

## Paper for Consideration by S-101PT8

### Loxodromic Interpolation in S-101 ENC

<b>Submitted by:</b>	IIC Technologies,
<b>Executive Summary:</b>	Loxodromes and Geodesics in S-101 ENCs
<b>Related Documents:</b>	S-101 Product Specification
<b>Related Projects:</b>	

#### Introduction / Background

Clause 4.8.1 of the S-101 ENC product specification contains the following restriction:

- The interpolation of GM\_CurveSegment must be loxodromic.

Similarly the S-57 Appendix B1 Clarifications contained in Maintenance Document 8 (MD8) contains the following clause:

- 4.Cl.14 Linear geometry between two explicit coordinates is defined as a loxodromic line on WGS84. Long lines may need to have additional explicit coordinates to cater for the effects of projection change. (See also [4.Co.16](#)).

Effectively specifying that all interpolation within all ENCs is defined as loxodromic. The rationale of this constraint is complex with a long history but is thought to be related to making implementation easier by ensuring that a mercator projected chart on screen can be drawn using straight lines, which are significantly easier to compute than true geodesics where many intermediate points need to be computed for accurate onscreen representation.

Because the segment lengths within ENC are small and most ECDIS portrayal uses some form of Mercator projection and does not occur within high latitudes, in the vast majority of cases the deviation between loxodromes and geodesics is too small to make any appreciable difference between their appearance on screen and more efficient rendering is possible of loxodromes.

This constraint to loxodromes does not appear anywhere in the machine readable files accompanying S-52, nor in the S-57 cells or metadata and was presented as a clarification within the standard only, approved in 1999 by TSMAD and codified in the maintenance document.

S-52 now contains guidance that ECDIS manufacturers should use a projection appropriate to the data being displayed and its geographical location, so for polar areas a choice is made by the ECDIS for suitable projection and associated portrayal (presumably without the loxodromic plotting). Polar datasets have been subsequently included in S-64 for testing of ECDIS equipped with the ability to display high latitude data. No S-64 tests specifically testing whether lines are drawn as actual loxodromes in the chosen projection are included.

#### Analysis/Discussion

With S-100 the situation is different. ENCs are defined within the S-101 product specification, and specified in the feature catalogue with the encoding (ISO8211) and metadata specified by the S-100 framework. Additionally, the (S-100) ECDIS is charged with developing compatibility with the whole of S-100, NOT just S-101. S-100's geometry model overtly defines interpolation and contains a number of potential interpolation methods, specified in Part 7 and explicitly encodes them in the INTP subfield in the ISO8211 encoding.

Potentially, other product specifications could use the ISO8211 encoding as well and would not include such a constraint (e.g. defence products, S-121, S-130). The problem with "constraining" ENC to loxodromic interpolation is twofold:

1. There is no way of enforcing such an encoding restriction except through validation tests for S-101. The feature catalogue is similarly incapable of restraining encoding to pure loxodromes.
2. ECDIS will be required to be capable of displaying all interpolation methods accurately, because it will implement S-100, not just S-101. Because the interpolation is now explicitly encoded within the data, the option for the ECDIS to “ignore” loxodromic plotting in high latitudes will be impossible.

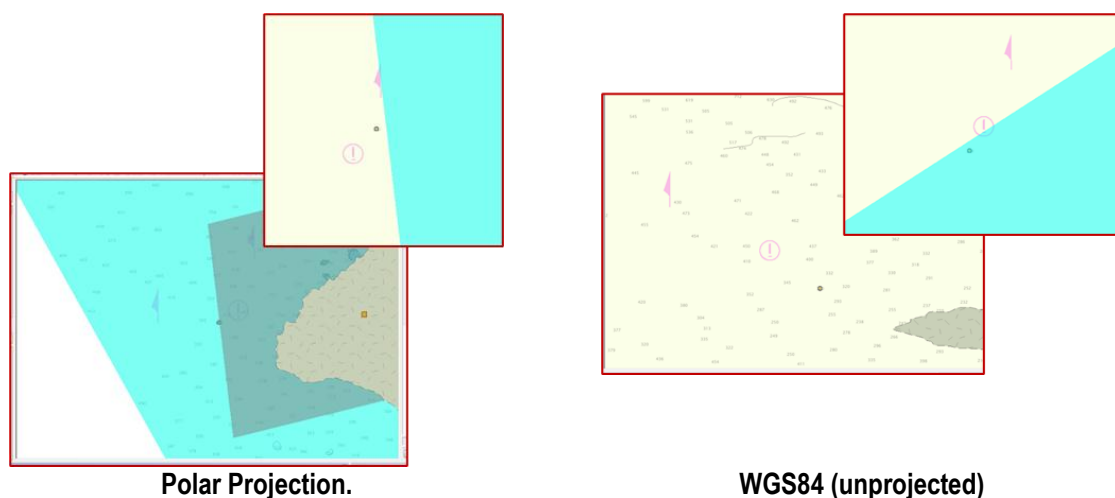
So, if ECDIS implements both geodesic and loxodromic portrayal why should S-101 restrict the range of allowable values to loxodromes only? The deeper issue is whether the use case exists for ENC to express different line interpolations. It could be argued that lines within ENCs represent a mixture of use cases:

