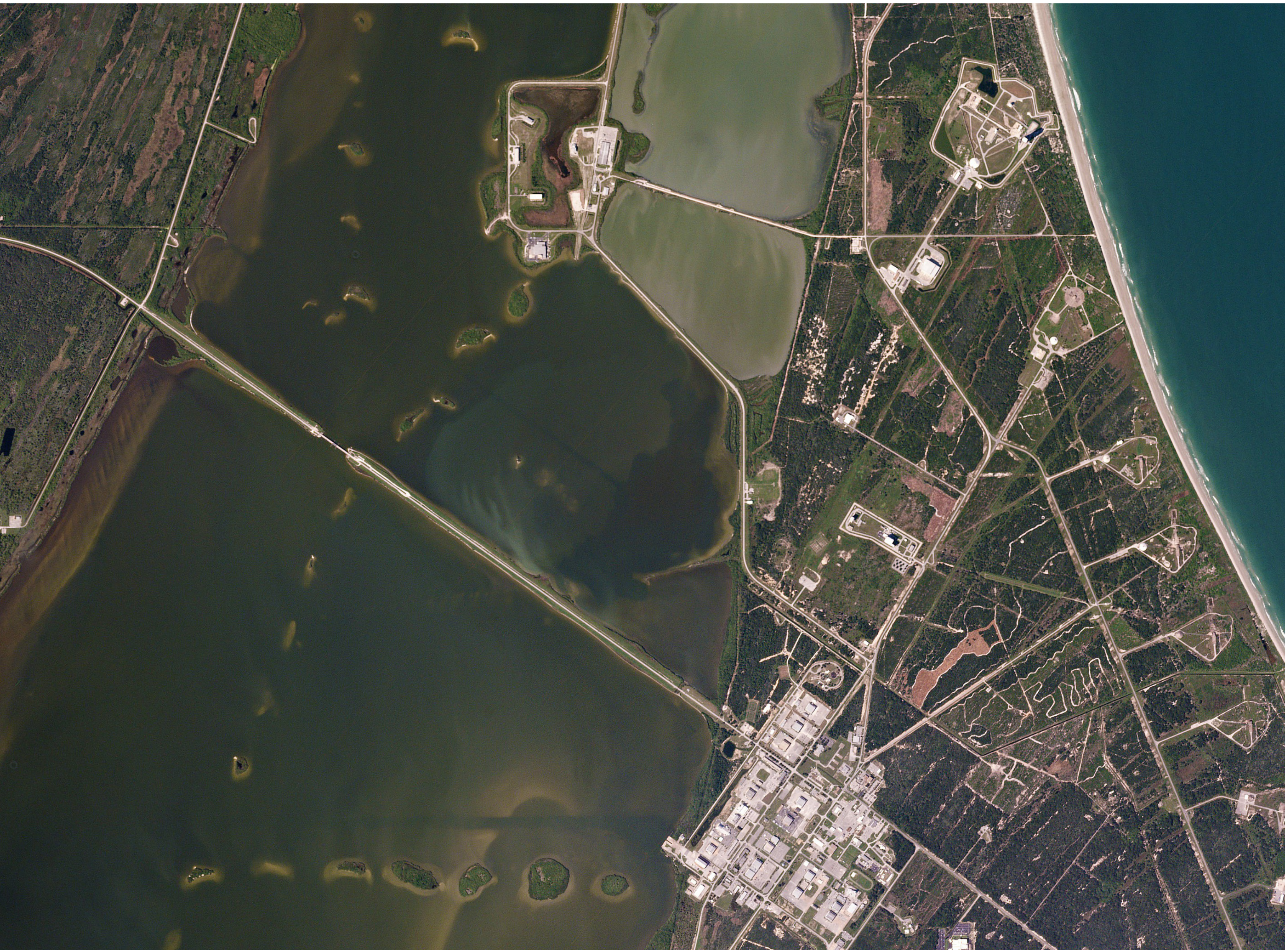

PLANET IMAGERY PRODUCT SPECIFICATION: PLANETSCOPE & RAPIDEYE

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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.

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)

The web-based graphical user interfaces allows users to browse, preview and download Planet's imagery products.

International Space Station (ISS) Orbit

International Space Station (ISS) orbits at a 51.6°inclination at approximately 400 km altitude. Planet deploys satellites from the ISS, each having a similar orbit.

JavaScript Object Notation (JSON)

Text-based data interchange format used by the Planet API.

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.

RapidEye

RapidEye refers to the five-satellite constellation in operation since 2009.

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.

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.

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.

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 is a fully integrated company that designs, builds, and actively operates satellites while also delivering data to customers via a web-based platform. Planet employs an "always on" image-capturing method as opposed to the traditional tasking model used by most satellite companies today.

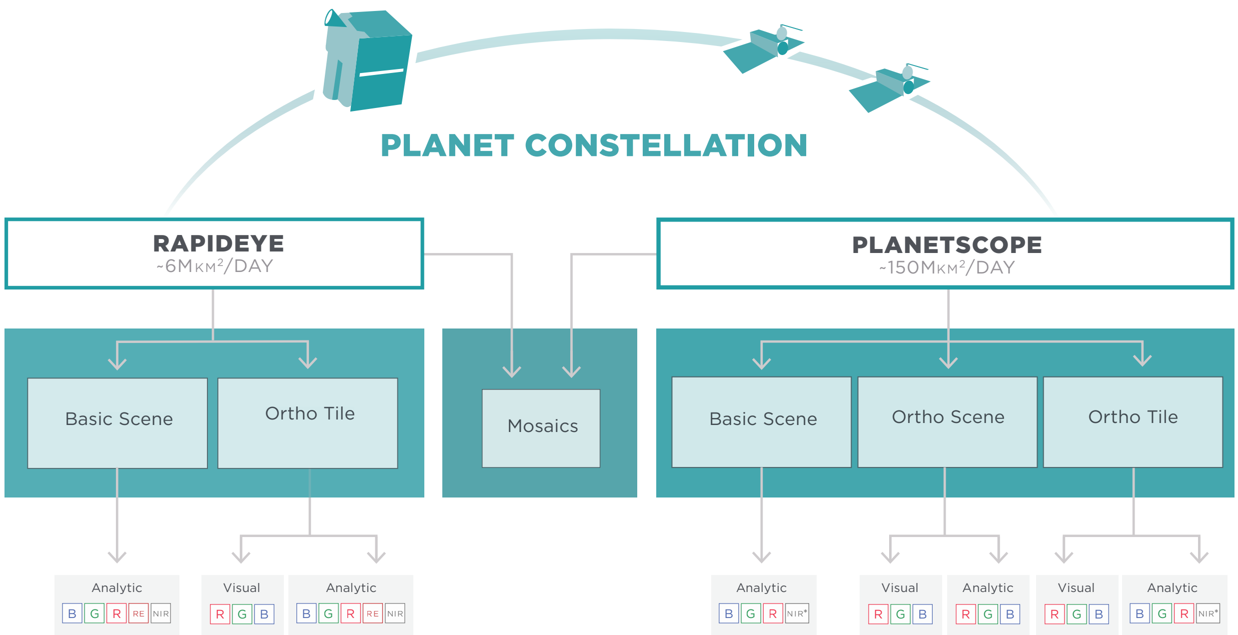
1.2. Data Product Overview

Planet operates the PlanetScope (PS) and RapidEye (RE) 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 may be acquired as 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.

Planet offers three product lines for PlanetScope imagery: a Basic Scene product, an Ortho Scene product, and an Ortho Tile 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. Ortho Tiles are multiple Ortho Scenes in a single strip that have been merged and then divided according to a defined grid.

Figure A: Planet Imagery Product Offerings



**NIR available on some PS2 imagery*
RapidEye Basic Scene product available soon

2. SATELLITE CONSTELLATIONS 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 120 satellites will be able to image the entire Earth every day (equating to a daily collection capacity of 150 million km^2/day).

