FarEarth for SmallSats

Data Format Control Book: L1C

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Change Control

Description	Person	Type of Change	Version	Date
First draft	Rob Furney	First draft	Rev 1.0	2024/02/21
Update	Rob Furney	Added colouring to JSON tables. Quality and attitude reports added back in. Metadata: 1. Viewing geometry is now latLong based instead of pixel 2. Added spectral group for sensor configurations 3. Added quality metrics per sensor 4. Changed the geometry tag to be a 3 dimensional array	Rev 2.0	2024/03/14
Update	Rob Furney	Metadata file: Changed the geometry tag to be a 3 dimensional array	Rev 3.0	2024/06/06

Notices

- **Although Pinkmatter takes care to follow industry best practices, we reserve the right to make periodic updates and changes to our data format, imagery products and workflows.**
- **Any files present in products that are not documented in the Data Format Control Books are for Pinkmatter use.**

Contents

1 Introduction

This document contains details of the L1C products generated by *FarEarth*. An L1C product is an orthorectified image that has been corrected and projected.

2 L1C files

The following table shows the files generated for each L1C product.

Name	Type	Roles	File Extension
Product File	application/geo+json		.json
Metadata	application/geo+json	metadata	.geojson
Thumbnail RGB	image/png	thumbnail	.png
Attitude Report	application/json	metadata	.json
Quality Report	application/json	metadata	.json

Table 1: L1C Product Files

Table 2 describes files produced for each group. Bands are collected into groups with similar resolutions.

Name	Type	Roles	File Extension
<GRP> image	image/tif	data	.tif
<GRP> QA	image/tif	quality	.tif

Table 2: L1C Files produced per band

2.1 Product file

The L1C Product File is a JSON file that complies with the STAC Item format. The keys and their contents are described in Table 3. Below the table is an example of an L1C Product File.

Element	Content Type	Description
type	string	Always “Feature”
id	string	The ID should be unique across the collection. It is recommended to use an ID that includes the acquisition date and source of the data.
geometry	object	May be null if the location of the image is provided in the data file (GeoTIFF), otherwise defines the full footprint of the asset represented by this item. Formatted according to RFC 7946, section 3.1. The footprint should be the default GeoJSON geometry, though additional geometries can be included. Coordinates are specified in Longitude/Latitude or Longitude/Latitude/Elevation based on WGS 84.
type	string	
properties	object	
geometry	object	
type	string	
coordinates	number array	
bbox	number array	Required if the geometry is not null. Bounding Box of the asset represented by this Item. Formatted according to RFC 7946, section 5.
properties	object	A dictionary of additional metadata for the Item.
datetime	string	An ISO-8601-formatted string to indicate the imagery date, e.g. “2019-10-25T09:00:00Z”
spacecraft	string	Name of the spacecraft.
correlationId	string	A unique identifier that is propagated from the input product file to the output product file.
productType	string	Indicates the product type of the asset. **L1C**
instruments	string array	A list of the sensors used to produce the data.
assets	object	Dictionary of asset objects. Only assets included in this list will be used in the workflow.
href	string	URI to the asset object **relative to the location of this file**.
title	string	The displayed title for clients and users.
type	string	Media type of the asset.
roles	string array	The semantic roles of the asset.
size	number	The size of the asset in bytes.
links	string array	
stac_version	string	Version of the STAC interface. Formatted as “X.Y.Z” where X, Y, and Z are numbers.

Table 3: L1C product file key and value pairs

An example of an L1C Product file is shown below:


```
{
  "type" : "Feature",
  "id" : "SPUTNIK_MS1_20220207T040105_20220207T040110_L1C",
  "assets" : {
    "METADATA" : {
      "title" : "Metadata", "roles" : ["metadata"],
      "href" : "SPUTNIK_MS1_20220207T040105_20220207T040110_L1C.geojson",
      "size" : 16649
    },
    "THUMB_RGB" : {
      "title" : "Thumbnail: RGB", "type" : "image/png", "roles" : ["thumbnail"],
      "href" : "SPUTNIK_MS1_20220207T040105_20220207T040110_L1C_RGB.png",
      "size" : 517664
    },
    "MS_QA" : {
      "title" : "Blue quality mask", "roles" : ["quality"],
      "href" : "SPUTNIK_MS1_20220207T040105_20220207T040110_L1C_MS_QA.tif",
      "size" : 30764
    },
    "MS" : {
      "title" : "Blue image", "roles" : ["data"],
      "href" : "SPUTNIK_MS1_20220207T040105_20220207T040110_L1C_MS.tif",
      "size" : 86648321
    }
  },
  "bbox" : [ 149.504, -31.848, 149.817, -31.519],
  "geometry" : {
    "type" : "Feature",
    "properties" : { },
    "geometry" : {
      "type" : "Polygon",
      "coordinates" : [ [
        [ 145.591, -35.519 ], [ 145.591, -35.519 ], [ 145.817, -35.548 ],
        [ 145.736, -35.846 ], [ 145.590, -35.519 ], [ 145.591, -35.519 ]
      ] ]
    }
  },
  "properties" : {
    "spacecraft" : "Sputnik",
    "datetime" : "2022-02-07T04:01:05Z",
    "instruments" : [ "MS1" ],
    "id" : "SPUTNIK_MS1_20220207T040105_20220207T040110_L1C",
    "productType" : "L1C",
    "orderId" : "AAAA-9223",
    "subscriptionId" : "farearth"
  },
  "links" : [ ],
  "stac_version" : "0.9.0"
}
```


