Handling *time* with gml:TemporalCRSs

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Rationale

- Time must be integrated in the coverage geometry in a seamless way, *just as an other dimension.*
- The current GML schema for coverages only allows numerical coordinates in the definition of their topology: timestamps/dates *cannot* be used as meter for the temporal axis. ☞
- Augmenting the Coordinate Reference System (CRS) of a coverage from the pure spatial to the *spatiotemporal* domain is the key.
- Temporal reference systems already exist in GML:
  they descend from the same type as common geospatial CRS (`gml:AbstractSingleCRS`), and they are called **`TemporalCRS`**.

```
<RectifiedGrid dimension="3" gml:id="MY_REGULAR_TIME_SERIES-grid">
   <limits>
      <GridEnvelope>
         <low> 66  260 0</low>
         <high>146 265 1</high>
      </GridEnvelope>
   </limits>
   <axisLabels>Long Lat t</axisLabels>
   <gml:origin>
      <gml:Point gml:id="MY_REGULAR_TIME_SERIES-origin"
       srsName="[...]/crs-compound?1=[...]/EPSG/0/4326&2=[...]/ISO/0/8601">
         <gml:pos>4 45 2010-06-19T09:00</gml:pos>
      </gml:Point>
   </gml:origin>
   <gml:offsetVector srsName="[...]/crs-compound?1=[...]/EPSG/0/4326
       &2=[...]/ISO/0/8601">0.01 0 0</gml:offsetVector>
   <gml:offsetVector srsName="[...]/crs-compound?1=[...]/EPSG/0/4326
       &2=[...]/ISO/0/8601">0 0.01 0</gml:offsetVector>
   <gml:offsetVector srsName="[...]/crs-compound?1=[...]/EPSG/0/4326
       &2=[...]/ISO/0/8601">0 0 P1H</gml:offsetVector>
</RectifiedGrid>
```

pixel space

domain space

invalid GML

Temporal Reference System

- A temporal CRS is simply defined as *"1D coordinate reference systems used for the recording of time"*.
- It is composed of:
  - a temporal Coordinate System (CS), defining one single axis with a specified **Unit of Measure** (UoM), a **label** (to be used in W*S subsets), and a **direction** (future/past);
  - a temporal datum, which binds the relative temporal axis to a fixed point in time by means of the **origin** element, in the form of a *date+time* concatenation (e.g. "2012-12-21T00:00").
- The GML definition would be referenced by its URI identifier – specified in the definition itself – and would be usually meant to be *compound* with an other geospatial CRS URI identifier.

Example 1: ANSI date

- The example shows a possible GML representation of the ANSI date numbers by means of a `TemporalCRS` element:
  - The reference of the CRS is specified in the `identifier` of the `TemporalCRS` itself: "**{resolver-prefix}/crs/OGC/0.1/ANSI-D**" in this case.
  - The (unique) axis of the CRS is labeled as **ansi**, (see `axisAbbrev`) and has atomic unit of measure of the day ("**d**") set in the *uom* attribute of the `CoordinateSystemAxis`.†
  - The origin of the axis is set (as in the ANSI date definition) to the **1st of January 1601**, at 00h00.
  - Increasing days count are in line with the passing of time, so **future** is the positive direction of the axis.

```
<TemporalCRS xmlns=[...] gml:id="ANSI-Date">
  <description>
    Continuous count of days starting from
    Jan 1, 1601 (00h00).
  </description>
  <identifier
   codeSpace="http://www.opengeospatial.org">
    {resolver-prefix}/crs/OGC/0.1/ANSI-D
  </identifier>
  <name>ANSI date number</name>
  <timeCS><TimeCS id="days-CS">
    <identifier
     codeSpace="http://www.opengeospatial.org">
      {resolver-prefix}/cs/OGC/0.1/days
    </identifier>
    <axis>
      <CoordinateSystemAxis id="day-axis" uom="d">
        <identifier
         codeSpace="http://www.opengeospatial.org">
          {resolver-prefix}/axis/OGC/0.1/days
        </identifier>
        <axisAbbrev>ansi</axisAbbrev>
        <axisDirection>future</axisDirection>
      </CoordinateSystemAxis>
    </axis>
  </TimeCS></timeCS>
    <temporalDatum><TemporalDatumid="ANSI-TD">
      <identifier
       codeSpace="http://www.opengeospatial.org">
        {resolver-prefix}/datum/OGC/0.1/ANSI
      </identifier>
      <origin>1601-01-01T00:00</origin>
    </TemporalDatum></temporalDatum>
</TemporalCRS>
```


† Thorough list of ISO UoMs : *http://aurora.regenstrief.org/~ucum/ucum.html*

Example 1 (cont.)

