Planet Labs Specifications: Satellite Imagery Products

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Disclaimer - This document is designed as a general guideline for customers interested in acquiring Planet Labs imagery products and services. Planet Labs takes an agile and iterative approach to its technology, and therefore may make changes to the product(s) described IN THIS DOCUMENT. This document is provided “as is” without warranty of any kind.

1. Introduction

1.1 Overview of this Document

This document describes Planet Labs' Satellite Imagery Products. It is intended for users of satellite imagery interested in working with Planet Labs' initial product offerings.

1.2 Company Overview

Planet Labs was founded in 2011 by three ex-NASA engineers to disrupt the traditional aerospace industry by using modern consumer electronics manufacturing techniques to build a large constellation of nanosatellites. Planet Labs 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 and information. It is the only fully integrated company that designs, builds, and actively operates satellites while also delivering data to customers via an internally developed web-based platform. Planet Labs employs an "always on" line-scanning image capturing method as opposed to the traditional tasking model used by most satellite companies today.

1.3 Data Product Overview

Planet Labs' core products come from high-resolution satellite images that are offered as individual images ("scenes") and mosaics.

Scenes are captured in red, blue, and green (RGB or visible) wavelengths, at 3-5 meters ground sampled distance (GSD). Planet Labs is testing near-infrared imagery capture in 2015. Scenes are available in three different product formats: visual, analytic, and unrectified.

Mosaics are single-layer composites of scenes, which are served as a set of GeoTIFF files or via web tile servers.

Metadata about each product (scene or mosaic) is available to assist in analyzing or further processing. All Planet Labs images are corrected for radiometric and sensor distortions.

All data is available through API access, as well as being available through User Interface (UI) tools built on top of the API.

2. Planet Labs Satellite Constellation

2.1 Satellites and Orbits

We launch multiple groups of satellites per year, each contributing to a larger constellation of satellites. Therefore, our on-orbit capacity is constantly under development, with technology improvements deployed at a rapid pace. Planet Labs provides high-frequency, high-resolution imagery. With a full constellation of 150-200 satellites, we will be able to image the entire Earth every day. Each satellite is in the CubeSat 3U form factor (10x10x30cm).

Table A: Orbit, Constellation and Satellite Specifications

	International Space Station Orbit	Sun Synchronous Orbit
Inclination	52°	98°
Expected Lifetime	1 year per satellite; constellation is replenished over time	2-3 years per satellite; constellation is replenished over time
Orbital Insertion Altitude	420km	475km (target altitude for future SSO launches
Equator Crossing Time	Varies	9:30-11:30am local solar time
Sensor Type	Bayer-masked CCD camera	Bayer-masked CCD camera
Spectral Bands	Red: 610-700nm Green: 500-590nm Blue: 420-530nm	Red: 610-700nm Green: 500-590nm Blue: 420-530nm
Ground Sampling Distance (Nadir)	2.7m-3.2m	3.7m-4.9m
Mission Continuity	Maintain up to 55 satellite constellation (continually replenishing/upgrading satellites)	Maintain 100-150 satellite constellation (continually replenishing/upgrading satellites)

Table B: Planet Labs estimated Constellation growth, Collection Capacity and Northern Hemisphere Revisit Rates

	Q3 2015	Q4 2015	Q1 2016	Q2 2016	Q3 2016
Estimated # Operational Satellites	20	25	30	50	150
Estimated Collection Capacity (Global Land Areas)	1.5	2	5	10	50
Latitude (Northern Hemisphere)	**Days to Revisit: Average (90% Certainty)**				
70°	60 (70)	70 (80)	50 (60)	3 (5)	1 (2)
60°	50 (60)	60 (70)	20 (36)	2 (4)	1 (2)
50°	22 (35)	14 (21)	8 (16)	1 (3)	1 (2)
40°	28 (38)	15 (25)	13 (19)	2 (3)	1 (2)
30°	30 (40)	17 (30)	15 (20)	2 (4)	1 (2)
20°	35 (46)	23 (33)	16 (22)	3 (4)	1 (2)