Table A: PlanetScope Constellation and Sensor Specifications

Mission Characteristic	International Space Station Orbit	Sun Synchronous Orbit
Orbit Altitude (reference)	400 km (51.6° inclination)	475 km (~98° inclination)
Max/Min Latitude Coverage	±52°	±81.5° (depending on season)
Equator Crossing Time	Variable	9:30 - 11:30 am (local solar time)
Sensor Type	Three-band frame Imager or four-band frame Imager with a split-frame NIR filter	Three-band frame Imager or four-band frame Imager with a split-frame NIR filter
Spectral Bands	Blue 455 – 515 nm Green 500 – 590 nm Red 590 – 670 nm NIR 780 – 860 nm	Blue 455 – 515 nm Green 500 – 590 nm Red 590 – 670 nm NIR 780 – 860 nm
Ground Sampling Distance (nadir)	3.0 m (approx.)	3.7 m (at reference altitude 475 km)
Swath Width	24.6 km x 16.4 km (at reference altitude 475 km)	24.6 km x 16.4 km (at reference altitude)
Maximum Image Strip per orbit	8,100 km^2	20,000 km^2
Revisit Time	Variable	Daily at nadir (early 2017)
Image Capture Capacity	Variable	150 million km^2/day (early 2017)
Camera Dynamic Range	12-bit	12-bit

2.2 RapidEye Satellite Constellation and Sensor Characteristics

The RapidEye satellite constellation consists of five satellites collectively able to collect over 6 million square kilometers of data per day at 6.5 meter GSD (at nadir). Each satellite measures less than one cubic meter and weighs 150 kg (bus + payload). All five satellites are equipped with identical sensors and are located in the same orbital plane.

Table B: RapidEye Constellation and Sensor Specifications

Mission Characteristic	Information
Number of Satellites	5
Orbit Altitude	630 km in Sun-Synchronous Orbit
Equator Crossing Time	11:00 am local time (approximately)
Sensor Type	Multispectral push broom
Spectral Bands	Blue 440 – 510 nm Green 520 – 590 nm Red 630 – 685 nm Red Edge 690 – 730 nm NIR 760 – 850 nm
Ground Sampling Distance (nadir)	6.5 m
Swath Width	77 km
Maximum Image Strip per Orbit	Up to 1500 km of image data per orbit
Revisit Time	Daily (off-nadir) / 5.5 days (at nadir)
Image Capture Capacity	>6 million km^2/day
Camera Dynamic Range	12-bit

3. PLANETSCOPE IMAGERY PRODUCTS

PlanetScope imagery products are available as either individual Ortho Scenes, Basic Scenes, or Ortho Tile products.

Table C: 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 applied to the data.	Level 1B
PlanetScope Ortho Scene Product	Orthorectified, scaled Top of Atmosphere radiance (at sensor) image product suitable for analytic and visual applications. This product has scene based framing and projected to a cartographic projection.	Level 3B
PlanetScope Ortho Tile Product	Radiometric and sensor corrections applied to the data. Imagery is orthorectified and projected to a UTM projection.	Level 3A

3.1 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 the GeoTIFF format.

3.1.1 PlanetScope Analytic Basic Scene Product Specification

The PlanetScope Analytic Basic Scene product is 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 minimally 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 Analytic Basic Scene is optimal for value-added image processing such as land cover classifications.

The Analytic 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 RPCs to enable orthorectification by the user.

The radiometric corrections applied to this product are:
- Correction of relative differences of the radiometric response between detectors

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 Analytic Basic Scene:

Table D: PlanetScope Analytic Basic Scene Product Attributes

Product Attribute	Description
Information Content	
Analytic Bands	3-band natural color (red, green, blue) or 4-band multispectral image (blue, green, red, near-infrared)
Ground Sample Distance	3.7 m (at reference altitude 475 km)
Processing	
Pixel Size (orthorectified)	N/A
Bit Depth	12-bit (DN), 16-bit (Radiance)
Positional Accuracy	Less than 10 m RMSE
Radiometric Calibration Accuracy	Initial availability • No correction applied • Pixel values are digital numbers (also provided as radiance)
Map Projection	N/A

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

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

3.2 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. They are delivered as visual (RGB) and analytic products. Ortho Scenes are radiometrically-, sensor-, and geometrically-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.

Table E: 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 file that contains image data and geolocation information • Metadata File – GeoJSON and detailed XML metadata available
Product Orientation	Map North up
Product Framing	Scene Based
Bit Depth	Visual: 8-bit | Analytic (DN): 12-bit | Analytic (Radiance): 16-bit
Product Size	Nominal scene size is approximately 24 km by 7 km, but varies by 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).
Horizontal Datum	WGS84
Map Projection	UTM
Resampling Kernel	Cubic Convolution

3.2.1 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 F: PlanetScope Visual Ortho Scene Product Attributes

Product Attribute	Description
Information Content	
Visual Bands	3-band natural color (red, green, blue)
Ground Sample Distance	3.7 m (at reference altitude 475 km)
Processing	
Pixel Size (orthorectified)	3 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
Color Enhancements	Enhanced for visual use and corrected for sun angle

3.2.2 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 orthorectified analytic scene is optimal for value-added image processing such as land cover classifications. In addition to orthorectification, the imagery has radiometric corrections applied to correct for any sensor artifacts and transformation to at-sensor radiance.

Table G: PlanetScope Analytic Ortho Scene Product Attributes

Product Attribute	Description
Information Content	
Analytic Bands	3-band natural color (red, green, blue).
Ground Sample Distance	3.7 m (at reference altitude 475 km)
Processing	
Pixel Size (orthorectified)	3 m
Bit Depth	12-bit (DN), 16-bit (Radiance)
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
Radiometric Calibration Accuracy	Initial availability • No correction applied • Pixel values are digital numbers (also provided as Radiance)

3.3 PlanetScope Ortho Tile Product Specification

The PlanetScope Ortho Tile products offer PlanetScope Satellite imagery orthorectified as individual 25 km by 25 km tiles referenced to a fixed, standard image tile grid system. 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 cartographic purposes.

For PlanetScope split-frame satellites, imagery is collected as a series of overlapping framed scenes from a single satellite in a single pass. These scenes are subsequently orthorectified and an ortho tile is then generated from a collection of consecutive scenes, typically 4 to 5. The process of conversion of framed scene to ortho tile is outlined in the figure below.

The PlanetScope 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.

Figure B: PlanetScope Scene to Ortho Tile Conversion

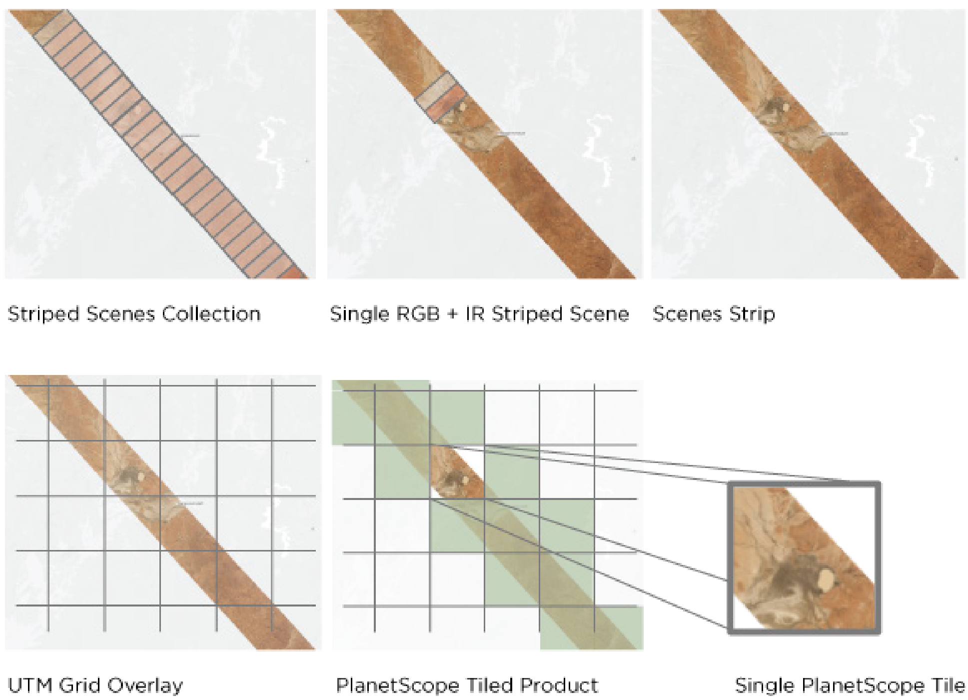


Table H: PlanetScope Ortho Tile Product Attributes

Product Attribute	Description
Product Components and Format	PlanetScope 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 • Thumbnail File – GeoTIFF format • Unusable Data Mask (UDM) file – GeoTIFF format
Product Orientation	Map North up
Product Framing	PlanetScope 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)	3.125 m
Bit Depth	16-bit unsigned integers
Product Size	Tile size is 25 km (8000 lines) by 25 km (8000 columns). 5 to 500 Mbytes per Tile for 4 bands at 3.125 m pixel size after orthorectification.
Geometric Corrections	Sensor-related effects are corrected using sensor telemetry and a sensor model. Orthorectified using GCPs and fine DEMs (30 m to 90 m posting).

