                    Relative Location Representation

Abstract

   This document defines an extension to the Presence Information Data
   Format Location Object (PIDF-LO) (RFC 4119) for the expression of
   location information that is defined relative to a reference point.
   The reference point may be expressed as a geodetic or civic location,
   and the relative offset may be one of several shapes. An alternative
   binary representation is described.

   Optionally, a reference to a secondary document (such as a map image)
   can be included, along with the relationship of the map coordinate
   system to the reference/offset coordinate system, to allow display of
   the map with the reference point and the relative offset.

Status of This Memo

   This is an Internet Standards Track document.

   This document is a product of the Internet Engineering Task Force
   (IETF). It represents the consensus of the IETF community. It has
   received public review and has been approved for publication by the
   Internet Engineering Steering Group (IESG). Further information on
   Internet Standards is available in Section 2 of RFC 5741.

   Information about the current status of this document, any errata,
   and how to provide feedback on it may be obtained at
   http://www.rfc-editor.org/info/rfc7035.

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1. Introduction

   This document describes a format for the expression of relative
   location information.

   A relative location is formed of a reference location plus a relative
   offset from that reference location. The reference location can be
   represented in either civic or geodetic form. The reference location
   can also have dynamic components such as velocity. The relative
   offset is specified in meters using a Cartesian coordinate system.

   In addition to the relative location, an optional URI can be provided
   to a document that contains a map, floor plan, or other spatially
   oriented information. Applications could use this information to
   display the relative location. Additional fields allow the map to be
   oriented and scaled correctly.

   Two formats are included: an XML form that is intended for use in
   PIDF-LO [RFC4119] and a TLV format for use in other protocols such as
   those that already convey binary representation of location
   information defined in [RFC4776].

2. Conventions Used in This Document

   The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT",
   "SHOULD", "SHOULD NOT", "RECOMMENDED", "MAY", and "OPTIONAL" in this
   document are to be interpreted as described in [RFC2119].

3. Overview

   This document describes an extension to PIDF-LO [RFC4119] as updated
   by [RFC5139] and [RFC5491], to allow the expression of a location as
   an offset relative to a reference.

```
                        Reference
                        Location
                           o
                            \
                             \ Offset
                              \
                             _\|
                               x
                            Relative
                            Location
```

   This extension allows the creator of a location object to include two
   location values plus an offset. The two location values, named
   "baseline" and "reference", combine to form the origin of the offset.

The final, relative location is described relative to this reference
point.

```
                      ..--"""--..
                   .-'           `-.
                 ,'                 `.
               / Reference            \
              /        o               \
              |          \             |
              |           \            |
              |            \           |
              \          _\|          /
               `.          x        .'  \_ Baseline
                 `._   Relative  _.'       Location
                    `--..___..--'
```

The baseline location is included outside of the <relative-location>
element. The baseline location is visible to a client that does not
understand relative location (i.e., it ignores the
<relative-location> element).

A client that does understand relative location will interpret the
location within the relative element as a refinement of the baseline
location. This document defines both a reference location, which
serves as a refinement of the baseline location and the starting
point, and an offset, which describes the location of the Target
based on this starting point.

Creators of location objects with relative location thus have a
choice of how much information to put into the baseline location and
how much to put into the reference location. For example, the
baseline location value could be precise enough to specify a building
that contains the relative location, and the reference location could
specify a point within the building from which the offset is
measured.

Location objects SHOULD NOT have all location information in the
baseline location. Doing this would cause clients that do not
understand relative location to incorrectly interpret the baseline
location (i.e., the reference point) as the actual, precise location
of the client. The baseline location is intended to carry a location
that encompasses both the reference location and the relative
location (i.e., the reference location plus offset).

It is possible to provide a valid relative location with no
information in the baseline. However, this provides recipients who
do not understand relative location with no information. A baseline
location SHOULD include sufficient information to encompass both the

reference and relative locations while providing a baseline that is
as accurate as possible.

Both the baseline and the reference location are defined as either a
geodetic location [OGC.GeoShape] or a civic address [RFC4776]. If
the baseline location was expressed as a geodetic location, the
reference MUST be geodetic. If the baseline location was expressed
as a civic address, the reference MUST be civic.

Baseline and reference locations MAY also include dynamic location
information [RFC5962].

The relative location can be expressed using a point (2- or
3-dimensional) or a shape that includes uncertainty: circle, sphere,
ellipse, ellipsoid, polygon, prism, or arc-band. Descriptions of
these shapes can be found in [RFC5491].

Optionally, a reference to a 'map' document can be provided. The
reference is a URI [RFC3986]. The document could be an image or
dataset that represents a map, floor plan, or other form. The type
of document the URI points to is described as a MIME media type
[RFC2046]. Metadata in the relative location can include the
location of the reference point in the map as well as an orientation
(angle from North) and scale to align the document Coordinate
Reference System (CRS) with the World Geodetic System 1984 (WGS84)
[WGS84] CRS. The document is assumed to be usable by the application
receiving the PIDF with the relative location to locate the reference
point in the map. This document does not describe any mechanisms for
displaying or manipulating the document other than providing the
reference location, orientation, and scale.

As an example, consider a relative location expressed as a point,
relative to a civic location:

```
<presence xmlns="urn:ietf:params:xml:ns:pidf"
          xmlns:dm="urn:ietf:params:xml:ns:pidf:data-model"
          xmlns:gp="urn:ietf:params:xml:ns:pidf:geopriv10"
          xmlns:ca="urn:ietf:params:xml:ns:pidf:geopriv10:civicAddr"
          xmlns:rel="urn:ietf:params:xml:ns:pidf:geopriv10:relative"
          xmlns:gml="http://www.opengis.net/gml"
          xmlns:gs="http://www.opengis.net/pidflo/1.0"
          entity="pres:relative@example.com">
  <dm:device id="relative1">
    <gp:geopriv>
      <gp:location-info>
        <ca:civicAddress xml:lang="en-AU">
          <ca:country>AU</ca:country>
          <ca:A1>NSW</ca:A1>
```

```
              <ca:A3>Wollongong</ca:A3>
              <ca:A4>North Wollongong</ca:A4>
              <ca:RD>Flinders</ca:RD>
              <ca:STS>Street</ca:STS>
              <ca:HNO>123</ca:HNO>
            </ca:civicAddress>
            <rel:relative-location>
              <rel:reference>
                <ca:civicAddress xml:lang="en-AU">
                  <ca:LMK>Front Door</ca:LMK>
                </ca:civicAddress>
              </rel:reference>
              <rel:offset>
                <gml:Point xmlns:gml="http://www.opengis.net/gml"
                           srsName="urn:ietf:params:geopriv:relative:2d">
                  <gml:pos>100 50</gml:pos>
                </gml:Point>
              </rel:offset>
            </rel:relative-location>
          </gp:location-info>
          <gp:usage-rules/>
          <gp:method>GPS</gp:method>
          <rel:map>
            <rel:url type="image/png">
               http://example.com/location/map.png
            </rel:url>
            <rel:offset>20. 120.</rel:offset>
            <rel:orientation>29.</rel:orientation>
            <rel:scale>20. -20.</rel:scale>
          </rel:map>
        </gp:geopriv>
        <dm:deviceID>mac:1234567890ab</dm:deviceID>
        <dm:timestamp>2007-06-22T20:57:29Z</dm:timestamp>
      </dm:device>
    </presence>
```

