# DRAFT 2

# CalVal Support System

## CalVal SensorML Handbook

| | name<br>function<br>company | *date*<br>signature |
|---|---|---|
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# DOCUMENT STATUS SHEET

| Issue | Date | Comments | Author |
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# 1 INTRODUCTION

## 1.1 Purpose of this document

This document describes the way sensor should be described in the framework of calibration / validation (CalVal) activities. This project has been performed on behalf the European Space Agency under the ESA contract 19112/05/I-LG with the company Brockmann Consult, which has subcontracted the description of sensors to VisioTerra. The proposed architecture has been elaborated in strait collaboration with Alexandre ROBIN, one of the specialists of SensorML.

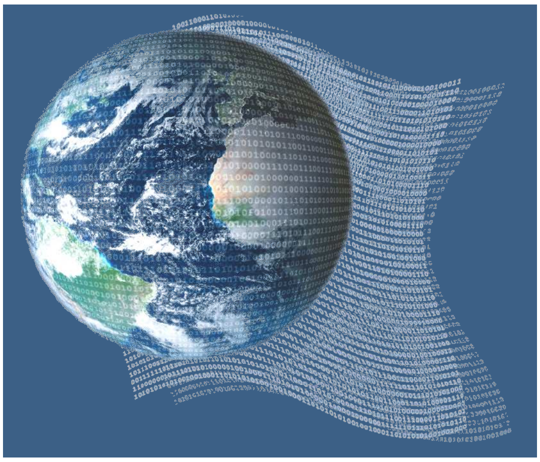


*fig. 1 - CalVal portal logo (Brockmann Consult).*

One of the objectives of the CalVal portal is to provide scientists with the calibration/validation methods and sensor characteristics to enable scientists to perform the comparison and inter-calibration of the instruments. Use of SensorML to describe the instruments is one of the recommendations of the CEOS WGCV (working group on calibration and validation of the Committee on Earth Observation Satellites).

In its first version, the sensor descriptions are limited to the information relative to radiometry. In its second version, the geometry description will be also encompassed.

## 1.2 Document overview

- Chapter 1 is the present section applicable to the overall document.
- Chapter 2 gives the architecture of SensorML CalVal documents and recommendations
- Chapter 3 details the contents of the elements in a CalVal instrument description document

## 1.3 Applicable documents

| | | |
|---|---|---|
| **A-1** | OGC 07-000 | OpenGIS® Sensor Model Language (SensorML) Implementation Specification<br>Version 1.0.0 – 17/07/2007<br>Open Geospatial Consortium Inc.<br>http://portal.opengeospatial.org/files/?artifact_id=21273 |

| | | |
|---|---|---|
| **A-2** | OGC 99-100r1 | OpenGIS® Abstract Specification<br>Topic 0: Overview<br>Topic 2 - Spatial Reference System, Version 4<br>Topic 7 – The Earth Imagery Case, Version 4<br>Topic 11 - Metadata (Same as ISO Metadata document 19115)<br>Topic 12 - OGC Services Architecture, Version 4.1<br>Open Geospatial Consortium Inc. |
| **A-3** | OGC 03-105r1 | Geographic Markup Language (GML) Implementation Specification<br>Version 3.1.1, 19 April 2004<br>Open Geospatial Consortium Inc. |
| **A-4** | | Namespaces in XML.<br>W3C Recommendation<br>14 January 1999<br>http://www.w3.org/TR/1999/REC-xml-names-19990114/ |
| **A-5** | | XML Schema Part 1: Structures.<br>W3C Recommendation<br>2 May 2001<br>http://www.w3.org/TR/xmlschema-1/ |
| **A-6** | | XML Schema Part 2: Datatypes<br>W3C Recommendation<br>2 May 2001<br>http://www.w3.org/TR/xmlschema-2/ |

## 1.4 Reference documents

This section describes the related documents and applied conventions to be considered within the present document.

| | | |
|---|---|---|
| **R-1** | VT-P014-DOC-001-E-01-00 | *CalVal Support System*<br>*Instrument Description Technical Note*<br>Issue 1, Revision 0 – 25/05/2007<br>VisioTerra |

*SensorML*

| | | |
|---|---|---|
| **R-2** | Web site UAH VAST | *Sensor Model Language – Overview*<br>UAH – Earth System Science Lab<br>VAST – Global Hydrology and Climate Center<br>http://vast.uah.edu/SensorML/ |
| **R-3** | | *Sensor Model Language (SensorML) Details*<br>Presentation Mike Botts<br>September 2007<br>University of Alabama in Huntsville (UAH)<br>http://vast.uah.edu/downloads/SensorML_Details_2007-08-26.ppt |

*Earth observation missions catalogs*

| | | |
|---|---|---|
| **R-4** | Web NSSDC | *National Space Science Data Center,*<br>*NASA's permanent archive for space science mission data*<br>NASA<br>http://nssdc.gsfc.nasa.gov/ |

| | | |
|---|---|---|
| **R-5** | Web CEOS | *Earth Observation Handbook*<br>CEOS - ESA - Symbios<br>http://www.eohandbook.com/ |
| **R-6** | Web CNES | *Earth Observation Satellites & Sensors*<br>CNES<br>http://www.space-risks.com/SpaceData/index.php?id_page=5 |
| **R-7** | Web NASA | *Satellite Missions*<br>NASA<br>http://ilrs.gsfc.nasa.gov/satellite_missions/list_of_satellites/ |
| **R-8** | Web EO-Portal | *Resources of Earth observation*<br>ESA<br>http://directory.eoportal.org/res_p1_Earthobservation.html |

## 1.5 Abbreviations and Acronyms

This section controls the definition of all abbreviations and acronyms used within this document. Special attention has been paid to adopt abbreviations, acronyms and their definitions from international standards as ISO, ANSI or ECSS.

