INSPIRE KEN Follow-Up Webinar on Coverages & WCS

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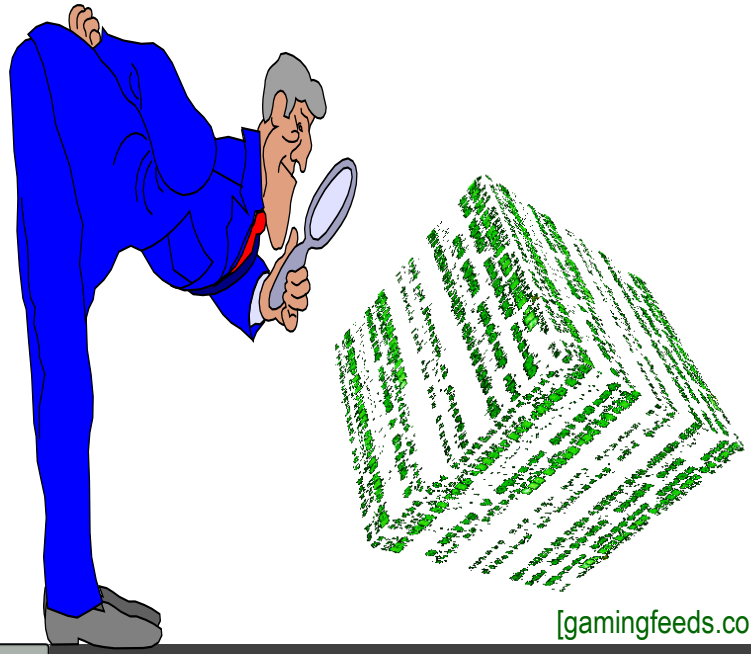

[gamingfeeds.com]

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Overview

- Part 1: Coverages / WCS Recap
- Part 2: The New Coverage Implementation Schema
- Part 3: Q&A

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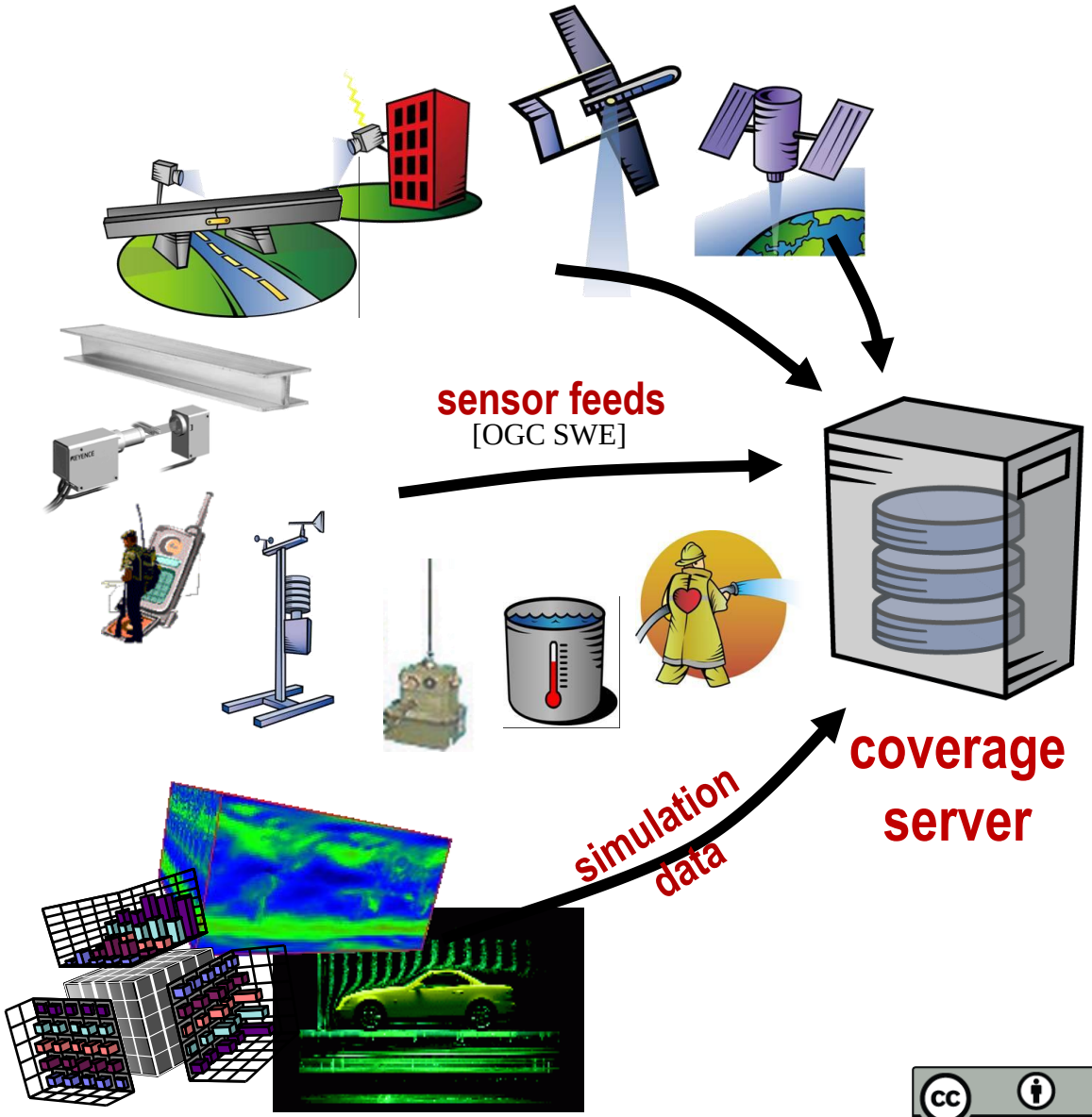
Part 1: Coverages / WCS Recap

Collecting Coverages



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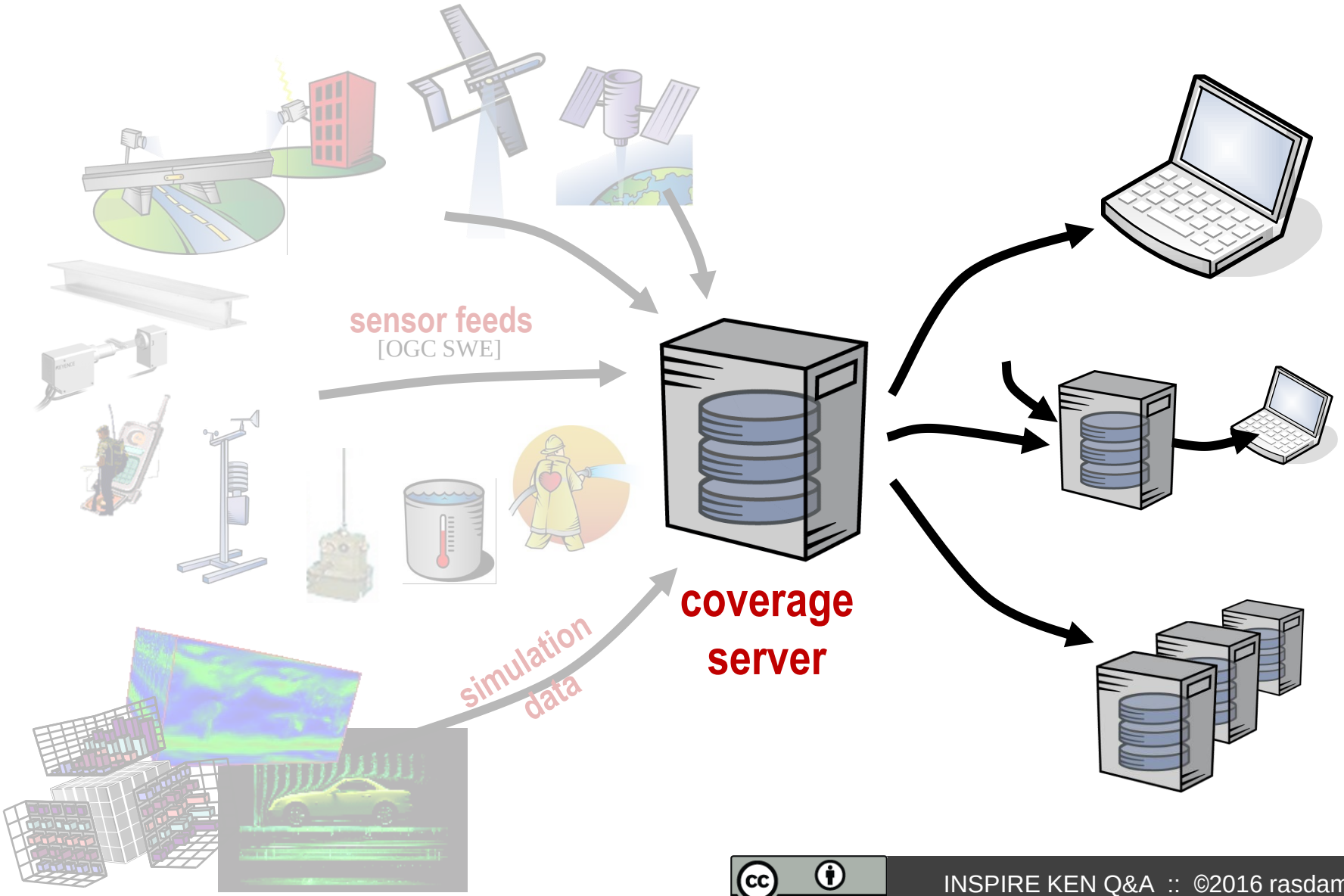
Serving Coverages



