INTERNATIONAL HYDROGRAPHIC ORGANIZATION

ORGANISATION HYDROGRAPHIQUE INTERNATIONALE

STANDARDIZATION of NAUTICAL PUBLICATION WORKING GROUP (SNPWG)

[A Working Group of the Hydrographic Services and Standards Committee (HSSC)]

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SNPWG Letter: 04/2013

To SNPWG Members Date 2 October 2013

Dear Colleagues,

Subject:

1. **Submission Paper for TSMAD 27**

A further file is now ready for a group check. This paper discusses the additional spatial types which we would like to have incorporated into the new S-100 version.

We expect that you will discuss the papers with your colleagues and require comments, suggestions, improvements and any other contributions on these files latest by the 31 October.

Yours sincerely,

Jens Schröder-Fürstenberg

Annex 1

TSMADXX-XX

Paper for consideration by TSMAD

Spatial Types for S-100 Edition 2.0.0

Submitted by:	SNPWG / Jeppesen
Executive Summary:	This is a proposal for adding extended spatial types to S-100 Edition 2.0.0.
Related Documents:	(1) S-100 Ed. 1.0.0
Related Projects:	(1) S-100

1 Introduction

The spatial types defined in S-100 Edition 1.0.0 are a subset of those defined in ISO 19107. TSMAD 25 assigned an action to produce a paper recommending how additional geometries (spatial types) defined in ISO 19107 can be added to S-100. Alternative approaches were presented and discussed at TSMAD 26. The working group determined that further development of this proposal should use a combination of two of the approaches presented. This paper develops the approaches selected by TSMAD 26 into a proposal for adding selected spatial types to S-100.

2 Terms and abbreviations

AIS	Automatic Identification System
ASM	(AIS) Application Specific Message
MSI	Marine Safety Information
SNPWG	Standardization of Nautical Publications Working Group
TSMAD	Transfer Standard Maintenance and Development Working Group

3 References

ISO 19107: Geographic Information – Spatial Schema
ISO 13249-3: Information technology — Database languages — SQL multimedia and application packages — Part 3: Spatial.
S-100: Universal Hydrographic Data Model, Edition 1.0.0, January 2010.
TSMAD26/DIPWG5-11.7B: S-100 Geometries Progress

4 Justification

S-100 will be used for data products of different kinds, in addition to ENCs and bathymetry. For some kinds of information, current practice, or an existing standard, sometimes uses geometries other than those included in Edition 1.0.0. Marine protected areas are often legally defined as the area within a given radius of a point. Marine safety information messages or notices and navigational warnings, may be legally designated as circular areas given in terms of centre and radius. Certain AIS Application Specific Messages use circle and sector geometries (e.g., the IMO-defined "Area Notice (broadcast)". Examples are given in Annex A.

SNPWG has identified the following spatial types as potential additional spatial types needed for nautical publications: circle (as centre/radius), arcs, sectors, and offset curves.

The absence of "non-traditional" spatial types from S-100 is an incentive for product specifications to define their own innovative spatial types (perhaps by stretching the definition of a thematic attribute?) which would increase complexity, reduce transparency, and reduce re-use of types across different domains. Further, some kinds of data are likely to be generated by non-cartographers using less-capable software, e.g., some types of MSI warnings are often created by watch officers at a VTS, who may be using web forms or other software not sophisticated enough to translate user-friendly specifications of geometry (e.g., centre-radius geometry) to the types required by S-100 Edition 1.0.0. Even for data created with sophisticated tools and compatible with Edition 1.0.0, there will be hidden costs in conversion effort, data verification, effort, and accuracy. Data volume is also a practical consideration, given a tendency to approximate circles by polygons.

The disadvantages of additional spatial types in general are the added complexity for implementations with data ingest, potential additional processing for map projections and portrayal, and implementation and

performance of spatial operations (the last will affect the generation of warnings by applications). Compatibility with off-the-shelf software is also a consideration, since the whole range of ISO 19107 types is not implemented as distinguished types in (for example) spatial extensions of database software.
The S-57 standard defines different types of curves but also prescribes that curves not be used in ENCs (App. B.1, clause 3.8) saying "the disadvantages are such (e.g., during updating, generating warnings/alarms) that they must not be used for ENC." The consequence is that edges must be encoded as a sequence of coordinates. Poor symbolisation caused by splitting a line into numerous small edges is suggested to be hidden by masking. The arc/curve types listed in S-57 are: arc 3 point centre; elliptical arc; uniform B-spline; piecewise Bezier; non-uniform rational B-spline. Some of these curve types may have roles in modelling surfaces and 3D information but we do not think that issue needs to be considered now.

