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## Implications for an OGC GeoPackage Symbology Encoding Standard

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**i. Abstract**

The GeoPackage Standards Working Group (SWG) presents a discussion of symbology encapsulation for conveying presentation information for vector features contained within in a GeoPackage.

**ii. Keywords**

The following are keywords to be used by search engines and document catalogues.

ogcdoc, OGC document, GeoPackage, symbology, MILSTD 2525, Military Symbology, Technical Symbology

**iii. Preface**

The GeoPackage Standards Working Group (SWG) has identified a need to encode vector feature presentation-related information within a GeoPackage. This document describes multiple use cases for the conveyance of feature presentation information to accompany the feature. The purpose of this document is to record these use cases and to discuss the constraints, implications, limitations and justification of each use case. The result of the discussion paper will provide one or more prioritized recommendations for supporting symbology in GeoPackage containers.

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**iv. Submitting organizations**

The following organizations submitted this Document to the Open Geospatial Consortium (OGC):

Image Matters LLC

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## 1. Scope

The members of the GeoPackage Standards Working Group (SWG) have identified a need for the ability to exchange symbology-encoded features. This capability will be used to support various use cases, such as the following:

- Visualization
  - 2D and 3D presentation of symbology
- Analysis
- 2D, 3D and nD analysis of features<sup>1</sup>

Ideally this capability will be relatively easy to implement and will be suitable for a wide variety of computing environments including mobile/handheld. As a practical matter, each of the use cases discuss herein presupposes one or more operational constraints, or imposes operational limitations on producers or consumers of GeoPackages containing symbology.

## 2. References

### 2.1 Normative References

The following normative documents contain provisions that, through reference in this text, constitute provisions of this document. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. For undated references, the latest edition of the normative document referred to applies.

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<sup>1</sup> Analysis is referenced to highlight the separation between feature geometry and presentation rendering primitives. The encoding of symbology presentation information must not negatively impact the ability of consumers of GeoPackage to perform analysis. Specifically, decomposition of complex symbols (e.g., geodetic ellipses, n-sided polygons, or spirals) into simple elements for the purpose of rendering MUST NOT negatively impact the ability of systems to perform analysis of features.

OGC 12-128r11 OGC® GeoPackage Encoding Standard with Corrigendum  
[https://portal.opengeospatial.org/files/?artifact\\_id=63378](https://portal.opengeospatial.org/files/?artifact_id=63378)

## 2.2 Informative References

|   |
|---|
| OGC 05-077r4, OpenGIS® Symbology Encoding Implementation Specification, Version 1.1.0, 2006.<br>Known as: OGC SE 1.1  |
| NATO Vector Graphics Protocol, Version 2.0, TIDE Baseline 4, Allied, Command Transformation, 22 May 2015,<br><a href="https://tide.act.nato.int/tidepedia/images/6/6a/TTB_ANNEX_N_NATO_Vector_Graphics_v2.0.pdf">https://tide.act.nato.int/tidepedia/images/6/6a/TTB_ANNEX_N_NATO_Vector_Graphics_v2.0.pdf</a> ,<br>Known as: NVG 2.0 |
| CartoCSS – Stylesheets for Maps,<br><a href="https://github.com/mapbox/cartocss/blob/master/docs/latest.md">https://github.com/mapbox/cartocss/blob/master/docs/latest.md</a>   |
| OpenGeoSuite 4.3 Component Manuals, Web Map Styling with YSLD,<br><a href="http://suite.opengeo.org/docs/latest/cartography/ysld/index.html">http://suite.opengeo.org/docs/latest/cartography/ysld/index.html</a> , Dec 2015<br>Known as: YSLD  |
| STANAG 7170, Additional Military Layers<br>Known as: AML  |
| Joint Military Symbology - MIL-STD-2525D<br>Known as: MIL-STD-2525 Revision D, superseding version MIL-STD-2525C  |
| Common Warfighting Symbology - MIL-STD-2525C;<br>Known as: MIL-STD-2525 Revision C, superseding version MIL-STD-2525B w/CHANGE 2, Common Warfighting Symbology  |
| Common Warfighting Symbology - MIL-STD-2525B w/CHANGE 2;<br>Known as: MIL-STD-2525 Revision B with Change 2, superseding version MIL-STD-2525B Ch1, Common Warfighting Symbology  |
| Common Warfighting Symbology - MIL-STD-2525B w/CHANGE 1;<br>Known as: MIL-STD-2525 Revision B with Change1, superseding version MIL-STD-2525B, Common Warfighting Symbology   |
| Common Warfighting Symbology - MIL-STD-2525B<br>Known as: MIL-STD-2525 Revision B, Common Warfighting Symbology, superseding version MIL-STD-2525A  |
| Common Warfighting Symbology - MIL-STD-2525A w/CHANGE 1;<br>Known as: MIL-STD-2525 Revision A CH1, Common Warfighting Symbology, superseding version MIL-STD-2525A  |
| Common Warfighting Symbology - MIL-STD-2525A  |