Product Attribute	Description
Horizontal Datum	WGS84
Map Projection	UTM
Resampling Kernel	Cubic Convolution

3.3.1 PlanetScope Visual Ortho Tile Product Specification

The PlanetScope Visual Ortho Tile 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. 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.

Table I: PlanetScope Visual Ortho Tile Product Attributes

Product Attribute	Description
Information Content	
Visual Bands	3-band natural color (red, green, blue).
Ground Sample Distance	3.7 m (at reference altitude 475 km)
Processing	
Pixel Size (orthorectified)	3.125 m
Bit Depth	8-bit
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) to <10 m RMSE positional accuracy.
Positional Accuracy	Less than 10 m RMSE
Color Enhancements	Enhanced for visual use and corrected for sun angle

3.3.2 PlanetScope Analytic Ortho Tile Product Specification

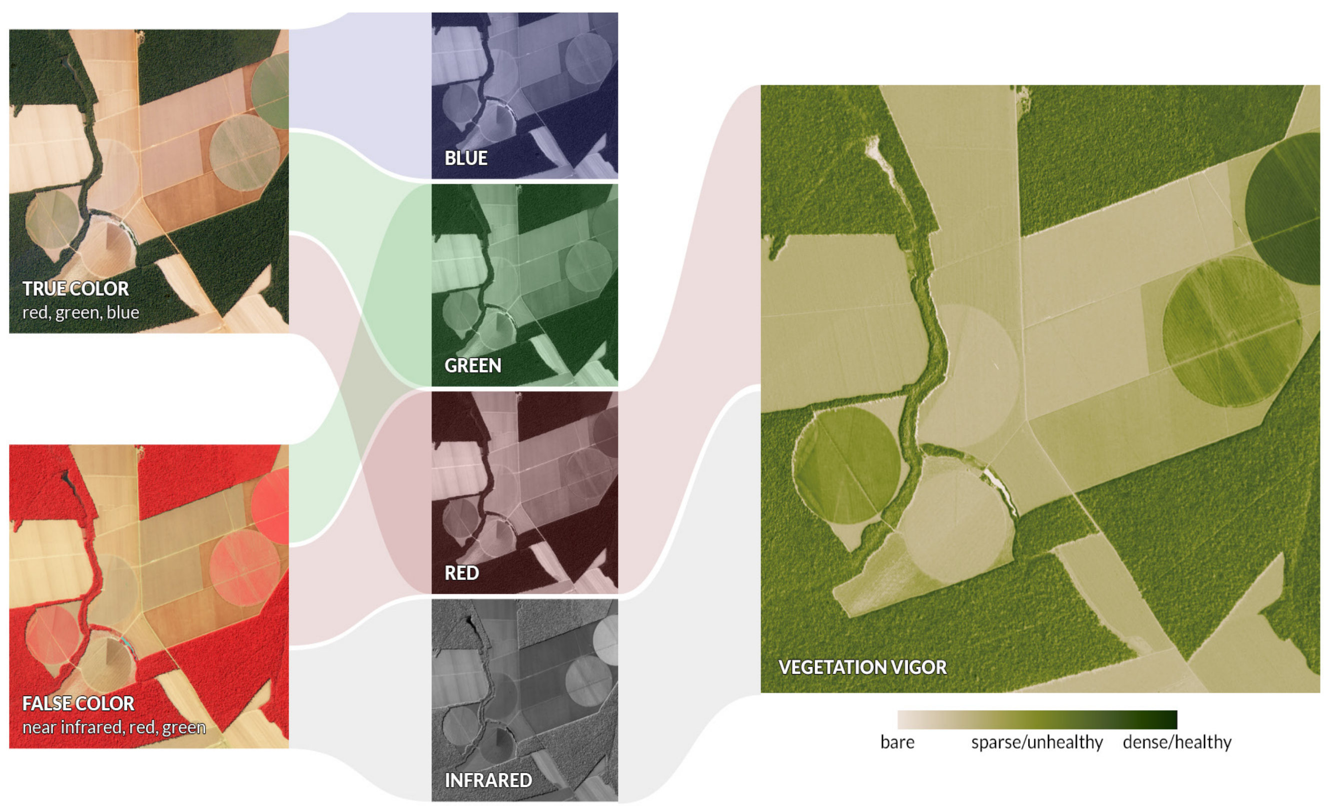
The PlanetScope Analytic Ortho Tile product is orthorectified, multispectral data from the satellite constellation. Analytic products are calibrated multispectral imagery products that have been processed to allow analysts to derive information products for data science and analytics. This product is designed for a wide variety of applications that require imagery with an accurate geolocation and cartographic projection. 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 visual 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.

Figure C: PlanetScope Analytic Ortho Tiles with RGB (left) and NIR False-Color Composite (right)

Table J: PlanetScope Analytic Ortho Tile Product Attributes

Product Attribute	Description
Information Content	
Analytic Bands	4-band multispectral image (blue, green, red, near-infrared).
Ground Sample Distance	3.7 m (at reference altitude 475 km)
Processing	
Pixel Size (orthorectified)	3.125 m
Bit Depth	16-bit
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) to <10 m RMSE positional accuracy.
Positional Accuracy	Less than 10 m RMSE
Radiometric Calibration Accuracy	Initial availability • No correction applied • Pixel values are digital numbers

Figure D: PlanetScope Analytic Bands



4. RAPIDEYE IMAGERY PRODUCTS

RapidEye imagery products are available in two different processing levels to be directly applicable to customer needs.

Table K: 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

4.1 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 will be available in the Planet Platform in early 2017, and will be available in GeoTIFF and NITF formats.

4.1.1 RapidEye Analytic Basic Scene Product Specification

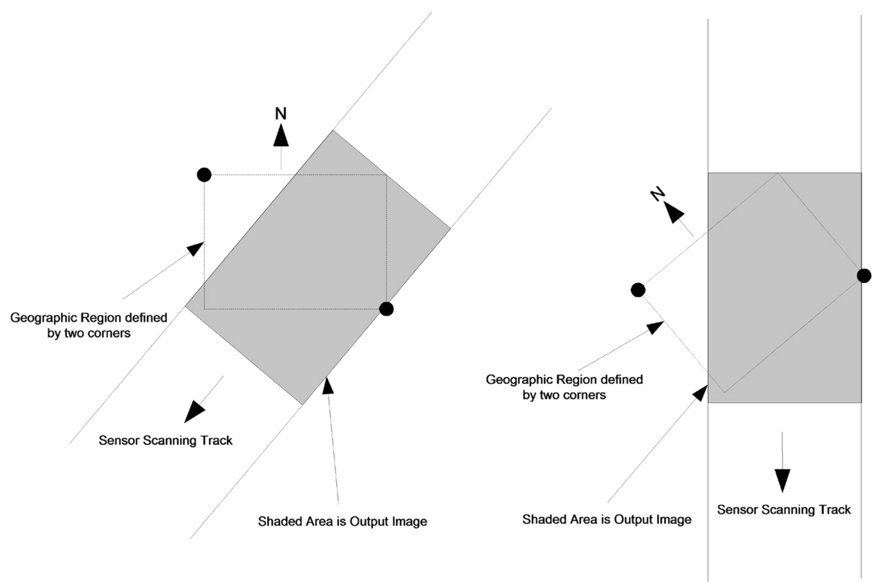
The RapidEye Analytic Basic Scene product is radiometrically- and sensor-corrected, providing imagery as seen from the spacecraft without correction for any geometric distortions inherent in the imaging process, and is not mapped to a cartographic projection. The imagery data is accompanied by all spacecraft 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 are:
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

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 Analytic Basic Scene product.

