ESA's PSA: PDS3/4 Geometry Generation Pipeline

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Introduction: The geometry of the Planetary Data System (PDS) data of the European Space Agency (ESA) is displayed using a standardized data format that allows for the efficient storage and retrieval of data related to planetary missions. The PDS3[4] and PDS4[5] data formats are specifically designed to store and disseminate data from planetary missions, and both formats include metadata that describes the geometric properties of the data.

This abstract describes the complete automatic flow which receives, processes, standardizes, ingests and publishes PDS data in order to offer consistency in geometric data and a richer visualization in a Geographic Information System (GIS).

Pipeline Overview: The workflow starts with the reception of the data by the mission SOC, that launches the pipeline ingesting the raw data into the archive database and executing the following Python[2] code (Geogen[6]) which computes all geometry observations and updates the record in the database, thus making the data available in the map view automatically.

The following figure illustrate the complete data flow implemented in the Planetary Science Archive (PSA)[1], from the ingestion and generation of the geometry for the user to interact with it in the PSA user interface (PSA UI)[11]

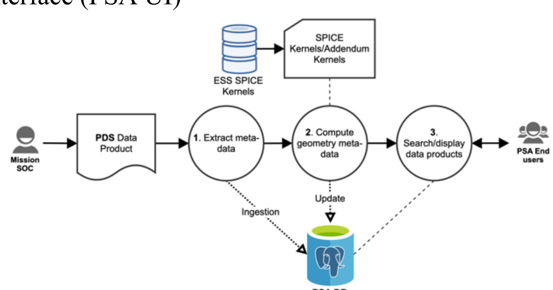

Figure 1: Overview of the PSA geometry generation end-to-end system

PDS Data: The geometry and coordinates of data in PDS3 and PDS4 are stored using a combination of tags, data structures, and other mechanisms that are designed to describe the spatial relationships between data points and their locations within a particular coordinate system.

In PDS3 data the geometry is found in the .LBL (label) files which in turn reference the file with the same name but with different extension, for example .TAB (table file), on the contrary in PDS4 data the geometry is found in the files with extension .XML (eXtensible Markup Language) which also refer to other files in the dataset such as .CSV (.Comma Separated Values)

```
OBJECT                 = COLUMN
  NAME                 = START_POINT_LATITUDE
  START_BYTE           = 336
  BYTES                =   7
  DATA_TYPE            = ASCII_REAL
  FORMAT               = "F7.3"
  UNIT                 = "DEGREE"
  NOT_APPLICABLE_CONSTANT = 999.999
  VALID_MAXIMUM        =  90.000
  VALID_MINIMUM        = -90.000
  DESCRIPTION          = "No description available. "
END_OBJECT             = COLUMN
OBJECT                 = COLUMN
  NAME                 = START_POINT_LONGITUDE
  START_BYTE           = 344
  BYTES                =   7
  DATA_TYPE            = ASCII_REAL
  FORMAT               = "F7.3"
  UNIT                 = "DEGREE"
  NOT_APPLICABLE_CONSTANT = 999.999
  VALID_MAXIMUM        = 359.999
  VALID_MINIMUM        =   0.000
  DESCRIPTION          = "No description available. "
```

Figure 2: Example of geometry metadata in a PDS3 label

```
<Discipline_Area>

  <geom:Geometry>

    <!-- <geom:SPICE_Kernel_Files/> -->
    <!-- <geom:Image_Display_Geometry/> -->


    <geom:Geometry_Orbiter>
      <geom:geometry_reference_time>2015-10-04T00:00:00Z</geom:geometry_reference_time>
      <geom:Reference_Frame_Identification/>

      <geom:Coordinate_System>
        <geom:coordinate_system_type>type</geom:coordinate_system_type>
        <geom:coordinate_system_time>2015-10-04T00:00:00Z</geom:coordinate_system_time>
        <geom:Coordinate_System_Origin_Identification></geom:Coordinate_System_Origin_Identification>
        <geom:Reference_Frame_Identification></geom:Reference_Frame_Identification>
      </geom:Coordinate_System>

      <geom:Target_Identification/>

      <geom:Distances>
        <geom:spacecraft_heliocentric_distance unit="AU">0</geom:spacecraft_heliocentric_distance>
      </geom:Distances>

      <geom:Illumination_Geometry>
        <geom:Illumination_Single_Values>
          <geom:emission_angle unit="deg">0</geom:emission_angle>
          <geom:incidence_angle unit="deg">0</geom:incidence_angle>
          <geom:phase_angle unit="deg">0</geom:phase_angle>
        </geom:Illumination_Single_Values>
        <geom:Illumination_FOV_Range_Values>
          <geom:illumination_range_designation>0</geom:illumination_range_designation>
        </geom:Illumination_FOV_Range_Values>
      </geom:Illumination_Geometry>


    </geom:Geometry_Orbiter>
  </geom:Geometry>

</Discipline_Area>
```

Figure 3: Example of geometry metadata in a PDS4 label

PDS Data Computation: In order to enable PSA end-users with searching capabilities for all observational data products based on geometrical parameters in a consistent way and starting from the information provided by labels, this geometry is computed, standardized and ingested in a format interoperable by many systems such as the geometry format of Postgis[10], which we can use from software such as QGIS[9] directly, export it to Geojson[8] or to another format etc.

The pipeline is a SPICE-based command line written in Python which from a specific dataset, instrument, dataset list etc, as it can be run with different inputs, extracts the necessary information from the labels and with that minimal information the SPICE kernels and the "addendums" text kernels, used to define supplementary information required to interpret the applicable detector geometry model, processes the geometry data, generating the geometry metadata including the observational geometry parameters and the footprint of each observation which are ingested into the archive database.

In case the footprint crossing the antimeridian and/or crossing the north or south poles, the geometry is splitted using TAMN[7] and the fixed geometry is ingested while maintaining the original geometry at all times. This is important because when displaying the information on the map, depending on the projection used by the user, we will have to show one or the other to avoid distortions.

The pipeline has been configured, tested and is being operationally used for:

Mission	Instruments
Mars Express	HRSC, MARSIS, PFS ASPERA 3, OMEGA, SPICAM, VMC
Rosetta	OSIWAC, OSINAC, NAVCAM, ALICE, VIRTIS, MIRO
ExoMars 2016	CASSIS

PDS Data Visualization: To visualize PDS data in a user-friendly way and using the common tools of any GIS, facilitating analysis, search and access to the data, all of which are available in the PSA UI.

All this provides many new use cases to the scientific community such as the possible comparison of the geometry coming from the labels and the geometry computed by the pipeline, the possible downloading of both and obviously the visualisation on a map.

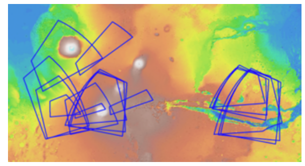

Figure 4: PDS3 visualization

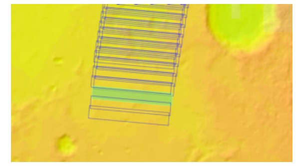

Figure 5: PDS4 visualization

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References:

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[6] N. Manaud (2019), Geogen software, http://www.spacefrog.design/ ,
[7] J. Gasperi (2019), The AntiMeridian Nightmare (TAMN) software, https://snapplanet.io/,
[8] Butler, et al., The GeoJSON Specification (RFC 7946), https://tools.ietf.org/html/rfc7946,
[9] QGIS, http://www.qgis.org/
[10]PostGIS,http://postgis.net/,
[11] PSA UI, https://psa.esa.int

Additional Information:

Further information about ESA's Planetary EPSC Science Archive and the data workshops can be found here: https://psa.esa.int