Many definitions laid down in the list above are extracted from the SensorML Implementation Specification (A-1).

| | |
|---|---|
| ADEOS | Advanced Earth Observing System (Japan) |
| AERONET | Aerosol RObotic NETwork (NASA Goddard Space Flight Center) |
| AGI | Advanced Global Imager (NPP, NASA) |
| ALOS | Advanced Land Observing Satellite (Japan) |
| ALS | Airborne Laser Scanning |
| ANSI | American National Standards Institute |
| ASTER | Advanced Spaceborne Thermal Emission and Reflection Radiometer (Japan; NASA EOS) |
| ATSR | Along-Track Scanning Radiometer (ESA ERS) |
| AVHRR | Advanced Very High Resolution Radiometer (NOAA) |
| AVNIR | Advanced Visible and Near-Infrared Radiometer (Japan, ADEOS) |
| BRDF | Bidirectional Reflection Distribution Function |
| CAL | Calibration |
| CAL/VAL | Calibration and Validation |
| CASI | Compact Airborne Spectrographic Imager (Canada) |
| CCSDS | Consultative Committee for Space Data Systems |
| CEOS | Committee on Earth Observation Satellites |
| CNES | Centre National d'Études Spatiales (France) |
| ECSS | European Cooperation for Space Standardization |
| EGM96 | Earth Gravity Model 1996 |
| Envisat | ESA polar SATellite for ENVIronment monitoring |

| | |
|---|---|
| EO | Earth Observation |
| EPS | EUMETSAT Polar System |
| ERS | European Remote Sensing satellite (ESA) |
| ESA | European Space Agency |
| ESRIN | European Space Research Institute |
| ETM+ | Enhanced Thematic Mapper (instrument of Landsat 7) |
| ETRS89 | European Terrestrial Reference System 1989 |
| EUMETSAT | European Organisation for the Exploitation of Meteorological satellites |
| FOV | Field-of-View |
| GLI | Global Imager (Japan, ADEOS) |
| GMES | Global Monitoring for Environment and Security |
| GML | Geographic Markup Language |
| GSD | Ground Sampling Distance |
| GSFC | Goddard Space Flight Center (NASA) |
| HIRS | High Resolution Infrared Radiation Sounder |
| HR | Haute Résolution |
| HRG | Haute Résolution Géométrique (instrument de SPOT-5) |
| HRPT | High Resolution Picture Transmission |
| HRS | Haute Résolution Stéréoscopique (instrument de SPOT-5) |
| HRV | Haute Résolution dans le Visible (SPOT) |
| IASI | Infrared Atmospheric Sounding Interferometer |
| IFOV | Instantaneous Field Of View |
| IfSAR | Interferometry from SAR |
| IGOS | Integrated Global Observing Strategy |
| InSAR | Interferometry from SAR |
| IOCCG | International Ocean-Colour Coordinating Group |
| IR | Infrared |
| IRS | Indian Remote-Sensing Satellite |
| ISO | International Standards Organization |
| ISRF | Instrument Spectral Response Function |
| JERS | Japanese Earth Resources Satellite |
| JPL | Jet Propulsion Laboratory (USA) |
| LiDAR | Light Detection and Ranging |
| MERIS | Medium Resolution Imaging Spectrometer (ESA Envisat) |
| METOP | METeorological OPerational Satellite. Europe's first polar-orbiting satellite dedicated to operational meteorology |
| MHS | Microwave Humidity Sounder |
| MISR | Multiangle Imaging Spectro-Radiometer (NASA EOS) |

| | |
|---|---|
| MODIS | Moderate-Resolution Imaging Spectroradiometer (NASA EOS) |
| MOS | Modular Optoelectronic Scanner (Germany) |
| MSG | Meteosat Second Generation |
| NASA | National Aeronautics and Space Administration (USA) |
| NASDA | National Space Development Agency (Japan) |
| NDVI | Normalised Difference Vegetation Index |
| NGA | National Geospatial intelligence Agency (ex NIMA) |
| NIR | Near Infrared |
| NIST | National Institute of Standards and Technology (USA) |
| NOAA KLM | NOAA-K through NOAA-M polar orbiter series of satellites |
| NOAA | National Oceanic and Atmospheric Administration (USA) |
| O&M | Observations and Measurements |
| OCS | Optical Sciences Center (UAZ) |
| OCTS | Ocean Colour and Temperature Scanner (Japan, ADEOS) |
| OGC | Open Geospatial Consortium |
| OWS | OGC Web Services |
| PDF | Adobe™ Portable Data Format |
| PDF | Probability Density Function |
| POLDER | Polarization and Directionality of the Earth's Reflectances (CNES, ADEOS) |
| PRISM | Panchromatic Remote-sensing Instrument for Stereo Mapping (Japan) |
| PSF | Point Spread Function |
| QA | Quality Assurance |
| QC | Quality Control |
| RADAR | RAdio Detection And Ranging |
| RAL | Rutherford Appleton Laboratories (UK) |
| RFC | Rational Function Model |
| RMS | Root-Mean-Square |
| RPC | Rational Polynomial Coefficients |
| RPF | Rational Polynomial Function |
| SAR | Synthetic Aperture Radar |
| SeaWiFS | Sea-Viewing Wide Field-of-View Sensor (USA) |
| SensorML | Sensor Model Language |
| SEVIRI | Spinning Enhanced Visible and Infrared Imager (ESA) |
| SNR | Signal-to-Noise Ratio |
| SOS | Sensor Observation Service |
| SOW | Statement Of Work |
| SPOT | Système Probatoire d'Observation Terrestre (France) |

| | |
|---|---|
| SPS | Sensor Planning Service |
| SRTM | Shuttle Radar Topography Mission |
| SWE | Sensor Web Enablement |
| SWIR | Short Wave Infrared |
| TBC | To Be Confirmed |
| TBD | To Be Defined |
| TIROS | Television Infrared Observation Satellite |
| TM | Thematic Mapper (instrument of Landsat) |
| TOA | Top Of the Atmosphere |
| UAH | University of Alabama in Huntsville |
| UML | Unified Modeling Language |
| URL | Unified Resource Locator |
| USA | United States of America |
| USGS | U.S. Geological Survey (USA) |
| UTM | Universal Transverse Mercator |
| UV | Ultraviolet |
| VAL | Validation |
| VAST | VisAnalysis Systems Technologies |
| VGT | SPOT-4 VEGETATION instrument (France) |
| VHR | Very High Resolution |
| VIIRS | Visible and Infrared Imaging Radiometer Suite (NPOESS) |
| VIRS | Visible Infrared Scanner (Japan) |
| VIS | Visible |
| VNIR | Visible and Near Infrared |
| W3C | World Wide Web consortium |
| WCRP | World Climate Research Programme (WMO) |
| WGCV | Working Group on Calibration and Validation (CEOS) |
| WGS84 | World Geodetic System 1984 |
| WLS | White light source |
| WMO | World Meteorological Organisation |
| WNS | Web Notification Service |
| WTF | WGISS Test Facility |
| XML | eXtensible Markup Language |
| XSL | eXtensible Stylesheet Language |
| XSL-FO | eXtensible Stylesheet Language – Formatting Object |
| XSLT | eXtensible Stylesheet Language Transformation |

## 1.6 Definitions

This section provides the definition of all common terms used within this document. Special attention has been paid to adopt definitions from international standards as ISO, ANSI or ECSS.

