RapidEye
Delivering the World

Satellite Imagery Product Specifications

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info@rapideye.com

www.rapideye.com

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ABBREVIATIONS

AOI	Area Of Interest
CCD	Charged-coupled Device
CE90	Circular Error 90%
DEM	Digital Elevation Model
DTED	Digital Terrain Elevation Data
GCP	Ground Control Point
GML	Geography Markup Language
GS	Ground Segment
IFOV	Instantaneous Field of View
ISD	Image Support Data
JFIF	JPEG File Interchange Format
JPEG	Joint Photographic Experts Group
KML	Keyhole Markup Language
MTF	Modulation Transfer Function
N/A	Not Applicable
NIR	Near Infra-red
NMAS	National Map Accuracy Standards
NITF	National Imagery Transmission Format
RPC	Rational Polynomial Coefficients or Rapid Positioning Coordinates
SRTM	Shuttle Radar Topography Mission
TBC	To Be Confirmed
TBD	To Be Defined
TIFF	Tagged Image File Format
TOA	Top Of Atmosphere
TOI	Time Of Interest
UDM	Unusable Data Mask
UTC	Coordinated Universal Time
UTM	Universal Transverse Mercator
WGS	World Geodetic System

1 INTRODUCTION

RapidEye offers image users a data source containing an unrivaled combination of large-area coverage, frequent revisit intervals, high resolution and multispectral capabilities. For the first time, there is a constellation of five earth imaging satellites that contain identical sensors that are in the same orbital plane and are calibrated equally to one another. This means an image from one RapidEye satellite will be identical in characteristics to an image from any of the other four satellites, thus allowing the user access to an unprecedented amount of imagery collected on a frequent basis.

RapidEye Satellite Imagery Products are offered at two different processing levels to support the varied needs of the customer: 1) RapidEye Basic (Level 1B) products are sensor level products with a minimal amount of processing (geometrically uncorrected) for customers who prefer to geo-correct the images themselves; and 2) RapidEye Ortho (Level 3A) are orthorectified products with radiometric, geometric and terrain corrections in a map projection. See Section 3 for detailed descriptions of each image product type.

This document provides detailed information on the following subjects related to the RapidEye Satellite Imagery Products:

RapidEye Satellite Constellation: RapidEye's constellation of 5 satellites offers something new and unique to the world of commercial remote sensing.

Product Level Descriptions: RapidEye offers two different processing levels which are described in detail. Attributes related to product quality are also discussed.

Product and Delivery Options: Each image data product is offered with several processing and delivery options.

Product Licensing: RapidEye offers customers several licensing options to ensure that all users who need to use the imagery may do so.

Product Naming: Provides a description of the product naming conventions used for the RapidEye Satellite Imagery Products.

Product Delivery: The Satellite Image Products are delivered in a standardized format and structure. Orders can be delivered via physical storage devices or electronically via FTP pull download. This section details what can be expected regarding the files and structure of a data delivery.

Image Support Data: All images are supported with several different metadata files to aid the customer with the use and analysis of the data.

2 RAPIDEYE SATELLITE CONSTELLATION

The RapidEye constellation of five satellites stands apart from other providers of satellite-based geospatial information in its unique ability to acquire high-resolution, large-area image data on a daily basis. The RapidEye system is able to collect an unprecedented 4 million square kilometers of data per day at 6.5 meter nominal ground resolution. Each satellite measures less than one cubic meter and weighs 150 kg (bus + payload), and has been designed for a minimum seven-year mission life. All five satellites are equipped with identical sensors and are located in the same orbital plane.

MISSION CHARACTERISTIC	INFORMATION	
Number of Satellites	5	
Spacecraft Lifetime	Over 7 years	
Orbit Altitude	630 km in Sun-synchronous orbit	
Equator Crossing Time	11:00 am local time (approximately)	
Sensor Type	Multi-spectral push broom imager	
Spectral Bands	Capable of capturing all of the following spectral bands:	
	Band Name Blue Green Red Red Edge NIR	Spectral Range (nm) 440 – 510 520 – 590 630 – 685 690 – 730 760 – 850
Ground sampling distance (nadir)	6.5 m	
Pixel size (orthorectified)	5 m	
Swath Width	77 km	
On board data storage	Up to 1500 km of image data per orbit	
Revisit time	Daily (off-nadir) / 5.5 days (at nadir)	
Image capture capacity	4 million sq km/day	
Camera Dynamic Range	12 bit	

Table 1: RapidEye System Mission Characteristics

3 RAPIDEYE SATELLITE IMAGE PRODUCT SPECIFICATIONS

RapidEye Satellite Imagery Products are available in two different processing levels to be directly applicable to customer needs.

LEVEL	DESCRIPTION
1B	RapidEye Basic Product - Radiometric and sensor corrections applied to the data. On-board spacecraft attitude and ephemeris applied to the data.
3A	RapidEye Ortho Product – Radiometric, sensor and geometric corrections applied to the data. The product accuracy depends on the quality of the ground control and DEMs used.

Table 2: RapidEye Satellite Image Product Processing Levels

3.1. RAPIDEYE BASIC – LEVEL 1B PRODUCT SPECIFICATION

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

The RapidEye Basic product is radiometric 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 ideal 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 nulls 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

Table 3 lists the product attributes for the RapidEye Basic product.

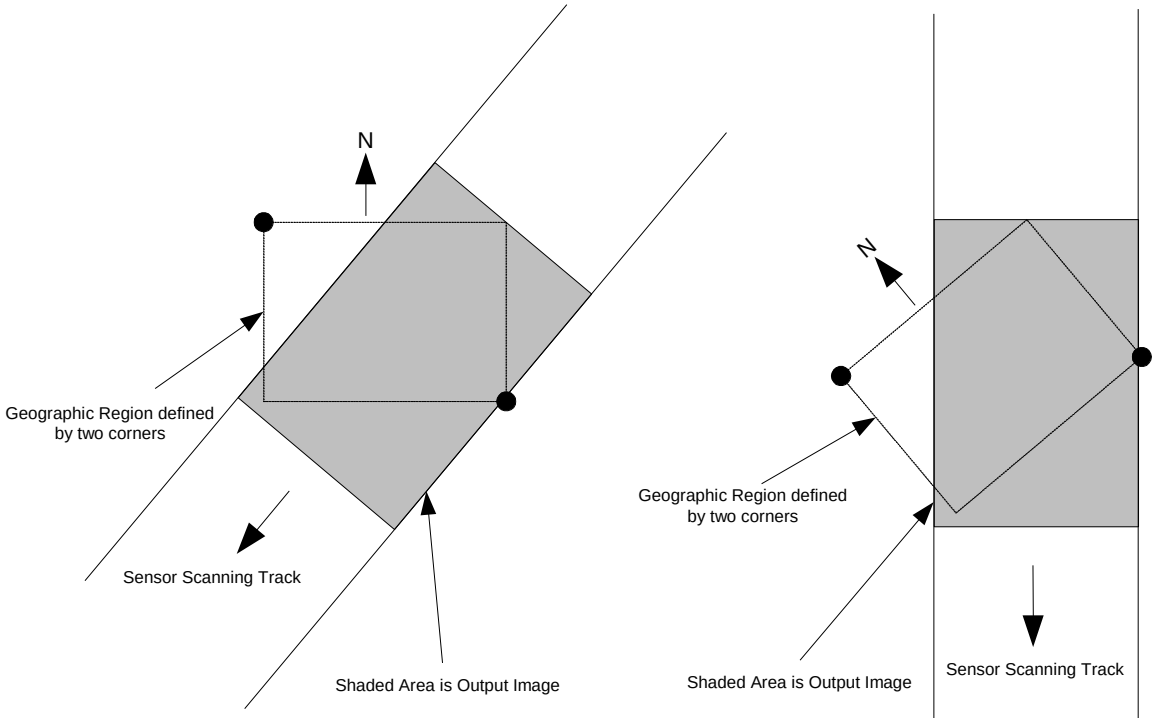
PRODUCT ATTRIBUTE	DESCRIPTION
Product Components and Format	RapidEye Basic image product consists of the following file components: Image File – Image product delivered as a group of single-band NITF 2.0 files with associated RPC values. Bands are co-registered. Metadata File – XML format metadata file. Metadata file contains additional information related to spacecraft attitude, spacecraft ephemeris, spacecraft temperature measurements, line imaging times, camera geometry, and radiometric calibration data. Browse Image 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 of between 50 and 300 km.  **Geographic Perspecitive** **Image Perspecitive**	
Pixel spacing	Native camera pixel spacing, nominally 6.5 m at nadir.
Bit Depth	For radiometrically corrected products, 16-bit unsigned integers.
Product Size	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 (default), MTF, or Nearest Neighbor

Table 3: Product attributes for RapidEye Basic products

3.2. RAPIDEYE ORTHO – LEVEL 3A PRODUCT SPECIFICATION

The RapidEye Ortho product offers the highest level of processing available for RapidEye Satellite Imagery Products. 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 product is radiometric, 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. 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. RapidEye Ortho image products are output as 25 by 25 kilometer tiles referenced to a fixed, standard RapidEye image tile grid system (see Appendix B). All Ortho image products (Level 3A) are black-filled 1000 meters (200 pixels) beyond the order polygon used to place the product order, except for when the order is tile-based. The Browse Image and Unusable Data Mask (UDM) files of an Ortho product show the full extent of valid imagery available for the given image tile regardless of the black-fill applied to a order.

