Planet Imagery Product Specifications

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Glossary

The following list defines terms used to describe Planet's satellite imagery products.

Alpha Mask
An alpha mask is an image channel with binary values that can be used to render areas of the image product transparent where no data is available.

Application Programming Interface (API)
A set of routines, protocols, and tools for building software applications.

Atmospheric Correction
The process of correcting at-sensor radiance imagery to account for effects related to the intervening atmosphere between the earth's surface and the satellite. Atmospheric correction has been shown to significantly improve the accuracy of image classification.

Blackfill
Non-imaged pixels or pixels outside of the buffered area of interest that are set to black. They may appear as pixels with a value of "0" or as "noData" depending on the viewing software.

Digital Elevation Model (DEM)
The representation of continuous elevation values over a topographic surface by a regular array of z-values, referenced to a common datum. DEMs are typically used to represent terrain relief.

GeoJSON
A standard for encoding geospatial data using JSON (see JSON below).

GeoTIFF
An image format with geospatial metadata suitable for use in a GIS or other remote sensing software.

Ground Sample Distance (GSD)
The distance between pixel centers, as measured on the ground. It is mathematically calculated based on optical characteristics of the telescope, the altitude of the satellite, and the size and shape of the CCD sensor.

Graphical User Interface (GUI)
Web based interfaces enable users to interact with Planet's imagery products without needing knowledge of how to use APIs or Application Programming Interfaces.

JavaScript Object Notation (JSON)
Text-based data interchange format used by the Planet API.

Landsat 8
Freely available dataset offered through NASA and the United States Geological Survey.

Metadata
Data delivered with Planet's imagery products that describes the products content and context and can be used to conduct analysis or further processing.

Nadir
The point on the ground directly below the satellite.

Near-Infrared (NIR)
Near Infrared is a region of the electromagnetic spectrum.

Orthorectification
The process of removing and correcting geometric image distortions introduced by satellite collection geometry, pointing error, and terrain variability.

Ortho Tile
Ortho Tiles are Planet's core product lines of high-resolution satellite images. Ortho tiles are available in two different product formats: Visual and Analytic, each offered in GeoTIFF format.

PlanetScope
The first three generations of Planet's optical systems are referred to as PlanetScope 0, PlanetScope 1, and PlanetScope 2.

Radiometric Correction
The correction of variations in data that are not caused by the object or image being scanned. These include correction for relative radiometric response between detectors, filling non-responsive detectors and scanner inconsistencies.

Reflectance Coefficient
The reflectance coefficient provided in the metadata is used as a multiplicative to convert Analytic TOA Radiance values to TOA Reflectance.

RapidEye
RapidEye refers to the five-satellite constellation operating between 2009 and 2020.

Scene
A single image captured by a PlanetScope satellite.

Sensor Correction
The correction of variations in the data that are caused by sensor geometry, attitude and ephemeris.

Sentinel-2
Copernicus Sentinel-2 is a multispectral imaging satellite constellation operated by the European Space Agency.

SkySat
SkySat refers to Planet's high resolution satellite constellation in operation since 2014.

Sun Azimuth
The angle of the sun as seen by an observer located at the target point, as measured in a clockwise direction from the North.

Sun Elevation
The angle of the sun above the horizon.

Sun Synchronous Orbit (SSO)
A geocentric orbit that combines altitude and inclination in such a way that the satellite passes over any given point of the planet's surface at the same local solar time.

Surface Reflectance (SR)
Surface reflectance is the amount of light reflected by the surface of the earth. It is a ratio of surface radiance to surface irradiance, and as such is unitless, and typically has values between 0 and 1. The Surface Reflectance (SR) Product is derived from the standard Planet Analytic (Radiance) Product and is processed to top of atmosphere reflectance and then atmospherically corrected to (bottom of atmosphere or) surface reflectance. Planet uses the 6S radiative transfer model with ancillary data from MODIS to account for atmospheric effects on the observed signal at the sensor for the PlanetScope constellation.

Tile Grid System
Ortho tiles are based on a worldwide, fixed UTM grid system. The grid is defined in 24 km by 24 km tile centers, with 1 km of overlap (each tile has an additional 500 m overlap with adjacent tiles), resulting in 25 km by 25 km tiles.

Unusable Data Mask

The unusable data mask is a raster image having the same dimensions as the image product, indicating on a pixel-by-pixel basis which pixels are unusable because they are cloud filled, outside of the observed area and therefore blackfilled, or the pixel value is missing or suspect (due to saturation, blooming, hot pixels, dust, sensor damage, etc). The unusable data mask is an 8-bit image, where each pixel contains a bit pattern indicating conditions applying to the imagery pixel. A value of zero indicates a "good" imagery pixel.

- Bit 0: Black fill - Identifies whether the area contains blackfill in all bands (this area was not imaged by the spacecraft). A value of "1" indicates blackfill.
- Bit 1: Cloud - This pixel is assessed to likely be an opaque cloud.
- Bit 2: Blue is missing or suspect.
- Bit 3: Green is missing or suspect.
- Bit 4: Red is missing or suspect.
- Bit 5: Red Edge is missing or suspect
- Bit 6: NIR is missing or suspect
- Bit 7: Coastal Blue and/or Green I and/or Yellow is missing or suspect

Usable Data Mask

The usable data mask is a raster image having the same dimensions as the image product, comprised of 8 bands, where each band represents a specific usability class mask. The usability masks are mutually exclusive, and a value of one indicates that the pixel is assigned to that usability class. Read more on [Planet's Developer Center - UDM2](#).

- Band 1: clear mask (a value of "1" indicates the pixel is clear, a value of "0" indicates that the pixel is not clear and is one of the 5 remaining classes below)
- Band 2: snow mask
- Band 3: shadow mask
- Band 4: light haze mask
- Band 5: heavy haze mask (all images acquired after November 29, 2023 will have a value of "0" in band 5)
- Band 6: cloud mask

- Band 7: confidence map (a value of “0” indicates a low confidence in the assigned classification, a value of “100” indicates a high confidence in the assigned classification)
- Band 8: unusable data mask (see Unusable Data Mask above)

1. Overview of Document

This document describes Planet satellite imagery products. It is intended for users of satellite imagery interested in working with Planet's product offerings.

1.1 COMPANY OVERVIEW

Planet uses an agile aerospace approach for the design of its satellites, mission control, and operations systems; and the development of its web-based platform for imagery processing and delivery. Planet employs an "always on" image capturing method as opposed to the traditional tasking model used by most satellite companies today.

1.2 DATA PRODUCT OVERVIEW

Planet operates the PlanetScope (PS) and SkySat (SS) Earth-imaging constellations. Imagery is collected and processed in a variety of formats to serve different use cases, be it mapping, deep learning, disaster response, precision agriculture, or simple temporal image analytics to create rich information products.

PlanetScope satellite imagery is captured as a continuous strip of single frame images known as "scenes." Scenes are derived from multiple generations of PlanetScope satellites. Older-generation of PlanetScope satellites acquired a single RGB (red, green, blue) frame or a split-frame with a RGB half and a NIR (near-infrared) half, depending on the capability of the satellite. The new generation of PlanetScope satellites (PS2.SD and PSB.SD) acquire images with a multistripe frame with bands divided between RGBNIR (PS2.SD) or RGBNIR, red edge, green I, yellow and coastal blue (PSB.SD).

Planet offers two product lines for PlanetScope imagery: a Basic Scene product and Ortho Scene product..The Basic Scene product is a scaled Top of Atmosphere Radiance (at sensor) and sensor-corrected product. The Basic Scene product is designed for users with advanced image processing and geometric correction capabilities. The product is not orthorectified or corrected for terrain distortions. Ortho Scenes represent the single-frame image captures as acquired by a PlanetScope satellite with additional post processing applied.

SkySat imagery is captured similar to PlanetScope in a continuous strip of single frame images known as "scenes," which are all acquired in the blue, green, red, nir-infrared, and panchromatic bands. SkySat data is available in four product lines: the Basic Scene, Ortho Scene, Basemap, and SkySat Collect products.

2. SATELLITE CONSTELLATION AND SENSOR OVERVIEW

2.1 PLANETSCOPE SATELLITE CONSTELLATION AND SENSOR CHARACTERISTICS

The PlanetScope satellite constellation consists of multiple launches of groups of individual satellites. Therefore, on-orbit capacity is constantly improving in capability or quantity, with technology improvements deployed at a rapid pace.

Each PlanetScope satellite is a CubeSat 3U form factor (10 cm by 10 cm by 30 cm). The complete PlanetScope constellation of approximately 130 satellites is able to image the entire land surface of the Earth every day (equating to a daily collection capacity of 200 million km^2/day). This capacity changes based on the number of satellites in orbit and throughout the season, as satellites image less in the northern hemisphere in the winter time because of a decrease in the amount of hours with sunlight.

PlanetScope satellites launched starting in November 2018 have sensor characteristics that enable improved spectral resolution. The second generation of PlanetScope satellites (known as Dove-R or PS2.SD) have a sensor plane consisting of four separate stripes organized vertically along the track of the flight path. PlaneScope images from PS2.SD satellites are available starting from March, 2019 (sparsely) to April 22, 2022.

A third generation of PlanetScope sensors (known as SuperDove or PSB.SD) is currently in orbit and is producing daily imagery with 8 spectral bands (coastal blue, blue, green I, green, red, yellow, red edge and near-infrared). These satellites were launched in early 2020 and started producing imagery in mid-March 2020. PSB.SD PlanetScope satellites reached near daily cadence in August 2021. Starting from April 29, 2022 all new PlanetScope images have 8-bands and are derived from the PSB.SD sensor (SuperDoves). The 8-Band PlanetScope images can be obtained using all Planet Platforms, Integrations and API. The item-type is PSScene.

Composite images with the second and third generation PlanetScope sensors are produced by an image registration process involving multiple frames ahead and behind an anchor frame. The band alignment is dependent on ground-lock in the anchor frame and will vary with scene content. For example, publication yield is expected to be lower in scenes over open water, mountainous terrain, or cloudy areas.

The band alignment threshold is based on across-track registration residuals, currently set to 0.3 pixels for “standard” PlanetScope products (instruments PS2.SD and PSB.SD), 0.5 pixels to qualify for “test.” Whether a PlanetScope image is classified as “standard” or “test” can be determined by looking at image GeoJSON metadata property “quality_category.”

Table 1-A: PlanetScope Constellation and Sensor Specifications

CONSTELLATION OVERVIEW: PLANETSCOPE			
Mission Characteristics	Sun-synchronous Orbit		
Instrument	**PS2**	**PS2.SD**	**PSB.SD**
Orbit Altitude (reference)	450 - 580 km (~98° inclination)		475 - 525 km

			(~98° inclination)
Field of View	3.0° (swath) 1.0° (scene length)	3.0° (swath) 2.0° (scene length)	4.0° (swath) 2.3° (scene length)
Max/Min Latitude Coverage		±81.5° (dependent on season)	
Equator Crossing Time		7:30 - 11:30 am (local solar time)	
Sensor Type	Four-band frame Imager with a split-frame VIS+NIR filter	Four-band frame imager with butcher-block filter providing blue, green, red, and NIR stripes	Eight-band frame imager with butcher-block filter providing coastal blue, blue, green I, green, yellow, red, red-edge, and NIR stripes
Spectral Bands	Blue: 455 - 515 nm Green: 500 - 590 nm Red: 590 - 670 nm NIR: 780 - 860 nm	Blue: 464 - 517 nm Green: 547 - 585 nm Red: 650 - 682 nm NIR: 846 - 888 nm	Coastal Blue 431-452 nm Blue: 465-515 nm Green I: 513. - 549 nm Green: 547. - 583 nm Yellow: 600-620 nm Red: 650 - 680 nm Red-Edge: 697 - 713 nm NIR: 845 - 885 nm
Ground Sample Distance (nadir)	3.0 m-4.1 m (approximate, altitude dependent)		3.7 m-4.2 m (approximate, altitude dependent)
Off-Nadir Angle		0° - 5° (latitude dependent)	
Frame Size	24 km x 8 km (approximate)	24 km x 16 km (approximate)	32.5 km x 19.6 km (approximate)
Maximum Image Strip per orbit		20,000 sq km	
Revisit Time		Daily at nadir	
Image Capture Capacity		200 million sq km/day	
Imagery Bit Depth		12-bit	
Availability Date	July 2014 - April 2022	March 2019 - April 2022	March 2020 - present

2.2 SKYSAT SATELLITE CONSTELLATION AND SENSOR CHARACTERISTICS

The SkySat-C generation satellite is a high-resolution Earth imaging satellite, first launched in 2016. Fourteen are currently in orbit, all collecting thousands of sq km of imagery. Each satellite is 3-axis stabilized and agile enough to slew between different targets of interest. Each satellite has four thrusters for orbital control, along with four reaction wheels and three magnetic torquers for attitude control.

All SkySats contain Cassegrain telescopes with a focal length of 3.6m, with three 5.5 megapixel CMOS imaging detectors making up the focal plane.

Table 1-B: SkySat Constellation Overview

CONSTELLATION OVERVIEW: SKYSAT

Attribute	Value
Mass	110 kg
Dimensions	60 x 60 x 95 cm
Total DeltaV	180 m/s
Onboard Storage	360 GB + 360 GB cold spare storage
RF Communication	X-band downlink (payload): variable, up to 580 Mbit/s X-band downlink (telemetry): 64 Kbit/s S-band uplink (command): 32 Kbit/s
Design Life	~6 years

Table 1-C: SkySat Pointing

SKYSAT POINTING

Attribute	Value
Geolocation Knowledge	30 - 50 m [SkySats 3 - 21]
Pixel Size (Orthorectified)	All assets: 0.50 m
Ground Sample Distance	[SkySat-1, SkySat-2] Panchromatic: 0.86m Multispectral: 1.0m
	[SkySat-3 - SkySat-15] Panchromatic: 0.65m Multispectral: 0.81m
	[SkySat-16 - SkySat-21] Panchromatic: 0.58m Multispectral: 0.72m

Revisit (per satellite)	4 - 5 days *Reference altitude 500 km
Equatorial Crossing (local time)	10:30 - SkySat-3 - 7, 14 - 15 13:00 - SkySat-1 and SkySat-2 13:00 - SkySat-8 - 13 SkySat 16 - 21 crossing times vary daily

Table 1-D: SkySat Sensor Specifications

SKYSAT SENSOR SPECIFICATIONS

Product Attribute	Description
Image Configurations	Multispectral Sensor (Blue, Green, Red, NIR)
	Panchromatic Sensor
Product Framing	SkySat satellites have three cameras per satellite, which capture overlapping strips. Each of these strips contain overlapping scenes. One scene is approximately 2560 x 1080 pixels
Sensor Type	CMOS Frame Camera with Panchromatic and Multispectral halves
Spectral Bands	Blue: 450 - 515 nm Green: 515 - 595 nm Red: 605 - 695 nm NIR: 740 - 900 nm Pan: 450 - 900 nm

2.3 SKYSAT STEREO IMAGING CAPABILITY

The SkySats are currently capable of capturing in the traditional satellite imaging stereo or tri-stereo approach. Stereo pairs are captured by a single SkySat, in a single pass, symmetrical from nadir with a total convergence angle between ~27 and 50 degrees. Tri-stereos are captured similarly, with a middle capture collected as close to nadir as possible, with ~27 degree convergence angle between the first and third collect. Hence the total convergence angle of a triplet is ~53 degrees between the first and last collect.

3. Planetscope Imagery Products

PlanetScope imagery products are available as either individual Basic Scenes andOrtho Scenes.. The Basic and Ortho Scenes can be obtained from the Planet API through the PSScene item type.

Table 2-A: PlanetScope Satellite Image Product Processing Levels

PLANETSCOPE SATELLITE IMAGE PRODUCT PROCESSING LEVELS

Name	Description	Product Level
PlanetScope Basic Scene Product	Scaled Top of Atmosphere Radiance (at sensor) and sensor corrected product. The Basic Scene product is designed for users with advanced image processing and geometric correction capabilities. This product has scene based framing and is not projected to a cartographic projection. Radiometric and sensor corrections are applied to the data.	Level 1B
PlanetScope Ortho Scene Product	Orthorectified, scaled Top of Atmosphere Radiance (at sensor) or Surface Reflectance image product suitable for analytic and visual applications. This product has scene based framing and projected to a cartographic projection.	Level 3B

The name of each acquired PlanetScope image is designed to be unique and allow for easier recognition and sorting of the imagery. It includes the date and time of capture, as well as the id of the satellite that captured it. The name of each downloaded image product is composed of the following elements:

```
<acquisition date>_<acquisition time>_<satellite_id>_<productLevel>_<bandProduct>.<extension>

Example:

20230207_143613_03_241c_3B_AnalyticMS_SR_8b.tif

20230207_143613_03_241c_3B_Visual.tif
```

The name of each searchable image product is composed of the following elements:

```
<acquisition date>_<acquisition time to 1/100th>_<satellite_id>
```

```
Example:

20230207_143613_03_241c
```

3.1 RADIOMETRIC INTERPRETATION

Analytic products are scaled to Top of Atmosphere Radiance. Validation of radiometric accuracy of the on-orbit calibration has been measured at 5% using vicarious collects in the Railroad Valley calibration site.

All PlanetScope satellite images are collected at a bit depth of 12 bits and stored on-board the satellites with a bit depth of up to 12 bits. Radiometric corrections are applied during ground processing and all images are scaled to a 16-bit dynamic range. This scaling converts the (relative) pixel DNs coming directly from the sensor into values directly related to absolute at-sensor radiances. The scaling factor is applied to minimize quantization error and the resultant single DN values correspond to 1/100th of a $W/(m^2*sr*\mu m)$. The DNs of the PlanetScope image pixels represent the absolute calibrated radiance values for the image.

Converting to Radiance and Top of Atmosphere Reflectance

To convert the pixel values of the Analytic products to radiance, it is necessary to multiply the DN value by the radiometric scale factor, as follows:

RAD(i) = DN(i) * radiometricScaleFactor(i), where radiometricScaleFactor(i) = 0.01

The resulting value is the at sensor radiance of that pixel in watts per steradian per square meter ($W/m^2*sr*\mu m$).

To convert the pixel values of the Analytic products to Top of Atmosphere Reflectance, it is necessary to multiply the DN value by the reflectance coefficient found in the XML file. This makes the complete conversion from DN to Top of Atmosphere Reflectance to be as follows:

REF(i) = DN(i) * reflectanceCoefficient(i)

Atmospheric Correction

Surface reflectance is determined from top of atmosphere (TOA) reflectance, calculated using coefficients supplied with the Planet Radiance product.

The Planet Surface Reflectance product corrects for the effects of the Earth's atmosphere, accounting for the molecular composition and variation with altitude along with aerosol content. Combining the use of standard atmospheric models with the use of MODIS water vapor, ozone and aerosol data, this provides reliable and consistent surface reflectance scenes over Planet's varied constellation of satellites as part of our normal, on-demand data pipeline. However, there are some limitations to the corrections performed:

- In some instances there is no MODIS data overlapping a Planet scene or the area nearby. In those cases, AOD is set to a value of 0.226 which corresponds to a “clear sky” visibility of 23km, the `aot_quality` is set to the MODIS “no data” value of 127, and `aot_status` is set to ‘Missing Data - Using Default AOT’. If there is no overlapping water vapor or ozone data, the correction falls back to a predefined 6SV internal model.
- The effects of haze and thin cirrus clouds are not corrected for.
- Aerosol type is limited to a single, global model.

- All scenes are assumed to be at sea level and the surfaces are assumed to exhibit Lambertian scattering - no BRDF effects are accounted for.
- Stray light and adjacency effects are not corrected for.

3.2 PLANETSCOPE NORMALIZATION AND HARMONIZATION

Planet provides a “harmonization” tool in all Planet platforms to perform a rigorous approximate transform of the Surface Reflectance measurements of the PS2 instrument PlanetScope satellites to the Surface Reflectance equivalents from PS2.SD and PSB.SD instrument PlanetScope satellites. This is done by using Sentinel-2 as the target sensor. Read technical details of normalizing data in Scene Level Normalization and Harmonization of Planet Dove Imagery.