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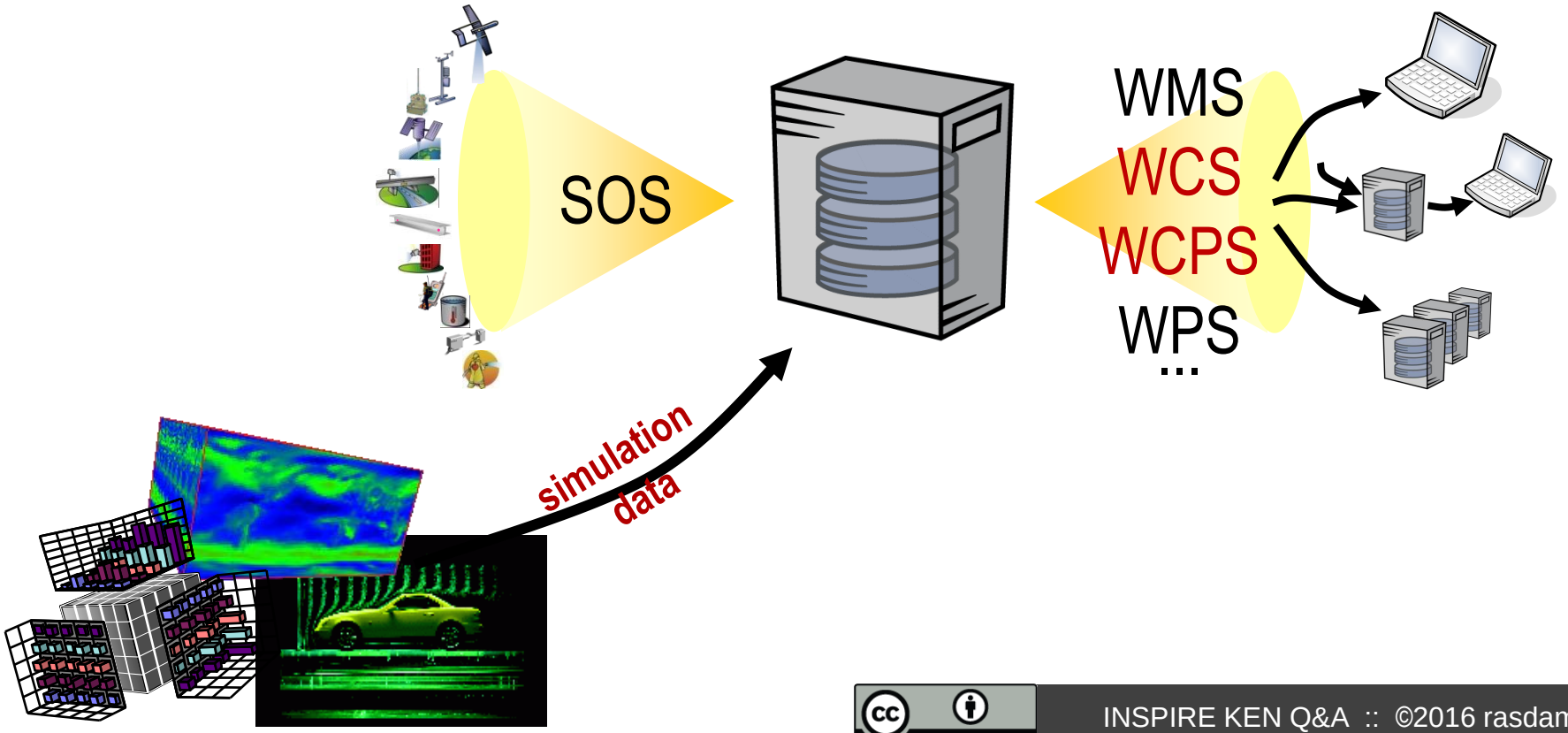
Service Orchestration

SWE, SOS: upstream
sensor data capturing

W*S: downstream
download, processing, visualization



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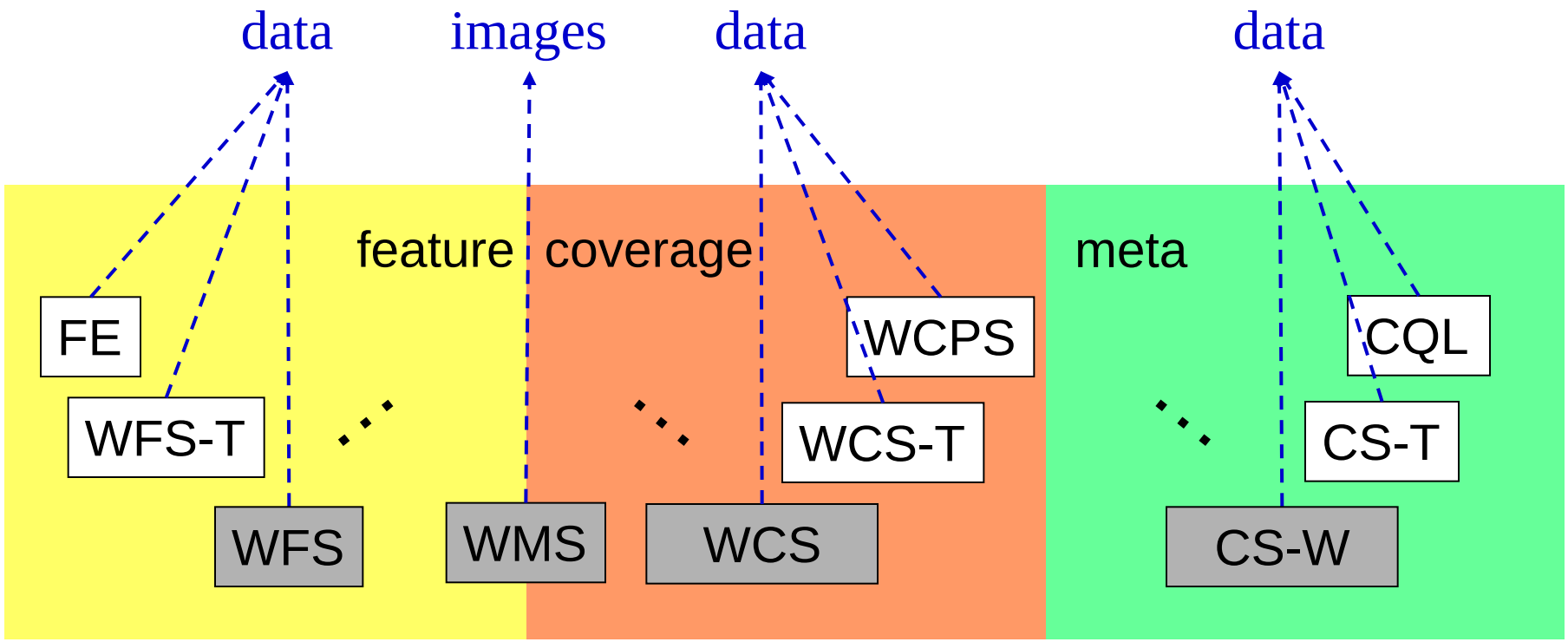
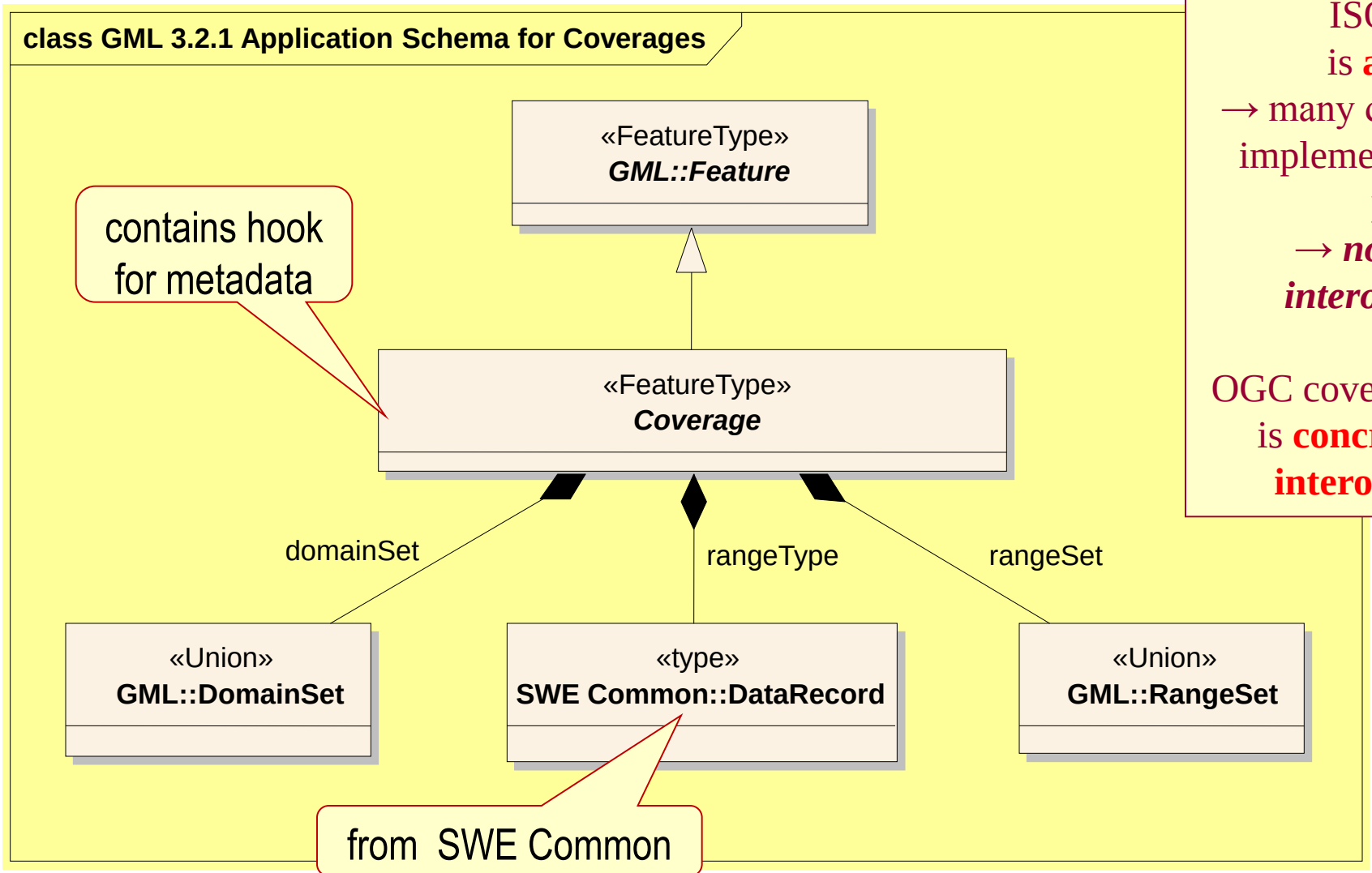
(Part of) The OGC Standards Quilt



- WMS "portrays spatial data → pictures"
- WCS: "provides data + descriptions; data with original semantics, may be interpreted, extrapolated, etc.“

[09-110r3]

Coverage Definition



ISO 19123 is **abstract** → many different implementations possible → ***not per se interoperable***

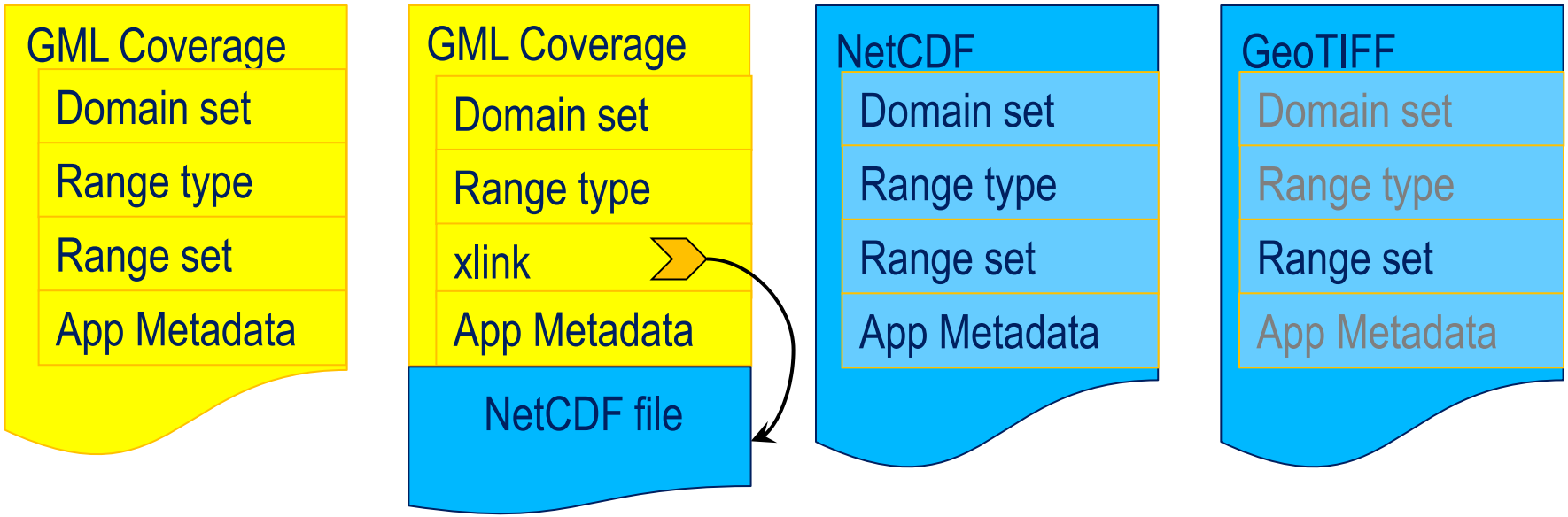
OGC coverage std is **concrete** and **interoperable**