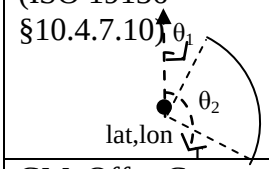
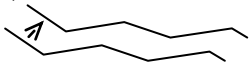
5 Process

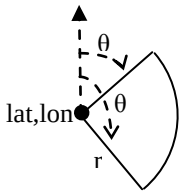
The ISO 19107 and ISO 19136 geometries most likely to be needed are proposed to be added now. Product specification writers can propose additional spatial types later as needed. Accepted proposals would become extensions to S-100 (this is mandated by §12-2.3) so proposals would go through the normal process for approval of extensions to S-100. This allows a reasonable spectrum of spatial types to start with, balances needs with implementation effort, and reduces the likelihood of future revisions of S-100 while retaining flexibility for the future.
The addition of a new spatial type in S-100 (either as part of this proposal or later) does not require that all product specifications will use it. Specifications are free to restrict types to a subset of those defined in S-100 (see also the section on conformance classes in S-100, later in this paper).

6 Proposed Types

The types proposed to be added along with justifications are given in Table 1.

Table 1. Proposed additional spatial types

Item	Type	Justification / Examples
CircleByCenterPoint (ISO 19136 §10.4.7.11) 	Coordinate Geometry	There are several examples of geographic features originally specified (in legislation and elsewhere) as circles by centre point and radius, e.g., marine protected areas, restricted areas, MSI, navigational warnings and messages, caution areas. AIS ASM 8FI22 also uses centre-radius geometry for circles. The ISO 19107 and S-100 Edition 1.0.0 representation by 3 points on the circumference has not been encountered in legislation or regulation. (Current practice is to convert the circle to polygons with enough points to approximate a circle.) This representation is distinct from GM_Circle (ISO 19107 §6.4.16), which represents a circle by 3 points on its circumference.
ArcByCenterPoint (ISO 19136 §10.4.7.10) 	Coordinate Geometry	Radar service areas. AIS ASM 8FI22 also uses centre-radius-bearing geometry for sector areas. The possibility of using interpolation type "circularArc3Points" with GM_CurveSegment is acknowledged but its semantics requires computation of control points on the arc. This representation is distinct from GM_Arc (ISO 19107 §6.4.15), which represents an arc by 3 points on the arc.
GM_OffsetCurve (ISO 19107 §6.4.23) 	Coordinate Geometry	Some protected areas are legally specified by means of a distance from a base curve, e.g., marine protected areas for the North American right whales in the U.S. Territorial seas and contiguous zones are defined similarly.

Item	Type	Justification / Examples
SectorByCenterPoint 	Coordinate type	AIS ASM 8FI22 also uses centre-radius-bearing geometry for sector areas. This can be defined using a composite of ArcByCenterPoint and line segments joining the centre to the ends of the arc. It is also possible to define another variant in terms of a boundary consisting of 3 curve segments with suitable constraints if needed but at this time it is not considered necessary to define this variant as a distinguished type. It can be encoded using types defined in Edition 1.0.0 by creating the boundary using the appropriate curve segments and interpolation types.

Note that **GM_Arc** and **GM_Circle**, which are defined in ISO 19107 (representations as 3 points on the circle or arc) are believed to be unnecessary, and are not being proposed at this time.

6.1 UML models

The UML models of the proposed spatial types are based on the corresponding diagrams in the UML models for ISO 19107 and ISO 19136, adapted to the existing spatial schema in S-100 Part 7 (e.g., **S100_Angle** instead of **Angle**). They are shown in the figures that follow. Yellow boxes are from the current spatial schema of S-100 Edition 1.0.0 and beige boxes are extensions proposed for Edition 2.0.0.