|  |
|--|
| Known as: MIL-STD-2525 Revision A, Common Warfighting Symbology, superseding version MIL-STD-2525  |
| Common Warfighting Symbology Version 1 - MIL-STD-2525<br>Known as: MIL-STD-2525 Version 1, Common Warfighting Symbology  |
| Army Doctrine Reference Publication (ADRP 1-02), Terms and Military Symbols, August 2012,<br><a href="https://armypubs.us.army.mil/doctrine/DR_pubs/dr_a/pdf/adp1_02_new.pdf">https://armypubs.us.army.mil/doctrine/DR_pubs/dr_a/pdf/adp1_02_new.pdf</a> |
| STANAG 2019 Edition 6, NATO Joint Military Symbology Allied Procedural Publication 6 (C)<br>Known as: NATO APP-6(C) Symbology  |
| STANAG 2019 Edition 6, NATO Joint Military Symbology Allied Procedural Publication 6 (B)<br>Known as: NATO APP-6(B) Symbology  |
| STANAG 2019 Edition 6, NATO Joint Military Symbology Allied Procedural Publication 6 (A)<br>Known as: NATO APP-6(A) Symbology  |

### 3. Terms and Definitions

This document uses the terms defined in Sub-clause 5.3 of [OGC 06-121r8], which is based on the ISO/IEC Directives, Part 2, Rules for the structure and drafting of International Standards. In particular, the word “shall” (not “must”) is the verb form used to indicate a requirement to be strictly followed to conform to this standard.

For the purposes of this document, the following additional terms and definitions apply.

#### 3.1

##### **military symbology**

Pictographic representations of features, movements or events on a map or other geospatial display context that convey information visually, particularly as it pertains to military arts (e.g. MILSTD-2525, NATO-APP6).

#### 3.2

##### **technical symbology**

Pictographic representations of features, movements or events on a map or other geospatial display context that convey information visually, particularly as it pertains to technical or scientific arts, such as weather symbols, emergency management symbols, aviation, geology, agriculture or any specialized fields that uses pictorial representations of ground, air, or water features (e.g. Homeland Security Working Group Emergency Response Symbology).

### 3.3

#### **symbol identifier (symbol ID)**

Each unique symbol within a symbology set is assigned a unique identifier within the symbology set. Each symbology set defines a set of rules for the composition of symbol components that are assembled from a decomposition of the symbol ID. For the purpose of this discussion, the symbol is modeled as an opaque resource string of indeterminate length, as it is beyond the scope of this document to detail symbol ID composition rules, which vary by symbology set, revision and even among change notices.

For the purpose of this discussion, the symbol ID is modeled as an opaque resource string of indeterminate length, as it is beyond the scope of this document to detail symbol ID composition rules, which vary by symbology set, revision and even among change notices.

### 3.4

#### **symbology set**

A collection of pictograms or glyphs that are used to visually depict features. A symbology set may also include an explicit set of rules for the composition and rendering of symbol. A symbology set may also rely on implicit rules for rendering a symbol, consisting of a single PNG or SVG renderable object for each unique symbol ID. A symbology set identifier is a opaque resource string of indeterminate length that uniquely identifies the symbology set. It is beyond the scope of this document to document the details of the symbology set identifier (E.g. MIL-STD-2525B-CN1, NATO-APP6(B), or HSWG-ERS-2.0)

### 3.5

#### **extended symbol ID**

The concatenation of the symbology set identifier and the symbol identifier is collectively referred to the *extended symbol ID* for the purpose of this document. The extended symbol ID uniquely identifies a symbol across all possible symbol sets.