4. Relative Location

   Relative location is a shape (e.g., point, circle, ellipse). The
   shape is defined with a CRS that has a datum defined as the reference
   (which appears as a civic address or geodetic location in the tuple)
   and the shape coordinates as meter offsets North/East of the datum
   measured in meters (with an optional Z offset relative to datum
   altitude). An optional angle allows the reference CRS be to rotated
   with respect to North.

4.1. Relative Coordinate System

   The relative coordinate reference system uses a coordinate system
   with two or three axes.

   The baseline and reference locations are used to define a relative
   datum. The reference location defines the origin of the coordinate
   system. The centroid of the reference location is used when the
   reference location contains any uncertainty.

   The axes in this coordinate system are originally oriented based on
   the directions of East, North, and Up from the reference location:
   the first (x) axis increases to the East, the second (y) axis points
   North, and the optional third (z) axis points Up. All axes of the
   coordinate system use meters as a basic unit.

   Any coordinates in the relative shapes use the described Cartesian
   coordinate system. In the XML form, this uses a URN of
   "urn:ietf:params:geopriv:relative:2d" for two-dimensional shapes and
   "urn:ietf:params:geopriv:relative:3d" for three-dimensional shapes.
   The binary form uses different shape type identifiers for 2D and 3D
   shapes.

   Dynamic location information [RFC5962] in the baseline or reference
   location alters the relative coordinate system. The resulting
   Cartesian coordinate system axes are rotated so that the y axis is
   oriented along the direction described by the <orientation> element.
   The coordinate system also moves as described by the <speed> and
   <heading> elements.

   The single timestamp included in the tuple (or equivalent) element
   applies to all location elements, including all three components of a
   relative location: baseline, reference, and relative. This is
   particularly important when there are dynamic components to these
   items. A location generator is responsible for ensuring the
   consistency of these fields.

4.2. Placement of XML Elements

   The baseline of the reference location is represented as
   <location-info> like a normal PIDF-LO. Relative location adds a new
   <relative-location> element to <location-info>. Within
   <relative-location>, <reference> and <offset> elements are described.
   Within <offset> are the shape elements described below. This
   document extends PIDF-LO as described in [RFC6848].

4.3. Binary Format

   This document describes a way to encode the relative location in a
   binary TLV form for use in other protocols that use TLVs to represent
   location.

   A type-length-value encoding is used.

```
         +------+------+------+------+------+------+------+
         | Type |Length|  Value                     ...
         +------+------+------+------+------+------+------+
         |  T   |  N   |  Value                     ...
         +------+------+------+------+------+------+------+
```

                     Figure 1: TLV Tuple Format

   The Type field (T) is an 8-bit unsigned integer. The type codes used
   are registered in an IANA-managed "Relative Location Parameters"
   registry defined by this document and restricted to not include the
   values defined by the "Civic Address Types (CAtypes)" registry. This
   restriction permits a location reference and offset to be coded
   within the same object without type collisions.

   The Length field (N) is defined as an 8-bit unsigned integer. This
   field can encode values from 0 to 255. The length field describes
   the number of bytes in the Value. Length does not count the bytes
   used for the Type or Length.

   The Value field is defined separately for each type.

   Each element of the relative location has a unique TLV assignment. A
   relative location encoded in TLV form includes both baseline and
   reference location TLVs and relative location TLVs. The reference
   TLVs are followed by the relative offset and optional map TLVs
   described in this document.

4.4. Distances and Angles

   All distance measures used in shapes are expressed in meters.

   All orientation angles used in shapes are expressed in degrees.
   Orientation angles are measured from WGS84 Northing to Easting with
   zero at Northing. Orientation angles in the relative coordinate
   system start from the second coordinate axis (y or Northing) and
   increase toward the first axis (x or Easting).

4.5. Value Encoding

   The binary form uses single-precision floating-point values
   [IEEE.754] to represent coordinates, distance, and angle measures.
   Single-precision values are 32-bit values with a sign bit, 8 exponent
   bits, and 23 fractional bits. This uses the interchange format
   defined in [IEEE.754] and Section 3.6 of [RFC1014], that is: sign,
   biased exponent and significand, with the most significant bit first.

   Binary-encoded coordinate values are considered to be a single value
   without uncertainty. When encoding a value that cannot be exactly
   represented, the best approximation MUST be selected according to
   [Clinger1990].

4.6. Relative Location Restrictions

   More than one relative shape MUST NOT be included in either a PIDF-LO
   or TLV encoding of location for a given reference point.

   Any error in the reference point transfers to the location described
   by the relative location. Any errors arising from an implementation
   not supporting or understanding elements of the reference point
   directly increases the error (or uncertainty) in the resulting
   location.

4.7. Baseline TLVs

   Baseline locations are described using the formats defined in
   [RFC4776] or [RFC6225].

4.8. Reference TLVs

   When a reference is encoded in binary form, the baseline and
   reference locations are combined in a reference TLV. This TLV is
   identified with the code 111 and contains civic address TLVs (if the
   baseline was a civic) or geo TLVs (if the baseline was a geo).

```
          +------+------+------+------+------+------+
          | 111  |Length|  Reference TLVs          |
          +------+------+------+------+------+------+
```

                     Figure 2: Reference TLV

4.9. Shapes

   Shape data is used to represent regions of uncertainty for the
   reference and relative locations. Shape data in the reference
   location uses a WGS84 [WGS84] CRS. Shape data in the relative
   location uses a relative CRS.