[OGC 09-146r2]

Coverage & CRS

Coverage Encoding

- Pure GML: complete coverage, in GML
- Special Format: other suitable file format (ex: MIME type “image/tiff”)
- Multipart-Mixed: multipart MIME, type “multipart/mixed”



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```
Content-Type: Multipart/Related; boundary=wcs;
      start="GML-Part"
      type="text/xml"

--wcs
Content-type: text/xml
Content-ID: GML-Part

<?xml version="1.0" …>
<gmlcov:RectifiedGridCoverage …>
<gml:domainSet>…</gml:domainSet>
 <gml:rangeSet>
  <gml:File>
   <gml:rangeParameters xlink:href="grey.tif"
    xlink:role="http://www.opengis.net/spec/GMLCOV_geotiff-coverages/1.0"
    xlink:arcrole="fileReference"/>
   <gml:fileReference>grey.tif</gml:fileReference>
   <gml:fileStructure/>
   <gml:mimeType>image/tiff</gml:mimeType>
  </gml:File>
 </gml:rangeSet>
 <gmlcov:rangeType>…</gmlcov:rangeType>
</gmlcov:RectifiedGridCoverage>
--wcs
Content-Type: image/tiff
Content-Description: coverage data
Content-Transfer-Encoding: binary
Content-ID: grey.tif
Content-Disposition: INLINE

...binary TIFF data...
--wcs--
```

rasdaman raster data management

JACOBS UNIVERSITY

Sample Mixed Encoding: TIFF

- Multipart/related MIME
- Part 1: GML
- Part 2: eg, TIFF
- Consistency in metadata required
  - Otherwise bug

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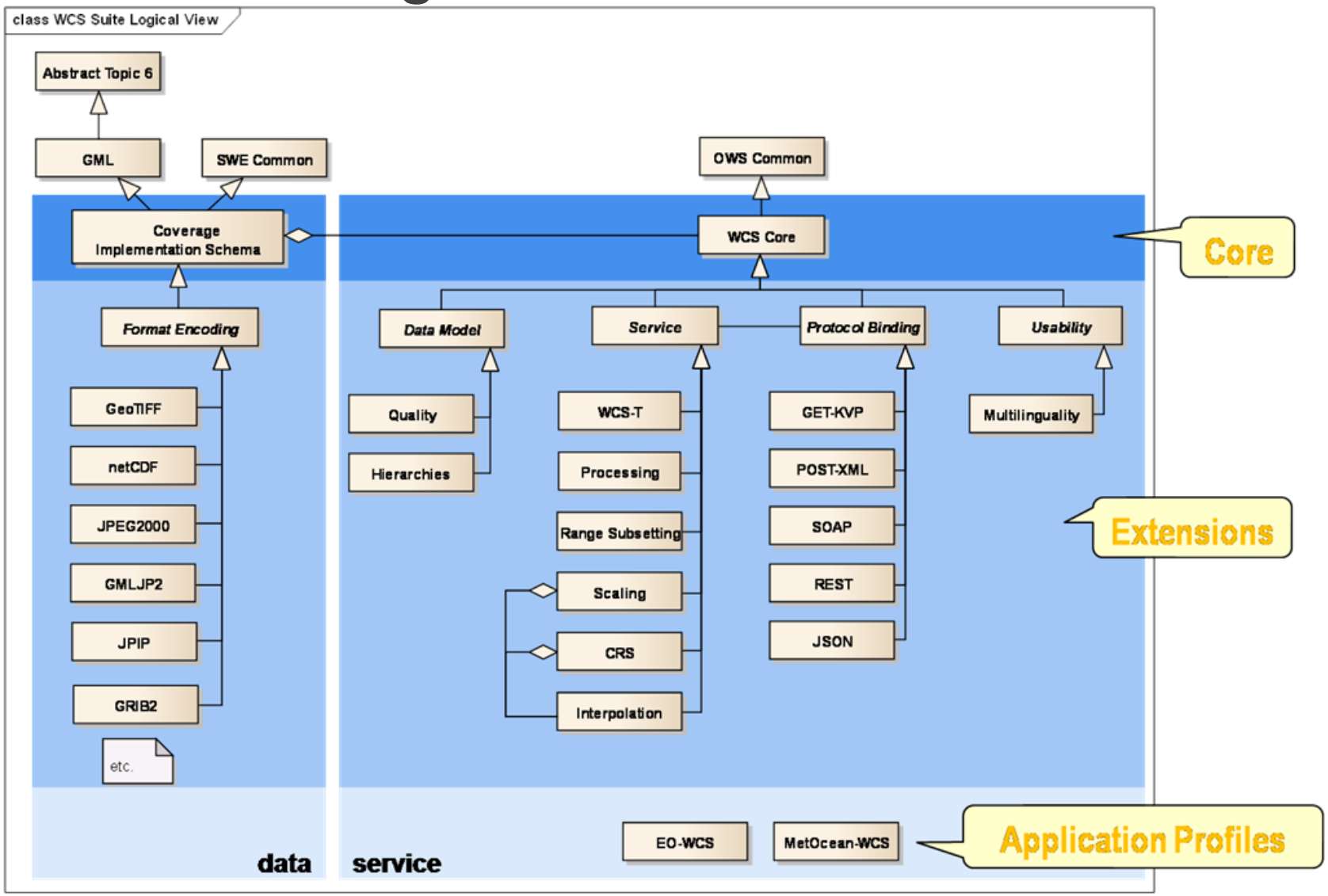
WCS Suite Big Picture



WCS Core *GetCoverage*: Trim & Slice

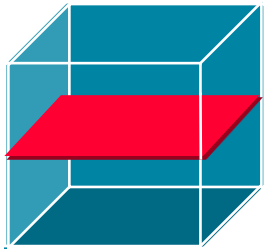
- Download a coverage [subset], values guaranteed unchanged
  - Delivery in „Native Format“

- Ex: „*download coverage c001*“

  http://www.acme.com/wcs ? SERVICE=WCS & VERSION=2.0
  & REQUEST=GetCoverage & COVERAGEID=c001

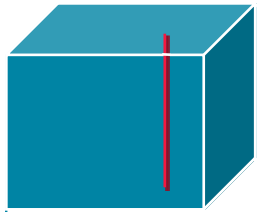
- Ex: „*coverage c001, lat/long cutout, time slice t=2009-11-06T23:20:52*”

  http://www.acme.com/wcs ? SERVICE=WCS & VERSION=2.0
  & REQUEST=GetCoverage & COVERAGEID=c001
  & SUBSET=Long(100,120) & SUBSET=Lat(50,60)
  & SUBSET=time("2009-11-06T23:20:52")



- Ex: „*coverage c001, lat/long slice, timeseries*”

  http://www.acme.com/wcs ? SERVICE=WCS & VERSION=2.0
  & REQUEST=GetCoverage & COVERAGEID=c001
  & SUBSET=Long(100) & SUBSET=Lat(60)



WCS Core *GetCoverage*: Format Encoding

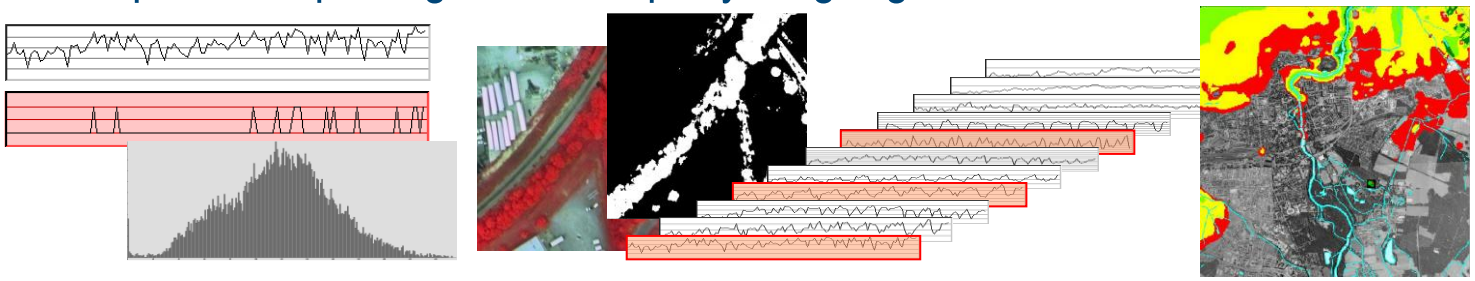
- Download a coverage [subset], values guaranteed unchanged
  - ...if format allows!
- Ex: "*coverage c001, in GeoTIFF*"

```
http://www.acme.com/wcs ? SERVICE=WCS & VERSION=2.0
   & REQUEST=GetCoverage & COVERAGEID=c001
   & FORMAT="image/tiff"
```

- MIME types preferred, but there may be conventions
  - Ex: GDAL
- formats may define add'l specific parameters
  - Ex: JPEG quality factor

WCS Extension – Processing [OGC 13-057]

- WCS wrapper for OGC Web Coverage Processing Service (WCPS)
  - high-level spatio-temporal geo raster query language

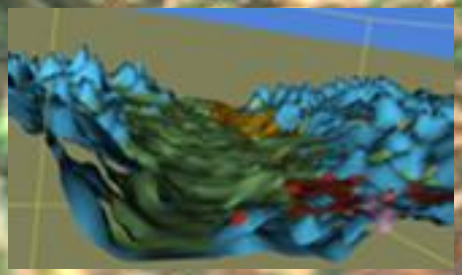


- "From MODIS scenes M1, M2, M3: difference between red & nir, as TIFF"
  - …but only those where nir exceeds 127 somewhere

```
for $c in ( M1, M2, M3 )
where
    some( $c.nir > 127 )
return
    encode(
        $c.red - $c.nir,
        "image/tiff"
    )
```

→ $(\text{tiff}_A, \text{tiff}_C)$

Visualization-as-a-Query