PRODUCT ATTRIBUTE	DESCRIPTION
Product Components and Format	RapidEye Ortho image product consists of the following file components: Image File – GeoTIFF file that contains image data and geolocation information Metadata File – XML format metadata file Browse Image File – GeoTIFF format Unusable Data Mask (UDM) file – GeoTIFF format
Product Orientation	Map North up
Product Framing	Image Tile (image tiles are based on a worldwide, 24km by 24km fixed grid system (see Appendix B for full tile grid definition). To each 24km by 24km grid square, a 500m overlap is added to produce a 25km by 25km image tile. Image tiles are black-filled 1km beyond the order polygon used during order placement. Tiles only partially covered by an image take will be also be black-filled in areas containing no valid image data.
Pixel spacing	5m
Bit Depth	For radiometrically corrected products, 16-bit unsigned integers.
Product Size	Tile size is 25km (5000 lines) by 25km (5000 columns). 250 Mbytes per Tile for 5 bands at 5m pixel spacing.
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. Ortho-rectified using GCPs and fine DEMs (30m to 90m posting)
Horizontal Datum	WGS84
Map Projection	Universal Transverse Mercator (UTM)
Resampling Kernel	Cubic Convolution (default), MTF, or Nearest Neighbor

Table 4: Attributes for RapidEye Ortho Products

3.3. PRODUCT QUALITY ATTRIBUTES

The following sections detail the quality attributes related to all RapidEye Satellite Imagery Products.

3.3.1. Geometric Product Accuracy

3.3.1.1. RapidEye Basic (1B) Accuracy

The RapidEye Basic (1B) products are geometrically corrected to an idealized sensor and satellite model, and band aligned. They are delivered as NITF (National Imagery Transmission Format) files together with Rapid Positioning Capability (RPC) described by rational functions. The horizontal accuracy of Level 1B products is determined by

satellite attitude (which is adjusted by pre-marking Ground Control Points during image cataloging) and ephemeris as well as terrain displacement, since no terrain model is used in the processing of the 1B products.

The worldwide RapidEye Ground Control Point database is populated with GCPs derived from several sources. These sources range from the GeoCover 2000 Landsat mosaic (CE90 50m or better) and GLS 2000 Landsat mosaic (CE90 30m or better) to higher accuracy datasets (CE90 10m or better) over Australia, Germany, Mexico and the United States. RapidEye strives for the continuous improvements to the accuracy of the datasets used for GCP creation with the less accuracy GCPs being replaced when a new, more suitable source as these dataset are identified.

The lowest expected accuracy of a 1B Basic product cataloged with GeoCover 2000 GCPs is 50m CE90 (RMSE = 32m), based on Nadir collect over flat (< 10^{o} slope) terrain. Products cataloged with different GCPs can be expected to have a better locational accuracy than this value.

3.3.1.2. RapidEye Ortho (3A) Accuracy

The locational accuracy of the RapidEye Ortho (3A) products depends on the quality of the reference data used (GCPs and 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.

As mentioned in the previous section, multiple sources are used for GCPs creation globally and vary in accuracy. Multiple sources of DEMs are also used for terrain correction. The default DEM used for ortho correction is the CGIAR v4 SRTM 90m DEM where available or GTOPO 30 in areas above 60 degree north where other sources are not available. For Australia, Canada, Mexico, New Zealand and parts of the United States (Alaska) 30 m or better DEMs are used. As with GCP creation, RapidEye is continuously engaged in improving its global DEM.

RapidEye Ortho products produced using GeoCover 2000 GCPs and the SRTM DEM will have a locational accuracy of 50m CE90 (32m RMSE) or better. In areas with more accurate GCPs and DEMs an accuracy of 9m CE90 (6m RMSE) can be achieved. These accuracies are valid for images collected at Nadir over flat (< 10^{o} slope) terrain.

3.3.2. Cloud Cover

Cloud detection for the RapidEye Satellite Image 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 Section 8.3 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); 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. This value is also used to report the Cloud cover Percentage value for the product in the EyeFind™ archive discovery tool

2) Processing: for each product generated (i.e. L1B or L3A) 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
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.

3.3.3. Band Co-registration

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 1B and L3A 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.

3.3.4. Product Radiometry and Radiometric Accuracy

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 satellites' lifetime.

All RapidEye satellite images are collected at 12 bit and stored on-board the satellites with a bit depth of up to 12 bit. 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 µm. The digital numbers of the RapidEye image pixels represent s the absolute calibrated radiance values for the image.

To convert the Digital Number (DN) of a pixel 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 µm).

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 (i.e. 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 fix, 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/m²µm

Green: 1863.5 W/m²µm

Red: 1560.4 W/m²µm

RE: 1395.0 W/m²µm

NIR: 1124.4 W/m²µm

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 January 1, 2010, but was only effective on or after April 27, 2010. Please see the “Papers” tab at http://www.rapideye.com/about/resources.htm for a complete list of papers and publications dealing with the calibration of the RapidEye satellites.

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 Near-infrared bands, compared with the Blue and Green bands. During image quality control a continuous check of the radiometric noise level is performed.

4 PRODUCT AND DELIVERY OPTIONS

Table 5 summarizes the product options available for all RapidEye Satellite Imagery Products.

PROCESSING OPTION	DISCUSSION
Processing Kernels	Nearest Neighbor, Cubic Convolution (default), or MTF
Image File Formats	GeoTIFF (default for level 3A); NITF (default for level 1B);
Projection (only for 3A products)	UTM WGS84
Delivery	FTP Pull USB Hard Drive USB Memory stick

Table 5: Product Processing and Delivery Options

5 PRODUCT LICENSING

RapidEye grants the right to use the Products under a standard End-User License Agreement (EULA). RapidEye offers several licensing options to address the needs of end-users. Please consult the Price List for available license types at:

http://www.rapideye.com/about/resources.htm

For a detailed description of the standard EULAs, please see:

http://www.rapideye.com/about/resources.htm?tab=7

The inclusion of the imagery or data contained in the RapidEye Products in any product by an end-user is considered value-added work. Resale or distribution of these value-added products is not permitted under the standard EULA. To redistribute the Products or value-added products to third parties, the customer must request additional licensing from RapidEye. Licensing allowing additional use may be granted to the customer upon the conclusion of a license upgrade. Contact RapidEye for details.

6 PRODUCT NAMING

The naming of RapidEye Satellite Imagery Products provides important information related to the image. The naming of the product depends on the product type and is different between the product levels. The name of each product is designed to be unique and allow for easier recognition and sorting of the imagery.

6.1. 1B – BASIC PRODUCT NAMING

The information provided in the 1B – Basic product name includes acquisition date and time, satellite that acquired the image, product level, product description, product and order identification and file type with format. The name of each 1B product is composed of the following elements:

<acquisition time>_<satellite>_<product ID>_<RE catalog ID>_<order number>_<band type>.<file extension>

For example:

1B Product File Name = 2008-10-26T012345_RE3_1B-NAC_0123456789_9876543210_band1.ntf

where:

<acquisition time> = 2008-10-26 (date) T012345 (time in UTC)

<satellite> = RE3

<product ID> = <processing level>-<product description>

= 1B (processing level) -NAC (product description)

<RE catalog ID> = 0123456789

<order number> = 9876543210

<file type> = band1 (only for L1B images)

<file extension> = ntf (NITF 2.0)

The expected values for the satellite, product ID (processing level + product description), file type and file extension fields are listed in Table 6.

SATELLITE	PRODUCT ID		FILE FORMATS	
	PROCESSING LEVEL	PRODUCT DESCRIPTION	FILE TYPE	FILE EXTENSIONS
1 - 5	1B = RE Basic	NAC = Non-atmospherically corrected	For Images : band*n* for 1B NITF images (where *n* = 1..5)	.ntf = NITF2.0
			browse	.tif
			license	.txt
			metadata	.xml
			readme	.txt
			udm	.tif

Table 6: Product naming values for 1B products by category

6.2. 3A – ORTHO PRODUCT NAMING

The information provided in the 3A – Ortho product name includes acquisition date, RapidEye Tile ID, satellite that acquired the image, processing level, order identification and file type with format. The name of each 3A product is composed of the following elements:

<RapidEye Tile ID>_<acquisition date>_<satellite>_<processing level>_<order number>.<file extension>

For example:

3A Product File Name = 3949726_ 2012-01-16_RE3_3A_9876543210.tif

where:

<Rapid Tile ID> = 3949726 (See Appendix B – Tile Grid Definition for more information)

<acquisition date> = 2008-10-26

<satellite> = RE3

<processing level> = 3A

<order number> = 9876543210

<file extension> = tif (GeoTIFF 6.0)

The expected values for the satellite, processing level, file type and file extension fields are listed in Table 7.

SATELLITE	PROCESSING LEVEL	FILE FORMATS	
		FILE TYPE	FILE EXTENSIONS
1 - 5	3A = RE Ortho	For Images : none for 3A GeoTIFF images	.tif = GeoTIFF
		browse	.tif
		license	.txt
		metadata	.xml
		readme	.txt
		udm	.tif

Table 7: Product naming values for 3A products by category

7 PRODUCT DELIVERY

RapidEye offers customers a number of different delivery options. This section describes those delivery options along with the expected files and file structure that accompanies any image delivery.