To convert the PS2 instrument PlanetScope Surface Reflectance values to a PSB.SD equivalent measurement, use the “harmonization” tool. This tool is available in Planet Explorer, ArcGIS Pro Add-In and QGIS Plug-In when placing an order. Use the “harmonization” tool in the Orders API, Subscriptions API, and Google Earth Engine if you are downloading data through the API.

Note: The harmonization process only applies to bands with a PS2 equivalent—specifically Blue, Green, Red, and Near-infrared—and only for Surface Reflectance values.

3.3 PLANETSCOPE BASIC SCENE PRODUCT SPECIFICATION

The PlanetScope Basic Scene product is a Scaled Top of Atmosphere Radiance (at sensor) and sensor corrected product, providing imagery as seen from the spacecraft without correction for any geometric distortions inherent in the imaging process. It has a scene based framing, and is not mapped to a cartographic projection. This product line is available in GeoTIFF and NITF 2.1 formats.

The PlanetScope Basic Scene product is a multispectral analytic data product from the satellite constellation. This product has not been processed to remove distortions caused by terrain and allows analysts to derive information products for data science and analytics.

The Basic Scene product is designed for users with advanced image processing capabilities and a desire to geometrically correct the product themselves. The imagery data is accompanied by Rational Polynomial Coefficients (RPCs) to enable orthorectification by the user.

The geometric sensor corrections applied to this product correct for:

- Optical distortions caused by sensor optics
- Co-registration of bands

The table below describes the attributes for the PlanetScope Basic Scene product:

Table 2-B: PlanetScope Analytic Basic Scene Product Attributes

PLANETSCOPE BASIC SCENE PRODUCT ATTRIBUTES

Product Attribute	Description
Product Components and Format	The PlanetScope Basic Scene product consists of the following file components:

	• Image File – GeoTIFF format • Metadata File – XML format • Rational Polynomial Coefficients (RPC) - XML format • Thumbnail File – GeoTIFF format • Unusable Data Mask (UDM) File – GeoTIFF format • Usable Data Mask (UDM2) File - GeoTIFF format
Information Content	
Analytic Bands	4-band multispectral image (blue, green, red, near-infrared) 8-band multispectral image (coastal blue, blue, green I, green, red, yellow, red edge and near-infrared - PSB.SD only)
File Size	500 - 700 MB (4-band multispectral image) 1.0 - 1.4 GB (8-band multispectral image)
Ground Sample Distance	Approximate, satellite altitude dependent **PS2**: 3.0 m-4.1 m **PS2.SD**: 3.0 m-4.1 m **PSB.SD:** 3.7 m-4.2 m
Processing	
Pixel Size	Approximate, satellite altitude dependent **PS2**: 3.0 m-4.1 m **PS2.SD**: 3.0 m-4.1 m **PSB.SD:** 3.7 m-4.2 m
Bit Depth	Analytic (DN): 12-bit Analytic (Radiance - W m-2 sr-1 μm-1): 16-bit
Product Size	Nominal scene size is approximately (at 475 km altitude): **PS2**: 24 km by 8 km **PS2.SD**: 24 km by 16 km **PSB.SD**: 32.5 km by 19.6 km with some variability by satellite altitude.
Geometric Corrections	Spacecraft-related effects are corrected using attitude telemetry and best available ephemeris data, and refined using GCPs.
Positional Accuracy	Less than 10 m RMSE at 90th percentile
Radiometric Corrections	• Conversion to absolute radiometric values based on calibration coefficients • Radiometric values scaled by 100 to reduce quantization error • Calibration coefficients are regularly monitored and updated with on-orbit calibration techniques.
Map Projection	N/A

3.4 PLANETSCOPE ORTHO SCENES PRODUCT SPECIFICATION

PlanetScope satellites collect imagery as a series of overlapping framed scenes, and these Scene products are not organized to any particular tiling grid system. The Ortho Scene products enable users to create seamless imagery by stitching together PlanetScope Ortho Scenes of their choice and clipping it to a tiling grid structure as required.

The PlanetScope Ortho Scene product is orthorectified and the product was designed for a wide variety of applications that require imagery with an accurate geolocation and cartographic projection. It has been processed to remove distortions caused by terrain and can be used for cartographic purposes. The Ortho Scenes are delivered as visual (RGB) and analytic products. Ortho Scenes are radiometrically-, sensor-, and geometrically-corrected (optional atmospherically corrected) products that are projected to a cartographic map projection. The geometric correction uses fine Digital Elevation Models (DEMs) with a post spacing of between 30 and 90 meters.

Ground Control Points (GCPs) are used in the creation of every image and the accuracy of the product will vary from region to region based on available GCPs. Computer vision algorithms are used for extracting feature points such as OpenCV's STAR keypoint detector and FREAK keypoint extractor. The GCP and tiepoint matching is done using a combination of RANSAC, phase correlation and mutual information.

The table below describes the attributes for the PlanetScope Ortho Scene product:

Table 2-C: PlanetScope Ortho Scene Product Attributes

PLANETSCOPE ORTHO SCENE PRODUCT ATTRIBUTES

Product Attribute	**Description**
Product Components and Format	PlanetScope Ortho Scene product consists of the following file components: ● Image File – GeoTIFF format ● Metadata File – XML format ● Thumbnail File – GeoTIFF format ● Unusable Data Mask (UDM) file – GeoTIFF format ● Usable Data Mask (UDM2) file - GeoTIFF format
Product Orientation	Map North up
Product Framing	Scene Based
Pixel Size (orthorectified)	3 m
Bit Depth	Visual: 8-bit Analytic (Radiance - W m-2 sr-1 μm-1): 16-bit Analytic SR (Surface Reflectance): 16-bit
Product Size	Nominal scene size is approximately (at 475km altitude): **PS2**: 25 km by 11.5 km **PS2.SD**: 25 km by 23.0 km **PSB.SD**: 32.5 km by 19.6 km with some variability by satellite altitude.
Geometric Corrections	Sensor-related effects are corrected using sensor telemetry and a sensor model. Orthorectification uses GCPs and fine DEMs (30 m to 90 m posting).
Atmospheric Corrections	Atmospheric effects are corrected using 6SV2.1 radiative transfer code. AOD, water vapor and ozone inputs are retrieved from MODIS near-real-time data (MOD09CMA, MOD09CMG and MOD08-D3).

Horizontal Datum	WGS84
Map Projection	UTM
Resampling Kernel	Cubic Convolution

3.4.1 PlanetScope Visual Ortho Scene Product Specification

The PlanetScope Visual Ortho Scene product is orthorectified and color-corrected (using a color curve). This correction attempts to optimize colors as seen by the human eye providing images as they would look if viewed from the perspective of the satellite. This product has been processed to remove distortions caused by terrain and can be used for cartographic mapping and visualization purposes. This correction also eliminates the perspective effect on the ground (not on buildings), restoring the geometry of a vertical shot. Additionally, a correction is made to the sun angle in each image to account for differences in latitude and time of acquisition.

The Visual Ortho Scene product is optimal for simple and direct use of an image. It is designed and made visually appealing for a wide variety of applications that require imagery with an accurate geolocation and cartographic projection. The product can be used and ingested directly into a Geographic Information System.

Table 2-D: PlanetScope Visual Ortho Scene Product Attributes

PLANETSCOPE VISUAL ORTHO SCENE PRODUCT ATTRIBUTES

Product Attribute	**Description**
Information Content	
Visual Bands	3-band natural color (red, green, blue)
Ground Sample Distance	Approximate, satellite altitude dependent **PS2**: 3.0 m-4.1 m **PS2.SD**: 3.0 m-4.1 m **PSB.SD:** 3.7 m-4.2 m
Processing	
Pixel Size (orthorectified)	3.0 m
Bit Depth	8-bit
Geometric Corrections	Sensor-related effects are corrected using sensor telemetry and a sensor model. Spacecraft-related effects are corrected using attitude telemetry and best available ephemeris data. Orthorectified using GCPs and fine DEMs (30 m to 90 m posting) to <10 m RMSE positional accuracy.
Positional Accuracy	Less than 10 m RMSE at 90th percentile
Color Enhancements	Enhanced for visual use and corrected for sun angle

3.4.2 PlanetScope Analytic Ortho Scene Product Specification

The PlanetScope Analytic Ortho Scene product is orthorectified, multispectral data from the satellite constellation. Analytic products are calibrated multispectral imagery products that have been processed to allow analysts to derive information products for data science and analytics. This product is designed for a wide variety of applications that require imagery with an accurate geolocation and cartographic projection. The product has been processed to remove distortions caused by terrain and can be used for many data science and analytic applications. It eliminates the perspective effect on the ground (not on buildings), restoring the geometry of a vertical shot. The PlanetScope Analytic Ortho Scene is optimal for value-added image processing such as land cover classifications. The imagery has radiometric corrections applied to correct for any sensor artifacts and transformation to at-sensor radiance.

Table 2-E: PlanetScope Analytic Ortho Scene Product Attributes

PLANETSCOPE ANALYTIC ORTHO SCENE PRODUCT ATTRIBUTES	
Product Attribute	**Description**
Information Content	
Analytic Bands	3-band multispectral image (red, green, blue) - only available for PS2 images 4-band multispectral image (blue, green, red, near-infrared) 8-band multispectral image (coastal blue, blue, green I, green, red, yellow, red edge and near-infrared) - only available for PSB.SD images
Ground Sample Distance	Approximate, satellite altitude dependent **PS2**: 3.0 m-4.1 m **PS2.SD**: 3.0 m-4.1 m **PSB.SD:** 3.7 m-4.2 m
Processing	
Pixel Size (orthorectified)	3.0 m
Bit Depth	Analytic (Radiance - W m-2 sr-1 μm-1): 16-bit Analytic SR (Surface Reflectance): 16-bit
Geometric Corrections	Sensor-related effects are corrected using sensor telemetry and a sensor model. Spacecraft-related effects are corrected using attitude telemetry and best available ephemeris data. Orthorectified using GCPs and fine DEMs (30 m to 90 m posting) to <10 m RMSE positional accuracy.
Positional Accuracy	Less than 10 m RMSE at 90th percentile
Radiometric Corrections	• Conversion to absolute radiometric values based on calibration coefficients • Radiometric values scaled by 100 to reduce quantization error • Calibration coefficients are regularly monitored and updated with on-orbit calibration techniques.
Atmospheric Corrections	• Conversion to top of atmosphere (TOA) reflectance values using at-sensor radiance and supplied coefficients • Conversion to surface reflectance values using the 6SV2.1 radiative transfer code and MODIS NRT data

	• Reflectance values scaled by 10,000 to reduce quantization error

3.5 PLANETSCOPE BASEMAP MOSAIC TILES PRODUCT SPECIFICATION

All PlanetScope basemaps can be viewed at full resolution within the Planet graphical user interface (up to Zoom Level 15 or 16 in the Web Mercator Projection), giving a resolution of 4.77 m or 2.39 m at the Equator. The projection used in Planet basemaps has been selected to match what is typically used in web mapping applications. The basemap resolution improves at higher and lower latitudes. The Alpha Mask indicates areas of the quad where there is no imagery data available. Refer to the Planet Basemaps Product Specification for additional details.

Table 2-F: Individual Quad Specifications'

INDIVIDUAL QUAD SPECIFICATIONS

Attribute	**Description**
Sensors	PlanetScope
Pixel Size (resolution)	4.77 m or 2.39 m
Image Bit Depth	8 bits per pixel (Visual) 16 bits per pixel (Surface Reflectance)
Bands	Red, Green, Blue, Alpha (Visual) Blue, Green, Red, NIR, Alpha (Surface Reflectance)
Projection	WGS84 Web Mercator (EPSG:3857)
Size	4096 x 4096 pixels
Processing	Atmospheric correction (Surface Reflectance Basemaps only). May be radiometrically balanced. Seamlines may be minimized with tonal balancing. Geometrically aligned.

4. Rapideye Imagery Products

RapidEye imagery products are available in two different processing levels.

Table 3-A: RapidEye Satellite Image Product Processing Levels

Name	Description	Product Level
RapidEye Basic Scene Product	Radiometric and sensor corrections applied to the data. On-board spacecraft attitude and ephemeris applied to the data.	Level 1B
RapidEye Ortho Tile Product	Radiometric and sensor corrections applied to the data. Imagery is orthorectified using the RPCs and an elevation model.	Level 3A

The name of each acquired RapidEye image is designed to be unique and allow for easier recognition and sorting of the imagery. It includes the date and time of capture, as well as the id of the satellite that captured it. The name of each downloaded image product is composed of the following elements:

RapidEye Ortho Tiles:

```
<tileid>_<acquisition_date>_<satellite_id>_<productLevel>_<productType>.<extension>
```

RapidEye Basic Scenes:

```
<acquisition_date>T<acquisition_time>_<satellite_id>_<productLevel>_<productType>.<extension>
```

4.1 RADIOMETRIC INTERPRETATION

Analytic products are scaled to Top of Atmosphere Radiance. Validation of radiometric accuracy of the on-orbit calibration has been measured at 5% using vicarious collects in the Railroad Valley calibration site. Furthermore, each band is maintained within a range of +/- 2.5% from the band mean value across the constellation and over the satellite's lifetime.

All RapidEye satellite images were collected at a bit depth of 12 bits and on-board the satellites, the least significant bit is removed, and thus 11 bits are stored and downloaded. On the ground, the bit shift is reversed by a multiplication factor of 2. The bit depth of the original raw imagery can be determined from the "shifting" field in the XML metadata file. During on-ground processing, radiometric corrections are applied and all images are scaled to a 16-bit dynamic range. This scaling converts the (relative) pixel DNs coming directly from the sensor into values directly related to absolute at sensor radiances. The scaling factor is applied so that the resultant single DN values correspond to 1/100th of a $W/(m^2*sr*\mu m)$. The DNs of the RapidEye image pixels represent the absolute calibrated radiance values for the image.

Converting to Radiance and Top of Atmosphere Reflectance

To convert the pixel values of the Analytic products to radiance, it is necessary to multiply the DN value by the radiometric scale factor, as follows:

RAD(i) = DN(i) * radiometricScaleFactor(i), where radiometricScaleFactor(i) = 0.01

The resulting value is the at-sensor radiance of that pixel in watts per steradian per square meter ($W/m^2*sr*\mu m$).

Reflectance is generally the ratio of the reflected radiance divided by the incoming radiance. Note that this ratio has a directional aspect. To turn radiance into reflectance it is necessary to relate the radiance values (e.g. the pixel DNs multiplied with the radiometric scale factor) to the radiance the object is illuminated with. This is often done by applying an atmospheric correction software to the image, because this way the impact of the atmosphere to the radiance values is eliminated at the same time. But it would also be possible to neglect the influence of the atmosphere by calculating the Top Of Atmosphere (TOA) reflectance taking into consideration only the sun distance and the geometry of the incoming solar radiation. The formula to calculate the TOA reflectance not taking into account any atmospheric influence is as follows:

$$REF(i) = RAD(i) \frac{\pi * SunDist^2}{EAI(i) * \cos(SolarZenith)}$$

with:

- i = Number of the spectral band
- REF = reflectance value
- RAD = Radiance value
- SunDist = Earth-Sun Distance at the day of acquisition in Astronomical Units. Note: This value is not fixed, it varies between 0.983 289 8912 AU and 1.016 710 3335 AU and has to be calculated for the image acquisition point in time.
- EAI = Exo-Atmospheric Irradiance
- SolarZenith = Solar Zenith angle in degrees (= 90° – sun elevation)

For RapidEye, the EAI values for the 5 bands are (based on the “New Kurucz 2005” model):

- Blue: 1997.8 $W/m^2\mu m$
- Green: 1863.5 $W/m^2\mu m$
- Red: 1560.4 $W/m^2\mu m$
- RE: 1395.0 $W/m^2\mu m$
- NIR: 1124.4 $W/m^2\mu m$

4.1.1 Atmospheric Correction

Surface reflectance is determined from top of atmosphere (TOA) reflectance, calculated using coefficients supplied with the Planet Radiance product.

The Planet Surface Reflectance product corrects for the effects of the Earth's atmosphere, accounting for the molecular composition and variation with altitude along with aerosol content. Combining the use of standard atmospheric models with the use of MODIS water vapor, ozone, and aerosol data, this provides reliable and consistent surface reflectance scenes over Planet's varied constellation of satellites as part of our normal, on-demand data pipeline. However, there are some limitations to the corrections performed:

- In some instances there is no MODIS data overlapping a Planet scene or the area nearby. In those cases, AOD is set to a value of 0.226 which corresponds to a “clear sky” visibility of 23km, the `aot_quality` is set to the MODIS “no data” value of 127, and `aot_status` is set to ‘Missing Data - Using Default AOT’. If there is no overlapping water vapor or ozone data, the correction falls back to a predefined 6SV internal model.
- The effects of haze and thin cirrus clouds are not corrected for.
- Aerosol type is limited to a single, global model.
- All scenes are assumed to be at sea level and the surfaces are assumed to exhibit Lambertian scattering - no BRDF effects are accounted for.
- Stray light and adjacency effects are not corrected for.

4.2 RAPIDEYE BASIC SCENE PRODUCT SPECIFICATION

The RapidEye Basic product is the least processed of the available RapidEye imagery products. This product is designed for customers with advanced image processing capabilities and a desire to geometrically correct the product themselves. This product line is available in GeoTIFF and NITF formats.

The RapidEye Basic Scene product is radiometrically- and sensor-corrected, providing imagery as seen from the spacecraft without correction for any geometric distortions inherent in the imaging process, and is not mapped to a cartographic projection. The imagery data is accompanied by all spacecraft telemetry necessary for the processing of the data into a geo-corrected form, or when matched with a stereo pair, for the generation of digital elevation data. Resolution of the images is 6.5 meters GSD at nadir. The images are resampled to a coordinate system defined by an idealized basic camera model for band alignment.

The radiometric corrections applied to this product:

- Correction of relative differences of the radiometric response between detectors
- Non-responsive detector filling which fills null values from detectors that are no longer responding (This isn’t currently done because there are no non-responsive detectors)
- Conversion to absolute radiometric values based on calibration coefficients

The geometric sensor corrections applied to this product correct for:

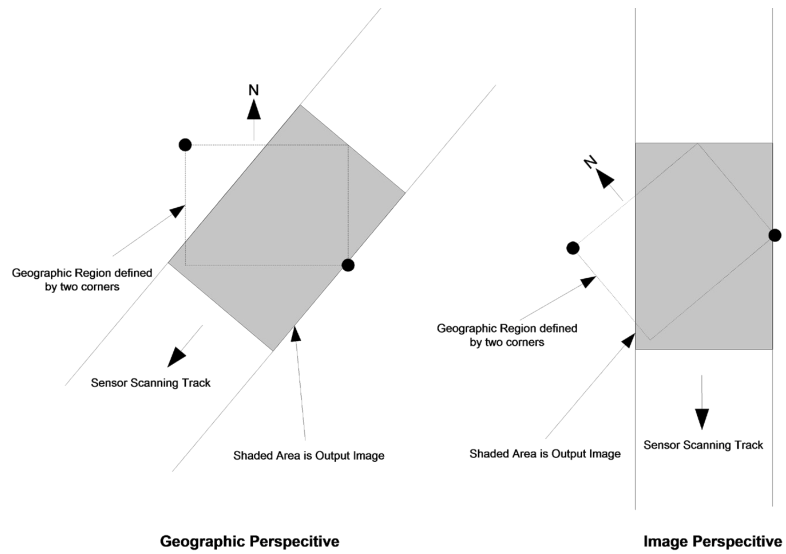
- Internal detector geometry which combines the two sensor chipsets into a virtual array
- Optical distortions caused by sensor optics
- Registration of all bands together to ensure all bands line up with each other correctly

The table below lists the product attributes for the RapidEye Basic Scene product.