```
for $s in (SatImage), $d in (DEM)
where $s/metadata/@region = "Glasgow"
return
  encode(
    struct {
      red:   (char) $s.b7[x0:x1,x0:x1],
      green: (char) $s.b5[x0:x1,x0:x1],
      blue:  (char) $s.b0[x0:x1,x0:x1],
      alpha: (char) scale( $d, 20 )
    },
    "image/png"
  )
```

[JacobsU, Fraunhofer; data courtesy BGS, ESA]

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WCS Extension – CRS [OGC 11-053]

- retrieval (& bbox) in CRSs different from Native CRS
  - Extension to *GetCoverage* request
  - Capabilities document lists supported CRSs
- Recall: coverage = 1 datacube, with 1 CRS in domainSet
  - Possibly compound: horizontal, height, time, non-referenced, ...
- Ex:

```
http://www.acme.com/wcs ? SERVICE=WCS & VERSION=2.0
    & REQUEST=GetCoverage & COVERAGEID=c001
    & SUBSETTINGCRS=http://www.opengis.net/def/crs/EPSG/0/4326
    & OUTPUTCRS=http://www.opengis.net/def/crs/EPSG/0/4326
```

- This needs
  - Compound CRSs → CRS NTS
  - New CRSs: vertical, time, index, proxies, ... → Time + Index CRS NTS [OGC 13-102r2]
    - *Ex: underspecific ImageCRS → Index1D, Index2D, ...*

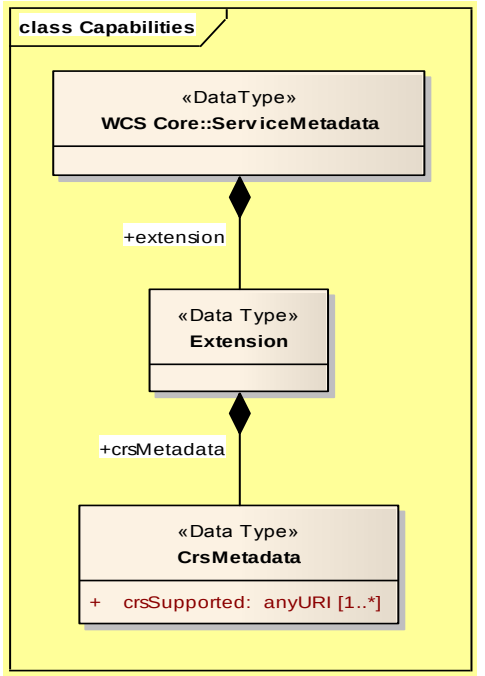
Inset: CRS Name Types

- WGS84, RESTful:
  - http://www.opengis.net/def/crs/EPSG/0/4326
- WGS84, KVP:
  - http://www.opengis.net/def/crs?authority=EPSG&version=0&code=4326
- Parametrized („AUTO“) CRSs:
  - *http://www.opengis.net/def/crs?authority=OGC&version=1.3 & code=AUTO42003 & UoM=m & CenterLongitude=-100 & CenterLatitude=45*
- Ad-hoc combination of CRSs:
  - *http://www.opengis.net/def/crs-compound? 1=http://www.opengis.net/def/crs/EPSG/0/4326 & 2=http://www.opengis.net/def/crs/OGC/0/AnsiDate*
- Proprietary CRS definition:
  - *http://www.acme.com/def/this-is-EPSG-4326*
- Inline CRS definition:
  - *srsName=“#crsdef”*

WCS CRS: Capabilities Retrieval

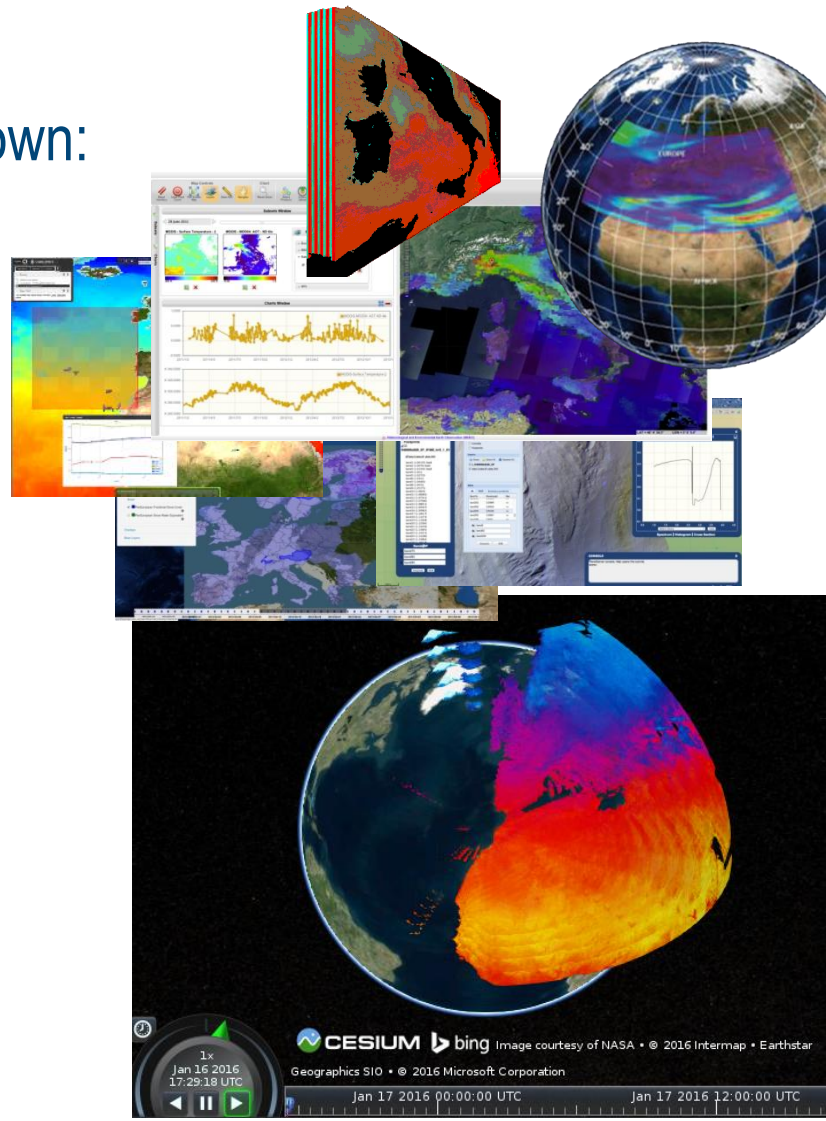
- With WCS-CRS: Capabilities doc contains list of supported CRSs
- Ex:

```
<wcs:crsSupported>
 http://www.opengis.net/def/crs/EPSG/0/4326
</wcs:crsSupported>
<wcs:crsSupported>
 http://www.opengis.net/def/crs/EPSG
</wcs:crsSupported>
<wcs:crsSupported>
 http://www.opengis.net/def/crs?authority=OGC&version=1.3&code=
 AUTO42003&UoM=m&CenterLongitude=-100&CenterLatitude=45
</wcs:crsSupported>
<wcs:crsSupported>
 http://www.acme.com/def/this-is-EPSG-4326
</wcs:crsSupported>
<wcs:crsSupported>
 http://www.opengis.net/def/crs/OGC/0/AnsiDate
</wcs:crsSupported>
```



WCS Adoption

- Large, growing implementation basis; known:
  - rasdaman, GDAL, GeoServer, MapServer, EOxServer, QGIS, OpenLayers, Leaflet, OPeNDAP, GMU, NASA WorldWind, …
  - Pyxis, ERDAS, ESRI ArcGIS, ...
- proven in large-scale deployments
  - 130+ TB per single database
  - 1 query → 1,000+ cloud nodes
- Going ISO:
  - OGC CIS 1.1 → ISO 19123-2
  - OGC WCS → ISO WCS



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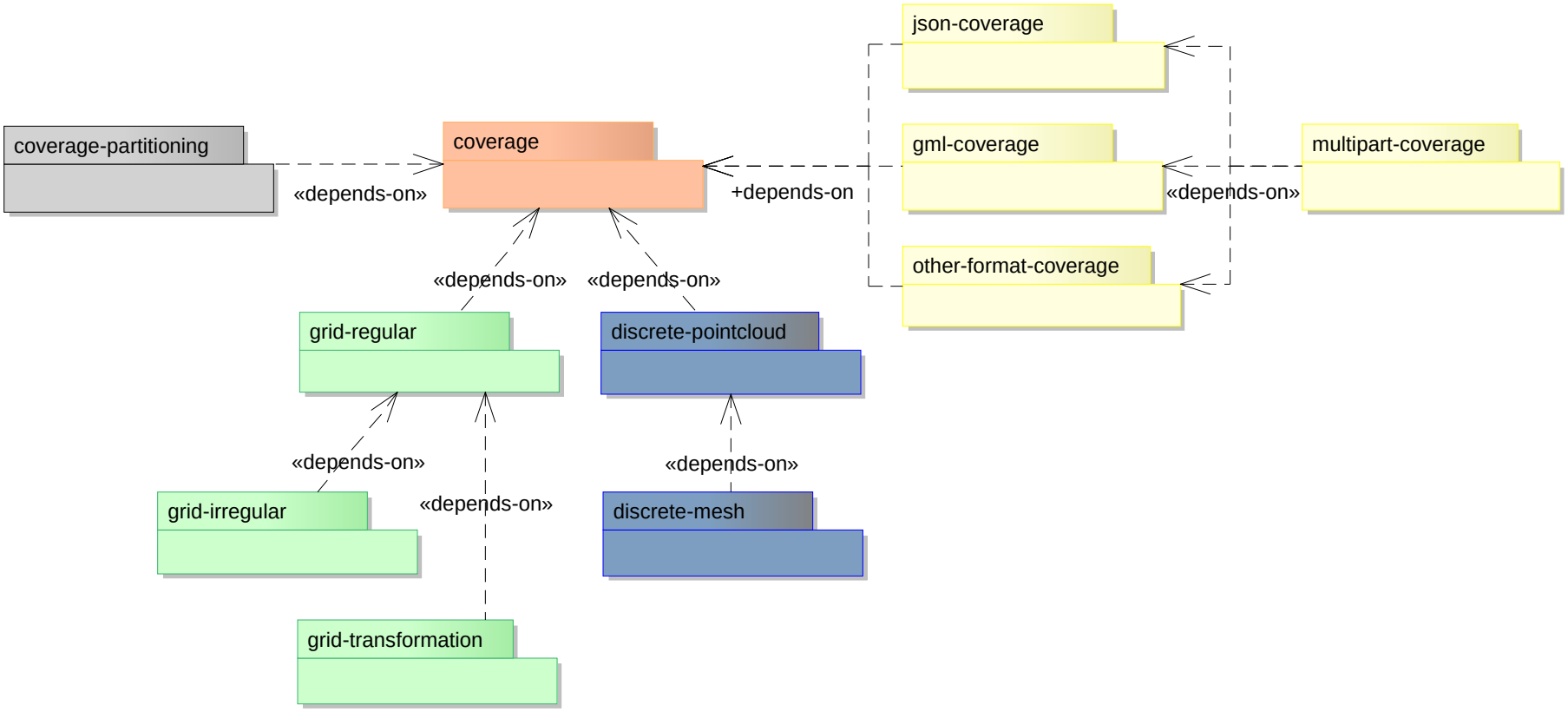
Part 2: The New Coverage Implementation Schema, CIS 1.1 (under adoption in OGC & ISO)

Coverages: Key Features Revisited / Added

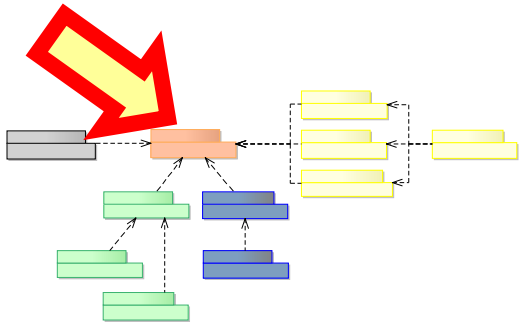
- Irregular grids: concise definition
  - Clarification on ReferenceableGrid, generalization of GML 3.3 GridByXXX
  - Sensor model support (SensorML 2.0)
  - Warped CRSs
- Interpolation: discrete vs continuous grids
- Interleaved representation → general partitioning scheme
- JSON prepared
- Spec renaming GMLCOV → CIS (adopted Spring 2015)

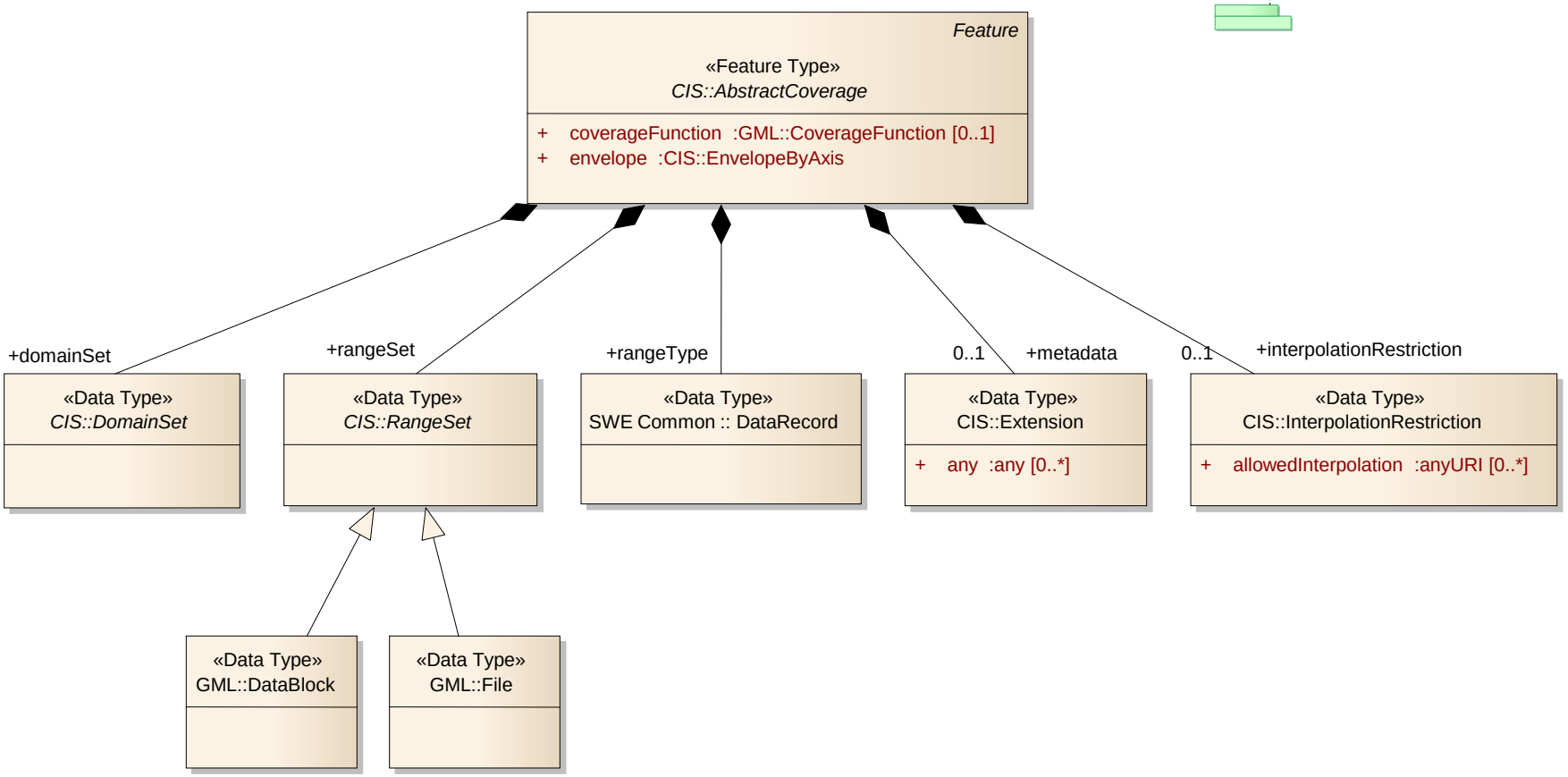
Managing Power

- Separate conformance classes for core, gridded and discrete data, partitioning, encoding



CIS::AbstractCoverage





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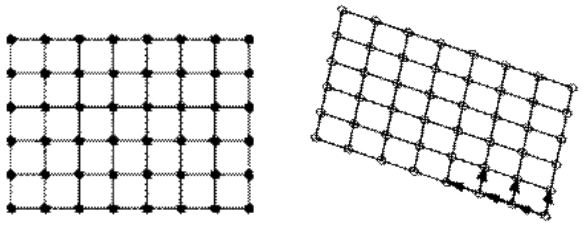
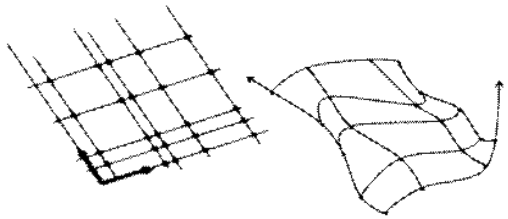
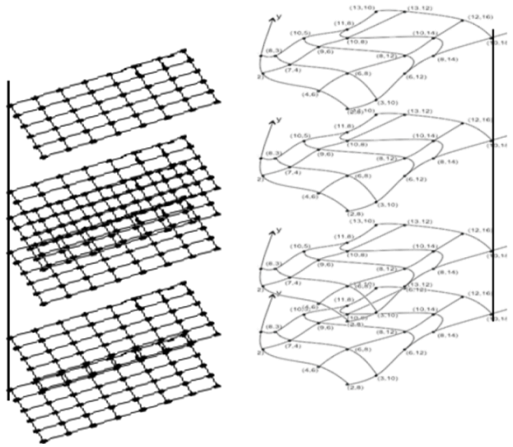
Grid Types → Axis Types

- Observation: GML Rectified, Referenceable
  non-intuitive, hard to describe, cases missing



- CIS approach: axis types
  - Index axis: not georeferenced, IndexCRS
  - Regular axis: georeferenced, constant spacing
  - Irregular axis: georeferenced, variable spacing
  - Distorted axes: georeferenced, arbitrary grid point locations
  - Algorithmic grids: such as sensor model





- All combinations possible
  - GML 3.3 as special cases, SensorML 2.0 integrated

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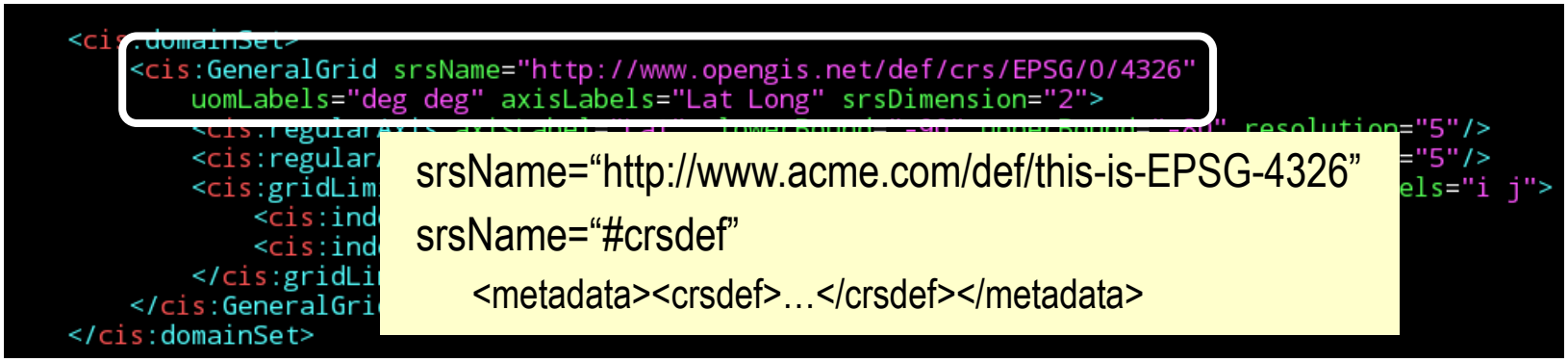
srsName is a Reference!

- „can we store WKT in srsName?“

No. It is a reference. But it can refer to a WKT, or any other (!) type of definition. Not determined in GMLCOV / CIS.

- „can we reference non-canonical (=OGC) CRss?“

Yes. It can refer to a WKT, or any other (!) type of definition.



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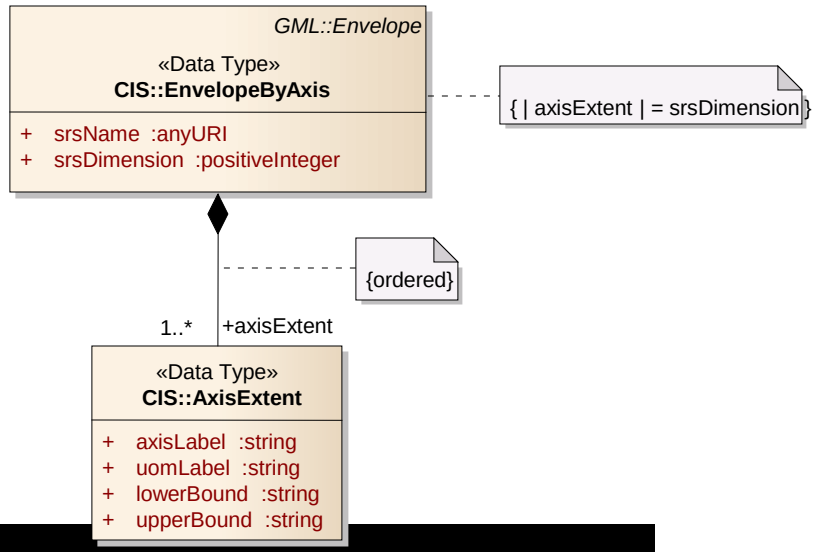
CIS::EnvelopeByAxis

see examples with CIS 1.1 schema

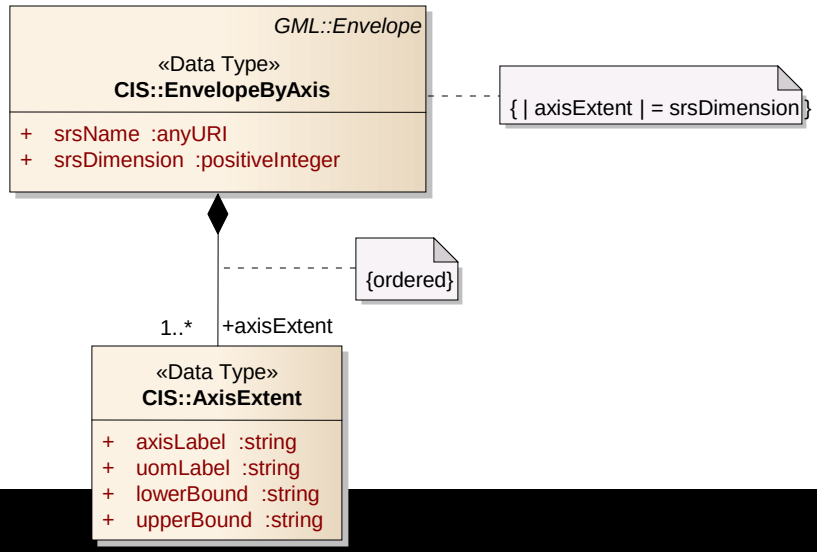