   The XML form for shapes uses Geography Markup Language (GML)
   [OGC.GML-3.1.1], consistent with the rules in [RFC5491]. Reference
   locations use the CRS URNs specified in [RFC5491]; relative locations
   use either a 2D CRS ("urn:ietf:params:geopriv:relative:2d") or a 3D
   ("urn:ietf:params:geopriv:relative:3d"), depending on the shape type.

   The binary form of each shape uses a different shape type for 2D and
   3D shapes.

   Nine shape type codes are defined.

4.9.1. Point

   A point "shape" describes a single point with unknown uncertainty.
   It consists of a single set of coordinates.

   In a two-dimensional CRS, the coordinate includes two values; in a
   three-dimensional CRS, the coordinate includes three values.

4.9.1.1. XML Encoding

   A point is represented in GML using the following template:

   <gml:Point xmlns:gml="http://www.opengis.net/gml"
              srsName="$CRS-URN$">
     <gml:pos>$Coordinate-1 $Coordinate-2$ $Coordinate-3$</gml:pos>
   </gml:Point>

                       Figure 3: GML Point Template

   Where "$CRS-URN$" is replaced by a
   "urn:ietf:params:geopriv:relative:2d" or
   "urn:ietf:params:geopriv:relative:3d" and "$Coordinate-3$" is omitted
   if the CRS is two-dimensional.

4.9.1.2. TLV Encoding

   The point shape is introduced by a TLV of 113 for a 2D point and 114
   for a 3D point.

```
                 +------+------+
                 | 113/4|Length|
                 +------+------+------+------+
                 |  Coordinate-1          |
                 +------+------+------+------+
                 |  Coordinate-2          |
                 +------+------+------+------+
                 |  (3D-only) Coordinate-3   |
                 +------+------+------+------+
```

                    Figure 4: Point Encoding

4.9.2. Circle or Sphere Shape

   A circle or sphere describes a single point with a single uncertainty
   value in meters.

   In a two-dimensional CRS, the coordinate includes two values, and the
   resulting shape forms a circle. In a three-dimensional CRS, the
   coordinate includes three values, and the resulting shape forms a
   sphere.

4.9.2.1. XML Encoding

   A circle is represented in and converted from GML using the following
   template:

```
   <gs:Circle xmlns:gml="http://www.opengis.net/gml"
            xmlns:gs="http://www.opengis.net/pidflo/1.0"
            srsName="urn:ietf:params:geopriv:relative:2d">
     <gml:pos>$Coordinate-1 $Coordinate-2$</gml:pos>
     <gs:radius uom="urn:ogc:def:uom:EPSG::9001">
       $Radius$
     </gs:radius>
   </gs:Circle>
```

                    Figure 5: GML Circle Template

A sphere is represented in and converted from GML using the following
template:

```
<gs:Sphere xmlns:gml="http://www.opengis.net/gml"
           xmlns:gs="http://www.opengis.net/pidflo/1.0"
           srsName="urn:ietf:params:geopriv:relative:3d">
  <gml:pos>$Coordinate-1 $Coordinate-2$ $Coordinate-3$</gml:pos>
  <gs:radius uom="urn:ogc:def:uom:EPSG::9001">
    $Radius$
  </gs:radius>
</gs:Sphere>
```

                    Figure 6: GML Sphere Template

4.9.2.2. TLV Encoding

   A circular shape is introduced by a type code of 115. A spherical
   shape is introduced by a type code of 116.

```
                    +------+------+
                    | 115/6|Length|
                    +------+------+------+------+
                    |  Coordinate-1          |
                    +------+------+------+------+
                    |  Coordinate-2          |
                    +------+------+------+------+
                    |  (3D-only) Coordinate-3   |
                    +------+------+------+------+
                    |  Radius                |
                    +------+------+------+------+
```

                 Figure 7: Circle or Sphere Encoding

4.9.3. Ellipse or Ellipsoid Shape

   An ellipse or ellipsoid describes a point with an elliptical or
   ellipsoidal uncertainty region.

   In a two-dimensional CRS, the coordinate includes two values plus a
   semi-major axis, a semi-minor axis, a semi-major axis orientation
   (clockwise from North). In a three-dimensional CRS, the coordinate
   includes three values, and in addition to the two-dimensional values,
   an altitude uncertainty (semi-vertical) is added.

4.9.3.1. XML Encoding

   An ellipse is represented in and converted from GML using the
   following template:

```
<gs:Ellipse xmlns:gml="http://www.opengis.net/gml"
            xmlns:gs="http://www.opengis.net/pidflo/1.0"
            srsName="urn:ietf:params:geopriv:relative:2d">
  <gml:pos>$Coordinate-1 $Coordinate-2$</gml:pos>
  <gs:semiMajorAxis uom="urn:ogc:def:uom:EPSG::9001">
    $Semi-Major$
  </gs:semiMajorAxis>
  <gs:semiMinorAxis uom="urn:ogc:def:uom:EPSG::9001">
    $Semi-Minor$
  </gs:semiMinorAxis>
  <gs:orientation uom="urn:ogc:def:uom:EPSG::9102">
    $Orientation$
  </gs:orientation>
</gs:Ellipse>
```

                      Figure 8: GML Ellipse Template

   An ellipsoid is represented in and converted from GML using the
   following template:

```
<gs:Ellipsoid xmlns:gml="http://www.opengis.net/gml"
              xmlns:gs="http://www.opengis.net/pidflo/1.0"
              srsName="urn:ietf:params:geopriv:relative:3d">
  <gml:pos>$Coordinate-1 $Coordinate-2$ $Coordinate-3$</gml:pos>
  <gs:semiMajorAxis uom="urn:ogc:def:uom:EPSG::9001">
    $Semi-Major$
  </gs:semiMajorAxis>
  <gs:semiMinorAxis uom="urn:ogc:def:uom:EPSG::9001">
    $Semi-Minor$
  </gs:semiMinorAxis>
  <gs:verticalAxis uom="urn:ogc:def:uom:EPSG::9001">
    $Semi-Vertical$
  </gs:verticalAxis>
  <gs:orientation uom="urn:ogc:def:uom:EPSG::9102">
    $Orientation$
  </gs:orientation>
</gs:Ellipsoid>
```

                     Figure 9: GML Ellipsoid Template

4.9.3.2. TLV Encoding

   An ellipse is introduced by a type code of 117, and an ellipsoid is
   introduced by a type code of 118.

```
        +------+------+
        | 117/8|Length|
        +------+------+------+------+
        |  Coordinate-1          |
        +------+------+------+------+
        |  Coordinate-2          |
        +------+------+------+------+
        |  (3D-only) Coordinate-3   |
        +------+------+------+------+------+------+------+------+
        |  Semi-Major Axis       |  Semi-Minor Axis          |
        +------+------+------+------+------+------+------+------+
        |  Orientation           |  (3D) Semi-Vertical Axis  |
        +------+------+------+------+------+------+------+------+
```

                  Figure 10: Ellipse or Ellipsoid Encoding

4.9.4. Polygon or Prism Shape

   A polygon or prism includes a number of points that describe the
   outer boundary of an uncertainty region. A prism also includes an
   altitude for each point and prism height.