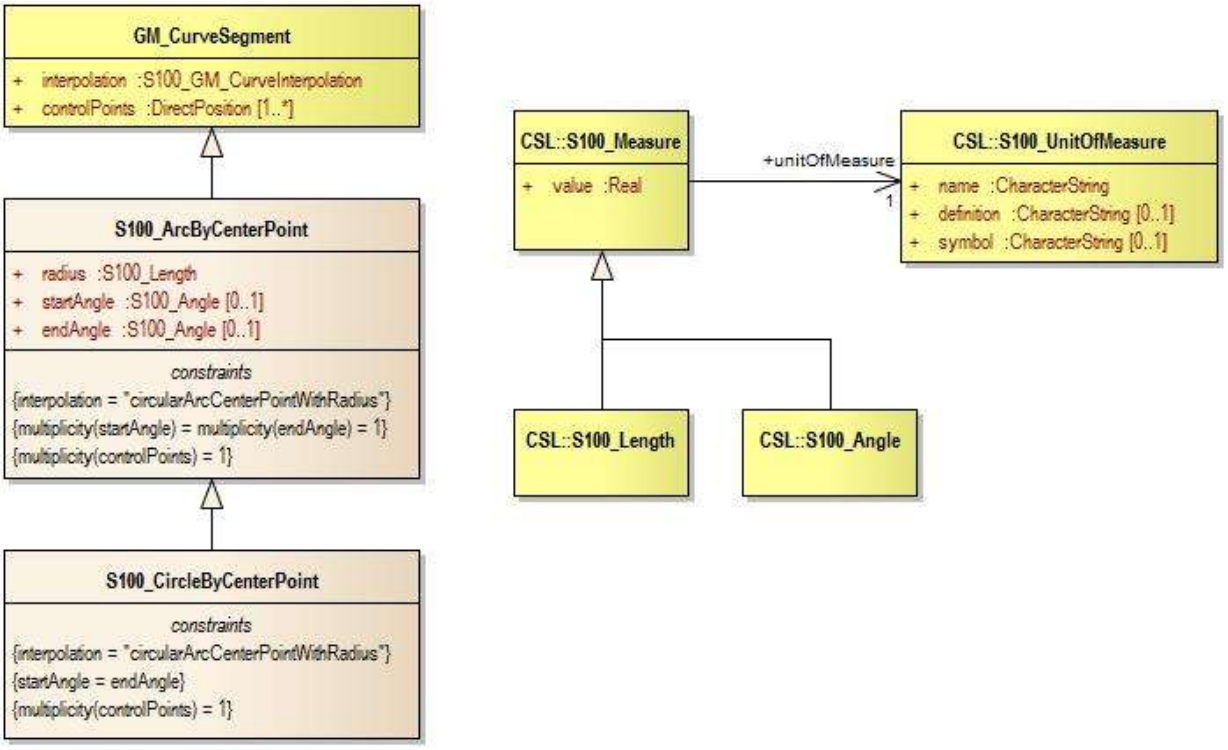


Figure 1. Conceptual model of arc by center point and circle by center point

S100_ArcByCenterPoint is a sub-type of **GM_CurveSegment** with additional attributes for the radius, start and end angles. The centre of the arc is the single member of the array of control points inherited from **GM_CurveSegment**. **S100_CircleByCenterPoint** is a sub-type of **S100_ArcByCenterPoint** with the attributes. (This hierarchy conforms to ISO 19136.)