Table L: RapidEye Analytic Basic Scene Product Attributes

Product Attribute	Description
Product Components and Format	RapidEye Basic product consists of the following file components: • Image File – Image product delivered as a group of single-band NITF or Geo-TIFF files with associated RPC values. Bands are co-registered. • Metadata File – XML format metadata file. Metadata file contains additional information related to spacecraft attitude, spacecraft ephemeris, spacecraft temperature measurements, line imaging times, camera geometry, and radiometric calibration data. • Thumbnail File – GeoTIFF format • Unusable Data Mask (UDM) file – GeoTIFF format
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	 Geographic Perspective Image Perspective
Ground Sample Distance (nadir)	6.5 m
Bit Depth	16-bit unsigned integers
Pixel Size (orthorectified)	• Variable number of pixels (less than 11980 per line) and up to a maximum of 46154 lines per band. • 462 Mbytes/25 km along track for 5 bands. • Maximum 5544 Mbytes.
Geometric Corrections	Idealized sensor, orbit and attitude models. Bands are co-registered.
Horizontal Datum	WGS84
Map Projection	N/A
Resampling Kernel	Cubic Convolution

4.2 RapidEye Ortho Tile Product Specification

The RapidEye Ortho Tile products offer RapidEye Satellite imagery 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.

Table M: 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 • Thumbnail File – GeoTIFF format • 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	16-bit unsigned integers
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

4.2.1 RapidEye Visual Ortho Tile Product Specification

The RapidEye Visual Ortho Tile 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. 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.

Below is a sample of a RapidEye Visual Ortho Tile:

Figure E: RapidEye Visual Ortho Tile

Table N: RapidEye Visual Ortho Tile Product Attributes

Product Attribute	Description
Information Content	
Visual Bands	3-band natural color (red, green, blue)
Ground Sample Distance	3.7 m (at reference altitude 475 km)
Processing	
Pixel Size (orthorectified)	5 m
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	Less than 10 m RMSE
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

4.2.2 RapidEye Analytic Ortho Tile Product Specification

The RapidEye Analytic Ortho Tile product is orthorectified, multispectral data from the RapidEye satellite constellation. 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 O: RapidEye Analytic Ortho Tile Product Attributes

Product Attribute	Description
Information Content	
Analytic Bands	5-band multispectral image (blue, green, red, red edge, near-infrared)
Processing	
Pixel Size (orthorectified)	5 m
Bit Depth	16-bit
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) to <10 m RMSE positional accuracy.
Positional Accuracy	Less than 10 m RMSE
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

5. PRODUCT PROCESSING

5.1 PlanetScope Processing

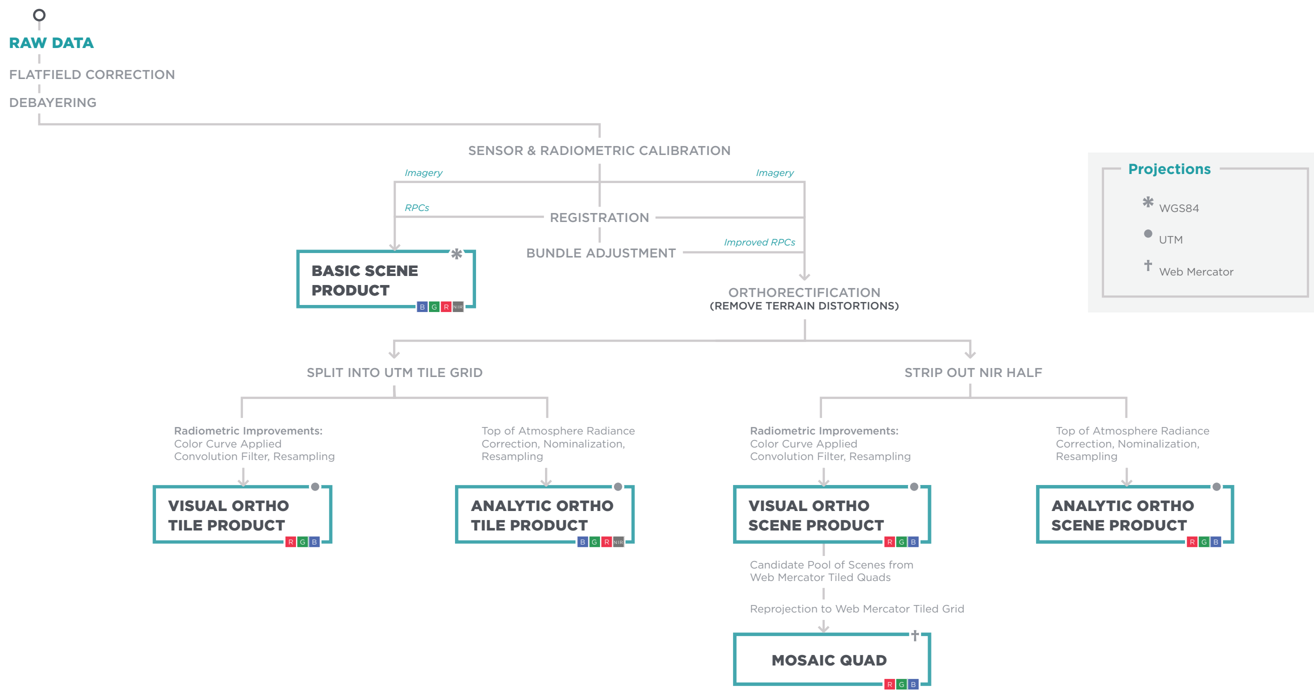
Several processing steps are applied to PlanetScope analytic imagery products, listed in the table below.

Table P: 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.
Camera Acquisition Parameter Correction	Determines a common radiometric response for each image (regardless of exposure time, TDI, 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*µm)*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). • 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 (NAIP, OSM, Landsat, ALOS) 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 each of Planet's imagery products.

Figure F: PlanetScope Image Processing Chain



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5.2 RapidEye Processing

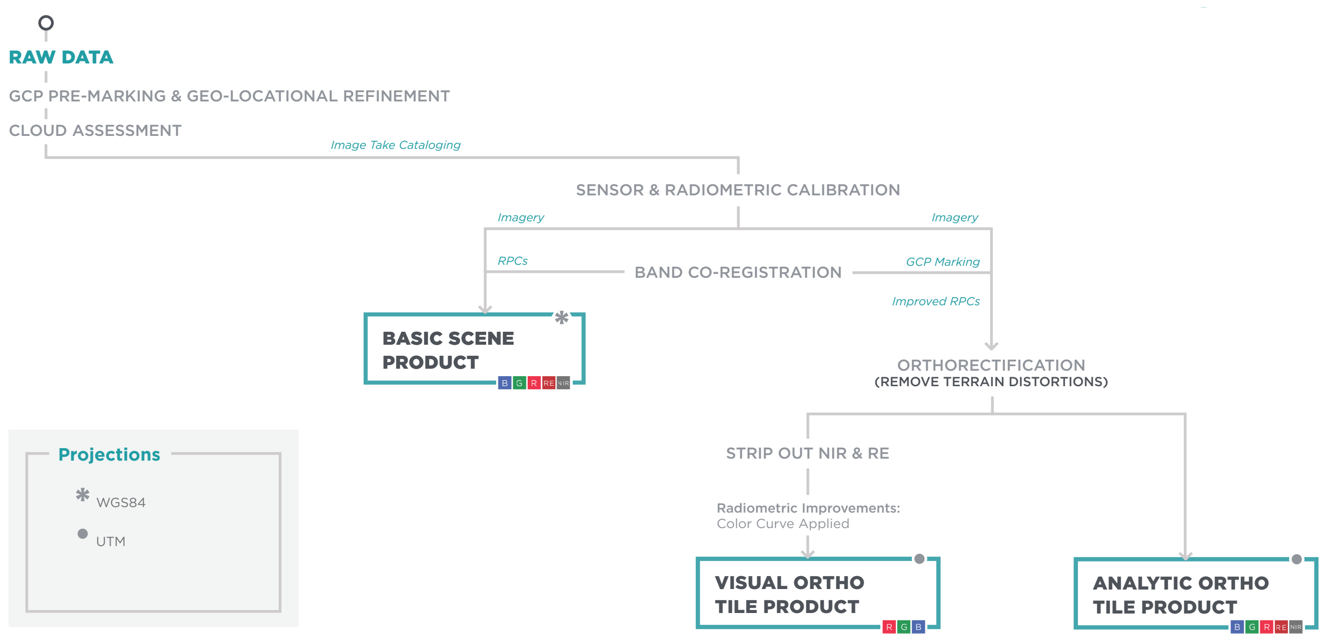
For RapidEye analytic imagery products, the processing steps are listed in the table below.