- Regular (but could as well be irregular) temporal series of 2D UTM grids over Armenia called *ARM-weeks-TS*, with **weekly resolution**: one image is representative of one entire week.
- rasdaman indexes starting from {0,0,0}, nominal spatial resolution of the pixels 1×1 km², spanning the area $(4 \cdot 10^5, 43 \cdot 10^5) \times (5 \cdot 10^5, 46 \cdot 10^5)$ m².
  The first image is on the 1st of January 2010 and ANSI dates are chosen as temporal reference (t_0=149385).
- If the rasdaman axes order is XYT, the CRS to be bound with the overall 3D coverage would be for instance:

```
{resolver-prefix }/def/crs-compound?
  1={resolver-prefix}/def/crs/EPSG/0/32638 &
  2={resolver-prefix}/def/crs/OGC/0.1/ANSI-D
```

WCS request

```
http://{petascope}/petascope/wcs2?
  service=WCS&
  version=2.0.1&
  request=GetCoverage&
  coverageid=ARM-weeks-TS &
  subset=E(415000,500000)&
  subset=N(4430000,4530000)&
  subset=ansi("2010-06-01","2010-06-30")& ↵
  format=application/gml+xml
```

Or: **ansi**(149536,149565)

```
<gmlcov:RectifiedGridCoverage xmlns=[...] gml:id="ID">
  <boundedBy>
    <Envelope srsName="{resolver-prefix}/crs-compound?
     1={resolver-prefix}/crs/EPSG/0/32638&
     2={resolver-prefix}/crs/OGC/0.1/ANSI-D"
     axisLabels="E N ansi" uomLabels="m m d"
     srsDimension="3">
      <lowerCorner>
        415000 4430000 149536
      </lowerCorner>
      <upperCorner>
        500000 4530000 149565
      </upperCorner>
    </Envelope>
  </boundedBy>

  <domainSet>
    <RectifiedGrid id="ID" dimension="3"
     srsName="{resolver-prefix}/crs-compound?
      1={resolver-prefix}/crs/EPSG/0/32638&
      2={resolver-prefix}/crs/OGC/0.1/ANSI-D"
     srsDimension="3">
      <limits>
        <GridEnvelope>
          <low>15 70 21</low>
          <high>100 170 25</high>
        </GridEnvelope>
      </limits>
      <axisLabels>E N ansi</axisLabels>
      <origin>
        <Point id="ID">
          <pos>415000 4430000 149536</pos>
        </Point>
      </origin>
      <offsetVector>1000 0 0</offsetVector>
      <offsetVector>0 1000 0</offsetVector>
      <offsetVector>0    0 7</offsetVector>
    </RectifiedGrid>
  </domainSet>

  <rangeSet>
    <DataBlock>
      <rangeParameters/>
      <tupleList>[...]</tupleList>
    </DataBlock>
  </rangeSet>
  <rangeType>[...]</rangeType>
</gmlcov:RectifiedGridCoverage>
```

WCS response

Example 2: Geologic time‡

- The example shows a possible GML representation of the chronometric geologic time, to express the "millions of years ago":
  - In this case, the reference of the CRS is "**{resolver-prefix}/crs/OGC/0.1/Ma-age**";
  - The axis of the CRS is labeled as **mya**, (see `axisAbbrev`), i.e. *million years ago*, and has atomic unit of measure of 10^6 years ("**Ma**") set in the *uom* attribute of the `CoordinateSystemAxis`.
  - The **origin** of the axis is set but is not relevant in this case: it is to be used when translating ISO timestamps in the *request* to time coordinates, but at this time scale it is just allowed to use `Ma`.
  - The axis is positive backwards (direction is **past**) so that we use a positive numbers when referring to this dimension.

```
<TemporalCRS xmlns=[...] gml:id="MYA">
  <description>
    Millions of years, backwards in time.
  </description>
  <identifier
   codeSpace="http://www.opengeospatial.org">
    {resolver-prefix}/crs/OGC/0.1/Ma-age
  </identifier>
  <name>Geologic chronometric time.</name>
  <timeCS><TimeCS id="Ma-CS">
    <identifier
     codeSpace="http://www.opengeospatial.org">
      {resolver-prefix}/cs/OGC/0.1/megaannum
    </identifier>
    <axis>
      <CoordinateSystemAxis id="ma-axis" uom="Ma">
        <identifier
         codeSpace="http://www.opengeospatial.org">
          {resolver-prefix}/axis/OGC/0.1/megaannum
        </identifier>
        <axisAbbrev>mya</axisAbbrev>
        <axisDirection>past</axisDirection>
      </CoordinateSystemAxis>
    </axis>
  </TimeCS></timeCS>
    <temporalDatum><TemporalDatumid="MYA-TD">
      <identifier
       codeSpace="http://www.opengeospatial.org">
        {resolver-prefix}/datum/OGC/0.1/MA-age
      </identifier>
      <origin>0001-01-01T00:00</origin>
    </TemporalDatum></temporalDatum>
</TemporalCRS>
```