   At least 3 points MUST be included in a polygon. In order to
   interoperate with existing systems, an encoding SHOULD include 15 or
   fewer points, unless the recipient is known to support larger
   numbers.

4.9.4.1. XML Encoding

   A polygon is represented in and converted from GML using the
   following template:

```
<gml:Polygon xmlns:gml="http://www.opengis.net/gml"
             srsName="urn:ietf:params:geopriv:relative:2d">
  <gml:exterior>
    <gml:LinearRing>
      <gml:posList>
        $Coordinate1-1$ $Coordinate1-2$
        $Coordinate2-1$ $Coordinate2-2$
        $Coordinate3-1$ ...
        ...
        $CoordinateN-1$ $CoordinateN-2$
        $Coordinate1-1$ $Coordinate1-2$
      </gml:posList>
    </gml:LinearRing>
  </gml:exterior>
</gml:Polygon>
```

                    Figure 11: GML Polygon Template

   Alternatively, a series of <pos> elements can be used in place of the
   single "posList". Each <pos> element contains two or three
   coordinate values.

   Note that the first point is repeated at the end of the sequence of
   coordinates and no explicit count of the number of points is
   provided.

   A GML polygon that includes altitude cannot be represented perfectly
   in TLV form. When converting to the binary representation, a two-
   dimensional CRS is used, and altitude is removed from each
   coordinate.

A prism is represented in and converted from GML using the following
template:

```
<gs:Prism xmlns:gml="http://www.opengis.net/gml"
          xmlns:gs="http://www.opengis.net/pidflo/1.0"
          srsName="urn:ietf:params:geopriv:relative:3d">
  <gs:base>
    <gml:Polygon>
      <gml:exterior>
        <gml:LinearRing>
          <gml:posList>
            $Coordinate1-1$ $Coordinate1-2$ $Coordinate1-3$
            $Coordinate2-1$ $Coordinate2-2$ $Coordinate2-3$
            $Coordinate2-1$ ... ...
            ...
            $CoordinateN-1$ $CoordinateN-2$ $CoordinateN-3$
            $Coordinate1-1$ $Coordinate1-2$ $Coordinate1-3$
          </gml:posList>
        </gml:LinearRing>
      </gml:exterior>
    </gml:Polygon>
  </gs:base>
  <gs:height uom="urn:ogc:def:uom:EPSG::9001">
    $Height$
  </gs:height>
</gs:Prism>
```

                    Figure 12: GML Prism Template

Alternatively, a series of <pos> elements can be used in place of the
single "posList". Each <pos> element contains three coordinate
values.

4.9.4.2. TLV Encoding

   A polygon containing 2D points uses a type code of 119. A polygon
   with 3D points uses a type code of 120. A prism uses a type code of
   121. The number of points can be inferred from the length of the
   TLV.

```
                    +------+------+
                    |119-21|Length|
                    +------+------+------+------+
                    |  (3D-only) Height        |
                    +------+------+------+------+
                    |  Coordinate1-1           |
                    +------+------+------+------+
                    |  Coordinate1-2           |
                    +------+------+------+------+
                    |  (3D-only) Coordinate1-3 |
                    +------+------+------+------+
                    |  Coordinate2-1           |
                    +------+------+------+------+
                     ...
                    +------+------+------+------+
                    |  CoordinateN-1           |
                    +------+------+------+------+
                    |  CoordinateN-2           |
                    +------+------+------+------+
                    |  (3D-only) CoordinateN-3 |
                    +------+------+------+------+
```

                  Figure 13: Polygon or Prism Encoding

   Note that unlike the polygon representation in GML, the first and
   last points are not the same point in the TLV representation. The
   duplicated point is removed from the binary form.

4.9.5. Arc-Band Shape

   An arc-band describes a region constrained by a range of angles and
   distances from a predetermined point. This shape can only be
   provided for a two-dimensional CRS.

   Distance and angular measures are defined in meters and degrees,
   respectively. Both are encoded as single-precision floating-point
   values.

4.9.5.1. XML Encoding

   An arc-band is represented in and converted from GML using the
   following template:

```
<gs:ArcBand xmlns:gml="http://www.opengis.net/gml"
            xmlns:gs="http://www.opengis.net/pidflo/1.0"
            srsName="urn:ietf:params:geopriv:relative:2d">
  <gml:pos>$Coordinate-1$ $Coordinate-2$</gml:pos>
  <gs:innerRadius uom="urn:ogc:def:uom:EPSG::9001">
    $Inner-Radius$
  </gs:innerRadius>
  <gs:outerRadius uom="urn:ogc:def:uom:EPSG::9001">
    $Outer-Radius$
  </gs:outerRadius>
  <gs:startAngle uom="urn:ogc:def:uom:EPSG::9102">
   $Start-Angle$
  </gs:startAngle>
  <gs:openingAngle uom="urn:ogc:def:uom:EPSG::9102">
    $Opening-Angle$
  </gs:openingAngle>
</gs:ArcBand>
```

                    Figure 14: GML Arc-Band Template

4.9.5.2. TLV Encoding

   An arc-band is introduced by a type code of 122.

```
      +------+------+
      | 122  |Length|
      +------+------+------+------+
      | Coordinate         |
      +------+------+------+------+
      | Coordinate         |
      +------+------+------+------+------+------+------+------+
      |  Inner Radius      |  Outer Radius             |
      +------+------+------+------+------+------+------+------+
      |  Start Angle       |  Opening Angle            |
      +------+------+------+------+------+------+------+------+
```
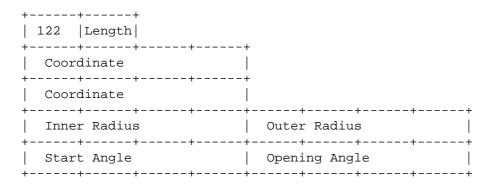
                    Figure 15: Arc-Band Encoding

4.10. Dynamic Location TLVs

   Dynamic location elements use the definitions in [RFC5962].