7.1. DELIVERY OPTIONS

There are several available options for the delivery of RapidEye Satellite Imagery. These options are:

- USB Hard Drive
- USB Memory Stick
- Electronic FTP Pull

7.2. DELIVERY FILES

Every order delivered is accompanied by a number of files which contain information about the delivery of the order. These files provide information on general delivery issues, as well as order specific information related to order Area of Interest (AOI) and an outline of the products delivered in the order. These files are:

1. Delivery Readme file
2. AOI shapefile
3. Delivery summary shapefile
4. Delivery summary KMZ file
5. Delivery Checksum file

7.2.1. Delivery Readme File

A basic delivery readme file is included for all orders. This simple text file contains a number of fields with information related to the delivery. These fields are described in Table 8 .

README FILE CONTENTS			
FIELD	**DESCRIPTION**	**RANGE/VALUE**	**CONDITIONS**
ISD version	Version of the ISD		
Delivery Description	A basic description of the delivery folder structure		
File Description	A description of the files and file types in the delivery		
Additional Reading	List of useful resources such as links to the RapidEye website, product specification document and other resources		
Contact	Contact Information for RapidEye		

Table 8: Delivery Readme File Contents

The delivery readme file is named delivery_README.txt.

7.2.2. Area of Interest (AOI) Shapefile

Every delivery is accompanied by an AOI shapefile. The AOI shapefile consists of a vector polygon showing the outline of the order area or area of interest (AOI) used to fulfill the delivery. The polygon is formatted as a series of files in ESRI® shapefile format and is in a WGS84 Geographic projection.

The AOI shapefile will be named *<ContractID>_aoi. ext*

Example:

01234_aoi.dbf

01234_aoi.prj

01234_aoi.shp

01234_aoi.shx

7.2.3. Delivery Summary Shapefile

Every delivery is accompanied by a delivery summary shapefile. The delivery summary shapefile consists of vector polygons showing the outline of each image delivered up to that time. If there are multiple deliveries, this file will show the cumulative total of all images delivered for the order up to that delivery increment. The polygons are formatted as a single ESRI® shapefile in WGS84 Geographic projection. Each polygon within the shapefile has the following fields of metadata information:

Name – name of the image product

Tile ID – the tile ID number only for 3A products

Order ID – ID number of the order to which the image belongs

Acq Date – date of acquisition of the image

View Angle – the spacecraft off-nadir view angle for the image

UDP – unusable data percentage, a combination of percentage original blackfill and clouds

CCP – cloud cover percentage, as a percentage of usable imagery

Cat ID – catalog ID of the image

Product – type of image product, i.e. 1B or 3A

The delivery summary shapefile is named *<ContractID>_delivery.ext*

Example:

01234_delivery.dbf

01234_delivery.prj

01234_delivery.shp

01234_delivery.shx

7.2.4. Delivery Summary KMZ File

Every delivery is accompanied by a delivery summary KMZ file. The delivery summary KMZ file consists of the order AOI and vector polygons showing the outline of each image delivered up to that time. If there are multiple deliveries, this file shows the cumulative total of all images delivered for the order up to that delivery increment. The file is formatted to work in any software that handles KMZ files.

When viewed in GoogleEarth® each image polygon has a distinct RapidEye placemarker located in the center of the polygon. When the cursor is placed over the placemarker the tile ID will become visible. If the placemarker is selected with the left mouse button, an information bubble will appear which contains the browse image of the product and the following metadata fields:

Name – name of the image product

Tile ID – the tile ID number only for 3A products

Order ID – ID number of the order to which the image belongs

Acquisition Date – date of acquisition of the image

View Angle – the spacecraft off-nadir view angle for the image

Unusable Data – unusable data percentage, a combination of percentage original blackfill and clouds

Cloud Coverage – cloud cover percentage, as a percentage of usable imagery

Catalog ID – catalog ID of the image

Product Level – type of image product, i.e. 1B or 3A

The KMZ file is named <Contract ID>_delivery. kmz

Example:

01234_delivery.kmz

7.2.5. Delivery Checksum File

Each delivery contains a checksum file in md5 format. This file can be used to validate the contents of the delivery in combination with certain software.

The delivery checksum file is named *<Contract ID>_delivery.md5*

Example:

01234_delivery.md5

7.3. DELIVERY FOLDER STRUCTURE

This section describes the folder structure that can be expected for the data deliveries. The folder structure described is for deliveries made via FTP. The folder structure for USB devices may be slightly different that those described below due to different delivery processes, but follows the same general layout.

Figure 1 below illustrates the expected folder structure for a delivery. The main folder name is comprised of two elements: 1) a randomly generated code used for secure inscription to ensure the safety of the delivery; and 2) the Contract ID number that is assigned to the order. A delivery will have only one Contract ID, but may consist of multiple sub-deliveries with differing order IDs as seen in the example below.

Under this main folder a number of files and additional folders may be found. These include:

1. One or more delivery sub-folders containing delivered products for a given date
2. The README text file
3. The AOI shapefile
4. The Delivery shapefile and KMZ files

5. The .md5 checksum file

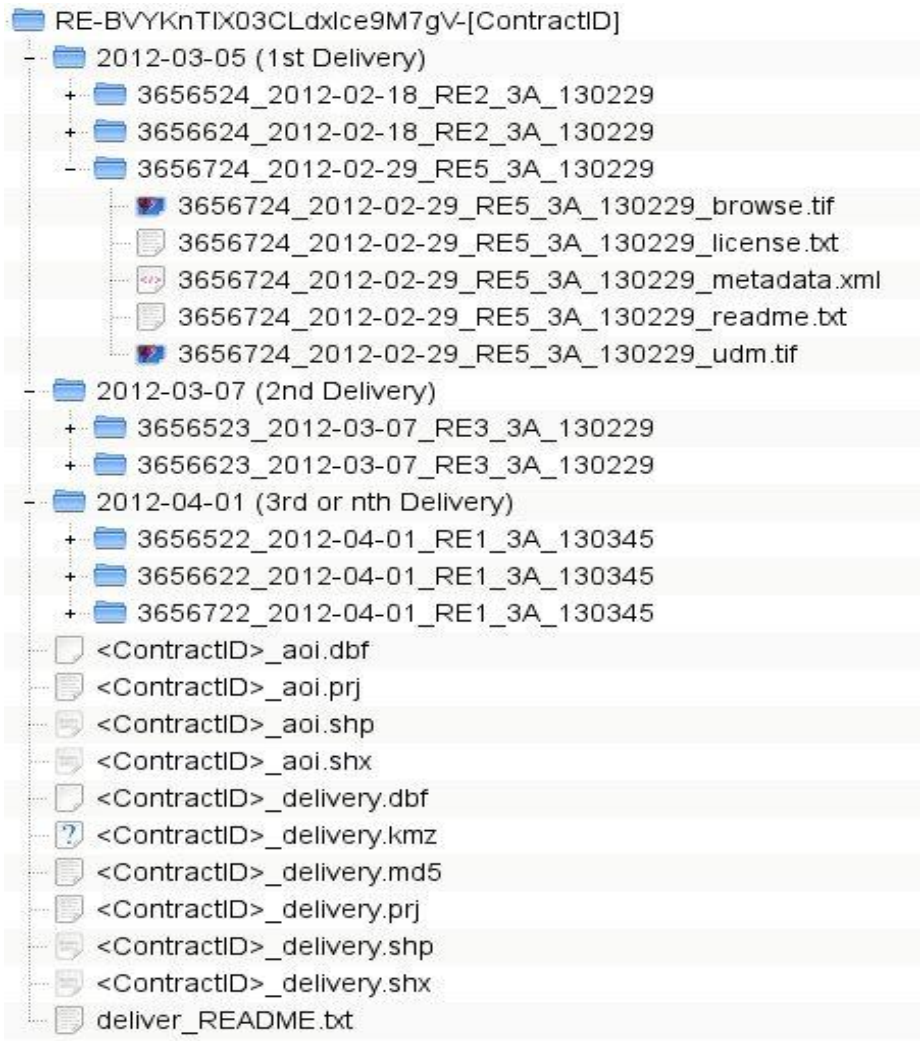


Figure 1: Expected Product Delivery Folder Structure for FTP Deliveries

Images are delivered into sub-folders named according to the date of delivery for the products, following the naming convention <YYYY-MM-DD>. This means that the dates shown in the delivery sub-folders correspond to the delivery date and NOT the acquisition date, unless the products are delivery on the same day they are acquired. Deliveries spanning multiple days will contain multiple delivery sub-folders named according to the appropriate dates, as seen in Figure 1 . In the example above, the delivery is a mix of archive and tasked images with the first product delivery being from the archive and the remaining products being tasked and processed on the day of acquisition. Under each delivery sub-folder a separate folder named according to the image product name can be found containing the expected image and associated ISD files.

For each new product delivered to the main folder the AOI shapefile, delivery shapefile and KMZ file, as well as the checksum file are updated by overwriting the pre-existing files of the same name.