Table Q: RapidEye Processing Steps

Step	Description
Flat Field Correction (also referred to as spatial calibration)	Correction parameters to achieve the common response of all CCD element when exposed to the same amount of light have been collected for each optical instrument prior to launch. During operations, these corrections are adjusted on an as-needed basis when effects become visible or measurable 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 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). • 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 (NAIP, OSM, Landsat, ALOS) 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 each of Planet's imagery products.

Figure G: RapidEye Image Processing Chain



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6. QUALITY ATTRIBUTES

6.1 Product Geometric Positional Accuracy

The locational accuracy of all the imagery products depends on the quality of the reference data used: Ground Control Points (GCPs) and Digital Elevation Model (DEMs). Additionally, the roll angle of the spacecraft during the image acquisition and the number as well as the distribution of GCPs within the image will impact the final product accuracy.

Planet utilizes a unique imagery rectification approach that minimizes processing steps to increase overall processing efficiency in preparation for the large amounts of imagery data that will be downloaded and rectified at Full Operational Capability (FOC). This approach reduces resampling steps through a proprietary parallel processing approach that enables moving from raw to orthorectified imagery without degradation of imagery quality.

To support the integration and compilation of multiple images over time, each pixel is adjusted for Bayer Masking, Telescope Geometry, Orbital Geometry, Satellite Pointing Accuracy, and Topography. All ortho tiles are orthorectified using GCPs and fine DEMs (30 m to 90 m posting) to less than 10 m RMSE positional accuracy. Some 50,000 points are automatically generated for each satellite image and converted into a mathematical model to match relevant points to a database of some 5 million local ground control points derived from Landsat 8 and other sources. The Landsat 8 archive and Open Street Map database are automatically referenced to quickly provide robust, year-round, tie points.

6.2 Cloud Cover

6.2.1 PlanetScope

The cloud estimation for PlanetScope is based off of the expected luminosity of pixels for a given time of year. A historical per-pixel database has been built from the Landsat 8 archive. If the luminosity of a PlanetScope pixel is significantly higher than expected for that time of year, the pixel is marked as 'cloudy'.

This method is fast and simple, but has limitations:

1. If a region may be covered by snow at a given time of year, clouds are much less likely to be identified.
2. Darker clouds are less likely to be identified. This includes both thin clouds and self-shadowed clouds.
3. Brighter areas, such as desert surfaces, sands, and salt flats, are less likely to be identified as containing clouds.
4. Specular reflection and noon local time are more likely to be marked as clouds.

6.2.2 RapidEye

Cloud detection for the RapidEye satellite imagery products is done at two different stages of image processing with the results being used to create the Unusable Data Mask (UDM) file that accompanies every image product (see Appendix A for a detailed description of the UDM file). The two stages in the processing chain where the cloud cover is determined are:

1. **Cataloging:** For each acquired image received on the ground, the system performs a cloud detection and provides an Unusable Data Mask (UDM) for each tile in the image (see Appendix B for a description of the tile grid system); the result of this assessment is used to determine whether each tile can be accepted or whether a new collection is required and the area re-tasked.
2. **Processing:** For each product generated, the system performs cloud detection and produces a UDM file for that product. This is provided to the Customer as part of the Image Support Data (ISD) metadata files.

The cloud cover algorithm used in the RapidEye processing system has been specifically developed for RapidEye imagery and detects clouds based on complex pattern recognition algorithms which use information from all available spectral bands. This cloud cover algorithm is an improvement over previous versions and further improvements are being pursued on an ongoing basis.

This cloud detection technique has a number of known limitations:

1. Haze and cloud shadow are not reported
2. Snow/ice may be incorrectly classified as clouds
3. Overly bright surfaces, such as some desert surfaces, sands and salt flats are more likely to be identified as containing clouds.
4. “Darker” and/or smaller “popcorn” clouds may be undetected

Due to the vast amount of imagery collected on a daily basis, the cloud detection in both stages is the result of a fully automatic process and thus there is no “manual” quality control of the UDMs.

6.3 Band Co-Registration

6.3.1 PlanetScope

The RGB and the NIR “stripes” are 2 separate acquisitions (approximately 0.5 seconds apart). The imagery is first rectified to the ground and any adjacent rectified scenes with high accuracy. All tiepoints from this rectification solution (geographic and image coordinate tuples) are saved for future use. The Planet Pipeline is then able to quickly perform an operation similar to bundle adjustment over all scenes in a strip, optimizing for ground alignment and band co-registration. If one is familiar with the traditional bundle adjustment workflow, think of it as replacing the camera models with RPC equations, with the added benefit of ground tiepoints.

6.3.2 RapidEye

The focal plane of the RapidEye sensors is comprised of five separate CCD arrays, one for each band. This means that the bands have imaging time differences of up to three seconds for the same point on the ground, with the blue and red bands being the furthest apart in time. During processing, every product is band co-registered using a DEM to roughly correlate the bands to the reference band (Red Edge); a final alignment is done using an auto-correlation approach between the bands. For areas where the slope is below 10°, the band co-registration should be within 0.2 pixels or less (1-sigma). For areas with a slope angle of more than 10° and/or areas with very limited image structure (e.g. sand dunes, water bodies, areas with significant snow cover) the co-registration threshold mentioned above may not be met.

The separation between the RapidEye spectral bands leads to some effects that can be seen in the imagery. In a regular RapidEye scene with clouds, the cloud may show a red-blue halo around the main cloud. This is due to the Red and Blue bands being furthest apart on the sensor array, and the cloud moving during the imaging time between the two bands. Also, clouds are not reflected within the DEM which may lead to mis-registration. The same effect is visible for jet exhaust trails and flying planes. Bright vehicles moving on the ground will also look like colored streaks due to the image time differences.

6.4 Radiometry and Radiometric Accuracy

6.4.1 PlanetScope

Significant effort is made to ensure radiometric image product quality of all PlanetScope Satellite Imagery Products. This is achieved through a vigorous sensor calibration concept that is based on lab calibration, regular checks of the statistics from all incoming image data, acquisitions over selected temporal calibration sites, and absolute ground calibration campaigns.
The current product release will include calibrated radiance values using a limited set of pre-launch calibration data in the Analytic Ortho Tiles. This preview release is intended to expose users to the format of the radiance product. Our objective is to keep the calibration accuracy of the PlanetScope constellation consistent over time with on-orbit calibration techniques.

6.4.2 RapidEye

Significant effort is made to ensure radiometric image product quality of all RapidEye Satellite Imagery Products. This is achieved through a vigorous sensor calibration concept that is based on regular checks of the statistics from all incoming image data, acquisitions over selected temporal calibration sites, and absolute ground calibration campaigns.

The long term stability and inter-comparability among all five satellites is done by monitoring all incoming image data, along with frequent acquisitions from a number of calibration sites located worldwide. Statistics from all collects are used to update the gain and offset tables for each satellite. These statistics are also used to ensure that each band is within a range of +/- 2.5% from the band mean value across the constellation and over the satellite's lifetime.