4.10.1. Orientation

   The orientation of the Target is described using one or two angles.
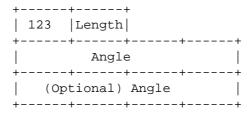   Orientation uses a type code of 123.

```
               +------+------+
               | 123  |Length|
               +------+------+------+------+
               |          Angle          |
               +------+------+------+------+
               |   (Optional) Angle      |
               +------+------+------+------+
```

                  Figure 16: Dynamic Orientation TLVs

4.10.2. Speed

   The speed of the Target is a scalar value in meters per second.
   Speed uses a type code of 124.

```
               +------+------+
               | 124  |Length|
               +------+------+------+------+
               |          Speed          |
               +------+------+------+------+
```

                     Figure 17: Dynamic Speed TLVs

4.10.3. Heading

   The heading, or direction of travel, is described using one or two
   angles. Heading uses a type code of 125.

```
               +------+------+
               | 125  |Length|
               +------+------+------+------+
               |          Angle          |
               +------+------+------+------+
               |   (Optional) Angle      |
               +------+------+------+------+
```

                    Figure 18: Dynamic Heading TLVs

4.11. Secondary Map Metadata

   The optional "map" URL can be used to provide a user of relative
   location with a visual reference for the location information. This
   document does not describe how the recipient uses the map nor how it
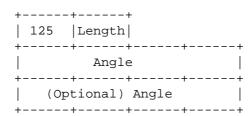   locates the reference or offset within the map. Maps can be simple
   images, vector files, 2D or 3D geospatial databases, or any other
   form of representation understood by both the sender and recipient.

4.11.1. Map URL

   In XML, the map is a <map> element defined within <relative-location>
   and contains the URL. The URL is encoded as a UTF-8-encoded string.
   An "http:" [RFC2616] or "https:" [RFC2818] URL MUST be used unless
   the entity creating the PIDF-LO is able to ensure that authorized
   recipients of this data are able to use other URI schemes. A "type"
   attribute MUST be present and specifies the kind of map the URL
   points to. Map types are specified as MIME media types as recorded
   in the IANA Media Types registry, for example, <map type="image/png">
   https://www.example.com/floorplans/123South/floor-2</map>.

   In binary, the map type is a separate TLV from the map URL. The
   media type uses a type code of 126; the URL uses a type code of 127.

```
        +------+------+------+------+------+------+------+
        | 126 |Length|   Map Media Type           ...
        +------+------+------+------+------+------+------+
        | 127 |Length|   Map Image URL            ...
        +------+------+------+------+------+------+------+
```

                       Figure 19: Map URL TLVs

   Note that the binary form restricts data to 255 octets. This
   restriction could be problematic for URLs in particular.
   Applications that use the XML form, but cannot guarantee that a
   binary form won't be used, are encouraged to limit the size of the
   URL to fit within this restriction.

4.11.2. Map Coordinate Reference System

   The CRS used by the map depends on the type of map. For example, a
   map described by a 3-D geometric model of the building may contain a
   complete CRS description in it. For some kinds of maps, typically
   described as images, the CRS used within the map must define the
   following:

   o The CRS origin

   o The CRS axes used and their orientation

   o The unit of measure used

   This document provides elements that allow for a mapping between the
   local coordinate reference system used for the relative location and
   the coordinate reference system used for the map where they are not
   the same.

4.11.2.1. Map Reference Point Offset

   This optional element identifies the coordinates of the reference
   point as it appears in the map. This value is measured in a map-
   type-dependent manner, using the coordinate system of the map.

   For image maps, coordinates start from the upper left corner, and
   coordinates are first counted by column with positive values to the
   right; then, rows are counted with positive values toward the bottom
   of the image. For such an image, the first item is columns, the
   second rows, and any third value applies to any third dimension used
   in the image coordinate space.

   The <offset> element contains 2 (or 3) coordinates similar to a GML
   <pos>. For example:

     <offset> 2670.0 1124.0 1022.0</offset>

   The map reference point uses a type code of 129.

```
                    +------+------+
                    | 129  |Length|
                    +------+------+------+------+
                    |  Coordinate-1            |
                    +------+------+------+------+
                    |  Coordinate-2            |
                    +------+------+------+------+
                    |  (3D-only) Coordinate-3  |
                    +------+------+------+------+
```
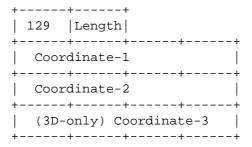
              Figure 20: Map Reference Point Coordinates TLV

   If omitted, a value containing all zeros is assumed. If the
   coordinates provided contain fewer values than are needed, the first
   value from the set is applied in place of any absent values. Thus,
   if a single value is provided, that value is used for Coordinate-2

and Coordinate-3 (if required). If two values are provided and three
are required, the value of Coordinate-1 is used in place of
Coordinate-3.

4.11.2.2. Map Orientation

The map orientation includes the orientation of the map direction in
relation to the Earth. Map orientation is expressed relative to the
orientation of the relative coordinate system. This means that map
orientation with respect to WGS84 North is the sum of the orientation
field and any orientation included in a dynamic portion of the
reference location. Both values default to zero if no value is
specified.

This type uses a single-precision floating-point value of degrees
relative to North.

In XML, the <orientation> element contains a single floating-point
value, for example, <orientation>67.00</orientation>. In TLV form,
map orientation uses the code 130:

```
+------+------+------+------+------+------+
| 130  |Length|  Angle                   |
+------+------+------+------+------+------+
```

Figure 21: Map Orientation TLV

4.11.2.3. Map Scale

The optional map scale describes the relationship between the units
of measure used in the map, relative to the meters unit used in the
relative coordinate system.

This type uses a sequence of IEEE 754 [IEEE.754] single-precision
floating-point values to represent scale as a sequence of numeric
values. The units of these values are dependent on the type of map
and could, for example, be pixels per meter for an image.

A scaling factor is provided for each axis in the coordinate system.
For a two-dimensional coordinate system, two values are included to
allow for different scaling along the x and y axes independently.
For a three-dimensional coordinate system, three values are specified
for the x, y, and z axes. Decoders can determine the number of
scaling factors by examining the length field.

Alternatively, a single scaling value MAY be used to apply the same
scaling factor to all coordinate components.