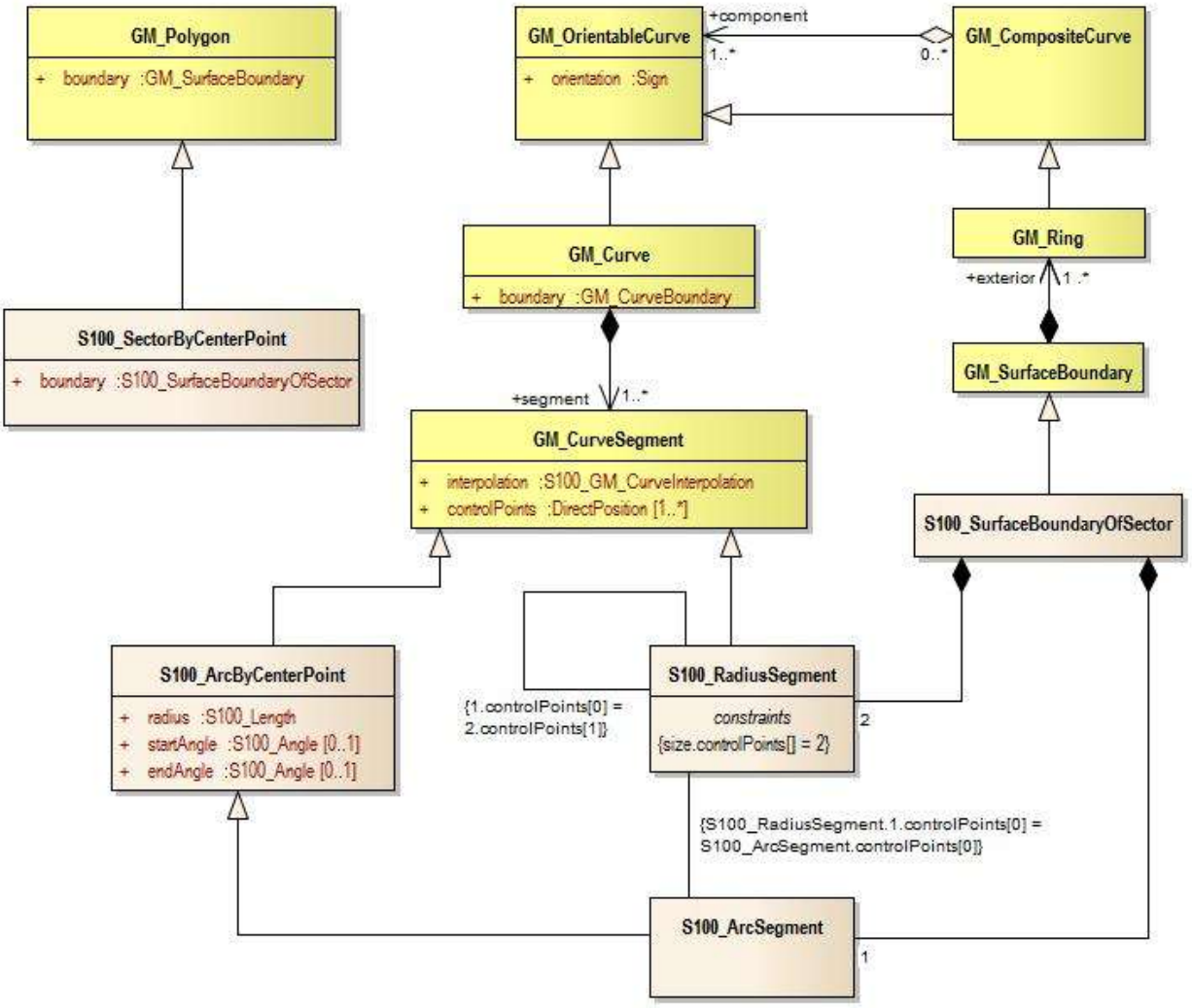


Figure 2. Conceptual model of sector by center point

Sectors are not defined as spatial types in ISO 19107 or ISO 19136 but SNPWG considered them to be needed. This proposal adds a spatial type for sector in S-100 Edition 2.0.0. A sector is a surface with its boundary, the boundary consisting of two radii of a circle and the arc swept in traversal from the first to the second. A sector can be defined in terms of either the arc alone (the segments for the side edges can be computed from the coordinates of the centre, radius, and bearing) or as a composite of **ArcByCenterPoint** and segment for each side edge. For uniformity with other spatial types the second alternative will be used.

SectorByCenterPoint is modelled as a sub-type of **GM_Polygon** with the *boundary* attribute specialized to a sub-type of **GM_SurfaceBoundary**. The boundary of a sector consists of 2 radial segments and 1 arc segment. The radial segments are mutually constrained to have the centre of the circle as a common end point (the constraint on the self-association for **S100_RadiusSegment**) and this point must be the centre for the arc segment (the constraint on the association **S100_RadiusSegment** / **S100_ArcSegment**).

The "extra" classes **S100_RadiusSegment** and **S100_ArcSegment** are conceptual conveniences and it remains to be decided whether they will be represented in the ISO 8211 encoding as distinguished ISO 8211 spatial records or simply as curve segment spatial records (which are already defined in the ISO 8211 encoding of S-100 Edition 1.0.0) with extra constraints for multiplicity and control points corresponding to the relevant restrictions shown in Figure 2.

General options for the ISO 8211 encoding of new spatial types are discussed in Section 7.