### 3.6

#### **symbol modifier**

Military symbology specifications (MIL-STD-2525 and NATO APP-6) allow the addition of text and graphic modifiers to be applied to a base symbol. For the purpose of this discussion, these modifiers further extend the extended symbol ID to define the symbol instance resource identifier. The symbol instance resource identifier must uniquely identify the symbol instance and the binding of a specific feature.

### 3.7

#### **feature geometry**

Refers to the geospatial positions that define a simple feature, such as a point, line, polyline or polygon. Feature geometries are typically expressed in absolute spatial coordinates, and are bound by simple feature topology rules.



**3.8****symbol geometry**

Refers to the drawing primitive geometry that is required to render a symbol at the location designated by the *feature geometry*. *Symbol geometry* is typically expressed in coordinates relative to the *feature geometry*.

**3.9****control point geometry**

Refers to the geospatial positions that define the parametric control points for a symbol. Control point geometry is expressed in absolute spatial coordinates, which often corresponds exactly with the feature geometry, but are not bound to topology rules. Within the scope of this discussion, control points refer to the corresponding control points within the symbol definition, including point ordinality restrictions.

**3.10****delineation**

Refers to the geometric dimension associated with the spatial attribute used to portray a feature.

**4. Process**

The SWG developed this approach by leveraging a series of interactions between October 2012 and November 2015, as part of Army Technical Working Groups Common Overlay and Single Shared Geospatial Foundation (SSGF). The Common Overlay Working Group, sponsored by Army Geospatial Center, and the GeoPackage SWG email list and teleconferences were the primary means of discussion and decision-making leading this discussion paper.

**5. Discussion**

Several use cases have been identified to highlight a need to support Symbology exchange within GeoPackage. The following discussion details these use cases and explores the implications and limitations of symbology support options for GeoPackage. The use cases fall into two broad categories: internal symbol references and external symbol references.

This discussion paper also draws attention to three distinct types of geometry identified as relevant to symbology. These geometry types are feature geometry, symbol geometry, and control point geometry, which are defined in section 3, Terms and Definitions.

A recommendation to decouple the symbology encoding effort from the GeoPackage charter has been proposed within the GeoPackage SWG. The rationale for this recommendation is due to the broader applicability of an updated symbology encoding standard to all users of Simple Features. Instead of incorporating the symbology encoding

as an extension within GeoPackage specification, it should serve to drive or incubate this vital capability and validate the resulting symbology expression standard.

As web mapping technology evolves, so must the standards that support mapping and symbology. Recent efforts such as CartoCSS and YSLD are gaining favor in the web map application community over XML-based standards such as OGC Style Layer Description (SLD), OGC Style Encoding Standard (SES) and NATO Vector Graphics (NVG).

CartoCSS and YSLD eschew the overhead of XML parsing for a CSS-style encoding of cartographic style information. NVG borrows heavily from the rendering primitive approach of SVG, defining geospatial primitives that include simple features as well as more complex primitives such as multi-point, rectangles, arrows, circles, ellipses, corridors, arcs and orbits, as well as composition operations.

A recommendation has been forwarded to the NVG governing body to separate the NVG symbol model from the encoding syntax (XML), as well as separating the services definition from the model. Similarly, YSLD proposes to retain the SLD model and substitute a browser-friendly encoding for XML<sup>2</sup>.

## 6. Symbol/Style References

### 6.1 External Symbol/Style References

External symbol/style references provide a linkage between a vector feature instance and a symbol/style lookup mechanism that is external to the GeoPackage, hereafter referred to as in *external symbol reference*. External symbol references refer to resources that require additional external resources or mechanisms to fully resolve symbol references.

Examples of external references include the use of symbol libraries and rendering algorithms required to draw MIL-STD-2525 symbology, modifiers and amplification text.

