DEFENCE AND SPACE
Intelligence

Pléiades Imagery
User Guide

Organisation of the Pléiades Imagery User Guide

The Pléiades Imagery User Guide provides essential information to the users about all Pléiades products and services.

The document is divided into four main parts, followed by technical appendices:

- **Chapter 1** details the Pléiades satellite system and its performance

- **Chapter 2** explains the different Pléiades products

- **Chapter 3** details product ordering

- **Chapter 4** presents product delivery

For the experienced users, several technical appendices complete the document by covering the following points:

A. DIMAP V2 format

B. Image quality performance

C. Geometric modelling

D. Spectral modelling

We would like this document to be as useful as possible. If you feel that information is missing or unclear, or for any feedback you may have on the content and format, please send an email to: technicalsupport@intelligence-airbusds.com.

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Figure 1.1: Pléiades 1A/1B and Spot 6/7 constellation

With four satellites – Pléiades 1A and 1B, and SPOT 6 and 7 – launched in a two-year time frame, Airbus Defence and Space Intelligence is giving its customers the very best that space technology has to offer.

Ensuring continuity of Earth optical imaging service up to 2024, these satellites operate as a true constellation, combining a twice-daily revisit capability with an ingenious range of resolutions.

The Pléiades twins are very high-resolution satellites delivering 50 cm Ortho products as standard. SPOT 6 and 7 are designed to extend SPOT 5's success to the 1.5 m product family. Phased on the same orbit, the combined Pléiades and SPOT 6/7 optical constellation enjoys unprecedented reactivity, with same-day revisit capacity anywhere on Earth. Multiple-tasking plans per day result in an unrivalled optimisation of data collection. Unforeseen weather changes, as well as last-minute requests, can be taken into account for a first-class level of service.

The Pléiades1A and Pléiades 1B were launched on a Soyuz ST from Europe's space port in Kourou, French Guiana, on December 17, 2011 and on December 2, 2012, respectively.

Figure 1.2: Artist's impression of the Pléiades satellite

Number of satellites	Two: Pléiades 1A and Pléiades 1B, featuring a true constellation
Launch	Pléiades 1A: December 17, 2011; Pléiades 1B: December 2, 2012
Orbit	Sun-synchronous, 10:30 am descending node, 26-day cycle, 694 km altitude
Period/ Inclination	98.79 minutes/ 98.2°
Optical system	The telescope is a Korsch type combination with 65cm aperture diameter, focal length of 12.905 m, f/20, TMA optics
Spectral bands	Pan: 0.47-0.83 µm Blue = 0.43-0.55 µm Green = 0.50-0.62 µm Red = 0.59-0.71 µm Near Infrared = 0.74-0.94 µm (NIR)
Detectors	Panchromatic array assembly: 5 x 6000 (30,000 cross-track) pixels Multispectral array assembly: 5 x 1500 (7,500 in cross-track) pixels Each pixel having a size of 13 µm in Panchromatic
Ground sampling distance (nadir)	Panchromatic 0.7 m; Multispectral 2.8 m
Product resolution	Panchromatic 0.5 m, Multispectral 2 m
Swath width	20 km at nadir
Dynamic range at acquisition	12 bits per pixel
NIIRS class	6
Viewing angle	Standard +/-30°, maximum +/- 47°
Revisit capacity, using both Pléiades 1A and 1B	Daily, everywhere
Pointing agility	Roll of 60° within 25 seconds; pitch of 60° within 25 seconds; 200 km in 11 seconds including stabilisation time
Acquisition capability	700,000 km²/day (max. capacity), with an average of 500,000 km²/day
Location accuracy at nadir	Performance (October 2017): 6.5 m CE90
Onboard storage	600 Gb (solid state mass memory)
Instrument TM link rate	The output rate is nominally of 465 MB/sec, on three individual channels of 155 MB/sec each
Mission lifetime	Minimum of 5 years with an estimated life of more than 10 years

Table 1.1: Main characteristics of the Pléiades satellites constellation

Main S-band receiving	Toulouse (France) Svalbard (Norway)
S-band uplink stations	Toulouse (France) Kiruna (Sweden) Kerguelen
Programming centre	Airbus/Geo-Intelligence – Toulouse (France) Airbus/Geo-Intelligence – Chantilly VA (USA)
Production	Airbus DS Intelligence – Toulouse (France)
Tasking plans refresh times/day/satellite frequency	3
Update of weather forecast	3 times/day – fully automatic
Satellite control centre	CNES, Toulouse, France

Table 1.2: Key attributes of the Pléiades satellite constellation

Table 1.1 outlines the main characteristics of the Pléiades satellites constellation and Table 1.2 its key attributes.

Flexibility, Agility and Availability 'The right information at the right time'

Pléiades is composed of two twin satellites operating as a true constellation on the same orbit and phased 180° from each other. Added to their oblique incidence capability (up to 45° angle) and exceptional agility, this orbit phasing allows the satellites to revisit any point on the globe daily – ideal for anticipating risks, effectively managing crises or for large areas coverage.

Figure 1.3 below shows Pléiades' 1A and 1B combined corridor of visibility for the same day.

Figure 1.3: Pléiades 1A and 1B combined corridor of visibility for the same day (+/-45°)

The daily revisit capacity is backed by a reactive operational loop. Work plans are updated every eight hours and three Pléiades uplink stations have been chosen, according to the three tasking periods, to meet customers' worldwide timeline requirements as efficiently as possible. These multiple work plans per day enable easy handling of last-minute tasking requests, as well as integration of the latest weather information, for an improved data collection success rate. Each of the Pléiades satellites provides the same coherent and high quality output. Tasking plans are natively optimised between the two satellites to fully leverage these synergies, through a unique and easy-to-use tasking interface and work plan.

In addition to Pléiades constellation's true daily revisit capability, its extra reactivity also utilises Airbus DS Intelligence's strategic network of ground-receiving stations, enabling an all-orbit contact and thus ensuring near real-time performances worldwide and rapid data access.

As soon as an area has been collected, the images are immediately downlinked, automatically processed and quickly delivered to the customer, allowing faster response when facing emergency situations.

For the user, this results in:

- More image collection opportunities.

- Improved map update capacity (coverage).

- Rapid access to data after acquisition.

- Unprecedented capacity for disaster response, regular or intensive monitoring, or change detection.

Equipped with Control Moment Gyros (CMGs), the Pléiades satellites benefit from exceptional performance in terms of agility (roll pitch: 5° in 6.5 seconds, 10° in 10 seconds, 60° in 25 seconds). The time required to cover over 200 kilometres is reduced to 11 seconds, including stabilisation time (satellites not equipped with CMGs do the same thing in approximately 20 seconds). That kind of performance results in a reduced average acquisition window for the users, allowing more images to be collected during the same pass; collection opportunities are more numerous, conflicts between contiguous requests are minimised, and the acquisition on the same pass of several targets at the same latitude becomes possible.
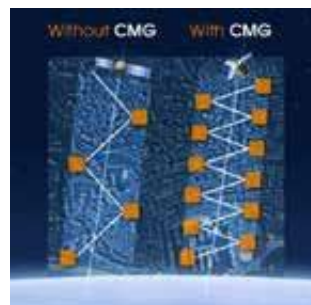
Figure 1.4: Benefits of CMGs

Acquisition Capacity

Pléiades has an impressive acquisition capacity:

- The maximum theoretical acquisition capacity is 700,000 square kilometres per day, with an average of 500,000 square kilometres per day.

- The acquisition capacity fully leverage the constellation's capacity. It takes into account the cloud cover optimisation and the time needed to slew from one tasking request to another.

Swath and Coverage

Pléiades coverage capacity is also due, in part, to its swath (20 km), the largest in this class of resolution – providing a larger native image footprint (from 30% to 73% better coverage compared to its peers in a single image).

This results in maximised information on a target and its surroundings and optimised production with a reduced requirement for cutlines and mosaicking work over large areas, as well as easier data handling, with fewer folders and products to manipulate for a given large AOI.

Single Pass Collection Scenarios – Overview

Image acquisition is tailored closely to match any user's needs, whatever the scenario:

- **Target collection**: image multiple targets (1 and 2): typically 20 targets within a 1,000 x 1,000 km area, in a corridor of +/-30 degrees or 10 images over a crisis theatre of 100 x 200 km.

- **Strip mapping**: large mosaics in a single pass (3): up to 100 x 150 km in the same pass.

- **Stereo and Tristereo acquisition** (4): for accurate 3D applications.

- **Corridor acquisition** (5): to follow linear features such as coastlines, borders, pipelines, rivers, roads, etc.

- **Persistent surveillance mode** (6): up to 25 images acquired over the same area to calculate the speed and direction of a moving target.

1 Multiple close targets during the same pass, typically 20 targets over a 1,000 x 1,000 km area inside a +/-30° corridor

2 CMGs allow maximising numbers of acquisitions over a given area, typically ten images over an area of 100 x 200 km
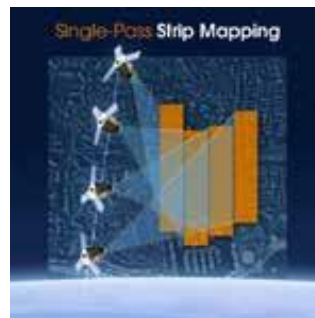
3 Strip mapping over large areas, typically up to five contiguous strips of 150 km each

4 Stereo and Tristereo acquisitions for 3D applications
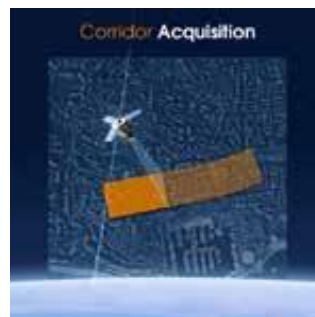
5 Corridor acquisition over linear targets (borders, roads, railways, pipelines…)

6 Persistent surveillance mode, for moving targets and/or improved photointerpretation

Figure 1.5: Single pass collection scenarios

Mosaics Acquired in a Single Pass

With its great agility, the system offers the possibility to artificially increase the instantaneous field of view. A mosaic image is built from several contiguous data strips acquired in the same orbit. Table 1.3 summarises this capability vs the authorised incidence angle. The Pléiades ground segment can then automatically compute the mosaicking and rectification.

Swath cover	Maximum length	Km²
Incidence angle +/-20°		
3 strips (55 km)	145 km	8,000
4 strips (75 km)	75 km	5,600
5 strips (90 km)	55 km	4,900
Incidence angle +/-30°		
3 strips (55 km)	260 km	14,500
4 strips (75 km)	160 km	12,200
5 strips (90 km)	105 km	9,500
6 strips (110 km)	70 km	7,900
Incidence angle +/-45°		
3 strips (55 km)	295 km	16,225
4 strips (75 km)	295 km	22,125
5 strips (90 km)	230 km	20,700
6 strips (110 km)	180 km	19,800

Table 1.3: Strip mapping coverage

Moreover, it is possible to stitch together mosaics from data strips acquired during different orbits. In this case, the processing is done on a manual basis.

Stereoscopic Cover Capabilities

A great feature of Pléiades is its high resolution stereoscopic cover capability. The stereoscopic cover is achieved within the same pass of the area, which enables a homogeneous product to be created quickly.

Stereo		Tristereo	
B/H	**Length**	**B/H**	**Length**
0.15	20 km	0.3	20 km
0.2	60 km	0.4	60 km
0.3	120 km	0.5	90 km
0.4	175 km	0.6	120 km
0.5	225 km	0.7	145 km
0.6	280 km	0.8	175 km

Table 1.4: Pléiades Stereo/Tristereo B/H

As shown in Table 1.4, the system offers the possibility to achieve a 'classical' stereoscopic imaging, composed of two images for which the angular difference (B/H) can be adjusted, but also stereoscopic imaging with an additional quasi vertical image (tristereoscopy), thus allowing the user to have an image and its stereoscopic environment.

Tristereo images can be used to create more accurate 3D models, compared to what is possible with basic stereo, as the near nadir acquisition minimises the risk of missing hidden items. This is ideal for dense urban and mountainous areas, see Figure 1.6 below. Please refer to 3.2.2, Step 5, processing options for more information about B/H.
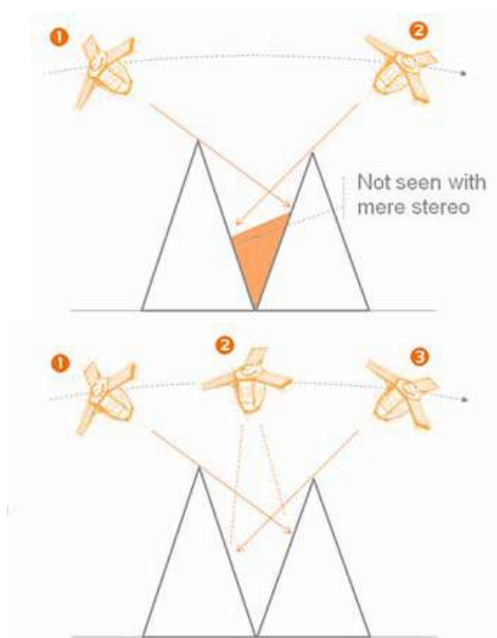
Figure 1.6: Stereoscopic cover capabilities over mountainous areas

Persistent Surveillance Mode

The Pléiades system offers the capability of persistent surveillance. This mode offers up to:

- 17 images of 20 x 20 km

- 25 images of 7 x 20 km

This enables:

- Trajectories, speed, and direction of moving targets of be assessed.

- The detection, characterisation and identification of small moving elements that would be undetectable elsewhere with a single shot at a similar resolution (e.g. people).

Pléiades Image Quality and Interpretability

Different Elements Shall Be Looked at when Assessing Pléiades Imagery Quality, GSD and Product Resolution

The first parametre that guarantees Pléiades' excellent image quality is the 50 cm post-processing resampling algorithm. This process (developed and implemented by the French Space Agency, CNES) is carried out through the following steps:

- Deconvolution to enhance image sharpness.

- De-noising to improve the visual interpretation and rendering of our products, especially in shadow areas.

- Zooming factor on on-board resolution ($\sqrt{2}$ on Primary level products).

The benefits gained by this processing are:

- Anti-aliasing.

- Exhaustive preservation of the acquired information.

- Robustness of the product, especially in the case of post processing, such as image rotation, reprojection, etc.

The benefits of the 50 cm zooming are significant and have been confirmed through independent testing, notably by defence photo interpreters:

- 50 cm resampled images reflect better quality in terms of information content and ensure the initial content is fully preserved in the final product.

- Further downstream processing applied by users on 50 cm images do not affect the image quality (robustness) and are not impacted by the type of interpolation used.

NIIRS Classes and Detection Capacity

The National Imagery Interpretability Rating Scale (NIIRS) is a scale used for rating the quality of imagery acquired from various types of imaging systems. The NIIRS defines different levels of image quality/interpretability based on the types of tasks an analyst can perform with images of a given NIIRS rating. The NIIRS consists of 10 levels, from 0 (worst quality) to 9 (best quality). The higher resolution an image, the higher the NIIRS rate is, and a higher level of details and insights can be extracted from the data.

Please refer to the Federation of American Scientists website for further detail about the NIIRS classification, **http://www.fas.org/irp/imint/niirs.htm**.

Pléiades, as well as GeoEye-1, WorldView-1, WorldView-2 and QuickBird, belongs to class 6 (0.40–0.75 m ground resolution distance), which means that an analyst can perform equivalent tasks with all these sensors, as the same objects can be detected, recognised and identified. The sharpness and acuity of GeoEye-1 images, being the sensor featuring the closest GSD to the lower threshold, making photointerpretation a little easier. However, Pléiades' resolution, as well as GeoEye-1, WorldView-1 and 2, and QuickBird resolutions, allows information to be visualised that cannot be retrieved from other lower class data.

We are happy to provide free Pléiades samples to enable users to carry out their own comparison, just email intelligence-services@airbus.com or directly download them from our website.

Competitors have been making comparisons between 30 cm and 50 cm data, and 70 cm unresampled Pléiades imagery. On the next page, you will find faithful displays of 'competitive' images compared to Pléiades 70 cm resampled to 50 cm data.

Pléiades images are not available at 30 cm; however, the comparisons shown on the next page will allow users to make their own assessment of the level of detail visible in Pléiades imagery.

Sao Paulo

'Competitive' 70 cm vs. Pléiades

'Competitive' 70 cm image

Pléiades 70 cm resampled to 50 cm

Pléiades © CNES - Distribution Airbus DS
Sao Paulo Segment ID:
DS_PHR1A_201309141321079_FR1_P
X_ W047S24_0610_02334

'Competitive' 50 cm vs. Pléiades

WorldView-2 50 cm image

Pléiades 70 cm resampled to 50 cm

Pléiades © CNES - Distribution Airbus DS
DS Sao Paulo Segment ID:
DS_PHR1A_201309141321079_FR1_PX
_ W047S24_0610_02334

New Delhi

'Competitive' 70 cm vs. Pléiades

'Competitive' 70 cm image

Pléiades 70 cm resampled to 50 cm
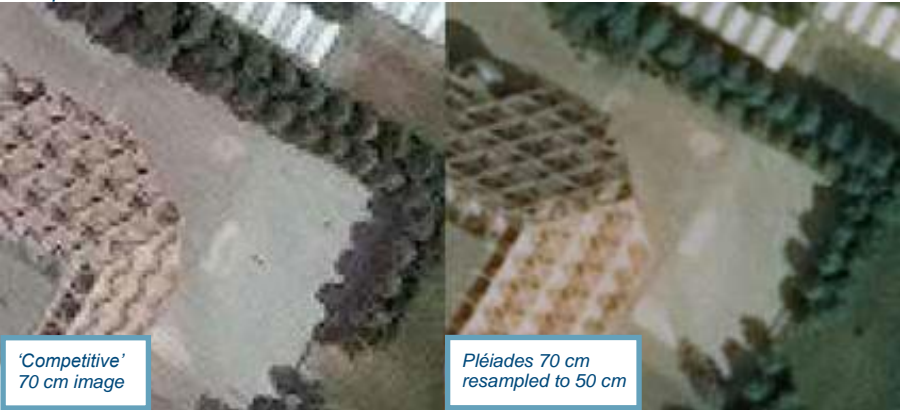
Pléiades © CNES - Distribution Airbus DS
DS New Delhi Segment ID:
DS_PHR1B_201402240538329_SE1_P
X_ E077N28_0311_08452

'Competitive' 50 cm vs. Pléiades

WorldView-2 50 cm image

Pléiades 70 cm resampled to 50 cm

Pléiades © CNES - Distribution Airbus DS
New Delhi Segment ID:
DS_PHR1B_201402240538329_SE1_P
X_ E077N28_0311_08452

Bit Depth at Acquisition

Pléiades' pixel depth at acquisition is 12 bits (2 power 12). For each spectral band, each pixel can take one value out of 4096. Other very high resolution sensors have a pixel depth at acquisition of 11 bits (2 power 11), meaning that each pixel can take one value out of 2048, thus displaying less capacity when distinguishing subtle nuances, especially in the beginning or the end of the spectrum:

- Pléiades is more likely to detect objects within the shadows of a building or mountain, as there are subtle nuances in each pixel.

- Similarly, it will be easier to detect pale-coloured elements in very light/bright environments (sand, ice, nearly-white ground), according to the same principle, as many saturation problems are avoided.

© ISIS – Professional photointerpretation report with an 11-bit image

Below, Pléiades image of the same area, 28 March 2012, where a vessel can be seen inside the reactor building.

Figure 1.7: Visual rendering of 11-bit vs. 12-bit images Pléiades © CNES 2012, Distribution Airbus DS

The 12-bit pixel depth of Pléiades makes the images easier to work with, as playing with extreme values does not degrade the rest of the image.

This characteristic also widens the range of 'good images'. Even during winter, humid weather, or with cloud shadows, Pléiades images are more likely to provide meaningful information.

SNR, MTF and Other Parameters

SNR and MTF are key parameters for image quality. The MTF (Modulation Transfer Function) allows the sharpness of an image to be measured. The SNR (Signal to Noise Ratio) is the ratio between the information present in the image and its noise. To measure how 'good' an image is (i.e. sharp (=MTF) with little noise (=SNR), the CNES has defined a 'merit value' – a performance measured multiplying SNR and MTF.

SNR ratios exceed the ground specifications: around 150 for each channel, and even 190 for B3 (NIR). The same goes for MTF for both line-wise and column-wise: on- board in-flight MTF was assessed as 0.15, without post- processing, for Panchromatic (specification was 0.08, and around 0.30 for Multispectral channels (specification was 0.20). The images do not need significant deconvolution in order to reach the final system MTF.

With this in mind, the so-called 'merit value' (defined by the CNES from the above parameters to synthesise the overall optical quality of Pléiades) was evaluated up to 24, against a specification of around eight – three times greater than specified.

Moreover, the assessment of on-board geometry quality shows the care taken during the design and manufacturing of the satellite. The geometric image quality of Pléiades allows, for instance, excellent DEM extraction.

All these parameters, and many others, are being constantly monitored by CNES and Airbus DS Intelligence.

All in all, these rather abstract values and facts show that Pléiades imagery is providing an excellent level of sharpness and legibility for every user, from automatic correlation for DEM extraction or change detection, to visual interpretation, classification or communication to the general public.

Please refer to Appendix B for more information about Pléiades image quality performance.

1.4 Pléiades Applications

Offering an ideal combination of coverage, resolution and speed, Pléiades satellites have been designed to meet the most demanding requirements. Pléiades products are especially useful for applications in defence, civil protection, hazard management, urban mapping, precision agriculture, maritime, and network and infrastructure management.

Defence intelligence

Sebastopol, Russia – © CNES – Distribution Airbus DS

Monitoring of regional conflicts:

- Situational awareness, border monitoring.
- Early detection and possible prevention of armed conflicts and humanitarian crises.
- Predict long-term analysis of emerging threats.

Military mapping

South China Sea – © CNES – Distribution Airbus DS

Updated military mapping of strategic areas to support:

- Deployed operations.
- Peacekeeping missions.
- Surveillance of terrorist organisations.

Land administration

Extract over Toulouse, France – Pléiades © CNES – 2014 - Distribution Airbus DS

Particularly adapted to urban planning, housing and transport management:

- Land use mapping (up to 1:10,000 and 1:5,000 scale maps).
- Assessment of urban sprawl thanks to temporal series and distribution of cities and green space in order to preserve biodiversity.
- New infrastructure planning, impact assessment, extraction of road networks.
- Construction monitoring, detection of illegal buildings.

Mapping

Toulouse, France – © CNES – Distribution Airbus DS

- Creation and update of 1:10,000 and 1:5,000 topographic maps (Stereo and Tristereo)
- Creation and update of 1:10,000 and 1:5,000 thematic maps.
- From raw imagery to the delivery of orthorectified imagery, 3D models or mosaics.

Crisis management

© CNES – Distribution Airbus DS

Before:

- Prevention and assessment of natural, geophysical or industrial hazards: modelling of risk, evacuation plans and aid deployment.

After:

- Comprehensive and quick damage assessment (before/ after).
- Emergency evacuation planning, prioritisation of human rescue: mapping of all-weather roads or infrastructures out of order.
- Reconstruction planning.

Civil security

Carte eTOD/Airport Mapping Database extract
© CNES – Distribution Airbus DS

Location and selection of potential areas that could welcome logistical and humanitarian aid camps:

- Crowd movements tracking, location of illegal gathering, detection of unusual changes to prevent a terrorist attack, contextual analyses.
- Mapping and update of the obstacles and vulnerabilities
  (2D, 3D) over sensitive areas and public places.
- Operation, mission planning (2D, 3D).
- Post crisis: footprint of the damage extent, rapid evaluation of gravity and impact.

Oil and gas

© CNES – Distribution Airbus DS

Pléiades sharp detail and daily revisit capabilities are especially adapted to support:

- Exploration: to support geological studies or up-to-date environmental mapping, rock and ore types.
- Development: engineering applications such as pipeline and infrastructure planning; competitive intelligence.
- Production: routine monitoring (e.g. operation progress/ follow-up, platform surveillance, team on-site safety), emergency response (oil spills, terrorist attacks) resulting in lower costs and less risk for people and equipment.
- Abandonment: 'cleaning phase' as per local environmental regulations.