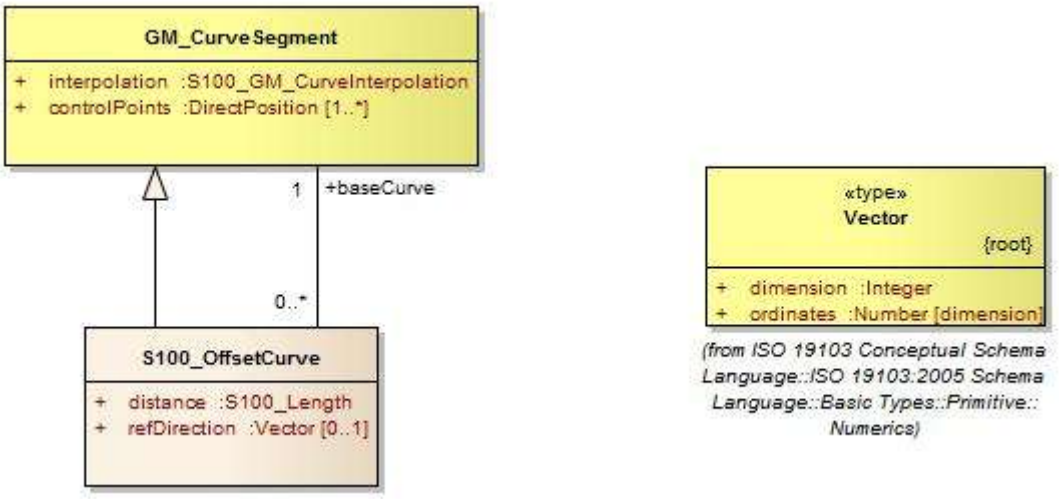


Figure 3. Conceptual model of offset curve

An offset curve is a curve at a constant distance from the base curve. It is determined in terms of an offset distance and direction from a basis curve. The attribute "distance" is the distance at which the offset curve is generated from the basis curve. The attribute *refDirection* is used to define the vector direction of the offset curve from the basis curve. It can be omitted in the 2D case, where the distance can be positive or negative. In that case, distance defines left side (positive distance) or right side (negative distance) with respect to the tangent to the basis curve. "Left" and "right" are determined by the direction of the basis curve.

6.2 Non-ISO spatial types

Certain representations used in nautical publications are different from any representation in ISO 19107 or 19136. An example is given in Figure 7 in Annex A, where an arc is given in terms of endpoint coordinates, radius, and centre. All such "unusual" representations which we have encountered so far can be converted to an ISO representation, and in theory any representation can be so converted (in the last resort, approximated by a curve or polygon). While it is possible to define GML or ISO 8211 encodings which map one-to-one to such unusual representations, we do not propose to develop any such for this proposal. Specification writers with a strong felt need for such representations can propose representations as extensions to S-100, or encode the special representation as an attribute of associated information objects. (The "sector by centre point" class in Figure 2 is not an exception because it does not add any attributes to its parent ISO type **GM_Polygon** but only constrains the values of its *boundary* attribute).

7 Encoding and Implementation

GML: GML includes definitions for **CircleByCenterPoint**, **ArcByCenterPoint**, and **GM_OffsetCurve**, defined in the GML standard ISO 19136. An encoding for **S100_SectorByCenterPoint** can be added to the GML profile for S-100 Edition 2.0.0. This is technically straightforward but the implications for compatibility with off-the-shelf GML software need to be carefully considered and such extensions may belong in a separate conformance class (conformance classes are discussed in Section 8).
ISO 8211: TSMAD requested that ISO 8211 encodings of any additional spatial types be provided with any proposal. Defining additional spatial type records for an ISO 8211 encoding of the additional spatial types can be done (in an update to S-100 Part 10a).
Options for encoding the new types in an ISO 8211 encoding are:

1) No changes are made to the ISO 8211 encoding of S-100 Edition 1.0.0. Convert all instances of the additional spatial types to use only spatial types defined in S-100 Edition 1.0.0. Arcs and circles could be encoded using curves with interpolation type *Arc3Points*. Offset curves are encoded as distinct curves.

2) A variation of the above would use only the encodings allowed in S-101 (ENC), which uses level 3a of S-100 with additional restrictions. For example, S-101 constrains the interpolation of **GM_CurveSegment** to be *loxodromic*[1]. *Arc3Points* is not allowed. This implies that arcs and circles

[1] Clauses 4.8.1, B1.6.17.

must be approximated by piecewise linear rings with sufficient resolution compared to the display scale range to produce a visually acceptable portrayal. The line string and polygonal approximations required tend to increase data volume and increase scale dependence.

3) Define new encodings for the additional spatial types. This means extending Part 10a of S-100 with new spatial record types, field names, etc. Encodings were defined in S-57 for some arc and curve spatial objects, and the same can be done for S-100. The S-57 encodings might be re-used in part, though some changes may be needed for closer conformance to the S-100 spatial schema, ISO 19107 and ISO 19136.
4) Define "enhanced" encodings for the new types, which conform to S-100 Edition 1.0.0 for format (i.e., use the existing spatial record types, field names, etc.) but add information pertaining to the new types (e.g., centre and radius for circles).

7.1 Consequences for portrayal

S-100 Part 9 will need to be updated to add the new spatial types to the input model, drawing instructions and rules. Subtyping the augmented geometry types in Part 9 is a possibility but needs further exploration. The April 2013 draft of S-100 Part 9 already includes classes for Sector, Annulus, and ArcByRadius in clause 10.2.2 which describes the *GraphicsBase* package and A.2 which is the symbol definition XML schema corresponding to it.
Curves represented by parameters, e.g., centre-radius representation, may need to be computed, and this calculation may need to include projection to the dataset's datum.