   Images that use a rows/columns coordinate system often use a left-
   handed coordinate system. A negative value for the y/rows axis
   scaling value can be used to account for any change in direction
   between the y axis used in the relative coordinate system and the
   rows axis of the image coordinate system.

   In XML, the <scale> element MAY contain a single scale value or MAY
   contain 2 (or 3) values in XML list form. In TLV form, scale uses a
   type code of 131. The length of the TLV determines how many scale
   values are present:

```
             +------+------+------+------+------+------+
             | 131 |Length|  Scale(s)            ...
             +------+------+------+------+------+------+
```

                      Figure 22: Map Scale TLV

4.11.3. Map Example

   An example of expressing a map is:

```
       <rel:map>
         <rel:url type="image/jpeg">
           http://example.com/map.jpg
         </rel:url>
         <rel:offset>200 210</rel:offset>
         <rel:orientation>68</rel:orientation>
         <rel:scale>2.90 -2.90</rel:scale>
       </rel:map>
```

                      Figure 23: Map Example

5. Examples

   The examples in this section combine elements from [RFC3863],
   [RFC4119], [RFC4479], [RFC5139], and [OGC.GeoShape].

5.1. Civic PIDF with Polygon Offset

```
   <presence xmlns="urn:ietf:params:xml:ns:pidf"
           xmlns:dm="urn:ietf:params:xml:ns:pidf:data-model"
           xmlns:gp="urn:ietf:params:xml:ns:pidf:geopriv10"
           xmlns:ca="urn:ietf:params:xml:ns:pidf:geopriv10:civicAddr"
           xmlns:rel="urn:ietf:params:xml:ns:pidf:geopriv10:relative"
           xmlns:gml="http://www.opengis.net/gml"
           xmlns:gs="http://www.opengis.net/pidflo/1.0"
           entity="pres:ness@example.com">
     <dm:device id="nesspc-1">
```

```
    <gp:geopriv>
      <gp:location-info>
        <ca:civicAddress xml:lang="en-AU">
          <ca:country>AU</ca:country>
          <ca:A1>NSW</ca:A1>
          <ca:A3>Wollongong</ca:A3>
          <ca:A4>North Wollongong</ca:A4>
          <ca:RD>Flinders</ca:RD>
          <ca:STS>Street</ca:STS>
          <ca:HNO>123</ca:HNO>
        </ca:civicAddress>
        <rel:relative-location>
          <rel:reference>
            <ca:civicAddress xml:lang="en-AU">
              <ca:LMK>Front Door</ca:LMK>
              <ca:BLD>A</ca:BLD>
              <ca:FLR>I</ca:FLR>
              <ca:ROOM>113</ca:ROOM>
            </ca:civicAddress>
          </rel:reference>
          <rel:offset>
            <gml:Polygon xmlns:gml="http://www.opengis.net/gml"
                 srsName="urn:ietf:params:geopriv:relative:2d">
              <gml:exterior>
                <gml:LinearRing>
                  <gml:pos>433.0 -734.0</gml:pos> <!--A-->
                  <gml:pos>431.0 -733.0</gml:pos> <!--F-->
                  <gml:pos>431.0 -732.0</gml:pos> <!--E-->
                  <gml:pos>433.0 -731.0</gml:pos> <!--D-->
                  <gml:pos>434.0 -732.0</gml:pos> <!--C-->
                  <gml:pos>434.0 -733.0</gml:pos> <!--B-->
                  <gml:pos>433.0 -734.0</gml:pos> <!--A-->
                </gml:LinearRing>
              </gml:exterior>
            </gml:Polygon>
          </rel:offset>
        </rel:relative-location>
      </gp:location-info>
     <gp:usage-rules/>
      <gp:method>GPS</gp:method>
    </gp:geopriv>
    <dm:deviceID>mac:1234567890ab</dm:deviceID>
    <dm:timestamp>2007-06-22T20:57:29Z</dm:timestamp>
  </dm:device>
</presence>
```

5.2. Geo PIDF with Circle Offset

```
<?xml version="1.0" encoding="UTF-8"?>
   <presence xmlns="urn:ietf:params:xml:ns:pidf"
         xmlns:dm="urn:ietf:params:xml:ns:pidf:data-model"
         xmlns:gp="urn:ietf:params:xml:ns:pidf:geopriv10"
         xmlns:rel="urn:ietf:params:xml:ns:pidf:geopriv10:relative"
         xmlns:gml="http://www.opengis.net/gml"
         xmlns:gs="http://www.opengis.net/pidflo/1.0"
         entity="pres:point2d@example.com">
      <dm:device id="point2d">
        <gp:geopriv>
          <gp:location-info>
            <gs:Circle srsName="urn:ogc:def:crs:EPSG::4326">
              <gml:pos>-34.407 150.883</gml:pos>
              <gs:radius uom="urn:ogc:def:uom:EPSG::9001">
                    50.0
              </gs:radius>
            </gs:Circle>
            <rel:relative-location>
              <rel:reference>
                <gml:Point srsName="urn:ogc:def:crs:EPSG::4326">
                  <gml:pos>-34.407 150.883</gml:pos>
                </gml:Point>
              </rel:reference>
              <rel:offset>
                <gs:Circle xmlns:gml="http://www.opengis.net/gml"
                      srsName="urn:ietf:params:geopriv:relative:2d">
                    <gml:pos>500.0 750.0</gml:pos>
                    <gs:radius uom="urn:ogc:def:uom:EPSG::9001">
                      5.0
                     </gs:radius>
                </gs:Circle>
              </rel:offset>
              <rel:map>
                 <rel:url type="image/png">
                   https://www.example.com/flrpln/123South/flr-2
                 </rel:url>
                 <rel:offset>2670.0 1124.0 1022.0</rel:offset>
                 <rel:orientation>67.00</rel:orientation>
                 <rel:scale>10 -10</rel:scale>
              </rel:map>
            </rel:relative-location>
          </gp:location-info>
          <gp:usage-rules/>
          <gp:method>Wiremap</gp:method>
        </gp:geopriv>
        <dm:deviceID>mac:1234567890ab</dm:deviceID>
```

```
      <dm:timestamp>2007-06-22T20:57:29Z</dm:timestamp>
    </dm:device>
  </presence>
```