Environment and biodiversity

Normandie, France – © CNES – Distribution Airbus DS

Monitoring of good environmental practices and agri-environmental measures:

- Environmental assessments.
- Habitat and natural areas characterisation, change monitoring (mapping, measurement of biophysical variables).
- Surveillance of vulnerable areas with geophysical risks: landslides, glaciers.
- Characterisation of human pressures on natural environments (urban changes, fragmentation of natural environments).

Water

Gorges du Verdon, France – © CNES – Distribution Airbus DS

Mapping and land use monitoring (dikes, canals, banks, contours of water sources, hydrological roads) – flow mapping:

- Forecasting hydrological hazards: assessment of run-off ratios, detection of rising water.
- Preparation of flood risk maps and assessment of soil vulnerability.
- Characterisation and assessment of sudden changes.

Coastline

Dieppe (Normandie), France – © CNES – Distribution Airbus DS

Mapping of coastal zones: habitats, aquaculture areas:

- Follow-up of coastal changes: assessing the impact of human activities (tourism, constructions).
- Assessment of natural event impacts (storms, wind, tides) in 2D or 3D.
- Coastline monitoring over highly evolving, areas or with heavy erosion or for movable coastlines.

Forest

© CNES – Distribution Airbus DS

Pléiades very high resolution imagery provides precious information and is particularly adapted to:

- Run forest inventories and follow up forest stands.
- Monitor and characterise changes: forest health, damage assessment before and after storms or forest fires, dynamics of natural regrowth.
- Follow-up of forest management, wood planting, harvesting and forest operations.

Agriculture

© CNES – Distribution Airbus DS

Especially adapted to fragmented landscapes, small parcels, experimental micro-plots or groves/permanent crops:

- Estimation of crop yields.
- Recommendations on adequate irrigation, accurate optimisation of inputs or agricultural treatments.
- Inventory/cadaster.

Tourism

Bora Bora, Polynésie française © CNES – Distribution Airbus DS

Assessment of tourism impact on environment, risk prevention related to demographic seasonal variation event images (Olympic Games, historical anniversaries, national days), 2D visualisation (edition, web) or 3D navigation (video, mobile applications) within tourism sites:

- Acquisitions with high viewing angles bringing spectacular rendering of buildings or other elevation features.
- Anaglyph images (3D) over villages, cities and any type of natural landscape (coastal lines, hills, mountains).
- 3D modelling of ski areas, gorges, cliffs, national parks.

Geophysics

Mont Blanc, France © CNES – Distribution Airbus DS

Identification and characterisation of relevant geomorphological features: risk assessment (e.g. volcanic hazards), geotechnical and scientific studies:

- Studies and monitoring of shifts: quantification of changes and surface movements, landslides, multi- temporal monitoring of glaciers, volcanoes.
- Assessment of volume changes (snow, ice).
- Thematic archives building (earthquake, seismic faults).

1.5   A Cooperation Programme

The decision to develop the Pléiades programme was the result of an in-depth study focused on the evolution of users' needs. A cooperation programme was initiated between France and Italy, taking advantage of all the CNES Earth observation skills, to develop ORFEO, a dual-Earth observation system with very high resolution capacity, in which Pléiades (France) is the optical component and COSMO-SkyMed (Italy) is the radar component. In agreement with the governmental directives and respecting the constraints of the Franco-Italian agreement, co-operations have also been set up with Austria, Belgium, Spain and Sweden.

French Space Agency, CNES, took over the responsibility of project manager for the Pléiades programme. Airbus DS Intelligence was appointed prime contractor for the satellite manufacturing, interacting with Thales Alenia Space, who designed the optical instrument. CNES appointed Airbus DS Intelligence (formerly known as SPOT Image) as the civilian operator and exclusive worldwide distributor of Pléiades data.

The collaboration between the French Space Agency CNES and Airbus DS Intelligence is indeed historical and is enhanced through further programmes and partnerships:

- **The ISIS programme: images for the scientific community**

Initiated by the French Space Agency - CNES, in 1990, after the launch of Spot 1 satellite (1986), the main objective of the ISIS Programme (Access to SPOT images for Science /Incitation à l'utilisation Scientifique des Images SPOT) is to facilitate access to French and European scientists to optical imagery acquired by satellites developed by CNES, SPOT 1-5 series and since 2011, Pléiades 1A and Pléiades 1B.

Through the ISIS Programme, French and European scientists can access Pléiades very high resolution images at preferential rates based on French institutional costs.
They can access the extensive archive imagery available since Pléiades satellites launches in 2011 and 2012 and, if they need fresh information, request a new collection over specific areas of interest. The historical archive imagery acquired by SPOT 1-5 satellites, formerly available through the ISIS Programme, is now provided through the Spot World Heritage Programme.

The images are always delivered for science purposes and non-commercial use, especially in the frame of general public interest for environment applications, education purposes, and for the development of innovative services or in the context of Research and Development activities.

The data are also available for university students registered for graduate or post-graduate studies subject to approval by CNES.

- **The International Charter 'Space & Major Disasters'** formed in November 2000 by the European Space Agency (ESA) and the French Space Agency (CNES), aims to provide unified access to satellite data to assist when responding to natural or man-made disasters. Each member agency commits resources to support the provisions of the Charter, collectively helping to mitigate the effects of disasters on human life and property. This service is available 24/7 at no cost to the end user.

  Some impressive figures:

  – Since its creation in 2000 through until May 2019, the International Charter has been activated 609 times by more than 125 countries. Climate change is the trigger for the majority of the activations.

  – Pléiades and SPOT were solicited for 30 activations in 2018 alone.

  – TerraSAR-X was solicited for 25 activations in 2018.

  When a disaster strikes, lives are too often at stake – making timeliness and rapid reactivity essential. Through The International Charter, the acquisition of satellite data over disaster areas can be prioritised, making sure that the necessary information is available directly to those responding to the situation. Airbus DS Intelligence's satellite constellation provides an efficient response thanks to its daily revisit capability and its weather independence.

  The agility and the configuration of our satellites means that we are able to guarantee access to a target area every day, regardless of location. As fast acquisitions and rush deliveries are key when dealing with crises, tasking plans can be easily updated to enable last- minute requests to be rapidly integrated.

2 Products, Services and Options

Pléiades delivers ready-to-use products, which can be easily integrated in GIS and/or transformed into thematic information while combined with other satellite, airborne or ground information. Pléiades satellites always acquire images simultaneously in both modes:

- Panchromatic: one band (black and white).

- Multispectral: four bands (colour).

Panchromatic and Multispectral image products are co-registered (completely superimposable).

The Pléiades twins offer a wide range of products and services, featuring different options to match as closely as possible to any customer's requirement.

2.1 Reliable and Immediate Access: An Image When and Where You Need It

2.1.1 Get Access to Premium Archive Imagery

Since the launch of Pléiades constellation, both satellites have collected millions of images on a daily basis. Once acquired and displayed in our catalogue, these images constitute the Pléiades archive, and are ready for immediate order. Users can search the archive via **http://www.intelligence-airbusds.com/geostore/**

Figure 2.1: Geostore homepage to access Pléiades imagery
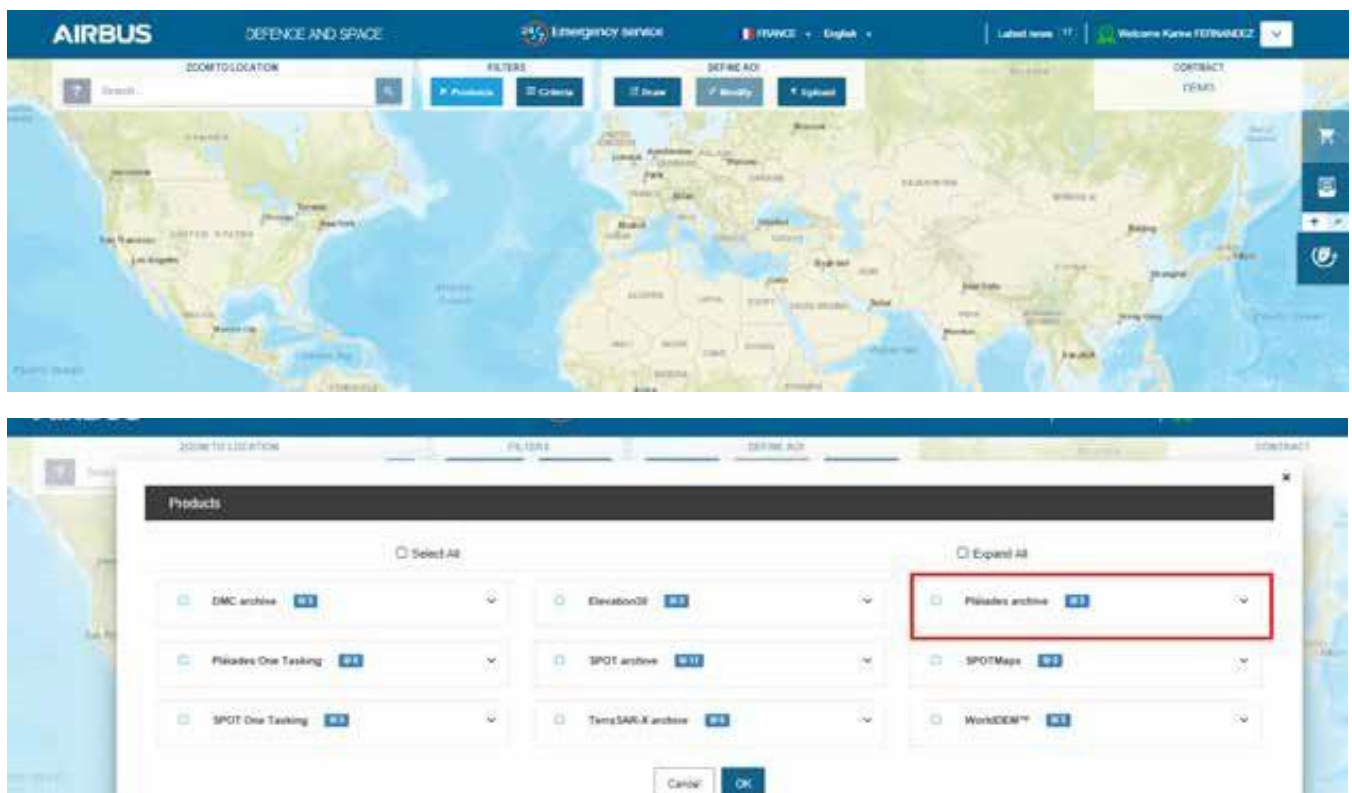
Figure 2.2: Selection of Pléiades archive in GeoStore product filters

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For any questions related to GeoStore, please do not hesitate to contact GeoStore team: **Intelligence-geostore@airbus.com**

In order to gain up-to-date information on what is currently happening on the ground, a customer can also request the acquisition of a new image.

2.1.2 One Tasking: Committed to Delivering Imagery

Commissioning a satellite and obtaining the imagery you requested – exactly when you need it – is now risk-free, fast, and incredibly easy.

30 years ago, Airbus DS Intelligence was the first to offer satellite-tasking services, revolutionising the satellite imagery market. Today, with One Tasking, the company sets the bar again, with an unprecedented commitment to deliver new imagery collections when and where its customers need them.

In a context of information overload, with One Tasking, Airbus DS Intelligence offers a unique and different offer on the market. It takes full advantage of its satellite resource availability and the true daily revisit capabilities of its satellite constellations, in order to collect and deliver – with unrivalled reliability – the image or coverage you requested, exactly when you need it.

Airbus DS Intelligence's programming offer, redesigned from the ground up, is committed to delivering the very best results, instead of the industry's typical 'best effort' approach, with a tasking service designed entirely around the customer's needs.

2.12.1 A Matter of Satellites, Talent and Dedication

Both genuine satellite constellations, SPOT and Pléiades, share the same orbit and tasking plan. They behave as a single flexible satellite gifted with true daily revisit capabilities
– maximising collection success rate and coverage speed.

In addition, a team of world-class tasking experts ensures that your area is covered on time and on spec. Airbus DS Intelligence's team carefully conducts feasibility studies and closely follows up open tasking requests, constantly adjusting priorities. All of that fine-tuning is in Airbus DS Intelligence's DNA and, more than any technical feature, is the secret of One Tasking's reliability.

One Tasking provides you with answers and support in any situation: from the most basic map update through to emergency response, not to mention land-use analysis, mission planning, and frequent insights through reliable monitoring.

Key benefits

- Best choice for maximising the success of your collection campaign.

- Financial compensation, if (ever) we do not make it on time.

- Flexible sensors, superior availability for ultra-fast delivery

- Streamlined offer, to lighten the ordering process for all satellites and sales channels.

- 24/7 access.

One Tasking offers four tasking options:

Pick the Right Product for Your Needs

ONEDAY

Choose your acquisition day

Imagery acquisition for a specific day is now risk-free. 24 hours before your acquisition date, you receive a weather forecast to let you confirm, postpone or cancel your request at no cost.

ONENOW

Access useful information in an instant

When immediate imagery is required, our satellites can be tasked to deliver valuable insights in the shortest possible timeframe. Don't panic if it's cloudy – we keep collecting images of your area until we are successful.

ONEPLAN

Obtain qualified coverage within an agreed timeframe

You select your timeframes, dates and preferred sensor – we ensure you receive the right qualified coverage, perfectly matching your project milestones.

ONESERIES

Get coverage on a regular basis

Whether you are dealing with long-term changes or highly dynamic situations, OneSeries brings you the required intelligence at the frequency you choose. For highest frequencies, our cloud cover commitment ensures you pay only for the most useful results.

	ONE DAY	ONE NOW	ONE PLAN	ONE SERIES
Pick the Right Product for Your Needs	**Choose your acquisition day** Imagery acquisition for a specific day is now risk-free. 24 hours before your acquisition date, you receive a weather forecast to let you confirm, postpone or cancel your request at no cost.	**Access useful information in an instant** When immediate imagery is required, our satellites can be tasked to deliver valuable insights in the shortest possible timeframe. Don't panic if it's cloudy – we keep collecting images of your area until we are successful.	**Obtain qualified coverage within an agreed timeframe** You select your timeframes, dates and preferred sensor – we ensure you receive the right qualified coverage, perfectly matching your project milestones.	**Get coverage on a regular basis** Whether you are dealing with long-term changes or highly dynamic situations, OneSeries brings you the required intelligence at the frequency you choose. For highest frequencies, our cloud cover commitment ensures you pay only for the most useful results.
Timeframe	1 day	The smallest period needed to secure three acquisitions – additional acquisitions are made until cloud cover rate reaches 10% or the customer decides to end the tasking	Customer selected	Customer selected, including frequency
Cloud Cover	≤100%	≤10%. All acquisitions are delivered. A validated acquisition ends the tasking	• ≤10% or ≤ 5% with uplift • Possibility to select three small cloud-free AOIs (Pléiades 1x1 km, SPOT 3x3 km) • For OneSeries Critical, 10% or 100% in case of daily acquisition, in this case, images are invoiced when reaching at least 40% cloud free	
Min AOI km²	• Pléiades: 100 • SPOT: 500 km²	• Pléiades: 100 km² • SPOT: 500 km²	• Pléiades: 100 km² • SPOT: 500 km²	• Pléiades: 100-50 km² if five revisits or more • SPOT: 500-250 km² if five revisits or more
Max AOI	Pléiades: 20 km EW x 40 km NS SPOT: 60 km EW x 120 km NS Bigger areas are subject to feasibility study		Subject to feasibility study	
Acquisition Mode	Mono (Stereo and Tristereo subject to feasibility study)	Mono, Stereo or Tristereo	Mono (Stereo and Tristereo submitted to feasibility study)	
Incidence Angle*	0-52° (<30° on customer selection)	0-52° (<30° on customer selection)	• OnePlan and OneSeries Routine:0-30° or customer selected • OneSeries Critical: 0-52° or <30° on customer selection	
B/H	Customer selected for all options or per default: Stereo 0.4-0.7 /Tristereo 0.2-0.35 between each pair			
Level	Premium		Regular	Regular/Premium
Acquisition Failure Terms	25% voucher on the value of the missed acquisition	If one acquisition is missing from the three firsts, the other two acquisitions will be delivered at no charge. OneNow with weather forecast consideration : 25% voucher of the missing acquisition value	10% voucher on the full order value	• OneSeries Routine: 10% voucher of the value of the missed acquisition • OneSeries Critical: 25% voucher of the value of the missed acquisition

Table 2.1: Overview of One Tasking options

* The official way to display angles in Airbus DS Intelligence's offering is based on the incidence angle. This is applicable to all documents and ordering forms/tools. For customers requesting viewing angle conversion, a tool which enables dynamic conversion has been set up on our website.

2.12.2 Cloud Cover Warranty

Optimising Pléiades satellite tasking in accordance with weather forecasts three times a day ensures that all resources are used as efficiently as possible. We propose image tasking with cloud cover less than 10% or 5% over the Area Of Interest (AOI) of the order. Depending on the area of interest, we can guarantee small cloud-free zones, typically three areas of 1 x 1 km within the initial AOI. Cloud cover does not include cloud shadow or semi-transparency haze.

2.12.3 Vouchers

In the event of a non-successful acquisition, as defined in each offer, the customer is entitled to receive a voucher in consideration of such a failure.

A voucher is valid for three months from the end of the acquisition period. It can be redeemed against any Airbus DS Intelligence product through GeoStore only.
The customer must redeem the voucher, i.e. it is not automatically deducted from the customer's next order. Once the voucher has been used, it expires. The voucher can only be spent in full; it cannot be split across several orders. If the voucher is used for an order where the amount is less than the voucher value, the unused balance of the voucher is lost. The voucher is considered as a means of payment; it should be made visible on the invoice and applied to the overall amount of the order, once potential discounts and reductions have been applied. Each voucher is linked to a customer account and the voucher notification is sent via email to the customer who placed the failed order. The overall view of vouchers attached to one customer account is not available externally. For more information on vouchers, please contact your usual point of contact: Airbus DS Intelligence Customer Care.

2.12.4 Feasibility Study

The feasibility study is a diagnosis performed by tasking experts in order to organise the acquisition plan and estimate the confidence in covering the area of interest within the defined acquisition period and parameters. To assess feasibility analysis, we ask the customer: where,
by when and for which application. With this information, the Tasking Team issues a tasking proposal that includes advice and recommendations that clearly indicate:

- The feasibility study diagnosis: feasible/difficult/very difficult

- The estimated area coverage: %

- New proposed parameters when relevant.

The feasibility study proposes the best programming parameters in order to successfully collect the area on time and on specifications (basis of our commitment and philosophy of One Tasking offer). However, the customer will always have the choice to select one tasking proposal or another.

- OneNow feasibility study mainly focuses on:

  - OneNow+: the first three days when the area can be entirely collected after the desired start date

  - _____ : the desired timeframe (7 days maximum), compared to the location, the size, the angle and cloud constraints.

  In both cases, the feasibility study indicates the incidence angle.

- For OneNow orders placed through GeoStore or Customer Care, it is possible to filter access for acquisitions with an incidence angle of 30° or less – thus displaying the new acquisition days able to entirely cover the AOI with the reduced angle. No choice is given on the acquisition days.

- OnePlan and OneSeries feasibility studies mainly focus on the desired timeframe compared to the location, the size, the angle and cloud constraints. Depending on all requested programming parameters, the Tasking Manager issues a diagnosis (feasible, difficult, and very difficult) to the customer and proposes alternatives if the feasibility results are 'very difficult' or 'difficult'.

  - If the request is judged unachievable, the Tasking Manager sends two proposals: one for it to become 'challenging', one for it to become 'achievable' – each with the relevant quotations.

  - If the request is judged to be difficult (challenging), the Tasking Manager sends two feasibility studies, each with the relevant quotation: one with challenging parameters to match the customer's request, and another with different parameters that will make the tasking easy (achievable) to complete.

The customer will always have the choice between both tasking proposals.

Early diagnostic for tasking orders submitted online

When an order is submitted online via the web portal, the Early Diagnostic section provides customers with automated early diagnostics with regards to the desired timeframe and specified location, size, angle and cloud constraints. If the automatic diagnosis says your tasking can be easily completed (achievable), it is activated automatically and the new collection is delivered (also automatically) after acquisitions. However, if there are specific tasking parameters, the Tasking Team confirms the feasibility and issues a Tasking proposal. If a request is considered 'difficult' or even sometimes 'very difficult' to achieve, the same process as above applies, i.e. two feasibility studies: one with lightened

tasking parameters and another with tighter parameters with corresponding achievable or challenging prices, so the customer can select his preferred option. The Tasking is activated once the customer confirms their order.

NENOW

2.12.5 Multi-AOI

Multi-polygon orders are possible. However, each AOI creates an order: a shape file featuring four polygons will be treated as four separate orders. Each order has its own service level agreement (SLA) and acquisition failure terms (i.e. if one acquisition for one polygon has failed, it has no impact on the success or failure of the other three). The polygons are also independent for the access study and the feasibility study, as well as any tracking progress service.

2.12.6 Regular and Premium Services

Two service levels are offered in the event of a new acquisition order.

	Premium Service Included in OneDay, OneNow and OneSeries Critical	Regular Service For OnePlan and OneSeries
Orderin	24/7, 365 days a year	From Monday-Friday from 7:00-16:00 (UTC) through Customer Care or 24/7 through
Response Time	1 hour from receipt of customer request (feasibility study included dependent upon simplicity of the request	24 hours from receipt of customer request (within normal working hours)
Customer Modification/ Cancellation After Order penalty Confirmation	Cancellation and modifications are possible, free of charge, up to 12 hours before image acquisition. However, a 100% cancellation fee applies within 12 hours of image acquisition.	Cancellation and modifications are possible or after the acquisition start date, with a €1000. All qualified images are invoiced. Upon acceptance of the tasking proposal, cancellation or modification shall be sent to Customer Care at least 24 hours before the image acquisition. In such a case, a penalty of
Tracked Progress	Automatic notification at each step of the tasking order: • Planned (or missing) acquisitions + expected image download time • Systematic acquisition notification + estimated delivery time (+ 2 hours) • Delivery notification	Automatic notification for: • Acquisition notification when matching the agreed cloud cover threshold + estimated delivery time[2] (+ 2 hours) • Delivery notification
Delivery Lead	Rush • 12 hours after the image is available in GeoStore catalogue, and 24/7/365 • Average performance: 74 minutes	Standard delivery per default (rush delivery optional) • Turnaround is 24 hours after the image is available in the GeoStore catalogue during working hours, i.e. from Monday-Friday from 7:00-16:00 (UTC) • Average performance: 12 hours

Table 2.2 One Tasking specifications extracted from the dedicated document, One Tasking Specifications.

2.2   Spectral Band Combinations

Combining the Panchromatic and Multispectral bands, images can be visualised as either black and white (50 cm product resolution), natural colour, false colour (2 m product resolution) or as a merged product (Pan-sharpened colour image) with the resolution of a Panchromatic image.

2.2.1 Panchromatic

The Pléiades Panchromatic product includes only one black and white band. It covers wavelengths between 0.47 and 0.83 µm of the visible spectrum. The product pixel size is 0.5 m (Ortho).

Figure 2.3: Example of a Panchromatic image

2.2.2 Multispectral

The Multispectral product includes four Multispectral (colour) bands: blue, red, green and near infrared. The product pixel size is 2 m (Ortho).