1. Chart boundaries are often frequently loxodromic with north/south limits defined by limiting latitudes
2. Navigation lines, undersea cables, regulatory limits, indeed any “straight” lines are predominantly geodesics (although most of the time the difference between loxodrome and geodesic is beyond measurement in 99.9999% of the time within ENC)
3. There are a number of regulatory limits which specify either loxodrome or geodesic and sometimes these curve segments are long enough to precipitate a noticeable difference between the two when portrayed.
4. Polar ENCs could require geodesic interpolation for coherent portrayal as loxodromes have increasing eccentricity at high latitudes

It is true that “straight” lines drawn on (predominantly Mercator projected) paper charts are loxodromic by definition (which they are: when drawn on the paper each intermediate point naturally follows a loxodromic path) but ENC segments do not include all intermediate points and are defined by only start/end vertices and the interpolation parameter. ECDIS has never been constrained by IHO standards in the projection methods used and S-100 ECDIS is not likely to change this requirement.

However, as stated earlier, S-100 provides a variety of interpolation methods which will require implementation and which may be used in product specifications other than ENC. The capability is therefore highly likely to be part of the OEMs implementation of S-100 ECDIS and tested within S-164. The crucial difference with S-100 is that it is explicit in specifying interpolation methods, unlike S-57 Appendix B1.

The traditional response to such proposals has always been to densify long segments however this is impractical and, ultimately, a workaround. The deviation of loxodromes from geodesics varies dramatically with the latitude of the segment and its orientation on the earth’s surface. Therefore, providing realistic guidance on densification is complex and may differ for individual use cases. The example below is derived from a real ENC encoding which arose during a client project. The cell shown (180k CSCL) has been edited to place a point LNDARE which appears inside a SEAARE in WGS84 and outside the SEAARE in a polar projection. The cell is located in 75° South and contains a segment approx. 60km in length. The deviation between the loxodromic interpolation and geodetic is approximately 185m, enough to show the Point LNDARE at a reasonable viewing scale.



## Conclusions

The real argument against the restrictive clause in the S-101 ENC product specification is:

Note: FOR REASONS OF ECONOMY, DELEGATES ARE KINDLY REQUESTED TO BRING THEIR OWN COPIES OF THE DOCUMENTS TO THE MEETING

1. It artificially constrains the encoding within the published ENC to a parameter which does not always reflect reality.
2. Portrayal performance could be affected if all line segments are converted to geodesics however, requiring many intermediate points to be calculated. It is in the interests of the OEM and end user that portrayal is efficient so in the majority of cases loxodromic interpolation can continue.
3. The explicit encoding of the interpolation method would adversely affect the portrayal of some Polar ENCs.
4. The issue is more likely to be manifested in long segments used for regulatory areas where the impact of incorrect vessel positioning may be significant.
5. In an integrated S-100 production environment IHO member states need to be able to store and maintain line interpolation in their source databases for alignment with legal sources.
6. As ECDIS manufacturers will be required to implement all interpolations (for S-100 compatibility, likely to be tested for within S-164) the constraint is an artificial one, anchoring electronic chart encodings to the 15th century for another generation.

## **Recommendations**

1. Remove the constraint within the S-101 Product Specification constraining encoding to loxodromes only
2. Provide appropriate guidance to encoders in the ENC DCEG on encoding of the INTP parameter dependent on the geographical region of data and length of line segments included within it (i.e in Polar regions above a certain limiting latitude).
3. Also provide strong guidance via DCEG and validation tests that the use of geodesics should be reserved only where an appreciable difference exists between them and loxodromes. ENC validation tests should capture such situations by restricting feature types and/or positions of such segments.
4. Reflect such guidance in S-100 Part 7.

## **Justification and Impacts**

1. The constraint is artificial, driven by the need for efficient portrayal and impacts the conceptual integrity of the ENC, perpetuating loxodromic lines within digital datasets where they may not be appropriate 100% of the time.
2. S-100 ECDIS will be bound to implement different interpolation methods due to their inclusion in S-100
3. Some features, particularly regulatory ones explicitly require geodesics.
4. Polar datasets could also be adversely affected by the explicit loxodrome encoding leading to S-100 Polar ECDIS anomalies.

## **Action Required of S101 PT**

The S-101PT is asked to

1. Consider the aims and content of the proposal
2. Remove the bullet point constraint in the S-101 Product Specification replacing it with strong recommendations and referencing both DCEG and validation tests to guide encoders and avoid unnecessary population of geodesic interpolation.
3. Support the creation of appropriate guidance for S-100 ECDIS OEMs and ENC encoders in the DCEG and validation tests.