7.2 Off-the-shelf software support

Current commercially available software such as the spatial modules of SQL Server 2012 and Oracle 12 support the spatial types of ISO 13249-3. As a practical matter this means that **GM_Arc** and **GM_Circle** are supported but centre point representations of arcs and circles are not currently natively supported.
Non-uniform rational B-splines (NURBS) are supported and may be useful for some types of e-navigation information such as terrain visualisations but we have not yet explored this aspect.

8 Conformance Classes for Implementations

S-100 Edition 1.0.0 Part 7 (Spatial Schema) already defines 5 basic levels of geometry. The extended spatial types can be placed in a new level perhaps with "transitional" and "strict" sub-levels derived from the considerations described in Section 7. The concepts of transitional and strict conformance should be familiar from HTML 4.01 which has "transitional" and "strict" DTDs (the first allows some elements and attributes which are deprecated, i.e., intended to be declared obsolete) . The levels concept for S-100 is summarized below.
Levels 1, 2a, 2b, 3a, and 3b are defined in Part 7 of S-100 Edition 1.0.0. The allowed primitives are listed in clause 7-5.1.1 of Edition 1.0.0 and include **GM_Point**, **GM_CurveSegment**, **GM_Polygon**, etc. It is proposed to add another table listing the new spatial types: **GM_OffsetCurve**, **S100_CircleByCenterPoint**, etc. The new updated set of levels is summarized in the table below.

Table 2. Summary of levels. The proposed new levels are 3c and 3d

Geometry configuration	Summary description
Level 1	0-, 1-Dimension; point and curve primitives
Level 2a	0-, 1-Dimension; points and curves, curves must not self-intersect, polygons represented as closed loop of curves, interior boundaries must not intersect, etc.
Level 2b	0-, 1-Dimension; constraints of Level 2a; intersecting curves must reference a point at the intersection, duplication of coincident geometry prohibited, etc.
Level 3a	0-, 1-, 2-Dimension; point, curve and surface primitives; constraints for Level 2a apply
Level 3b	0-, 1-, 2-Dimension; constraints for Level 3b; surfaces must be mutually exhaustive and provide mutual cover
Level 3c	0-, 1-, 2-Dimension; primitives and constraints of level 3a; spatial objects encoding the new types are annotated with constraints (e.g., as in Figure 1) on

	attribute cardinality and values but are otherwise indistinguishable from Level 3a data objects. (Implementations need not read any new spatial record types and can even ignore the constraint annotations).
Level 3d	0-, 1-, 2-Dimension; primitives and constraints of level 3a plus the new spatial types listed in the added table (circle by centre point, offset curve, etc.).

Product specifications can choose whether or not to use the additional types by specifying the level to be used. For example, the current draft S-101 standard specifies Level 3a.
Defining levels or conformance classes also allows implementers to declare conformance to a normative subset of S-100. E.g., implementations conforming only to Level 3d need not be capable of ingesting the new spatial record types.

9 Recommendations

Recommendation 1: Add the ISO 19107 and 19136 types CiecleByCenterPoint, ArcByCenterPoint, and OffsetCurve to the S-100 Spatial Schema.
Recommendation 2: Add the new type SectorByCenterPoint to the S-100 Spatial Schema.
Recommendation 3: Include data formats for the new types in the S-100 GML profile and ISO 8211 encoding.

10 Impacts

No impact on product specifications which already claim conformance to an existing spatial level (S-101 conforms to level 3a with restrictions). Implementations claiming conformance to the new spatial levels will need to be extended to handle the spatial types corresponding to the new levels.

11 Conclusion

ISO 19107 defines several geometric primitives and coordinate geometries, ranging from point to polyhedral surface and splines. To these are added geometric aggregates and geometric complexes. S-100 Part 7 implements a subset of these which are theoretically sufficient to model necessary 0- 1- and 2-dimensional geometries though not all possible geometry types. S-100 also allows limited extension into a 3rd dimension. The proposed spatial types add some additional types expected to be needed for S-10x data products.

12 Actions Requested

TSMAD is requested to:

- Consider the proposed new spatial types individually for addition to the S-100 Spatial Schema: (1) S100_CircleByCenterPoint; (2) S100_ArcByCenterPoint; (3) S100_OffsetCurve; (4) S100_SectorByCenterPoint
- Accept the proposed spatial types and include the proposed data formats in (1) the GML profile; (2) the ISO8211 encoding;
- Review the accompanying change proposal and redline markup.