Table 3-B: RapidEye Basic Scene Product Attributes

RAPIDEYE BASIC SCENE PRODUCT ATTRIBUTES

Product Attribute	Description
Product Components and Format	RapidEye Basic Scene product consists of the following file components:

	● Image File – Image product delivered as a group of single-band NITF or GeoTIFF files with associated RPC values. Bands are co-registered. ● Metadata File – XML format metadata file and GeoJSON metadata available ● Unusable Data Mask (UDM) File – GeoTIFF format ● Spacecraft information (SCI) file - XML format and contains additional information related to spacecraft attitude, spacecraft ephemeris, spacecraft temperature measurements, line imaging times, camera geometry, and radiometric calibration data. ● Browse Image - GeoTIFF format (also referred to as “Quicklook”)
Product Orientation	Spacecraft/Sensor Orientation
Product Framing Geographic based framing – a geographic region is defined by two corners. The product width is close to the full image swath as observed by all bands (77 km at nadir, subject to minor trimming of up to 3 km during processing) with a product length that does not exceed 300 km with a minimum length of 50 km and around a 10km overlap.	
Ground Sample Distance (nadir)	6.5 m
Bit Depth	16-bit unsigned integers
Pixel Size (orthorectified)	6.5m at Nadir
Radiometric Accuracy	Absolute accuracy less than +/- 5.0% Inter-satellite Accuracy less than +/- 2.5% of the band mean across the constellation
Geometric Corrections	Idealized sensor, orbit and attitude models. Bands are co-registered.
Positional Accuracy Band-to-Band Registration	Less than 10 m RMSE Less than 0.2 pixels (1-sigma) for terrain with slope below 10°
Horizontal Datum	WGS84
Resampling Kernel	Cubic Convolution

4.3 RAPIDEYE VISUAL ORTHO TILE PRODUCT SPECIFICATION

The RapidEye Ortho Tile products are orthorectified as individual 25 km by 25 km tiles. This product was designed for a wide variety of applications that require imagery with an accurate geolocation and cartographic projection. It has been processed to remove distortions caused by terrain and can be used for many cartographic purposes.

The RapidEye Ortho Tile products are radiometrically-, sensor- and geometrically-corrected and aligned to a cartographic map projection. The geometric correction uses fine DEMs with a post spacing of between 30 and 90 meters. GCPs are used in the creation of every image and the accuracy of the product will vary from region to region based on available GCPs. RapidEye Ortho Tile products are output as 25 km by 25 km tiles referenced to a fixed, standard RapidEye image tile grid system.

The table below lists the product attributes for the RapidEye Ortho Tile product.

Table 3-C: RapidEye Ortho Tile Product Attributes

RAPIDEYE ORTHO TILE PRODUCT ATTRIBUTES

Product Attribute	Description
Product Components and Format	RapidEye Ortho Tile product consists of the following file components: ● Image File – GeoTIFF file that contains image data and geolocation information ● Metadata File – XML format metadata file and GeoJSON metadata available ● Unusable Data Mask (UDM) File – GeoTIFF format
Product Orientation	Map North Up
Product Framing	RapidEye Ortho Tiles are based on a worldwide, fixed UTM grid system. The grid is defined in 24 km by 24 km tile centers, with 1 km of overlap (each tile has an additional 500 m overlap with adjacent tiles), resulting in 25 km by 25 km tiles.
Pixel Size (orthorectified)	5 m
Bit Depth	Visual: 8-bit Analytic (Radiance - W m-2 sr-1 μm-1): 16-bit
Product Size	Tile size is 25 km (5000 lines) by 25 km (5000 columns). 250 Mbytes per Tile for 5 bands at 5 m pixel size after orthorectification.
Geometric Corrections	Sensor-related effects are corrected using sensor telemetry and a sensor model, bands are co-registered, and spacecraft-related effects are corrected using attitude telemetry and best available ephemeris data. Orthorectified using GCPs and fine DEMs (30 m to 90 m posting).
Horizontal Datum	WGS84
Map Projection	UTM
Resampling Kernel	Cubic Convolution

4.3.1 RapidEye Visual Ortho Tile Product Specification

The RapidEye Visual Ortho Tile product is orthorectified and color-corrected (using a color curve). This correction optimizes colors as seen by the human eye, providing images as they would look if viewed from the perspective of the satellite. It has been processed to remove distortions caused by terrain and can be used for cartographic mapping and visualization purposes. It eliminates the perspective effect on the ground (not on buildings), restoring the geometry of a vertical shot. Additionally, a correction is made to the sun angle in each image to account for differences in latitude and time of acquisition.

The visual product is optimal for simple and direct use of the image. It is designed and made visually appealing for a wide variety of applications that require imagery with an accurate geolocation and cartographic projection. The product can be used and ingested directly into a Geographic Information System.

Figure 4: RapidEye Visual Ortho Tile

Table 3-D: RapidEye Visual Ortho Tile Product Attributes

RAPIDEYE VISUAL ORTHO TILE PRODUCT ATTRIBUTES

Product Attribute	Description
Information Content	
Visual Bands	3-band natural color (red, green, blue)
Ground Sample Distance	6.5 m (at reference altitude 630 km)
Processing	
Pixel Size (orthorectified)	5 m
Bit Depth	8-bit

Geometric Corrections	Sensor-related effects are corrected using sensor telemetry and a sensor model, ban are co-registered, and spacecraft-related effects are corrected using attitude telemetry and best available ephemeris data. Orthorectified using GCPs and fine DEMs (30 m to 90 m posting) to < 10 m RMSE positional accuracy.
Positional Accuracy Band-to-Band Registration	Less than 10 m RMSE Less than 0.2 pixels (1-sigma) for terrain with slope below 10°
Radiometric Corrections	• Correction of relative differences of the radiometric response between detectors. • Non-responsive detector filling which fills nulls values from detectors that are no longer responding. • Conversion to absolute radiometric values based on calibration coefficients.
Color Enhancements	Enhanced for visual use and corrected for sun angle

4.3.2 RapidEye Analytic Ortho Tile Product Specification

The RapidEye Analytic Ortho Tile product is orthorectified, multispectral data. This product is designed for a wide variety of applications that require imagery with an accurate geolocation and cartographic projection. It has been processed to remove distortions caused by terrain and can be used for many data science and analytic applications. It eliminates the perspective effect on the ground (not on buildings), restoring the geometry of a vertical shot. The orthorectified imagery is optimal for value-added image processing including vegetation indices, land cover classifications, etc. In addition to orthorectification, the imagery has radiometric corrections applied to correct for any sensor artifacts and transformation to at-sensor radiance.

Table 3-E: RapidEye Analytic Ortho Tile Product Attributes

RAPIDEYE ANALYTIC ORTHO TILE PRODUCT ATTRIBUTES

Product Attribute	Description
Information Content	
Analytic Bands	5-band multispectral image (blue, green, red, red edge, near-infrared)
Ground Sample Distance	6.5 m (at reference altitude 630 km)
Processing	
Pixel Size (orthorectified)	5 m
Bit Depth	16-bit
Radiometric Accuracy	Absolute accuracy less than +/- 5.0% Inter-satellite Accuracy less than +/- 2.5% of the band mean across the constellation
Geometric Corrections	Sensor-related effects are corrected using sensor telemetry and a sensor model, ban are co-registered, and spacecraft-related effects are corrected using attitude telemetry and best available ephemeris data. Orthorectified using GCPs and fine DEMs (30 m to 90 m posting) to < 10 m RMSE positional accuracy.

Positional Accuracy Band-to-Band Registration	Less than 10 m RMSE Less than 0.2 pixels (1-sigma) for terrain with slope below 10°
Radiometric Corrections	● Correction of relative differences of the radiometric response between detectors. ● Non-responsive detector filling which fills null values from detectors that are no longer responding. ● Conversion to absolute radiometric values based on calibration coefficients.
Atmospheric Corrections	● Conversion to top of atmosphere (TOA) reflectance values using at-sensor radiance and supplied coefficients ● Conversion to surface reflectance values using the 6SV2.1 radiative transfer code and MODIS NRT data ● Reflectance values scaled by 10,000 to reduce quantization error

5. Skysat Imagery Products

5.1 SKYSAT BASIC SCENE PRODUCT SPECIFICATION

The SkySat Basic Scene product includes Analytic, Analytic DN, L1A Panchromatic DN, and Panchromatic imagery that is uncalibrated and in a raw digital number format. The Basic Scene Product is not corrected for any geometric distortions inherent in the imaging process.

Imagery data is accompanied by Rational Polynomial Coefficients (RPCs) to enable orthorectification by the user. This product is designed for users with advanced image processing capabilities and a desire to geometrically correct the product themselves.

The Basic L1A Panchromatic DN assets (basic_l1a_panchromatic_dn, basic_l1a_panchromatic_dn_rpc) are made available for download immediately after production, before the remaining imagery assets, which may require super-resolution and orthorectification. Hence the L1A Pan browse image will be visible in Explorer and the API before all other image assets are ready for download.

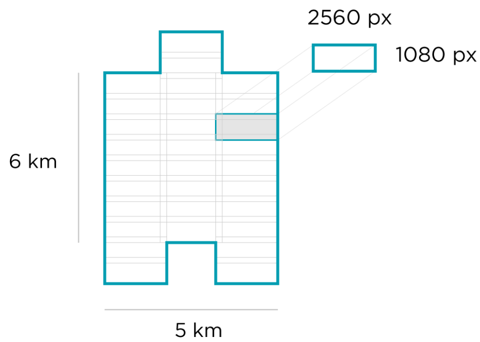
The SkySat Basic Scene Product has a sensor-based framing, and is not mapped to a cartographic projection.

- Analytic - unorthorectified, radiometrically corrected, multispectral BGRN
- Analytic DN - unorthorectified, multispectral BGRN
- Panchromatic - unorthorectified, radiometrically corrected, panchromatic (PAN)
- Panchromatic DN - unorthorectified, panchromatic (PAN)
- L1A Panchromatic DN - unorthorectified, pre-super resolution, panchromatic (PAN)

Table 4-A: SkySat Basic Scene Product Attributes

SKYSAT BASIC SCENE PRODUCT ATTRIBUTES

Product Attribute	Description
Product Components and Format	Image File – GeoTIFF format Metadata File – JSON format Rational Polynomial Coefficients – Text File UDM File – GeoTIFF format
Information Content	
Image Configurations	4-band Analytic DN Image (Blue, Green, Red, NIR)
	1-band Panchromatic DN Image (Pan)
Product Orientation	Spacecraft/Sensor Orientation
Product Framing	Scene based:



SkySat Satellites have three cameras per satellite, which capture overlapping strips. Each of these strips contain overlapping scenes.
One scene is approximately 2560px x 1080px.

Sensor Type	CMOS Frame Camera with Panchromatic and Multispectral halves
Spectral Bands	Blue: 450 - 515 nm Green: 515 - 595 nm Red: 605 - 695 nm NIR: 740 - 900 nm Pan: 450 - 900 nm

Processing	**Basic Scene**
Product Bit Depth	16-bit Unsigned Integer Multispectral and Panchromatic Imagery
Radiometric Corrections	Cross-Sensor Non Uniformity Correction (1%) Conversion to absolute radiometric values based on calibration coefficients Calibration coefficients regularly monitored and updated with on-orbit calibration techniques
Geometric Corrections	Idealized sensor model and Rational Polynomial Coefficients (RPC) Bands are co-registered
Horizontal Datum	WGS84
Map Projection	N/A
Resampling Kernel	Resampling of Analytic Multispectral Data to > 1.0m GSD
Ground Sample Distance	Approximate, satellite altitude dependent [SkySat-1, SkySat-2] Panchromatic: 0.81m - 0.87m Multispectral: 0.95m - 1.0m
	[SkySat-3 - SkySat-15] Panchromatic: 0.81m - 0.87m Multispectral: 1.01m - 1.08m
	[SkySat-16 - SkySat-21] Panchromatic: 0.70m - 0.82m Multispectral: 0.87m - 1.02m
Pixel Size (Orthorectified)	All assets: 0.50 m

Geometric Accuracy	<50m RMSE

5.2 SKYSAT VIDEO PRODUCT SPECIFICATION

Full motion videos are collected between 30 and 120 seconds by a single camera from any of the SkySats. Videos are collected using the panchromatic half of the camera, hence all videos are PAN only.

Videos are packaged and delivered with a video mpeg-4 file, plus all image frames with accompanying video metadata and a frame index file (reference Product Types below).

- 1A Panchromatic DN - unorthorectified, pre-super resolution, panchromatic (PAN)

Table 4-B: SkySat Video Product Attributes

SKYSAT VIDEO SCENE PRODUCT ATTRIBUTES

Product Attribute	**Description**
Product Components and Format	Video file - MP4 Video frames - folder - Image Frame File – TIFF format - Rational Polynomial Coefficients – Text File - Frame Index - CSV File Metadata File – JSON format
Information Content	
Image Configurations	1-band L1A Panchromatic DN Image (Pan)
Product Orientation	Spacecraft/Sensor Orientation
Sensor Type	CMOS Frame Camera with Panchromatic and Multispectral halves
Spectral Bands	Pan: 450 - 900 nm
Video Duration	30 - 120 seconds
Processing	Basic Video Scene
Bit Depth	16 Unsigned Integer
Radiometric Corrections	Cross-Sensor Non Uniformity Correction (1%)
Geometric Corrections	Idealized sensor model and Rational Polynomial Coefficients (RPC)
Horizontal Datum	WGS84
Map Projection	N/A
Resampling Kernel	N/A

Ground Sample Distance	Approximate, satellite altitude dependent [SkySat-3 - SkySat-15] Panchromatic: 0.81m - 0.87m
	[SkySat-16 - SkySat-21] Panchromatic: 0.70m - 0.82m
Geometric Accuracy	<50m RMSE

5.3 SKYSAT ALL-FRAMES PRODUCT SPECIFICATION

The SkySats capture up to 50 frames per second per Collect. The All-frames asset includes all of the originally captured frames in a Collect, uncalibrated and in a raw digital number format. Delivered as a zip file containing all frames as basic L1A panchromatic DN imagery files, with accompanying RPC txt files, and a JSON pinhole camera model.

Table 4-C: SkySat All-Frames Product Attributes

SKYSAT ALL-FRAMES SCENE PRODUCT ATTRIBUTES

Product Attribute	**Description**
Product Components and Format	All frames - folder - Image Frame File – TIFF format - Rational Polynomial Coefficients – Text File - Pinhole camera model - JSON format Metadata File – JSON format Frame Index – CSV file
Information Content	
Image Configurations	1-band L1A Panchromatic DN Image (Pan)
Product Orientation	Spacecraft/Sensor Orientation
Sensor Type	CMOS Frame Camera with Panchromatic and Multispectral halves
Spectral Bands	Pan: 450 - 900 nm
Processing	**Basic L1A Scene**
Bit Depth	16 Unsigned Integer
Radiometric Corrections	Cross-Sensor Non Uniformity Correction (1%)
Geometric Corrections	Idealized sensor model and Rational Polynomial Coefficients (RPC)
Horizontal Datum	WGS84
Map Projection	N/A
Resampling Kernel	N/A

Ground Sample Distance	Approximate, satellite altitude dependent [SkySat-3 - SkySat-15] Panchromatic: 0.81m - 0.87m
	[SkySat-16 - SkySat-21] Panchromatic: 0.70m - 0.82m
Geometric Accuracy	<50m RMSE

5.4 PINHOLE CAMERA MODEL

Described here is the JSON pinhole model that accompanies each all-frames asset. The pinhole model is based on projective matrices, omitting the optical distortion model. As built, the SkySat telescopes have ~1 pixel or less of distortion across all three sensors.

Projective Model

Note that this model uses 3D and 2D homogeneous coordinates.

Let $\mathbf{x}_{ECEF} = \begin{pmatrix} x \\ y \\ z \\ 1 \end{pmatrix}$ be a position in ECEF coordinates, with values in meters, in 3D homogeneous coordinates.

Let $\mathbf{im} = \begin{pmatrix} wu \\ wv \\ w \end{pmatrix}$ be a position in imaging plane coordinates, with values in pixels (or fractional pixels), in 2D homogeneous coordinates.

The projective model is described by three matrices, $P_{extrinsic} \in R^{4x4}$, $P_{intrinsic} \in R^{4x4}$, $P_{camera} \in R^{3x4}$ such that $im = P_{camera} P_{intrinsic} P_{extrinsic} X_{ECEF}$

For efficiency, we can also combine all three components into a single projective matrix, $P_{projective} \in R^{3x4}$ such that $P_{projective} = P_{camera} P_{intrinsic} P_{extrinsic}$

A given value of ***im*** describes a projective ray in the pinhole camera frame, representing the projection of X_{ECEF} onto the camera sensor. Note that ***w=0*** indicates a ray parallel to the imaging plane and will never intersect the sensor. For ***w≠0***, we can simply solve for *u* and *v*.

Exterior Orientation

Let $\mathbf{x}_{SAT,ECEF} = \begin{pmatrix} x_{sat} \\ y_{sat} \\ z_{sat} \end{pmatrix}$ describe the satellite position at a particular time, in ECEF coordinates and with values in meters.

Let $\mathbf{q}_{SAT,ECEF} = \begin{pmatrix} q_w \\ q_x \\ q_y \\ q_z \end{pmatrix}$ be a quaternion describing the rotation from the ECEF frame to the boresight frame (positive z-axis aligned with telescope boresight).

$P_{extrinsic}$ is constructed from the exterior orientation by translating the origin to the satellite position and applying the ECEF-to-boresight rotation (following the conventions in https://en.wikipedia.org/wiki/Conversion_between_quaternions_and_Euler_angles#Rotation_matrices):

$$\mathbf{P}_{extrinsic} = \begin{bmatrix} 1 - 2(q_y^2 + q_z^2) & 2(q_x q_y - q_w q_z) & 2(q_w q_y + q_x q_z) & 0 \\ 2(q_x q_y + q_w q_z) & 1 - 2(q_x^2 + q_z^2) & 2(q_y q_z - q_w q_x) & 0 \\ 2(q_x q_z - q_w q_y) & 2(q_w q_x + q_y q_z) & 1 - 2(q_x^2 + q_y^2) & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} 1 & 0 & 0 & -x_{sat} \\ 0 & 1 & 0 & -y_{sat} \\ 0 & 0 & 1 & -z_{sat} \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

Interior Orientation

$P_{intrinsic}$ and P_{camera} are based on the rigorous model from "SkySat Imaging Geometry." Their derivation involves multiple frame changes and axis flips and is not described here. We expect that these will remain nearly constant over time for each satellite and camera. $P_{extrinsic}$ is unique to each satellite and imaging time, but shared across cameras for each capture event.