2.2 Metadata

Metadata for the product is stored in a GeoJSON FeatureCollection format compliant with RFC7946. A single feature is present inside the collection per L1C product.

Only the custom properties that are specific to *FarEarth* are documented in the table below:

Element	Content Type	Description
properties	object	
product	object	
descriptor	object	
productId	string	The name of this product made up of spacecraft, sensors, from date, to date and product type.

Element	Content Type	Description
productType	string	Always “L1C” for this product type.
spacecraft	string	The name of the spacecraft.
sensors	string array	An array of sensors on the spacecraft. There is one entry in the product/sensors array for each entry in this array.
temporalRange	object	
from	string	An ISO-8601-formatted string to indicate the start date and time the data was captured, e.g. “2019-10-25T09:00:00Z”
to	string	An ISO-8601-formatted string to indicate the end date and time the data was captured, e.g. “2019-10-25T09:00:00Z”
generationDate	string	An ISO-8601-formatted string to indicate the date the product was generated, e.g. “2019-10-25T09:00:00Z”
sensors	object array	An array with each object representing a sensor on the spacecraft.
descriptor	object	
name	string	Name of the sensor.
id	string	ID of the sensor.
ancillaries	object	
cpf	string	Filename of the Calibration Parameter File used by this product.
rpf	string	Filename of the Radiometric Parameter File used by this product.
images	object array	
group	string	Name of the group.
ids	string array	Band IDs of all the bands in this group.
bands	string array	Band names of all the bands in this group.
image	string	Filename of this groups data.
qaMask	string	Filename of the qa mask file for this group.
radiometric	object	
units	string	Units the Digital Numbers in the data files represent.
esun	object array	Array of ESUN values for each band.
band	string	Name of the band.
value	number	ESUN value.
units	string	The units of the ESUN value.
Each band’s ESUN value		
spectral	object array	
band	string	Band name.
centerWavelength	number	The centre wavelength of the band.
fullWidthHalfMax	number	The full-width-half-maximum wavelength difference from the centre wavelength.

Element	Content Type	Description
Each band's spectral characteristics		
earthSunDistance	number	Earth-sun distance.
solarElevation	number	Solar elevation.
solarAzimuth	number	Solar azimuth.
geometric	object	
quality	object	
bandAlignment	object	
systematicBands	string array	Bands that were corrected using a direct application of the geometric sensor model.
precisionBands	string array	Bands that were corrected by nesting with other bands.
projection	string	Projection of the geometry object.
dimensions	number array	Across and along track pixel dimensions.
resolution	number array	Across and along track GSD.
geometry	object array	Array of coordinates in the projection specified. This may contain additional list(s) of hole areas.
-	object array	
-	number array	Coordinate pairs in the projection specified.
Geometry polygon coordinates		
viewingGeometry	object array	
latLong	number array	Latitude and longitude coordinates.
incidenceZenith	number	The incidence zenith at the specified coordinates.
incidenceAzimuth	number	The incidence azimuth at the specified coordinates.
Viewing geometry for multiple points		
An image object for each group		
quality	object	
geometric	object	
orthorectification	string	Systematic or precision. **precision**: Ground control points and elevation data are used. **systematic**: Raw application of the geometric sensor model. No elevation data is used.
metrics	object	
<sensor name>	object array	Array of pixels and coordinates.
location	string	String indicating the position of the pixel in the image.
systematicLocation	number array	Coordinates of the pixel when located using a systematic algorithm.
precisionLocation	number array	Coordinates of the pixel when located using a precision algorithm.
disparityMeter	number	The distance between the systematic and precision locations.

Element	Content Type	Description
Metrics for multiple locations		
Metrics may be included for multiple sensors		
Sensor object for each sensor		
thumbnails	object array	Array of thumbnails available in the product
name	string	Name of the thumbnail
image	string	Filename of the thumbnail
elevation	object	
averageMsl	number	Average mean sea level
averageHae	number	Average height above ellipsoid.