Figure 2.4: Example of a Multispectral image

2.2.3 Bundle

The Panchromatic (0.5 m) and Multispectral (2 m) products, simultaneously acquired, are delivered together separately (not merged) for a single delivery (one file for Multispectral and one file for Panchromatic).
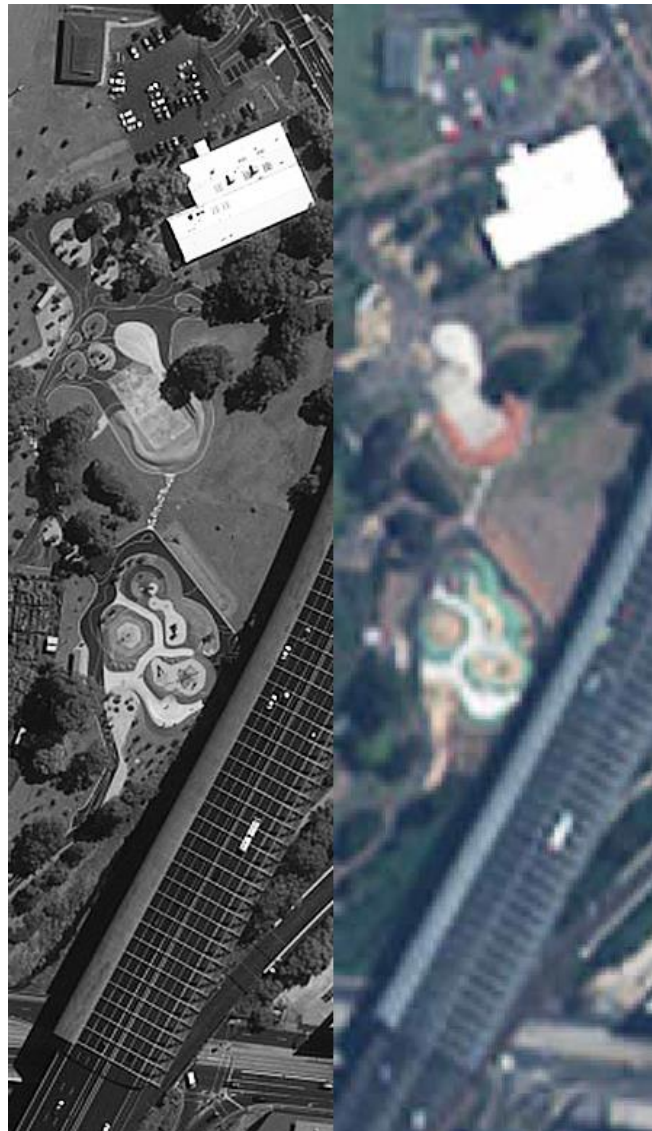
Figure 2.5: Example of a bundle product with the Panchromatic image on the left and the Multispectral image on the right.

2.2.4 Pan-sharpened

Pan-sharpened products combine the visual coloured information of the Multispectral data with the details provided by of the Panchromatic data, resulting in a higher resolution 0.5 m colour product. Typically, three or four low-resolution visible bands – blue, green and red or green, red and near infrared – are used as the main inputs in the process to produce a very high-resolution natural colour or false colour image.

For Pan-sharpened products, Airbus DS Intelligence uses its proprietary fusion processing. Performing its own pan- sharpening is a delicate process.

- PAN_{soft} = Panchromatic image at the same spatial resolution as the Multispectral image.

- i, j = image coordinates.

In Figure 2.6, right, the top image (A) is a natural colour image with a spatial resolution of 0.5 m (resampled 400%), and the second image (B) is a Panchromatic image with
a spatial resolution of 0.5 m. By combining these images,
a very high-resolution colour Pan-sharpened image (D) is produced. In the merged image, spectral signatures of the input colour image and spatial features of the input Panchromatic image (the best attributes of both input images) are almost completely retained.

A. Multispectral 'zoom' image (with zoom 4)

B. Panchromatic image

C. Pan- sharpened image

Figure 2.6: This illustrates the Pan-sharpening process.

Pan-sharpened products are offered as three- and four-band products. The three-band colour products are available in natural colour (blue, green and red) or false colour (green, red and near infrared).

The natural and false colour images are derived from Multispectral combinations, with bands that have been acquired simultaneously.

- To produce a natural colour image, the red band (B2) is put in the red component of the monitor, the green band (B1) is put in the green component of the monitor, and the blue band (B0) is put in the blue component of the monitor. Figure 2.7 is an example of a natural colour image.

- For a false colour image, any of the bands can be put in any RGB channel. The chosen band combination can be changed to highlight the desired features. Figure 2.8 is an example of the standard false colour composite produced by putting the green band (B1) in the blue component of the monitor, the red band (B2) into the green component of the monitor, and the near infrared band (B3) in the red component of the monitor.

Figure 2.7: An example of a Pan-sharpened three-band natural colour image

Figure 2.8: An example of a Pan-sharpened three-band false colour image

2.3 Geometric Processing Levels

Pléiades core imagery products are available in three different geometric processing levels: Primary, Projected and Ortho, which are illustrated in Appendix E.

All Pléiades products are corrected for non-uniformity sensor radiometric and distortions, using internal calibration parameters, ephemeris and attitude measurements.

Standard products offer the Panchromatic channel (product resolution: 0.5 m) or the Multispectral channels (four bands, product resolution: 2 m) already registered and possibly merged.

2.3.1 Primary Products

The Primary product is the geometric processing level closest to the natural image acquired by the sensor. This product restores perfect collection conditions: the sensor is placed in rectilinear geometry, and the image is clear of all radiometric distortion. This product is optimal for those clients familiar with satellite imagery processing techniques who want to apply their own production methods (orthorectification or 3D modelling for example). To this end, RPCs and the sensor model are provided with the product to ensure full autonomy and simplicity for users. The Primary level product is:

- In sensor geometry, synthesised on a perfect single and linear push-broom array.

- With an equalised radiometry on the native dynamic range of the sensor, 12 bits (4096 values).

The product is extracted from one strip acquisition. The support for this extraction is a polygonal region of interest in WGS84 coordinates.

The main geometric processing includes:

- The combination of all sub-swaths across in the field of view (20 km nadir condition): synthesis in a virtual focal plane represented by a single linear array for all spectral bands.

- Correction of instrumental and optical distortions: viewing angles adjusted to the single linear array model.

- Co-registration of all spectral bands: Multispectral and Panchromatic.

- Attitudes and ephemeris data are refined at ground on
the mean estimation:

  - Adjustment of the time stamp sampling (along scan line).

  - Attitudes filtering over time of acquisition or a posteriori extended over several orbits (aka Refined Attitude Data).

- Consistent alignment of the physical model ancillary data and RPC analytic model data.

The main radiometric corrections/enhancements include:

- Inter-detector equalisation: correction of differences in sensitivity between the detectors (on-board correction).

- Aberrant detectors correction (none at that time).

- Panchromatic band restored and de-noised.

- Pixel sampling at Shannon optimising image quality for downstream value-added processing: Spline kernel resampling into the Primary geometry, zoomed to the factor 7/5 (equivalent resolution of 0.5/2 m in nadir condition).
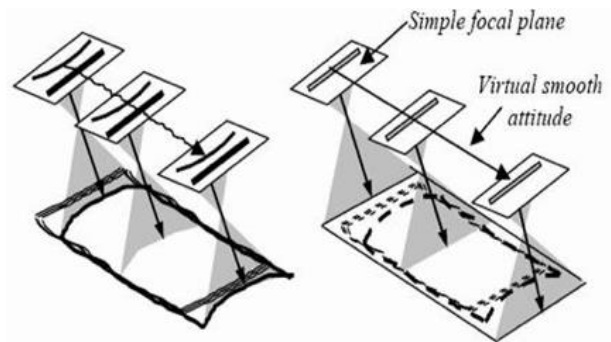
Figure 2.9: Perfect sensor geometry

The final format includes:

- Masking of pixels (blackfill) outside the region of interest polygon.

- Physical tiling: images beyond a certain size are split into several files (see A.4.3 for more details).

The user selects:

- The spectral band combination: Panchromatic; Pan- sharpened 3-band natural colour; Pan-sharpened 3-band false colour; Pan-sharpened 4-band; Multispectral 4-band; Bundle.

- The radiometric processing: Basic or Reflectance or Display.

- The bit-depth in basic processing: 12-bit native (4096 values) or reduced to 8 bits (adjusted linearly to 256 values) for screen display without adaptation.

- The raster file format: JPEG 2000, with optimised or regular compression, or GeoTIFF, or NITF.

Please refer to 3.2.2 Ordering through Customer Services for assistance in selecting the appropriate options (see Step 5: Processing Options).

2.3.2 Projected Products

Compared to Primary level, the projected level results from an additional process to map the image onto an Earth cartographic system at a fixed altitude value. The image is georeferenced without correction from acquisition and terrain off-nadir effects. This image-to-map transformation is directly compatible with GIS environment, for example to overlay the image on other data.

The projected image cannot be superimposed on a map, the effects of the true relief being preserved in the image. Just like Primary images, data processed at projected level can be used for geometric modelling, orthorectification or 3D extraction, for example. This is possible thanks to the RPC model provided with the product, which is supported by many software programmes available on the market, from standard Geographic Information System (GIS) to expert photogrammetry ones. The main benefits for users are:

• Directly compatible with GIS environments.

• Easier orthorectification by users who use their own reference layers (Ortho, GCPs and DEM), thanks to the geometric model described in the embedded RPC file.

For users looking for ultimate geometric performances, generally speaking, the sensor model (Primary only) is more focused on image strip and large bundle adjustment, while the RPC analytic model has the same level of accuracy with shorter images.

The projected product is mapped on the Earth onto a standard reference datum and projection system at a constant terrestrial altitude, relative to the reference ellipsoid.

By default, the map projection system is WGS84/ UTM, and the altitude is the mean altitude computed over the image area. The user also has the choice to select a projection system from the many offered by Airbus DS Intelligence (see Figure 2.10) and to customise the altitude value.

The product is extracted from one strip acquisition. The support for this extraction is a polygonal region of interest in WGS84 coordinates.

The Projected level inherits geometric corrections from the Primary level, with additional adjustments:

• Image projected in a map projection or geographic projection.

• Alignment of the RPC analytic model on this Earth projection geometry.

The projected product inherits radiometric corrections and enhancements from the Primary level, with additional adjustments:

• Pixel sampling at Shannon Sampling (Spline kernel) at a fixed resolution of 2 m for Multispectral products and 0.5 m for Panchromatic and Pan-sharpened products.

The final format includes:

• Masking of pixels (black fill) outside the region of interest polygon.

• Physical tiling: images above a certain size are split into several files (see Figure 2.10).
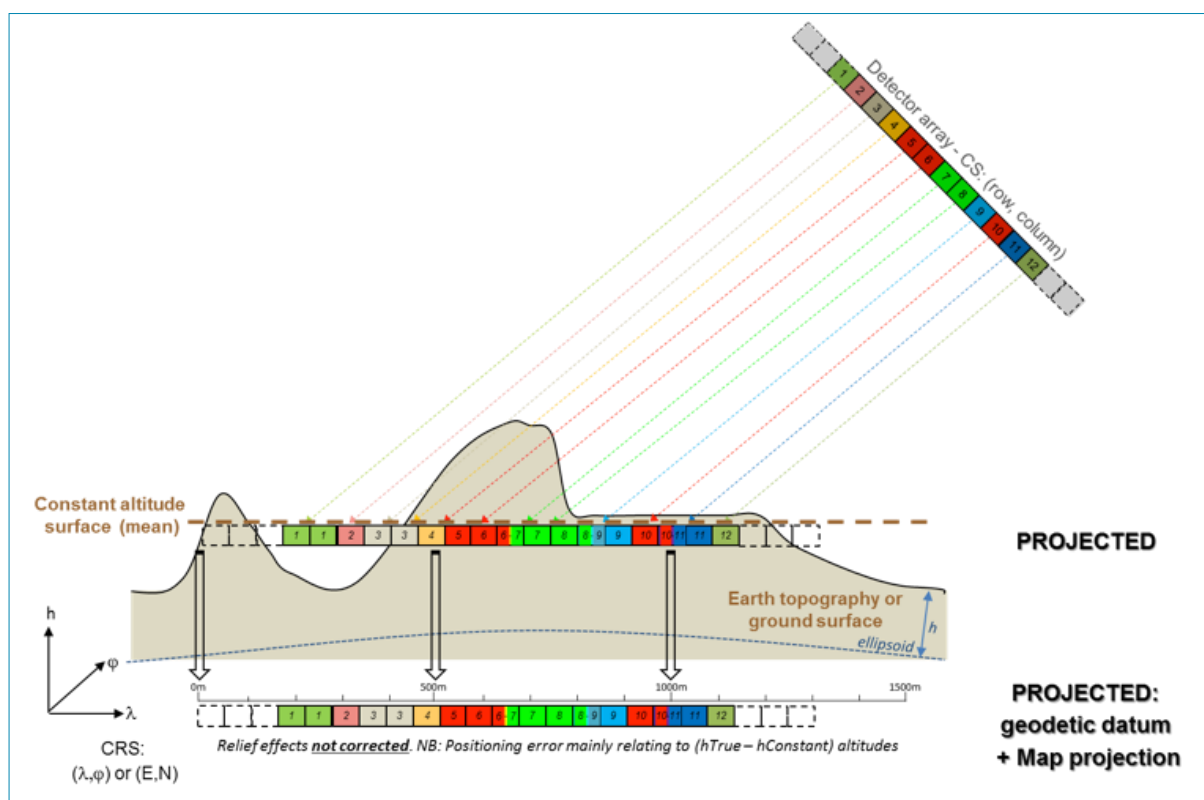
Figure 2.10: Projected product mapped on the Earth

The user selects:

- The spectral band combinations: Panchromatic; Pan- sharpened 3-band natural colour; Pan-sharpened 3-band false colour; Pan-sharpened 4-band; Multispectral 4-band; Bundle.

- The radiometric processing level: Basic, Reflectance or Display.

- The bit-depth in basic processing: 12-bit native (4096 values) or 8 bits (adjusted linearly to 256 values) for screen display without adaptation.

- The raster file format: JPEG 2000 with Optimised or Regular compression, or GeoTIFF, or NITF.

Please refer to *3.2.2 Ordering through Customer Services, Step 5: Processing Options*, for assistance in selecting the appropriate options.

2.3.3 Orthoimages

2.3.3.1 Standard Orthoimages

The Ortho product is a georeferenced image in Earth geometry, corrected from acquisition and terrain off-nadir effects. The Ortho is produced as a standard, with fully automatic processing.

The standard Ortho product is an image that has been corrected (viewing angle and ground effects) so that it can be superimposed on a map. In addition to radiometric and geometric adjustments, a geometric process using a relief model (known as orthorectification) eliminates the perspective effect on the ground (not on buildings), restoring the geometry of a vertical shot. The Ortho product is optimal for simple and direct use of the image. It can be used and ingested directly into a Geographic Information System. This processing level facilitates the management of several layers of products, from the same sensor or others, while reducing localisation gaps that can be caused by different viewing angles or relief between the various layers. The standard 3D model used for ground corrections is the worldwide Reference3D dataset, which is part of Airbus Intelligence Elevation30 suite.

The product is extracted from one to several contiguous strip acquisitions: single ortho or mosaic. Support for this extraction is a polygonal region of interest in WGS84 coordinates.

The Ortho level product inherits geometric corrections from the Primary level, with additional adjustments:

- Planimetric reset: if ground reference data is available and will optimise the location, reset on Ground Control Points (Elevation30 Ortho layer).

- Altimetric reset: correction of the panoramic effects induced by the off-nadir incidence angles over the relief thanks to a Digital Elevation Model (DEM). By default, the Reference3D DEM layer is used where available, otherwise SRTM is used

- Mosaics of contiguous pass acquisitions (if acquired during the same pass).

- Map projection or geographic projection.

The Ortho product inherits radiometric corrections and enhancements from the Primary or Projected processing level, with additional adjustments:

- If mosaicking, colour balancing of acquisitions (seamless).

- Pixel sampling at Shannon Sampling (Spline kernel) at a fixed resolution of 2 m for Multispectral products and 0.5 m for Panchromatic and Pan-sharpened products.

The final format includes:

- Masking of pixels (black fill) outside the region of interest polygon and raster trim to the region of interest bounding box.

- Physical tiling: images beyond a certain size are split into several files (see *A.4.3, Image Tiling* for more details).

The user selects:

- The spectral band combinations: Panchromatic; Pan- sharpened 3-band natural colour; Pan-sharpened 3-band false colour; Pan-sharpened 4-band; Multispectral 4-band; Bundle (see section 2.2).

- The radiometric processing level: Basic, Reflectance or Display.

- The bit-depth in Basic processing: 12-bit native (4096 values) or reduced to 8 bits (adjusted linearly to 256 values) for screen display without adaptation.

- The raster file format: JPEG 2000, with Optimised or Regular compression, or GeoTIFF, or NITF.

Main characteristic	Information
Geographic projections	WGS84 – latitude/longitude sampling according to ARC or DTED2 zoning standards (please refer to A.5.1 for more details)
Mapping projection	Most of the projections registered by EPSG, in metres (please refer to A.5.2 for more details)
GCP	Reference3D Ortho layer
DEM	Reference3D DEM layer (DTED2), SRTM (DTED1), GLOBE (DTED0)

Please refer to *3.2.2 Ordering through Customer Services, Step 5: Processing Options*, for assistance in selecting the appropriate options.

Table 2.3: Geometric details of the Ortho product

2.3.3.2 Tailored Orthoimages

Apart from the standard Ortho product, when different specifications are needed, Airbus Intelligence can also provide on-demand, custom orthorectification, with a more precise 3D model provided by the client or acquired for purpose. The tailored Ortho product can also be requested to create a mosaic of images acquired at different dates.
Ingestion of Ground Control Points can also improve the overall precision of the product. Each tailored Ortho product is subject to a feasibility study and specific delivery timeframes.

2.3.3.3 Premium Orthoimages

The premium Ortho is an image that has been corrected (viewing angle and ground effects), so that it can be superimposed on a map. Radiometric and geometric adjustments, and the use of a 3D model to reproduce relief, mean that all 'perspective' effects are eliminated, simulating a vertical shot. A Pléiades DTM with 5 m posting is used for ground corrections and gives the best compromise between accuracy and aesthetics of the orthoimage.

2.4   Radiometric Processing Level

Pléiades core imagery products are available in three different radiometric processing levels: Basic, Reflectance and Display. Please refer to *Appendix D* for detailed information and spectral analysis.

2.4.1 Basic Radiometric Processing

Basic imagery corresponds to raw data without any radiometric processing. Each pixel is given in digital numbers (DN), i.e. native pixel values from the sensor acquisition (after equalisation). Those digital numbers quantify the energy recorded by the detector, corrected relative to the other detectors to avoid non-uniformity noise.

The sensor absolute calibration aims to turn back the DN value into a physical unit value (radiance, light power) at the input of the camera. 'Top-of-Atmosphere' (TOA) is not applied to the image bands. The absolute calibration coefficients are provided in the DIMAP metadata file, ensuring spectral corrections from space to ground by the user.

The source DN values at sensor level range from 1–4095. These Basic values are maintained to the original 12 bit- depth, also for byte-oriented format as GeoTIFF needing 16 bits integer storage.

In order to minimise the image file volume, the user can order Basic in 8 bit-depth. The conversion to 8 bits coding (range 1–255) is performed by a linear stretch on the effective histogram of the source image.

Key benefits

- Perfect for expert users addicted to pure data and familiar with satellite imagery applications and image processing tools.

- Ideal to carry up calibration and own spectral analysis.

2.4.2 Reflectance Radiometric Processing

Reflectance imagery is radiometrically corrected from sensor calibration and systematic atmospheric effects of the atmosphere (molecular or 'Rayleigh' diffusion). Cloud, cloud veil, haze, aerosol (pollution, sand wind) remain. Image values are provided in normalised reflectance values with a 1/10,000 ratio.

In clear sky conditions (no dynamic factors affecting the low atmosphere as veils), the reflectance value is directly assimilated to the ground surface reflectance.

Reflectance is more straightforward and easier to use than Basic radiometric processing. Such benefits are, for example, on spectral and monitoring analysis to ensure direct comparison between images at different dates or different calibrated sensors and on image processing to correct the bluish effects from atmosphere to achieve reliable true colour.

In addition, the product with Reflectance radiometric option provides an XML file of colour curves (Look-Up Table, LUT) for true colour image rendering. LUT uses GDAL and MapServer form to ease integration in display applications.
The colour curve is optimised by a stretch taking care of sensor calibration and atmospheric correction. The rendering is the same as the Display radiometric option but without altering the original imagery physical values.

Reflectance and Basic have the same spectral capability. The reflectance model is a universal atmospheric correction addressing the most common user needs. The model is also reversible back to radiance or DN through coefficients provided in the DIMAP metadata file. It allows expert users with locally accurate atmospheric measurements to refine the correction.

The image values are given in 1/10,000 reflectance, having range 1–10,000, possibly overcome on specular targets. A quantisation on 8 bit would revoke the benefit of a direct readable count in physical unit and is not proposed.

Key benefits

- Corrects the bluish effects from atmosphere, so that colours are reliable and true.

- Ensures better stability of luminosity/contrast on screen.

- Prepares end users for seamless coverage (e.g. mosaicking).

2.4.3 Display Radiometric Processing

Display products are generated on a new algorithm based on the Reflectance product.

In the Display radiometric option, a true colour curve has been applied to the image directly usable for visualisation on screen. The colour curve is the LUT computed by the Reflectance processing. The image true colour is properly retrieved from sensor calibration and correction of systematic effects of the atmosphere.

Display processing is to be used when imagery needs to be immediately usable with optimised visual rendering. The imagery values are 8-bit numbers optimised for a direct rendering on the screen. The values are not reversible to spectral physical unit.

The image values are encoded in 8-bit depth per band, addressing the 16.78 million colours of RGB space for Multispectral, plus an extra channel for four-band delivery. A larger encoding would not have extra values for display purposes. 8-bit pixel coding should be requested since 16- bit pixel coding does not provide any additional information.

Key benefits

- Ideal radiometric processing level when imagery needs to be immediately usable with optimised visual rendering.

- Optimised for display on screens (8 bit).

2.5 Product and Image Format

Pléiades imagery are available in different product and image formats:

- DIMAP – JPEG 2000 Optimized

- DIMAP – JPEG 2000 Regular

Pléiades products are, by default, delivered in DIMAP V2, just like SPOT 6 and 7:

- The image can be output in different raster formats, either GeoTIFF or JPEG 2000.

- Rational Polynomial Coefficients (RPCs) are provided for easier orthorectification and geometric processing.

- A KMZ is included for a rapid, easy and user-friendly display of the main metadata in a Google Earth environment.

- Quality and cloud cover masks are included.

However, National Imagery Transmission Format 2.1 (NITF 2.1) is also available, with raster format in GeoTIFF or JPEG2000 (Regular). Within the products, the imagery file is available in two formats, GeoTIFF or JPEG 2000. Although JPEG 2000 is used less today than GeoTIFF, this format saves on file space. JPEG 2000 files can be up to five times smaller than GeoTIFF files, making data warehouse management, handling, post-processing and streaming much easier. Depending on your needs, you can choose between two compression rates:

- **JPEG 2000 Optimised** is intended for those looking for fast download and easy data sharing:

  - 3.5 bits/pixel compression.

  - Lossy compression: the compression rate is optimised to avoid any spatial effect but is not reversible.

  - A spectral effect of 1/1000 is tolerated.

- **JPEG 2000 Regular** is perfect for users who plan to do high precision post-processing:

  - 8 bits/pixel compression.

  - Lossless compression: the JPEG 2000 compression is completely reversible and does not include any effects in terms of information content.

Neither JPEG 2000 compression impacts on the image quality. However, they do have a direct impact on file size with the Regular compression file size twice as large as the Optimised compression file size.

The GeoTIFF format is free of any compression (the standard TIFF specification provides a simple JPEG compression scheme, which is unable to preserve the information content correctly). The file size is huge compared to JPEG 2000 because the GeoTIFF format stores integer values, encoded on the power of two: either 8 or 16 bits. As Pléiades acquires images with a 12-bit depth, there is no benefit to the GeoTIFF 16-bit products storing 4 bits.