5.5 FRAME INDEX FILE

FRAME INDEX (CSV)

Field	Value	Sample
name	Frame image filename(w/o file extension)	1207431805.69566202_sc00110_c2_PAN
datetime	Time of frame capture	2018-04-10T21:43:07Z
gsd	Ground Sample Distance	0.964506
sat_az	Avg satellite azimuth for frame	48.3168
sat_elev	Avg satellite elevation for frame	55.477
x_sat_eci_km	X-axis aligned ECI coordinate	3074.73
y_sat_eci_km	Y-axis aligned ECI coordinate	3057.87

z_sat_eci_km	Z-axis aligned ECI coordinate	5338.56
qw_eci	First pointing quaternion coordinate in ECI coordinate system	0.28172862
qx_eci	Second pointing quaternion coordinate in ECI coordinate system	-0.55973753
qy_eci	Third pointing quaternion coordinate in ECI coordinate system	-0.74397115
qz_eci	Fourth pointing quaternion coordinate in ECI coordinate system	-0.23201253
x_sat_ecef_km	X-axis aligned ECEF coordinate	3816.34769
y_sat_ecef_km	Y-axis aligned ECEF coordinate	4718.37789
z_sat_ecef_km	Z-axis aligned ECEF coordinate	2999.05659
qw_ecef	First pointing quaternion coordinate in ECEF coordinate system	0.3396504
qx_ecef	Second pointing quaternion coordinate in ECEF coordinate system	-0.3795945
qy_ecef	Third pointing quaternion coordinate in ECEF coordinate system	0.85021459
qz_ecef	Fourth pointing quaternion coordinate in ECEF coordinate system	-0.13296909
bit_dpth	Pixel bit depth of frame	16
geom	Frame dimensions	POLYGON((-123.132 49.2933,-123.089 49.294,-123.092 49.2825,-123.135 49.2818))
integration_time_ms	Capture integration time, in ms	433.59375
filename	Full filename with 12 digit timestamp	1289391430.33374000_sc00114_c3_PAN_i0000000604.tif

5.6 RADIOMETRIC INTERPRETATION

To convert the pixel values of the Analytic products to radiance, it is necessary to multiply the DN value by the radiometric scale factor, as follows:

RAD(i) = DN(i) * radiometric_scale_factor(i), where radiometric_scale_factor(i) = 0.01

The resulting value is the Top of Atmosphere Radiance of that pixel in watts per steradian per square meter ($W/m^2*sr*\mu m$).

To convert the pixel values of the Analytic products to Top of Atmosphere Reflectance, it is necessary to multiply the DN value by the reflectance coefficient found in the GeoTiff header. This makes the complete conversion from DN to Top of Atmosphere Reflectance to be as follows:

REF(i) = DN(i) * reflectance_coefficient(i)

Alternatively, the customer may perform the TOA Reflectance conversion on their own using the following equation, with the ESUN values given below in Table 3.

$$TOAR = \frac{(\pi \times Radiance \times d^2)}{ESUN \times cos(90 - sun\ elevation)}$$

d =Earth to sun distance in astronomical units

Table 4-D: Skysat Analytic Ortho Scene ESUN values, resampled from Thuillier irradiance spectra

	PAN	BLUE	GREEN	RED	NIR
SkySat-1	1587.94	1984.85	1812.88	1565.83	1127
SkySat-2	1587.94	1984.85	1812.88	1565.83	1127
SkySat-3	1585.89	2000.7	1821.8	1584.13	1120.33
SkySat-4	1585.89	2000.7	1821.8	1584.13	1120.33
SkySat-5	1573.42	2009.23	1820.33	1584.84	1104.96
SkySat-6	1573.42	2009.23	1820.33	1584.84	1104.96
SkySat-7	1573.42	2009.23	1820.33	1584.84	1104.96
SkySat-8	1582.79	2009.28	1820.25	1583.3	1114.22
SkySat-9	1583.61	2009.29	1821.04	1583.83	1109.44
SkySat-10	1583.88	2008.61	1820.87	1583.5	1112.3
SkySat-11	1586.89	2009.26	1821.14	1583.66	1113.77
SkySat-12	1581.65	2009.5	1821.24	1584.91	1109.01
SkySat-13	1580.89	2009.43	1821.7	1583.77	1108.74
SkySat-14	1581.65	2009.5	1821.24	1584.91	1109.01
SkySat-15	1580.89	2009.43	1821.7	1583.77	1108.74
SkySat-16 - 21	1582.43	2005.51	1817.55	1580.98	1113.57

5.7 SCENE METADATA

Basic Scene GeoJSON metadata

Table 4-E: Skysat Basic Scene Geojson Metadata Schema

SKYSAT BASIC SCENE GEOJSON METADATA SCHEMA

Parameter	**Description**	**Type**
acquired	The RFC 3339 acquisition time of the image.	string

camera_id	The specific detector used to capture the scene.	String (e.g. “d1”, “d2”)
cloud_cover	Ratio of the area covered by clouds to that which is uncovered.	number (0 - 1)
ground_control	If the image meets the positional accuracy specifications this value will be true. If the image has uncertain positional accuracy, this value will be false.	boolean
gsd	The ground sampling distance of the image acquisition.	number
item_type	The name of the item type that models shared imagery data schema.	string (e.g. “PSScene3Band”, ”SkySatScene”)
provider	Name of the imagery provider.	string ("planetscope","rapideye", “skysat”)
published	The RFC 3339 timestamp at which this item was added to the API.	string
publishing_stage	Stage of publishing for an item. Both "l1a" assets and SkySatScenes with fast-rectification applied will have a publishing_stage = "preview". Fast-rectification refers to the initial rectification of the orthorectified product, to enable faster publication. Once full-rectification is applied, all assets will be updated to publishing_stage = "finalized	string (“preview”, “finalized”)
quality_category	Metric for image quality. To qualify for “standard” image quality an image must meet a variety of quality standards, for example: PAN motion blur less than 1.15 pixels, compression bits per pixel less than 3. If the image does not meet these criteria it is considered “test” quality.	string (“standard”, “test”)
satellite_azimuth	Angle from true north to the satellite vector at the time of imaging, projected on the horizontal plane in degrees.	number (0 - 360)
satellite_id	Globally unique identifier of the satellite that acquired the underlying imagery.	string
strip_id	Globally unique identifier of the image strip this scene was collected against	string
sun_azimuth	Angle from true north to the sun vector projected on the horizontal plane in degrees.	number (0 - 360)
sun_elevation	Elevation angle of the sun in degrees.	number (0 - 90)

updated	The RFC 3339 timestamp at which this item was updated in the API.	string
view_angle	Spacecraft across-track off-nadir viewing angle used for imaging, in degrees.	number (0 - 90)

5.8 BASIC SCENE RPC METADATA

Table 9: Skysat Basic Scene Text file Metadata Schema

Parameter	Description	Sample
LINE_OFF	Row offset of center point	534.896219421794
SAMP_OFF	Column offset of center point	1267.3960612691
LAT_OFF	Latitude coordinate of center point	-18.1132
LONG_OFF	Longitude coordinate of center point	178.4441
HEIGHT_OFF	Altitude of center point	123
LINE_SCALE	Scaling factor for row coordinate	534.896219421794
SAMP_SCALE	Scaling factor for column coordinate	1267.39606126914
LAT_SCALE	Scaling factor for latitude coordinates	-0.0264
LONG_SCALE	Scaling factor for longitude coordinates	0.0331
HEIGHT_SCALE	Scaling factor for altitude coordinates	77
LINE_NUM_COEFF_	Numerator coefficient in row RPC equation (1-20)	4.27902854674
LINE_DEN_COEFF_	Denominator Coefficient in row RPC equation(1-20)	0.00174493132019
SAMP_NUM_COEFF_	Numerator coefficient in column RPC equation(1-20)	0.0110620153979
SAMP_DEN_COEFF_	Denominator coefficient in column RPC equation (1-20)	0.00174477677906

5.9 SKYSAT VIDEO METADATA

Table 9: Skysat Video Geojson Metadata Schema

SKYSAT VIDEO GEOJSON METADATA SCHEMA

Parameter	Description	Type
acquired	The RFC 3339 acquisition time of the image.	string

camera_id	The specific detector used to capture the scene.	String (e.g. “d1”, “d2”)
item_type	The name of the item type that models shared imagery data schema.	string (e.g. “PSScene3Band”, ”SkySatScene”)
provider	Name of the imagery provider.	string ("planetscope","rapideye", “skysat”)
published	The RFC 3339 timestamp at which this item was added to the API.	string
publishing_stage	SkySatVideo assets will always have a “finalized” publishing_stage	string (“finalized”)
quality_category	Metric for image quality. To qualify for “standard” image quality an image must meet a variety of quality standards, for example: PAN motion blur less than 1.15 pixels, compression bits per pixel less than 3. If the image does not meet these criteria it is considered “test” quality.	string (“standard”, “test”)
satellite_azimuth	Angle from true north to the satellite vector at the time of imaging, projected on the horizontal plane in degrees.	number (0 - 360)
satellite_id	Globally unique identifier of the satellite that acquired the underlying imagery.	string
strip_id	Globally unique identifier of the image strip this scene was collected against	string
sun_azimuth	Angle from true north to the sun vector projected on the horizontal plane in degrees.	number (0 - 360)
sun_elevation	Elevation angle of the sun in degrees.	number (0 - 90)
updated	The RFC 3339 timestamp at which this item was updated in the API.	string
view_angle	Spacecraft across-track off-nadir viewing angle used for imaging, in degrees.	number (0 - 90)

Video Scene metadata

Table 4-F: Skysat Video JSON file Metadata Schema

VIDEO PRODUCT METADATA

Field	Value	Sample

Satellite	Satellite ID	00110
Camera	Camera used for imaging	2
Geometry	Composite of the geospatial extent of all frames in the video	GeoJson Polygon
Time		
Start	Start time of video capture	2018-04-10T21:43:07
End	End time of video capture	2018-04-10T21:44:07
Duration (s)	Duration of video in seconds	59.976592063903809
Angle		
Start	Satellite collection elevation of first frame in video	55.476973516035933
End	Satellite collection elevation of last frame in video	61.410026752389307
Convergence	Convergence angle between first and last frames	5.9330532363533734
Azimuth		
Start	Satellite azimuth angle of first frame in video	48.316762122631033
End	Satellite azimuth angle of last frame in video	143.12580513942621
Delta	Difference between start and end satellite azimuth angle	94.809043016795172

Exposure		
Panchromatic Gain	Sensor amplification of the signal	1.0, 10.0, or 30.0
Panchromatic Integration Time	Integration time, in ms	433.59375
Compression Ratio	The ratio comparing an image's true size to its size on the file system	4.0
Scan Rate Kms	The ground speed at which the SkySat captures image frames	433.59375

Table 4-G: Frame Index (csv)

FRAME INDEX (CSV)

Field	Value	Sample
name	Frame image filename(w/o file extension)	1207431805.69566202_sc00110_c2_PAN
datetime	Time of frame capture	2018-04-10T21:43:07Z
gsd	Ground Sample Distance	0.964506
sat_az	Avg satellite azimuth for frame	48.3168
sat_elev	Avg satellite elevation for frame	55.477
x_sat_eci_km	X-axis aligned ECI coordinate	3074.73
y_sat_eci_km	Y-axis aligned ECI coordinate	3057.87
z_sat_eci_km	Z-axis aligned ECI coordinate	5338.56
qw_eci	First pointing quaternion coordinate in ECI coordinate system	0.28172862
qx_eci	Second pointing quaternion coordinate in ECI coordinate system	-0.55973753
qy_eci	Third pointing quaternion coordinate in ECI coordinate system	-0.74397115
qz_eci	Fourth pointing quaternion coordinate in ECI coordinate system	-0.23201253
x_sat_ecef_km	X-axis aligned ECEF coordinate	3816.34769
y_sat_ecef_km	Y-axis aligned ECEF coordinate	4718.37789
z_sat_ecef_km	Z-axis aligned ECEF coordinate	2999.05659
qw_ecef	First pointing quaternion coordinate in ECEF coordinate system	0.3396504
qx_ecef	Second pointing quaternion coordinate in ECEF coordinate system	-0.3795945
qy_ecef	Third pointing quaternion coordinate in ECEF coordinate system	0.85021459
qz_ecef	Fourth pointing quaternion coordinate in ECEF coordinate system	-0.13296909
bit_dpth	Pixel bit depth of frame	16
geom	Frame dimensions	POLYGON((-123.132 49.2933,-123.089 49.294,-123.092 49.2825,-123.135 49.2818))
integration_time_ms	Capture integration time, in ms	433.59375
filename	Full filename with 12 digit timestamp	1289391430.33374000_sc00114_c3_PAN_i0000000604.tif

5.10 SKYSAT ORTHO SCENE PRODUCT SPECIFICATION

The SkySat Ortho Scene product includes Visual, Analytic DN, Analytic, Panchromatic, and Pansharpened Multispectral imagery. The Ortho Scene product is sensor- and geometrically-corrected, and is projected to a cartographic map projection. The geometric correction uses fine Digital Elevation Models (DEMs) with a post spacing of between 30 and 90 meters.

Ground Control Points (GCPs) are used in the creation of every image and the accuracy of the product will vary from region to region based on available GCPs. Also note, ortho accuracy is not guaranteed for scenes with a view angle greater than 30 degrees, captured above +/-85 degrees latitude, with low solar angles, varying terrain, or with a large concentration of clouds, snow, or water within the scene or full collect.

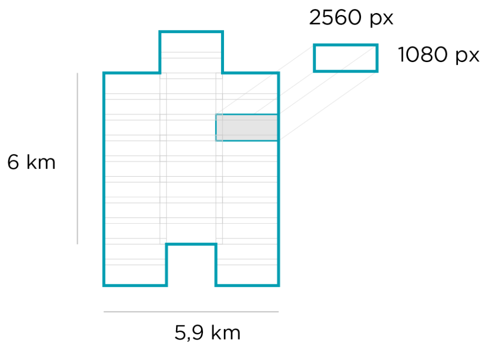
Additionally, publication is not guaranteed for collections with very large view angles (i.e. greater than 45 degrees) and very low solar elevation (i.e. lower than 20 degrees).

- Visual - orthorectified, pansharpened, and color-corrected (using a color curve) 3-band RGB Imagery
- Pansharpened Multispectral - orthorectified, pansharpened 4-band BGRN Imagery
- Analytic SR - orthorectified, multispectral BGRN. Atmospherically corrected Surface Reflectance product.
- Analytic - orthorectified, multispectral BGRN. Radiometric corrections applied to correct for any sensor artifacts and transformation to top-of-atmosphere radiance
- Analytic DN - orthorectified, multispectral BGRN, uncalibrated digital number imagery product Radiometric corrections applied to correct for any sensor artifacts
- Panchromatic - orthorectified, radiometrically correct, panchromatic (PAN)
- Panchromatic DN - orthorectified, panchromatic (PAN), uncalibrated digital number imagery product

Table 4-H: SkySat Ortho Scene Product Attributes

SKYSAT ORTHO SCENE PRODUCT ATTRIBUTES

Product Attribute	Description
Product Components and Format	Image File – GeoTIFF format Metadata File – JSON format UDM File – GeoTIFF format
Information Content	
Product Framing	Scene Based:



SkySat Satellites have three cameras per satellite, which capture overlapping strips.
Each of these strips contain overlapping scenes.
One scene is approximately 2560px x 1080px.

Sensor Type	CMOS Frame Camera with Panchromatic and Multispectral halves
Spectral Bands	Blue: 450 - 515 nm Green: 515 - 595 nm Red: 605 - 695 nm NIR: 740 - 900 nm Pan: 450 - 900 nm
Processing	
Radiometric Corrections	Cross-Sensor Non Uniformity Correction (1%) Conversion to absolute radiometric values based on calibration coefficients Calibration coefficients regularly monitored and updated with on-orbit calibration techniques Conversion to surface reflectance values using the 6SV2.1 radiative transfer code and MODIS NRT data
Geometric Corrections	Sensor-related effects are corrected using sensor telemetry and a sensor model. Orthorectification uses GCPs and fine DEMs (30 m to 90 m posting).
Horizontal Datum	WGS84
Map Projection	UTM
Resampling Kernel	Cubic Convolution
Geometric Accuracy	<10 m RMSE

Table 4-I: SkySat Ortho Scene Asset Attributes

Product Attribute	Description
Bands	Visual: 3-band Pansharpened (PS Red, PS Green, PS Blue)
	Pansharpened Multispectral: 4-band Pansharpened (PS Blue, PS Green, PS Red, PS NIR)
	Analytic, Analytic DN, Analytic SR: 4-band Multispectral (B, G, R, N)

	Panchromatic, Panchromatic DN: 1-band Panchromatic
Pixel Size (Orthorectified)	All assets: 0.50 m
Bit Depth	Visual: 8-bit Unsigned Integer Pansharpened Multispectral, Analytic, Analytic DN, Panchromatic, Panchromatic DN: 16 Unsigned Integer
Geometric Corrections	Sensor-related effects are corrected using sensor telemetry and a sensor model. Orthorectification uses GCPs and fine DEMs (30m to 90m posting).
Radiometric Calibration Accuracy	Visual, Pansharpened Multispectral, Analytic DN, Panchromatic DN: ● No correction applied, pixel values are digital numbers Analytic, Panchromatic: ● Absolute Radiance derived using vicarious calibration methods ● Product is radiometrically calibrated to radiance units [W/(µm * m^2 * str)], and scaled by 100 to reduce quantization errors ● Calibration is regularly monitored and updated with on-orbit calibration techniques. ● Conversion to surface reflectance values using the 6SV2.1 radiative transfer code and MODIS NRT data
Radiometric Accuracy (Analytic, Panchromatic)	+/- 5% Relative accuracy at < 10 degrees off-nadir angle
Color Enhancements (Visual)	Enhanced for visual use

Atmospheric Correction

Surface reflectance is determined from top of atmosphere (TOA) reflectance, calculated using coefficients supplied with the Planet Radiance product.

The Planet Surface Reflectance product corrects for the effects of the Earth's atmosphere, accounting for the molecular composition and variation with altitude along with aerosol content. Combining the use of standard atmospheric models with the use of MODIS water vapor, ozone and aerosol data, this provides reliable and consistent surface reflectance scenes over Planet's varied constellation of satellites as part of our normal, on-demand data pipeline. However, there are some limitations to the corrections performed:

- In some instances there is no MODIS data overlapping a Planet scene or the area nearby. In those cases, AOD is set to a value of 0.226 which corresponds to a “clear sky” visibility of 23km, the `aot_quality` is set to the MODIS “no data” value of 127, and `aot_status` is set to ‘Missing Data - Using Default AOT’. If there is no overlapping water vapor or ozone data, the correction falls back to a predefined 6SV internal model.
- The effects of haze and thin cirrus clouds are not corrected for.
- Aerosol type is limited to a single, global model.

- All scenes are assumed to be at sea level and the surfaces are assumed to exhibit Lambertian scattering - no BRDF effects are accounted for.

Stray light and adjacency effects are not corrected for.