ESA also provides the following glossaries (only those interesting for this document have been selected):

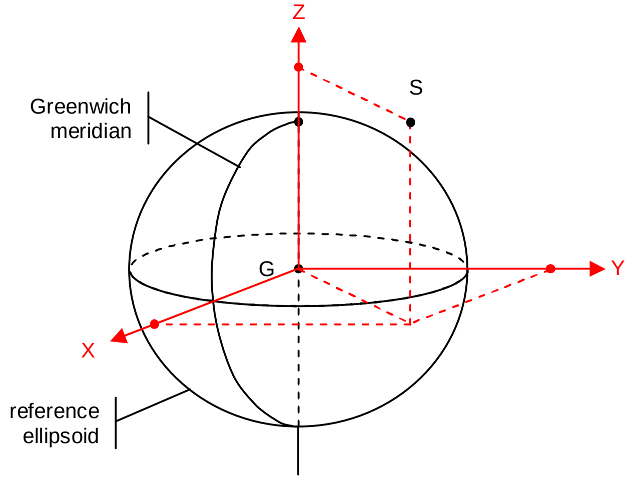
- Geometry –http://envisat.esa.int/dataproducts/meris/CNTR5-2-1.htm,
- Optics - http://envisat.esa.int/dataproducts/meris/CNTR5-2-9.htm,
- Product - http://envisat.esa.int/dataproducts/meris/CNTR5-2-10.htm,

Many definitions laid down in the list above are extracted from the SensorML Implementation Specification (A-1).

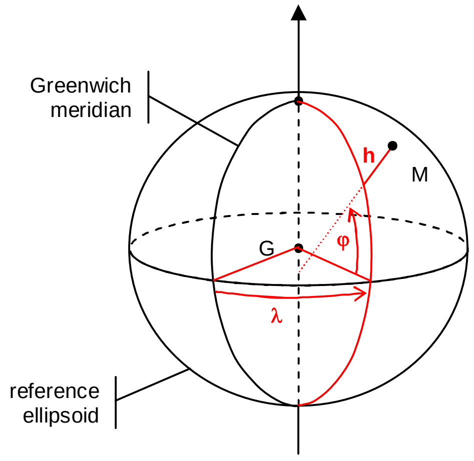
**actuator** A type of transducer that is a simple element that converts a signal to some action or real world phenomenon. In SensorML a detector is a particular type of Process Model.

**coordinate reference system (CRS)** A spatial or temporal framework within which a position and/or time can be defined.

**coordinate reference system geocentric**




**coordinate reference system geographic**



**detector** Atomic part of a composite *Measurement System* defining sampling and response characteristic of a simple detection device. A detector has only one input and one output, both being scalar quantities. More complex *sensors* such as a frame camera which are composed of multiple detectors can be described as a detector group or array using a *system* or *sensor*. In SensorML a detector is a particular type of *Process Model*.

**geocoded** An image (or more generally any EO data) is geocoded if a simple relation exists giving the geodetic coordinates (λ,φ) or the Cartesian coordinates (X,Y) of a particular reference system from the coordinates of any point (l,p) of the image.

Generally, the geodetic position is given using a simple linear formula:

$$\begin{cases} X = X_0 + d_X \times p \\ Y = Y_0 - d_Y \times l \end{cases}$$

Where:

- $(X_0,Y_0)$ are the coordinates of the upper-left pixel in the image,
- $(d_X,d_Y)$ are the horizontal and vertical pixels spacing respectively.

Note that a geocoded image is a georeferenced image in which the localisation function is the simple linear equation given here above.

**georeferenced** An image (or more generally any EO data) is georeferenced if a relation exists (also called *localisation function*) giving the geodetic coordinates (λ,φ) or the Cartesian coordinates (X,Y) of a particular reference system from the coordinates of any point (l,p) of the image and from possible auxiliary data.

$$\begin{cases} X = f_X(l, p, \text{var}) \\ Y = f_X(l, p, \text{var}) \end{cases}$$

Where:

- var are auxiliary data (ephemeris and/or attitude of the platform, characteristics of the instrument, point elevation…).

**location** The translational relationship of a point in space to some reference frame..

**location model** A model that allows one to locate objects within one reference frame (localFrame) relative to another reference frame (referenceFrame).

**measurement** An instance of a procedure to estimate the value of a natural phenomenon, typically involving an instrument or sensor. This is implemented as a dynamic feature type, which has a property containing the result of the measurement. The measurement feature also has a location, time, and reference to the method used to determine the value. A measurement feature effectively binds a value to a location and to a method or instrument.

**observed value** A value describing a natural phenomenon, which may use one of a variety of scales including nominal, ordinal, ratio and interval. The term is used regardless of whether the value is due to an instrumental observation, a subjective assignment or some other method of estimation or assignment.

**orientation** The rotational relationship of one spatial reference frame to another.

**orthorectified** — An image is orthorectified if its internal deformations due to the relief and the viewing geometry have been corrected. The orthorectified image does not exhibit parallax defects for the optical instrument or the foreshortening / layover defects caused by the radar instrument.

**phenomenon** — An event or physical property that can be observed and measured, such as temperature, gravity, chemical concentration, orientation, number-of-individuals.

**position** — The location and orientation of one reference frame to another.

**process model** — A process that takes one or more inputs, and based on parameters and methodologies, generates one or more outputs.

**process method** — Definition of the behaviour and interface of a *Process Model*. It can be stored in a library so that it can be reused by different *Process Model* instances (by using 'xlink' mechanism). It essentially describes the process interface and algorithm, and can point the user to existing implementations.

**process chain** — Composite processing block consisting of interconnected sub-processes, which can in turn be *Process Models* or *Process Chains*. A process chain also includes possible data sources as well as connections that explicitly link input and output signals of sub-processes together. It also precisely defines its own inputs, outputs and parameters.