#### 6.1.1 USE CASE #1 Military Symbology Set (UC1)

Military symbologies are characterized by highly structured, hierarchical symbology-lookup schemes. Symbology presentation consists of a symbology set identifier (such as MIL-STD-2525-B-CN1<sup>3</sup>), a Symbol ID, zero or more modifiers that affect the graphic or text, annotation text, and control point geometries that determine the position, orientation and/or scale of the military symbol. Due to the complex rendering rules and standards define for military symbology, the rendering rules are difficult to express without the use of rendering heuristics found within rendering libraries. Thus UC1 would typically

<sup>2</sup> <http://boundlessgeo.com/2014/12/ysld/>

<sup>3</sup> MIL-STD-2525-B-CN1 Refers to MIL-STD-2525 Revision B, Change Notice 1.

require an external style reference. A special case of UC1, which is restricted to a single control point geometry, could be expressed as an internal reference symbol, but the need to encode text and graphic modifiers requires a one-to-one relationship between feature instance and symbol instance resource (i.e. one sprite per feature), resulting in significant storage overhead.

The following information must be encoded within a feature instance attribute record to express the symbol rendering information for an external symbol reference:

- Symbology Set Designation or URI
- Symbol ID
- Text Modifier(s)
- Graphic Modifier(s)
- Control Point Geometry
  - 1 Point
  - 2 Points
  - 3+ Points

Rendering rules for military symbology will sometimes contain guidance to support symbol clustering and multiscale rendering. Such libraries require rendering context information that extends to the entire renderable footprint, and the scale of the rendering surface in order to satisfy specific rendering standard guidance, such as Army Doctrine Reference Publication (ADRP 1-02), Terms and Military Symbols.

#### **6.1.1.1 UC1 Implications**

The use of external military symbology support libraries introduces external dependencies, thereby eliminating self-contained symbology approaches. Even if the SVG symbol library files were carried as payload within GeoPackage file, the business rules required to compose military symbology to each feature would also need to be encoded with the symbol extension. No rule language has been identified that could meet this functional requirement.

Although open source rendering libraries such as Mission Command mil-sym project ([Java](#), [Javascript](#), [Android](#)), Spatial Illusions, and FalconView Library exist, each implementation invokes a language-specific dependency, and no single implementation support all revisions and change notices of MIL-STD-2525 or NATO APP6 symbology standards.

A GeoPackage extension would be required to encode the symbol set ID, symbol ID, modifiers, and control point geometry in the primary feature attribute tables, or a secondary attribute table.

The use of an external library eliminates implied or expressed responsibility of rendering consistency, placing this responsibility solely within the external rendering library. This approach maintains the exchange-based model of the GeoPackage standard, which hitherto does not address rendering or style.

### 6.1.2 USE CASE #2 Feature Styling Set – External (UC2)

Feature styling is characterized by feature rendering heuristics or rules that depend on rendering context such as scale and feature conflict areas. Styling presentation consists of a styling set identifier (such as GeoSym V5), a Feature code (e.g. FACC<sup>4</sup>), and the feature geometry that serves as input to the feature styling rule.

- Feature Set Designation
- Feature Code
- Feature Geometry

Rendering rules for feature styling may contain guidance to support feature clustering and multiscale rendering or Level of Detail (LOD) management. LOD management includes selective rendering and deconfliction. Such capabilities require sophisticated rendering business rules and rendering context information that extends to the entire renderable footprint, and the scale of the rendering surface in order to satisfy specific rendering standard guidance. Examples include such as Geospatial Symbols for Digital Displays ([GeoSym](#)) that used feature geometry and feature codes to support sophisticated multiscale rendering.

Potential components of Feature Styles:

- GeoPackage Vectors with Style ID
  - Vector attributes specify a Style ID
  - Style ID refers to a Style “table” that contains
    - Line Style (Color, Width, Transparency, Dash, Miter, End, ...)  
information (i.e. Symbology Encoding Standard)
    - Fill Style (Pattern, Transparency)
  - Styles may be shared or feature unique
  - Style rules are identified by numeric or alphanumeric identifier

#### 6.1.2.1 UC2 Implications

The use of rendering rules, leveraging rendering context such as scale and feature deconfliction requires external business logical that is difficult to encode within a feature record in any practical manner. Even if the necessary drawing library files were carried as payload within GeoPackage file, the business rules required to handle rendering scale and context such as deconfliction would likely preclude any practical self-contained encoding.