5.11 SKYSAT ANALYTIC SCENE GEOTIFF PROPERTIES

Table 4-J: Properties included in the GeoTIFF Header, under 'TIFFTAG_IMAGEDESCRIPTION'

Field	Value	Sample
radiometric_scale_factor	Provides the parameter to convert the scaled radiance pixel value to radiance. Multiplying the scaled radiance pixel values by the scale factor, derives the Top of Atmosphere Radiance product. This value is a constant, set to 0.01	0.01
reflectance_coefficients	The value is a multiplicative, when multiplied with the DN values, provides the Top of Atmosphere Reflectance values, in watts per steradian per square meter ($W/m^2*sr*\mu m$)	[0.0019093447035360626, 0.0021074819723268657, 0.0024206308893552 43, 0.003471901841411239]
satellite_azimuth	Angle from true north to the satellite vector at the time of imaging, projected on the horizontal plane in degrees.	103.22169693
satellite_elevation	Angle between the satellite pointing direction and the local horizontal plane in degrees.	61.32334041
sun_azimuth	Angle from true north to the sun vector projected on the horizontal plane in degrees.	136.7200917
sun_elevation	Elevation angle of the sun in degrees.	56.98039498

5.12 SKYSAT ORTHO SCENE GEOJSON METADATA

Table 4-K: Skysat Ortho Scene Geojson Metadata Schema

SKYSAT ORTHO SCENE GEOJSON METADATA SCHEMA		
Parameter	**Description**	**Type**
acquired	The RFC 3339 acquisition time of the image.	string
camera_id	The specific detector used to capture the scene.	String (e.g. "d1", "d2")
cloud_cover	Ratio of the area covered by clouds to that which is uncovered.	number (0 - 1)

ground_control	If the image meets the positional accuracy specifications this value will be true. If the image has uncertain positional accuracy, this value will be false.	boolean
gsd	The ground sampling distance of the image acquisition.	number
item_type	The name of the item type that models shared imagery data schema.	string (e.g. “PSScene3Band”, ”SkySatScene”)
provider	Name of the imagery provider.	string ("planetscope","rapideye", “skysat”)
published	The RFC 3339 timestamp at which this item was added to the API.	string
publishing_stage	Stage of publishing for an item. Both "l1a" assets and SkySatScenes with fast-rectification applied will have a publishing_stage = "preview". Fast-rectification refers to the initial rectification of the orthorectified product, to enable faster publication. Once full-rectification is applied, all assets will be updated to publishing_stage = "finalized	string (“preview”, “finalized”)
quality_category	Metric for image quality. To qualify for “standard” image quality an image must meet a variety of quality standards, for example: PAN motion blur less than 1.15 pixels, compression bits per pixel less than 3. If the image does not meet these criteria it is considered “test” quality.	string (“standard”, “test”)
satellite_azimuth	Angle from true north to the satellite vector at the time of imaging, projected on the horizontal plane in degrees.	number (0 - 360)
satellite_id	Globally unique identifier of the satellite that acquired the underlying imagery.	string
strip_id	Globally unique identifier of the image strip this scene was collected against	string
sun_azimuth	Angle from true north to the sun vector projected on the horizontal plane in degrees.	number (0 - 360)
sun_elevation	Elevation angle of the sun in degrees.	number (0 - 90)
updated	The RFC 3339 timestamp at which this item was updated in the API.	string
view_angle	Spacecraft across-track off-nadir viewing angle used for imaging, in degrees with + being east and - being west.	number (-90 - +90)

5.13 SKYSAT ORTHO COLLECT PRODUCT SPECIFICATION

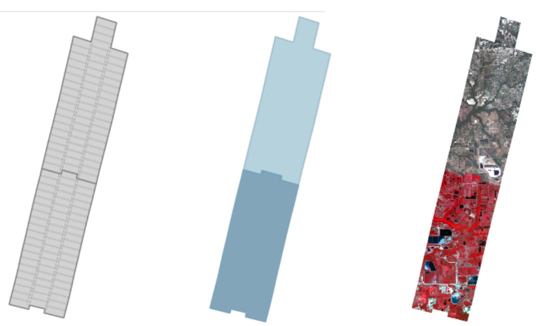
The Ortho Collect product is created by composing SkySat Ortho Scenes along an imaging strip into segments typically unifying ~60 SkySat Ortho Scenes. The product may contain artifacts resulting from the composing process, particular offsets in areas of stitched source scenes. In a next version artifacts caused by scene misalignment will be hidden by cutlines. This is particularly important for the appearance of objects in built-up areas and their accurate extraction.

- Visual - pansharpened, orthorectified, color corrected RGB
- Pansharpened Multispectral - pansharpened, orthorectified, color corrected BGRN
- Analytic - orthorectified, radiometrically corrected, multispectral BGRN
- Analytic DN - orthorectified, multispectral BGRN
- Panchromatic - orthorectified, radiometrically correct, panchromatic (PAN)
- Panchromatic DN - orthorectified, panchromatic (PAN)

*Asset attributes match those of the Scene counterparts listed above

Table 4-L: SkySat Ortho Collect Attributes

SKYSAT ORTHO COLLECT ATTRIBUTES

Attribute	Description
Product Framing	Strip Based  SkySat Satellites have three cameras per satellite, which capture overlapping strips. Each of these strips contain overlapping scenes. One Collect product composes up to 60 scenes (up to 20 per camera) and is approximately 20km x 5.9km.
Assets	Visual: 3-band Pansharpened Image (8-bit Unsigned Integer) Multispectral: 4-band Pansharpened Image (16-bit Unsigned Integer) 4-band Analytic DN Image (B, G, R, N) (16-bit Unsigned Integer) 1-band Panchromatic Image (16-bit Unsigned Integer)

Projection	UTM WGS84
Geometric Corrections	Sensor-related effects are corrected using sensor telemetry and a sensor model. Orthorectification uses GCPs and fine DEMs (30m to 90m posting).
Positional Accuracy	Less than 10 m RMSE
Radiometric Corrections	No correction applied; pixel values are digital numbers

5.14 SKYSAT ANALYTIC COLLECT GEOTIFF PROPERTIES

Table 4-M: Properties included in the GeoTIFF Header, under 'TIFFTAG_IMAGEDESCRIPTION'

Field	Value	Sample
radiometric_scale_factor	Provides the parameter to convert the scaled radiance pixel value to radiance. Multiplying the scaled radiance pixel values by the scale factor, derives the Top of Atmosphere Radiance product. This value is a constant, set to 0.01	0.01
reflectance_coefficients	The value is a multiplicative, when multiplied with the DN values, provides the Top of Atmosphere Reflectance values, in watts per steradian per square meter (W/m²*sr*μm)	[0.0019093447035360626, 0.0021074819723268657, 0.0024206308893552543, 0.003471901841411239]
satellite_azimuth	Angle from true north to the satellite vector at the time of imaging, averaged across the full SkySatCollect, projected on the horizontal plane in degrees.	103.22169693
satellite_elevation	Angle between the satellite pointing direction and the local horizontal plane in degrees, averaged across the full SkySatCollect.	61.32334041
sun_azimuth	Angle from true north to the sun vector projected on the horizontal plane in degrees, averaged across the full SkySatCollect.	136.7200917
sun_elevation	Elevation angle of the sun in degrees, averaged across the full SkySatCollect.	56.98039498

5.15 SKYSAT COLLECT METADATA

Ortho Collect GeoJSON metadata

Table 4-N: Skysat Ortho Collect Geojson Metadata Schema

SKYSAT ORTHO COLLECT GEOJSON METADATA SCHEMA

Parameter	Description	Type
acquired	The RFC 3339 acquisition time of the image.	string
camera_id	The specific detector used to capture the scene.	String (e.g. “d1”, “d2”)
cloud_cover	Ratio of the area covered by clouds to that which is uncovered.	number (0 - 1)
ground_control_ratio	The ratio of scenes that make up the Collect with ground_control = true	float
gsd	The ground sampling distance of the image acquisition.	number
item_type	The name of the item type that models shared imagery data schema.	string (e.g. “PSScene”, ”SkySatCollect”)
provider	Name of the imagery provider.	string ("planetscope","rapideye", “skysat”)
published	The RFC 3339 timestamp at which this item was added to the API.	string
publishing_stage	Stage of publishing for an item. Both "l1a" assets and SkySatScenes with fast-rectification applied will have a publishing_stage = "preview". Fast-rectification refers to the initial rectification of the orthorectified product, to enable faster publication. Once full-rectification is applied, all assets will be updated to publishing_stage = "finalized	string (“preview”, “finalized”)
quality_category	Metric for image quality. To qualify for “standard” image quality an image must meet a variety of quality standards, for example: PAN motion blur less than 1.15 pixels, compression bits per pixel less than 3. If the image does not meet these criteria it is considered “test” quality.	string (“standard”, “test”)
satellite_azimuth	Angle from true north to the satellite vector at the time of imaging, projected on the horizontal plane in degrees.	number (0 - 360)
satellite_id	Globally unique identifier of the satellite that acquired the underlying imagery.	string
strip_id	Globally unique identifier of the image strip this scene was collected against	string

sun_azimuth	Angle from true north to the sun vector projected on the horizontal plane in degrees.	number (0 - 360)
sun_elevation	Elevation angle of the sun in degrees.	number (0 - 90)
updated	The RFC 3339 timestamp at which this item was updated in the API.	string
view_angle	Spacecraft across-track off-nadir viewing angle used for imaging, in degrees.	number (0 - 90)

5.16 SKYSAT BASEMAP MOSAIC TILES PRODUCT SPECIFICATION

All basemaps can be viewed at full resolution within the Planet graphical user interface (up to Zoom Level 18 in the Web Mercator Projection), giving a resolution of 0.597 m at the Equator. The projection used in Planet basemaps has been selected to match what is typically used in web mapping applications. The basemap resolution improves at higher and lower latitudes. The Alpha Mask indicates areas of the quad where there is no imagery data available.

Table 4-O: Individual Quad Specifications

INDIVIDUAL QUAD SPECIFICATIONS

Attribute	Description
Sensors	SkySat
Pixel Size (resolution)	.597m
Image Bit Depth	8 bits per pixel
Bands	Red, Green, Blue, Alpha
Projection	WGS84 Web Mercator (EPSG:3857)
Size	4096 x 4096 pixels
Processing	Pansharpened. Geometrically aligned. Seam lines are minimized with tonal balancing. Cutlines to minimize visual breaks

6. Other Provider Imagery Products

Planet provides access to two other freely available datasets: Landsat 8, operated by NASA and the United States Geological Survey, and Sentinel-2, operated by the European Space Agency. The goal is to make these products easily available to Planet users to augment their analyses.

6.1 LANDSAT 8

For detailed characteristics of the Landsat 8 sensor and mission please refer to the official Landsat 8 documentation which can be found here: https://landsat.usgs.gov/landsat-8

Table 5-A: Landsat 8 data properties

LANDSAT 8 L1G PRODUCT ATTRIBUTE

Product Attribute	**Description**
Information Content	
Analytic Bands	
Pan	Band 8
Visible, NIR, SWIR	Band 1-7 and Band 9 (Coastal/Aerosol, Blue, Green, Red, NIR, SWIR 1, SWIR 2, Cirrus)
Processing	
Pixel Size	4-band Analytic DN Image (Blue, Green, Red, NIR)
	1-band Panchromatic DN Image (Pan)
Pan	15 m
Visible, NIR, SWIR	30 m
TIR	100 m
Bit Depth	12-bit data depth, distributed as 16-bit data for easier processing
Geometric Corrections	The Geometric Processing Subsystem (GPS) creates L1 geometrically corrected imagery (L1G) from L1R products. The geometrically corrected products can be systematic terrain-corrected (L1Gt) or precision terrain-corrected products (L1T). The GPS generates a satellite model, prepares a resampling grid, and resamples the data to create an L1Gt or L1T product. The GPS performs sophisticated satellite geometric correction to create the image according to the map projection and orientation specified for the L1 standard product.
Positional Accuracy	12 m CE90
Radiometric Corrections	• Converts the brightness of the L0R image pixels to absolute radiance in preparation for geometric correction.

	• Performs radiometric characterization of L0R images by locating radiometric artifacts in images. • Corrects radiometric artifacts and converts the image to radiance.
Metadata	Landsat 8 MTL text file

6.2 SENTINEL-2

For detailed characteristics of the Sentinel-2 sensor and mission please refer to the official Sentinel-2 documentation which can be found here:

https://earth.esa.int/web/sentinel/user-guides/sentinel-2-msi/product-types/level-1c

Table 5-B: Sentinel-2 Data Properties

SENTINEL-2 LEVEL 1C PRODUCT ATTRIBUTE

Product Attribute	Description
Information Content	
Analytic Bands	
Visible, NIR	4 bands at 10 m: blue (490 nm), green (560 nm), red (665 nm) and near infrared (842 nm).
RedEdge and NIR	4 narrow bands for vegetation characterisation (705 nm, 740 nm, 783 nm and 865 nm)
SWIR	2 larger SWIR bands (1610 nm and 2190 nm)
Aerosol, Water Vapor, Cirrus	443 nm for aerosols, 945 for water vapor and 1375 nm for cirrus detection
Processing	
Pixel Size	
Visible, NIR (4 bands)	10 m
RedEdge, NIR (6 bands)	20 m
SWIR (2 bands)	20 m
Cirrus, Aerosol, Water Vapor (3 bands)	60 m
Bit Depth	12
Geometric Corrections	• Resampling on the common geometry grid for registration between the Global Reference Image (GRI) and the reference band. • Collection of the tie-points from the two images for registration between the GRI and the reference band.

	● Tie-points filtering for image-GRI registration: filtering of the tie-points over several areas. A minimum number of tie-points is required. ● Refinement of the viewing model using the initialized viewing model and GCPs. The output refined model ensures registration between the GRI and the reference band. ● Resampling grid computation: enabling linking of the native geometry image to the target geometry image (ortho-rectified). ● Resampling of each spectral band in the geometry of the ortho-image using the resampling grids and an interpolation filter.
Positional Accuracy	20 m 2σ without GCPs; 12.5 m 2σ with GCPs
Radiometric Corrections	● Dark Signal Correction ● Pixel Response non-uniformity correction ● Crosstalk correction ● Defective pixels identification ● High Spatial resolution bands restoration (deconvolution and de-noising) ● Binning of the 60m spectral bands ● TOA reflectance calculation
MetaData/Data Structure	● Level-1C_Tile_Metadata_File (Tile Metadata): XML main metadata file (DIMAP mandatory file) containing the requested level of information and referring to all the product elements describing the tile. ● IMG_DATA: folder containing image data files compressed using the JPEG2000 algorithm, one file per band. ● QI_DATA: folder containing QLQC XML reports of quality checks, mask files and PVI files. ● Inventory_Metadata.xml: inventory metadata file (mandatory). ● manifest.safe: XML SAFE manifest file (Mandatory) ● rep-info: folder containing the XSD schema provided inside a SAFE Level-0 granule

7. Product Processing

7.1 PLANETSCOPE PROCESSING

Several processing steps are applied to PlanetScope imagery products, listed in the table below.

Table 6-A: PlanetScope Processing Steps

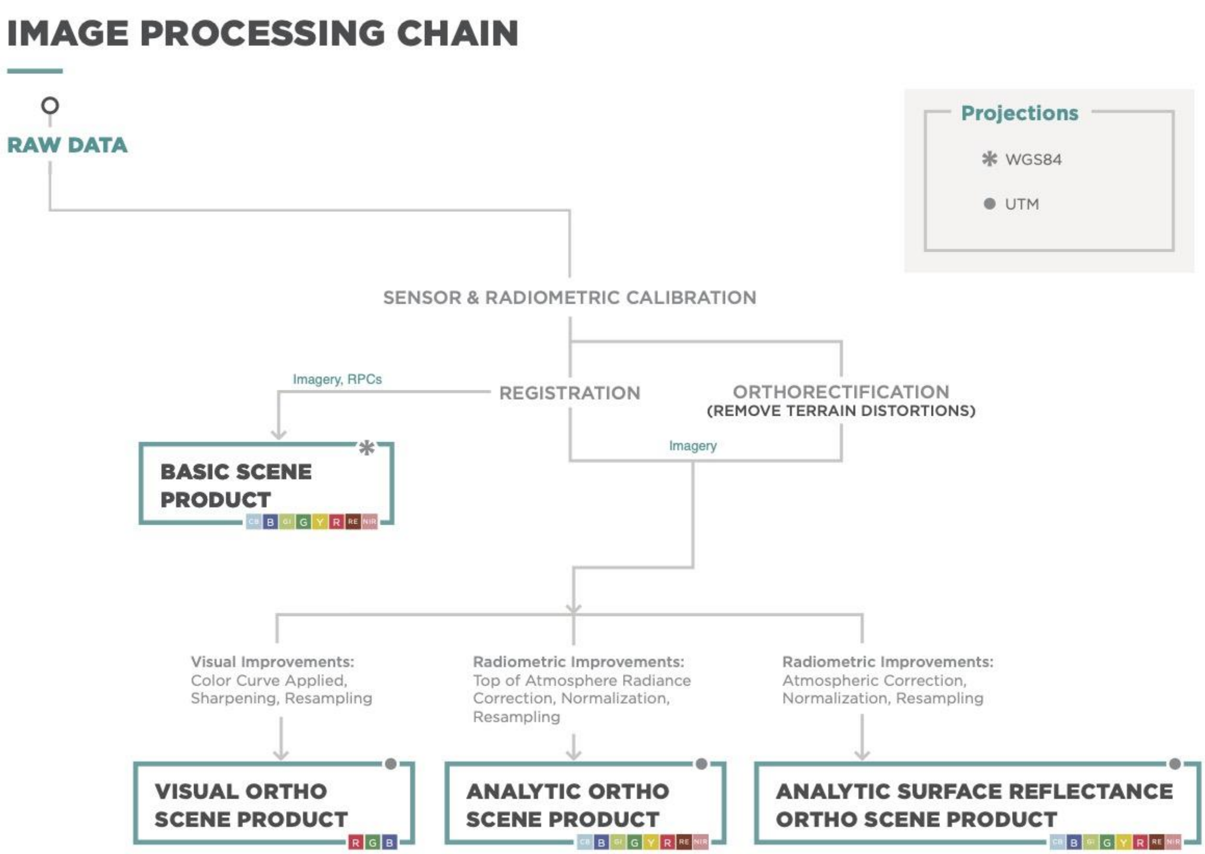
PLANETSCOPE PROCESSING STEPS

Step	Description
Darkfield/Offset Correction	Corrects for sensor bias and dark noise. Master offset tables are created by averaging on-orbit darkfield collects across 5-10 degree temperature bins and applied to scenes during processing based on the CCD temperature at acquisition time.
Flat Field Correction	Flat fields are collected for each optical instrument prior to launch. These fields are used to correct image lighting and CCD element effects to match the optimal response area of the sensor. Flat fields are routinely updated on-orbit during the satellite lifetime.
Camera Acquisition Parameter Correction	Determines a common radiometric response for each image (regardless of exposure time, number of TDI stages, gain, camera temperature and other camera parameters).
Absolute Calibration	As a last step, the spatially and temporally adjusted datasets are transformed from digital number values into physical based radiance values (scaled to $W/(m^2*str*\mu m)*100$).
Visual Product Processing	Presents the imagery as natural color, optimize colors as seen by the human eye. This process is broken down into 4 steps: ● Flat fielding applied to correct for vignetting. ● Nominalization - Sun angle correction, to account for differences in latitude and time of acquisition. This makes the imagery appear to look like it was acquired at the same sun angle by converting the exposure time to the nominal time (noon). ● Two filters applied: an unsharp mask for improving local dynamic range, and a sharpening filter for accentuating spatial features. ● Custom color curve applied post warping.
Orthorectification	This process is broken down into 2 steps: ● The rectification tiedown process wherein tie points are identified across the source images and a collection of reference images (ALOS, NAIP, OSM, Landsat) and RPCs are generated. ● The actual orthorectification of the scenes using the RPCs, to remove terrain distortions. The terrain model used for the orthorectification process is derived from multiple sources (SRTM, Intermap, and other local elevation datasets) which are periodically updated. Snapshots of the elevation datasets used are archived (helps in identifying the DEM that was used for any given scene at any given point).

Atmospheric Correction	Removes atmospheric effects. This process consists of 3 steps: ● Top of Atmosphere (TOA) reflectance calculation using coefficients supplied with the at-sensor radiance product. ● Lookup table (LUT) generation using the 6SV2.1 radiative transfer code and MODIS near-real-time data inputs. ● Conversion of TOA reflectance to surface reflectance for all combinations of selected ranges of physical conditions and for each satellite sensor type using its individual spectral response as well as estimates of the state of the atmosphere.

The figure below illustrates the processing chain and steps involved to generate each of PlanetScope's imagery products.

Figure 5: PlanetScope Image Processing Chain



7.2 RAPIDEYE PROCESSING

For RapidEye imagery products, the processing steps are listed in the table below.