```
<cis:GeneralGridCoverage
    xmlns:cis='http://www.opengis.net/cis/1.1'
    xmlns:gml='http://www.opengis.net/gml/3.2'
    xmlns:swe='http://www.opengis.net/swe/2.0'
    xmlns:xsi='http://www.w3.org/2001/XMLSchema-instance'
    xsi:schemaLocation= 'http://www.opengis.net/cis/1.1 ../cisAll.xsd'
    gml:id="CIS_002">

    <cis:domainSet>
        <cis:GeneralGrid srsName="http://www.opengis.net/def/crs/EPSG/0/4326"
            uomLabels="deg deg" axisLabels="Lat Long" srsDimension="2">
            <cis:regularAxis axisLabel="Lat"  lowerBound="-90" upperBound="-80" resolution="5"/>
            <cis:regularAxis axisLabel="Long" lowerBound="0"   upperBound="10"  resolution="5"/>
            <cis:gridLimits srsName="http://www.opengis.net/def/crs/OGC/0/Index2D" axisLabels="i j">
                <cis:indexAxis axisLabel="i" lowerBound="0" upperBound="2"/>
                <cis:indexAxis axisLabel="j" lowerBound="0" upperBound="2"/>
            </cis:gridLimits>
        </cis:GeneralGrid>
    </cis:domainSet>
```

CIS::EnvelopeByAxis

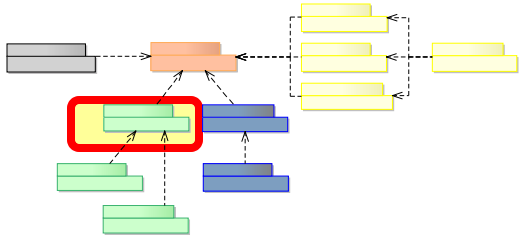
see examples with CIS 1.1 schema

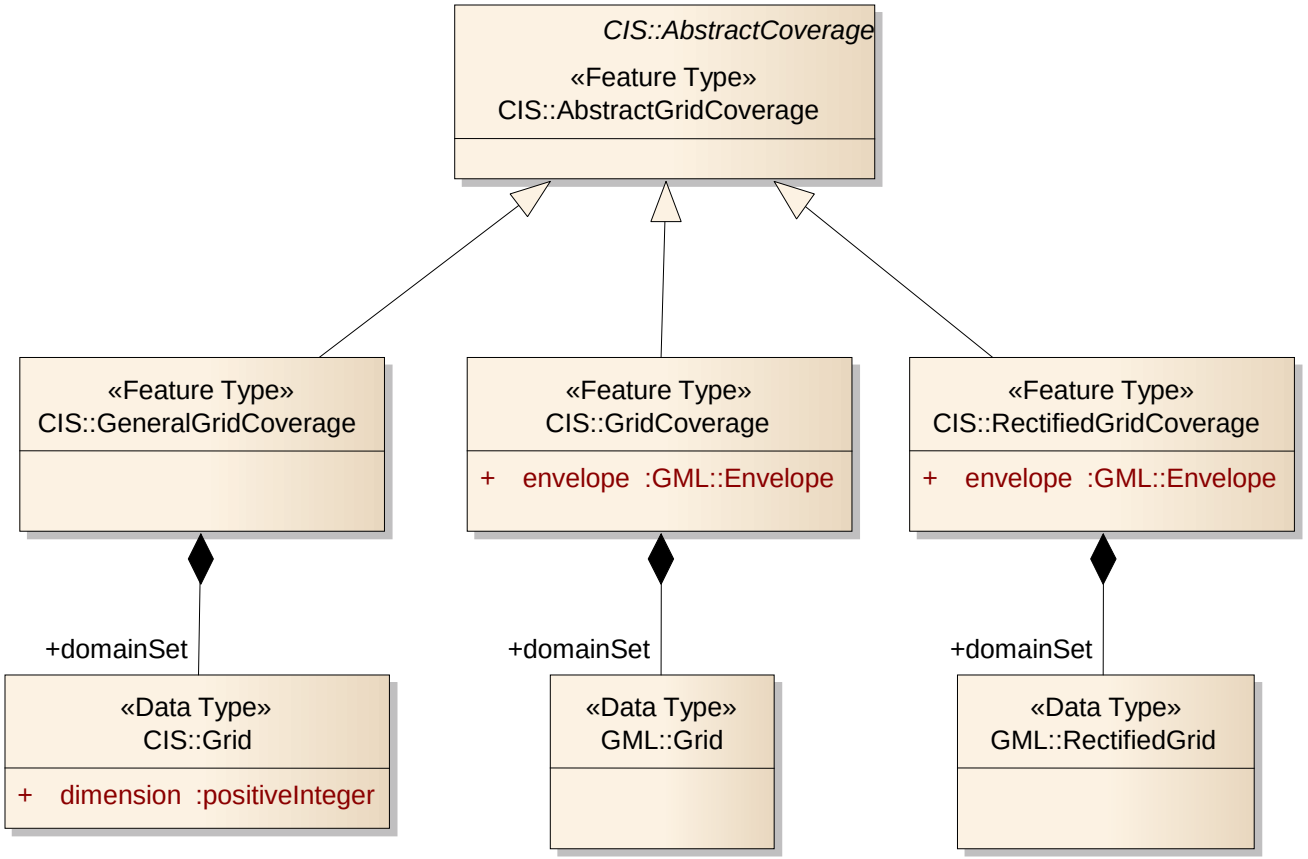



```
<cis:GeneralGridCoverage
    xmlns:cis='http://www.opengis.net/cis/1.1'
    xmlns:gml='http://www.opengis.net/gml/3.2'
    xmlns:swe='http://www.opengis.net/swe/2.0'
    xmlns:xsi='http://www.w3.org/2001/XMLSchema-instance'
    xsi:schemaLocation= 'http://www.opengis.net/cis/1.1 ../cisAll.xsd'
    gml:id="CIS_001">