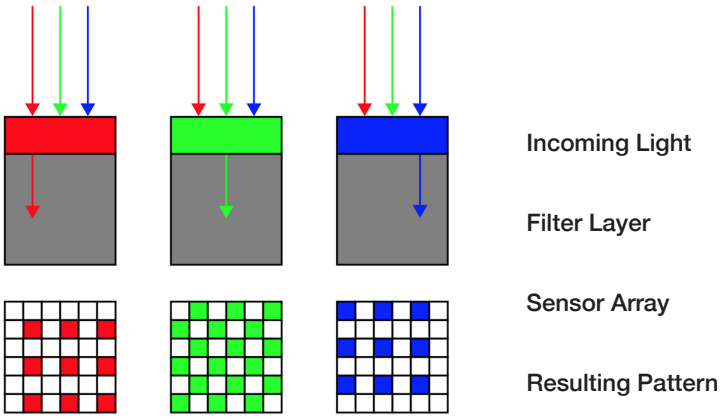
Planet Labs' forecasts are strongly driven by successful completion of launch. Launch manifests are subject to change. Collection capacity estimates include the effect of clouds (on average 45% of the Earth's surface is obscured by cloud cover). Revisit estimate are based on orbital parameters only, and do not include the effect of clouds. Note that estimated number of operational satellites is less than Planet Labs launch manifest, as this figure includes buffers for non-operational and technology demonstration satellites.

2.2 Imaging

2.2.1 Color Filter Array (CFA)

Planet Labs' satellites have a CCD camera equipped with a Bayer mask style Color Filter Array (CFA). This means that at the time of image capture, each sensor well measures one of red, green, or blue wavelengths. These values are interpolated to assign a red, green, and blue value to each pixel.

Figure I: Bayer Mask



2.2.2 Time Delay Integration (TDI)

Time Delay Integration (TDI) is a technique designed to increase the effective exposure time of images. TDI is a default configuration for Planet Labs' image capture. It works by shifting the rows of pixels within the CCD (Charge-Coupled Device) at the same rate as the ground motion of the scene. The number of lines (or pulses) of TDI is limited by the well capacity of the detector. The specific TDI mode used to capture each scene is available in that scene's metadata.

3. Planet Labs Scene Product Specifications

A “scene” refers to a single image as taken by one of Planet Labs’ satellites. Planet Labs offers three scene-based products.

3.1 Scene Product Types

Visual (8-bit): the visual product is an orthorectified 8-bit GeoTIFF that has a color curve pre-applied in order to be more readily usable in most visual analysis and display applications.
Analytic (12-bit): the analytic product is 12-bit data delivered in a orthorectified 16-bit GeoTIFF file with no visual color-corrections are applied; it is designed for analytical and scientific applications.
Unrectified (12-bit): a 12-bit analytic product without orthorectification applied. Radiometric and flat field corrections are made to the unrectified product to account for radiometric and sensor distortions. Rational Polynomial Coefficients (RPCs) are available to transform unrectified data.

Table C: Planet Labs Scenes Product Offerings

	Visual	Analytic	Unrectified
Image Bit Depth	8-bit	12-bit	12-bit
File Bit Depth	8-bit	16-bit	16-bit
Visual Color Curve Applied	Yes	No	No
Radiometric Correction	Yes	Yes	Yes
Geo- and Orthorectification	Yes	Yes	No
Accuracy[1]	20m CE90	20m CE90	N/A
Ground Sample Distance[2]	3m-5m	3m-5m	3m-5m
Projection	WGS 84 / UTM	WGS 84 / UTM	N/A
Format	GeoTIFF	GeoTIFF	TIFF
Bands	RGB	RGB	RGB
Includes Alpha Mask	Yes	Yes	Yes
Atmospheric Correction	No	No	No

[1] Based on a sample of imagery, Planet Labs estimates approximately 20m using CE90 standards. Planet Labs has not yet determined absolute accuracy for its imagery. Accuracy is relative to Landsat 8.
[2] Dependent on altitude of satellite

3.2 Processing

3.2.1 Product Radiometry and Radiometric Accuracy

Several radiometric corrections are applied to Planet Labs images. These steps include:

- **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).
- **Sun angle correction** - adjusts all images to radiometric response equivalent to solar noon (sun at nadir).
- **Image anomaly correction** - adjusts for temporary CCD effects.

3.2.2 Orthorectification and Geographic Accuracy

Planet Labs uses a proprietary parallel processing approach, enabling the transformation of raw imagery to orthorectified imagery without degradation of imagery quality.

All scenes are orthorectified against a basemap based on Landsat 8 image raster data, a global DEM (SRTM 90 meters), and an Open Street Map (OSM) vector data layer (where available). Orthorectification results is better than 20m CE90 accuracy. The orthorectified products retain their initial image quality.

3.2.3 Atmospheric Correction

Planet Labs is working on Top of Atmosphere Radiance (TOAR) techniques, but these are not yet incorporated into our imagery products.

3.3 Metadata Available

Table D: Scenes Metadata Properties Available in the Scenes API.