JPEG 2000	GeoTIFF
Pixel encoding 12 bits: • Optimised compression	Pixel encoding 16 bits: (12 bit-depth dynamic range)
Pixel encoding 8 bits: • Optimised compression	Pixel encoding 8 bits: • Without

Table 2.4: Image format options

Combinations	JPG 2000 Regular	JPG 2000 Optimised	GeoTIFF 16 bits
Pan – 1 band – 50 cm	1526	668	3052
Multispectral (MS) – 4 bands – 62 m	381	167	763
Bundle (Pan+MS) – 5 bands – 50 cm + 2 m	1907	835	3815
Pansharpening – 3 bands – 50 cm	4578	2003	9155
Pansharpening – 4 bands – 50 cm	6104	2670	12207

Table 2.5: Image size according to image format (values in mb)

Please refer to *3.2.2 Ordering through Customer Services, Step 5: Processing Options*, for assistance in selecting the appropriate options.

Most of the software providers have eased the ingestion of Pléiades data into their systems. The detailed status, per software and version, is available upon request at technicalsupport@intelligence-airbusds.com.

2.6. Licensing

Airbus Intelligence offers flexible licensing options to meet
your needs:

- **The Standard End User Licence Agreement (EULA)** permits the end user to share the Pléiades product with affiliated end users identified in the data request form, in the frame of a joint project. The standard price of the Pléiades product allows for up to five affiliated end users; for six or more end users, the 'Multi' option should be selected (available at an increased price).
  Under the EULA licence, the end user can:

- Use the Pléiades product for their own internal needs.

- Create value added products (VAP) containing imagery data and use them for their own internal needs.

- Create derivative works (DW) that do not contain imagery data from the initial Pléiades product and are irreversible and decoupled from the source imagery data of the Pléiades product. DW can be freely used and distributed.

- Share the Pléiades product with their consultant and contractor for use on behalf of the end user and/or affiliated end users.

- Print an extract of the Pléiades product for promotional activities.

- **The Academic Licence** is focused on research and educational purposes. It permits the use of the product by one educational entity for academic research or training. An extract of the Pléiades product may be reproduced in certain training tools and publications related to the results of a research.

- **The Technical Evaluation Licence** permits the end user to use the Pléiades product for technical evaluation only. The end user shall not transfer the Pléiades product to any third party but may make the product available to a consultant or contractor for use on
behalf of the end user. The end user shall inform Airbus Intelligence of the results of the performed evaluation.

- **The Demonstration Licence** allows the end user to use the product, the value added product, and/ or derivative works, for demonstration and display at events such as a trade fair, trade show, conference or exhibition, and to selected clients and prospects.

- **The Web Licence** permits the end user to convert the product into an image and post it on a website for public access or subscription-based access, allowing any internet user to see the image.

- **The Media Licence** allows the end user to use the product for communication purposes and post the Pléiades image on any means of communication, which can be either digital (e.g. displayed on the Internet, TV, advertising, banners) or print medium (e.g. magazine, newspaper, flyer, promotional brochure, etc.).

- **Other needs** – for specific commercial needs, we may propose tailored licence conditions (such as a governmental licence, visual simulation licence, etc.) on a case-by-case basis. For such a requirement, please contact your Sales Manager or your Customer Care representative.

3   Product Ordering

3.1   Access to Pléiades Data

Pléiades data can be ordered either directly through the web portal https://www.intelligence-airbusds.com/geostore/ or contacting our Customer Care Service:

- Telephone: +33 5 62 19 40 40

- Email: intelligence-services@airbus.com

Depending on your location, you will be served directly by Airbus or put in contact with a local partner.

The order form is available on our website or can be provided by our Customer Care Service, upon request.

3.2   How to Order

3.2.1 GeoStore, our online web portal

GeoStore web portal has been especially created to offer customers and partners an advanced 24/7 access service for satellite data.

The overall platform features multiple e-business functionalities to address the needs of a wide variety of users: distributors, value-added resellers, end users, partners on their way to Pléiades Direct Access Services (Direct Receiving Station), etc. Easy, intuitive and autonomous, user- and map-centric, GeoStore is the backbone of the relationship between the user and Airbus Intelligence.

This unique e-business portal is a powerful web catalogue that gives access to Airbus satellite products on one convenient and easy-to-use online platform. In a few easy steps, users can select, order and track their geospatial content and orders online. GeoStore is perfectly suited for browsing and ordering, offering a seamless solution from data searching to product delivery and order management satellite imagery.

- Users with little Earth observation knowledge can search the catalogue without any specific technical criteria. Remote sensing experts can perform advanced searches with seasonal criteria, snow cover, cloud cover, angle, resolution, product type, etc., and even download an ArcGIS plug-in to perform an archive search directly from their GIS. Alerts can be set up over specific areas, so users are notified as soon as new data is available.

- With a Premier customer account ('Buy' button), customers are granted access to the full Airbus optical and radar offer. They can:

  - Order archive images online.

  - Task the Airbus optical and radar satellite constellations, thanks to a unique access to the One Tasking offer.

  - Follow online the status of archive or tasking orders.

  - Access other online functionalities.

  - Access other useful tools.

  - Access GeoStore.

Order archive images online

In addition to Pléiades, users also have access to:

- The full SPOT series archive (from 1986 to present), DMC, TerraSAR-X and TanDEM-X data. SPOTMaps are also available through GeoStore.

- Available for online ordering, SPOTMaps are created from orthorectified 2.5 m natural colour SPOT 5 and SPOT 6/7 images, and provide nationwide or regional seamless coverage over currently more than 100 countries. The coverage of available 3D products such as Reference3D can also be accessed.

- The Elevation product including WorldDEM™ and Elevation 30.

Task the Airbus optical and radar satellite constellations thanks to a unique access to the One Tasking offer

For new collections, users can:

- Select the best One Tasking option for their needs: OneDay, OneNow, OnePlan or OneSeries.

- Specify their own tasking parameters.

- Modify, postpone, cancel or stop new acquisitions if required.

GeoStore is an excellent tool offering direct access to satellite resources, plus unrivalled online tasking capabilities.

A One Tasking GeoStore User Guide is available at: https://www.intelligence-airbusds.com/files/pmedia/public/r45425_9_170814_one_tasking_geo_store_user_manual_v4.2_online.pdf

Follow online the status of archive or tasking orders

This includes tracking your acquisition's progress, the ability to validate or reject new acquisitions, and information on the delivery status.

An order status request form allows you to track all orders in progress, those delivered over the last 12 months or all orders for the last 12 months.

Access other online functionalities

Other online functionalities allow users to:

- Share information and selections in their baskets with other users (e.g. the end user in the case of a distributor account). The project-sharing functionality enables users to share AOIs, search criteria, annotations over selected images (text, drawings), as well as search results.

- Visualise all completed orders.

- Sort and/or filter completed orders by date, end user, country, order ID or order status (see Figure 3.1 below), and export to an Excel file.

- Visualise on a map the AOI of the ordered items, the quicklooks of the selected products (currently SPOT and Pléiades), and the footprints of the selected products.

Access other useful tools

Other useful tools include:

- User rights management: for a given organisation's account, different rights can be granted to each individual user, from just being able to view selections up to having permissions to order online.

- Automatic email notifications can be set up and sent to the internal manager of the organisation's account for all orders and deliveries done by any of its users.

- The option to set a threshold per user, for which the internal manager of the organisation's account has to approve the order. For example, if user A is ordering more than €1,000, approval is needed, if customer B is ordering more than €2,000 then approval is needed.

- Easy setup for prepaid accounts.

Access GeoStore

To access the GeoStore, enter **www.geostore.com** in your browser, which will take you to the homepage. Click on Join/My account, which appears in the top right corner.

Once you have logged in, the load screen will appear and your login name will appear in the top right corner.

To place an order through GeoStore, go to https://www.intelligence-airbusds.com/geostore/ and follow the help instructions to select your product and order it online.
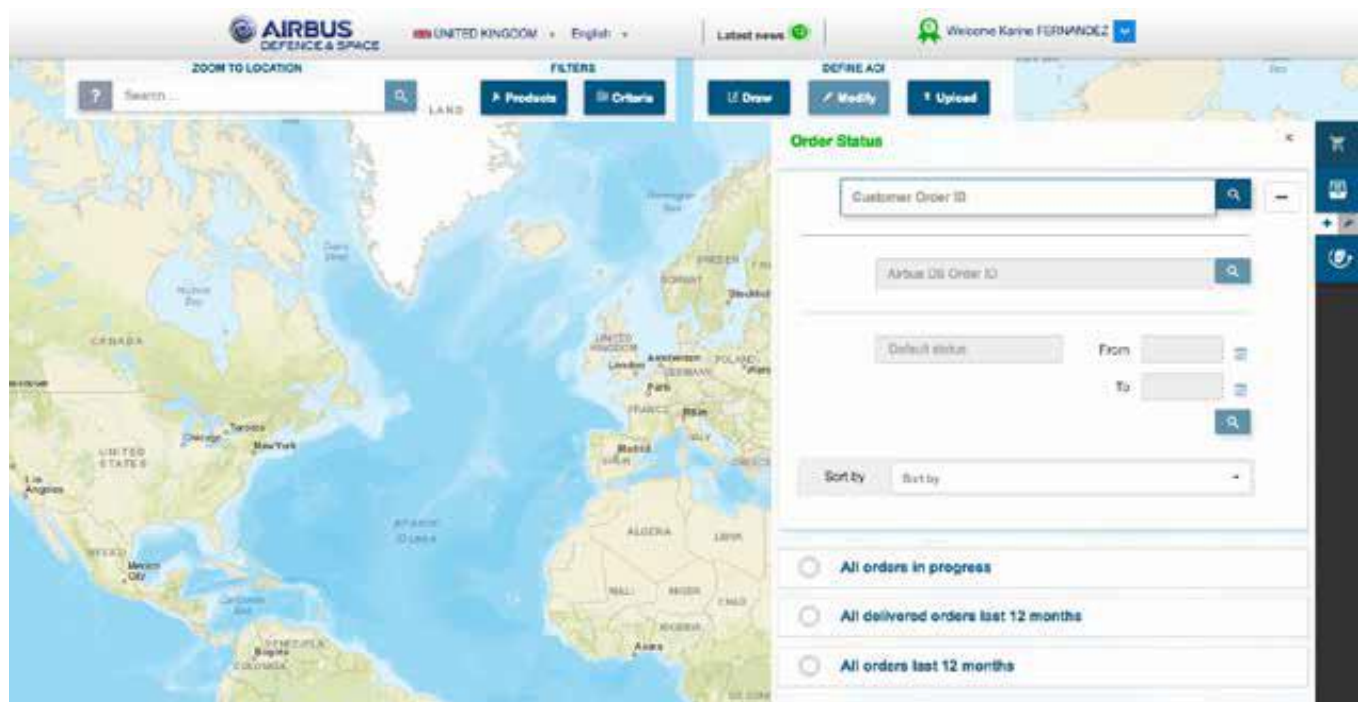
Figure 3.1: GeoStore catalogue – order status

3.2.2 Ordering Through Customer Services

You can place an order with our Customer Care Services or local partner by completing the *Pléiades & SPOT Data Request Form (in PDF format).*

Over the next few pages, we outline how to fill in the form's requested parameters, and give additional useful information for ordering your products online.

DEFENCE AND SPACE
Intelligence

Pléiades & SPOT
Data Request Form

Step 1: General information (mandatory)
including contact and end-user
information
Step 2: Your requested products:
• **Your Area Of Interest**
• **Archive imagery or**
New collection with One Tasking
• **Processing options**

AIRBUS
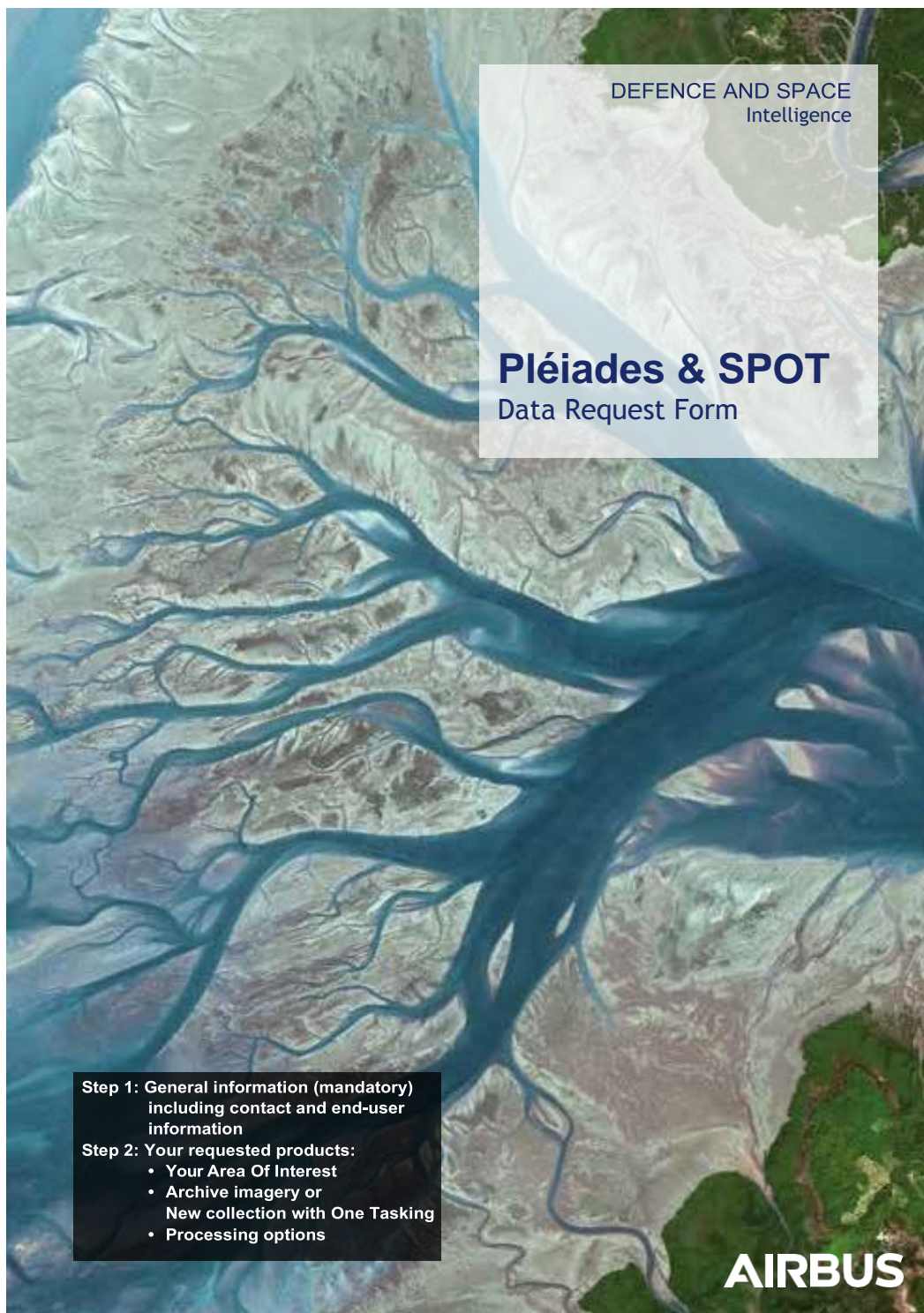
Figure 3.2: Front cover of the Pléiades & SPOT Data Request Form

2 SPOT & Pléiades Data Request Form 2017

Contact Information

A Billing Address

Order ID	
Company name	
Contact name	
Address/country	
Phone no.	
Email address(es)	
VAT no.	

A Delivery Address (if different from the above)

Company name	
Contact name	
Address/country	
Phone no.	

Delivery

B Delivery mode	Network for FTP delivery ⬤	Physical media (DVD, hard drive, USB)	⬤
FTP address (if needed)			
Email address(es)			
C Delivery turnaround	Standard		

End User Information

D Final End User Market

Market segment	
If 'Other', please specify	

E Licensing

License type	Academic
If 'Other', please describe	
If more than one end user, please specify affiliated end users	Contact, company name, country

F Application

Choose an item	
If 'Other', please specify	

Figure 3.3: Page 2 of the Pléiades & SPOT Data Request Form featuring Contact Information and End User Information

Note: Step 1, A-C, and Step 2, D-F, opposite, refer to page 2 of the *Pléiades & SPOT Data Request Form,* annotated above.

Step 1: Contact Information and Delivery Method

A) Billing address/Delivery address

Specify customer information, billing address, and shipping address (if different from billing address), as well as the end user details.

B) Delivery mode

- Select from FTP, DVD, hard disk drive or USB flash drive (please refer to the pricelist).

- Airbus will provide the most appropriate delivery media
  for the size of the image file:

  - **Hard drives:** Available in 500 GB, 1 TB, 2 TB or 3 TB.

  - **Flash drives:** 8 GB, 16 GB, 32 GB or 64 GB.

  - **DVDs:** Up to 4.7 GB.

  - **CDs:** 800 MB.

- Streaming access to Pléiades archive data or new collections is also available as a standard delivery mode or through diverse digital offers.

C) Delivery turnaround

- Standard delivery turnaround is 24 hours, during working days/working hours.

- Rush delivery is 12 hours, 24/7/365.

- For archive products, T0 is the order confirmation sent by our Customer Service (telephone/email ordering) or by the online ordering portal (online ordering).

- For new collections, T0 is when the image appears in our external catalogue.

- The standard delivery lead time applies to FTP or streaming deliveries in all options.

- The rush delivery option is available:

  - For the Primary, Projected Standard Ortho processing levels.

  - In DIMAP or NITF.

  - In GeoTIFF or JPEG 2000.

  - With FTP delivery or streaming access or download API.

- The rush option applies to archive imagery as well as new collections. It is automatically included in OneDay, OneNow, and OneSeries Critical, but it is optional for OnePlan and OneSeries Routine, as these products are delivered within a short timeframe, so image quality control is not performed and Refined Attitude Data is not
- integrated.

- Both standard and rush delivery times are applicable for archive data stored in one of our main receiving stations: Toulouse, Kiruna, or Svalbard. Delivery turnaround for archive data stored in one of our partner's direct receiving stations might take more time.

- Note that if you place your order online, you can select the image production priority:

  - Standard: only available during working hours but guarantees a quality check on the image prior to the delivery.

  - Rush: allows immediate production but without a manual quality check.

Step 2: End User Information

D) Final End User Market

Specify the activity of the end user.

E) Licensing

Please select the license type that fits your needs (refer to section *2.6 Licensing* for the licensing option summary):

- EULA – up to five affiliated end users.

- Multi – more than six users.

- Academic.

- Technical evaluation.

- Demonstration.

- Web.

- Media.

- Other.

If multiple users will use the same product, please list them and provide their contact details in the Pléiades Data Request Form.

F) Application

Scroll through the list of options to select the application for which the data will be used.

Area of Interest

G Country and place name

H Please upload your AOI(s) using one of the following options:

ESRI shapefile (UTM WGS84 preferably)	Please send it with this form.	
Google Earth KML / KMZ (UTM WGS84 preferably)	Please send it with this form.	
Circle (UTM WGS84 preferably)	Centre point (latitude/longitude)	Radius (km)
Rectangle (UTM WGS84 preferably)	Upper left (latitude/longitude)	Lower right (latitude/longitude)

Archive Imagery

Minimum Order Size

Satellite	Minimum order size	Minimum width
Pléiades	25km^2	500m in any direction
SPOT 6/7	100km^2	5km in any direction
SPOT 1-5	3,600km^2	1 scene

Optical satellite	Pléiades	SPOT 6/7	SPOT 1-5
Mode			
I Segment IDs	Important: please allow one line per ID and press 'Enter' after each.		

Figure 3.4: Page 3 of the Pléiades & SPOT Data Request Form featuring Area of Interest and product type: Archive Imagery.

Note: Step 3, G-H, and Step 4A, I, reviewed opposite and annotated above, refer to page 3 of the *Pléiades & SPOT Data Request Form*.

Step 3: Area of Interest

G) Country and place name

Indicate the country and place name of your area of interest.

H) Upload your AOI(s)

You can define your Area of Interest using coordinates or a Shapefile, KML or KMZ.

- ESRI shapefiles, as well as KML/KMZ files, will be provided in Universal Transverse Mercator Geographic Projection using latitude and longitude, decimal or sexagesimal degrees, based on the WGS84 ellipsoid.
  Polygons must have a minimum of three points and a maximum of 999 points. The polygon must be one ring and cannot intersect itself. The minimum distance between two contiguous points shall be at least 500 m.

- Coordinates can be provided in two different ways:

  - As a circle, giving latitude and longitude information of the centre in decimal or sexagesimal degrees, based on the WGS84 ellipsoid and a radius size, in kilometres.

  - By specifying the latitudes and longitudes of the upper left and the bottom right corners of a rectangle, still in decimal or sexagesimal degrees and based on the WGS84 ellipsoid.

- In all cases (Shapefile, KML, KMZ, coordinates), the AOI shall be a minimum 25 sq km wide for archive orders and 100 sq km wide for new acquisition orders, with a minimum width of 5 km in any direction for new acquisitions, and 500 m for archive.

Step 4A: Product Type – Archive Imagery

On pages 3 and 4 of the *Pléiades & SPOT Data Request Form*, you specify the product type that you need – archive data and/or a new acquisition.

To order archive data, you will complete the Archive Imagery section of the form.

I) Segment IDs

If you have found the data you need in our online catalogue, please indicate the source segment ID/s.

We also have a specific department in charge of managing archive searches on your behalf. This team can deal with standard or complex requests, including multi-sensor.

If you would prefer Airbus to do the search for you, enter 'Don't know' in the Segment IDs answer field.

Step 4B: Product Type – New Collections with One Tasking

To order a new acquisition, select the One Tasking option that best meets your needs:

This step (4B, J–M) refers to pages 4 and 5 of the *Pléiades & SPOT Data Request Form*, as annotated. Detailed explanations relating to the One Tasking offer and One Tasking specifications are given in section *2.1.2 One Tasking: Committed to Delivering Imagery*.

J) ONEDAY
Choose your acquisition date.

K) ONENOW
Access useful information in an instant.

L) ONEPLAN
Obtain qualified coverage within an agreed timeframe.

M) ONESERIES
Get Routine or Critical coverage on a regular basis.

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New Collections with ONE TASKING

Minimum Order Size

Satellite	Minimum order size	Minimum width
Pléiades	100km²	5km in any direction
SPOT 6/7	500km²	15km in any direction

J OneDay

Optical satellite	Choose between:	Pléiades ⬤	SPOT 6/7 ⬤
Acquisition date	DD | MM | YY		
Subscription			
Acquisition mode			
Incidence angle	<30° ⬤	<52° ⬤	
B/H for 'Stereo' or 'Tristereo'	Min B/H	Max B/H	
Maximum cloud cover	100% accepted		

OneNow

Optical satellite	Choose between:	Pléiades ⬤	SPOT 6/7 ⬤
Start date	DD | MM | YY		
Acquisition mode			
Incidence angle	<30° ⬤	<52° ⬤	
B/H for 'Stereo' or 'Tristereo'	Min B/H	Max B/H	
Maximum cloud cover			
If 'Other', please specify			

SPOT & Pléiades Data Request Form 2017

L OnePlan

Optical satellite	Choose between:		Pléiades ⬤		SPOT 6/7 ⬤
Acquisition period	Start DD | MM | YY			End	DD | MM | YY
Acquisition mode	⬤		⬤		⬤
Incidence angle	<20°		<30°		<52°
B/H for 'Stereo' or 'Tristereo'	Min B/H			Max B/H	
Maximum cloud cover					

M OneSeries

Optical satellite	Choose between:	Pléiades ⬤		SPOT 6/7 ⬤	
OneSeries type*	Choose between:	OneSeries Routine ⬤		OneSeries Critical ⬤	
Total no. of images required					

Multi-period monitoring	Period 1	Period 2	Period 3
	Start DD | MM | YY	Start DD | MM | YY	Start DD | MM | YY
	End DD | MM | YY	End DD | MM | YY	End DD | MM | YY
	Period 4	Period 5	Period 6
	Start DD | MM | YY	Start DD | MM | YY	Start DD | MM | YY
	End DD | MM | YY	End DD | MM | YY	End DD | MM | YY

Additional periods: If more than six periods are needed, please detail them below.