**reference frame** — A coordinate system by which the position (location and orientation) of an object can be referenced.

**sample** — A subset of the physical entity on which an observation is made.

**sensor** — An entity capable of observing a phenomenon and returning an observed value. In SensorML, modelled as a specific type of *system* representing a complete *sensor*. This could be for example a complete airborne scanner which includes several *detectors* (one for each band).

**sensor model** — In line with traditional definitions of the remote sensing community, a *sensor model* is a type of *location model* that allows one to georegister observations from a *sensor* (particularly remote sensors).

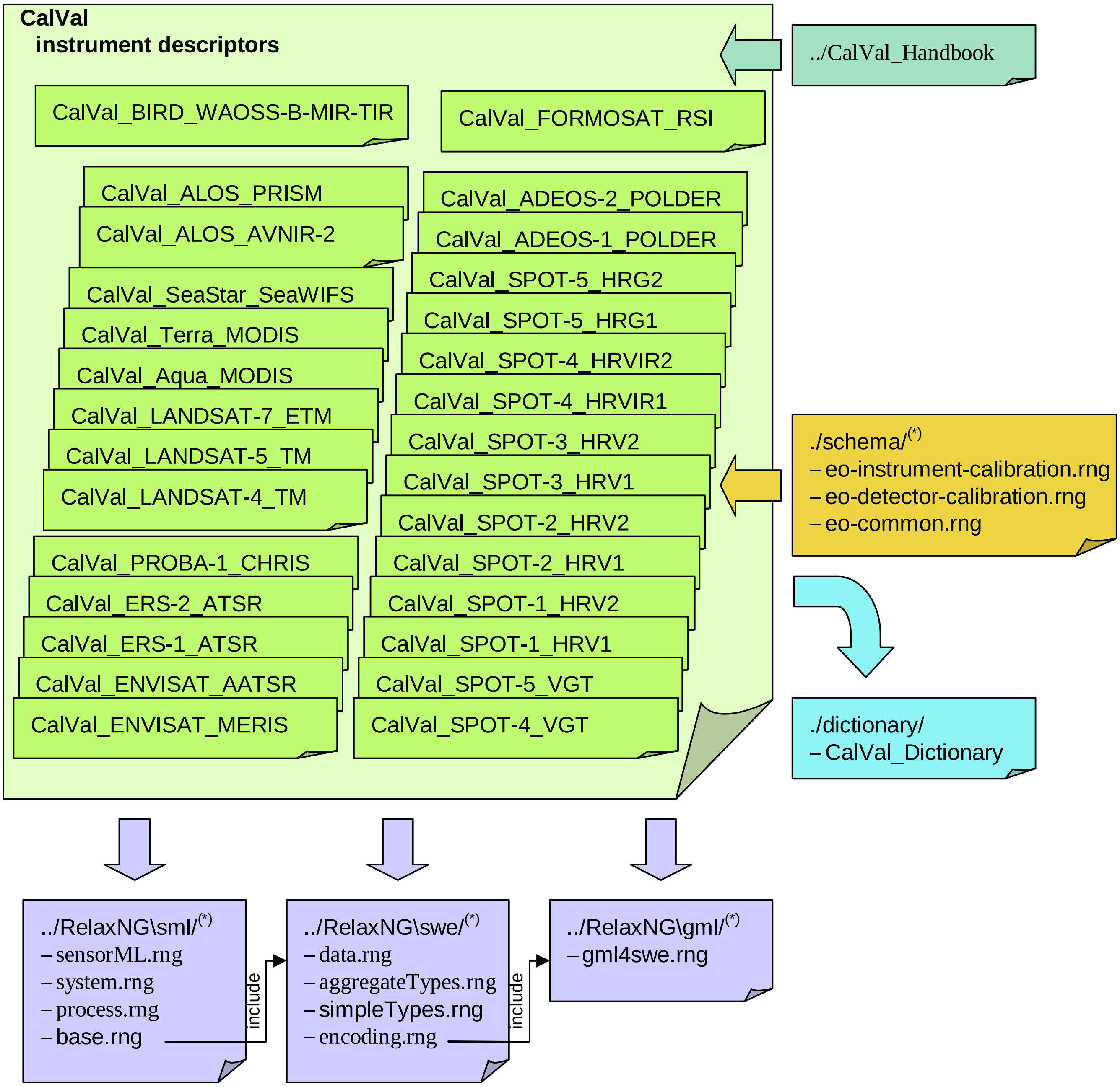
**(sensor) platform** — An entity to which can be attached sensors or other platforms. A *platform* has an associated local coordinate frame that can be referenced to an external coordinate reference frame and to which the frames of attached sensors and platforms can be referenced.

**system** — Composite model of a group or array of components, which can include detectors, actuators, or sub-systems. A system relates a process chain to the real world and therefore provides additional definitions regarding relative positions of its components and communication interfaces.

**transducer** — An entity that receives a signal as input and outputs a modified signal as output. Includes *detectors*, *actuators*, and *filters*.

# 2 ARCHITECTURE AND RECOMMENDATIONS

The proposed architecture aims to be as simple as possible while enabling scientists to add their own instrument descriptors validated by a common schema and which definitions are stored in a common dictionnary.




(*) Documents of the “schema” and “RelaxNG” directories are listed in the inclusion orders.

*fig. 2 - Documents architecture.*

## 2.1 Instrument descriptors

### 2.1.1 Configuration management

#### 2.1.1.1 Naming convention

Instrument descriptors are named according to the following syntax:

CalVal_*Mission*_*Instrument*_v*NN*.xml

Where

*Mission* matches an unique identifier identifying the platform carrying the instrument. This name is exactly the one given by the agency or organisation in charge of the mission using the adequate upper-case and lower-case letters. When the platform is one instance of a platform family, a sequential number is usually appended the mission family name after an hyphen character (examples: SPOT-4, Landsat-7, IRS-1D...).

*Instrument* matches an unique identifier identifying the instrument carrying the instrument. This name is exactly the one given by the agency or organisation in charge of the mission using the adequate upper-case and lower-case letters. When the instrument is one instance of a platform family, or when more than one instrument of the same type is on-board a same platform, a sequential number is usually appended the mission family name (examples: HRV1 and HRV2 on-board SPOT-1, SPOT-2 or SPOT-3...).