    <cis:domainSet>
        <cis:GeneralGrid srsName="http://www.opengis.net/def/crs-compound?
                        1=http://www.opengis.net/def/crs/EPSG/0/4979
                       &2=http://www.opengis.net/def/crs/OGC/0/AnsiDate"
            uomLabels="deg deg m d" axisLabels="Lat Long h date" srsDimension="4">
            <cis:regularAxis   axisLabel="Lat"  lowerBound="-90"        upperBound="-80"        resolution="5"/>
            <cis:regularAxis   axisLabel="Long" lowerBound="0"          upperBound="10"         resolution="5"/>
            <cis:irregularAxis axisLabel="h"    lowerBound="0"          upperBound="100"        directPositions="0,100"/>
            <cis:irregularAxis axisLabel="date" lowerBound="2015-12-01" upperBound="2015-12-02" directPositions="2015-12-01, 2015-12-02"/>
            <cis:gridLimits srsName="http://www.opengis.net/def/crs/OGC/0/Index4D" axisLabels="i j k l" >
                <cis:indexAxis axisLabel="i" lowerBound="0" upperBound="2"/>
                <cis:indexAxis axisLabel="j" lowerBound="0" upperBound="2"/>
                <cis:indexAxis axisLabel="k" lowerBound="0" upperBound="1"/>
                <cis:indexAxis axisLabel="l" lowerBound="0" upperBound="1"/>
            </cis:gridLimits>
        </cis:GeneralGrid>
    </cis:domainSet>
```

CIS::AbstractGridCoverage





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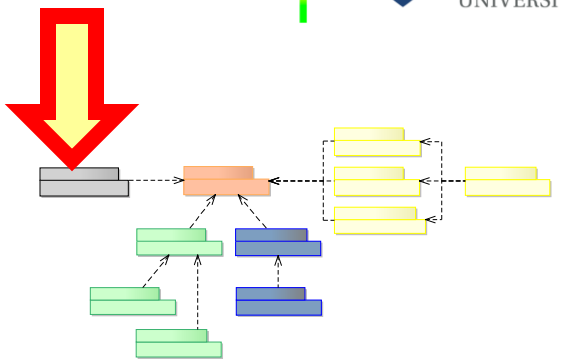
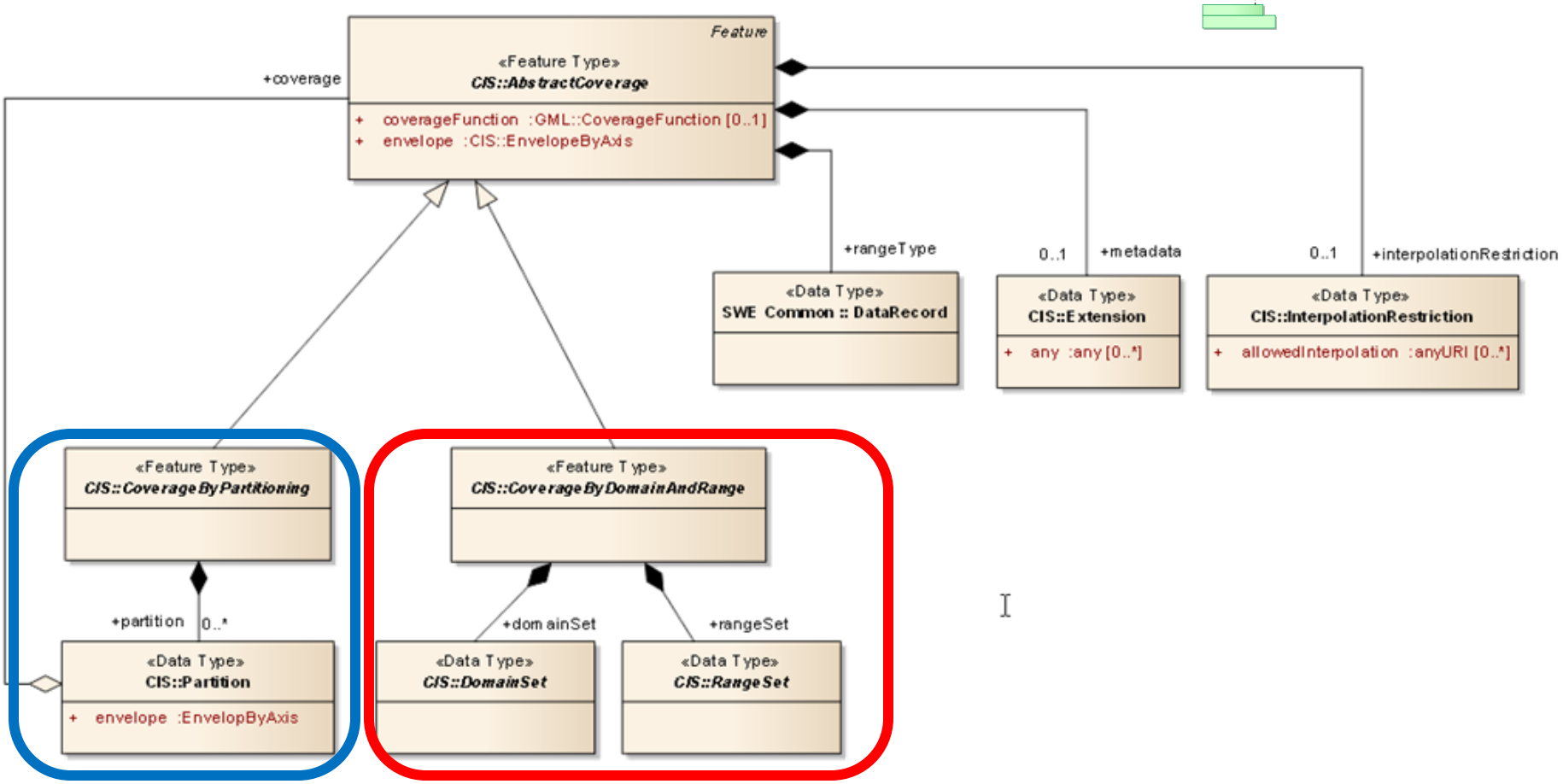
CIS::C'ByPartitioning





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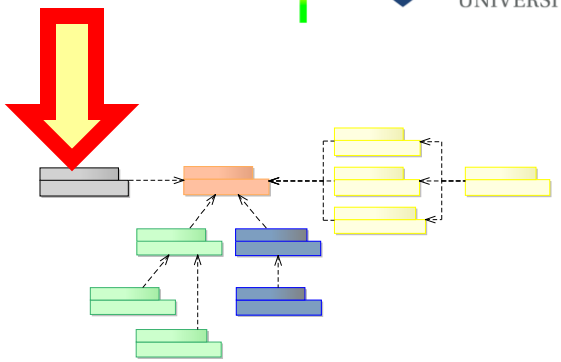
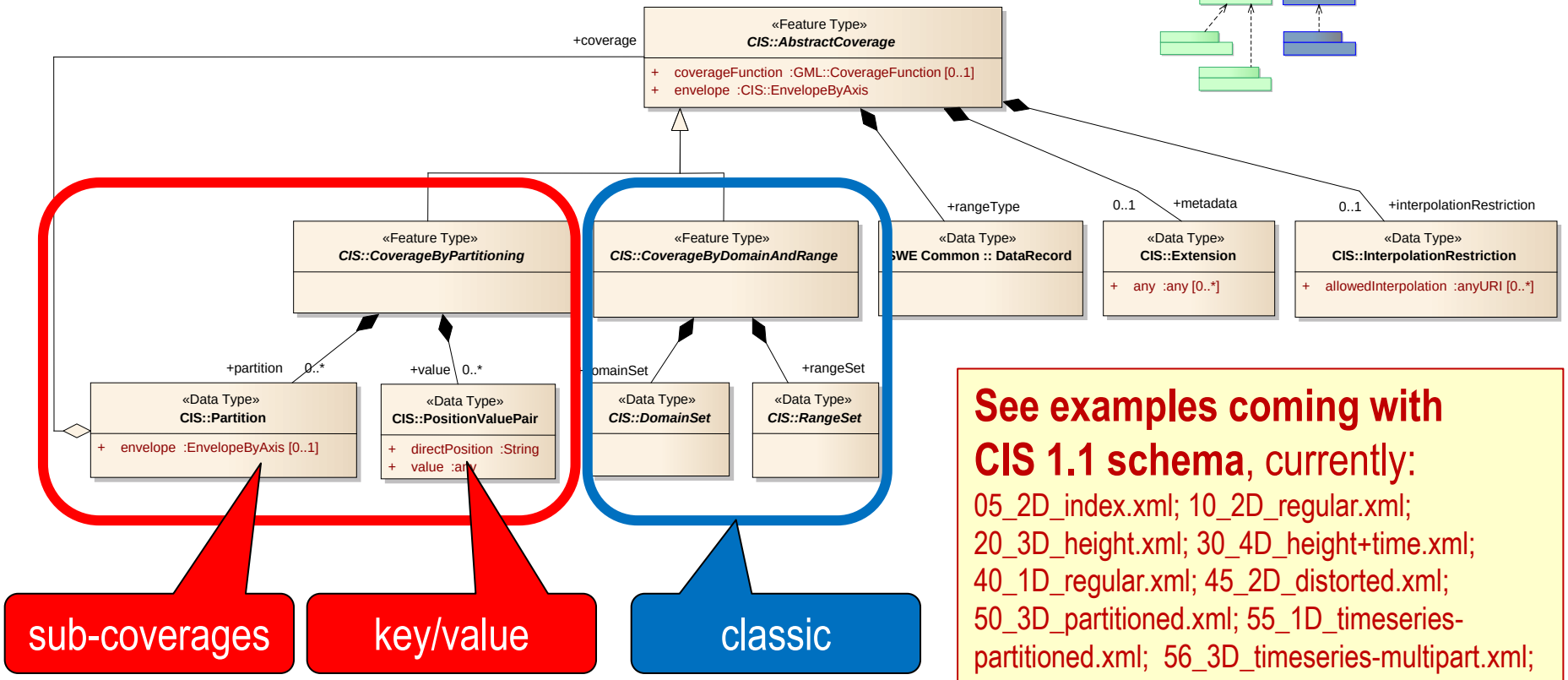
CIS::C'ByPartitioning





See examples coming with CIS 1.1 schema, currently:

05_2D_index.xml; 10_2D_regular.xml; 20_3D_height.xml; 30_4D_height+time.xml; 40_1D_regular.xml; 45_2D_distorted.xml; 50_3D_partitioned.xml; 55_1D_timeseries-partitioned.xml; 56_3D_timeseries-multipart.xml; 57_1D_timeseries-interleaved.xml; 60_point-cloud.xml; 80_2D_interpolation.xml; 90_sensormodel.xml; z0_gridcoverage.xml; z1_rectifiedgridcoverage.xml

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CIS 1.1: Summary

- CIS 1.1 = compatible extension to GMLCOV 1.0
  - General grids; SensorML 2 integration; nonnumeric coordinates; „time-interleaved“, interpolation; splitting into req classes
  - In sync with ISO TC211
- Concepts elaborated in T-11 (10 change requests)
- Spec + ATS ready, on pending >3 weeks
  - Approach: full copy GMLCOV→CIS (not inc, like GML 3.3)
- Implementations available for critical points:
  - Irregular grids: EarthServer project
  - Sensor model: KEYW
  - Partitioning: rasdaman and other array databases
  - GMLCOV 1.0 parts pre-existing, copied over
- Outlook: adding JSON

```
Content-Type: Multipart/Related; boundary=wcs;
      start="GML-Part"
      type="text/xml"

--wcs
Content-type: text/xml
Content-ID: GML-Part

<?xml version="1.0" …>
<gmlcov:RectifiedGridCoverage …>
<gml:domainSet>…</gml:domainSet>
 <gml:rangeSet>
  <gml:File>
   <gml:rangeParameters xlink:href="grey.tif"
    xlink:role="http://www.opengis.net/spec/GMLCOV_geotiff-coverages/1.0"
    xlink:arcrole="fileReference"/>
   <gml:fileReference>grey.tif</gml:fileReference>
   <gml:fileStructure/>
   <gml:mimeType>image/tiff</gml:mimeType>
  </gml:File>
 </gml:rangeSet>
 <gmlcov:rangeType>…</gmlcov:rangeType>
</gmlcov:RectifiedGridCoverage>
--wcs
Content-Type: image/tiff
Content-Description: coverage data
Content-Transfer-Encoding: binary
Content-ID: grey.tif
Content-Disposition: INLINE