Regular monitoring	Acquisition period	Total number of images required
	Start DD | MM | YY	Minimum interval between two images:
	End DD | MM | YY	days

Acquisition mode		
Incidence angle (select the relevant option)	OneSeries Routine	
	OneSeries Critical	
B/H for 'Stereo' or 'Tristereo'	Min B/H	Max B/H

OneSeries Routine

OneSeries Critical

*OneSeries criticality
OneSeries Routine: acquisition period/frequency: 8 days or more; OneSeries Critical: acquisition period/frequency: 7 days or less. Depending on the requested acquisition time to collect the image, your tasking may be considered as Routine or Critical.

Figure 3.5: Pages 4 and 5 of the Pléiades & SPOT Data Request Form

OneDay option

Choose your acquisition date.

OneDay tasking allows you to task the satellites on a specific day. The satellite resource will be booked for your requested date and the satellite will then cover your area with the highest priority. The collected image will be delivered to you regardless of the cloud cover.

However, the OneDay tasking option for a specific chosen day is now risk-free: 24 hours before your acquisition date, you will receive a weather forecast to let you confirm, postpone or cancel your request at no cost. This option is especially useful when you need an image for a specific event, for example, to provide intelligence to a security agency, which is planning a military operation on a particular day.

Weather Forecast Alert

A weather forecast alert is sent 24 hours before the acquisition.

Acquisition Failure Terms

The success/failure criterion of a OneDay tasking is whether the acquisition happens on the planned day.

- If the acquisition does not occur on the selected day, a 25% voucher of the acquisition value will be offered to the customer. This acquisition failure term does not apply if due to unforeseeable circumstances (please refer to article 11 'Force Majeure' in our terms and conditions).

- In the case of subscriptions, if one acquisition is missing, the tasking is considered as failed and a 25% voucher will be offered and calculated as follows: 25% x (total subscription value)/(total number of acquisitions purchased in the subscription).

- For AOIs covered by multiple images, if one image is missing, the tasking is considered as failed. A voucher representing 25% of the missing acquisition value will be issued to the customer.

  All successful images collected are delivered and invoiced as specified in the acknowledgement of tasking order receipt.

Timefram	One day	
Number of Acquisition	1	
Start	Any day during the upcoming year.	
Minimum Order Size	Pléiades: 100 km² SPOT 6/7: 500 km²	
Max Bounding Box	Pléiades: 20 km East-West 40 km North-South	SPOT 6/7: 60 km East-West 120 km North-South
	Bigger areas are subject to a feasibility study	
Cloud Cover	Up to 100%	
Acquisition Notification	Acquisition notification will be sent to the customer regardless of the cloud cover, as soon as the image is acquired.	
Acquisition Mode	Mono, Stereo or Tristereo	
Incidence Angle	From 0-52°	
B/H	From 0.2-0.8 By default: 0.4-0.7 for Stereo 0.2-0.35 between each Tristereo pair	
Service Level	Premium	
Delivery Lead Time	Rush	

Tasking parameters

The tasking parameters when selecting the OneDay option include:

- The acquisition date.

- The subscription package if required (choice of 5, 10 or 20).

- The acquisition mode (Mono, Stereo, Tristereo). For further details about the acquisition mode, please see OnePlan option on page 41.

- The incidence angle which is extended by default up to 52°. Accepting extended angles allows you to increase the available number of acquisition dates.

◀ *Figure 3.6: Acquisition failure terms*
If several images are necessary to fully cover the area but one acquisition is missing (bottom right in the example above), the voucher will be calculated on the missing acquisition. All the images acquired that do cover the area will be invoiced.

OneNow option

Access useful information in an instant.

When immediate imagery is required, our satellites can be tasked to deliver valuable insights in the shortest possible timeframe. This option is mainly dedicated to answer emergency needs when up-to-date information on what is happening on the ground is requested.

Thanks to ☼NENOW✚, we offer intensive acquisitions of the area with the maximum satellite resource allocation. We ensure up to three acquisitions resulting in three deliveries in the shortest possible timeframe. All acquisitions are delivered regardless of the cloud cover. The tasking ends as soon as a good image is acquired. In the event of poor weather conditions, upon your decision, we continue collecting imagery over your area until successful data is acquired or the customer decides to end the tasking.

Timeframe	The shortest period needed to secure three acquisitions; the timeframe may be extended if additional attempts are necessary.
Number of Acquisition	Up to three acquisitions. Additional acquisitions are proposed until cloud cover rate reaches 10% or the customer decides to end the tasking.
Start Date	Any day during the upcoming year. Current day if possible or the day
Minimum Order Size	Pléiades: 100 km² SPOT 6/7: 500 km²
Max Bounding Box	Pléiades: 20 km East-West 40 km North-South	SPOT 6/7: 60 km East-West 120 km North-South
	Bigger areas subject to feasibility study
Cloud Cover	≤ 10% – all acquisitions are delivered. A validated acquisition ends the
Acquisition Notification	Acquisition notification will be sent to the customer as soon as the image is acquired, regardless of the cloud
Acquisition Mode	Mono, Stereo or Tristereo
Incidence Angle	From 0-52°
B/H	From 0.2-0.8 By default: 0.4-0.7 for Stereo 0.2-0.35 between each Tristereo pair
Service Level	Premium
Delivery Lead Time	Rush

Acquisition Failure Terms

The success or failure of tasking OneNow is based on the initial three planned attempts period (these are not necessarily consecutive days but three attempts).

A voucher will not be issued if an acquisition is missing, but the available imagery will be delivered free of charge in the following cases:

• If one acquisition is missing from the initial three attempts and the other two acquisitions do not meet the validation criteria specified in the tasking proposal accepted by the customer, then these two images are delivered at no charge.

• For AOIs covered by multiple images: if one image is missing, then the acquisition is considered as failed. The other images collected are delivered at no charge.

If an AOI is more than one mesh, in the limit of the maximum bounding box, then the commercial commitment is to collect three times the complete AOI. These three days are communicated at the beginning to the customer. This implies excluding some days where the AOI can only be partially covered. Nevertheless, these partial coverage days will still be attempted in order to make the coverage progress in between. They do not count in the failure rating and are considered as an add-on.

With our commitment to delivering useful results, larger areas are subject to a feasibility study before the acquisition of imagery. In this instance, there is no requirement to collect imagery of the complete area three times. The main objective is to collect the area as soon as possible.

However, if you urgently require only one coverage of your area, you can switch ☼NENOW☼ with weather forecast considerations. This option will still acquire the area at the soonest time with the highest satellite tasking priority, but also takes into account weather conditions, so satellite attempts are only made when cloud cover is not expected to be a problem. Then only the validated coverage/image is delivered to you.

In the event of poor weather conditions and upon your decision:

• We extend the survey period and continue to collect the area until it is successfully covered (i.e. within your requested validation criteria).

• This option will soon be available online via GeoStore.

☀NENOW☀ (with weather forecast considerations)	
Timeframe	7 days to collect the area; the timeframe may be extended if additional attempts are necessary.
Number of Acquisitions	Only one good
Start Date	Any day during the upcoming year. Current day if possible or the day
Minimum Order Size	Pléiades: 100 km²
Max Bounding Box	**Pléiades:** 20 km East-West 40 km North-South **SPOT 6/7:** 60 km East-West 120 km North-South
	Bigger areas subject to feasibility study
Cloud Cover	≤ 10% by default or any other selected cloud cover depending on the location of the area or specific requirements A validated acquisition ends the tasking.
Acquisition Notification	Acquisition notification will be sent to the customer as soon as the image is acquired, regardless of the cloud cover. Specific acquisition notification threshold can be requested.
Acquisition Mode	Mono, Stereo or Tristereo
Incidence Angle	From 0-52°
B/H	From 0.2-0.8 By default: 0.4-0.7 for Stereo 0.2-0.35 between each Tristereo pair
Service Level	Premium
Delivery Lead Time	Rush

Acquisition Failure Terms

OneNow tasking service acquires the area of interest until an image featuring less than 10% cloud cover (or any other specific cloud cover or validation criteria requested/ accepted by the customer) is taken.

- If the AOI is not collected in full and on specification within the acquisition window, a 25% voucher of the missing acquisition/coverage value is granted. In addition, the customer is given the choice to:

  - Extend the acquisition period up to 15 days via the web portal or by directly emailing the customer service.[1]

  - Close the request and receive delivery of everything that has been collected on spec (if applicable). In this particular case, all acquisitions shall be invoiced as per delivery.

- In the case of subscriptions, if one acquisition is missing, the tasking is considered as failed and a 25% voucher will be offered and calculated as follows:

  25% x (total subscription value)/(total number of acquisitions purchased in the subscription). 25% x (total subscription value)/(total number of acquisitions purchased in the subscription).

- If several images are necessary to fully cover the area but one acquisition is missing (bottom right in the example above): if one image is missing, then the acquisition is considered as failed:

  - All successful images collected and automatically processed and delivered are invoiced as specified in the acknowledgement of tasking order receipt.

  - The voucher will be calculated on the missing acquisition. All the images acquired that do cover the area will be invoiced.

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1 If the customer agrees on extending the observation period, and if the tasking request is not completed at the end of this new observation period, no voucher will be issued.

If an AOI is more than one mesh, in the limit of the maximum bounding box, then the commercial commitment is to successfully collect the complete AOI during the initial tasking timeframe agreed with the customer. This implies including some days where the AOI can only be partially covered. These partial coverage days may still be attempted in order to make the coverage progress in between. They do not count in the failure rating and are considered as an add-on.

The success/failure criterion of an acquisition is technically based on the tasking performance to successfully collect the area in full and on specification within the initial 7-day acquisition window.

However, upon customer claim, we accept voucher emission if the production has taken longer than planned (more than the rush SLA after publication in our catalogue).

With our commitment to delivering useful results, larger areas are subject to a feasibility study before the acquisition of imagery. In this instance, there is no requirement to collect imagery of the complete area within a 7-day survey period. The main objective is to successfully collect the area as soon as possible.

Tasking parameters

The tasking parameters when selecting the OneNow option include:

- The start date.

- The acquisition mode (Mono, Stereo, Tristereo). For further details about the acquisition mode, please see details in the OnePlan option (right).

- The maximum cloud cover accepted, especially in the case ONENOW selected.

- The incidence angle: accepting extended angles allows you to increase the available number of acquisition days but could impact the geometric performance of your product.

- The B/H value if Stereo or Tristereo acquisition requested (please see details in the OnePlan option).

- The subscription package, if required (5, 10 or 20).

OnePlan option

Obtain qualified coverage within an agreed timeframe.

Whether for a map update, infrastructure planning or any other specific project, OnePlan will provide you with the imagery you need. You select timeframes, dates and preferred sensor – we ensure you receive the right qualified coverage, perfectly matching your project milestones.

Timeframe	From 7-365 days
Start Date	Any day during the upcoming year
Cloud Cover	≤10% ≤ 5% Possibility to select three small cloud-free
Minimum Order Size	Pléiades: 100 km² SPOT: 500 km²
Max Bounding Box	Subject to feasibility study
Acquisition Notification	By default, 25% Or customer selected: 5-100%
Acquisition Mode	Mono, Stereo or Tristereo
Incidence Angle	0-20° 0-30° Custom [5-52°]
B/H	From 0.2-0.8 By default: 0.4-0.7 for Stereo 0.2-0.35 between each Tristereo pair
Feasibility	Diagnosis on the probability of collecting the AOI in full complying with the specifications: Achievable, Challenging, Unachievable
Service Level	Regular
Delivery Lead Time	• Standard • Rush

Acquisition Failure Terms

If the AOI is not collected in full and on specification within the acquisition window, a 10% voucher of the full order value is granted. In addition, the customer is given the choice to:

- Extend the acquisition period, or

- Close the request and receive delivery of all that has been collected on spec (if applicable). In this instance, all acquisitions shall be invoiced as per delivery.

The success/failure criterion of an acquisition is technically based on the tasking performance of the initial tasking timeframe agreed with the customer. If the customer agrees on extending the observation period, and if the tasking

request is not completed at the end of this new observation period, no voucher will be issued.

> *i* **The optimum B/H ratio to process 3D models by automatic correlation is in the range of 0.25 and above, depending on the relief. Generally, for Stereo, you may request a B/H of 0.25–0.40, if the 3D processing is automated, and even more if the processing is manual. You can request an increased B/H ratio for rather flat areas, with little relief or small buildings. In a mountainous or high building area, a large B/H ratio (>0.4) increases the rate of hidden items or areas (in-between two high mountains or around buildings) and decreases the global automatic matching accuracy. This risk can be mitigated by using the Tristereo mode. For Tristereo, a B/H around 0.25 can be recommended for each pair (e.g. 12°/0°/15°).**

- The max incidence angle field allows you to choose between <20°, <30°, <52°.

  Note that <20° viewing angle values are recommended for orthoimagery.

- The B/H (base/height) value if stereo or tristereo acquisition requested; please refer to explanations in panel, left. The optimum B/H is dependent on the relief. If in doubt, our tasking experts will recommend the most adapted values.

- The maximum cloud cover accepted, the standard value is 10%. If you need a lower cloud cover commitment, please select another cloud cover threshold or describe your need in the dedicated section. This space can also be used for requesting other specific requirements such as:

  - A small cloud-free area (max 1 km x 1 km) that will be submitted for a feasibility study with the rest of your parameters.

  - Other specifications (snow, haze, sand wind) can be specified in the blank space left for a customer's comments.
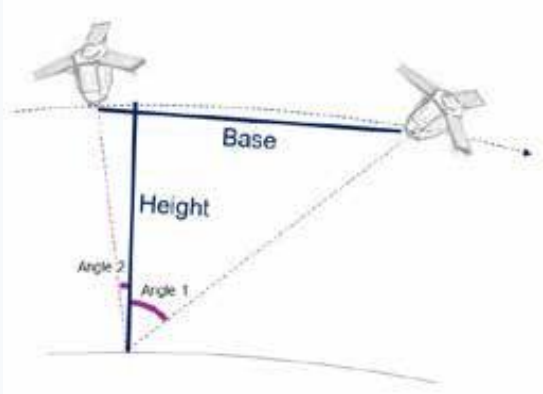
Figure 3.7: Illustration of B/H Ratio
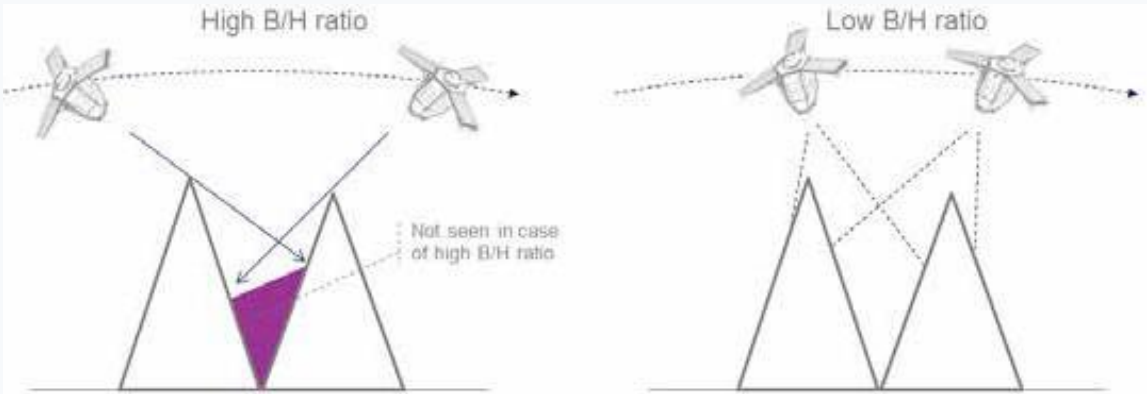
Figure 3.8: Illustration of B/H Ratio and hidden items

Tasking parameters

The tasking parameters when selecting the OnePlan option include:

- **The acquisition period**

  For a single acquisition, you may indicate your preferred collection period, with start and end dates. For instance, if you indicate 01/01/19 – 31/03/19, it means that you want the image to be acquired during the first three months of 2019.

- **The acquisition mode – Mono, Stereo, Tristereo**

  If you need a new image, you can also specify if you need a Mono, Stereo or Tristereo acquisition. A monoscopic image means a single image is delivered over your AOI. Stereoscopic (or. Tristereoscopic) acquisition means that the satellite acquires two (resp. three) images over the area of interest within the same orbital pass. Each of the two (resp. three) images are shot with a different viewing angle within the same orbit, enabling the creation of 3D models over the area of interest. For a Tristereo acquisition, the second image is acquired nearly vertically. The near-nadir acquisition minimises the risk of missing hidden items, which is ideal for dense urban and mountainous areas.

  - If you select **Mono**, you can indicate the maximum viewing angle you want. The standard viewing angle is 30° (a maximum of 20° is recommended for Ortho products). Please refer to the *Abbreviations, Acronyms and Terms* section for the definition of the viewing angle.

    Note: the smaller the maximum viewing angle is, the longer the required collection window. The amount of additional time required depends on the latitude of your area of interest and your tasking choice. Please contact Customer Care Service for more information about how the viewing angle will affect your specific order.

  - With **Stereo** or **Tristereo**, you can select your B/H. Please refer to the *Abbreviations, Acronyms and Terms* section for the definition of the B/H ratio.

OneSeries options

Get Routine or Critical coverage on a regular basis.

Whether you are dealing with long-term changes or highly dynamic situations, OneSeries brings you the required intelligence at a time frequency of your choosing. For urgent acquisitions, our cloud cover commitment ensures that you pay only for the most useful results.

OneSeries offers two options – Routine or Critical – dependent on customer requirements.

OneSeries Routine

OneSeries Routine corresponds to standard monitoring of the same area of interest. OneSeries Routine aims at providing regular information on a specific area with a minimum of eight days or more between two acquisitions. This is the perfect solution for fortnightly, monthly and quarterly monitorings.

Cloud Cover	≤10% ≤ 5% Possibility to select three small cloud-free AOIs (Pléiades: 1x1 km, SPOT: 3x3 km)
Acquisition Notification	By default, 25%
Acquisition Mode	Mono, Stereo or Tristereo
Incidence Angle	0-20° 0-30° by default Custom [5-52°]
B/H	From 0.2-0.8 By default, 0.4-0.7 for Stereo 0.2-0.35 between each Tristereo pair
Feasibility	Diagnosis on the probability to collect the AOI in full compliance with the specifications: Achievable, Challenging, Unachievable
Service Level	Regular or Premium
Delivery Lead Time	• Standard • Rush

Acquisition Failure Terms

If the AOI is not collected in full and on specification within the acquisition window, a 10% voucher is granted on the value of the missed acquisition.

The voucher shall be calculated as follows: the full amount of the order / number of requested acquisitions.

In addition, the customer can choose between:

- Extending the acquisition period of the missed observation, or

- Closing the ongoing period and taking delivery of everything that has been collected on specification (if applicable). In this particular case, all acquisitions shall be invoiced as per delivery.

The success/failure criterion of an acquisition is technically based on the tasking performance of the initial tasking period agreed with the customer.

If the customer agrees to extend the tasking period of the on-going observation and their request is not completed by the end of this second period, no new voucher is issued.

OneSeries Critical

OneSeries Critical has been specially designed for the most demanding monitorings with intensive acquisitions and deliveries with very short observation periods up to daily and forced acquisitions over an area. All data is delivered promptly to provide the most up-to-date information on what is happening on the ground.

Cloud Cover	≤ 10% or 100% in case of daily acquisitions.
Acquisition Notification	You are notified of all images acquired.
Acquisition Mode	Mono, Stereo or Tristereo
Incidence Angle	From 0-52°
B/H	From 0.2-0.8 By default: 0.4-0.7 for Stereo 0.2-0.35 between each Tristereo pair
Feasibility	Diagnosis on the probability to collect the AOI in full compliance with the specifications:
Achievable, Challenging, Unachievable	Regular or Premium
Service Level	Premium
Delivery Lead Time	Rush

Acquisition Failure Terms

If one acquisition is missing on the expected day or during the observation period, a 25% voucher shall be granted on the value of the missed acquisition (= full order value/ number of requested observations).

For AOIs covered by multiple images: if one scene is missing, the acquisition is classed as failed and a voucher of 25% of the value of the missed acquisition will be granted.

Any successful images collected are delivered and invoiced as specified in the acknowledgment of order receipt.

If several images are necessary to fully cover the area but one acquisition is missing (bottom left in the example above), the voucher will be calculated on the missing acquisition. All the images acquired that do
cover the area will be invoiced.

In case of cloud cover validation, the success/failure criterion of an acquisition is technically based on the tasking performance of the initial tasking period or acquisition frequency agreed with the customer.

If the customer agrees on extending the tasking period of the on-going observation and their request is not completed by the end of this second period, no new voucher is issued.

For daily acquisitions, the success/failure criteria of an acquisition is technically based on the tasking performance (i.e. if the acquisition happened on the planned day).

Multi-period Monitoring

You can plan several acquisitions over the same AOI with your own custom periods. When acquisitions over the area are validated for one period, the tasking request is stopped until the next period starts.

For example:

- Duration of the construction project: three months from 1 September to 30 November
- Monitoring request: three monthly acquisitions

The customer defines three observation periods: 1-20 September, 1-20 October, and 1-20 November. He will receive one image per period = a total of three images.

The customer will have to provide Airbus DS with the following details.

Number of Observations	2-50 upon customer selection.
Observation Periods	Open start and end dates – upon customer selection.

Regular Monitoring

If regularly monitored, the AOI will be covered several times at regular intervals. A dead period between two acquisitions needs to be specified.

For example:

- Duration of the construction project: three months from 1 September to 30 November
- Monitoring request: three monthly acquisitions
- Dead period: 15 days

Let's assume that a total number of three new acquisitions collected from 1 September to 30 November are required, with a minimum of 15 days between two acquisitions.

The customer will have to provide Airbus DS with the necessary details as outlined below.

Number of Observations	Indicates the number of desired observations: 2-50 upon customer selection.
Start and End Dates	Dates on which the monitoring project starts and ends – on customer selection
Dead Period	Minimum number of days between two validated images: upon customer selection.
Criticality	Discriminates the request according to: • Multi-period: one period is 'critical' if period end to period start ≤ 7 days; alternatively, it is considered as 'routine' • Regular: the series is considered 'critical' if (end date to start date/number of observations) ≤ 7 days; alternatively, it is considered 'routine'

How to order a series of images over your AOI

First, define the observation periods for your monitoring. Once you have chosen your OneSeries type, Routine or Critical, you select one of two monitoring options: multi- period or regular.

Tasking parameters

The tasking parameters when selecting the OneSeries option include:

- The acquisition mode (Mono, Stereo, Tristereo)

- Any other requirements you might have, such as:

  - A specific cloud cover percentage.

  - For OneSeries Routine (and upon feasibility study), a small cloud-free area (maximum 1 km x 1 km)

  - Specifications for snow, haze, sand wind or any other weather condition

  can be indicated in the blank Comments field on page 6 of the *Pléiades & SPOT Data Request Form*.

- The maximum incidence angle applicable to your monitoring. Depending on if you opted for OneSeries Routine or OneSeries Critical, different values are available.

- The B/H value if Stereo or Tristereo acquisitions are requested; please refer to explanations indicated in the OnePlan option. The optimum B/H is dependent on the relief. If in doubt, our tasking experts will recommend the most adapted values.

- The maximum cloud cover accepted:

  - For OneSeries Routine, like the OnePlan option, the standard value is 10%, whereas other cloud cover values can be selected depending on your needs or location of your area.

  - OneSeries Critical offers cloud cover validation – upon feasibility study – even though observation periods are usually short. If daily acquisitions are required then no cloud cover restriction can be selected.