All RapidEye 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. 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.

Results from an on-orbit absolute calibration campaign have been used to update the pre-launch absolute calibration of all five sensors. This calibration change applies to all imagery acquired after 1 January, 2010, but was only effective on or after 27 April, 2010.

The radiometric sensitivity for each band is defined in absolute values for standard conditions (21 March, 45° North, Standard Atmosphere) in terms of a minimum detectable reflectance difference. This determines the already mentioned bit depth as well as the tolerable radiometric noise within the images. It is more restrictive for the Red, Red Edge, and NIR bands, compared with the Blue and Green bands. During image quality control, a continuous check of the radiometric noise level is performed.

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 radiances into a reflectance it is necessary to relate the radiance values (e.g. the pixel DNs) 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:

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 $W/m^2\mu m$

For PlanetScope, the EAI values will be published online.

7. PRODUCT METADATA

7.1 Ortho Tiles

7.1.1 PlanetScope

As mentioned in earlier sections, the Ortho Tile data in the Planet API will contain metadata in machine-readable GeoJSON and supported by standards-compliant GIS tools (e.g. GDAL and derivatives, JavaScript libraries). The product metadata is also provided in XML format.

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

Table R: PlanetScope Ortho Tile GeoJSON Metadata Schema

Parameter	Description	Type
acquired	The RFC 3339 acquisition time of underlying imagery.	string
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.	number (0 - 1)
grid_cell	The grid cell identifier of the gridded item.	string
provider	Name of the imagery provider.	string (“planetscope”,”rapideye”)
resolution	Pixel resolution of the imagery in meters.	number
satellite_id	Globally unique identifier of the satellite that acquired the underlying imagery.	string
strip_id	The imaging strip from which the ortho tile originated.	number
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)
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)
published	The RFC 3339 timestamp at which this item was added to the catalog.	string

7.1.2 RapidEye

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

Table S: RapidEye Ortho Tile GeoJSON Metadata Schema

Parameter	Description	Type
acquired	The RFC 3339 acquisition time of underlying imagery.	string
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.	number (0 - 1)
grid_cell	The grid cell identifier of the gridded item.	string
provider	Name of the imagery provider.	string (“planetscope”,”rapideye”)
resolution	Pixel resolution of the imagery in meters.	number
satellite_id	Globally unique identifier of the satellite that acquired the underlying imagery.	string
strip_id	The imaging strip from which the ortho tile originated.	number
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)
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)
published	The RFC 3339 timestamp at which this item was added to the catalog.	string

7.2 Ortho Scenes

7.2.1 PlanetScope

The table below describe the GeoJSON metadata schema for PlanetScope Ortho Scene products, respectively:

Table T: PlanetScope Ortho Scene GeoJSON Metadata Schema

Parameter	Description	Type
acquired	The time that image was taken in ISO 8601 format, in UTC.	string
camera.bit_depth	Bit depth with which the image was taken onboard the satellite. Currently 8 or 12.	number (0 - 1)
camera.color_mode	The color mode of the image as taken by the satellite. Currently “RGB” or “Monochromatic”.	number (0 - 1)
camera.exposure_time	The exposure time in microseconds.	string
camera.gain	The analog gain with which the image was taken.	number
camera.tdi_pulses	The number of pulses used for time delay and integration on the CCD. Currently 0 (if TDI was not used), 4, 6, or 12.	number (1+)
cloud_cover.estimated	The estimated percentage of the image covered by clouds. Decimal 0-100.	number (0 - 100)
image_statistics.gsd	The ground sample distance (distance between pixel centers measured on the ground) of the image in meters.	number
image_statistics.image_qulaity	Image quality category for scene. One of ‘test,’ ‘standard,’ or ‘target.’	string (“test”,“standard”, “target”)
image_statistics.snr	The estimated signal to noise ratio. Values greater than or equal to 50 are considered excellent quality. Values less than 50 and greater than or equal to 20 are considered adequate quality. Values less than 20 are considered poor quality..	number (>0)
published	The time the image was first exposed in the API, in ISO 8601 format, in UTC. Note that this can vary by user.l	string
sat.alt	The altitude of the satellite when the image was taken in kilometers.	number
sat.id	A unique identifier for the satellite that captured this image.	string
sat.lat	The latitude of the satellite when the image was taken in degrees.	number
sat.lng	The longitude of the satellite when the image was taken in degrees.	number

Parameter	Description	Type
sat.off_nadir	The angle off nadir in degrees at which the image was taken.	number
strip_id	A unique float identifier for the set of images taken sequentially be the same satellite.	string
sun.altitude	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
sun.local_time_of_day	The local sun time at the imaged location at the time of capture..	number (0-24)

7.2.2 RapidEye

The tables below describe the GeoJSON metadata schema for RapidEye Scene products:

Table U: RapidEye Scene GeoJSON Metadata Schema

Parameter	Description	Type
acquired	The time that image was taken in ISO 8601 format, in UTC.	string
cloud_cover.estimated	The estimated percentage of the image covered by clouds.	number (0 - 100)
image_statistics.gsd	The ground sample distance (distance between pixel centers measured on the ground) of the image in meters.	number
strip_id	The base RapidEye Level 1B catalog id.	string
area	Area covered by the image (excluding black_fill) in square kilometers	number
sat.alt	The altitude of the satellite when the image was taken in kilometers.	number
sat.id	A unique identifier for the satellite that captured this image.	string
sat.off_nadir	The angle off nadir in degrees at which the image was taken (absolute view angle)..	number
sat.view_angle	The view angle in degrees at which the image was taken.	number
sun.azimuth_angle	The azimuth of the satellitefrom the imaged location at the time of capture in degrees..	number
sun.altitude	The altitude (angle above horizon) of the sun from the imaged location at the time of capture in degrees..	number

Parameter	Description	Type
sun.azimuth	The azimuth (angle clockwise from north) of the sun from the imaged location at the time of capture in degrees..	number
rapideye.black_fill	The percent of image pixels without valid image data	number (0 - 100)
rapideye.tile.id	The RapidEye tile id - corresponds to a fixed footprint.	string
rapideye.catalog_id	The base RapidEye Level 3A catalog id...	string

8. PRODUCT DELIVERY

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

8.1 Planet Application Programming Interface (API)

The Planet API offers REST API access that allows listing, filtering, and downloading of data to anyone using a valid API key. The metadata features described later in this document are all available in the responses to API queries. The full TIFF / GeoTIFF image data files are accessible (in the different product formats) at the /full URL endpoints.

Metadata associate with imagery products can be requested through the API endpoint: https://api.planet.com/data/v1/

8.2 Planet Graphical User Interface (GUI)

The Planet GUI is a set of web-based tools 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.

The home page for the Planet GUI is: www.planet.com/explorer

Planet's GUI allows users to:

1. **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).
2. **Save Search:** The Save functionality allows a user to save search criteria based on area of interest, dates, and filters.
3. **Filter:** A user can filter by a specific date range and/or customizing metadata parameters (e.g. estimated cloud cover, GSD).
4. **Zoom and Preview Imagery:** Zoom and Preview allows a user to zoom in or out of the selected area and preview imagery.
5. **View Imagery Details:** A user can review metadata details about each imagery product.
6. **Download:** The Download icon allows a user to download imagery based on subscription type.
7. **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.
8. **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.

8.3 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.

8.4 File Format

The Basic Scene products are available as NITF and GeoTIFFs; the Visual and Analytic Ortho Tile products are GeoTIFFs.

The Ortho Tile product GeoTIFFs are resampled at 3.125 m, and projected in the UTM projection using the WGS84 datum. An alpha mask is provided as a binary color channel. The alpha mask can be used to remove or hide low-image-quality pixels near the periphery of a given scene. The alpha mask compensates for effects due to vignetting, low SNR, or hot or cold pixels.

The Ortho Scene product GeoTIFFs are resampled at 3 m, and projected in the UTM projection using the WGS84 datum. An alpha mask is provided as a binary color channel. The alpha mask can be used to remove or hide low-image-quality pixels near the periphery of a given scene. The alpha mask compensates for effects due to vignetting, low SNR, or hot or cold pixels.