5.3. Civic TLV with Point Offset

```
   +--------+-------------------------------------------------+
   | Type   | Value                                           |
   +--------+-------------------------------------------------+
   | 0      | en                                              |
   |        |                                                 |
   | 1      | IL                                              |
   |        |                                                 |
   | 3      | Chicago                                         |
   |        |                                                 |
   | 34     | Wacker                                          |
   |        |                                                 |
   | 18     | Drive                                           |
   |        |                                                 |
   | 19     | 3400                                            |
   |        |                                                 |
   | 112    | Reference                                       |
   |        |                                                 |
   | 25     | Building A                                      |
   |        |                                                 |
   | 27     | Floor 6                                         |
   |        |                                                 |
   | 26     | Suite 213                                       |
   |        |                                                 |
   | 28     | Reception Area                                  |
   |        |                                                 |
   | 115    | 100 70                                          |
   |        |                                                 |
   | 126    | image/png                                       |
   |        |                                                 |
   | 127    | http://maps.example.com/3400Wacker/A6           |
   |        |                                                 |
   | 129    | 0.0 4120.0                                      |
   |        |                                                 |
   | 130    | 113.0                                           |
   |        |                                                 |
   | 131    | 10.6                                            |
   +--------+-------------------------------------------------+
```

6. Schema Definition

      Note: The pattern value for "mimeType" has been folded onto
      multiple lines. Whitespace has been added to conform to comply
      with document formatting restrictions. Extra whitespace around
      the line endings MUST be removed before using this schema.

```
<?xml version="1.0"?>
<xs:schema
    xmlns:rel="urn:ietf:params:xml:ns:pidf:geopriv10:relative"
    xmlns:xs="http://www.w3.org/2001/XMLSchema"
    xmlns:gml="http://www.opengis.net/gml"
    targetNamespace="urn:ietf:params:xml:ns:pidf:geopriv10:relative"
    elementFormDefault="qualified"
    attributeFormDefault="unqualified">

  <xs:annotation>
    <xs:appinfo
        source="urn:ietf:params:xml:schema:pidf:geopriv10:relative">
      Relative Location for PIDF-LO
    </xs:appinfo>
    <xs:documentation source="http://ietf.org/rfc/rfc7035.txt">
      This schema defines a location representation that allows for
      the description of locations that are relative to another.
      An optional map reference is also defined.
    </xs:documentation>
  </xs:annotation>

  <xs:import namespace="http://www.opengis.net/gml"/>

  <xs:element name="relative-location" type="rel:relativeType"/>

  <xs:complexType name="relativeType">
    <xs:complexContent>
      <xs:restriction base="xs:anyType">
        <xs:sequence>
          <xs:element name="reference" type="rel:referenceType"/>
          <xs:element name="offset" type="rel:offsetType"/>
          <xs:any namespace="##any" processContents="lax"
                  minOccurs="0" maxOccurs="unbounded"/>
        </xs:sequence>
        <xs:anyAttribute namespace="##other" processContents="lax"/>
      </xs:restriction>
    </xs:complexContent>
  </xs:complexType>

  <xs:complexType name="referenceType">
    <xs:complexContent>
```

```
      <xs:restriction base="xs:anyType">
        <xs:sequence>
          <xs:any namespace="##other" processContents="lax"
                  minOccurs="0" maxOccurs="unbounded"/>
        </xs:sequence>
      </xs:restriction>
    </xs:complexContent>
  </xs:complexType>

  <xs:complexType name="offsetType">
    <xs:complexContent>
      <xs:restriction base="xs:anyType">
        <xs:sequence>
          <xs:element ref="gml:_Geometry"/>
          <xs:any namespace="##other" processContents="lax"
                  minOccurs="0" maxOccurs="unbounded"/>
        </xs:sequence>
      </xs:restriction>
    </xs:complexContent>
  </xs:complexType>

  <xs:element name="map" type="rel:mapType"/>
  <xs:complexType name="mapType">
    <xs:complexContent>
      <xs:restriction base="xs:anyType">
        <xs:sequence>
          <xs:element name="url" type="rel:mapUrlType"/>
          <xs:element name="offset" type="rel:doubleList"
                      minOccurs="0"/>
          <xs:element name="orientation" type="rel:doubleList"
                      minOccurs="0"/>
          <xs:element name="scale" type="rel:doubleList"
                      minOccurs="0"/>
        </xs:sequence>
      </xs:restriction>
    </xs:complexContent>
  </xs:complexType>

  <xs:complexType name="mapUrlType">
    <xs:simpleContent>
      <xs:extension base="xs:anyURI">
        <xs:attribute name="type" type="rel:mimeType"
                      default="application/octet-stream"/>
      </xs:extension>
    </xs:simpleContent>
  </xs:complexType>

  <xs:simpleType name="mimeType">
```

```
      <xs:restriction base="xs:token">
       <xs:pattern value="[!#$%&amp;'\*\+\-\.\dA-Z^_`a-z\|~]+
       /[!#$%&amp;'\*\+\-\.\dA-Z^_`a-z\|~]+([\t ]*;([\t ])*[!#$%&amp;
       '\*\+\-\.\dA-Z^_`a-z\|~]+=([!#$%&amp;'\*\+\-\.\dA-Z^_`a-z\|~]+|
        &quot;([!#-\[\]-~]|[\t ]*|\\[\t !-~])*&quot;))*"/>
      </xs:restriction>
    </xs:simpleType>

    <xs:simpleType name="doubleList">
      <xs:list itemType="xs:double"/>
    </xs:simpleType>

  </xs:schema>
```

7. Security Considerations

   This document describes a data format. To a large extent, security
   properties of this depend on how this data is used.

   Privacy for location data is typically important. Adding relative
   location may increase the precision of the location but does not
   otherwise alter its privacy considerations, which are discussed in
   [RFC4119].

   The map URL provided in a relative location could accidentally reveal
   information if a Location Recipient uses the URL to acquire the map.
   The coverage area of a map, or parameters of the URL itself, could
   provide information about the location of a Target. In combination
   with other information that could reveal the set of potential Targets
   that the Location Recipient has location information for, acquiring a
   map could leak significant information. In particular, it is
   important to note that the Target and Location Recipient are often
   the same entity.

   Access to map URLs MUST be secured with TLS [RFC5246] (that is,
   restricting the map URL to be an https URI), unless the map URL
   cannot leak information about the Target's location. This restricts
   information about the map URL to the entity serving the map request.
   If the map URL conveys more information about a Target than a map
   server is authorized to receive, that URL MUST NOT be included in the
   PIDF-LO.

8. IANA Considerations

8.1. Relative Location Registry

   This document creates a new registry called "Relative Location
   Parameters". This shares a page, titled "Civic Address Types
   Registry" with the existing "Civic Address Types (CAtypes)" registry.
   As defined in [RFC5226], this new registry operates under "IETF
   Review" rules.