Step 5: Processing Options

Note: Step 5, N-T, refer to page 6 of the *Pléiades & SPOT Data Request Form* shown opposite and annotated on the next page.

N) Specify the product resolution

- 50 cm Colour

- 50 cm Black and White

- 2 m Colour

O) Specify the spectral bands combination

- Bundle (Panchromatic, 50 cm + Multispectral 4-Band Colour, 2 m): one Panchromatic image + the Multispectral (Blue, Green, Red and Near Infrared) bands delivered separately (not merged)

- Pan-sharpened 3-Band Natural Colour (50 cm): merging the Panchromatic with the Blue, Green and Red bands

- Pan-sharpened 3-Band False Colour (50 cm): merging the Panchromatic with the Green, Red and Near Infrared bands

- Pan-sharpened 4-Band (50 cm): merging the Panchromatic with the full set of colour Blue, Green, Red and Near Infrared bands

- Panchromatic (50 cm): black and white

- Multispectral 4-Band (2 m): full set of colours Blue, Green, Red and Near Infrared bands

(See section *2.2 Spectral Band Combinations* for complete details.)

P) You can also select the geometric processing level

- **Primary:** Sensor image, not georeferenced or map-projected. delivered with RPC file and rigourous model metadata (attitude, ephemeris) allowing geometric processing (orthorecification – DEM extraction).

- **Projected:** Map projected image at a constant altitude (mean). Delivered with RPC file allowing geometric processing (orthorectification – DEM extraction).

  Note that if you place your order online through GeoStore and need a projected level, select 'Elevation' (option only available for the projected processing level).

  By default, the constant average altitude over the AOI is proposed. For the high relief variation, the average value may not be representative. In this case, you can specify your preferred value.

- **Ortho:** Map projected image corrected from off-nadir and relief effects (rectified as nadir position through DEM knowledge) and possibly improved with GCP.

If you require an Ortho level, select the level needed from the following:

- **Standard Ortho:** Automatically processed with the best DEM available.

- **Tailored Ortho:** When DEM and/or GCPs are provided by the customer.

  If you select Tailored Ortho, please indicate your specifications in terms of location accuracy. Before a Tailored Ortho order is accepted, Airbus DS Intelligence must verify that we can obtain the required DEMs and GCPs to make your product or use and ingest the DEM and GCPs you provide to compute your orthorectified product. In the first instance, Airbus DS Intelligence will work to acquire the appropriate support data for your order, as determined by the specifications of the product.
  Alternatively, we can accept customer provided DEMs and GCPs upon request. DEMs and GCPs must conform to format requirements that are available through our Customer Care Service.

- **Premium Ortho:** Acquisition of stereo or tristereo pairs in order to process a DTM that will be used to orthorectify the Pléiades imagery.

  Note that a maximum viewing angle of 20° is recommended.

See section *2.3 Geometric Processing Levels* for the differences between Primary, Projected and Ortho levels.

See section *2.3.3 Orthoimages* for complete details on Ortho level options.

Q) Specify the projection for your Projected and Ortho products

Universal Transverse Mercator (UTM)/WGS 84 cartographic by default or WGS 84 geographic projection, or most cartographic projections registered by EPSG library.
Please refer to *Appendix A.5* for available geographic and cartographic projections.

If you place your order online through GeoStore, please select 'Orthorectification DEM reference' (only for Ortho); By default, the best DEM available is selected to orthorectify your product (Elevation30, SRTM, Globe). Select from:

- Best available

- SRTM

- Globe

'Best available' will select Airbus Elevation30 DEM (DTED2 class) if available, otherwise SRTM DEM (DTED1) or Globe DEM (DTED0). Choosing SRTM or Globe lower resolutions will smooth the orthorectification.

R) Specify the suitable radiometric processing

Basic: Digital numbers from the sensor acquisition (native pixel values after equalisation). This option is mainly for proficient users who are able to process pure/raw data and are familiar with satellite imagery applications and image processing tools, and who need to carry out calibration and their own spectral analysis.

Reflectance: Pixel values radiometrically corrected from sensor calibration and systematic effects of the atmosphere (molecular or 'Rayleigh' diffusion). Image values are provided in reflectance physical values. Especially suitable and ready to use for spectral analysis and most applications based on image processing. Thanks to auxiliary data, users are able to reverse back to sensor count (Basic) or to apply an optimal true colour visual rendering (Display option) neutral for the imagery values themselves.

Display: Image optimised for a direct true colour rendering on the screen. The true colour is properly retrieved from sensor calibration and correction of systematic effects of the atmosphere. For users who need ready-to-use images and high aesthetic display. Perfectly adapted for display applications and direct integration on GIS. For visual analysis and communication purposes, not reversible to spectral values.

See section *2.4 Radiometric Processing Levels* for complete details.

S) Specify the product and image format

Select from:

- DIMAP – JPEG 2000 Optimised
- DIMAP – JPEG 2000 Regular
- DIMAP – GeoTIFF
- NITF – JPEG 2000 Regular
- NITF – GeoTIFF

DIMAP V2 is the default Pléiades product format. Inside that product, you can select an image format:

- JPEG 2000: regular compression (8 bits/pixels), recommended for users willing to do some high precision post-processing.
- JPEG 2000: optimised compression (3.5 bits/pixels), perfect for fast download and easy data sharing.
- GeoTIFF: uncompressed.

NITF 2.1 can also be selected instead of DIMAP V2. NITF is standard for exchanges of geographic data between defence organisations – highly recommended for users who already work regularly with this format.

See section *2.5 Product and Image Format* for further details. Full technical details can be found in *Appendix A.4 Image Format*.

T) Specify the bit depth (pixel depth or pixel coding)

Pixel depth determines the maximum number of colours that can be displayed at one time. The dynamic range of the Pléiades sensor is 12 bits at acquisition.

If you are interested in easy-to-use images for visual interpretation, you should select 8-bit images. In an 8-bit image, each pixel is represented by 256 shades of gray per band. If you are interested in the full dynamic range, you should select the 12-bit option where each pixel is represented by 4,096 shades of gray, which provides more information to discern subtle feature differences. Some older software versions cannot manage 12 bits. Contact your software provider or our Technical Support for more details (technicalsupport@intelligence-airbusds.com).

The Pléiades products are available as either:

- JPEG 2000: 8 bits or 12 bits depth per pixel
- GeoTIFF: 8 bits or 16 bits (only the 12-bit depth is used) per pixel

N	Product resolution
O	Spectral bands combination
P	Geometric processing level
Q	Projection (only for projected and ortho product levels)
	If 'Other', please specify
R	Radiometric processing level
S	Product and image format
T	Bit depth
	Comments

Figure 3.8: Extract from page 6 of the Pléiades & SPOT Data Request Form featuring Processing Options

Bit depth selection according to the radiometric processing level previously selected:

Radiometric processing	JPEG2000	GeoTIFF
Basic	8 or 12	8 or 16
Reflectance	Pixel values are scaled with a factor of 10,000 (i.e. 10,000 corresponds to a reflectance of 1), therefore only the JPEG 2000/GeoTIFF 16-bit coding is available	
Display	We highly recommend that you choose the 8-bit coding, either JPEG 2000 or GeoTIFF.	

When you select 8-bit image, a **linear adjustment** is necessary to range the original 4096 shade scale into a 256 shade scale. As the 8-bit image is intended for users who do not have the software tools to custom stretch
imagery on native 12-bit imagery, the 8-bit linear adjustment should be done with a linear stretch adjustment, possibly with a luminosity enhancement.

We recommend you select Auto to let the system enhance the image luminosity. If None is selected, no luminosity enhancement is applied, preserving any addition of saturation. The level of shade might decrease with 8-bit images, this product is not recommended for users intending to perform scientific analysis or spectral
classification, as the pixel values of the original data cannot be accurately recovered from the 8-bit dynamically adjusted product. The 12-bit image maintains absolute radiometric accuracy and full dynamic range. No linear adjustment will be performed prior to delivery.

Figure 3.9: Example of an 8-bit product without linear adjustment (top) and with linear adjustment (bottom).

If you have any questions about any of the parameters, please contact our Customer Care Service.

Step 6 – Feasibility Study and Order Confirmation

Once you have submitted your order, you will be contacted by a member of our customer care team within the day
or you will receive an automatic order confirmation, immediately after you place your order online.

When a new tasking order is submitted online, and the automatic diagnosis is achievable, then the tasking is activated automatically and your data is automatically delivered after acquisition.

When new tasking is requested through our Customer Service, our tasking experts will study the feasibility of your request and propose the best tasking parameters that will allow Pléiades satellites to collect your area on time and within the requested specifications.

For further details on tasking feasibility studies, please refer to section *2.1.2.4 Feasibility Study*.

3.3 Order Cancellation, Order Modification, Terms and Conditions

Please refer to our General Supply Conditions of Satellite Imagery Products on our website.

4   Product delivery

4.1   Order Completion and Delivery

4.1.1 See your ordering status

Once an order is confirmed, users can begin requesting information about the progress of their requests either through our Customer Care Service or by logging on to the order management page of GeoStore (www.geostore.com).

On the GeoStore web portal, users can track all orders in progress or delivered over the last 12 months, and also sort and/or filter them by country, date, amount, end user, order ID and order status. This list may be exported to an Excel file to ensure easy compatibility with your organisation's information system.

4.1.2 Follow your acquisitions

You can view the progress of your acquisitions in this section. For example, if you have tasked OnePlan, every time a validated acquisition is made of your AOI, then the percentage of completion of your tasking is updated accordingly. You can also accept or reject ('refuse') new acquisitions.

When you click on a proposed acquisition (the blue tinted area in the order status, user confirmation is required. One of two possible pop-ups will appear:
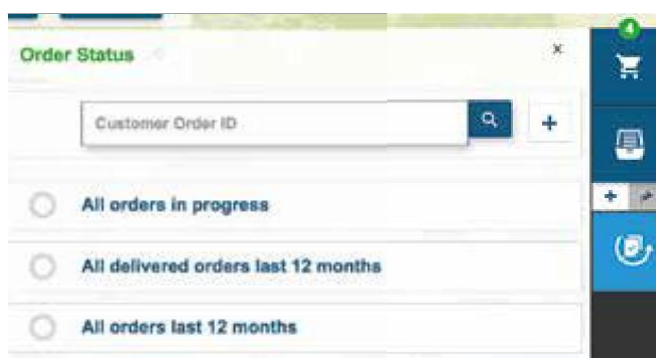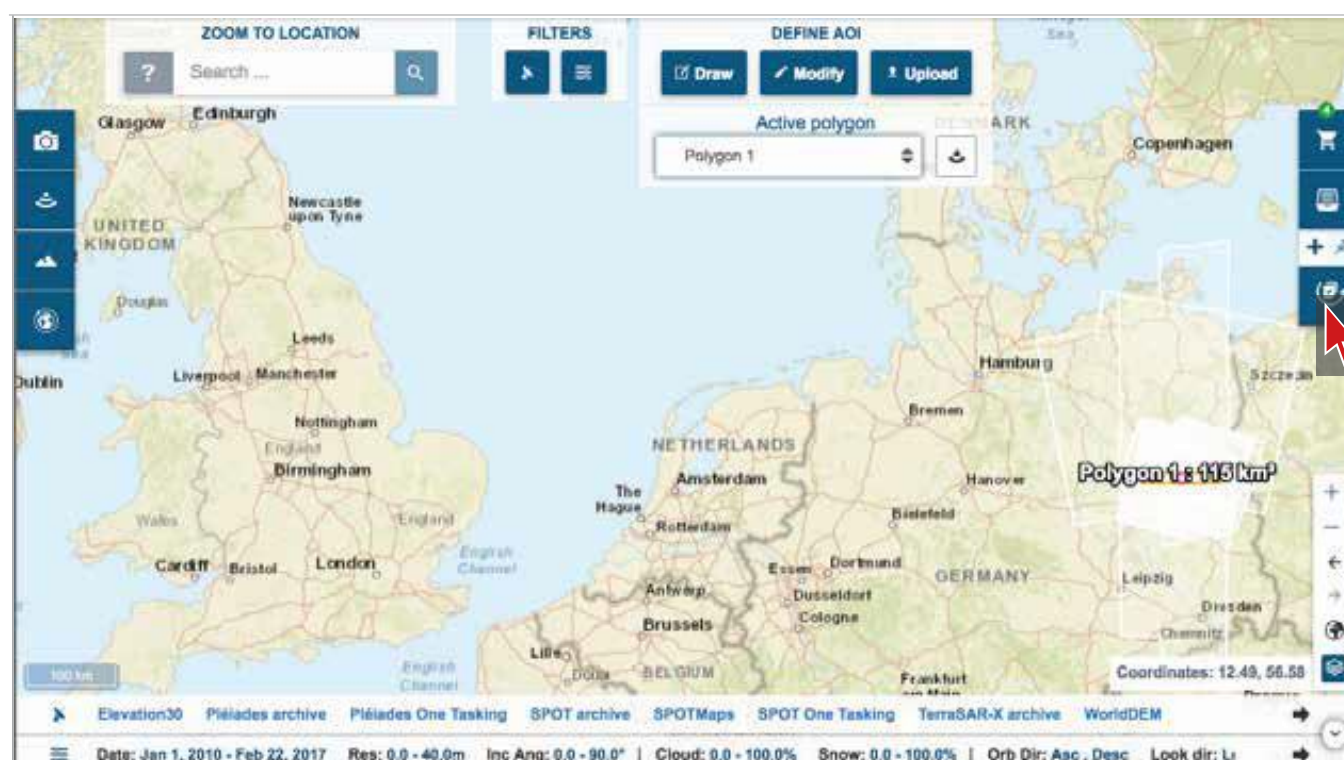
Figure 4.1: GeoStore Order Management page (above) and Order Status on Customer Care Service (left).

- **User confirmation pop-up**

  The validated acquisition does not end the tasking (the most frequent case).

  ## Valid / Refuse scene

  If you validate the scene, it will be delivered. Then you will be allowed to stop the tasking or not.
  If you refuse the scene, the tasking will not be stopped.

  [Valid] [Refuse] [Cancel]

- **User confirmation – continue or end the tasking?**

  The validated acquisition could end the tasking (because the entire AOI has been acquired). In that instance, we ask the user if they want to continue collecting images over the area.

  ## Valid / Refuse scene

  You have validated the scene. Do you want to stop the tasking also?

  [Stop the tasking] [Resume the tasking] [Cancel]
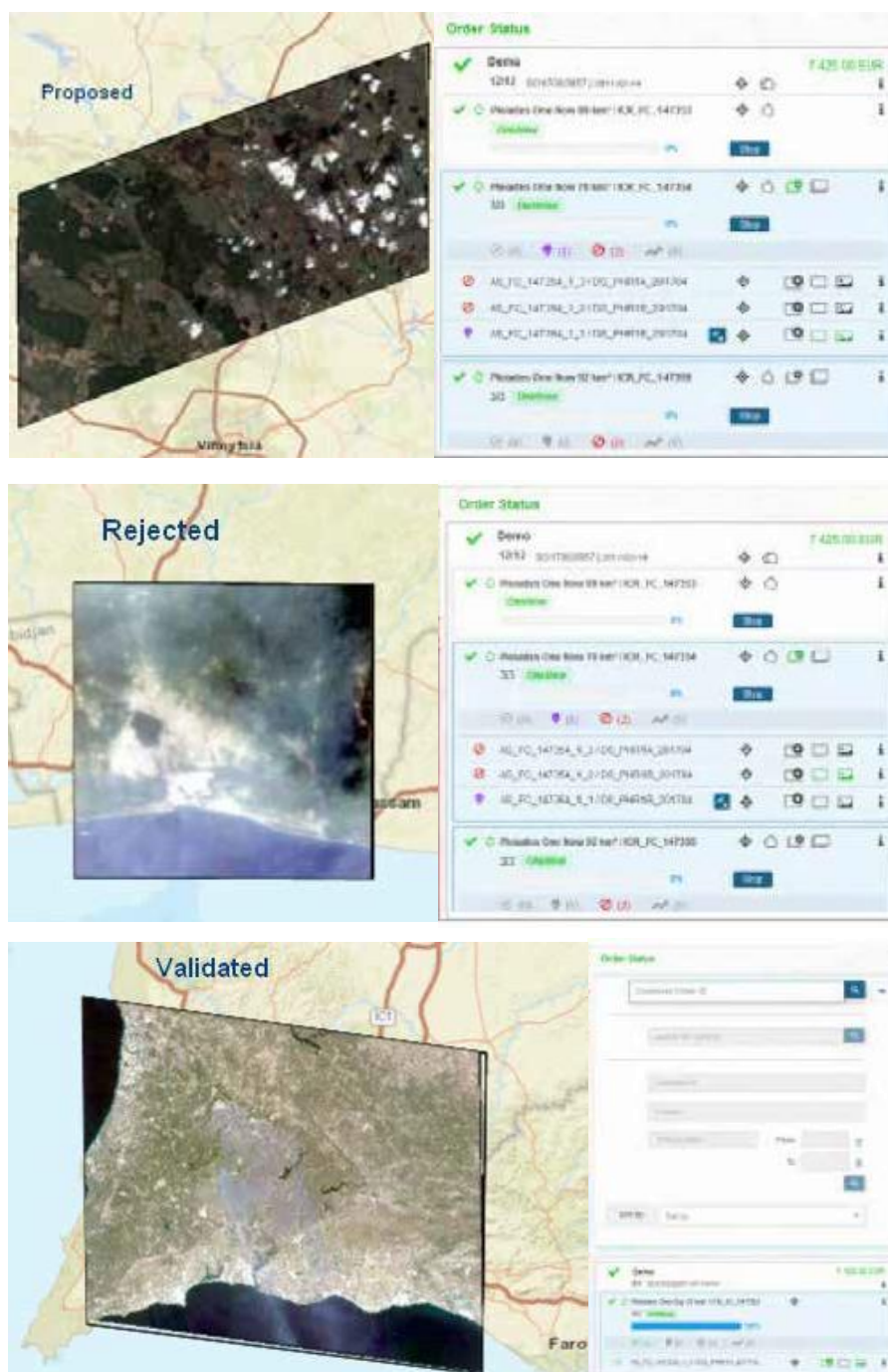
Figure 4.2: Examples of Proposed, Rejected and Validated images.

During the tasking observation period, **Proposed acquisitions** become available. Proposed acquisitions are recently acquired images, which are close to the requested criteria but don't perfectly match them. For example, the proposed acquisition might have more cloud coverage than you initially specified. In this case, the customer has two possibilities:

- **Validate the image:** the customer accepts the new acquisition, which is then considered a validated image; the new acquisition will be processed and delivered as soon as possible. The tasking over this area will then end.

- **Reject the image:** the customer rejects the proposed image and the tasking keeps attempting to collect the area in order to get an acquisition matching their criteria.

See Figure 4.2 (previous page), which shows the three order statuses.

After Airbus DS Intelligence has successfully collected all of the appropriate data, we will process and deliver orders. The table below describes the estimated processing timelines based on the combination of the product and order parameters chosen.

Description	Standard	Rush
Primary, Standard Ortho, any spectral band combination – source segment data available in Toulouse or Kiruna	24 hours	12 hours during working days, JPEG 2000 or GeoTIFF, FTP delivery only
Primary, Standard Ortho, any spectral band combination – source segment data available in a Partner's Direct Receiving Station	Please contact our Customer Care Department	N.A.
Tailored Ortho	Ad hoc estimate provided with the quotatio	N.A.

Table 4.1: Delivery times according to processing levels

Processing timelines for all Tailored Ortho products do not begin until all imagery is collected and all the necessary support data (DEMs and GCPs) are received. The timeframe to obtain DEMs and GCPs depends on the geographic location of the area of interest. Large orders may require additional processing time.

Depending on the delivery method selected, the order will either be posted to an FTP site or shipped. Please contact our Customer Care Service at any time during the order process for further information or to check on the status of your order.

4.2 Deliverable

There are various delivery methods to choose from: FTP, DVD, Hard Drive, or Flash Drive.

Streaming access to Pléiades data is also available as a standard delivery mode or through diverse existing or to- come digital offers.

Product Size

The product size depends on the area size, spectral mode, resolution, format, and image compression. The table below illustrates an example for a 50 cm, Pan-sharpened 4-band, 400 sq km product.

JPEG 2000	GeoTIFF
Bit-depth 12 bits Optimised: 2.6 GB Regular: 6 GB	**Bit-depth 12 bits** (storage 16 bits) 12 GB
Bit-depth 8 bits Optimised: 2.6 GB Regular: 6 GB	**Bit-depth 8 bits** 6 GB

Table 4.2: Examples of file size

For 12-bit products, a JPEG 2000 file is two times smaller with a Regular compression, and around five times smaller with an Optimised compression, than the same product delivered as a GeoTIFF.

- **JPEG 2000 12-bits vs. GeoTIFF 12-bits:** the image features the same dynamic and the same quality, but the file size is much smaller.

  Theoretically, for JPEG 2000, file sizes are the same for 8 and 12 bits in Optimised and Regular compression. This is related to the fact that the JPEG 2000 compression process determines a targeted bit-rate (3.5 bits/pixel for Optimised compression, 8 bits/pixel for Regular), which can be directly linked to a target file size, whether the dynamic range is 8 or 12 bits.

- **JPEG 2000 12-bits vs. JPEG 2000 8-bits:** the image features a larger dynamic, but the file size is almost the same.

Image Files

The product contains one image file (regardless of tiling) for each spectral mode, containing one or several bands:

Band Combination products	Image files*	Number of band
Panchromatic (Black and White, 50 cm)	1	1
Pan-sharpened 3-Band (Natural Colour, 50 cm)	1	3
Pan-sharpened 3-Band (False Colour, 50 cm)	1	3
Pan-sharpened 4-Band (Colour, 50 cm)	1	4
Multispectral 4-Band (Colour, 2 m)	1	4
Bundle (Panchromatic, 50 cm + 4-Band Colour, 2 m)	1 + 1	1 + 4

* Regardless of tiling

Table 4.3: Number of image files and of bands per product type

Band Naming and Band Order

Pléiades spectral bands are defined as:

- B0 = Blue spectral band

- B1 = Green spectral band

- B2 = Red spectral band

- B3 = NIR spectral band

And the band order in the image file is defined to have directly a natural colour display (in RGB system):

- 4 bands:

  - 1st channel in JPEG200/TIFF = Red spectral band (B2)

  - 2nd channel in JPEG200/TIFF = Green spectral band (B1)

  - 3rd channel in JPEG200/TIFF = Blue spectral band (B0)

  - 4th channel in JPEG200/TIFF = NIR spectral band (B3)

- 3 bands Natural Colour:

  - 1st channel in JPEG200/TIFF = Red spectral band (B2)

  - 2nd channel in JPEG200/TIFF = Green spectral band (B1)

  - 3rd channel in JPEG200/TIFF = Blue spectral band (B0)

- 3 bands False Colour:

  - 1st channel in JPEG200/TIFF = NIR spectral band (B3)

  - 2nd channel in JPEG200/TIFF = Red spectral band (B2)

  - 3rd channel in JPEG200/TIFF = Green spectral band (B1)

This is described in the DIM_*.XML metadata file:

```
<Band_Display_Order>

 <RED_CHANNEL>B2</RED_CHANNEL>

 <GREEN_CHANNEL>B1</GREEN_CHANNEL>

 <BLUE_CHANNEL>B0</BLUE_CHANNEL>

 <ALPHA_CHANNEL>B3</ALPHA_CHANNEL>

</Band_Display_Order>
```

Image Tiling

Products exceeding a certain size limit are broken up into smaller pieces called 'tiles' constituting the whole product.