*NN* is a 2-digits version number of the CalVal description of this (mission, instrument) starting from 01.

For its first delivery, the following instrument descriptors have been released:

CalVal_ALOS_AVNIR-2_v01.xml
CalVal_ALOS_PRISM_v01.xml
CalVal_AQUA_MODIS_v01.xml
CalVal_ENVISAT_AATSR_v01.xml
CalVal_ENVISAT_MERIS_v01.xml
CalVal_ERS-1_ATSR-1_v01.xml
CalVal_ERS-2_ATSR-2_v01.xml
CalVal_LANDSAT-4_TM_v01.xml
CalVal_LANDSAT-5_TM_v01.xml
CalVal_LANDSAT-7_ETM_v01.xml
CalVal_PROBA-1_CHRIS_v01.xml
CalVal_SeaStar_SeaWIFS_v01.xml
CalVal_SPOT-1_HRV1_v01.xml
CalVal_SPOT-1_HRV2_v01.xml
CalVal_SPOT-2_HRV1_v01.xml
CalVal_SPOT-2_HRV2_v01.xml
CalVal_SPOT-4_HRVIR1_v01.xml
CalVal_SPOT-4_HRVIR2_v01.xml
CalVal_SPOT-5_HRG1_v01.xml
CalVal_SPOT-5_HRG2_v01.xml
CalVal_TERRA_MODIS_v01.xml

#### 2.1.1.2 Version management

Any change in the contents of a instrument descriptor will produce a new version of the document. Versioning is simply managed incrementing the 2-digits version number and adding a record in the "HISTORY OF MODIFICATIONS" header.

The "COPYRIGHT NOTICE" shall be reproduced adding the name, company and e-mail address of the contributor(s).

```
<!--
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  contributors are preserved. Do not hesitate to contact the developers
  for more information.

  Initial Developers:
    Alexandre Robin - Sensia Software LLC <alex.robin@sensiasoftware.com>
    Serge Riazanoff - VisioTerra SARL <Serge.Riazanoff@visioterra.fr>

  Contributors:

************************** HISTORY OF MODIFICATIONS ************************
  2006-12-19: Creation of First Version
  2007-05-19: Updated to validate with SensorML schema v1.0
  2007-08-03: Changed hierarchy of camera outputs

-->
```

### 2.1.2 Instrument descriptor contents

#### 2.1.2.1 SensorML

The SensorML element is the root of the description. Each instrument is described as a "member". Because Earth observation instruments are almost always composed of more than one camera and/or more than one CCD array, the description is done through "components". Measurements performed by the components are listed in the "outputs" element.

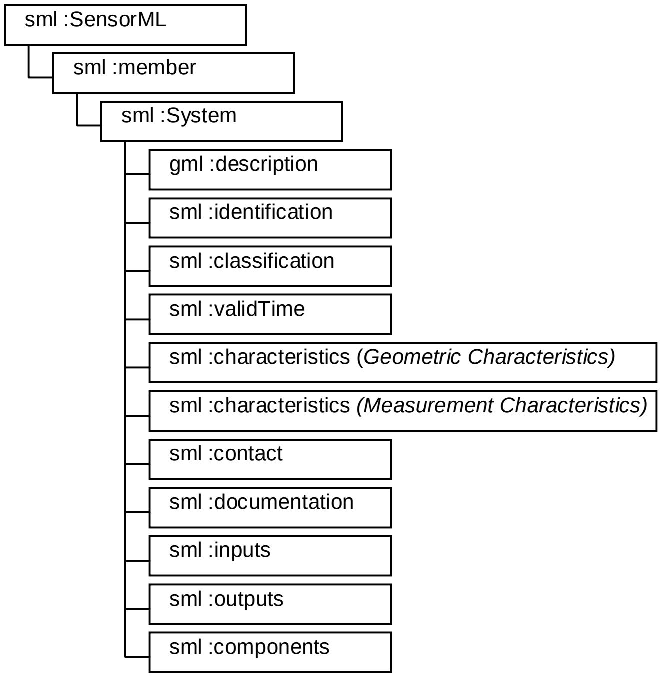


*fig. 3 - CalVal structure – "SensorML" element*

### 2.1.2.2 sml:identification

The "gml:description" is completed by a SensorML identification giving the UID of the system, a short and a long name of the instrument and the name of the mission.

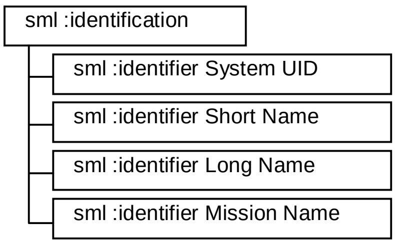


*fig. 4 - CalVal structure – "identification" element*

#### 2.1.2.3 sml:classification

Scope of the classification is to provide with generic classes that will enable further automatic processing of the measurements for this instrument.

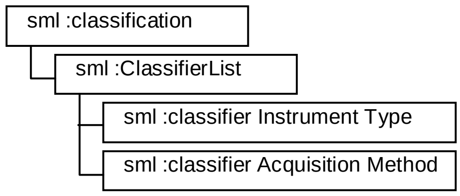


*fig. 5 - CalVal structure – "classification" element*

#### 2.1.2.4 sml:validTime

Validity time is the only one of the three constraints (securityConstraints, validTime, and legalConstraints) that has been kept for the description of the instruments.

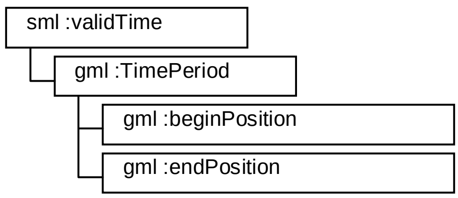


*fig. 6 - CalVal structure – "validTime" element*

#### 2.1.2.5 sml:characteristics (Geometric Characteristics)

This block of information gives high-level characteristics of the instrument geometry (for example the swath width).

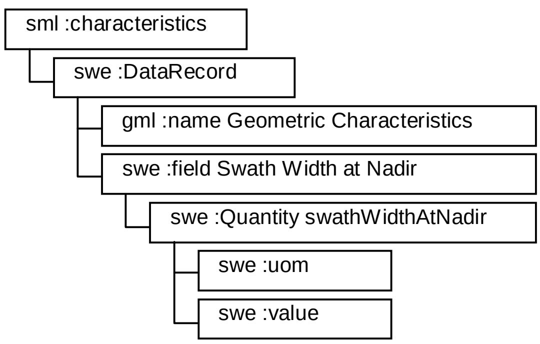


*fig. 7 - CalVal structure – "(Geometric) characteristics" element*

#### 2.1.2.6 sml:characteristics (Measurement Characteristics)

This block of information gives high-level characteristics of the measurement (for example the number of bands).