There is historical precedent for Use Case #2. Systems supporting Vector Product Format (VPF) data using FACC and external GeoSym libraries have successfully addressed this use case. If the symbology library, the attribute rules were contained within GeoPackage extensions, UC2 would be achievable.

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<sup>4</sup> Feature Attribute Coding Catalog (FACC) – DIGEST Part 4, [https://www.dgiwg.org/digest/html/DIGEST\\_2-1\\_Part4.pdf](https://www.dgiwg.org/digest/html/DIGEST_2-1_Part4.pdf), Nov 2015

This use case could also support a self-contained, internal reference (see section 6.2.3).

## 6.2 Internal Symbol/Style References

Internal symbol/style references provide a linkage between a vector feature instance and a symbol/style map lookup stored within the GeoPackage, hereafter referred to as in *internal symbol reference*. Internal symbol references refer to resources that are entirely self-contained within the GeoPackage and Symbology Extensions.

Examples of internal references include the use of symbol tables containing sprites and SVG rendering instructions within a table that is distinct from the feature table containing geospatial position geometry.

### 6.2.1 USE CASE #3 Technical Symbology Set (UC3)

Technical symbologies are characterized by structured symbology lookup schemes that may or may not represent a hierarchical structure. Symbology presentation consists of a symbology set identifier (such as HSWG-2.0), a Symbol ID and a single control point that determines the position of the symbol.

- Symbology Set Designation
- Symbol ID
- Control Point Geometry
  - 1 Point

A symbol table consisting of relative position rendering instructions (e.g. PNG or SVG) added to the GeoPackage, using a feature table foreign key reference should be adequate to meet the requirements of UC3.

#### 6.2.1.1 UC3 Implications

The use of external technical symbology libraries introduces external dependencies, but does not necessarily eliminate self-contained symbology approaches. If the SVG symbol library files were carried as payload within GeoPackage file, and a simple lookup rule is applied, self-contained symbology encoding is possible.

Although open source symbol libraries such as Homeland Security Working Group Emergency Response Symbology exist, there is no universal agreement on resource identification, or symbol encoding format, although symbol libraries are often expressed as PNG image files, SVG files, or font files.

A GeoPackage extension would be required to encode the symbol set ID and symbol ID and associate a feature to a symbol ID.

The use of an external library eliminates implied or expressed responsibility of rendering consistency, placing this responsibility solely within the external symbol library. The use of external dependencies maintains the exchange-based model of the GeoPackage standard, which hitherto does not address rendering or style.

## 6.2.2 USE CASE #4 Geometry Styling (UC4)

Geometry styling is limited to the augmentation of simple feature rendering with line style modifiers such as line width, dash pattern, line color, line caps, and line miter properties. There has been extensive analysis of the geometry styling use cases, including sophisticated composition rules, as captured in the Symbology Encoding Standard. See TENET Report on the OGC Symbology Encoding Standard (OGC SE) [http://portal.opengeospatial.org/files/?artifact\\_id=29160](http://portal.opengeospatial.org/files/?artifact_id=29160).

### 6.2.2.1 UC4 Implications

Geometry styling requires compliant producers to add appropriate style extensions and compliant consumers to apply styling rules when rendering geometries.

The TENET report<sup>5</sup> enumerates several limitations of the OGC SE in portraying military Alternative Military Layers or AML, as well as hydrographic layers compliant with S-52. These limitations include the following.

- OGC SE does not adequately address complex line styles required to portray complex styles, as found in hydrographic layers, such as anchorage areas. The report notes that incorporation of standards such as SVG would address this problem.
- OGC SE does not support symbology ‘pivot points’, that is rotation of symbology about a reference hot spot positioned along an explicitly defined control point geometry.
- OGC SE does not support feature types that require multiple delineations. It is therefore impossible to define feature portrayals that differentiate between different delineations.
- OGC SE is insufficiently aligned to ISO19117, including:
  - PF\_FeaturePortrayal uses an attribute to identify the geometry delineation; FeatureTypeStyle does not explicitly support this concept.
  - ISO 19117 models portrayal mapping conditions such as scale, lighting and display medium using the interface PF\_Context attached to a higher level interface PF\_PortrayalMapping; SE supports scale conditions at the level of the FeatureTypeStyle element.
  - A PF\_PortrayalRule instance is associated with a single SR\_Symbol – a composition of other subordinate SR\_Symbols and leaf SR\_SymbolElements; whereas an SE Rule element may consist of multiple Symbolizers but these do not support the hierarchical structure of SR\_Symbol.