Field	Description
acquired	The time that image was taken in ISO 8601 format, in UTC.
camera.bit_depth	Bit depth with which the image was taken on-board the satellite. Currently 8 or 12 bit
camera.color_mode	The color mode of the image as taken by the satellite. Currently “RGB”
camera.exposure_time	The exposure time in microseconds
camera.gain	The analog gain with which the image was taken
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
cloud_cover.estimated	The estimated percentage of the image covered by clouds. Decimal 0-100.
image_statistics.gsd	The ground sample distance (distance between pixel centers measured on the ground) of the image in meters
image_statistics.image_quality	Image quality category for scene. ‘Standard’, or ‘target’
image_statistics.snr	The estimated signal to noise ratio. Decimal > 0. Values greater than or equal to 50 are considered good quality. Values less than 50 and greater than or equal to 20 are considered adequate quality. Values less than 20 are considered poor quality
sat.alt	The altitude of the satellite when the image was taken in kilometers
sat.id	A unique identifier for the satellite that captured this image
sat.lat	The latitude of the satellite when the image was taken in degrees
sat.lng	The longitude of the satellite when the image was taken in degrees
sat.off_nadir	The angle off nadir in degrees at which the image was taken
strip_id	A unique float identifier for the set of images taken sequentially by the same satellite
sun.altitude	The altitude (angle above horizon) of the sun from the imaged location at the time of capture in degrees
sun.azimuth	The azimuth (angle clockwise from north) of the sun from the imaged location at the time of capture in degrees
sun.local_time_of_day	The local sun time at the imaged location at the time of capture as a decimal (0-24)

3.3.1 Image Quality Categories

Each scene has a calculated image quality category. As our image quality metrics improve, we will update this categorization.

Test: Test grade imagery captured by Planet which is not accessible to users.
Standard: This imagery meets high SNR, in-focus, and on-nadir requirements and is accessible to users.
Target: This imagery meets the requirements for 'standard' imagery, and in addition is representative of the imagery Planet seeks an image capture time of 9:00-11:00 a.m. sun time, and ground sampling distance of 3m. Target imagery is accessible to users.

3.3.2 Cloud Cover

Planet Labs is working on cloud estimation and masking techniques. A preliminary estimate of cloud cover is available in scene level metadata. Images with a very high percentage of clouds are not currently available to users.

3.4 Product Delivery

3.4.1 File Format

All scenes are downloaded as TIFFs — the visual and analytic products are GeoTIFFs.

GeoTIFFs are re-sampled at 3m, and projected in the Universal Transverse Mercator (UTM) projection using the WGS84 datum. An alpha mask is provided as a binary color channel in the fourth layer of the image file (R,G,B, Alpha). 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.

3.4.2 Naming

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 product is composed of the following elements:
<sceneId>_<productType>.<fileExtension>

Example: 20150528_094807_090c_visual.tif

sceneId: Scene's unique id (ex: 20150528_094807_090c)
productType: 'visual', 'analytic' or 'unrectified' (ex: 'visual')
fileExtension: 'tif', 'json', or 'zip' (ex: 'tif')

3.4.3 Scenes API

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

More details are available in the ***APIs and Tools Specification*** document.

3.4.4 Scenes Explorer

The Scenes Explorer is a User Interface (UI) built on top of the Scenes API, which provides access to the same listing, filtering, and downloading of scene data with a map-based experience.

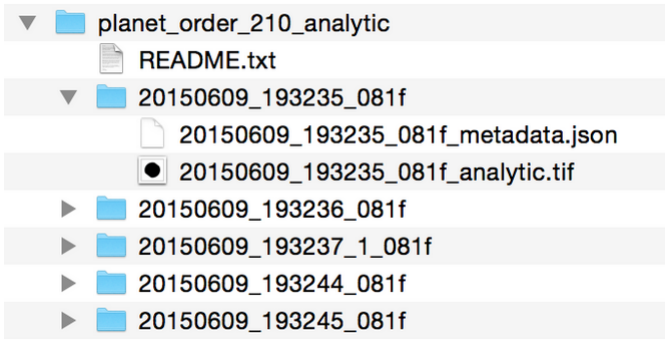
More details are available in the ***APIs and Tools Specification*** document.

3.4.5 Bulk Delivery Folder Structure

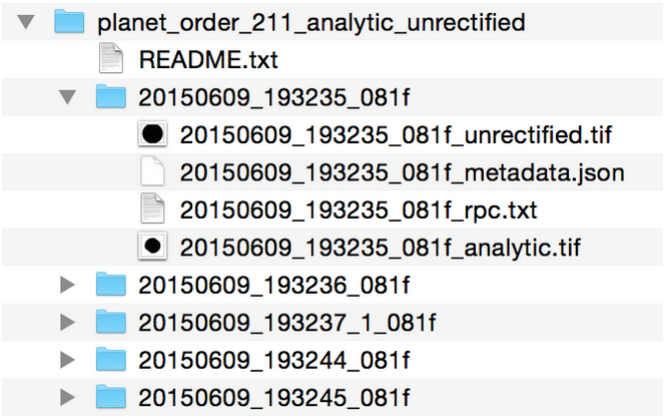
Sets of image products can be ordered through the Scenes API and Scenes Explorer.