8 IMAGE SUPPORT DATA

All RapidEye Satellite Imagery Products are accompanied by a set of five 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 five ISD files are:

1. XML Metadata File
2. Browse Image File
3. Unusable Data Mask File
4. License File
5. Readme File

Each file is described along with its contents and format in the following sections. In addition to the XML metadata file, for RapidEye Basic products (L1B) further metadata information that may be of interest is located in the header of the NITF image file. A description of the header section of the Level 1B NITF image file can be found in Appendix C.

8.1. XML METADATA FILE

All RapidEye Satellite Imagery Products will be accompanied by a single 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 image products regardless of the processing level. However, some fields within this group of metadata may only apply to certain product levels and are indicated as such in Table 9. In addition, certain blocks within the metadata file apply to only to certain product types. These blocks are noted within the table.

8.1.1. Contents

Table 9 describes the fields present in the XML metadata file for all product levels.

METADATA FILE FIELD CONTENTS			
FIELD	**DESCRIPTION**	**RANGE/VALUE**	**CONDITIONS**
"metaDataProperty" Block			
EarthObservationMetaData			
identifier	Root file name of the image		
acquisitionType	Type of image acquisition	NOMINAL	
productType	Product level of image	L1B L2A L3A	
status	Status type of image, if newly acquired or produced from a previously archived image	ACQUIRED ARCHIVED	
downlinkedTo			
acquisitionStation	X-band downlink station that received image from satellite	Svalbard	
acquisitionDate	Date and time image was acquired		

METADATA FILE FIELD CONTENTS			
FIELD	**DESCRIPTION**	**RANGE/VALUE**	**CONDITIONS**
	by satellite		
archivedIn			
archivingCenter	Location where image is archived	BRB	
archivingDate	Date image was archived		
archivingIdentifier	Catalog ID of image within the RE DMS processing system		
processing			
processorName	Name of ground processing system	DPS	
processorVersion	Version of RE DPS software used to process image		
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 RE Tile Grid		Only for Level 2A and 3A products
pixelFormat	Number of bits per pixel per band in the product image file.	16U – 16 bit unsigned 16S – 16 bit signed	16U for non-atmospherically corrected data 16S for atmospherically corrected data
"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	RE00	
serialIdentifier	ID of the satellite that acquired the data	RE-1 to RE-5	
orbitType	Orbit type of satellite platform	LEO	
instrument			
shortName	Identifies the name of the satellite instrument used to collect the image	MSI	
sensor			
sensorType	Type of sensor used to acquire the data.	OPTICAL	
resolution	Spatial resolution of the sensor used to acquire the image, units in meters	6.5	
scanType	Type of scanning system used by the sensor	PUSHBROOM	
acquisitionParameters			

METADATA FILE FIELD CONTENTS			
FIELD	**DESCRIPTION**	**RANGE/VALUE**	**CONDITIONS**
orbitDirection	The direction the satellite was traveling in its orbit when the image was acquired	DESCENDING	
incidenceAngle	The angle between the view direction of the satellite and a line perpendicular to the image or tile center.	0.0 to 90.0	
illuminationAzimuthAngle	Sun azimuth angle at center of product, in degrees from North (clockwise) at the time of the first image line		
illuminationElevationAngle	Sun elevation angle at center of product, in degrees		
azimuthAngle	The angle from true north at the image or tile center to the scan (line) direction at image center, in clockwise positive degrees.	0.0 to 360.0	
spaceCraftViewAngle	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		

METADATA FILE FIELD CONTENTS			
FIELD	**DESCRIPTION**	**RANGE/VALUE**	**CONDITIONS**
longitude	Longitude of bottom left corner in geodetic WGS84 coordinates		
bottomRight			
latitude	Latitude of bottom right corner in geodetic WGS84 coordinates		
longitude	Longitude of bottom right corner in geodetic WGS84 coordinates		
"resultOf" Block			
EarthObservationResult			
browse			
BrowseInformation			
type	Type of browse image that accompanies the image product as part of the ISD	QUICKLOOK	
referenceSystemIdentifier	Identifies the reference system used for the browse image		
fileName	Name of the browse image file		
product			
ProductInformation			
fileName	Name of image file.		For L1B images only the root file name is listed and not the individual band files
size	The size of the image product in kbytes		
productFormat	File format of the image product	GeoTIFF NITF2.0	
spatialReferenceSystem			
epsgCode	EPSG code that corresponds to the datum and projection information of the image		EPSG code = 4326 for L1B images as images are unprojected
geodeticDatum	Name of datum used for the map projection of the image		Only for Level 2A and 3A products
projection	Projection system used for the image		Only for Level 2A and 3A products
projectionZone	Zone used for map projection		Only for Level 2A and 3A products
resamplingKernel	Resampling method used to produce the image. The list of possible algorithms is extendable.	NN = Nearest Neighbor CC = Cubic Convolution MTF = Modulation Transfer Function	
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	1 to 5	
rowGsd	The GSD of the rows (lines) within the image product		Only for Level 2A and 3A

METADATA FILE FIELD CONTENTS			
FIELD	**DESCRIPTION**	**RANGE/VALUE**	**CONDITIONS**
			products
columnGsd	The GSD of the columns (pixels) within the image product		Only for Level 2A and 3A products
radiometricCorrectionApplied	Indicates whether radiometric correction has been applied to the image	true false	
radiometricCalibrationVersion	Version of the radiometric calibration file used to correct the file		
geoCorrectionLevel	Level of correction applied to the image	Sensor for L1B images Systematic Geocorrection for 2A images Precision Geocorrection for 3A images	
elevationCorrectionApplied	Type of elevation correction applied to the image	false CoarseDEM FineDEM	
atmosphericCorrectionApplied	Indicates whether atmospheric correction has been applied to the image	true false	
atmosphericCorrectionParameters			Present only if atmospheric correction is performed
autoVisibility	Indicates whether the visibility was automatically calculated or defaulted	true false	
visibility	The visibility value used for atmospheric correction in km		
aerosolType	The aerosol type used for atmospheric correction	Rural Urban Maritime Desert	
waterVapor	The water vapor category used	Dry Mid-latitude Winter Fall US Standard Subarctic Summer Mid-latitude Summer Tropical	
hazeRemoval	Indicates whether haze removal was performed	true false	
roughTerrainCorrection	Indicates whether rough terrain correction was performed	true false	
bRDF	Indicates whether BRDF correction was performed	true false	
productAccuracy	Estimated product horizontal CE90 uncertainty, in meters		
mask			
MaskInformation			
type	Type of mask file accompanying the image as part of the ISD	UNUSABLE DATA	
format	Format of the mask file	RASTER	

METADATA FILE FIELD CONTENTS			
FIELD	**DESCRIPTION**	**RANGE/VALUE**	**CONDITIONS**
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	-1 = not assessed 0-100	
cloudCoverPercentageAssessmentConfidence	Estimate of cloud cover assessment confidence in percentage	70	
cloudCoverPercentageQuotationMode	Method of cloud cover determination	AUTOMATIC	
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.	1 = Blue 2 = Green 3 = Red 4 = Red Edge 5 = Near IR	
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)	1x1 2x2 3x3 1x2 2x1	
shifting	Indicates the sensor applied right shifting	none 1bit 2bits 3bits 4bits	
masking	Indicates the sensor applied masking	111, 110, 100, or 000	
radiometricScaleFactor	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		

METADATA FILE FIELD CONTENTS			
FIELD	**DESCRIPTION**	**RANGE/VALUE**	**CONDITIONS**
	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 and sub-fields are only included in the file for L1B RapidEye Basic products			
spacecraftAttitudeMetadata			
attitudeMeasurement	Attitude measurements are provided for the time period during which the image data was captured. The time interval between measurements is 1 second		
measurementTime	UTC Time of measurement		
measurements			
roll	Roll attitude measurement in radians		
pitch	Pitch attitude measurement in radians		
yaw	Yaw attitude measurement in radians		
spacecraftEphemerisMetadata			
ephemerisMeasurement	Ephemeris measurements are provided for the time period during which the image data was captured. The time interval between measurements is 1 second. The coordinate system for the ephemeris measurements is WGS-84 (Earth Centered Earth Fixed) Cartesian coordinates		
measurementTime	UTC Time of measurement		
position			
x	Position of x-axis, in meters		
y	Position of y-axis, in meters		
z	Position of z-axis, in meters		
velocity			
vx	Velocity of x-axis in meters/sec		
vy	Velocity of y-axis in meters/sec		
vz	Velocity of z-axis in meters/sec		
lineTimeMetadata – This group is repeated for each band present in the image product			
bandNumber	Band number of the spectral band	1 = Blue 2 = Green 3 = Red 4 = Red Edge 5 = Near IR	
lineInfomation	Record for each line in the image file for this band		
imagingTime	UTC Date/Time line imaged		
lineMissing	Indicates whether the line was missing from the input data	true false	
spacecraftTemperatureMetadata			
temperatureMeasurements			
averageFocalPlaneTemperature	Average temperature (over imaging time) from each of the temperature sensors on the focal plane. There are 4 temperature sensors		
averageTelescopeTemperature	Average temperature (over imaging		

METADATA FILE FIELD CONTENTS			
FIELD	**DESCRIPTION**	**RANGE/VALUE**	**CONDITIONS**
	time) from each of the temperature sensors in the telescope. There are 4 temperature sensor		
cameraGeometryMetadata			
focalLength	Focal length of the idealized sensor model, in meters		
firstDetectorXCoord	First detector coordinate on the x-axis of the focal plane for the idealized camera model, in meters		
firstDetectorYCoord	First detector coordinate on the y-axis of the focal plane for the idealized camera model, in meters		
detectorPitch	Size of the detector, in meters		
radiometricCalibrationMetadata – This group is repeated for each band present in the image product			
bandNumber	Band number of the spectral band	1 = Blue 2 = Green 3 = Red 4 = Red Edge 5 = Near IR	
perDectectorData	Record for each detector		
gain	Identifies gain used to radiometrically correct the product		
offset	Identifies offset used to radiometrically correct the product		
deadDetectorIndicator	Indicates where the detector is performing outside of its specification and is considered to be dead	true false	

Table 9: XML Metadata File Field Descriptions

8.1.2. File Naming

The XML Metadata file will follow the naming convention described in Sections 6.1 and 6.2.