   The content of this registry includes:

   Relative Location Code (RLtype): Numeric identifier, assigned by
      IANA.

   Brief description: Short description identifying the meaning of the
      element.

   Reference to published specification: A stable reference to an RFC
      that describes the value in sufficient detail so that
      interoperability between independent implementations is possible.

   Values requested to be assigned into this registry MUST NOT conflict
   with values assigned in the "Civic Address Types (CAtypes)" registry
   or vice versa, unless the IANA Considerations section for the new
   value explicitly overrides this prohibition and the document defining
   the value describes how conflicting TLV codes will be interpreted by
   implementations. To ensure this, the CAtypes entries are explicitly
   reserved in the initial values table below. Those reserved entries
   can be changed, but only with caution, as explained here.

   To make this clear for future users of the registry, the following
   note is added to the "Civic Address Types (CAtypes)" registry:

      The registration of new values should be accompanied by a
      corresponding reservation in the Relative Location Parameters
      registry.

   Similarly, the "Relative Location Parameters" registry bears the
   note:

      The registration of new values should be accompanied by a
      corresponding reservation in the Civic Address Types (CAtypes)
      registry.

The values defined are:

```
+--------+--------------------------------------+-----------+
| RLtype | description                          | Reference |
+--------+--------------------------------------+-----------+
| 0-40   | RESERVED by CAtypes registry         | RFC 7035 &|
| 128    |                                      | RFC 4776  |
+--------+--------------------------------------+-----------+
| 111    | relative location reference          | RFC 7035  |
| 113    | relative location shape 2D point     | RFC 7035  |
| 114    | relative location shape 3D point     | RFC 7035  |
| 115    | relative location shape circular     | RFC 7035  |
| 116    | relative location shape spherical    | RFC 7035  |
| 117    | relative location shape elliptical   | RFC 7035  |
| 118    | relative location shape ellipsoid    | RFC 7035  |
| 119    | relative location shape 2D polygon   | RFC 7035  |
| 120    | relative location shape 3D polygon   | RFC 7035  |
| 121    | relative location shape prism        | RFC 7035  |
| 122    | relative location shape arc-band     | RFC 7035  |
| 123    | relative location dynamic orientation| RFC 7035  |
| 124    | relative location dynamic speed      | RFC 7035  |
| 125    | relative location dynamic heading    | RFC 7035  |
| 126    | relative location map type           | RFC 7035  |
| 127    | relative location map URI            | RFC 7035  |
| 129    | relative location map coordinates    | RFC 7035  |
| 130    | relative location map angle          | RFC 7035  |
| 131    | relative location map scale          | RFC 7035  |
+--------+--------------------------------------+-----------+
```

8.2. URN Sub-Namespace Registration

   This document registers a new XML namespace, as per the guidelines in
   [RFC3688].

    URI: urn:ietf:params:xml:ns:pidf:geopriv10:relative

   Registrant Contact: IETF, GEOPRIV working group (geopriv@ietf.org),
      Martin Thomson (martin.thomson@skype.net).

   XML:

      BEGIN
        <?xml version="1.0"?>
        <!DOCTYPE html PUBLIC "-//W3C//DTD XHTML 1.0 Strict//EN"
            "http://www.w3.org/TR/xhtml1/DTD/xhtml1-strict.dtd">
        <html xmlns="http://www.w3.org/1999/xhtml" xml:lang="en">
          <head>
            <title>GEOPRIV Relative Location</title>
          </head>
          <body>
            <h1>Format for representing relative location</h1>
            <h2>urn:ietf:params:xml:ns:pidf:geopriv10:relative</h2>
            <p>See
                RFC 7035.</p>
          </body>
        </html>

         END

8.3. XML Schema Registration

   This section registers an XML schema as per the procedures in
   [RFC3688].

   URI: urn:ietf:params:xml:schema:pidf:geopriv10:relative

   Registrant Contact: IETF, GEOPRIV working group (geopriv@ietf.org),
      Martin Thomson (martin.thomson@skype.net)

   Schema: The XML for this schema is found in Section 6 of this
      document.

8.4. Geopriv Identifiers Registry

   This section registers two URNs for use in identifying relative
   coordinate reference systems. These are added to a new "Geopriv
   Identifiers" registry according to the procedures in Section 4 of
   [RFC3553]. The "Geopriv Identifiers" registry is entered under the
   "Uniform Resource Name (URN) Namespace for IETF Use" category.

   Registrations in this registry follow the "IETF Review" [RFC5226]
   policy.

   Registry name: Geopriv Identifiers

   URN Prefix: urn:ietf:params:geopriv:

   Specification: RFC 7035 (this document)

   Repository: http://www.iana.org/assignments/geopriv-identifiers

   Index value: Values in this registry are URNs or URN prefixes that
      start with the prefix "urn:ietf:params:geopriv:". Each is
      registered independently.

   Each registration in the "Geopriv Identifiers" registry requires the
   following information:

   URN: The complete URN that is used or the prefix for that URN.

   Description: A summary description for the URN or URN prefix.

   Specification: A reference to a specification describing the URN or
      URN prefix.

   Contact: Email for the person or groups making the registration.

   Index value: As described in [RFC3553], URN prefixes that are
      registered include a description of how the URN is constructed.
      This is not applicable for specific URNs.

   The "Geopriv Identifiers" registry has two initial registrations,
   included in the following sections.

8.4.1. Registration of Two-Dimensional Relative Coordinate Reference
        System URN

   This section registers the "urn:ietf:params:geopriv:relative:2d" URN
   in the "Geopriv Identifiers" registry.

   URN: urn:ietf:params:geopriv:relative:2d

   Description: A two-dimensional relative coordinate reference system

   Specification: RFC 7035 (this document)

   Contact: IETF, GEOPRIV working group (geopriv@ietf.org), Martin
      Thomson (martin.thomson@skype.net)

   Index value: N/A

8.4.2. Registration of Three-Dimensional Relative Coordinate Reference
        System URN

   This section registers the "urn:ietf:params:geopriv:relative:3d" URN
   in the "Geopriv Identifiers" registry.

   URN: urn:ietf:params:geopriv:relative:3d

   Description: A three-dimensional relative coordinate reference
      system

   Specification: RFC 7035 (this document)

   Contact: IETF, GEOPRIV working group (geopriv@ietf.org), Martin
      Thomson (martin.thomson@skype.net)

   Index value: N/A

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10. References

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