SNPWG 17-11.4

Paper for consideration by SNPWG

S-100 Spatial Types - Update

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Executive Summary:	This paper updates SNPWG on the status of additional spatial types proposed for Edition 2.0.0 of S-100 and describes options.
Related Documents:	(1) S-100 Ed. 1.0.0 (2) TSMAD27-4.3.11B: Spatial Types for S-100 Edition 2.0.0 (3) TSMAD27-4.3.12A: More Spatial Types for S-100 Edition 2.0.0
Related Projects:	(1) S-100

1 Introduction/Background

Edition 1.0.0 of S-100 includes simple geometric primitives, aggregate, and composite spatial types for describing feature geometry. The allowed types are a subset of the types defined in ISO 19107 and are defined in Part 7 of S-100 Edition 1.0.0. Discussions at SNPWG 16 identified 4 candidate spatial types for inclusion in S-100 Edition 2.0.0 and later discussions identified two additional spatial types. Change proposals or papers were submitted to TSMAD and discussed at TSMAD 27. This paper reports on status and describes future options.

2 References

ISO 19107: Geographic Information – Spatial Schema

ISO 19136: Geography Markup Language (GML)

ISO 19137: Core Profile of the Spatial Schema

3 Discussion/Analysis

3.1 Introduction

ISO 19107 defines several spatial types. ISO 19136 (GML) describes an XML encoding for many but not all of those spatial types, and also adds new spatial types for ArcByCenterPoint and CircleByCenterPoint. A third ISO standard, ISO 19137 "provides a core profile of the geometry part of the spatial schema specified in ISO 19107 that is easy to understand and has a low cost of implementation." Other "simple feature" standards are ISO 19125 and OGC 06-0134a "Simple feature access."

S-100 Edition 1.0.0 Part 7 includes a limited selection of ISO 19107 spatial types along with additional restrictions. The spatial model in Part 7 of S-100 Edition 1.0.0 is similar but not identical to the core profile of ISO 19137. Many off-the-shelf and open source implementations of ISO 19107 and GML implement a limited subset of primitives (points, curves, and polygons) with some support for complexes and aggregates.

3.2 Status of proposals

The 6 types identified by SNPWG at SNPWG 16 and later are listed below. The common characteristic is the introduction of parametric shapes as compared to the interpolated shapes of Edition 1.0.0.

- Arc by centre point and radius (ISO 19136 §10.4.7.10 ArcByCenterPoint)
- Circle by centre point and radius (ISO 19136 §10.4.7.11 CircleByCenterPoint)
- Sector by centre point and radius (not defined in ISO 19107 or ISO 19136)
- Offset curve (ISO 19107 §6.4.23 GM_OffsetCurve)
- Ellipse (not defined in ISO 19107 or ISO 19136)
- Annular sector (not defined in ISO 19107 or ISO 19136)

All the proposed spatial types were discussed in a breakout group at TSMAD 27 and were not approved. Objections focused mainly on perceptions of implementation complexity and broad support in software for only point, curve, and polygon geometry. There were objections to addition of types not already defined in the ISO standards. It was stated that other types can be reduced to point, curve, and polygon geometry and user software should convert from user-friendly formats to S-100 Edition 1.0.0 compatible format.

A substitute proposal replacing encoding conic sections was requested. This will be considered at a meeting of the S-100 working group March 10-14.

3.3 Conic sections proposal

ISO 19107 defines the type GM_Conic (§ 6.4.19), representing any general conic curve. Any of the conic section curves can be represented by equations in P and e, where P is the semi-latus rectum and e the eccentricity. For $e = 0$, the conic section is a circle, for $0 < e < 1$ an ellipse, for $e = 1$ a parabola, for $e > 1$ one branch of a hyperbola. Conic sections are therefore capable of representing both circles and ellipses.

ISO 19107 defines GM_Conic as a sub-type of curve, with attributes for the position, eccentricity, semi-latus rectum, and parameters determining the start and end of the curve. Definitions relate to construction on a planar surface. The proposal for adding this type to S-100 Edition 2.0.0 represents location on the surface of the Earth by substituting location coordinates and azimuth in place of the "position" attribute in ISO 19107. For circles and arcs, the semi-latus rectum is the radius, the centre of the circle is given by the "location" attribute, and the value of the eccentricity attribute is zero.