Figure 4.3: Product Tiling

If a product is not tiled, the file name is: 'product_R1C1. JP2'

If a product is tiled, there are as many image files as tiles, named 'Product_RiCi.JP2'. The tiles are delivered without overlap.

```
IMG_PHR1A_PMS_201202250025599_ORT_IPU_20120523_2858-001_R2C2.JP2
IMG_PHR1A_PMS_201202250025599_ORT_IPU_20120523_2858-001_R2C1.JP2
IMG_PHR1A_PMS_201202250025599_ORT_IPU_20120523_2858-001_R1C2.JP2
IMG_PHR1A_PMS_201202250025599_ORT_IPU_20120523_2858-001_R1C1.JP2
```

A georeferencing World File J2W (or TFW for GEOTIFF products) is associated to each image tile to assemble all image files.

IMG_PHR1A_PMS_201202250025599_ORT_IPU_20120523_2858-001_R2C2.J2W
IMG_PHR1A_PMS_201202250025599_ORT_IPU_20120523_2858-001_R2C1.J2W
IMG_PHR1A_PMS_201202250025599_ORT_IPU_20120523_2858-001_R1C2.J2W
IMG_PHR1A_PMS_201202250025599_ORT_IPU_20120523_2858-001_R1C1.J2W

All other metadata (RPC XML and DIM XML) are not tiled and are applicable to the whole product. This means that the product can be visualised and processing into software using the metadata file (DIM_PHR*.XML

The tiling is applied automatically depending on the file size, which rely on the AOI production size and the following production options:

- File format (TIF/JP2)

- Spectral mode (PAN, MS,PMS)

- Bands number and image encoding.

It is not possible to choose the tiling parametre

customized. Tile size limit is approximately:

- 2 GB for GeoTIFF products

- Max. 4 GB for JPEG 2000 products

Since the product size depends on the image format, the same product will be cut into more tiles in GeoTIFF than in JPEG 2000. For example, for one Pan-sharpened, 4-band, 400 sq.km product, a JPEG 2000 12-bit (Optimised) product will be 2.6 GB: no tiling is needed. A GeoTIFF 12- bit product will be approximately 12 GB, with 6 image tiles.

4.2.1 Overview of the Product in DIMAP V2 format

Pléiades products are delivered in DIMAP V2 format.
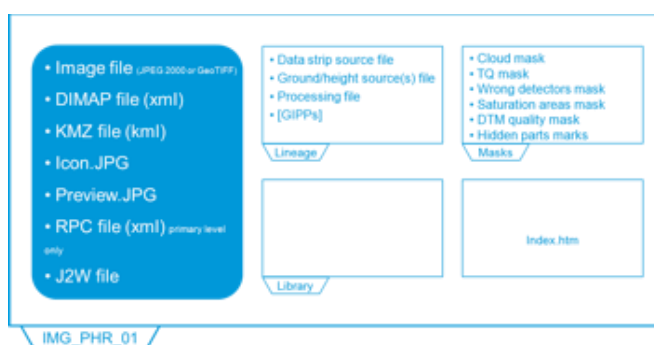
Figure 4.4: DIMAP V2 Structure

4.2.2 Example
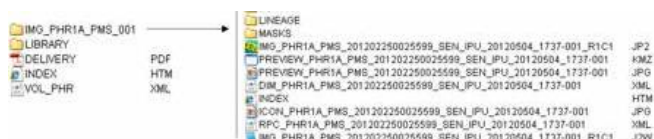
Figure 4.5: Example of DIMAP V2 Structure

Primary, Projected and Ortho products can be discovered with the following files:

- The delivery PDF file

- The image file, including The 'PREVIEW' quicklook files, either in KMZ or JPEG

- The index file named 'INDEX.HTM', that allows an easy display of the main information about the product

Delivery File

In the delivery PDF file, you will find general technical information of the product such as acquisition angles, band information, coordinate system, and histograms.

Image File/KMZ (PREVIEW_...KMZ)

This file gives a visual and easy-to-use overview of the products. You can open it from Google Earth and:

- Preview the footprints:

Figure 4.6: KMZ Preview, Footprint

Click on different objects to get more information:
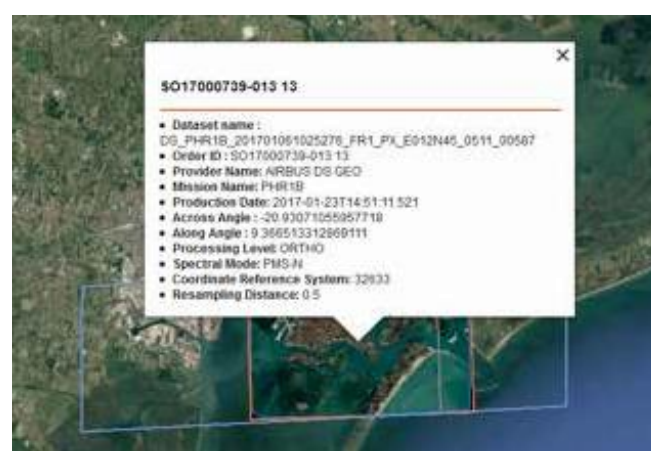
Figure 4.7: KMZ Preview, Bubble

The file contains several information layers which can be
displayed or hidden:

Figure 4.8: KMZ Preview, Layers

- **Start animation:** By double-clicking on this layer, you zoom on the product.

- **Tiles:** This layer shows the footprint and information (name, media) of each tile contained in the product.

- **Product:** This layer gives the footprint, information (name, mode, angle ...), and preview of the whole product.

- **Sources:** This layer displays the entire footprint and information (date, angles) of all source strips, necessary for the production of the product.

- **Sources extracts:** This layer provides the footprint of the source strips, intersecting with the area of interest.

Image File/Main Metadata File (DIM_...XML)

The file contains all the product metadata needed for image processing.

Top level information can be found by opening it in a web browser, such as Internet Explorer or Mozilla Firefox: product description, quicklook, coordinate system.

More information can be found by opening it with a text editor like WordPad: find all data related to the image acquisition, processing parameters, etc. Examples:

- **Radiometric values:** gain and offset calibration value to radiance count:

  <GAIN>9.1</GAIN>
  <BIAS>0</BIAS>

- **Geometric values:** acquisition angles :

  <VIEWING_ANGLE_ACROSS_TRACK unit='deg'>0.8921924132232172</VIEWING_ANGLE_ACROSS_TRACK>

  <VIEWING_ANGLE_ALONG_TRACK unit='deg'>-0.08521426592279865</VIEWING_ANGLE_ALONG_TRACK>

  <VIEWING_ANGLE unit='deg'>0.8962513185196064</VIEWING_ANGLE>

  <INCIDENCE_ANGLE_ALONG_TRACK>-0.2708528386076501</INCIDENCE_ANGLE_ALONG_TRACK>

  <INCIDENCE_ANGLE_ACROSS_TRACK>-0.9928120136270051</INCIDENCE_ANGLE_ACROSS_TRACK>

  <INCIDENCE_ANGLE>1.029080944248358</INCIDENCE_ANGLE>

RPC File (RPC_...XML)

This file allows users to do geometric processing (orthorectification, DEM extraction) easily with software that supports RPC models.

J2W or TFW File (IMG_...J2W)

This file (worldfile) allows software to georeference Primary and ortho images or to assembly tiles for Primary products.

Please refer to *Appendix A* for a complete DIMAP V2 description.

4.3 How to Open Your Product

To open a Pléiades product and access the image coordinates and metadata, it is possible to use a GIS or image processing software. Most commercial off-the-shelf software is able to read, georeference and process (orthorectify, etc.) Pléiades products. The various software packages use different methods to georeference Pléiades products. Georeferencing is achieved by reading:

- The GMLJP2 header*, J2W worldfile**, or XML metadata file for products in JPEG 2000

- The GEOTIFF header*, TFW worldfile**, or XML metadata file for products in GeoTIFF

* Not applicable for Primary products.
** Coarse for Primary products.

For more than a year before Pléiades 1A launch, Astrium has been working with the main image processing software providers to ease the ingestion of Pléiades data into their systems. The detailed status, per software and version, is available upon request at technicalsupport@intelligence-airbusds.com.

4.4 Technical Support and Claims

Whether you are looking for specific metadata, need to know how to use the RPC file, have questions about the format you need, think your image does not look right, cannot open a file, or anything else, we are here to help. For any question, advice or problem, please contact your Customer Care representative or the Technical Support Team: technicalsupport@intelligence-airbusds.com. .

Appendix A: File Format – DIMAP V2

The following physical format applies to Primary, Projected and Standard Ortho level products. For Tailored Ortho products, the physical format is shared with other sensors and is based on the standard we describe thereafter.

A.1 File and Folder Naming

A.1.1 Naming Conventions

Names provide concise information about the product and its context. The naming is composed of:

- a prefix
- a suffix (possibly)
- a variable string composed of key information contained in the DIMAP V2 metadata file
- a file extension

A.1.1.1 Fixe Names

The prefixes are as shown in the table below:

Prefix	Folder	File	Subject	Remark
VOL_		X	Index file of products contained in the delivery	
IMG_	X	X	Product directory, or image file(s), or associated georeferencing file(s)	
DIM_		X	DIMAP, main product metadata file	
LUT_		X	DIMAP, LUT colour curves metadata files	Reflectance processing only
RPC_		X	DIMAP, RPC metadata file	Primary and Projected Products only
PREVIEW_		X	Quicklook raster file, or associated KMZ file	
ICON_		X	Thumbnail raster file	
STRIP_		X	DIMAP, Data Strip Source metadata file	One per Data Strip Source
GROUND_		X	DIMAP, Ground Source metadata file	If Ground reset at Ortho level, one per source
HEIGHT_		X	DIMAP, Height Source metadata file	If Vertical reset at Ortho level, one per source
PROCESSING_		X	DIMAP, processing lineage file	
GIPP_		X	GIPP file	(optional)
ROI_		X	Region of Interest vector mask	
CLD_		X	Cloud vector mask	
QTE_		X	Synthetic technical quality vector mask	
SNW_		X	Snow vector mask	
DET_		X	Out of order detectors vector mask	
VIS_		X	Hidden area vector mask	Ortho, Mosaic (optional)
SLT_		X	Straylight vector mask	
DTM_		X	DTM quality vector mask	(optional)

Table A.1: Naming – Prefixes

The suffixes are:

Suffix	Folder	File	Subject	Remark
_DIM		X	Various DIMAP metadata files (different from the main product metadata file)	
_RiCj		X	Image product file, possibly tiled	ij, Row (R) and Col (C) tile indexes
_MSK		X	Mask, raster or vector	Vector, GML format

Table A.2: Naming – Suffixes

The following files/directories have fixed naming:

Names	Folder	File	Subject	Remark
DELIVERY		X	Delivery note	
LICENSE		X	License file	Optional file
LINEAGE	X		Directory for source information	
MASKS	X		Directory for mask information	
LIBRARY	X		Directory for files activated by the XML Style Sheet	
LOGO		X	Logo file	

Table A.3: Naming – Main Directories

The file extensions are:

Extension	File	Subject	Remark
.GML	X	GML vector files	Mask file
.HTM	X	HTML file	
.JPG	X	JPEG raster file	Thumbnail and quicklook files
.JP2	X	JPEG 2000 raster file(s)	Image file(s)
.J2W	X	ESRI World file(s) for JPEG 2000	Simple assembling/georeferencing file(s)
.KMZ		KML file (archived in zip format)	Preview file
.PDF	X	PDF file	Delivery file
.TIF	X	TIFF/GeoTIFF raster file(s)	Image file(s)
.TFW	X	ESRI World file(s) for TIFF/GeoTIFF	Simple assembling/georeferencing file(s)
.XML	X	DIMAP file encoding in XML or simple XML file	Metadata files
.XSL	X	XML Style Sheet file	

Table A.4: Naming – Extensions

A.1.1.2 Variable Key Information

The naming convention uses key information contained in
the DIMAP product metadata file.

The product directory name is comprised of:

<DirImage_ID>

**PHR<SAT_NUMBER>_<SPECTRAL_
PROCESSING>_<NUM_PRODUCT>**

Example: **PHR1A_PMS_001**

Where:

<SAT_NUMBER> = {1A, 1B}, Pléiades 1A or Pléiades
1B, or one of them if both used in a mosaic

<SPECTRAL_PROCESSING> = {P, MS, PMS, MS-N, MS-
X, PMS-N, PMS-X}

SPECTRAL_ PROCESSING	Spectral Mode
P	Panchromatic
MS	Multispectral 4 bands
PMS	Pan-sharpened 4 bands
PMS-N	Pan-sharpened 3 bands (B, G, R bands)
PMS-X	Pan-sharpened 3 bands (G, R, NIR bands, False colour)

Table A.5: Naming – spectral processing

<NUM_PRODUCT> = Product index within the Volume.
Format is three digits from 001 to 999

The product name for Primary and single Ortho files is
comprised of:

<Product_ID>

**PHR<SAT_NUMBER>_<SPECTRAL_
PROCESSING>_<IMAGING_TIME>_<PROCESS_
LEVEL>_<JOB_ID>**
Example:
**PHR1A_PMS_201006181052299_
ORT_123456789**

Where:

<SAT_NUMBER> = see previous section

<SPECTRAL_PROCESSING> = see previous section

<IMAGING_TIME> = UTC strip source acquisition start
time. Format = 'YYYYMMDD_HHMMSSS'

<JOB_ID> = Internal production identifier. Format =
variable string

<PROCESS_LEVEL> = {SEN, PRJ, ORT, MOS}

PROCESS_ LEVEL	Product
SEN	Primary (abbreviation for SENSOR)
PRJ	Projected
ORT	Ortho, single image
MOS	Ortho, mosaic image

Table A.6: Naming – processing levels

Specifically, the product name of Ortho mosaic files are
derived from the same principle:

<ProductMOS_ID>

**PHR_<INTERNAL_REF>_<SPECTRAL_
PROCESSING>_<PROCESS_LEVEL>_<JOB_ID
>**
Example: **PHR_Mymosaic_PMS_MOS_123456789**

Where:

<INTERNAL_REF> = Internal identifier, generally shared
with the customer. Format = variable string.

Name(s) of Pléiades Data Strip Source metadata file(s) is
comprised of:

<DATA_STRIP_ID>

**DS_ PHR<nn>_<YYYYMMDDHHMMSSS>_<RRR>
_<PP>_<XxxxYyy>_<KKLL>_<TTTTT>**

Example:
**DS_PHR1A_201006181052297_FR1_PX_
E001N43_0612_06488**

Where:<nn> = satellite number {1A, 1B}

<YYYYMMDDHHMMSSS> = UTC strip source acquisition start time

<RRR> = initial archiving centre acronym

<PP> = acquisition spectral mode {PA, XS, PX [i.e. PA+XS]}

<XxxxYyy> = closest square degree of the strip centre
with:

X = {W,E}, West or East, xxx longitude degree (000 to 180)

Y = {N,S}, North or South, yy latitude degree (00 to 90)

<KKLL> = closest cell in the Pléiades Grid of the strip centre with:

KK = step number in

longitude LL = step number

in latitude

<TTTTT> = Number of source frames PA (or XS if spectral mode is XS)

Name(s) of Height Source metadata file(s) for an Ortho produced with a standard DEM is comprised of:

<DEM_Source_ID>

- For Reference3D DTED2 DEM layer (one arc second posting):

<DEM_Source_ID> = R3D_DT2_<Tile_ID>

Example: R3D_DT2_N44E001

Where:

<Tile_ID> = one-square-degree tile South-West corner geographic coordinates in degrees {N|S}xx{E|W}yyy

- For SRTM1 DEM Source (nine arc seconds posting):

<DEM_Source_ID> = SRTM_DT1

Example: SRTM_DT1

- For Global DEM Source (thirty arc seconds posting):

<DEM_Source_ID> = GLOBE

Example: GLOBE

Name(s) of Ground Source metadata file(s), for an Ortho reset on standard ground source is comprised of:

<OR_Source_ID>

- For the Reference3D Ortho layer Source (one sixth of an arc second posting)

<OR_Source_ID> = R3D_OR_<Ref3D_Tile_ID>

Example: R3D_OR_N44E001, R3D_OR_SPOTView_N44E001

Where:

<OR_Source_ID> = one-square-degree tile South-West corner geographic coordinates in degrees {N|S}xx{E|W} yyy

A.1.2 Tree Structure

The delivery tree layout is a typical DIMAP product data structure, with three hierarchic levels of information:

- The root level index

- A product level (1 to n)

- Inside a product level, a set of sub-levels with additional information like striping masks

The layout is the same for all kinds of deliveries, physical delivery (DVD, Hard Drive or Flash Drive) or electronic delivery via FTP.

A.1.2.1 Primary, Projected or Single Ortho Level Image Products

The file naming convention is detailed in the previous section. The usual file structure is as shown below.

For products delivered in TIFF/GeoTIFF format instead of JPEG 2000 format, file extensions TIF and TFW replace file extensions JP2 and J2W.

Primary, Projected Single Ortho Level Image

VOL_**<MISSION>**.XML [1:1]

INDEX.HTM [1:1]

DELIVERY.PDF [1:1]

📁

    LIBRARY

        LOGO.JPG

        STYLE.XSL

📁

    IMG_**<DirImage_ID>**

        INDEX.HTM

        DIM_**<Product_ID>**.XML [1:1]

        LUT_**<Product_ID>**.XML [0:1]   for Reflectance processing option only

        RPC_**<Product_ID>**.XML [0:1]   for Primary and Projected Products only

        PREVIEW_**<Product_ID>**.KMZ [1:1]

        PREVIEW_**<Product_ID>**.JPG [1:1]

        ICON_**<Product_ID>**.JPG [1:1]

        IMG_**<Product_ID>**_RiCj.JP2 [1:n]   n if image is physically tiled

        IMG_**<Product_ID>**_ RiCj.J2W [1:n]   n if image is physically tiled

        📁

        LINEAGE

            PROCESSING_**<Product_ID>**_DIM.XML [1:1]

            STRIP_**<DATA_STRIP_ID>**_DIM.XML [1:1]

            GROUND_R3D_OR_**<Ref3D_Tile_ID**>_DIM.XML [0:n]   if Ortho Product if ground

            reset HEIGHT_R3D_DT2_**<Ref3D_Tile_ID>**_DIM.XML [0:n]   or

            HEIGHT_**SRTM_DT1**_DIM.XML [0:n]   or

            HEIGHT_**GLOBE**_DIM.XML [0:n]   if Ortho Product vertical reset

        📁

        MASKS

            CLD_**<Product_ID>**_MSK.GML [1:1]

            QTE_**<Product_ID>**_MSK.GML [1:1]

            SNW_**<Product_ID>**_MSK.GML [1:1]

            DET_**<Product_ID>**_MSK.GML [1:1]

            SLT_**<Product_ID>**_MSK.GML [1:1]

            ROI_**<Product_ID>**_MSK.GML [1:1]

            VIS_**<Product_ID>**_MSK.GML [0:1]   for ortho and mosaic products only

            DTM_**<Product_ID>**_MSK.GML [0:1]

        📁

        LIBRARY

            LOGO.JPG

            STYLE.XSL

A.1.2.2 Mosaic Ortho Image Products

The previous <Product_ID> is slightly modified in <ProductMOS_ID>, since the final Mosaic is a merge of several images, at different times and possibly dates. Each image is considered an independent source described by its own DATA_STRIP lineage metadata file.

For products delivered in TIFF/GeoTIFF format instead of JPEG 2000 format, file extensions TIF and TFW replace file extensions JP2 and J2W.

Mosaic Ortho Image

VOL_**<MISSION>**.XML [1:1]

INDEX.HTM [1:1]

DELIVERY.PDF [1:1]

📁 LIBRARY
    LOGO.JPG STYLE.XSL

📁 IMG_**<DirImage_ID>**
    INDEX.HTM
    DIM_**<ProductMOS_ID>**.XML [1:1]
    PREVIEW_**<ProductMOS_ID>**.KMZ [1:1]
    PREVIEW_**<ProductMOS_ID>**.JPG [1:1]
    ICON_**<ProductMOS_ID>**.JPG [1:1]
    IMG_**<ProductMOS_ID>**_RiCj.JP2 [1:n]   n if image is physically tiled
    IMG_**<ProductMOS_ID>**_ RiCj.J2W [1:n]   n if image is physically tiled

    📁 LINEAGE
        PROCESSING_**<ProductMOS_ID>**_DIM.XML [1:1]
        STRIP_**<DATA_STRIP_ID>**_DIM.XML [1:n]   n if multi pass
        mosaic GROUND_**R3D_OR_<Ref3D_Tile_ID>**_DIM.XML [0:n]   if ground reset
        HEIGHT_**R3D_DT2_<Ref3D_Tile_ID>**_DIM.XML [0:n]   or
        HEIGHT_**SRTM_DT1**_DIM.XML [0:n]   or
        HEIGHT_**GLOBE**_DIM.XML [0:n]   ground reset

    📁 MASKS
        CLD_**<ProductMOS_ID>**_MSK.GML [1:1]
        QTE_**<ProductMOS_ID>**_MSK.GML [1:1]
        SNW_**<ProductMOS_ID>**_MSK.GML [1:1]
        DET_**<ProductMOS_ID>**_MSK.GML [1:1]
        SLT_**<ProductMOS_ID>**_MSK.GML [1:1]
        ROI_**<ProductMOS_ID>**_MSK.GML [1:1]
        VIS_**<ProductMOS_ID>**_MSK.GML [1:1]
        DTM_**<ProductMOS_ID>**_MSK.GML [0:1]

    📁 LIBRARY
        LOGO.JPG
        STYLE.XSL

A.1.2.3 Product Delivered on Several Media

When the product image size exceeds the delivery medium capacity, the tree structure is duplicated on every medium. Each medium gets a subset of image raster tiles up to the media limit. The complete product can be gathered with the information provided into index, metadata and KMZ files. The same rule applies to electronic delivery via FTP, considered here to have the same capacity as a DVD
(4 GB).

A.2   Levels of Information and File Short Contents

File name	Standard Products		Other Products
	Primary/ Projected	Ortho	
Root Level			
Index File	Y	Y	Y
Delivery File	Y	Y	
Product Level			
Product File	Y	Y	Y
RPC File	Y	N	
LUT file	If Reflectance	If Reflectance	
World File	Y	Y	
KMZ File	Y	Y	
Preview File	Y	Y	Y
Thumbnail File	Y	Y	Y
Lineage Sub-Level			
Data Strip Source File	Y	Y	
Ground Source File	If set	If set	
Height Source File	N	Y	
Processing File	Y	Y	
Mask Sub-Level			
Mask File	Y	Y	

Levels

A.2.1 The Root Level Index

The root level index provides information on all products collected by the delivery order. This level is also called the volume level. The delivery may be stored on one or several media. The delivery contains one or several products. Each is a component of the full delivery.

A.2.1.1 Index Metadata File

VOL_<MISSION>.XML: file encoding = XML, metadata format = DIMAP V2

The Index metadata file, or Volume file, lists all components of the delivery order (i.e. all unitary products on the media): the access path to the metadata file and the associated tiled images. For delivery on several media, the index metadata file collects all volume entries (multi-volume) and the index flag indicates the medium allocation.

Using web tools supporting XLST, the integrated XSL style sheet allows the main information and product navigation to be displayed. The display is activated with the file itself or through the INDEX.HTM file.

A.2.1.2 Delivery File

DELIVERY.PDF: format = PDF

The delivery PDF file is easier to print than the XML/HTML files. It gathers significant information from the index
and product metadata files. The order and processing identifications are summarised in the headings. Like the index metadata file, the first page gives an overview of the media content.

For each product the content provides a selection of information and, possibly for standard products, the histograms of each spectral band in Basic radiometric count.

A.2.1.3 License File

The product and its content are copyright protected. The user must refer to the conditions of agreement and licensing authorised by Airbus DS Intelligence.

A.2.2 The Product Level

IMG_<DirImage_ID>

The product directory contains the product itself and the associated discovery files.

A.2.2.1 Product Metadata File

DIM_<Product_ID>.XML: file encoding = XML, metadata format = DIMAP V2

The product metadata file provides, in detail, the product information consistent with its final processing level. It also provides links to all files incorporated into the product: image, lineage files, and mask files.

The information is organised by groups of DIMAP metadata. See *Table A.8* overleaf.