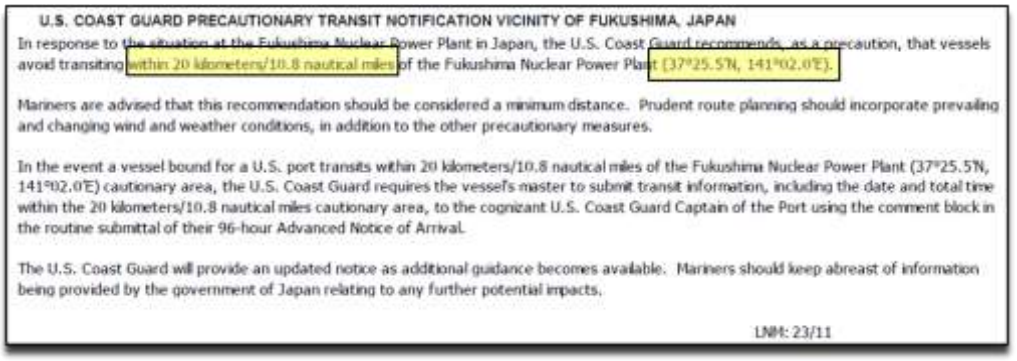
Annex A. Examples of non-traditional formats for spatial representations

Examples of areas defined using circles, arcs, and offsets from a base curve.

3. Entry prohibited areas for vessels over 500GT extend from the coastline or centre of the following islands:

Island	*Position*	*Chart*	*Maximum Radius*
Isola Gorgona (centre of island)	43° 25´·70N., 9° 54´·00E.	1998, 1999	6NM
Isola Capraia (coastline)	43° 02´·30N., 9° 43´·40E.	1998, 1999	5NM
Isola d'Elba including Isola Palmaiola (coastline)	42° 47´·90N., 10° 18´·00E.	131, 1999	2NM
Isola Cerboli (centre of island)	42° 51´·58N., 10° 32´·80E.	131, 1999	0·9NM
Isola Pianosa (centre of island)	42° 35´·30N., 10° 04´·70E.	1999	4·5NM
Scog. Africa (centre of island)	42° 21´·51N., 10° 03´·84E.	1999	2NM
Isola di Montecristo (centre of island)	42° 20´·00N., 10° 18´·60E.	1999	6NM
Isola del Giglio (coastline)	42° 21´·50N., 10° 53´·90E.	1911, 1999	2NM
Isola di Giannutri (coastline)	42° 15´·06N., 11° 06´·30E.	1911, 1999	5NM

Figure 4. Notice designating prohibited areas in terms of centre/radius and offsets from a curve. From Italian notice 8.10/13, as reproduced in Admiralty Notice 2429(P)/13, Admiralty NTM edition 22, dated 30 May 2013. Also in NGA Publication 160.



U.S. COAST GUARD PRECAUTIONARY TRANSIT NOTIFICATION VICINITY OF FUKUSHIMA, JAPAN

In response to the situation at the Fukushima Nuclear Power Plant in Japan, the U.S. Coast Guard recommends, as a precaution, that vessels avoid transiting within 20 kilometers/10.8 nautical miles of the Fukushima Nuclear Power Plant (37°25.5'N, 141°02.0'E).

Mariners are advised that this recommendation should be considered a minimum distance. Prudent route planning should incorporate prevailing and changing wind and weather conditions, in addition to the other precautionary measures.

In the event a vessel bound for a U.S. port transits within 20 kilometers/10.8 nautical miles of the Fukushima Nuclear Power Plant (37°25.5'N, 141°02.0'E) cautionary area, the U.S. Coast Guard requires the vessel's master to submit transit information, including the date and total time within the 20 kilometers/10.8 nautical miles cautionary area, to the cognizant U.S. Coast Guard Captain of the Port using the comment block in the routine submittal of their 96-hour Advanced Notice of Arrival.

The U.S. Coast Guard will provide an updated notice as additional guidance becomes available. Mariners should keep abreast of information being provided by the government of Japan relating to any further potential impacts.

LNM: 23/11

Figure 5. Extract from USCG District 11 Local Notice to Mariners 23/11, defining an area in terms of centre and radius.

10. **False Bay (Simon's Town)**—Seaward range. Bound by lines joining the following positions:

a. Arc of a circle, with a radius of 11 miles (20,384m) centered on position 34°10'30.0"S, 18°25'45.0"E, between the bearings of 254° and 291°

b. 34°15'00.0"S, 18°37'51.0"E.

c. 34°11'13.2"S, 18°26'19.2"E. (T-Wall)

d. 34°10'30.0"S, 18°25'45.0"E.

