2	65.3183759283274	2E72D8F3	00B47	00000	00B48	00800
64.2666676919907	2DB363CB	64.2666677758097	2DB363CC	00885	00800	00886	00000
63.2045318651944	2CF208AD	63.2045319490134	2CF208AE	005BC	00000	005BD	00800
62.1319682803004	2C2EC797	62.1319683641195	2C2EC798	002EC	00800	002ED	00000
61.0489770211279	2B69A08A	61.0489771049469	2B69A08B	00015	00000	00016	00800
59.9540684558451	2AA24E1A	59.9540685396641	2AA24E1B	00D36	00800	00D37	00000
58.8472424168139	29D8D045	58.8472425006330	29D8D046	00A4F	00000	00A50	00800
57.7270093560218	290CE1A0	57.7270094398409	290CE1A1	0075F	00800	00760	00000
56.5933692734688	283E822B	56.5933693572878	283E822C	00466	00000	00467	00800
55.4433428216725	276D270D	55.4433429054915	276D270E	00162	00800	00163	00000
54.2784195486456	269915B1	54.2784196324646	269915B2	00E54	00000	00E55	00800
53.0956203583627	25C1C341	53.0956204421818	25C1C342	00B3A	00800	00B3B	00000
51.8934553675353	24E6EA4E	51.8934554513543	24E6EA4F	00813	00000	00814	00800
50.6719245761632	24088AD8	50.6719246599823	24088AD9	004DF	00800	004E0	00000
49.4280488044023	23261A08	49.4280488882213	23261A09	0019C	00000	0019D	00800
48.1603382527828	223F5270	48.1603383366018	223F5271	00E49	00800	00E4A	00000
46.8673032894730	2153EEA4	46.8673033732920	2153EEA5	00AE5	00000	00AE6	00800
45.5459645669907	206363CB	45.5459646508097	206363CC	0076E	00800	0076F	00000
44.1948324535042	1F6D6C79	44.1948325373232	1F6D6C7A	003E3	00000	003E4	00800
42.8094378858804	1E713868	42.8094379696995	1E713869	00041	00800	00042	00000
41.3868014328181	1D6E3CBE	41.3868015166372	1D6E3CBF	00C86	00000	00C87	00800
39.9224542826414	1C63A938	39.9224543664604	1C63A939	008AF	00800	008B0	00000

Input 32bAWB Boundary Latitudes (Input Longitude = 180°)				Expected Outputs			
South		North		South		North	
Decimal	32bAWB	Decimal	32bAWB	Enc Lat	Enc Lon	Enc Lat	Enc Lon
38.4119272883981	1B50AD8F	38.4119273722171	1B50AD90	004B9	00000	004BA	00800
36.8507513869553	1A34797D	36.8507514707744	1A34797E	000A1	00800	000A2	00000
35.2284990716725	190D270D	35.2284991554915	190D270E	00C60	00000	00C61	00800
33.5392113961279	17D9A08A	33.5392114799469	17D9A08B	007F2	00800	007F3	00000
31.7724608536809	1697FFFF	31.7724609375000	16980000	00350	00000	00351	00800
29.9118610750883	154549C3	29.9118611589074	154549C4	00E6F	00800	00E70	00000
27.9395358078181	13DE3CBE	27.9395358916372	13DE3CBF	00943	00000	00944	00800
25.8286711759865	125DF752	25.8286712598055	125DF753	003BA	00800	003BB	00000
23.5450045578181	10BE3CBE	23.5450046416372	10BE3CBF	00DBD	00000	00DBE	00800
21.0289492551237	0EF43411	21.0289493389427	0EF43412	00724	00800	00725	00000
18.1866557803004	0CEEC797	18.1866558641195	0CEEC798	00FB0	00000	00FB1	00800
14.8274463135749	0A8B4115	14.8274463973939	0A8B4116	006E1	00800	006E2	00000
10.4701568651944	077208AD	10.4701569490134	077208AE	00B74	00000	00B75	00800
-10.4701569490134	F88DF752	-10.4701568651944	F88DF753	0048B	00800	0048C	00000
-14.8274463973939	F574BEEA	-14.8274463135749	F574BEEB	0091E	00000	0091F	00800
-18.1866558641195	F3113868	-18.1866557803004	F3113869	0004F	00800	00050	00000
-21.0289493389427	F10BCBEE	-21.0289492551237	F10BCBEF	008DB	00000	008DC	00800
-23.5450046416372	EF41C341	-23.5450045578181	EF41C342	00242	00800	00243	00000
-25.8286712598055	EDA208AD	-25.8286711759865	EDA208AE	00C45	00000	00C46	00800
-27.9395358916372	EC21C341	-27.9395358078181	EC21C342	006BC	00800	006BD	00000
-29.9118611589074	EABAB63C	-29.9118610750883	EABAB63D	00190	00000	00191	00800
-31.7724610213190	E967FFFF	-31.7724609375000	E9680000	00CAF	00800	00CB0	00000
-33.5392114799469	E8265F75	-33.5392113961279	E8265F76	0080D	00000	0080E	00800
-35.2284991554915	E6F2D8F2	-35.2284990716725	E6F2D8F3	0039F	00800	003A0	00000
-36.8507514707744	E5CB8682	-36.8507513869553	E5CB8683	00F5E	00000	00F5F	00800
-38.4119273722171	E4AF5270	-38.4119272883981	E4AF5271	00B46	00800	00B47	00000
-39.9224543664604	E39C56C7	-39.9224542826414	E39C56C8	00750	00000	00751	00800
-41.3868015166372	E291C341	-41.3868014328181	E291C342	00379	00800	0037A	00000
-42.8094379696995	E18EC797	-42.8094378858804	E18EC798	00FBE	00000	00FBF	00800
-44.1948325373232	E0929386	-44.1948324535042	E0929387	00C1C	00800	00C1D	00000
-45.5459646508097	DF9C9C34	-45.5459645669907	DF9C9C35	00891	00000	00892	00800
-46.8673033732920	DEAC115B	-46.8673032894730	DEAC115C	0051A	00800	0051B	00000
-48.1603383366018	DDC0AD8F	-48.1603382527828	DDC0AD90	001B6	00000	001B7	00800
-49.4280488882213	DCD9E5F7	-49.4280488044023	DCD9E5F8	00E63	00800	00E64	00000
-50.6719246599823	DBF77527	-50.6719245761632	DBF77528	00B20	00000	00B21	00800
-51.8934554513543	DB1915B1	-51.8934553675353	DB1915B2	007EC	00800	007ED	00000
-53.0956204421818	DA3E3CBE	-53.0956203583627	DA3E3CBF	004C5	00000	004C6	00800
-54.2784196324646	D966EA4E	-54.2784195486456	D966EA4F	001AB	00800	001AC	00000
-55.4433429054915	D892D8F2	-55.4433428216725	D892D8F3	00E9D	00000	00E9E	00800
-56.5933693572878	D7C17DD4	-56.5933692734688	D7C17DD5	00B99	00800	00B9A	00000
-57.7270094398409	D6F31E5F	-57.7270093560218	D6F31E60	008A0	00000	008A1	00800
-58.8472425006330	D6272FBA	-58.8472424168139	D6272FBB	005B0	00800	005B1	00000
-59.9540685396641	D55DB1E5	-59.9540684558451	D55DB1E6	002C9	00000	002CA	00800
-61.0489771049469	D4965F75	-61.0489770211279	D4965F76	00FEA	00800	00FEB	00000
-62.1319683641195	D3D13868	-62.1319682803004	D3D13869	00D13	00000	00D14	00800
-63.2045319490134	D30DF752	-63.2045318651944	D30DF753	00A43	00800	00A44	00000
-64.2666677758097	D24C9C34	-64.2666676919907	D24C9C35	0077A	00000	0077B	00800