Example:

2008-10-26T012345_RE3_1B-NAC_0123456789_9876543210_metadata.xml

8.2. BROWSE IMAGE FILE

All RapidEye Satellite Imagery Products will be accompanied by a reduced resolution browse image file.

8.2.1. Contents

The browse image file contains a reduced-resolution representation of the product. It has the same aspect ratio and radiometric corrections as the product, but with a pixel resolution of roughly 48m. The GeoTIFF file will contain 1 or 3 bands and will be an 8-bit image that is georeferenced to a WGS84 Geographic (Latitude-Longitude) projection. The 3-band browse image contains the Red, Green, and Blue bands. The single band browse image will contain the first available band in the following list: Red, Red Edge, Green, Blue, or NIR. Since the browse image is derived from the parent image, the re-projection into geographic coordinates may create areas of blackfill on the borders of the browse image that will not be present in the full resolution parent image.

8.2.2. File Naming

The Browse Image file will follow the naming convention described in Section 6.1 and 6.2.

Example:

2008-10-26T012345_RE3_1B-NAC_0123456789_9876543210_browse.tif

8.3. UNUSABLE DATA MASK FILE

All RapidEye Satellite Imagery Products will be accompanied by an unusable data mask file.

8.3.1. Contents

The unusable data mask file provides information on areas of unusable data within an image (i.e. cloud and non-imaged areas). The pixel resolution of the file will be roughly 48m. The UDM file has 11m or more of horizontal geolocational uncertainty and combined with its lower resolution cannot absolutely accurately capture the edges of areas of unusable data. 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”.

Figure 2 illustrates the concepts behind the Unusable Data Mask file.

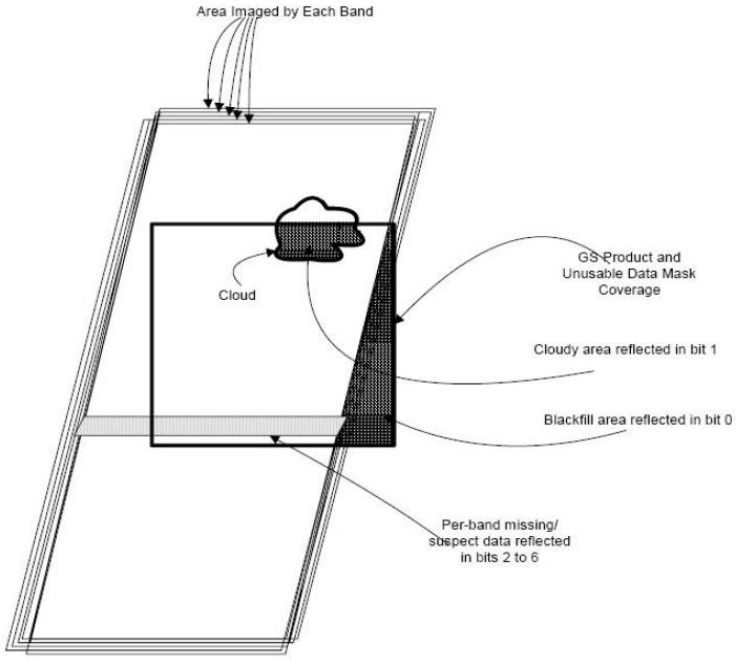


Figure 2: Concepts behind the Unusable Data Mask file

The projection of the UDM file is identical to the projection of the parent image; however there are some differences between the two files for the L1B Basic product. The UDM file for a L1B Basic product is the standard GeoTIFF format for the UDM, whereas the L1B image is in NITF format. This difference in formats leads to slightly different georeferencing between the two files and may lead to the UDM file not exactly overlaying the image file at the right location. For the L3A Ortho product both the UDM and image files are in GeoTIFF format, so the UDM overlays the image tile exactly.

8.3.2. File Naming

The Unusable Data Mask file will follow the naming convention described in Sections 6.1 and 6.2.

Example:

2008-10-26T012345_RE3_1B-NAC_0123456789_9876543210_udm.tif

8.4. LICENSE FILE

All RapidEye Satellite Imagery Products will be accompanied by a license file for the image.

8.4.1. Contents

The license file is a simple text file that contains the text of the license that was selected at the time the image order was placed.

8.4.2. File Naming

The license file will follow the naming convention described in Sections 6.1 and 6.2.

Example:

2008-10-26T012345_RE3_1B-NAC_0123456789_9876543210_license.txt

8.5. README FILE

All RapidEye Satellite Imagery Products will be accompanied by a Readme file.

8.5.1. Contents

The Readme file is a simple text file that contains a number of fields with general information regarding the image and the files that accompany it. These fields are described in Table 10.

README FILE CONTENTS			
FIELD	**DESCRIPTION**	**RANGE/VALUE**	**CONDITIONS**
ISD version	Version of the ISD		
Copyright Text	Copyright and restricted use text		
Product Generation Time	End time when the Image Product was generated		
Order Number	Order number that the image belongs to		
File List	A list of file names that accompany the image product file		
Product Type	Level of image product	L1B L3A	
Comments	comment field for customer comments or other information pertaining to the order		Empty if none supplied

Table 10: Readme File Contents

8.5.2. File Naming

The Readme file will follow the naming convention described in Sections 6.1 and 6.2.

Example:

2008-10-26T012345_RE3_1B-NAC_0123456789_9876543210_readme.txt

APPENDIX A – GLOSSARY OF TERMS

The following list defines terms used to describe RapidEye image products.

Bidirectional Reflectance Distribution Function (BRDF)	Describes the directional dependence of reflected energy (light). BRDF is a fundamental optical property. It characterizes the energy scattered into the hemisphere above a surface as a result of incident radiation.
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)	A digital model of the terrain surface usually derived from stereo imagery. A DEM is used to remove terrain distortions from the imagery for the geo-corrected products.
Digital Number (DN)	The value assigned to a pixel in a digital image. This gray density value represents the intensity of reflected light from a feature collected by the sensor for a particular spectral range.
Dynamic Range	The number of possible DN values for each pixel in a band of an image. RapidEye has a 12-bit dynamic range which translates into 4096 possible values.
Ground Control Point (GCP)	A visible point on the ground with known geographic coordinates. GCPs can be planimetric (latitude, longitude) or vertical (latitude, longitude, elevation). GCPs can be collected from ground survey, maps, or orthorectified imagery.
Ground Sample Distance (GSD)	The size of one pixel, as measured on the ground.
Instantaneous Field of View (IFOV)	The area on the ground visible to the satellite.
Metadata	Ancillary data that describes and defines the RapidEye imagery product. Metadata files differ for the two image processing types. See Section 6 for a complete breakdown of metadata files and the fields within them.
Nadir	The point on the ground that is directly below the satellite.
Off-nadir Angle	The angle between nadir and the point on the ground that the satellite is pointing to.
Orthorectification	The correction of distortions caused by terrain relief displacement on the image.
Pixel	The smallest element comprising a digital image.
Radiometric Correction	The correction of variations in data that are not caused by the object or scene being scanned. These include correction for relative radiometric response between detectors, filling non-responsive detectors and scanner inconsistencies.
Resolution	The resampled image pixel size derived from the GSD.
Revisit Time	The amount of time it takes to image the same point on the ground.
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	An orbit which rotates around the earth at the same rate as the earth rotates on its axis.
Swath Width	The width of the ground area that is recorded by one image strip.
Terrain Correction	The correction for variations in data caused by terrain displacement due to off-nadir viewing.

APPENDIX B – TILE GRID DEFINITION

RapidEye image tiles 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.