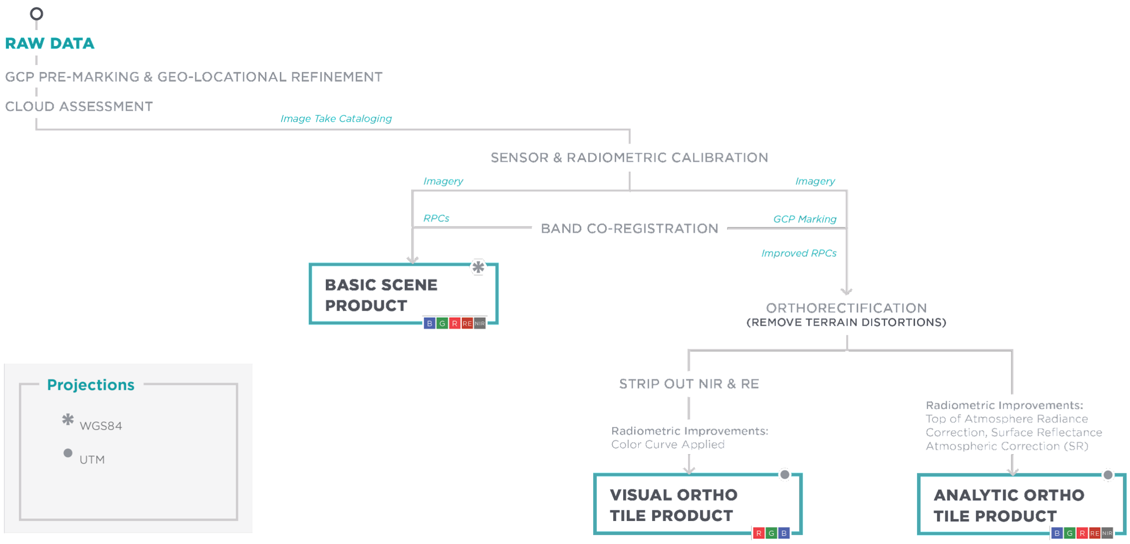
Table 6-B: RapidEye Processing Steps

RAPIDEYE PROCESSING STEPS

Step	Description
Flat Field Correction (also referred to as spatial calibration)	Correction parameters to achieve the common response of all CCD elements when exposed to the same amount of light have been collected for each optical instrument prior to launch. During operations, these corrections are adjusted every quarter or more frequently on an as-needed basis when effects become visible or measurable. The corrections are derived using side slither or statistical methods. This step additionally involves statistical adjustments of the read-out channel gains and offsets on a per image basis.
Temporal Calibration	Corrections are applied so that all RapidEye cameras read the same DN (digital number) regardless of when the image has been taken in the mission lifetime. Additionally with this step a cross calibration between all spacecraft is achieved.
Absolute Calibration	As a last step the spatially and temporally adjusted datasets are transformed from digital number values into physical based radiance values (scaled to $W/(m^2*str*\mu m)*100$).
Visual Product Processing	Presents the imagery as natural color, optimize colors as seen by the human eye. This process is broken down into 3 steps: ● Nominalization - Sun angle correction, to account for differences in latitude and time of acquisition. This makes the imagery appear to look like it was acquired at the same sun angle by converting the exposure time to the nominal time (noon). ● Unsharp mask (sharpening filter) applied before the warp process. ● Custom color curve applied post warping.
Orthorectification	Removes terrain distortions. This process is broken down into 2 steps: ● The rectification tiedown process wherein tie points are identified across the source images and a collection of reference images (ALOS, NAIP,Landsat) and RPCs are generated. ● The actual orthorectification of the scenes using the RPCs, to remove terrain distortions. The terrain model used for the orthorectification process is derived from multiple sources (Intermap, NED, SRTM and other local elevation datasets) which are periodically updated. Snapshots of the elevation datasets used are archived (helps in identifying the DEM that was used for any given scene at any given point).
Atmospheric Correction	Removes atmospheric effects. This process consists of 3 steps: ● Top of Atmosphere (TOA) reflectance calculation using coefficients supplied with the at-sensor radiance product. ● Lookup table (LUT) generation using the 6SV2.1 radiative transfer code and MODIS near-real-time data inputs. ● Conversion of TOA reflectance to surface reflectance for all combinations of selected ranges of physical conditions and for each satellite sensor type using its individual spectral response as well as estimates of the state of the atmosphere.

The figure below illustrates the processing chain and steps involved to generate each of RapidEye's imagery products.

Figure 6: RapidEye Image Processing Chain



7.3 SKYSAT PROCESSING

For SkySat imagery products, the processing steps are listed in the table below.

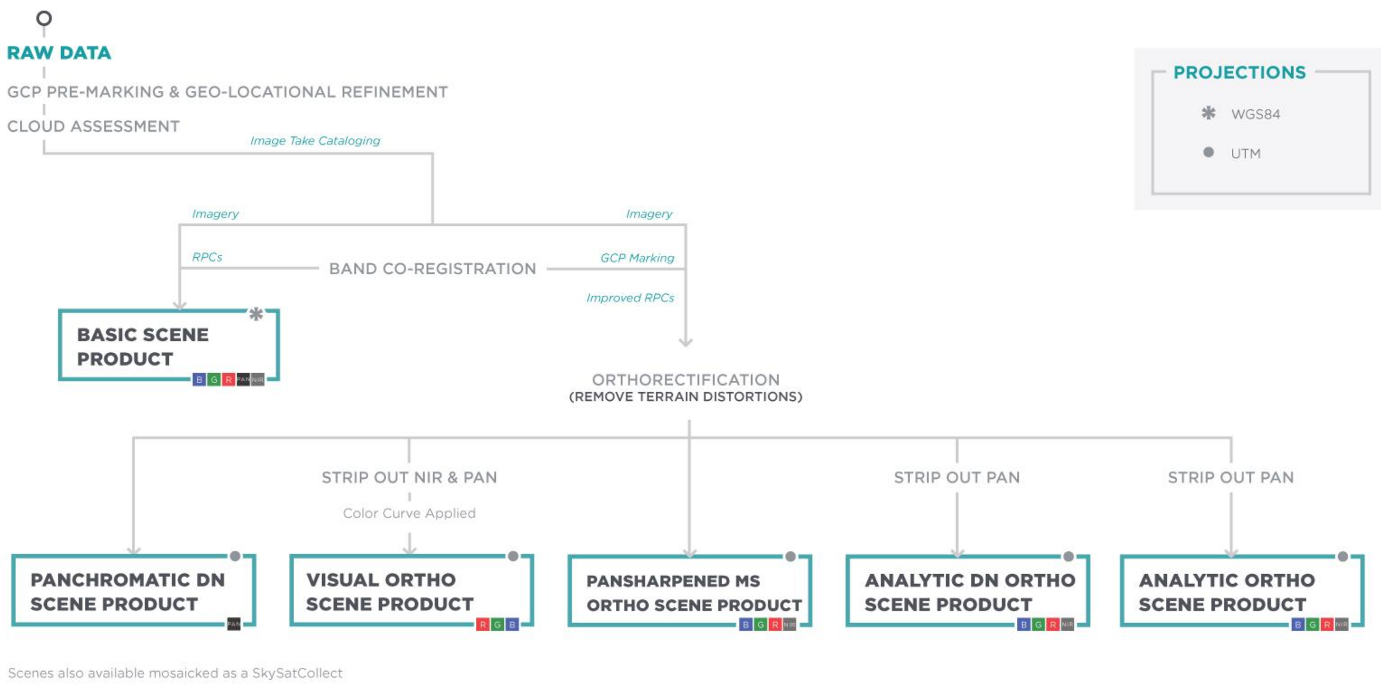
Table 6-C: SkySat Processing Steps

SKYSAT PROCESSING STEPS

Step	Description
Darkfield/Offset Correction	Corrects for sensor bias and dark noise. Master offset tables are created by averaging ground calibration data collected across 5-10 degree temperature bins and applied to scenes during processing based on the CCD temperature at acquisition time.
Flat Field Correction	Flat fields are created using cloud flats collected on-orbit post-launch. These fields are used to correct image lighting and CCD element effects to match the optimal response area of the sensor.
Camera Acquisition Parameter Correction	Determines a common radiometric response for each image (regardless of exposure time, TDI, gain, camera temperature and other camera parameters).
Inter Sensor Radiometric Response (Intra Camera)	Cross calibrates the 3 sensors in each camera to a common relative radiometric response. The offsets between each sensor are derived using on-orbit cloud flats and the overlap regions between sensors on SkySat spacecraft.
Super Resolution (Level 1B Processing)	A super-resolved image, SR, is the process of creating an improved resolution image fusing information from low resolution images, with the created higher resolution image being a better description of the scene.
Visual Product Processing	Presents the imagery as natural color, optimizing colors as seen by the human eye. Custom color curves applied post warping to deliver a visually appealing image.
Orthorectification	Removes terrain distortions. This process is broken down into 2 steps: The rectification tiedown process wherein tie points are identified across the source images and a collection of reference images (NAIP, ALOS, Landsat, and high resolution image chips) and RPCs are generated. The actual orthorectification of the scenes using the RPCs, to remove terrain distortions. The terrain model used for the orthorectification process is derived from multiple sources (SRTM, Intermap, and other local elevation datasets) which are periodically updated. Snapshots of the elevation datasets used are archived (helps in identifying the DEM that was used for any given scene at any given point.

The figure below illustrates the processing chain and steps involved to generate SkySat's Basic and Ortho Scene products.

Figure 7: SkySat Image Processing Chain



8. Product Metadata

8.1 ORTHO TILES

8.1.1 RapidEye

The table below describes the GeoJSON metadata schema for RapidEye Ortho Tile products:

Table 7-A: RapidEye Ortho Tile GeoJSON Metadata Schema

RAPIDEYE ORTHO TILE GEOJSON METADATA SCHEMA

Parameter	Description	Type
acquired	The RFC 3339 acquisition time of the image.	string
catalog_id	The catalog ID for the RapidEye Basic Scene product.	string
anomalous_pixel	Percentage of anomalous pixels. Pixels that have image quality issues documented in the quality taxonomy (e.g. hot columns). This is represented spatially within the UDM.	number
black_fill	Ratio of image containing artificial black fill due to clipping to actual data.	number (0 - 1)
cloud_cover	Ratio of the area covered by clouds to that which is uncovered.	number (0 - 1)
columns	Number of columns in the image.	number
epsg_code	The identifier for the grid cell that the imagery product is coming from if the product is an Ortho Tile (not used if Scene)	number
grid_cell	The grid cell identifier of the gridded item.	string
ground_control	If the image meets the positional accuracy specifications this value will be true. If the image has uncertain positional accuracy, this value will be false.	boolean
gsd	The ground sampling distance of the image acquisition.	number
item_type	The name of the item type that models shared imagery data schema.	string (e.g “REOrthoTile”)

origin_x	ULX coordinate of the extent of the data. The coordinate references the top left corner of the top left pixel	number
origin_y	ULY coordinate of the extent of the data. The coordinate references the top left corner of the top left pixel	number
pixel_resolution	Pixel resolution of the imagery in meters.	number
provider	Name of the imagery provider.	string (e.g. "planetscope","rapideye"")
published	The RFC 3339 timestamp at which this item was added to the API.	string
rows	Number of rows in the image.	number
satellite_id	Globally unique identifier of the satellite that acquired the underlying imagery.	string
sun_azimuth	Angle from true north to the sun vector projected on the horizontal plane in degrees.	number (0 - 360)
sun_elevation	Elevation angle of the sun in degrees.	number (0 - 90)
updated	The RFC 3339 timestamp at which this item was updated in the API.	string
usable_data	Ratio of the usable to unusable portion of the imagery due to cloud cover or black fill.	number (0 - 1)
view_angle	Spacecraft across-track off-nadir viewing angle used for imaging, in degrees with + being east and - being west.	number (-25 - +25)

The table below describes the metadata schema for Surface Reflectance products stored in the GeoTIFF header:

Table 7-B: RapidEye Ortho Tile Surface Reflectance Metadata Schema

RAPIDEYE ORTHO TILE SURFACE REFLECTANCE METADATA SCHEMA

Parameter	Description	Example
aerosol_model	6S aerosol model used	continental
aot_coverage	Percentage overlap between MODIS data and the scene being corrected	0.5625

aot_method	Method used to derive AOD value(s) for an image. 'Map' indicates that per-pixel AOD values are used based on an interpolated map over the scene; 'fixed' indicates a single value for the entire image used when there is not enough data coverage to produce a map.	fixed
aot_mean_quality	Average MODIS AOD quality value for the overlapping NRT data in the range 1-10. This is set to 127 when no data is available	1.0
aot_source	Source of the AOD data used for the correction	mod09cma_nrt
aot_std	Standard deviation of the averaged MODIS AOD data	0.033490001296168699
aot_status	A text string indicating state of AOD retrieval. If no data exists from the source used, a default value 0.226 is used	Missing Data - Using Default AOT
aot_used	Aerosol optical depth used for the correction	0.061555557780795626
atmospheric_correction_algorithm	The algorithm used to generate LUTs	6SV2.1
atmospheric_model	Custom model or 6S atmospheric model used	water_vapor_and_ozone
luts_version	Version of the LUTs used for the correction	3
ozone_coverage	Percentage overlap between MODIS data and the scene being corrected	0.53125
ozone_mean_quality	Average MODIS ozone quality value for the overlapping NRT data. This will always be 255 if data is present	255
ozone_method	Method used to derive ozone value(s) for an image. Currently only 'fixed' is used, indicating a single value for the entire image	fixed
ozone_source	Source of the ozone data used for the correction	mod09cmg_nrt
ozone_status	A text string indicating state of ozone retrieval. If no ozone data is available for the scene being corrected, the corrections falls back to a 6SV built-in atmospheric model	Data Found
ozone_std	Standard deviation of the averaged MODIS ozone data.	0

ozone_used	Ozone concentration used for the correction, in cm-atm	0.255
satellite_azimuth_angle	Always defined to be 0.0 degrees and solar zenith angle measured relative to it	0.0
satellite_zenith_angle	Satellite zenith angle, fixed to nadir pointing	0.0
solar_azimuth_angle	Sun azimuth angle relative to satellite, in degrees	111.42044562850029
solar_zenith_angle	Solar zenith angle in degrees	30.26950393461825
sr_version	Version of the correction applied.	1.0
water_vapor_coverage	Percentage overlap between MODIS data and the scene being corrected	0.53215
water_vapor_mean_quality	Average MODIS ozone quality value for the overlapping NRT data in the range 1-10. This is set to 127 when no data is available	1.5294
water_vapor_method	Method used to derive water vapor value(s) for an image. Currently only 'fixed' is used, indicating a single value for the entire image	fixed
water_vapor_source	Source of the water vapor data used for the correction	mod09cma_nrt
water_vapor_status	A text string indicating state of water vapor retrieval. If no water vapor data is available for the scene being corrected, the corrections falls back to a 6SV built-in atmospheric model	Data Found
water_vapor_std	Standard deviation of the averaged MODIS AOD data	0.0587
water_vapor_used	Water vapor concentration used for the correction in g/cm^2	4.0512

8.2 ORTHO SCENES

8.2.1 PlanetScope

The table below describes the GeoJSON metadata schema for PlanetScope Ortho Scene products:

Table 7-C: PlanetScope Ortho Scene GeoJSON Metadata Schema

PLANETSCOPE ORTHO SCENE GEOJSON METADATA SCHEMA

Parameter	Description	Type
acquired	The time that image was taken in RFC 3398 format, in UTC.	string
anomalous_pixel	Percentage of anomalous pixels. Pixels that have image quality issues documented in the quality taxonomy	number
clear_percent	Percent of clear values in dataset. Clear values represents scene content areas (non-blackfilled*) that are deemed to be not impacted by cloud, haze, shadow and/or snow.	integer (0-100)
clear_confidence_percent	percentage value: per-pixel algorithmic confidence in 'clear' classification	integer (0-100)
cloud_percent	Percent of cloud values in dataset. Cloud values represent scene content areas (non-blackfilled) that contain opaque clouds which prevent reliable interpretation of the land cover content.	integer (0-100)
cloud_cover	Ratio of the area covered by clouds to that which is uncovered.	number (0 - 1)
ground_control	If the image meets the positional accuracy specifications this value will be true. If the image has uncertain positional accuracy, this value will be false.	boolean
gsd	The ground sampling distance of the image acquisition.	number

heavy_haze_percent	Percent of heavy haze values in dataset. Heavy haze values represent scene content areas (non-blackfilled) that contain thin low altitude clouds, higher altitude cirrus clouds, soot and dust which allow fair recognition of land cover features, but not having reliable interpretation of the radiometry or surface reflectance.	integer (0-100)
instrument	The generation of the satellite telescope.	string (e.g.”PS2”, “PS2.SD”)
item_type	The name of the item type that models shared imagery data schema.	string (e.g. “PSScene)
light_haze_percent	Percent of light haze values in dataset. Light haze values represent scene content areas (non-blackfilled) that contain thin low altitude clouds, higher altitude cirrus clouds, soot and dust which allow reliable recognition of land cover features, and have up to +/-10% uncertainty on commonly used indices (EVI and NDWI).	integer (0-100)
pixel_resolution	Pixel resolution of the imagery in meters.	number
provider	Name of the imagery provider.	string (e.g. "planetscope","rapideye"")
published	The RFC 3339 timestamp at which this item was added to the API.	string
publishing_stage	Stage of publishing for an item. PSScene with fast-rectification applied will have a publishing_stage = "preview". Fast-rectification refers to the initial rectification of the orthorectified product, to enable faster publication. Once full-rectification is applied, all assets will be updated to publishing_stage = "finalized”,	string
quality_category	Metric for image quality. To qualify for “standard” image quality an image must meet the following criteria: sun altitude greater than or equal to 10 degrees, off nadir view angle less than 20 degrees, and saturated pixels fewer than 20%. If the image does not meet these criteria it is considered “test” quality.	string: “standard” or “test”
satellite_azimuth	Spacecraft off track pointing direction, in degrees (0-360).	float
satellite_id	Globally unique identifier of the satellite that acquired the underlying imagery.	string

shadow_percent	Percent of shadow values in dataset. Shadow values represent scene content areas (non-blackfilled) that are not fully exposed to the solar illumination as a result of atmospheric transmission losses due to cloud, haze, soot and dust, and therefore do not allow for reliable interpretation of the radiometry or surface reflectance.	integer (0-100)
strip_id	The unique identifier of the image stripe that the item came from.	string
snow_ice_percent	Percent of snow and ice values in dataset. Snow_ice values represent scene content areas (non-blackfilled) that are hidden below snow and/or ice.	integer (0-100)
sun_azimuth	Angle from true north to the sun vector projected on the horizontal plane in degrees.	number (0 - 360)
sun_elevation	Elevation angle of the sun in degrees.	number (0 - 90)
updated	The RFC 3339 timestamp at which this item was updated in the API.	string
view_angle	Spacecraft across-track off-nadir viewing angle used for imaging, in degrees with + being east and - being west.	number (-25 - +25)
visible_percent	Visible values represent the fraction of the scene content (excluding the portion of the image which contains blackfill) which is comprised of clear, light haze, shadow, snow/ice categories, and is given as a percentage ranging from zero to one hundred.	integer (0-100)
visible_confidence_percent	Average of confidence percent for clear_percent, light_haze_percent, shadow_percent and snow_ice_percent	integer (0-100)

The PlanetScope Ortho Scenes Surface Reflectance product is provided as a 16-bit GeoTIFF image with reflectance values scaled by 10,000. Associated metadata describing inputs to the correction is included in a GeoTIFF TIFFTAG_IMAGEDESCRIPTION metadata header as a JSON encoded string.