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<sup>5</sup> Some Unresolved Issues with the OGC Symbology Encoding (SE), 18 July 2008, [http://portal.opengeospatial.org/files/?artifact\\_id=29160](http://portal.opengeospatial.org/files/?artifact_id=29160)

### 6.2.3 USE CASE #5 Feature Type Styling – Internal (UC5)

Feature Type Styling is characterized by feature style lookup based upon a feature type identified in the feature attribute. This is similar to Use Case 2, but does not depend on external dependencies. Feature lookup is based upon a feature type or feature ID lookup, referenced to an internal feature resource (PNG or SVG). Rendering of the PNG or SVG resource is relatively straightforward.

Unlike UC2, rendering rules for feature type styling do not support feature clustering, multiscale rendering, or Level of Detail (LOD) management.

#### 6.2.3.1 UC5 Implications

To support self-contained UC2 symbology, GeoPackage extension(s) would be required to encode the attribute encoding rules, the symbol composition rules, and the symbology lookup rendering instructions. This would require a significant effort to extend the standard, and would require a significant commitment for producers and consumers of GeoPackage to properly support this extension. This would represent a significant departure from the ‘data exchange only’ approach that characterizes the current GeoPackage standard.

## 7. Next Steps

We propose the following next steps:

- Discuss this proposal in the broader community (outside the SWG itself) to reach a consensus on approach.
- Prioritize the use cases and pursue design and reference implementations of the viable use case(s).
- Establish a separate working group, coordinating with the GeoPackage SWG (composed of interested GeoPackage SWG members and other stakeholders)
- Analyze applicable informative references to apply towards defining a draft specification to address viable use cases identified.

## 8. Frequently Asked Questions

Q: Would Symbology Extension(s) to GeoPackage replace Joint Military Symbology (JMS) Standards (MILSTD-2525 or NATO APP 6)?

A: No. External symbol/style references would encode symbol IDs, modifiers and amplifying text using standards such as MIL-STD-2525 or NATO APP 6.

Q: Would Symbology Extension(s) to GeoPackage be limited to Military Symbology (JMS) Standards (MILSTD-2525 or NATO APP 6)?

A: No. External symbol/style references may refer to a broad spectrum of problem domains, to include weather, law enforcement, homeland security, and military applications. Any domain where symbolic or pictographic representation of spatially positioned objects is desired are applicable, as long as a suitable encoding of symbol ID references can be standardized and resolved as part of the extension specification.

Q: Would Symbology Extension(s) to GeoPackage contain the symbology rendering instructions, or just the minimum information necessary to present a symbolic representation of a feature, event, activity or movement?

A: This would depend on the need to support self-contained symbology (internal references) or leverage external resources and rendering mechanisms, such as symbol libraries.

External symbol references rely upon “well-known” symbology sets, with “well-known” symbol identifiers, symbol hierarchy, and “presentation modifiers” (text modifiers and graphic modifiers in MILSYM vernacular). Such symbology extensions require the encoding of the symbol set ID (e.g. MILSTD-2525B-CN1, APP-6A, HSWG-1.0, ...) in addition to instance-specific information such as symbol ID, modifiers, and text annotations.

Q: Would the resulting Symbology Encoding effort necessarily be limited to GeoPackage?

A: No. The GeoPackage community is highly motivated to address the symbology encoding question for GeoPackage, but any resulting symbology encoding specification would be applicable to a broad audience, and would not be necessarily limited to GeoPackage.

Q: Would the resulting Symbology Encoding effort necessarily be limited to Simple Features geometries?

A: No. There is sufficient justification to create style definition mechanism that are extensible to more complex features, as described in the NVG specification, or 3D placemarks as expressed in the OGC KML standard<sup>6</sup>.

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<sup>6</sup> It is important to understand that KML does NOT encode geospatial feature data. KML encodes geospatial geometry portrayal instructions. KML encodes rendering instructions, not feature exchange data.