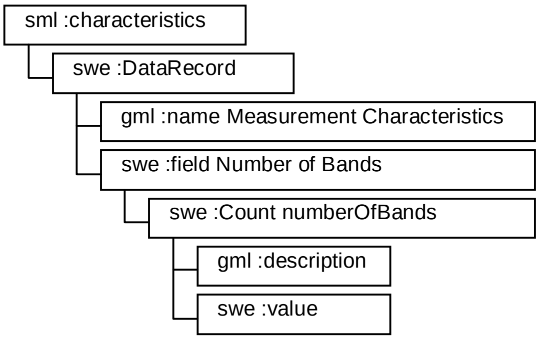


*fig. 8 - CalVal structure – "(Measurement) characteristics" element*

#### 2.1.2.7 sml:contact

This block of information provides with the name and address of the agency in charge of the mission and the with the person to contact in the framework of calibration-validation activities.

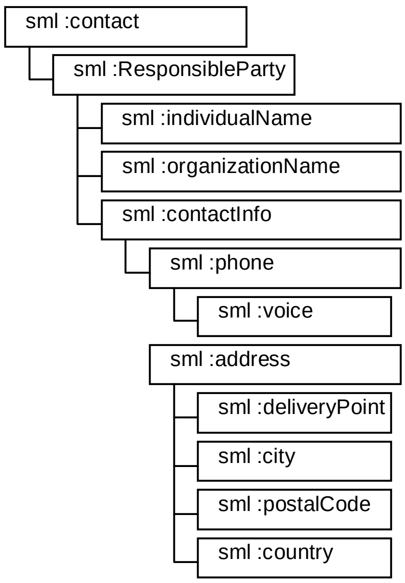


*fig. 9 - CalVal structure – "contact" element*

#### 2.1.2.8 sml:documentation

Scope of this element is to provide with the description and link of the document(s) describing the instrument, its physical characteristics, its measurements and possibly products.

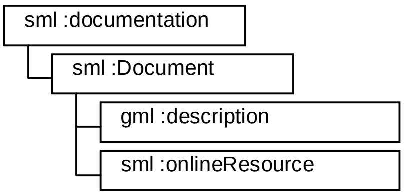


*fig. 10 - CalVal structure – "documentation" element*

#### 2.1.2.9 sml:inputs

Input of an Earth observation instruments is the observable property measured by this instrument.

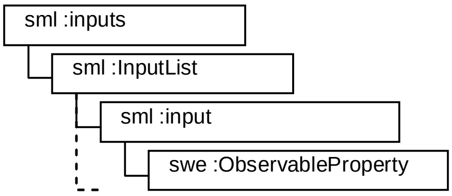


*fig. 11 - CalVal structure – "inputs" element*

#### 2.1.2.10 sml:outputs

This block defines the output(s) of the instrument. One instrument may be composed of different parts (for example more than one camera or more than one CCD array). Depending on the level of the description, one may detail one "sml:output" per part or an unique component considering the data processing that leads to a "virtual" unit (for example an unique CCD array resampling the measurements).

In the same way, the spectral bands acquired by the instrument will to the definition of different "swe:field" elements (one per band).

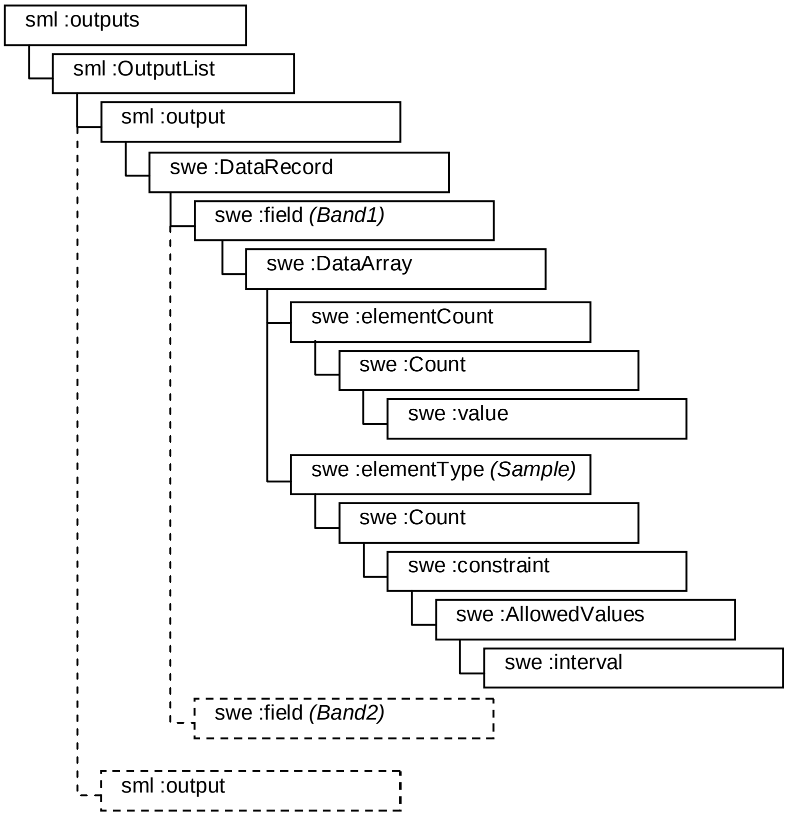


*fig. 12 - CalVal structure – "outputs" element*

#### 2.1.2.11 sml:components

Components of the instrument are fully described in the "components" block. According to SensorML, this block gives the identification, characteristics and parameters of each component.

In the framework of the CalVal project, characteristics are divided in "Geometric" and "Measurement" features.