The table below describes the metadata schema for Surface Reflectance products stored in the GeoTIFF header:

Table 7-D: PlanetScope Ortho Scene Surface Reflectance GeoTIFF Metadata Schema

PLANETSCOPE ORTHO SCENE SURFACE REFLECTANCE GEOTIFF METADATA SCHEMA

Parameter	Description	Example
aerosol_model	6S aerosol model used	continental
aot_coverage	Percentage overlap between MODIS data and the scene being corrected	0.5625
aot_method	Method used to derive AOD value(s) for an image. 'Map' indicates that per-pixel AOD values are used based on an interpolated map over the scene; 'fixed' indicates a single value for the entire image used when there is not enough data coverage to produce a map.	fixed
aot_mean_quality	Average MODIS AOD quality value for the overlapping NRT data in the range 1-10. This is set to 127 when no data is available	1.0
aot_source	Source of the AOD data used for the correction	mod09cma_nrt
aot_std	Standard deviation of the averaged MODIS AOD data	0.033490001296168699
aot_status	A text string indicating state of AOD retrieval. If no data exists from the source used, a default value 0.226 is used	Missing Data - Using Default AOT
aot_used	Aerosol optical depth used for the correction	0.061555557780795626
atmospheric_correction_algorithm	The algorithm used to generate LUTs	6SV2.1
atmospheric_model	Custom model or 6S atmospheric model used	water_vapor_and_ozone
luts_version	Version of the LUTs used for the correction	3
ozone_coverage	Percentage overlap between MODIS data and the scene being corrected	0.53125
ozone_mean_quality	Average MODIS ozone quality value for the overlapping NRT data. This will always be 255 if data is present	255
ozone_method	Method used to derive ozone value(s) for an image. Currently only 'fixed' is used, indicating a single value for the entire image	fixed

ozone_source	Source of the ozone data used for the correction	mod09cmg_nrt
ozone_status	A text string indicating state of ozone retrieval. If no ozone data is available for the scene being corrected, the corrections falls back to a 6SV built-in atmospheric model	Data Found
ozone_std	Standard deviation of the averaged MODIS ozone data.	0
ozone_used	Ozone concentration used for the correction, in cm-atm	0.255
satellite_azimuth_angle	Always defined to be 0.0 degrees and solar zenith angle measured relative to it	0.0
satellite_zenith_angle	Satellite zenith angle, fixed to nadir pointing	0.0
solar_azimuth_angle	Sun azimuth angle relative to satellite, in degrees	111.42044562850029
solar_zenith_angle	Solar zenith angle in degrees	30.26950393461825
sr_version	Version of the correction applied.	1.0
water_vapor_coverage	Percentage overlap between MODIS data and the scene being corrected	0.53215
water_vapor_mean_quality	Average MODIS ozone quality value for the overlapping NRT data in the range 1-10. This is set to 127 when no data is available	1.5294
water_vapor_method	Method used to derive water vapor value(s) for an image. Currently only 'fixed' is used, indicating a single value for the entire image	fixed
water_vapor_source	Source of the water vapor data used for the correction	mod09cma_nrt
water_vapor_status	A text string indicating state of water vapor retrieval. If no water vapor data is available for the scene being corrected, the corrections falls back to a 6SV built-in atmospheric model	Data Found
water_vapor_std	Standard deviation of the averaged MODIS AOD data	0.0587
water_vapor_used	Water vapor concentration used for the correction in g/cm^2	4.0512

8.2.2 SkySat

The table below describes the GeoJSON metadata schema for SkySat Ortho Scene products:

Table 7-E: Skysat Ortho Scene Geojson Metadata Schema

SKYSAT ORTHO SCENE GEOJSON METADATA SCHEMA

Parameter	Description	Type
acquired	The time that image was taken in RFC 3398 format, in UTC.	string
camera_id	The specific detector used to capture the scene.	String (e.g. “d1”, “d2”)
cloud_cover	Ratio of the area covered by clouds to that which is uncovered.	number (0 - 1)
ground_control	If the image meets the positional accuracy specifications this value will be true. If the image has uncertain positional accuracy, this value will be false.	boolean
gsd	The ground sampling distance of the image acquisition.	number
item_type	The name of the item type that models shared imagery data schema.	string (e.g. “PSScene3Band”, ”SkySatScene”)
provider	Name of the imagery provider.	string ("planetscope","rapideye", “skysat”)
published	The RFC 3339 timestamp at which this item was added to the API.	string
publishing_stage	Stage of publishing for an item. Both "l1a" assets and SkySatScenes with fast-rectification applied will have a publishing_stage = "preview". Fast-rectification refers to the initial rectification of the orthorectified product, to enable faster publication. Once full-rectification is applied, all assets will be updated to publishing_stage = "finalized	string (“preview”, “finalized”)
quality_category	Metric for image quality. To qualify for “standard” image quality an image must meet a variety of quality standards, for example: PAN motion blur less than 1.15 pixels, compression bits per pixel less than 3. If the image does not meet these criteria it is considered “test” quality.	string (“standard”, “test”)

satellite_azimuth	Angle from true north to the satellite vector at the time of imaging, projected on the horizontal plane in degrees.	number (0 - 360)
satellite_id	Globally unique identifier of the satellite that acquired the underlying imagery.	string
strip_id	Globally unique identifier of the image strip this scene was collected against	string
sun_azimuth	Angle from true north to the sun vector projected on the horizontal plane in degrees.	number (0 - 360)
sun_elevation	Elevation angle of the sun in degrees.	number (0 - 90)
updated	The RFC 3339 timestamp at which this item was updated in the API.	string
view_angle	Spacecraft across-track off-nadir viewing angle used for imaging, in degrees.	number (0 - 90)

8.3 BASIC SCENES

8.3.1 PlanetScope

The table below describes the GeoJSON metadata schema for PlanetScope Basic Scene products:

Table 7-F: PlanetScope Basic Scene GeoJSON Metadata Schema

Parameter	Description	Type
acquired	The time that image was taken in RFC 3398 format, in UTC.	string
anomalous_pixel	Percentage of anomalous pixels. Pixels that have image quality issues documented in the quality taxonomy	number
cloud_cover	Ratio of the area covered by clouds to that which is uncovered.	number (0 - 1)
ground_control	If the image meets the positional accuracy specifications this value will be true. If the image has uncertain positional accuracy, this value will be false.	boolean
gsd	The ground sampling distance of the image acquisition.	number

instrument	The generation of the satellite telescope.	string (e.g."PS2", "PS2.SD")
item_type	The name of the item type that models shared imagery data schema.	string (e.g. "PSScene)
pixel_resolution	Pixel resolution of the imagery in meters.	number
provider	Name of the imagery provider.	string (e.g. "planetscope","rapideye"")
published	The RFC 3339 timestamp at which this item was added to the API.	string
publishing_stage	Stage of publishing for an item. SkySatScenes are first published in a "preview" stage and graduate to a "finalized" stage.	string
quality_category	Metric for image quality. To qualify for "standard" image quality an image must meet the following criteria: sun altitude greater than or equal to 10 degrees, off nadir view angle less than 20 degrees, and saturated pixels fewer than 20%. If the image does not meet these criteria it is considered "test" quality.	string: "standard" or "test"
satellite_azimuth	Spacecraft off track pointing direction, in degrees (0-360).	float
satellite_id	Globally unique identifier of the satellite that acquired the underlying imagery.	string
strip_id	The unique identifier of the image stripe that the item came from.	string
sun_azimuth	Angle from true north to the sun vector projected on the horizontal plane in degrees.	number (0 - 360)
sun_elevation	Elevation angle of the sun in degrees.	number (0 - 90)
updated	The RFC 3339 timestamp at which this item was updated in the API.	string
view_angle	Spacecraft across-track off-nadir viewing angle used for imaging, in degrees with + being east and - being west.	number (-25 - +25)

8.3.2 RapidEye

The table below describes the GeoJSON metadata schema for RapidEye Basic Scene products:

Table 7-G: RapidEye Basic Scene GeoJSON Metadata Schema

RAPIDEYE BASIC SCENE GEOJSON METADATA SCHEMA

Parameter	Description	Type
acquired	The time that image was taken in ISO 8601 format, in UTC.	string
anomalous_pixel	Count of any identified anomalous pixels	number
cloud_cover	The estimated percentage of the image covered by clouds.	number (0 - 100)
gsd	The ground sample distance (distance between pixel centers measured on the ground) of the image in meters.	number
black_fill	The percent of image pixels without valid image data. It is always zero.	number (0)
catalog_id	The catalog ID for the RapidEye Basic Scene product.	string
satellite_id	A unique identifier for the satellite that captured this image.	string
view_angle	The view angle in degrees at which the image was taken.	number
strip_id	The RapidEye Level 1B catalog id for older L1B products or the ImageTake ID for newer versions.	string
sun_elevation	The altitude (angle above horizon) of the sun from the imaged location at the time of capture in degrees.	number
sun_azimuth	The azimuth (angle clockwise from north) of the sun from the imaged location at the time of capture in degrees.	number
updated	The last time this asset was updated in the Planet archive. Images may be updated after they are originally published	string
usable_data	Amount of image that is considered usable data, for example non-cloud cover pixels,	Number (0-1)

	expressed as a percentage. Applies only to RapidEye data.	
columns	The number of columns in the image	number
rows	The number of rows in the image	number
published	The date the image was originally published	string
provider	The satellite constellation	String: “rapideye”
item_type	The item type as cataloged in the Planet Archive	String: “REScene”

8.3.3 SkySat

The table below describes the GeoJSON metadata schema for SkySat Basic Scene products:

Table 7-H: Skysat Basic Scene Geojson Metadata Schema

SKYSAT BASIC SCENE GEOJSON METADATA SCHEMA

Parameter	Description	Type
acquired	The RFC 3339 acquisition time of the image.	string
camera_id	The specific detector used to capture the scene.	String (e.g. “d1”, “d2”)
cloud_cover	Ratio of the area covered by clouds to that which is uncovered.	number (0 - 1)
ground_control	If the image meets the positional accuracy specifications this value will be true. If the image has uncertain positional accuracy, this value will be false.	boolean
gsd	The ground sampling distance of the image acquisition.	number
item_type	The name of the item type that models shared imagery data schema.	string (e.g. “PSScene3Band”, ”SkySatScene”)
provider	Name of the imagery provider.	string ("planetscope","rapideye", “skysat”)
published	The RFC 3339 timestamp at which this item was added to the API.	string

publishing_stage	Stage of publishing for an item. Both "l1a" assets and SkySatScenes with fast-rectification applied will have a publishing_stage = "preview". Fast-rectification refers to the initial rectification of the orthorectified product, to enable faster publication. Once full-rectification is applied, all assets will be updated to publishing_stage = "finalized	string (“preview”, “finalized”)
quality_category	Metric for image quality. To qualify for “standard” image quality an image must meet a variety of quality standards, for example: PAN motion blur less than 1.15 pixels, compression bits per pixel less than 3. If the image does not meet these criteria it is considered “test” quality.	string (“standard”, “test”)
satellite_azimuth	Angle from true north to the satellite vector at the time of imaging, projected on the horizontal plane in degrees.	number (0 - 360)
satellite_id	Globally unique identifier of the satellite that acquired the underlying imagery.	string
strip_id	Globally unique identifier of the image strip this scene was collected against	string
sun_azimuth	Angle from true north to the sun vector projected on the horizontal plane in degrees.	number (0 - 360)
sun_elevation	Elevation angle of the sun in degrees.	number (0 - 90)
updated	The RFC 3339 timestamp at which this item was updated in the API.	string
view_angle	Spacecraft across-track off-nadir viewing angle used for imaging, in degrees.	number (0 - 90)

8.4 ORTHO COLLECT

8.4.1 SkySat

The table below describes the GeoJSON metadata schema for SkySat Ortho Collect products:

Table 7-I: Skysat Ortho Collect Geojson Metadata Schema

SKYSAT ORTHO SCENE GEOJSON METADATA SCHEMA

Parameter	Description	Type

acquired	The time that image was taken in RFC 3398 format, in UTC.	string
camera_id	The specific detector used to capture the scene.	string (e.g. “d1”, “d2”)
cloud_cover	Ratio of the area covered by clouds to that which is uncovered.	number (0 - 1)
ground_control	If the image meets the positional accuracy specifications this value will be true. If the image has uncertain positional accuracy, this value will be false.	boolean
gsd	The ground sampling distance of the image acquisition.	number
item_type	The name of the item type that models shared imagery data schema.	string (e.g. “PSScene3Band”, ”SkySatScene”)
provider	Name of the imagery provider.	string ("planetscope","rapideye", “skysat”)
published	The RFC 3339 timestamp at which this item was added to the API.	string
publishing_stage	Stage of publishing for an item. Both "l1a" assets and SkySatScenes with fast-rectification applied will have a publishing_stage = "preview". Fast-rectification refers to the initial rectification of the orthorectified product, to enable faster publication. Once full-rectification is applied, all assets will be updated to publishing_stage = "finalized	string (“preview”, “finalized”)
quality_category	Metric for image quality. To qualify for “standard” image quality an image must meet a variety of quality standards, for example: PAN motion blur less than 1.15 pixels, compression bits per pixel less than 3. If the image does not meet these criteria it is considered “test” quality.	string (“standard”, “test”)
satellite_azimuth	Angle from true north to the satellite vector at the time of imaging, projected on the horizontal plane in degrees.	number (0 - 360)
satellite_id	Globally unique identifier of the satellite that acquired the underlying imagery.	string
strip_id	Globally unique identifier of the image strip this scene was collected against	string
sun_azimuth	Angle from true north to the sun vector projected on the horizontal plane in degrees.	number (0 - 360)

sun_elevation	Elevation angle of the sun in degrees.	number (0 - 90)
updated	The RFC 3339 timestamp at which this item was updated in the API.	string
view_angle	Spacecraft across-track off-nadir viewing angle used for imaging, in degrees.	number (0 - 90)
ground_lock_ratio	The percentage of SkySat frames that make up the full Collect product that have good ground control	Number (0 - 1)

9. Product Delivery

All imagery products are made available via Application Processing Interface (API) and Graphical User Interface (GUI).

9.1 PLANET APPLICATION PROGRAMMING INTERFACES (APIS)

Planet offers REST API access that allows listing, filtering, and downloading of data to anyone using a valid API key. The metadata features described in this document are all searchable via our Data API and downloadable via our Orders API.

Details on searching and ordering via Planet APIs are available in Planet's Developer Center. Links are also available below.

- Catalog Overview (Items Types & Assets Types)
- Search with Planet's Data API
- Order with Planet's Orders API

9.2 PLANET EXPLORER GRAPHICAL USER INTERFACE (GUI)

Planet Explorer is a web-based tool that can be used to search Planet's catalog of imagery, view metadata, and download full-resolution images. The interface and all of its features are built entirely on the externally available Planet API.

Planet Explorer allows users to:

1. **View Timelapse Mosaics**: A user can view Planet's quarterly and monthly mosaics, and can zoom in up to zoom level 12 (38 m / pixel per OpenStreetMap)
2. **Search**: A user can Search for any location or a specific area of interest by entering into the input box OR by uploading a geometry file (Shapefile, GeoJSON, KML, or WKT).
3. **Save Search**: The Save functionality allows a user to save search criteria based on area of interest, dates, and filters.
4. **Filter**: A user can filter by a specific date range and/or customizing metadata parameters (e.g. estimated cloud cover, GSD).
5. **Zoom and Preview Imagery:** Zoom and Preview allows a user to zoom in or out of the selected area and preview imagery.
6. **View Imagery Details**: A user can review metadata details about each imagery product.
7. **Download**: The Download icon allows a user to download imagery based on subscription type.

8. **Draw Tools**: These tools allow you to specify an area to see imagery results. The draw tool capabilities available are drawing a circle, drawing a rectangle, drawing a polygon, and/or limiting the size of the drawing to the size of loadable imagery.

9. **Imagery Compare Tool**: The Compare Tool allows you to compare sets of Planet imagery from different dates.

Planet will also enable additional functionality in the form of "Labs," which are demonstrations of capability made accessible to users through the GUI. Labs are active product features and will evolve over time based on Planet technology evolution and user feedback.

9.3 PLANET ACCOUNT MANAGEMENT TOOLS

As part of the Planet GUI, an administration and account management tool is provided. This tool is used to change user settings and to see past data orders. In addition, users who have administrator privileges will be able to manage users in their organization as well as review usage statistics.

The core functionality provided by account management tools are outlined below, and Planet may evolve Account Management tools over time to meet user needs:

1. **User Accounts Overview:** Every user account on the Planet Platform is uniquely identified by an email address. Each user also has a unique API key that can be used when interacting programmatically with the Platform.

2. **Organization and Sub-organization Overview:** Every user on the Planet Platform belongs to one organization. The Platform also supports "sub-organizations," which are organizations that are attached to a "parent" organization. An administrator of a parent organization is also considered an administrator on all sub-organizations.

3. **Account Privileges:** Every user account on the Planet Platform has one of two roles: user or administrator. An administrator has elevated access and can perform certain user management operations or download usage metrics that are not available to standard users. An administrator of a parent organization is also considered an administrator on all sub-organizations. Administrators can enable or disable administrator status and enable or disable users' access to the platform altogether.

4. **Orders and Usage Review:** This tool records all part orders made and allows users and administrators to view and download past orders. Usage metrics are also made available, including imagery products downloaded and bandwidth usage. Usage metrics are displayed for each individual API key that is part of the organization.

Appendix A – Image Support Data

All PlanetScope Ortho Products are accompanied by a set of image support data (ISD) files. These ISD files provide important information regarding the image and are useful sources of ancillary data related to the image. The ISD files are:

1. General XML Metadata File
2. Unusable Data Mask File
3. Usable Data Mask File

Each file is described along with its contents and format in the following sections.

GENERAL XML METADATA FILE

All PlanetScope Ortho Products will be accompanied by a single general XML metadata file. This file contains a description of basic elements of the image. The file is written in Geographic Markup Language (GML) version 3.1.1 and follows the application schema defined in the Open Geospatial Consortium (OGC) Best Practices document for Optical Earth Observation products version 0.9.3, see http://www.opengeospatial.org/standards/gml.

The contents of the metadata file will vary depending on the image product processing level. All metadata files will contain a series of metadata fields common to all imagery products regardless of the processing level. However, some fields within this group of metadata may only apply to certain product levels. In addition, certain blocks within the metadata file apply only to certain product types. These blocks are noted within the table.

The table below describes the fields present in the General XML Metadata file for all product levels.