...binary TIFF data...
--wcs--
```

rasdaman raster data management

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Sample Mixed Encoding: TIFF

- Multipart/related MIME
- Part 1: GML
- Part 2: eg, TIFF
- Consistency in metadata required
  - Otherwise bug

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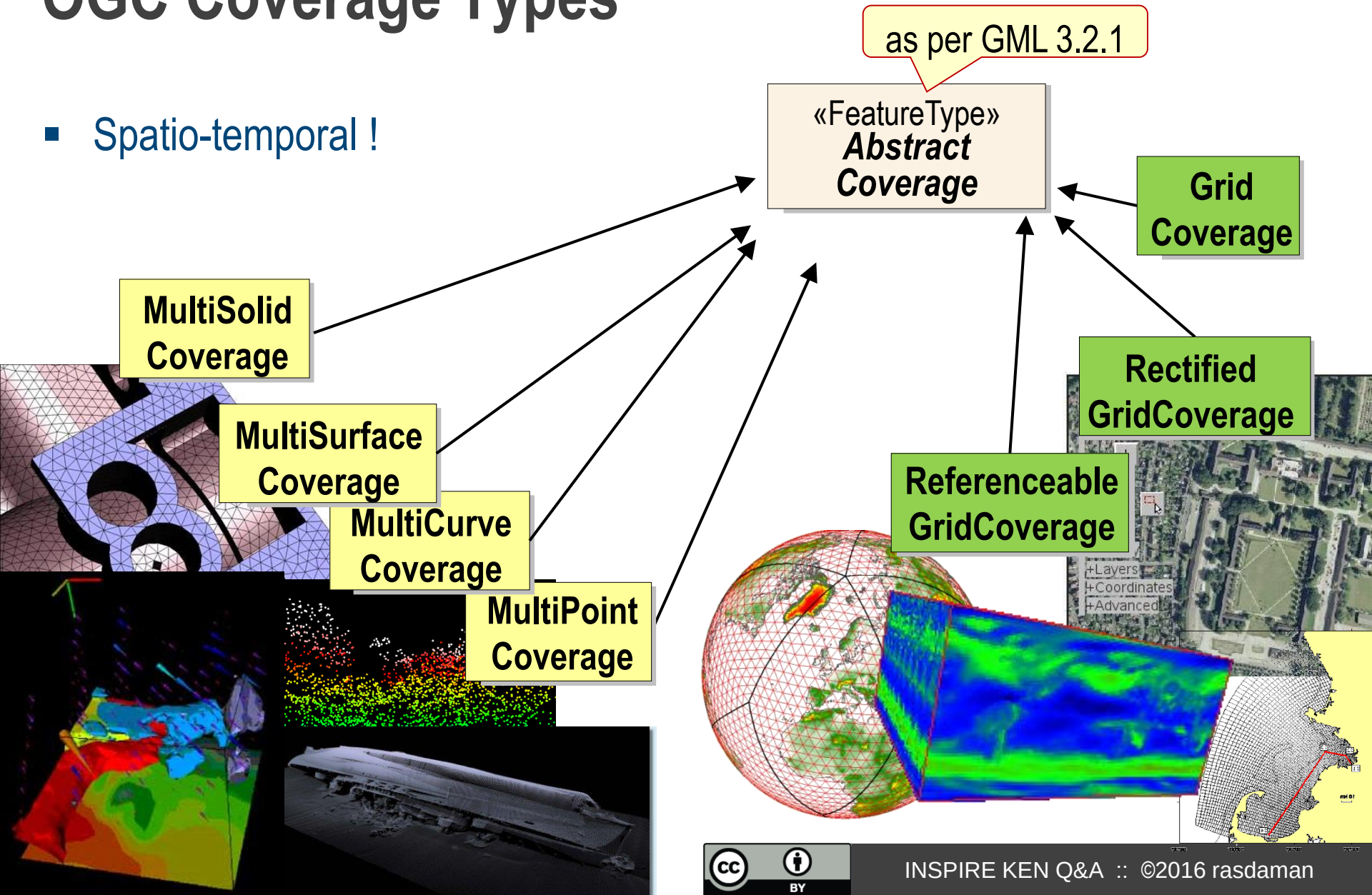
OGC Coverage Types

- Spatio-temporal !



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Part 3: Q&A

Questions

- Q: Harmonize the CRS used in the “srsName” parameter for different GMLCOV file components.
  - https://themes.jrc.ec.europa.eu/discussion/view/50299/harmonize-the-crs-used-in-the-%E2%80%9Csrsname%E2%80%9D-parameter-for-different-gmlcov-file-components
  - https://themes.jrc.ec.europa.eu/file/view/49498/elevation-grid-coverage-gmlcov-example-implementation-ign-spain

Example uncorrelated with OGC coverages

OGC coverages offer simple, powerful (n-D!) way of handling space/time coordinates

- boundedBy is optional, may be different CRS, may be approximate; from GML!
- domainSet is mandatory, authoaritative: contains Native CRS of coverage
- domainExtent is unknown to me (not found in GML 3.2.1)

Questions

- Elevation: Vertical CRS defining elevation values in rangeSet?
  - https://themes.jrc.ec.europa.eu/discussion/view/42326/need-more-guidance-for-elevation-encoding-and-correct-example-for-elevationgridcoverage-on-the-basis-of-gmlcov-schema
  - referenceFrame property from rangeType/swe:Quantity [OGC 08-094r1 SWE Common Data Model]
    - https://themes.jrc.ec.europa.eu/pages/view/60561/provide-an-elevationgridcoverage-encoding-example-and-guidelines-for-identifying-the-vertical-crs

Use of swe:Quantity not governed by WCS.SWG! Best practice highly desirable.
„Me no expert“ – who is willing to join a task force? Mail thread wrap-up?

```
−<gml:domainSet>
 −<gml:RectifiedGrid gml:id="rg0001_C0002" dimension="2" srsName="http://www.opengis.net/def/crs/EPSG/0/32633">
  +<gml:limits></gml:limits>
   <gml:axisName>x</gml:axisName>
   <gml:axisName>y</gml:axisName>
  +<gml:origin></gml:origin>
   <gml:offsetVector srsName="http://www.opengis.net/def/crs/EPSG/0/32633">0.298582141738734 0</gml:offsetVector>
   <gml:offsetVector srsName="http://www.opengis.net/def/crs/EPSG/0/32633">0 -0.298582141738591</gml:offsetVector>
 </gml:RectifiedGrid>
</gml:domainSet>
+<gml:rangeSet></gml:rangeSet>
−<gmlcov:rangeType>
 −<swe:DataRecord>
  −<swe:field name="Height">
   +<swe:Quantity definition="http://sweet.jpl.nasa.gov/2.0/spaceExtent.owl#Height" referenceFrame="http://www.opengis.net/def/crs/EPSG/0/5714">
   </swe:field>
 </swe:DataRecord>
</gmlcov:rangeType>
```

[Emmanuel Devys et al]

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DEM Example

```
<cis:GeneralGridCoverage …>
 <cis:domainSet>
    <cis:GeneralGrid srsName=http://www.opengis.net/def/crs/EPSG/0/4326
      uomLabels="deg deg" axisLabels="Lat Long" srsDimension="2">
      <cis:regularAxis axisLabel="Lat"  lowerBound="-90" upperBound="-80" resolution="5"/>
      <cis:regularAxis axisLabel="Long" lowerBound="0"   upperBound="10"  resolution="5"/>
      <cis:gridLimits srsName="http://www.opengis.net/def/crs/OGC/0/Index2D" axisLabels="i j">
        <cis:indexAxis axisLabel="i" lowerBound="0" upperBound="2"/>
        <cis:indexAxis axisLabel="j" lowerBound="0" upperBound="2"/>
      </cis:gridLimits>
    </cis:GeneralGrid>
  </cis:domainSet>
  <cis:rangeSet>…</cis:rangeSet>
  <cis:rangeType>
    <swe:DataRecord>
      <swe:field name="elevation">       // as per ESA + SPOT Image, 2011
        <swe:Quantity definition="http://www.opengis.net/def/dataType/OGC/0/float16"
          referenceFrame="http://www.opengis.net/def/crs/EPSG/0/3855">
          <swe:uom>m</swe:uom>
        </swe:Quantity>
      </swe:field>
    </swe:DataRecord>
  </cis:rangeType>
</cis:GeneralGridCoverage>
```

Based on email discussion with Emmanuel Devys, Roger Lott, et al

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Questions

- tiling / mosaicking, coverage aggregations within the GMLCOV files
  - https://themes.jrc.ec.europa.eu/discussion/view/50412/how-to-implement-tiling-model-mosaic-elements-coverages-and-coverage-aggregations-in-gmlcov-files
- Build GMLCOV example for Elevation & Orthoimagery
  - standardized way to implement tiling (describing logical structures like e.g. mapsheets, administrative units like regions or districts, etc.)
  - mosaic elements (OI)
  - modelling coverage aggregations

Meaning, purpose?

Meaning, purpose, how to serve?

Caveat: implementation detail, WCS interface std does not define implementation.
COVERAGE ≠ IMAGE
Do NOT standardize tiling on server!
Why should it be necessary?
Any serious server today can do seamless mosaicked maps

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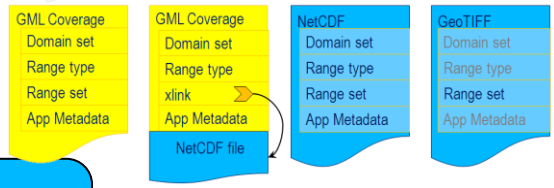
Questions

- partial conceptual redundancies between INSPIRE coverages attributes and GMLCOV components / INSPIRE coverage model extensions
  - Ex: domainExtent vs. gml:boundedBy
    - https://themes.jrc.ec.europa.eu/discussion/view/12901/domainextent-vs-gmlboundedby-el-oi-coverages-encoding
  - agreed to minimize INSPIRE extensions as possible

Complete list of INSPIRE deviations from OGC coverages?

- Issues:
  - Sometimes duplication of information



not much danger (consistency can be verified automatically) - Redundancy existing, eg, with format encodings

  - WCS2.0 ignores INSPIRE extensions

dangerous

Relevant Links

- Wikipedia primers:
  - Coverages
  - Web Coverage Service
  - Web Coverage Processing Service
- OGC:
  - coverages info page: http://external.opengeospatial.org/twiki_public/CoveragesDWG/WebHome
  - Authoritative standards source: http://www.opengeospatial.org/standards/wcs
- Coverage service standards online demo: http://standards.rasdaman.com
- The rasdaman Array Database System
- The EarthServer initiative

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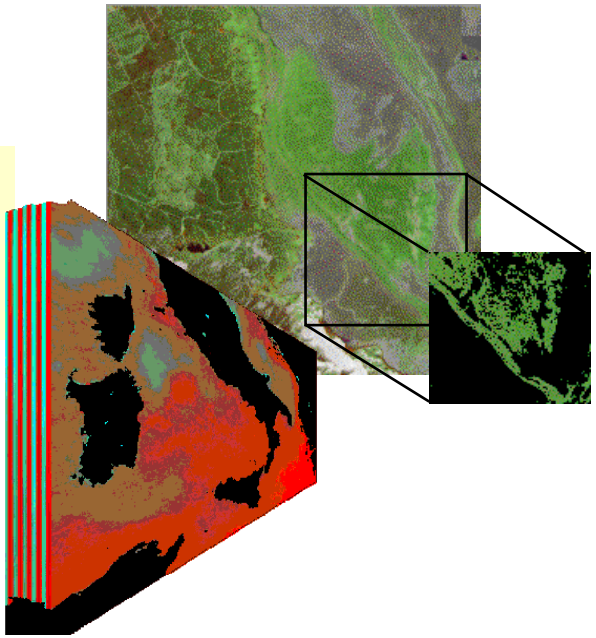
That's all folks!

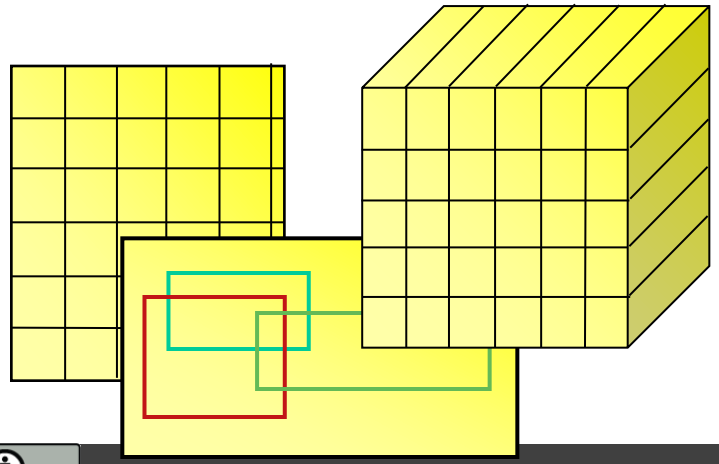
rasdaman: Agile Array Analytics

- „raster data manager“: SQL + n-D raster objects

```
select img.green[x0:x1,y0:y1] > 130
from   LandsatArchive as img
where  avg_cells( img.nir ) < 17
```



- Scalable parallel “tile streaming” architecture
- In operational use
  - OGC Web Coverage Service Core Reference Implementation



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