Table 4: Metadata key and value pairs

An example of the metadata file is included below:


```
{
  "type": "FeatureCollection",
  "features": [ {
      "type": "Feature",
      "properties": {
        "product": {
          "descriptor": {
            "productId": "SPUTNIK_MS1_20231103T093915_20231103T093925_L1C",
            "productType": "L1C",
            "spacecraft": "Sputnik",
            "sensors": [ "MS1" ],
            "temporalRange": {
              "from": "2023-11-13T09:19:15.732635Z",
              "to": "2023-11-13T09:19:25.706286Z"
            },
            "generationDate": "2024-02-01T14:34:07.977760Z"
          },
          "sensors": [ {
              "descriptor": {
                "name": "MS1",
                "id": "Primary",
                "ancillaries": {
                  "cpf": "CPF_SPUTNIK_MS1_20221004_20290923_03.json",
                  "rpf": "RPF_SPUTNIK_MS1_20220101_20311231_01.h5"
                }
              },
              "images": [ {
                "group": "MS",
                "ids": [ "pan", "blue", "green", "red" ],
                "bands": [ "pan", "blue", "green", "red" ],
                "image": " SPUTNIK_MS1_20231103T093915_20231103T093925_L1C_MS.tif",
                "qaMask": " SPUTNIK_MS1_20231103T093915_20231103T093925_L1C_MS_QA.tif",
                "radiometric": {
                  "units": "TOA Reflectance x 10k",
                  "esun": [ {
                    "band": "pan", "value": 1653.287, "units": "W / (m^2 * um)"
                  } ],
                  "spectral": [ {
                    "band": "red", "centerWavelength": 600.0, "fullWidthHalfMax": 50.0
                  } ],
                  "earthSunDistance": 0.9920991441297553,
                  "solarElevation": 68.0310774907989,
                  "solarAzimuth": 33.46302087982758
                },
                "geometric": {
                  "quality": {
                    "bandAlignment": {
                      "systematicBands": [],
                      "precisionBands": [ "blue", "green", "red"]
```

```
                    }
                  },
                  "dimensions": [ 2000, 6000 ],
                  "projection": "EPSG:32734",
                  "resolution": [ 5.0, -5.0 ],
                  "geometry": [ [
                    [ 282288.051, 6214367.022 ], [ 264683.218, 6291122.260 ],
                    [ 287043.375, 6294537.712 ], [ 304660.950, 6217772.732 ],
                    [ 282288.051, 6214367.022 ]
                  ] ]
                },
                "viewingGeometry": [ {
                  "latLong": [ 18.637, -34.188 ],
                  "incidenceZenith": 1.574,
                  "incidenceAzimuth": -90.615
                }, {
                  "latLong": [ 18.637, -34.188 ],
                  "incidenceZenith": 1.543,
                  "incidenceAzimuth": -88.431
                } ]
              } ],
              "quality": {
                "geometric": {
                  "orthorectification": "precision",
                  "metrics": {
                    "MS1": [ {
                        "location": "UL",
                        "systematicLocation": [ 0.0192, 41.932 ],
                        "precisionLocation": [ 0.0232, 41.938 ],
                        "disparityMeter": 702.626
                      }, {
                        "location": "LL",
                        "systematicLocation": [ -0.054, 41.712 ],
                        "precisionLocation": [ -0.049, 41.717 ],
                        "disparityMeter": 721.592
                      } ]
                    }
                  }
                }
              }
            ],
            "thumbnails": [ {
                "name": "RGB",
                "image": "SPUTNIK_MS1_20231103T093915_20231103T093925_L1C_RGB.png"
            } ],
            "elevation": {
              "averageMsl": 97.92066296051658,
              "averageHae": 129.24883725431786
            }
          }
        },
        "geometry": {
          "type": "Polygon",
          "coordinates": [
            [ [ 18.637, -34.188 ], [ 18.467, -33.493 ], [ 18.708, -33.467 ],
              [ 18.880, -34.162 ], [ 18.637, -34.188 ]
            ]
          ]
        }
    } ]
}
```


2.3 Attitude report

An attitude report is generated if the L1C product is generated using precision modelling.

2.4 Quality report

A quality report is generated for each L1C product. This is a JSON file; the content of the file is still under development.

2.5 Thumbnails

A small image suitable for display in a web browser representing the data files. The format and size of these images is configurable.

2.6 Group image

Image data is included in an L1C product in TIFF format. Bands that have similar dimensions are grouped together in a file. Bands are included in the same order they appear in the bands key in the metadata file. By default, L1C products produced by *FarEarth* use a data format of Int16 and a no data value of -9999.

2.7 Group QA

A Quality Assessment (QA) file is included for each group. The QA file is an 8-bit unsigned integer TIFF file that should not be interpreted as an image. The values in this file have discrete meanings regarding the pixels at the same coordinates in the image file. These discrete meanings are described in Table 5.

Value	Interpretation
0	No special information regarding this pixel.
1	The pixel is undersaturated.
2	The pixel is oversaturated.

Table 5: QA File interpretation