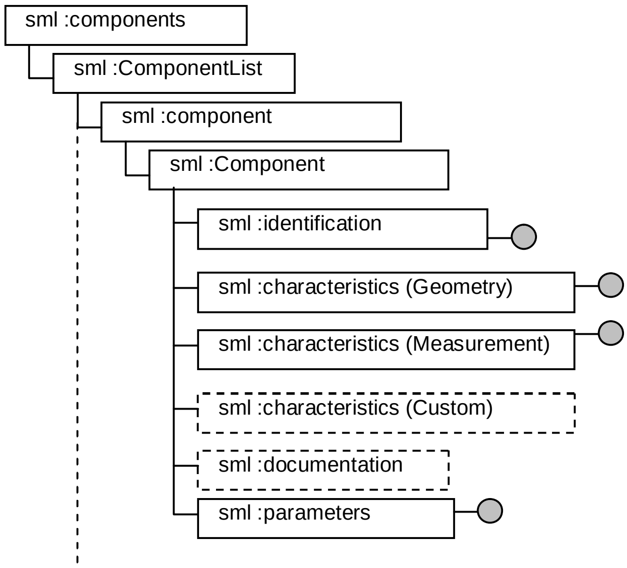


*fig. 13 - CalVal structure – "components" element*

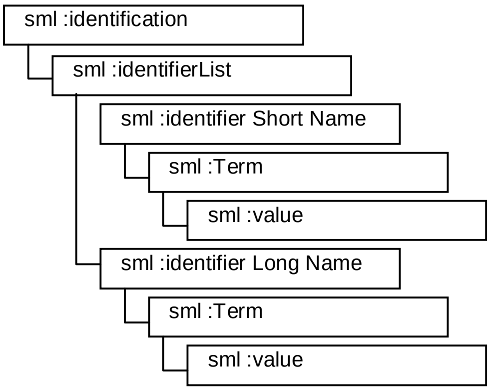


*fig. 14 - CalVal structure – "Component : identification" element*

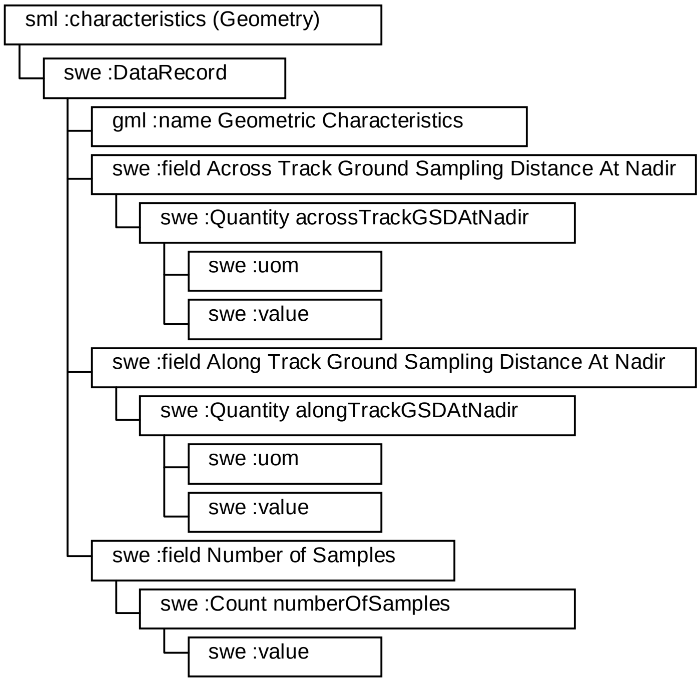


*fig. 15 - CalVal structure – "Component : characteristics (Geometry)" element*

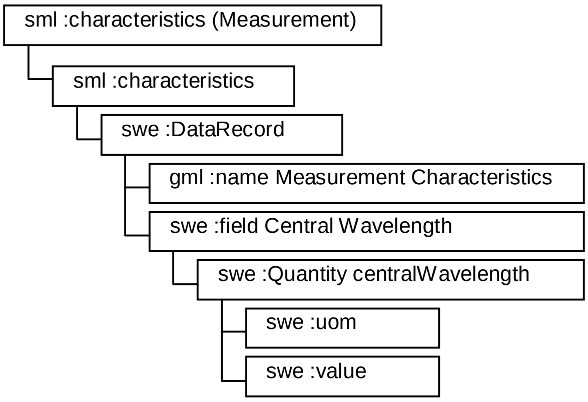


*fig. 16 - CalVal structure – "Component : characteristics (Measurement)" element*

### 2.1.2.12 sml:parameters

The "parameters" blocks give the values that will enable analyzing how measurements have been acquired and processed in the CalVal context.

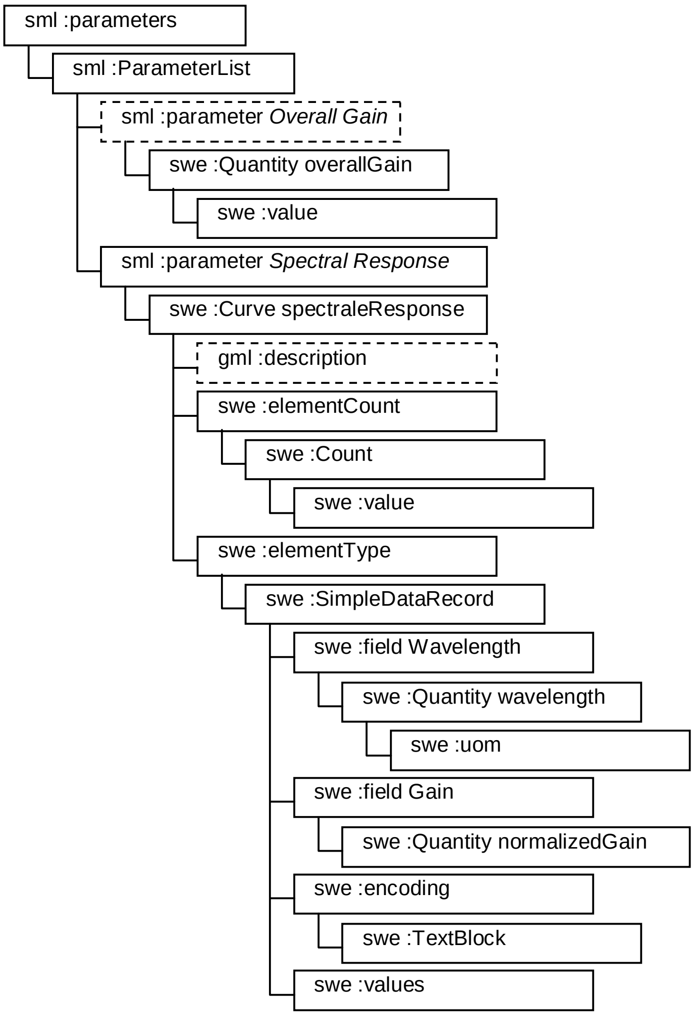


*fig. 17 - CalVal structure – "Component:parameters" element*

## 2.2 <u>CalVal dictionary</u>

### 2.2.1 Configuration management

### 2.2.2 Document structure

## 2.3 CalVal schemas

### 2.3.1 Configuration management

### 2.3.2 Document structure

# 3 ELEMENT DESCRIPTION

This section is an enhanced and formatted version of the information to be found in the "CalVal_Dictionary".