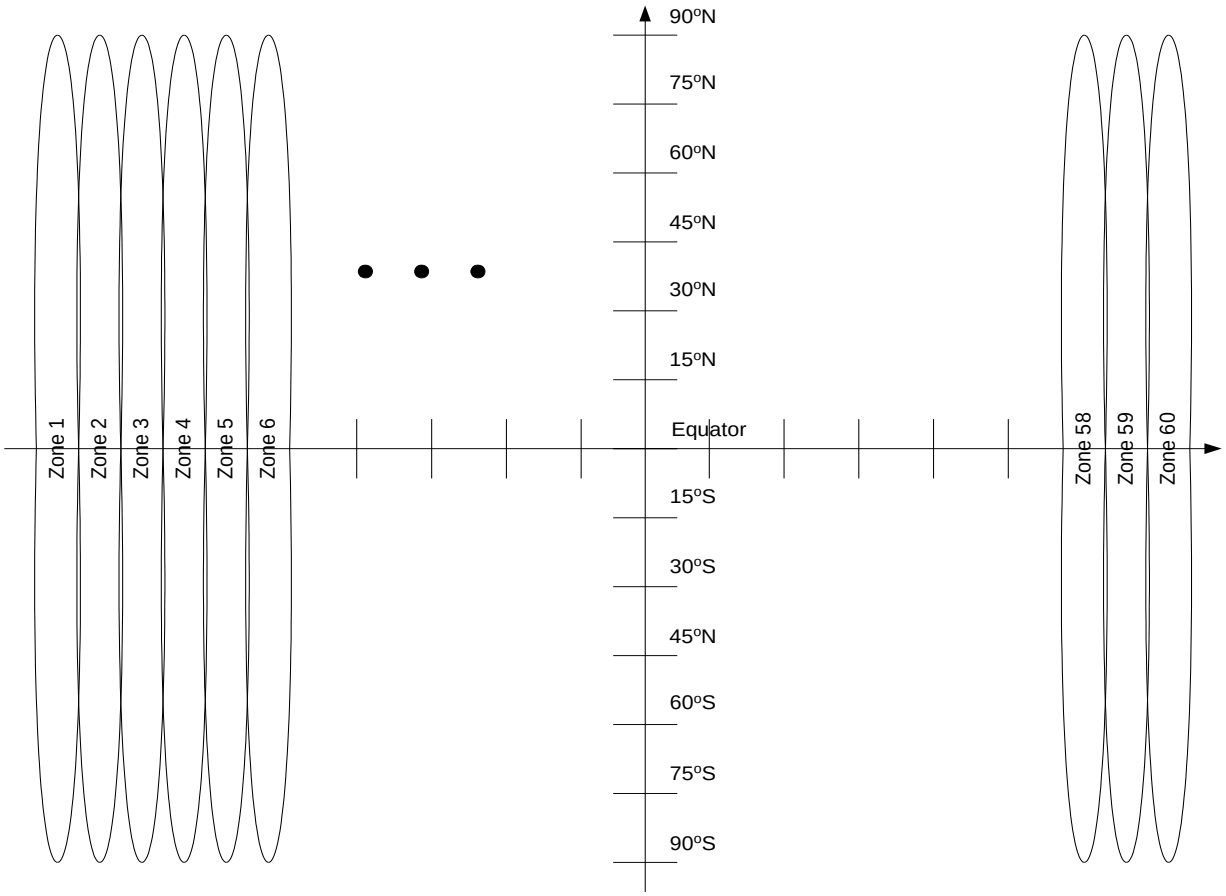


Figure B-1 Layout of UTM Zones

A RapidEye tile 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)

For example:

Tile 547904 = UTM Zone = 5, Tile Row = 479, Tile Column = 04

Tile 3363308 = UTM Zone = 33, Tile Row = 633, Tile Column = 08

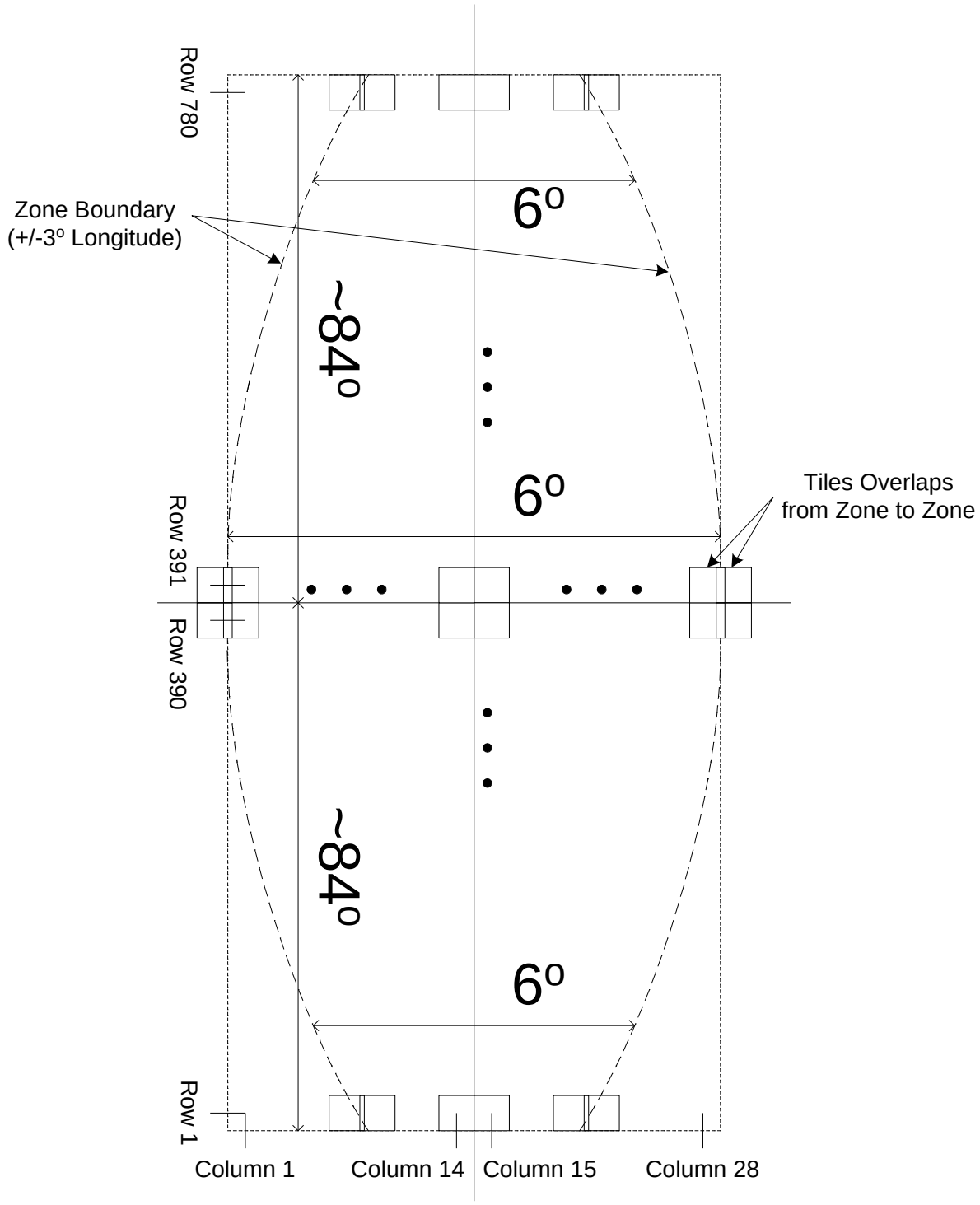


Figure B-2 Layout of Tile Grid within a single UTM Zone

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

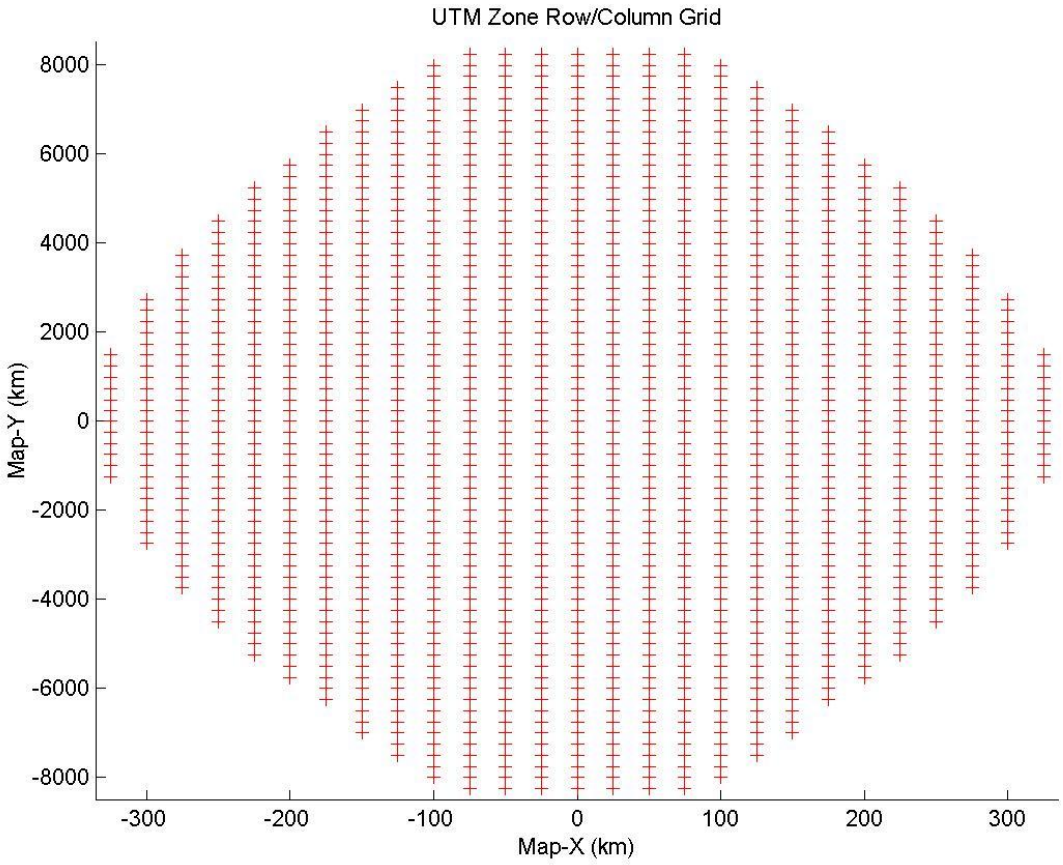


Figure B-3 Illustration of grid layout of Rows and Columns for a single UTM Zone

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 – NITF FILE STRUCTURE AND CONTENTS

The RapidEye Basic image product is delivered as a series of NITF 2.0 files. The NITF 2.0 file format contains image data and basic metadata about the image. The structure of the NITF file for the RapidEye Basic product is shown in Figure D-1.