8.5 Bulk Delivery Folder Structure

Sets of imagery products can be ordered through the Planet API. The name of the parent folder is:

```
planet_order_[id]
```

Bulk deliveries are delivered in a .zip folder file format. Each .zip file contains:

- A README file with information about the order.
- A subfolder for each scene requested named with the scene id.
- Each subfolder contains the TIFF or GeoTIFF requested and an associated metadata file.
- If basic data is requested, the subfolder will also contain an RPC text file.

APPENDIX A – IMAGE SUPPORT DATA

All PlanetScope and RapidEye Ortho Tile 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:

A. General XML Metadata File
B. Unusable Data Mask File

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

1. General XML Metadata File

All PlanetScope Ortho Tile 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 Metadata File Field Contents

Field	Description
“metaDataProperty” Block	
EarthObservationMetaData	
Identifier	Root file name of the image
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.

General Metadata File Field Contents

Field	Description
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

General Metadata File Field Contents

Field	Description
acquisitionParameters	
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.
illumination AzimuthAngle	Sun azimuth angle at center of product, in degrees from North (clockwise) at the time of the first image line
illumination ElevationAngle	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

General Metadata File Field Contents

Field	Description
longitude	Longitude of bottom left corner in geodetic WGS84 coordinates

General Metadata File Field Contents

Field	Description
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
reference SystemIdentifier	Identifies the reference system used for the browse image
fileName	Name of the browse image file
product	
fileName	Name of image file.
size	The size of the image product in kbytes
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
radiometric CorrectionApplied	Indicates whether radiometric correction has been applied to the image

geoCorrectionLevel	Level of correction applied to the image
atmosphericCorrectionApplied	Indicates whether atmospheric correction has been applied to the image

General Metadata File Field Contents

Field	Description
atmosphericCorrectionParameters	
autoVisibility	Indicates whether the visibility was automatically calculated or defaulted
visibility	The visibility value used for atmospheric correction in km
aerosolType	The aerosol type used for atmospheric correction
waterVapor	The water vapor category used
hazeRemoval	Indicates whether haze removal was performed
roughTerrainCorrection	Indicates whether rough terrain correction was performed
bRDF	Indicates whether BRDF correction was performed
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)

General Metadata File Field Contents

Field	Description
shifting	Indicates the sensor applied right shifting
masking	Indicates the sensor applied masking
radiometricScale-Factor	Provides the parameter to convert the pixel value to radiance (for radiance product) or reflectance (for a reflectance product). To convert to radiance/reflectance engineering units, the pixel values should be multiplied by this scale factor. Hence the pixel values in the product are: **Radiance product:** (W/m^2 sr µm) / (Radiometric Scale Factor). The Radiometric Scale Factor is expected to be 1/100. For instance, a product pixel value of 1510 would represent radiance units of 15.1 W/m^2 sr µm. **Reflectance product:** Percentage / (Radiometric Scale Factor). The Radiometric Scale Factor is expected to be 1/100. For instance, a product pixel value of 1510 would represent 15.1% reflectance.
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: 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**

2. Unusable Data Mask File

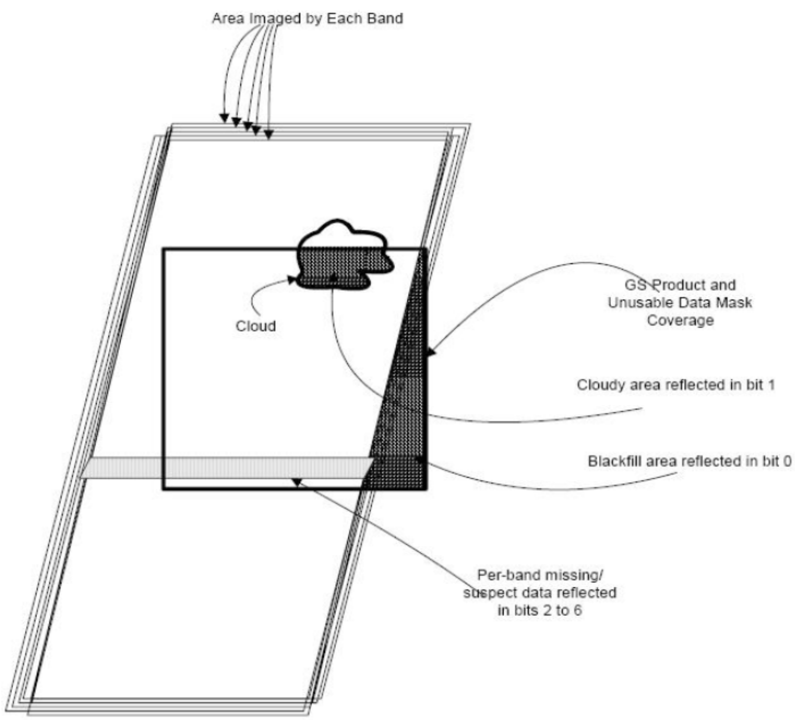
All PlanetScope and RapidEye Ortho Tile products will be accompanied by an unusable data mask file.

The unusable data mask file provides information on areas of unusable data within an image (e.g. cloud and non-imaged areas). As mentioned previously, the pixel size after orthorectification will be 3.125 m for PlanetScope and 5 m for RapidEye. 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 by the spacecraft). A value of "1" indicates blackfill.
- Bit 1: Identifies whether the area is cloud covered. A value of "1" indicates cloud covered. 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 downlink errors) data in the 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 blackfilled) 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 NIR 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: Is currently set to "0".

The figure below illustrates the concepts behind the Unusable Data Mask file.

Figure A-1: Concepts behind the Unusable Data Mask File



File Naming

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

Example: **2328007_2010-09-21_RE4_3A_visual_udm.tif**

APPENDIX B – TILE GRID DEFINITION

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.