ISO 19136 (GML 3.2.1) does not describe an XML encoding for GM_Conic. It does allow for defining new geometry types not defined in the GML schemas as part of a "GML application schema", so an S-100 encoding is allowable. Actual utility obviously requires widespread implementation within the domain.

The proposal for conic sections therefore incorporates circles, arcs, and ellipses, but:

- Adds a small amount of complexity to conversion of circular shapes in centre-radius form since the eccentricity is zero and the semi-latus rectum is the radius of the circle (adjusted for projection if needed). Centre-radius descriptions of circles or arcs are found in several places e.g., maritime safety information and marine protected areas.
- Adds a little more complexity to ellipses since it requires eccentricity (which can be computed from semi-major and semi-minor axis lengths), the coordinates of a focus, and the azimuth.
- Loses some semantic precision and reduces performance by leaving it to the application to determine the shape if needed (e.g., by checking eccentricity value). The practical effect is that spatial queries cannot exploit shape-based efficiencies.

3.4 Methods of encoding using only Edition 1.0.0 spatial types

The main reason to use only a spatial type recognized in S-100 is that it allows S-100 applications to use common APIs for all S-1xx products. This simplifies the rendering of shapes on a screen, setting and triggering alarms, spatial queries/pick reports, etc.

Some points to note about using types defined in Edition 1.0.0:

- A curve interpolation type circularArc3Points is included in Edition 1.0.0, theoretically allowing arcs to be encoded with 3 control points (2 endpoints and an intermediate point on the arc). It is not clear whether this interpolation type is widely implemented in off-the-shelf software.
- Curve interpolation types "elliptical", "conic" and different spline types are defined in ISO 19107 and GML but not included in S-100 Edition 1.0.0. Elliptical arcs can theoretically be defined in a plane using four control points located on the ellipse and general conic sections by five points.
- Arcs, circles, ellipses, etc., can also be encoded as commonly done today, by approximating the shape by a sequence of short line segments. Tool support may be provided for some shapes, e.g., approximating a circle by a polygon. The number of vertices which need to be computed to provide a reasonable

approximation is generally high enough (e.g., 72 points or more for a circle) that manual calculations though possible are not practical, and tool support is needed. The implications are described in section 3.5 below.

- Composite curves are permitted, e.g., a sector can be encoded as three segments, two for the radii and a third for the arc, the third being an arc. An annular sector can be encoded as two radial lines and two arcs. Obviously more segments can also be defined if necessary.
- Offset curves will have to be encoded as a distinct curve. The coordinates of the control points on the offset curve must be computed from the geometry of the basis curve. Again, tool support will be needed.
- The above observations also apply to other shapes like rectangles, i.e., they will need to be converted to sequences of line segments or composite curves.
- Spatial parameters (radius, etc.) can still be included in the data as feature attributes or associated information types.

3.5 Consequences

The primary consequence is that product specifications using geometries other than those included in Edition 1.0.0 must convert those geometries to one of the types defined in Edition 1.0.0. The basic consequences are:

- Increased complexity at the producer end of the data chain – in tools, workflow, business processes for production and maintenance, or a combination of them.
- Implementation of the end-user application (ECDIS, ECS, or other system) is simplified since that needs to handle fewer spatial types and use existing methods of queries – in other words, fewer changes to current implementation libraries are needed, with less development and testing effort.

Details are in the following paragraphs.

Data acquisition and conversion will need more labour and tool support in order to create S-100 compatible geometries that are reasonable approximations to geometry as originally specified. Specifically, a graphic interface may be required to define geometry, or at least a form-based software tool capable of generating the points needed to approximate the shape to the required accuracy.

Data originators will also need the same level of sophistication in software if they are to generate S-100 compatible data. Note that originators may not be cartographers and may not even be located in a hydrographic office. For example, VTS or water and shipping administration officers preparing marine safety notices and navigational warnings will need a tool with a form-based or graphical UI and conversion software library (for entering warning areas in terms of radius and coordinates of the centre of the area, and computing the vertices of the approximating polygon, respectively). Or, a workflow to convert to S-100-compatible format at some stage between creation and ingest must be defined. Either way, additional complexity is introduced in either the tools or the workflow and business processes.