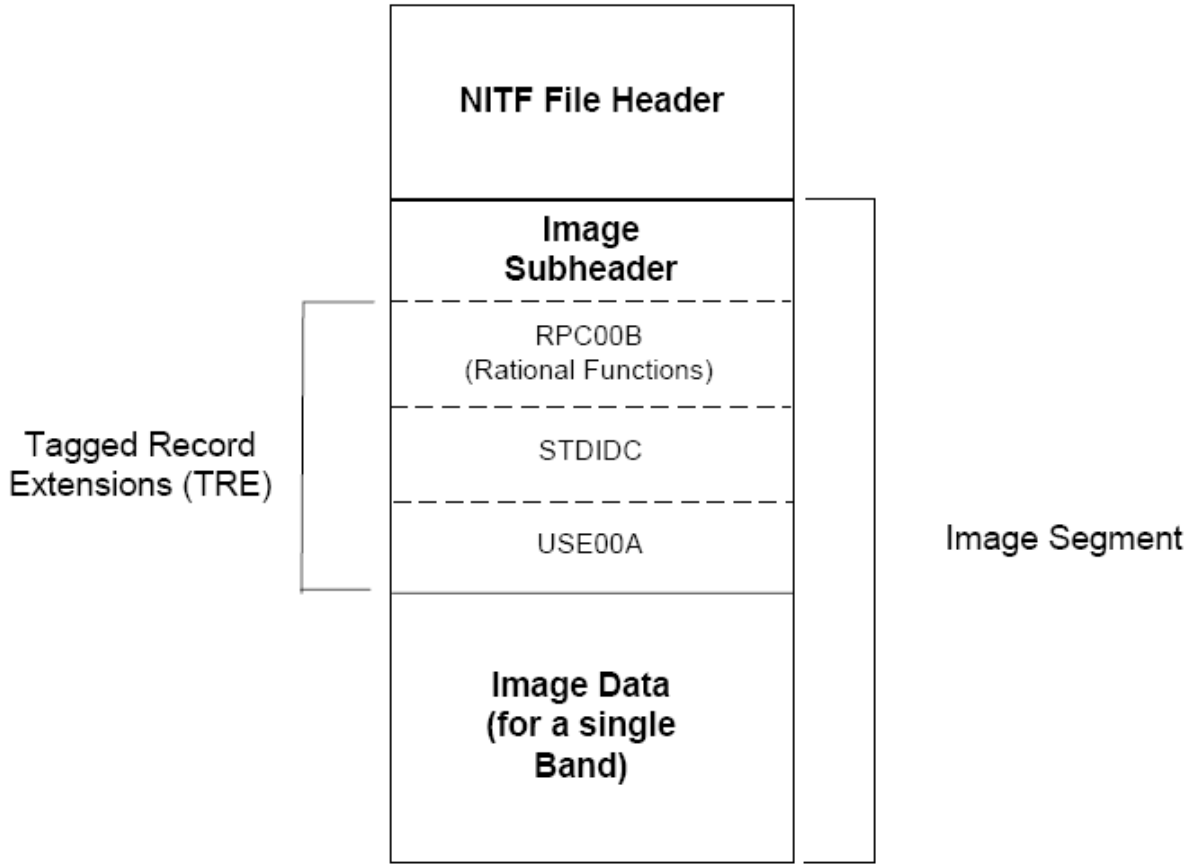


Figure C-1: Structure of NITF 2.0 File

The contents of the NITF File Header are detailed in the Table 11. The “Req” column indicates whether the field is required. Valid values are:

R = Required

C = Conditional

<> = null data allowed

NITF FILE MAIN HEADER CONTENTS				
FIELD	**DESCRIPTION**	**RANGE/VALUE**	**REQ**	**CONDITIONS**
FHDR	File type and version	NITF02.00	R	
CLEVEL	Complexity level required to fully interpret all components of the file. Note: Multi-spectral products will have a minimum CLEVEL of 06. A CLEVEL of 99, as required by specifications, is assigned for imagery greater than 2GB, which may adversely affect some software packages.	03, 05, 06 or 99	R	
STYPE	Standard System type	" " (4 spaces)	R	
OSTAID	Originating station identification code	RE	R	
FDT	File date and time	DDHHMMSSZMONYY	R	
FTITLE	File Title	"RE Image Data"	<R>	
FSCLAS	File security classification	U	R	
FSCOP	Copy number of the file. Message copy number. Not Used.	00000	R	
FSCPYS	Contains the total number of copies of the fileMessage number of copies. Not Used.	00000	R	
ENCRYP	Encryption '0' represents no encryption	0	R	
FBKGC	File background color in the order Red, Green, Blue. Set to a soft gray background	7E 7E 7E	R	
ONAME	Originator's name	RapidEye	<R>	
OPHONE	Originator's phone number	RapidEye Phone Number	<R>	
FL	Length in bytes of the entire file, including all headers, subheaders and data	000000000388-999999999998,999999999999	R	
HL	NITF 2.0 file header length	000404	R	
NUMI	Number of separate image segments in a file "1" is used for all products	001	R	
LISHn	Length of n-th image subheader, where n = NUMI	000439 to 999998,999999	C	This field occurs as many times as specified in the NUMI field
LI00n	Length of n-th image segment, where n = NUMI	0000000001 to 9999999998, 999999999	C	This field occurs as many times as specified in the NUMI field
NUMS	Number of graphic symbols in file. Not Used.	000	R	
NUML	Number of labels. Not Used.	000	R	
NUMT	Number of text segments in file. Not Used.	000	R	
NUMDES	Number of data extensions segments in file. Not Used.	000	R	
NUMRES	Number of reserved extension segments (RES) in file. Not Used.	000	R	
UDHDL	User defined header data (UDHD) length. Not Used.	00000	R	
XHDL	Extended header data (XHD) length. Not Used.	00000	R	

Table 11: NITF File Main Header Contents

The contents of the NITF Image Subheader are detailed in the Table 12.

NITF FILE SUBHEADER CONTENTS				
FIELD	**DESCRIPTION**	**RANGE/VALUE**	**REQ**	**CONDITIONS**
IM	Identifies the subheader as an image subheader	IM	R	
IID	Image identifier	0000000 to 9999999	R	ID of Image Segment from which this image was extracted
IDATIM	Image Date and Time. The image acquisition date and time in GMT	DDHHMMSSZMONYY	R	
ITITLE	Image Tile	"RE Image Data"	<R>	
TGTID	Target Identifier Where: BBBBBBBBBB = Basic Encyclopedia identifier OOOOO = facility OSUFFIX CC = country code Zero-filled	000000000000000000	<R>	
ISCLAS	Classification level of image RE products are Unclassified ("U")	U	R	
ENCRYP	Encryption "0" represents no encryption.	0	R	
ISORCE	Image source	RE01-RE05	<R>	
NROWS	Number of significant rows in image	00000000 to 99999998, 99999999	R	
NCOLS	Number of significant columns in image	00000000 to 99999998, 99999999	R	
PVTYPE	Pixel value type	INT SI	R	INT for unsigned integer pixel values SI for signed integer pixel values
IREP	Image representation - "MONO" is used for single-band products - "MULTI" is used for multi-band products	MONO	R	
ICAT	Image category	MS	R	
ABPP	Actual bits-per-pixel per band This is also related to the value in NBPP filed of the subheader	12 or 16	R	
PJUST	Pixel Justification Pixels will be right justified	R	R	
ICORDS	Image coordinate representation Geographic ("G") or MGRS ("U")	G	<R>	