Figure 6. Extract from NGA Publication 160 defining an area bounded by an arc defined by centre and bearings. The example is for the coast of South Africa.

In addition to the ISO 19107 and ISO 19136 representations used in the preceding examples, areas are sometimes defined with arc segments represented in terms of centre, radius, and the coordinates of the end points. This representation is very similar to one of the "arc/curve" representations mentioned in S-57 though not permitted for use in ENCs.

Nature of Activity	Times of Use	Area limits bound by lines joining positions stated, unless otherwise indicated
Military flying/non-flying	NOTAM	**R230A**—11°05'02"S, 130°53'39"E; then the minor arc of a circle 80 NM in radius centered on Darwin DME (12°25'24"S, 130°54'23"E) to 11°20'50"S, 131°42'58"E; 12°05'13"S, 131°09'35"E; then the minor arc of a circle 25 NM in radius centered on Darwin DME to 12°00'17"S, 130°54'53"E.
(... other areas ...)		
Military flying/non-flying	NOTAM	**R264D**—12°59'22"S, 128°56'35"E; then the minor arc of a circle 120 NM in radius centered on Darwin DME (12°25'24"S, 130°54'23"E) to 11°50'34"S, 128°57'06"E; 11°35'48"S, 128°08'23"E; then the minor arc of a circle 170 NM in radius centered on Darwin DME to 13°13'15"S, 128°07'20"E.

Figure 7. Extract from NGA Publication 160 defining areas in terms of bounding arcs joined by lines[2]. The data are for Australia.

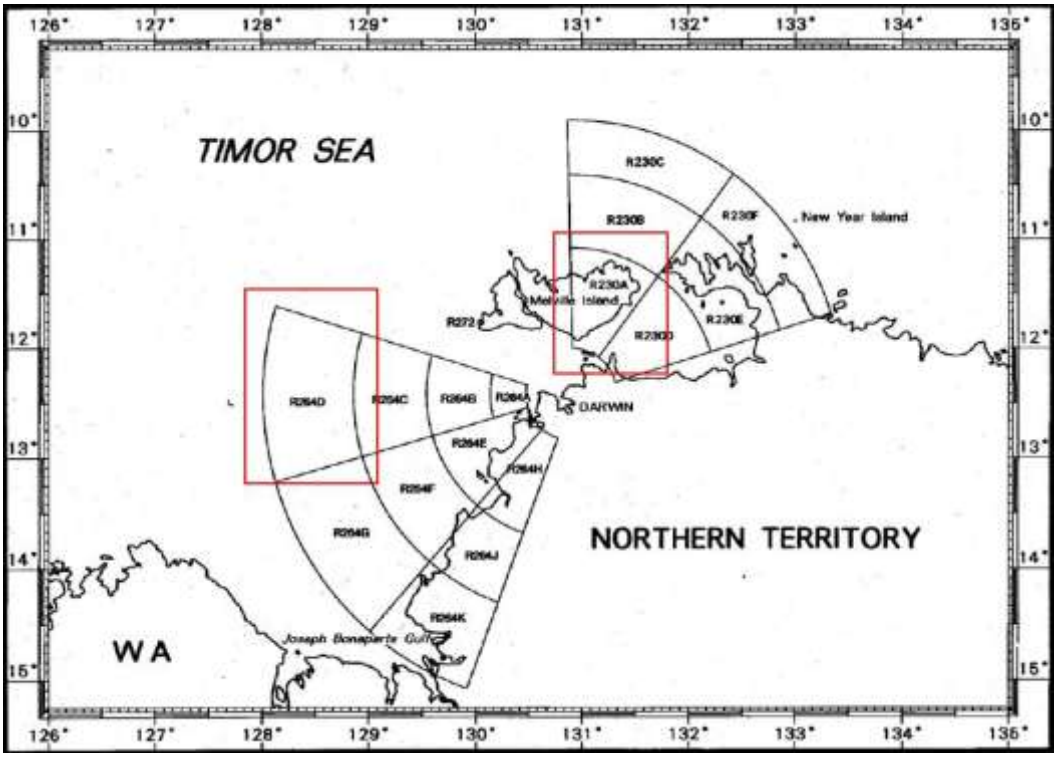


Figure 8. Chartlet showing areas described in Figure 7 Error! Reference source not found.[Error! Bookmark not defined.]**.**

[2] Original data courtesy Australian Hydrographic Service.