## 3.1 Central Wavelength

Attention au Smile effect -> C'est une MEAN Central Wavelength

Note that the central wavelength is not always given for all the instruments. One may compute this central wavelength $\lambda_C$ from the spectral response values $R[\lambda_i]$ using the following formula:

$$\lambda_C(k) = \frac{\sum_{i=1}^{n_k} \lambda_i(k) \times R[\lambda_i(k)]}{\sum_{i=1}^{n_k} R[\lambda_i(k)]}$$

Such a computation has been performed for example for the SPOT instruments. In this case, we suggest to had a comment indicating that this characteristics has not been provided by the mission manager (see example here below of the panchromatic band of the SPOT-1/HRV1 instrument).

```
<swe:field name="Central Wavelength">
   <swe:Quantity
    definition="urn:x-esa:def:phenomenon:ESA:centralWavelength">
      <swe:uom code="nm"/>
      <!-- This value has been integrated from the spectral responses -->
      <swe:value>615.90</swe:value>
   </swe:Quantity>
</swe:field>
```

## 3.2 Component

## 3.3 Number of Bands

Band = image measurements

Cas de SPOT avec le spectral mode.

Cas de SPOT-5 avd 2 bands HMA et HMB

## 3.4 Observable Property

The « swe:ObservableProperty » part of « sml :inputs » defines the physical phenomenon being measured by the instrument.

In most of the cases, the object of the measure is “Radiation” for the passive instruments and “Backscattering” for Radar instruments.

## 3.5 Outputs

This block gives the outputs of the instrument.

Example here below shows the outputs (one panchromatic band and three multispectral bands) of the SPOT-1/HRV1 instrument. When a CCD array of a pushbroom instrument is concerned, the number of CCDs and the range of the digital counts shall be given.

Note that if the successive bands (XS2 and XS3 in our example) have the same characteristics as the first band (XS1), data are not copied and the characteristics are just pointed using a named xlink (here “XS_BAND_DAT”).

```
<!-- ================================================= -->
<!--                  System Outputs                   -->
<!-- ================================================= -->
<sml:outputs>
   <sml:OutputList>
      <sml:output name="HRV1">
         <swe:DataRecord gml:id="SCANLINE_DATA">
            <swe:field name="PAN_Band">
               <swe:DataArray gml:id="PAN_BAND_DATA">
                  <swe:elementCount>
                     <swe:Count>
                        <swe:value>6000</swe:value>
                     </swe:Count>
                  </swe:elementCount>
                  <swe:elementType name="Sample">
                     <swe:Count definition="urn:x-esa:def:phenomenon:ESA:DN">
                        <swe:constraint>
                           <swe:AllowedValues>
                              <swe:interval>0 255</swe:interval>
                           </swe:AllowedValues>
                        </swe:constraint>
                     </swe:Count>
                  </swe:elementType>
               </swe:DataArray>
            </swe:field>
            <swe:field name="XS1_Band">
               <swe:DataArray gml:id="XS_BAND_DATA">
                  <swe:elementCount>
                     <swe:Count>
                        <swe:value>3000</swe:value>
                     </swe:Count>
                  </swe:elementCount>
                  <swe:elementType name="Sample">
                     <swe:Count definition="urn:x-esa:def:phenomenon:ESA:DN">
                        <swe:constraint>
                           <swe:AllowedValues>
                              <swe:interval>0 255</swe:interval>
                           </swe:AllowedValues>
                        </swe:constraint>
                     </swe:Count>
                  </swe:elementType>
               </swe:DataArray>
            </swe:field>
            <swe:field name="XS2_Band" xlink:href="#XS_BAND_DATA"/>
            <swe:field name="XS3_Band" xlink:href="#XS_BAND_DATA"/>
         </swe:DataRecord>
      </sml:output>
   </sml:OutputList>
</sml:outputs>
```

## 3.6 Spectral response

Table showing the spectral response of a detector by giving pairs of (wavelength, normalized response) values.

Also called "Relative Spectral Response" (RSR).

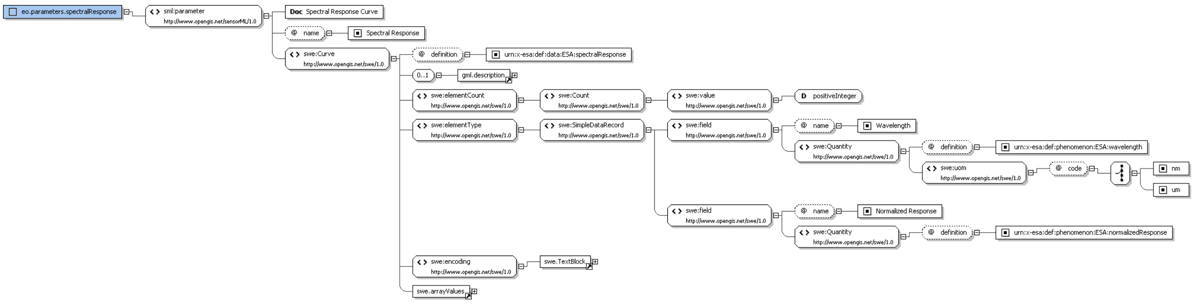


*fig. 18 - Spectral response model.*

## 3.7 System

When a sensor is complex (for example the MERIS instrument is composed of 5 cameras), one may define the SensorML member as a "System". Each part of the system (in our example, each camera of the MERIS instrument) is to be defined as an independent Component.

## 3.8 Validity Time

The "sml:validTime" gives the period(s) at which the measurements can be considered as valid. By default, this period starts at mission launch and ends at an "indeterminatePosition".