Table A-1: General XML Metadata File Field Descriptions

GENERAL XML METADATA FILE FIELD DESCRIPTIONS

Field	Description
“metaDataProperty” Block	
EarthObservationMetaData	
Identifier	Root file name of the image
acquisitionType	Nominal acquisition
productType	Product level listed in product filename
status	Status type of image, if newly acquired or produced from a previously archived image
downlinkedTo	

acquisitionStation	X-band downlink station that received image from satellite
acquisitionDate	Date and time image was acquired by satellite
archivedIn	
archivingCenter	Location where image is archived
archivingDate	Date image was archived
archivingIdentifier	Catalog ID of image
processing	
processorName	Name of ground processing system
processorVersion	Version of processor
nativeProductFormat	Native image format of the raw image data
license	
licenseType	Name of selected license for the product
resourceLink	Hyperlink to the physical license file
versionIsd	Version of the ISD
orderId	Order ID of the product
tileId	Tile ID of the product corresponding to the Tile Grid
pixelFormat	Number of bits per pixel per band in the product image file
“validTime” Block	
TimePeriod	
beginPosition	Start date and time of acquisition for source image take used to create product, in UTC
endPosition	End date and time of acquisition for source image take used to create product, in UTC
“using” Block	
EarthObservationEquipment	
platform	
shortName	Identifies the name of the satellite platform used to collect the image
serialIdentifier	ID of the satellite that acquired the data
orbitType	Orbit type of satellite platform
instrument	
shortName	Identifies the name of the satellite instrument used to collect the image

sensor	
sensorType	Type of sensor used to acquire the data.
resolution	Spatial resolution of the sensor used to acquire the image, units in meters
scanType	Type of scanning system used by the sensor
acquistionParameters	
orbitDirection	The direction the satellite was traveling in its orbit when the image was acquired
incidenceAngle	The angle between the view direction of the satellite and a line perpendicular to the image or tile center
illuminationAzimuthAngle	Sun azimuth angle at center of product, in degrees from North (clockwise) at the time of the first image line
illuminationElevationAngle	Sun elevation angle at center of product, in degrees
azimuthAngle	The angle from true north at the image or tile center to the scan (line) direction at image center, in clockwise positive degrees.
spaceCraftView Angle	Spacecraft across-track off-nadir viewing angle used for imaging, in degrees with "+" being East and "-" being West
acquisitionDateTime	Date and Time at which the data was imaged, in UTC. Note: the imaging times will be somewhat different for each spectral band. This field is not intended to provide accurate image time tagging and hence is simply the imaging time of some (unspecified) part of the image.
"target" Block	
Footprint	
multiExtentOf	
posList	Position listing of the four corners of the image in geodetic coordinates in the format: ULX ULY URX URY LRX LRY LLX LLY ULX ULY where X = latitude and Y = longitude
centerOf	
pos	Position of center of product in geodetic coordinate X and Y, where X = latitude and Y = longitude
geographicLocation	
topLeft	
latitude	Latitude of top left corner in geodetic WGS84 coordinates
longitude	Longitude of top left corner in geodetic WGS84 coordinates
topRight	
latitude	Latitude of top right corner in geodetic WGS84 coordinates
longitude	Longitude of top right corner in geodetic WGS84 coordinates

bottomLeft	
latitude	Latitude of bottom left corner in geodetic WGS84 coordinates
longitude	Longitude of bottom left corner in geodetic WGS84 coordinates
bottomRight	
latitude	Latitude of bottom right corner in geodetic WGS84 coordinates
longitude	Longitude of bottom right corner in geodetic WGS84 coordinates
“resultOf” Block	
EarthObservationResult	
browse	
BrowseInformation	
type	Type of browse image that accompanies the image product as part of the ISD
referenceSystemIdentifier	Identifies the reference system used for the browse image
fileName	Name of the browse image file
product	
fileName	Name of image file.
productFormat	File format of the image product
spatialReferenceSystem	
epsgCode	EPSG code that corresponds to the datum and projection information of the image
geodeticDatum	Name of datum used for the map projection of the image
projection	Projection system used for the image
projectionZone	Zone used for map projection
resamplingKernel	Resampling method used to produce the image. The list of possible algorithms is extendable
numRows	Number of rows (lines) in the image
numColumns	Number of columns (pixels) per line in the image
numBands	Number of bands in the image product
rowGsd	The GSD of the rows (lines) within the image product
columnGsd	The GSD of the columns (pixels) within the image product
radiometricCorrectionApplied	Indicates whether radiometric correction has been applied to the image
geoCorrectionLevel	Level of correction applied to the image

elevationCorrectionApplied	Indicates the production elevation model used for ortho
atmosphericCorrectionApplied	Indicates whether atmospheric correction has been applied to the image
atmosphericCorrectionParameters	
mask	
MaskInformation	
type	Type of mask file accompanying the image as part of the ISD
format	Format of the mask file
referenceSystemIdentifier	EPSG code that corresponds to the datum and projection information of the mask file
fileName	File name of the mask file
cloudCoverPercentage	Estimate of cloud cover within the image
cloudCoverPercentageQuotationMode	Method of cloud cover determination
unusableDataPercentage	Percent of unusable data with the file
The following group is repeated for each spectral band included in the image product	
bandSpecificMetadata	
bandNumber	Number (1-5) by which the spectral band is identified.
startDateTime	Start time and date of band, in UTC
endDateTime	End time and date of band, in UTC
percentMissingLines	Percentage of missing lines in the source data of this band
percentSuspectLines	Percentage of suspect lines (lines that contained downlink errors) in the source data for the band
binning	Indicates the binning used (across track x along track)
shifting	Indicates the sensor applied right shifting
masking	Indicates the sensor applied masking
radiometricScaleFactor	Provides the parameter to convert the scaled radiance pixel value to radiance Multiplying the Scaled Radiance pixel values by the values, derives the Top of Atmosphere Radiance product. This value is a constant, set to 0.01
reflectanceCoefficient	The value is a multiplicative, when multiplied with the DN values, provides the Top of Atmosphere Reflectance values
The remaining metadata fields are only included in the file for L1B RapidEye Basic products	
spacecraftInformationMetadataFile	Name of the XML file containing attitude, ephemeris and time for the 1B image
rpcMetadataFile	Name of XML file containing RPC information for the 1B image

mask	
MaskInformation	
type	Type of mask file accompanying the image as part of the ISD
format	Format of the mask file
referenceSystemIdentifier	EPSG code that corresponds to the datum and projection information of the mask file
fileName	File name of the mask file
cloudCoverPercentage	Estimate of cloud cover within the image
cloudCoverPercentageQuotationMode	Method of cloud cover determination
unusableDataPercentage	Percent of unusable data with the file
The following group is repeated for each spectral band included in the image product	
bandSpecificMetadata	
bandNumber	Number (1-5) by which the spectral band is identified.
startDateTime	Start time and date of band, in UTC
endDateTime	End time and date of band, in UTC
percentMissingLines	Percentage of missing lines in the source data of this band
percentSuspectLines	Percentage of suspect lines (lines that contained downlink errors) in the source data for the band
binning	Indicates the binning used (across track x along track)
shifting	Indicates the sensor applied right shifting
masking	Indicates the sensor applied masking
radiometricScaleFactor	Provides the parameter to convert the scaled radiance pixel value to radiance Multiplying the Scaled Radiance pixel values by the values, derives the Top of Atmosphere Radiance product. This value is a constant, set to 0.01
reflectanceCoefficient	The value is a multiplicative, when multiplied with the DN values, provides the Top of Atmosphere Reflectance values
harmonizationTransform	Provides coefficients to transform the Next-Generation PlanetScope sensor values to match those of the previous PlanetScope satellites
sourceSensor	The new instrument to be transformed to the targetSensor
targetSensor	The target instrument that the transform harmonizes values to
targetMeasure	The physical unit that the harmonization transform is valid for
bandCoefficients	Matrix of coefficients to transform band values to match those of the targetSensor, in combination with the finalOffset

finalOffset	An offset value for each band used in combination with the bandCoefficients to perform the transform
The remaining metadata fields are only included in the file for L1B RapidEye Basic products	
spacecraftInformationMetadataFile	Name of the XML file containing attitude, ephemeris and time for the 1B image
rpcMetadataFile	Name of XML file containing RPC information for the 1B image

File Naming Example: Ortho Tiles

The General XML Metadata file will follow the naming conventions as in the example below.

Example: 2328007_2010-09-21_RE4_3A_visual_metadata.xml

UNUSABLE DATA MASK FILE

The unusable data mask file provides information on areas of unusable data within an image (e.g. cloud and non-imaged areas).

The pixel size after orthorectification will be 3.0m for PlanetScope Scenes, 50 m for RapidEye, and 0.8 m for SkySat. It is suggested that when using the file to check for usable data, a buffer of at least 1 pixel should be considered. Each bit in the 8-bit pixel identifies whether the corresponding part of the product contains useful imagery:

- **Bit 0**: Identifies whether the area contains blackfill in all bands (this area was not imaged). A value of “1” indicates blackfill.
- **Bit 1**: Identifies whether the area is cloud covered. A value of “1” indicates cloud coverage. Cloud detection is performed on a decimated version of the image (i.e. the browse image) and hence small clouds may be missed. Cloud areas are those that have pixel values in the assessed band (Red, NIR or Green) that are above a configurable threshold. This algorithm will:
    - Assess snow as cloud
    - Assess cloud shadow as cloud free
    - Assess haze as cloud free
- **Bit 2**: Identifies whether the area contains missing (lost during downlink) or suspect (contains down-link errors) data in Blue Band. A value of “1” indicates missing/suspect data. If the product does not include this band, the value is set to “0”.
- **Bit 3**: Identifies whether the area contains missing (lost during downlink and hence backfilled) or suspect (contains downlink errors) data in the Green Band. A value of “1” indicates missing/suspect data. If the product does not include this band, the value is set to “0”.

- Bit 4: Identifies whether the area contains missing (lost during downlink) or suspect (contains downlink errors) data in the Red Band. A value of "1" indicates missing/suspect data. If the product does not include this band, the value is set to "0".
- Bit 5: Identifies whether the area contains missing (lost during downlink) or suspect (contains downlink errors) data in the Red-Edge band. A value of "1" indicates missing/suspect data. If the product does not include this band, the value is set to "0".
- Bit 6: Identifies whether the area contains missing (lost during downlink) or suspect (contains downlink errors) data in the Near-Infrared band. A value of "1" indicates missing/suspect data. If the product does not include this band, the value is set to "0".
- Bit 7: Identifies whether the area contains missing (lost during downlink) or suspect (contains downlink errors) data in the Coastal Blue and/or Green I and/or Yellow Band. A value of "1" indicates missing/suspect data. If the product does not include this band, the value is set to "0."

The UDM information is found in band 8 of the Usable Data Mask file.

USABLE DATA MASK FILE

The usable data mask file provides information on areas of usable data within an image (e.g. clear, snow, shadow, light haze, and cloud).

The pixel size after orthorectification will be 3.0m for PlanetScope Scenes. The usable data mask is a raster image having the same dimensions as the image product, comprised of 8 bands, where each band represents a specific usability class mask. The usability masks are mutually exclusive, and a value of one indicates that the pixel is assigned to that usability class. Read more on Planet's Developer Center - UDM2.

- Band 1: clear mask (a value of "1" indicates the pixel is clear, a value of "0" indicates that the pixel is not clear and is one of the 5 remaining classes below)
- Band 2: snow mask
- Band 3: shadow mask
- Band 4: light haze mask
- Band 5: heavy haze mask (all images acquired after November 29, 2023 will have a value of "0" in band 5)
- Band 6: cloud mask
- Band 7: confidence map (a value of "0" indicates a low confidence in the assigned classification, a value of "100" indicates a high confidence in the assigned classification)
- Band 8: unusable data mask

File Naming

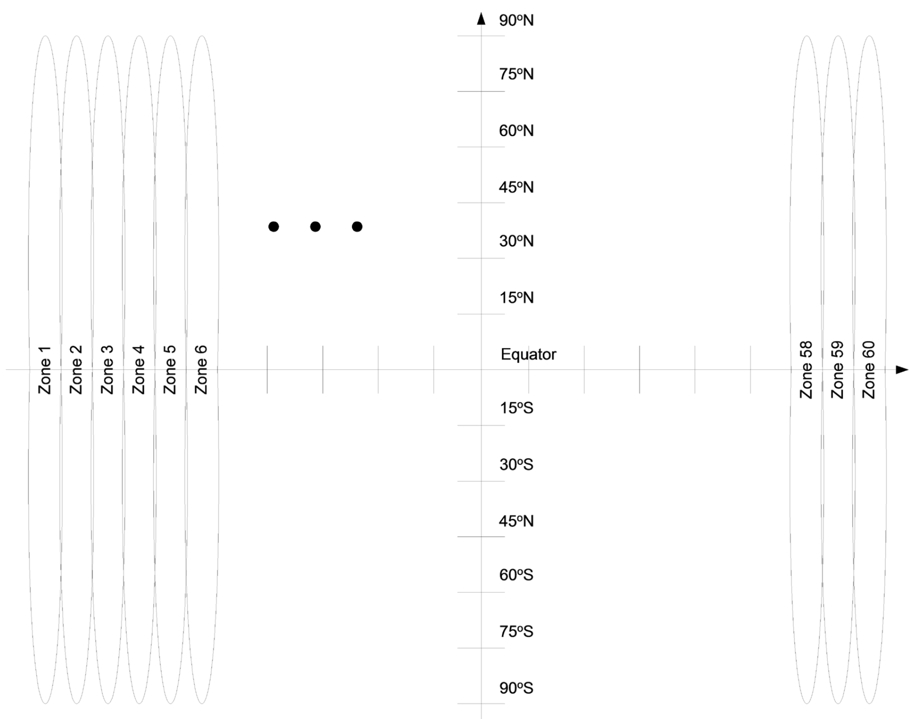
The UDM2 file will follow the naming conventions as in the example below.

Example: 20180921_102852_0f34_1A_udm2.tif (**basic_udm2** asset)
20180921_102852_0f34_3B_udm2.tif (**ortho_udm2** asset)

Appendix B - Tile Grid Definition

RapidEye Ortho Tile imagery products are based on the UTM map grid as shown in Figure B-1 and B-2. The grid is defined in 24km by 24km tile centers, with 1km of overlap, resulting in 25km by 25km tiles.

Figure B-1: Layout of UTM Zones



An Ortho Tile imagery products is named by the UTM zone number, the grid row number, and the grid column number within the UTM zone in the following format:

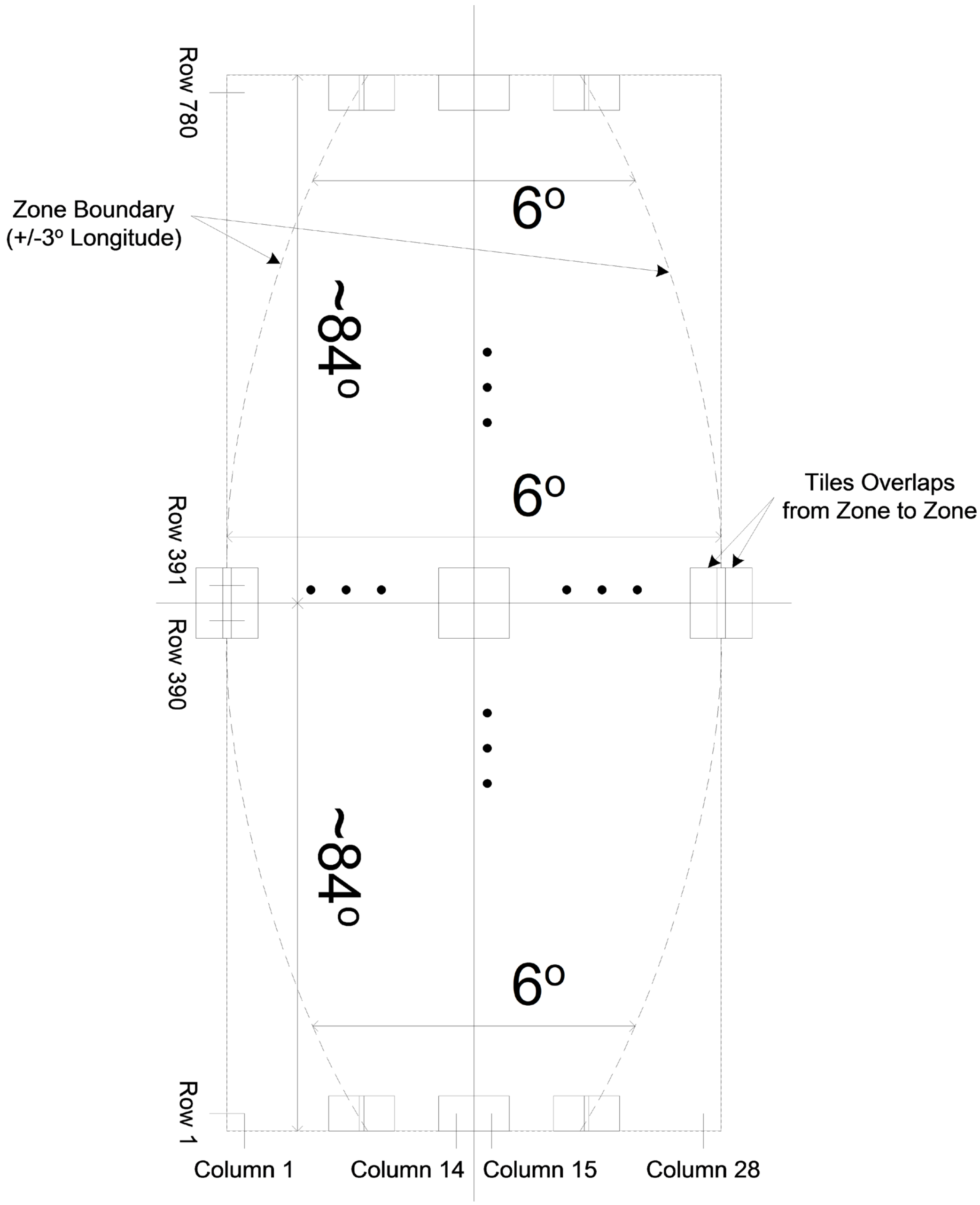
```
<ZZRRRCC>
```

Where:

```
ZZ = UTM Zone Number (This field is not padded with a zero for single digit zones in the tile shapefile)
RRR = Tile Row Number (increasing from South to North, see Figure B-2)
CC = Tile Column Number (increasing from West to East, see Figure B-2)
```

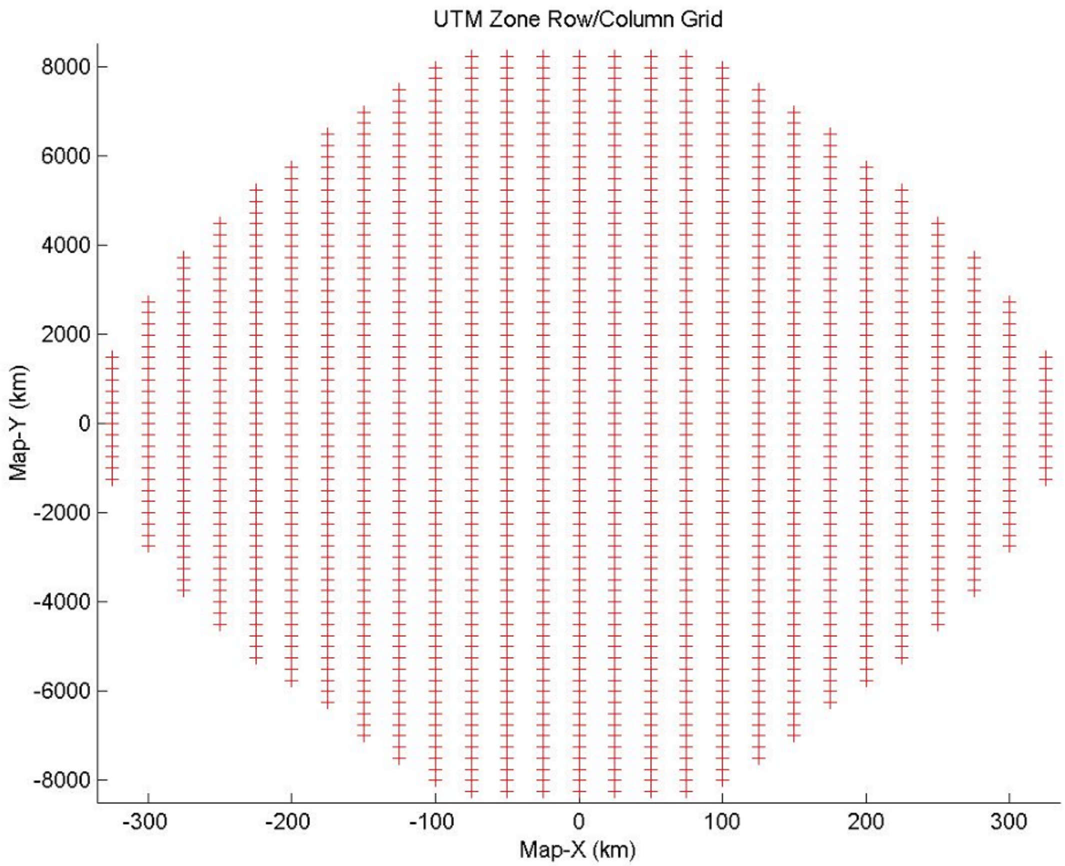
Example:	Tile 547904	= UTM Zone = 5, Tile Row = 479, Tile Column = 04
	Tile 3363308	= UTM Zone = 33, Tile Row = 633, Tile Column = 08

Figure B-2: Layout of Tile Grid within a single UTM zone



Due to the convergence at the poles, the number of grid columns varies with grid row as illustrated in Figure B-3.

Figure B-3: Illustration of grid layout of Rows and Columns for a single UTM Zone



The center point of the tiles within a single UTM zone are defined in the UTM map projection to which standard transformations from UTM map coordinates (x,y) to WGS84 geodetic coordinates (latitude and longitude) can be applied.

```
col = 1..29
row = 1..780
Xcol = False Easting + (col -15) x Tile Width + Tile Width/2
Yrow = (row – 391) x Tile Height + Tile Height/2
```

Where: (X and Y are in meters)

False Easting	=	500,000m
Tile Width	=	24,000m
Tile Height	=	24,000m

The numbers 15 and 391 are needed to align to the UTM zone origin.