‡ The proposed example won't probably make much sense; more insights from e.g. BGS are appreciated.

Example 2 (cont.)

- Regular (but, again, could be irregular as well) temporal series of 2D lat/lon images called *Rock-Units-TS*, with resolution of 10 millions of years.
- rasdaman indexes starting from {0,0,0}, nominal spatial resolution of the pixels 0.01°×0.01°, spanning the area (9°E,43°N)×(10°E,46°N).
  Suppose the first image is 34 mya (~end of Eocene).
- If the rasdaman axes order is TXY, the CRS to be bound with the overall 3D coverage would be for instance:

```
{resolver-prefix }/def/crs-compound?
  1={resolver-prefix}/def/crs/OGC/0.1/Ma-age &
  2={resolver-prefix}/def/crs/EPSG/0/4326
```

WCS request

```
http://{petascope}/petascope/wcs2?
  service=WCS&
  version=2.0.1&
  request=GetCoverage&
  coverageid=Rocks-Units-TS &
  subset=Long(9,10)&
  subset=Lat(45,46)&
  subset=mya(57.8,65)&   // Paleocene
  format=application/gml+xml
```

```
<gmlcov:RectifiedGridCoverage xmlns=[...] gml:id="ID">
  <boundedBy>
    <Envelope srsName="{resolver-prefix}/crs-compound?
     1={resolver-prefix}/crs/OGC/0.1/Ma-age&
     2={resolver-prefix}/crs/EPSG/0/4326"
     axisLabels="mya Long Lat"
     uomLabels="Ma degree degree" srsDimension="3">
      <lowerCorner>
        57 9 45
      </lowerCorner>
      <upperCorner>
        65 10 46
      </upperCorner>
    </Envelope>
  </boundedBy>

  <domainSet>
    <RectifiedGrid id="ID" dimension="3"
     srsName="{resolver-prefix}/crs-compound?
     1={resolver-prefix}/crs/OGC/0.1/Ma-age&
     2={resolver-prefix}/crs/EPSG/0/4326"
     srsDimension="3">
      <limits>
        <GridEnvelope>
          <low>22 0 0</low>
          <high>30 99 99</high>
        </GridEnvelope>
      </limits>
      <axisLabels>mya Long Lat</axisLabels>
      <origin>
        <Point id="ID">
          <pos>57 9 45</pos>
        </Point>
      </origin>
      <offsetVector>1 0    0</offsetVector>
      <offsetVector>0 0.01 0</offsetVector>
      <offsetVector>0 0 0.01</offsetVector>
    </RectifiedGrid>
  </domainSet>

  <rangeSet>
    <DataBlock>
      <rangeParameters/>
      <tupleList>[...]</tupleList>
    </DataBlock>
  </rangeSet>
  <rangeType>[...]</rangeType>
</gmlcov:RectifiedGridCoverage>
```

WCS response

Links

- OpenGIS GML Encoding Standard 3.2.1
  http://portal.opengeospatial.org/files/?artifact_id=20509
- ISO:19108, Geographic Information – Temporal schema
  http://im.eurocontrol.int/wiki/index.php/ISO_19108,_Geographic_information_%E2%80%94_Temporal_schema
- OGC standard issues for temporal coordinates
  http://www.earthserver.eu/trac/wiki/OgcStandardsIssues/Temporal
- CRS GML definition candidates for SECORE
  http://rasdaman.eecs.jacobs-university.de/trac/rasdaman/wiki/GmlDefinitions#TemporalCRSs