Input 32bAWB Boundary Latitudes (Input Longitude = 180°)				Expected Outputs			
South		North		South		North	
Decimal	32bAWB	Decimal	32bAWB	Enc Lat	Enc Lon	Enc Lat	Enc Lon
-65.3183759283274	D18D270D	-65.3183758445084	D18D270E	004B8	00800	004B9	00000
-66.3611461222171	D0CF5270	-66.3611460383981	D0CF5271	001FC	00000	001FD	00800
-67.3964679054915	D012D8F2	-67.3964678216725	D012D8F3	00F45	00800	00F46	00000
-68.4228516463190	CF57FFFF	-68.4228515625000	CF580000	00C94	00000	00C95	00800
-69.4417869765311	CE9E822B	-69.4417868927121	CE9E822C	009E8	00800	009E9	00000
-70.4547636955976	CDE61A08	-70.4547636117786	CDE61A09	00740	00000	00741	00800
-71.4602920040488	CD2F0D04	-71.4602919202297	CD2F0D05	0049D	00800	0049E	00000
-72.4583719857037	CC795B1E	-72.4583719018846	CC795B1F	001FF	00000	00200	00800
-73.4519829880446	CBC4797D	-73.4519829042255	CBC4797E	00F64	00800	00F65	00000
-74.4396352116018	CB10AD8F	-74.4396351277828	CB10AD90	00CCD	00000	00CCE	00800
-75.4198391921818	CA5E3CBE	-75.4198391083627	CA5E3CBF	00A3B	00800	00A3C	00000
-76.3970637414604	C9AC56C7	-76.3970636576414	C9AC56C8	007AB	00000	007AC	00800
-77.3683295957744	C8FB8682	-77.3683295119553	C8FB8683	0051F	00800	00520	00000
-78.3336368389427	C84BCBEE	-78.3336367551237	C84BCBEF	00297	00000	00298	00800
-79.2944750189781	C79CE1A0	-79.2944749351590	C79CE1A1	00012	00800	00013	00000
-80.2493545040488	C6EF0D04	-80.2493544202297	C6EF0D05	00D91	00000	00D92	00800
-81.1982752941548	C6424E1A	-81.1982752103358	C6424E1B	00B14	00800	00B15	00000
-82.1397477574646	C596EA4E	-82.1397476736456	C596EA4F	0089C	00000	0089D	00800
-83.0722821783274	C4ED270D	-83.0722820945084	C4ED270E	0062A	00800	0062B	00000
-83.9914095774292	C445D49C	-83.9914094936102	C445D49D	003C1	00000	003C2	00800
-84.8911712598055	C3A208AD	-84.8911711759865	C3A208AE	00165	00800	00166	00000
-85.7551807723939	C304BEEA	-85.7551806885749	C304BEEB	00F21	00000	00F22	00800
-86.5357687231153	C276A4E1	-86.5357686392962	C276A4E2	00D15	00800	00D16	00000
-87.0005462598055	C22208AD	-87.0005461759865	C22208AE	00BDD	00800	00BDE	00800

7 Summary

This appendix presents an expanded description of the CPR equations given in Appendix A. Any point on the globe is described by zone numbers, bin numbers and a CPR format in the CPR coordinate system. The encoding algorithm converts latitude and longitude into bin numbers. Global decoding is used to find the position of a target when it is first acquired, and recovers latitude and longitude from a pair of even and odd messages. Local decoding is used when a previous position is known and recovers latitude and longitude from a single position message and last known position of the target. Surface decoding is the same as airborne decoding except the surface zone size is ¼ of the airborne zone size.