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 unrectified data is requested, the subfolder will also contain and RPC. text file.



Example of folder structure for single product type (analytic).



Example of folder structure for multiple product types (analytic and unrectified), and showing RPC text file.

4. Mosaic Product Specifications

A “mosaic” refers a composite of many scenes into a single layer or file. This data product will be available in 2016.

Each mosaic is served as a number of GeoTIFF “quads”, approximately 20km x 20km in size, with pixels re-sampled to 4.8m spatial resolution, which all together compose the mosaic.

4.1 Technique

Planet Labs uses a “best pixel” mosaicking technique to build its mosaics. The intent is not to cut and stitch individual images together but to select the best available pixel for every single pixel in a mosaic

The mosaicking methodology is under development.

To make mosaics appear visually uniform, each scene is color-balanced to existing Landsat8 imagery before being mosaicked.

4.2 Mosaic Specification (Available in 2016)

Description	Broad area composite pixel mosaic of orthorectified products collected over 90- or 180-day period
Spatial Resolution	4.78m
Cloud Cover Target	<10%
Data Formats Available	GeoTIFF, map-tiles
Bit-depth	8-bit

4.3 Metadata Available per Mosaic

Field	Description
coordinate_system	The EPSG code of the coordinate system in which the quad GeoTIFFs are projected, i.e. EPSG:3857 or EPSG:4326
datatype	The datatype for each quad GeoTIFF. One of byte, uint16, int16,uint32, int32, float32, float64, cint16, cint32, cfloat32,cfloat64
first_acquired	The UTC time that the first input scene was taken in ISO 8601 format
last_acquired	The UTC time that the last input scene was taken in ISO 8601 format
level	Zoom level of available quads, maximum zoom level of tileserver
links.quadmap	API link to the quad map for this mosaic, or null if one does not exist
links.quads	API link to the list of GeoTIFF quads that make up this mosaic
links.self	API link to the mosaic resource
links.tiles	API link to the tileserver URL for the mosaic
name	The name of the mosaic
quad_pattern	The naming scheme for quads, as a format string with glevel, tilex, and tiley

4.4 Metadata Available per Quad

Field	Description
geometry	GeoJSON describing the polygon that the quad covers. Includes 5 longitude, latitude pairs, with the first being a repeat of the last
id	The unique identifier for this quad
properties.num_input_scenes	The number of scenes that were used as input to make this portion of the mosaic
properties.percent_covered	The percentage of the GeoTIFF pixels that are not no-data values
properties.links.full	API link to download the GeoTIFF
properties.links.mosaic	API link to the mosaic that the quad belongs to
properties.links.scenes	API link to the available scenes that were used to generate this quad
properties.links.thumbnail	API link to a thumbnail of this quad
type	Always "Feature" to make dictionary a valid GeoJSON Feature

4.5 Product Naming

The naming scheme for quad ids within each mosaic is available on the mosaic as the `quad_pattern` property. It is generally `L{glevel:d}-{tilex:04d}E-{tiley:04d}N`, where glevel is the zoom of the max zoom level for the mosaic (`mosaic.level`), and `tilex` and `tiley` are the x and y positions of tiles at that zoom level.

4.6 Product Delivery

4.6.1 File Format

Details of the file format can vary by mosaic, and can be determined from the mosaic metadata. Provided here are the standard values for mosaics.

GeoTIFF Property	Mosaic Property	Planet Labs Data Mosaics
Image size	quad_size	4096 x 4096 pixels
Pixel size	resolution	4.78 m
Coordinate System	coordinate_system	EPSG:385
Bit depth	datatype	8-bit

4.6.2 Mosaics API

The Mosaics API offers REST API access that allows for listing, filtering, and downloading of mosaic quads in addition to listing the available scenes used as input to each quad.

More details are available in the ***APIs and Tools*** document.

4.6.3 Mosaics Explorer

The Mosaics Explorer is a web graphical user interface (GUI), built on top of the API, designed to enable visual exploration of the mosaics, and access to mosaic quad file downloads.

More details are available in the ***APIs and Tools*** document.

5. Product Licensing

Planet Labs grants the right to use the Product Offerings under a standard End User License Agreement (EULA). The inclusion of the imagery or data contained in the Data Products in any product or tool is considered a Value-Added Product. External resale or distribution of Data Products and Value-Added Products is not permitted under the standard EULA. To redistribute the Data Products or Value-Added Products to third parties, additional licensing from Planet Labs is required. Please contact sales@planet.com for details.

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