Shapes may be defined in legal documents, and there might be some **regulatory implications** in only being able to produce an approximation of a shape defined in a regulation. This needs to be clarified with each producer's legal office to ensure the approximation is sufficient in an official document, which NPubs are. Current practice seems to address this problem informally with a "technical solution" by creating good-enough approximations at high enough resolutions, or avoid it by having the responsible authority define the area in the implementing regulation in terms of polygon vertices[1].

Maintenance and provenance tracking will probably require retention of the original source information. Both verification and updates to the spatial object will need the original information. This adds some complexity to databases as well as workflow processes.

Verification of data is made more difficult since the coordinates of the converted shape must be verified against parametric shape data. Again, tool support will almost certainly be needed.

[1] The outer boundary of the US Papahanaumokuakea Marine National Monument is described in the US CFR (2011) using 100 points.

Dataset **volume** increases, since data interchange of shape information using points at sufficient resolution will take up more space than shape parameters.

Cutting shapes at cell boundaries can follow existing rules instead of requiring production and loading algorithms to be adapted for parametric shapes, e.g., to use envelope data for parametric shapes.

Scale dependence may be introduced, since the resolution and hence the number of points needed for acceptable piecewise approximations depends on the scale of the display.

Adoption by e-navigation services and applications becomes less certain as some have very restrictive constraints such as bandwidth and legacy standards (e.g., AIS messages). Again, either additional complexity will be introduced, or some compromise needs to be reached for those domains, perhaps by relaxing or compromising on other Parts of S-100.

Advanced spatial queries must be implemented using a workaround that makes the parameters available in the data in another format.

3.6 Other Options

The obvious workaround is to annotate features with information about extended spatial types while also providing an Edition 1.0.0 type as the nominal geometry of the feature. This would have to be specified in each product specification. Options for adding shape parameters are given below. In all cases, the precise model would also have to consider practical issues such as compatibility with off-the-shelf software.

1. As feature attributes giving shape parameters, e.g., attributes circlularAreaCentre (complex attribute with sub-attributes latitude and longitude) and circularAreaRadius (radius in nautical miles). This complicates application schemas, as well as processing (queries, portrayal, etc.) if features can have different shapes. For example, protected areas can be circles, polygons, areas bounded by shoreline and offset curve, etc.
2. As instances of an information type or types with attributes for the shape parameters. This information type can be associated with the feature as any other information type.
3. Extended geometry might in theory also be encoded in a second spatial attribute with a different name and semantics since ISO 19109 (Rules for Application Schema) and ISO 19136 (GML) allow a feature to have multiple spatial attributes with distinct semantics (ISO 19109 has an example of a Building feature with two spatial attributes, “Centre point” and “Shape”).
4. Circles and arcs by centre point are included in ISO 19136 (GML) though not in ISO 19107. The ISO 19136 (GML) standard also explicitly allows application schemas to define additional geometry types though obviously the utility depends on implementations recognizing the additional types. Product specification authors may consider using either the GML types as a spatial types limited to their data product/domain, or defining additional types given sufficient prevalence in use and implementation support.
5. The final option is to define a new spatial type and propose an extension to S-100 through the usual change proposal process. Sufficient demand or demonstrated implementations may be enough to get it accepted. Standards-based types especially from ISO standards may be better received than non-standard types.

In all cases consideration should be given to the likelihood that a system (e.g., an ECDIS) supporting only the types defined in S-100 Edition 1.0.0 may not be able to load or display features whose geometry is encoded using a spatial type not defined in S-100 Edition 1.0.0.

Finally, as of February 18 2014 the status of ISO 19107 is designated as “to be revised”. While this revision is likely to take years and may not result in new spatial types being added to ISO 19107, the process should be monitored and comments discussed with HSSC and ISO liaisons.

4 Conclusion

This paper presented different options to cope with the limited range of spatial types provided by S-100 Edition 1.0.0. The main consequences are additional effort and tool support. Other options were also described. Product specification writers considering additional spatial types should consider which of these options may be suitable, whether an alternative or more efficient solution exists for their application, or whether a change proposal for extending S-100 with a new spatial type can be justified. Consideration should be given to reusability and compatibility with the S-100 software and application ecosystem.

5 Actions Requested

SNPWG is invited to:

- note this paper
- consider the options described while developing product specifications
- monitor progress on revising ISO 19107 and discuss with ISO liaison and HSSC