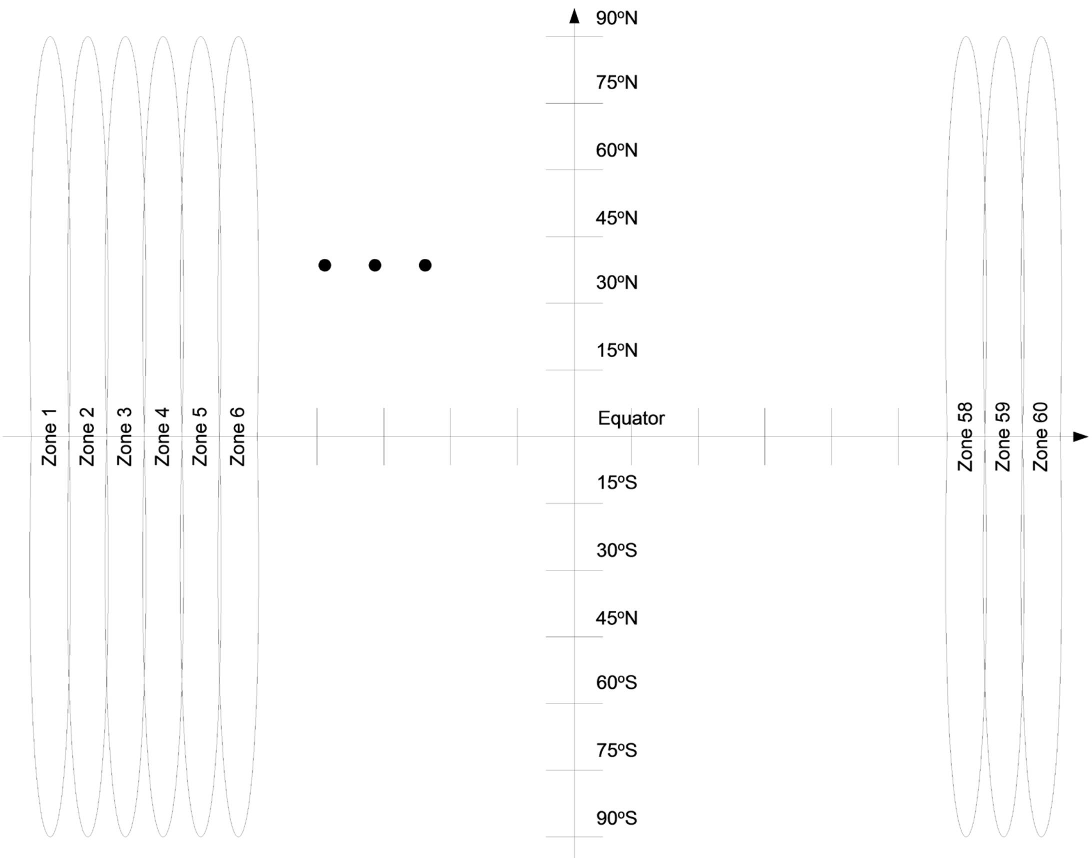


Figure B-1 Layout of UTM Zones

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

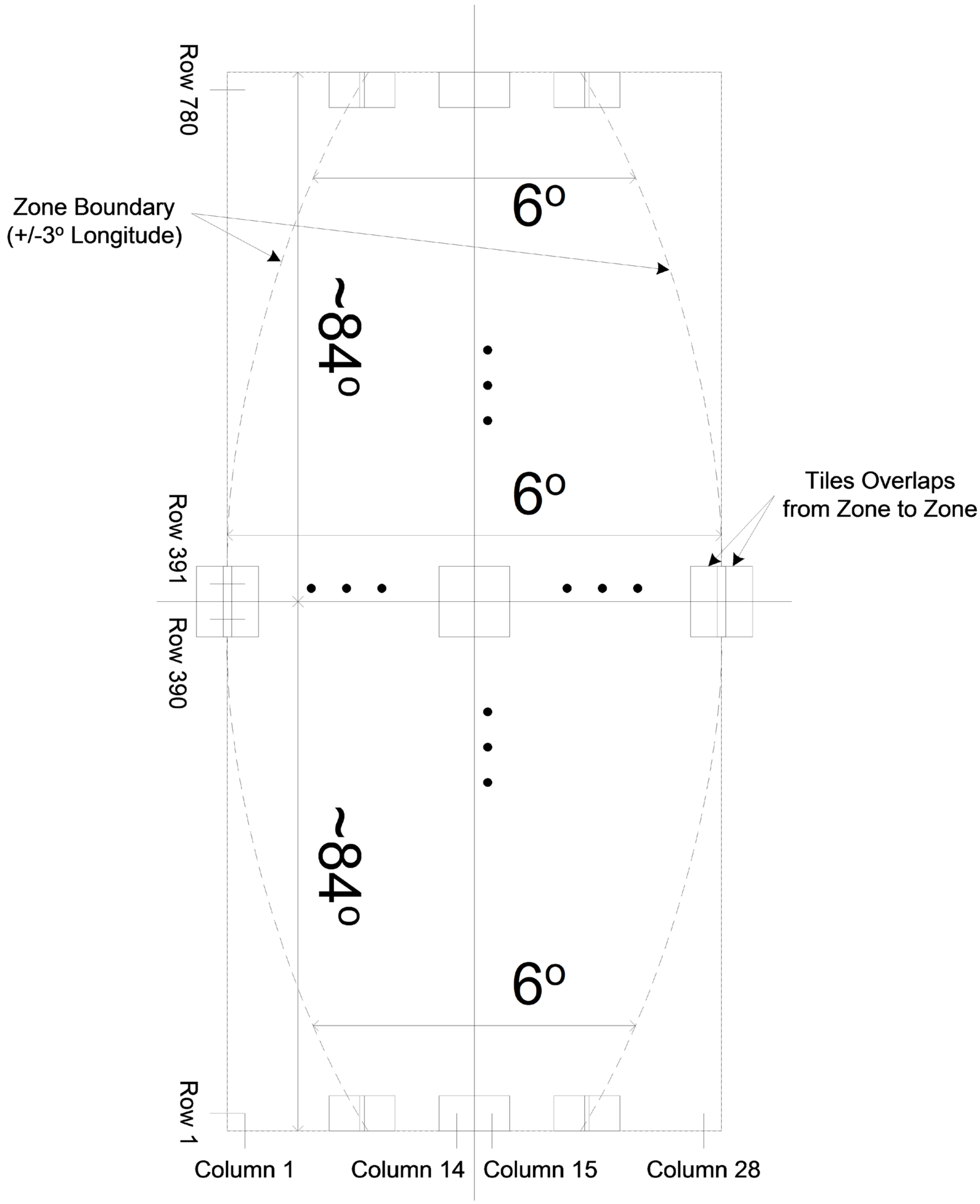


Figure B-2 Layout of Tile Grid within a single UTM Zone

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

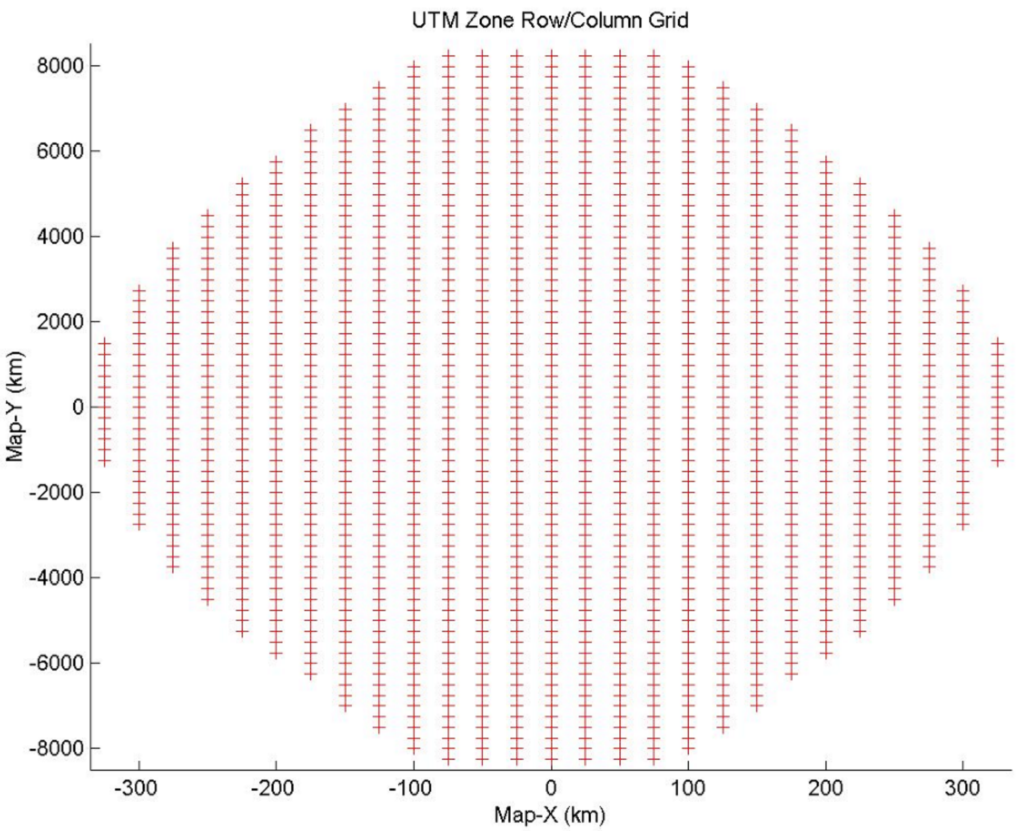


Figure B-3 Illustration of grid layout of Rows and Columns for a single UTM Zone

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.

APPENDIX C – POSITIONAL ACCURACY TIMELINE

Planet is currently validating the positional accuracy of our imagery across the globe. We will be gradually updating data in different regions to ensure that we meet our target of having a positional accuracy of less than 10m RMSE in each of them.

See the following table with the schedule for when validated data will be available:

Table C-1: Positional Accuracy Availability

Month and Year	Region
July 2016	<10m RMSE in USA, Mexico and Australia
August 2016	<10m RMSE in North and South America, Australia
September 2016	<10m RMSE in North and South America, Europe and Australia
October 2016	<10m RMSE globally