NITF FILE SUBHEADER CONTENTS				
FIELD	**DESCRIPTION**	**RANGE/VALUE**	**REQ**	**CONDITIONS**
IGEOLOn (where: n = 1..4)	Image Geographic Location. Represents the 4 corners of the image, and is presented in image coordinate order: (0,0),(0,NCOLS),(NROWS,NCOLS),(NROWS,0). When ICORDS = "G", IGEOLO is expressed as latitude and longitude and uses the format ddmmssXdddmmssY where "ddmmss" represents degrees, minutes, and seconds of latitude with "X" represents North (N) or South (S), and "ddmmss" represents degrees, minutes, and seconds of longitude with "Y" representing East (E) or West (W).	ddmmssXdddmmss	C	
NICOM	Number of free text image comments	1	R	
ICOMn	Image comments #n, where n = 1..5 Empty by default – configurable text.		C	
IC	Image compression form. Compression is not supported.	NC	R	
NBANDS	Number of data bands	1	R	
IREPBANDn	n^{th} Band representation, where n= 1..NBANDS Note: When NBAND in subheader = 1 this field contains all spaces	blank	<R>	
ISUBCATn	n^{th} Band subcategory – center wavelength of the band, where n = 1..NBANDS	RE spectral centers	<R>	
IFCn	n^{th} Band image filter condition, where n = 1..NBANDS N – no filters	N	R	
NLUTSn	Number of LUTs for the n^{th} Image Band, where n = 1..NBANDS Not used.	0	<R>	Required only if the PVTYPE is INT hence the inclusion
ISYSNC	Image sync code – reserved for future use	0	R	
IMODE	Indicates how image pixels are stored. "B" represents band interleaved by block, and is used on all products.	B	R	
NBRP	Number of blocks per row. Contains the number of image blocks (1 block = 1024 x 1024 pixels) in the horizontal direction	0001 - 9999	R	
NBPC	Number of blocks per column. Contains the number of image blocks (1 block = 1024 x 1024 pixels) in the vertical direction	0001 - 9999	R	
NPPBH	Number of pixels per block horizontal	1024	R	
NPPBV	Number of pixels per block vertical	1024	R	
NBPP	Number of bits per pixel per band. RE 12 bits product imagery is stored via 16.bit integers. This is also related to the value in ABPP of the subheader.	16	R	
IDLVL	Image display level. All products consist of a single level.	001	R	

NITF FILE SUBHEADER CONTENTS				
FIELD	**DESCRIPTION**	**RANGE/VALUE**	**REQ**	**CONDITIONS**
IALVL	Attachment level of image. All products are created with the minimum attachment level.	000	R	
ILOC	Image Location. This is the location of he first pixel of the first line of the image and is represented as RRRRRCCCCC, where RRRRR represents row values and CCCCC represents column values.	0000000000	R	Note: The coordinates are line/column numbers. Important when the image is a portion of a larger image (this is not the case for the RE Basic product so the field will always be constant 0000000000).
IMAG	Magnification factor of the image relative to the original source image. Set 10 1.0 to signify no magnification	1.0	R	
UDIDL	User defined image data length. Not used.	00000	R	
IXSHDL	Image extended subheader data length. This is the sum of the length of all the Controlled Extensions (CETAG) appearing in the image plus 3:(sum(CEL + 11)) + 3, where 11 is the size of the extension header and 3 is the length of the IXSOFL field.	00003 - 99999	R	
IXSOFL	Image extended subheader overflow. Not used.	000	C	
CETAG	Controlled unique extension type identifier	RPC00B STDIDC USE00A	R	
CEL	Contains the length in bytes of the data contained in the CEDATA field 1041 = length of RPC00B data 89 = length of STDIDC data 107 = length of USE00A data	1041, 89 or 107	R	

Table 12: NITF Subheader Contents

The contents of the RPC00B portion of the NITF Image Subheader are detailed in the Table 13.

NITF RPC00B PORTION OF THE SUBHEADER CONTENTS				
FIELD	**DESCRIPTION**	**RANGE/VALUE**	**REQ**	**CONDITIONS**
FIELD1 (SUCCESS)		1	R	
FIELD2 (ERR_BIAS)	Error bias. 68% non time-varying error estimate assumes correlated images	0000.00 to 9999.99	R	
FIELD3 (ERR_RAND)	Error random. 68% non time-varying error estimate assumes uncorrelated images	0000.00 to 9999.99	R	
FIELD4 (LINE_OFF)	Line offset	0000000 to 9999999	R	
FIELD5 (SAMP_OFF)	Sample offset	0000000 to 9999999	R	
FIELD6 (LAT_OFF)	Geodetic latitude offset	±90.0000	R	
FIELD7 (LONG_OFF)	Geodetic longitude offset	±180.0000	R	
FIELD8 (HEIGHT_OFF)	Geodetic height offset	±9999	R	
FIELD9 (LINE_SCALE)	Line scale	000001 to 999999	R	
FIELD10 (SAMP_SCALE)	Sample scale	000001 to 999999	R	
FIELD11 (LAT_SCALE)	Geodetic latitude scale	±90.0000	R	
FIELD12 (LONG_SCALE)	Geodetic longitude scale	±180.0000	R	
FIELD13 (HEIGHT_SCALE)	Geodetic height scale	±9999	R	
FIELD14 (LINE_NUM_COEFF1..20)	Line numerator coefficient: 20 coefficients for the polynomial in the Numerator of the r sub n equation All values are expressed in scientific notation.	-1.000000E+00 to +1.000000E+00	R	
FIELD15 (LINE_DEN_COEFF1..20)	Line denominator coefficient: 20 coefficients for the polynomial in the Denominator of the r sub n equation All values are expressed in scientific notation.	-1.000000E+00 to +1.000000E+00	R	
FIELD16 (SAMP_NUM_COEFF1..20)	Sample numerator coefficient: 20 coefficients for the polynomial in the Numerator of the r sub n equation All values are expressed in scientific notation.	-1.000000E+00 to +1.000000E+00	R	
FIELD17 (SAMP_DEN_COEFF1..20)	Sample denominator coefficient: 20 coefficients for the polynomial in the Denominator of the r sub n equation All values are expressed in scientific notation.	-1.000000E+00 to +1.000000E+00	R	

Table 13: RPC00B (Rapid Positioning Capability) portion of the NITF Subheader Contents

The contents of the STDIDC portion of the NITF Image Subheader are detailed in the Table 14.

NITF STDIDC PORTION OF THE SUBHEADER CONTENTS				
FIELD	**DESCRIPTION**	**RANGE/VALUE**	**REQ**	**CONDITIONS**
ACQ_DATE	Date and time of image acquisition in GMT.	yyyymmddhhmmss	R	
MISSION	Identifies the specific RE vehicle as the source of image data	RE01 - RE05	R	
PASS	Identifies pass in the day of the image acquisition. A new day starts at 00:00Z	01 -16	R	
OP_NUM	Image Operation Number.	000	R	
START_SEGMENT	Start Segment ID. Identifies images as separate pieces (segments) within an imaging operation. This field will always contain AA.	AA	R	
REPRO_NUM	Reprocess Number. Indicates whether data is original or has been reprocessed or enhanced. We assume “00” for original data.	00	R	
REPLAY_REGEN	Replay/Regeneration. Indicates remapping or regeneration mode of imagery. We assume “000” as all images are produced from raw data.	000	R	
START_COLUMN	Starting Column Block. The first column block in the image. All products start at 1.	001	R	
START_ROW	Starting Row Block. The first row block in the image. All products start at 1.	00001	R	
END_SEGMENT	Ending segment ID of the file. This field will always contain AA.	AA	R	
END_COLUMN	Ending Column Block. The last column block in the image.	001 - 999	R	
END_ROW	Ending Row Block. The last row block in the image.	00001 - 99999	R	
LOCATION	Location. Natural reference point (in WGS84) of the sensor, expressed as latitude and longitude The format used is ddmmXdddmmY, where “ddmmX” represents degrees and minutes of latitude with “X” representing North (N) or South (S), and “dddmmY” represents degrees and minutes of longitude with “Y” representing East (E) or West (W).	ddmmXdddmmY	R	

Table 14: STDIDC (Standard ID Extension Format) portion of NITF Subheader Contents

The contents of the USE00A portion of the NITF Image Subheader are detailed in the Table 15.

NITF USE00A PORTION OF THE SUBHEADER CONTENTS				
FIELD	**DESCRIPTION**	**RANGE/VALUE**	**REQ**	**CONDITIONS**
ANGLE_TO_NORTH	Angle to north. Angle to true north measured clockwise from first row of the image.	0 - 360	R	
MEAN_GSD	Mean Ground Sample Distance. The geometric mean of the cross and along scan center-to-center distance between contiguous ground samples, in inches.	000.0 to 999.9	R	
DYNAMIC_RANGE	Dynamic range of the pixels in image. "255" is used for 8-bit products, "4095" is used for 12-bit products, "65535" is used for 16-bit products. This corresponds to the bit-depth value in ABPP of the file subheader section.	00255, 04095 or 65535	<R>	
OBL_ANG	Obliquity angle. This is the angle between the local NED horizontal plane and the optical axis of the image.	00.00 to 90.00	<R>	
ROLL_ANG	Roll angle. Roll is the rotation angle about the platform roll axis. Roll is positive if the platform positive pitch axis lies below the NED horizontal plane.	±90.00	<R>	
N_REF	Number of reference lines in image.	00	R	
REV_NUM	Orbit revolution number at the time of exposure.	00001 to 99999	R	
N_SEG	Number of image segments. This value is always set to 1.	001	R	
MAX_LP_SEG	Maximum Lines Per Segment. This is the number of rows per image segment. This value is equal to NROWS value in subheader.	000001 to 999999	<R>	
SUN_EL	Sun Elevation. Degrees measured from the target plane at intersection of the optical line of sight with the earth's surface at the time of the first image line.	+90.0 or 999.9	R	
SUN_AZ	Sun azimuth. Degrees measured from true North clockwise (as viewed from space) at the time of the first image line.	000.0 to 359.0 or 999.9	R	

Table 15: USE00A (Exploitation Usability) portion of the NITF Subheader Contents