Metadata_Identification	Metadata format and language identification.
Dataset_Identification	Brief text and links for a visual representation of the dataset. This information is mainly provided for dataset search and discovery purposes. Rights and constraints to access and use.
Dataset_Content	Localisation of the dataset and geometric extent. User should use this information for cataloging purposes and not for accurate positioning. Links to the main files encapsulated into the current dataset (component).
Product_Information	Responsible party of the product: contact, order, and delivery information.
Coordinate_Reference_System	Coordinate Reference System (CRS) into which the data will be related. The DIMAP CRS scheme is based on the industrial standard EPSG. It includes five single entities: • Projected: map projection, horizontal plane usually Cartesian coordinates in linear unit. • Geodetic: Earth mapping based on a geographic (angular unit) or geocentric shape of the Earth. • Vertical: CRS used for gravity-related (geoid) height or depth data. • Temporal: CRS used for recording time data. • ECI: CRS used for recording Earth-Centred Inertial data. Projected and geodetic are the most common for image mapping. Conventionally, Primary images are recorded with WGS84 geodetic CRS. CRS are recorded to EPSG registry, if known. The subsequent parameters are only given if no identifier is found in the registry (commonly known as a «user-defined» definition).
Geoposition	Easiest relationship between the dataset coordinates and the CRS coordinates: • Georectified image (Primary and Ortho): insertion point and dimension. • Sensor image (Primary): link to RPC analytic model.
Processing_Information	Information on production facility, level of processing, processing settings: geometric, radiometric, sampling, MTF.
Raster_Data	Raster file path(s) and tiling size organisation, encoding and displaying.
Radiometric_Data	Radiometric information, how to set the image count (pixel values) to radiometre measurement: dynamic range, radiometric adjustment performed on data, histogram, radiometric calibration values as spectral range, radiance, reflectance solar irradiance.
Geometric_Data	Geometric information: • Sensor image (Primary): data for rigorous sensor model (acquisition time and date, ephemeris, attitudes, and geometric calibration of the instrument). This data is consistent with the inner image geometry and self-contained for the user processing (any data in other files is required, see Appendix C: Geometric Modelling). • Pre-computed useful geometric location data at fixed posting in the image: acquisition angles, solar incidence, ground sample distances.
Quality_Assessment	Quality information. Should be: • Planimetric accuracy (Ortho Product). • Vertical accuracy (DEM product). • Link to various data giving quality information: lineage masks.
Dataset_Sources	Original data identification from which the current dataset was made and a link to the corresponding lineage metadata file(s)

Table A.8: Metadata organisation

Using web tools supporting XLST, the integrated XSL style sheet allows the main information and product navigation information to be displayed. The display is activated with the file itself or through the INDEX.HTM file.

A.2.2.2 RPC Metadata File

RPC_<Product_ID>.XML: file encoding = XML, metadata format = DIMAP V2 (NITF V2.1 naming)

The RPC file contains the coefficients and Normalisation parameters for the Rational Polynomial Coefficients (also called Rapid Positional Capability, Rational Function Model) geometric analytic model. This file is only given for images supporting a geometric modelisation (Primary and Projected product).

The metadata names are those specified by the Controlled Extension (CE) of NITF V2.1 (direct model). The coefficients are arranged in the RPC00B order.

The RPC file provides the following functions:

- Direct analytic model (Image ➜ Ground)

- Inverse analytic model (Ground ➜ Image)

Each function is estimated for the whole image (Global). In some cases, several subset functions (partial) are added for a better accuracy over the subset domain.

RPC is a generalised analytic model independent of the sensor data handling by the most current software. Users needing the highest level of accuracy (estimation greater than 3rd degree polynomial, block adjustment...) should prefer the rigorous sensor model (Primary product).

The specific metadata are in the following DIMAP groups:

Direct_Model	Rational function polynomial coefficients from image to ground.
Inverse_ Model	Rational function polynomial coefficients from ground to image.
Global_RFM	Global model defining the best fit model to the whole dataset, as delimited by the RFM validity.
Partial_RFM	Partial model(s) defining the best fit model to a dataset subset, as delimited by the RFM Validity Domain.

Table A.9: RPC Metadata File

A.2.2.3 World File

IMG_<Product_ID>_RiCj.J2W/TFW: file encoding = ASCII, metadata format = ESRI

ESRI World File is a popular way for geographic information systems to reference the image in the

Coordinate Reference System (CRS). For details, users can refer to ESRI ArcGIS documentation. (See help. arcgis.com/en/arcgisdesktop/10.0/help/index. html#//009t00000028000000.htm or refer to the georeferencing section).

> The J2W is the file extension of JPEG 2000 raster format. The TFW is the file extension of (Geo)TIFF raster format.

For Primary products the World File is adapted to assemble raster tile files, if any. At Primary level, World File has no ability for georeferencing the image (sensor geometry); please use XML metadata files (Dimap or RPC files).

A.2.2.4 KMZ File

> PREVIEW_<Product_ID>.KMZ: file encoding = ZIP, metadata format = KML V2.2

The KML fulfills the KML specification with the Google extension namespace. The Google extension is selected for advanced objects in KML. As specified by the OGC, these specific tags must be ignored by a KML parser based on the standard version V2.2.

The KML file is zipped with the associated PREVIEW image into a KMZ file for independent distribution such as email or web server.

The KML file is composed of six layers of features displayed or selected by double-clicking on the viewer. The places panel may be helpful to arrange hierarchically or expand the features. These layers provide a preview of features positioning. The associated place marks are textual information brought into DIMAP and GML mask files. The different layers are as shown in the following table:

Table A.10: KML Metadata File

Start Animation	A quick animation activated by double-clicking on the layer from the satellite to the dataset footprint (Viewer supporting Google extension).
Sources	The acquisition extent of source strip(s) and acquisition scan line positioning at the middle of the extract for the current product.
Sources Extracts	The outline extract(s) performed by the data production system for the current product.
Tiles	The footprint of each image tile with its media identifier.
Product	The footprint of the whole product (order polygon) and its PREVIEW image.
Logos Layer	

Figure A.1: KMZ Overview

Note: KML figures are provided for preview or discovering purposes only. For exact positioning, please refer to the metadata information. The reason is KML features are not necessary located at the true Ground Surface, but positioning with the following conventions:

- Sources – the source strip extent(s) at a mean elevation value over the complete strip area, using a rigorous model.

- Source extracts – the outline extract(s) at a mean elevation value over the complete extract area, using a simplified location model.

- Tiles – the footprint of each tile is positioned:

  – For Primary products, at a mean elevation value over the area of each individual tile. According to the relief, this elevation value may vary from tile to tile.

  – For Ortho products, at Ground surface, according to planimetric accuracy of the product.

- Product – the footprint of the product is positioned:

  – For Primary products, at the elevation values given at each vertex by the system DEM (possibly coarse).

  – For Ortho products, at Ground surface, according to planimetric accuracy of the product.

For products with a significant acquisition angle and/or on significant relief, some misalignments between KML features may occur, especially with Primary products. Thus, alignments should be made through a coarse projection on- ground. In Google Earth, we recommend to deactivate the 'Show terrain' option to avoid incorrect mapping.

A.2.2.5 Preview Raster File

PREVIEW_<*Product_ID*>.JPG: file format = JPEG

The subsampled image (also called a quicklook). Typically, the PREVIEW image is subsampled by a ratio of 32 towards the original image sampling (8 towards XS), i.e. approximately 22 m, and compressed. On the Basic radiometric option the original dynamic is dynamically stretched by threshold (by default 2%).

A.2.2.6 Thumbnail Raster File

ICON_<*Product_ID*>.JPG: file format = JPEG

This is the thumbnail of the image. The ICON image is sub-scaled from the PREVIEW image to fit a fixed size of 128 columns.

A.2.2.7 LUT metadata File

LUT_<*Product_ID*>.XML: file encoding = XML, metadata format = DIMAP V2

For Reflectance radiometric option only, the colour curves for true colour image rendering, in Look-Up-Table form. The LUT has the same syntax of VRT files (Raster Virtual format) adopted by GDAL or MapServer.

A.2.3 Sub-Levels with Additional Information

A.2.3.1 The Lineage Sub-Level

LINEAGE

The lineage directory deals with information about the processing history. It gathers files from the initial source data used to process the current product and also a processing metadata file.

A.2.3.2 Data Strip Source Metadata File

> STRIP_<DATA_STRIP_ID>_DIM.XML: file encoding = XML, metadata format = DIMAP V2

The data strip file relates to the full imagery strip used to generate the product. It is generally a variable portion extracted from a strip, given by the order polygon. For mosaic products resulting from the mosaicking of several input strips, extracts of each original data strip file are provided.

The information contained in data strip files relates to their processing level before the extraction of the product. As this internal processing level (Archive, L1...) is prior to the final product processing level, the content must be used for information use only or some raw data assessment by expert.

The specific metadata are in the following DIMAP groups:

Strip_ Identification	Brief identification of the strip, the mission and the instrument.
Acquisition_ Configuration	Configuration information and specific data about the spacecraft, its subsystems and instruments at strip acquisition.
Telemetry_ Acquisition	Downlink and receiving information.
Raster_Data	Raster file extracted from the original imagery strip.
Radiometric_Data	Erroneous data into the original data strip. Mosaic product only: radiometric data related to the input strip extract – dynamic range, histogram, radiometric calibration values for spectral range, solar irradiance.
Geometric_Data	Acquisition time and date of the full strip. Mosaic product only: precomputed, useful, geometric location data at a fixed posting related to the input strip extract – acquisition angles, solar incidence, ground sample distances.
Catalog	Coordinate of the strip as stored in the catalogue system.

Table A.11: Datastrip Source Metadata File

A.2.3.3 Ground Source Metadata File

> GROUND_R3D_OR_<Ref3D_Tile_ID>_DIM: file encoding = XML, metadata format = DIMAP V2

The ground source file describes the quality of the planimetric source data used to reset the native location of the image, if activated at the moment of the production launch.

This file is not supplied for products with no reset applied (native location of the sensor data).

For Standard products, the location reset is performed on the Reference3D™ database orthorectified layer, organised by square degree. For each tile used for the processing, the file stores the tile identifier and its accuracy values. The specific metadata are in the following DIMAP groups:

Source_Information	Name of the source data.
Source_Content	Source data identifier.
Quality_Assessment	Accuracy measurements (specification values).

Table A.12: Ground Source metadata fle

A.2.3.4 Height Source Metadata File

> HEIGHT_{R3D_DT2_<Ref3D_Tile_ID>, SRTM_DT1, GLOBE}_DIM.XML: file encoding = XML, metadata format = DIMAP V2

The height source file describes the quality of the elevation source data used at orthorectification to reset the off- nadir effects of the image caused by the relief in the orthorectification process.

For Standard Ortho products, the location reset is performed on the Reference3D™ database DTED2 layer. If Reference3D is unavailable, SRTM DTED1 is used; if SRTM is unavailable, the location reset is done on the global DTED0 DEM, also called Globe. For each tile used for the processing, the file stores the tile identifier and its accuracy values.

DIMAP groups: same as Ground Source metadata file.

A.2.3.5 Processing Metadata File

> PROCESSING_<Product_ID>_DIM: file encoding = XML, metadata format = DIMAP V2

The processing file describes the processing steps and the ground image processing parameters (GIPP) files activated during the process from the archiving system to standard level production. Downstream steps might not be documented. The specific metadata are in the following DIMAP groups:

Processing_Step_ List	Significant processes or events occurring during the dataset production.
Processing_ Parameter_List	Significant ground image processing parameters applied at dataset production.

Table A.13: Processing Metadata File

A.2.3.6 *The Mask Sub-level*

MASKS

The mask directory contains the overlaying masks delivered with the product in vector or raster format.

A.2.3.7 *Mask Files*

{ROI, CLD, SNW, QTE, DET, SLT, VIS, DTM}_<Product_ID>_MSK.GML: file encoding = XML, metadata format =
GML V3.1.1

GML vector masks are available for standard products. They are registered with the image product (same geometry and CRS) for overlaying purposes. They include:

- Masks related to an ordering parameter: cloud cover (CLD), snow indicator (SNW), technical quality rate (QTE).

- Masks built by the data process:

  - Product footprint (ROI, Region Of Interest – one per strip extract for mosaics, i.e. the intersection between the global ROI and each strip)

  - Image quality masks: out-of-order detectors (DET), saturation or straylight (SLT), hidden areas (VIS, visibility).

A.3 Metadata Contents and Organisation

The metadata is encoded in DIMAP format using XML scheme. DIMAP is a public-domain format for describing geographic data, developed in partnership with space agencies like CNES, SSC and ESA. The format was introduced in May 2002 for SPOT products. The format has been improved in 2012 with DIMAP V2. DIMAP V2 is the standard used by Airbus for Pléiades 1A, Pléiades 1B, SPOT 6 and SPOT 7 products, and other Ortho imagery.

For an overview of the main improvements brought by DIMAP V2, please refer to section *2.5 Product and Image Format*.

A.4 Image Format

Products are available in two raster formats:

- TIFF (including GeoTIFF)

- JPEG 2000

The file sizing is managed by image tiling. With the Basic option, both formats offer dynamic range (also called bit- depth or radiometric resolution) of 12 bits (4096 values) or 8 bits (256 values). The original 4096 scale into a 256 scale is performed with a linear adjustment.

The original 4096-bit scale could be recovered with the DIMAP group Dynamic_ Adjustment (MIN, MAX, BIAS, SLOPE).

A.4.1 JPEG 2000

The CODEC uses Part I of the JPEG 2000 standard, ISO/IEC 15444-1, plus some options of Part II. Using the Kakadu Library, settings should be expressed as (informative):

```
Sdims=\{4000,4000\} -flush_period 2048 Stiles=\{2048,2048\} Ssigned=no Sprecision=16 Cycc=yes
Creversible=yes Qstep=0.000015 Cblk=\{64,64\}
Clevels=5 Cuse_precincts=yes
Cprecincts=\{256,256\},\
{256,256\},\{128,128\},\{128,128\},\{64,64\}
Corder=RPCL ORGgen_plt=yes -no_weights -rate 9
Clayers=5.
```

Two compression schemes are available:

- JPEG 2000 Optimised is meant for users looking for fast download and easy data sharing. It has a compression of 3.5 bits/pixel. It uses the so-called lossy compression: the compression rate is optimised to avoid any spatial effect but is not reversible. A spectral effect of 1/1000 is tolerated.

- JPEG 2000 Regular is perfect for users willing to do some high precision post-processing. It has a compression of around 8 bits/pixel. It uses the so-called lossless compression: the JPEG 2000 compression is in this case completely reversible and does not include any effects in terms of information content.

- Both JPEG 2000 compressions ensure no impact in terms of image quality; however, they have a direct impact on the file size. The Regular compression file size is about twice as large as the Optimised compression file size.

A.4.2 TIFF

The file is coded according to the TIFF V1.0 specification. The 32-bit offset capability (4 GB) like BigTIFF is not used. The TIFF requires huge file sizes compared to JPEG 2000, as TIFF is not a compressed format and the 12-bit dynamic range is coded over 2 bytes (16 bits).

A.4.3 Image Tiling

Products exceeding a certain size limit are broken in several image pieces, called physical tiles. This limit is approximately:

- 2 GB file size for GeoTIFF products.

- Maximum 4 GB file size for JPEG 2000.

In the future, this limit could change as software capabilities progress.

The physical tiling is based on an orthonormal regular grid (as a matrix): y-axis for each row (Ri) and x-axis for each column (Cj) of the grid.

The tile size is constant, meaning all tiles have the same size, with a possible exception of the tiles in the last rows and columns, as black fill pixels are not included to fill the constant size.

- The tiles of the first row begin at the upper and left borders of the bounding rectangle of the AOI.

- The tiles of the last row and column are trimmed to the bottom and right borders of the bounding rectangle of the AOI.

- Tiles are not overlapping.

The product metadata file describes:

- The tiling characteristic for the full product (Raster_Data/ Raster_Dimensions).

- The list of all tiled images composing the product (Raster_Data/Raster_Access).

The Index metadata file (multi-volume) describes the distribution of tile images within one or several media.

A.5 Available Geographic and Cartographic Projections

Airbus DS Intelligence offers orthorectification in nearly any geodetic parameters and National Mapping System registered in the EPSG database.

A.5.1 Geographic Projections

A geographic projection is a simple mapping projection based on a geodetic datum and ellipsoid model of the Earth to convert the coordinates to a planar system as angular coordinates.

Geographic projections are related to WGS84 geodetic datum/ellipsoid in decimal degree angular unit. The pixels are regularly posted in latitude/longitude according to the two following zoned systems:

- DTED2: 5 zones: [0° to 50°], [50° to 70°], [70° to 75°], [75° to 80°], [80° to 90°] North or South latitude

- ARC: 8 zones: [0° to 32°], [32° to 48°], [48° to 56°], [56° to 64°], [64° to 68°], [68° to 72°], [72° to 76°], [76° to 80°] North or South latitude

Figure A.2: Tiling (below)

Non-tiled product

Media1
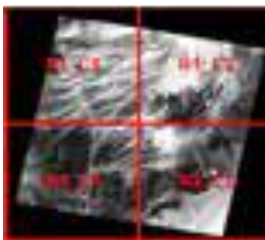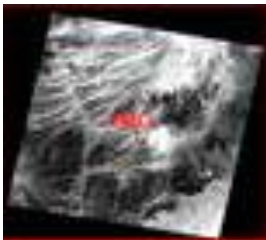
PHR*_001

IMG_*R1C1.JP2

Tiled product

Media1

PHR*_001

IMG_*R1C1.JP2

IMG*_R1C2.JP2

Media2

PHR*_001

IMG_*R2C.JP2

IMG*_R2C2.JP2

A.5.2 Mapping Projections

A mapping projection is based on a geodetic Coordinate Reference System (CRS) and uses a map projection model to convert the coordinates to a horizontal plane as Cartesian linear coordinates.

Mapping projections are related to National Mapping Agencies or International Authorities. The default parametre values are those registered in EPSG. The linear unit is the meter.

Some six hundred CRS mapping projections are offered for Standard Ortho Products. Others are available for Tailored Ortho Products. Please ask Customer Care Service for availability. The CRS should use one of the following map projection models.

Map Projections
Albers Equal Area
American Polyconic
Azimuthal
Equivalent
Azimuthal
Equidistant Bonne
Cassini-Soldner
Map Projections
Hotine Oblique Mercator
Laborde Oblique Mercator
Lambert Conic Conformal
(1SP) Lambert Conic
Conformal (2SP) Mercator
(1SP)
Mercator (2SP)
Oblique Mercator
Transverse Mercator
Transverse Mercator (South Oriented)
Mollweide
Oblique

Table A.14: Map Projections

A.6 How to Georeference the Image

The product offers various ways to georeference the image. The following table gives the corresponding fields, if relevant:

DIMAP	TIFF/GeoTIFF	JPEG 2000/GMLJP2	World File
NCOLS	ImageWidth	gml:high (1)	n/a
NROWS	ImageLength	gml:high (1)	n/a
NBITS	BitsPerSample	In Jp2h :ihdr	n/a
NBANDS	SamplesPerPixel	In Jp2h :ihdr	n/a
XDIM / YDIM	ModelPixelScaleTag	gml:offsetVector (2)	A / E
ULXMAP/ULYMAP	ModelPixelScaleTag	gml:pos	C / F
Projected_CRS or Geodetic_CRS	GTModelTypeGeoKey		n/a
PROJECTED_CRS_CODE	ProjectedCSTypeGeoKey	attribut SrsName	n/a
PROJECTED_CRS_NAME	PCSCitationGeokey		n/a
GeoDETIC_CRS_CODE	GeographicTypeGeoKey	attribut SrsName	n/a
GeoDETIC_CRS_NAME	GeoCitationGeokey		n/a
VERTICAL_CRS_NAME	VerticalCitationGeoKey		n/a
VERTICAL_CRS_CODE	n/a		n/a

(1) GML: counting from 0 (gml:high = NROWS-1 NCOLS-1); DIMAP & GeoTIFF: counting from 1 -- (2) GML: offset; DIMAP & GeoTIFF: dimension

Table A.15: Georeferencing

A.6.1 GMLJP2

The GMLJP2 header is stored in the XML box embedded in the JPEG 2000 file according to the OGC V1.0 Specification (OGC-05-047r3): JPEG 2000 Part I (XML BOX) and II (label BOX and association BOX).

- Primary products: the image is in sensor geometry, header does not have any geocoding information and uses a simple grid feature scheme (column, row axis).

- Projected and Ortho products: the header uses the RectifiedGrid feature type scheme (grids.xsd):

  - Upper left pixel as the location origin and a vector that specify the posting locations into the image. Axes are ordered in conformity with EPSG standard. For instance, WGS84 geographic projection (EPSG: 4326) axis 1=Geodetic latitude, axis 2=Geodetic longitude (y then x). Most software packages manage this automatically using a lon/lat order (x then y) by default.

  - Coordinate Reference System (CRS) encoding in conformance with the EPSG standard.

A.6.2 GeoTIFF Tags

The GeoTIFF tags are embedded in the TIFF file, according to the GeoTIFF V1.0 Specification:

- Primary products: the image is in sensor geometry, no GeoTIFF information (column, row axis).

- Projected and Ortho products:

  - Upper left pixel as the location origin and a dimension for sizing the pixel.

  - Coordinate Reference System (CRS) encoding in conformance with the EPSG standard (if unknown 'user-defined' encoding).

A.6.3 World File

Georeferencing with World File is dedicated for images in map geometry: Projected, Ortho.

For an image processed in sensor geometry processing level (Primary), the georeferencing must be performed though a geometric model. Please refer to the RPC metadata file or the geometric modelling section.

One World File is associated with each image tile. It describes the georeferencing through an affine transformation. The six parameters of the affine transformation are in the form:

$$x1 = A_x + B_y + C$$
$$y1 = D_x + E_y + F$$

Where:

x1 = calculated x-coordinate of the pixel on the Ground CRS

y1 = calculated y-coordinate of the pixel on the Ground CRS

x = column number of a pixel in the image y = row number of a pixel in the image

A = x-scale; dimension of a pixel in CRS units in x direction (XDIM)

B, D = rotation terms

C, F = translation terms; x, y CRS coordinates of the
centre of the upper left pixel (UL{X,Y}MAP)

E = negative of y-scale; dimension of a pixel in CRS
units in y direction (YDIM)

For the Projected and Ortho products, the CRS is the one formatted with the product.

For Primary products, the World File is adapted to assemble raster tile files, if any. The CRS is the raster Coordinate System (column, row).

The y-scale (E) is negative because the origins of an image and a Ground coordinate system are different. Row values in the image increase from the origin downward, while y-coordinate values in the map increase from the origin upward.

The rotation terms B and D are always set to zero value (meaning no rotation needed).

The translation terms C and F, for tilled images, are the location of the centre of the upper left pixel for each tile.

The World File is an ASCII file containing six lines, giving the six parameters in the following order (one per line):

Parameter	Example
A	20.17541308822119
D	0.00000000000000
B	0.00000000000000
E	-20.17541308822119
C	424178.11472601280548
F	4313415.90726399607956

Table A.16: Projected or Ortho Worldfile

Parameter	Example
A	1
D	0
B	0
E	-1
C	1
F	-1

Table A.17: PRIMARY Worldfile

Appendix B: Image Quality and Resampling Process

B.1 Image Quality Commitments

The following table gives our commitments to image quality performances that are significant for the user.

The measurements are expressed as:

- Geometry – inside the cone of 30° around nadir.

- Radiometry – at nearly 100 W/m²/sr/microns (L2).

- Resolution – no sampling factor. Bpp= 2.86 for Pan and 3.33 for MS.

Abbreviations

MTF: Modulation Transfer Function; SNR: Signal to Noise Ratio; IQF: Image Quality Factor; bpp: bit per pixel.

MTF/SNR: Satellite = RAW data; Restored = after Ground deconvolution

Image Quality Item	IQ Commitment	Remark
GEOMETRY – Global		
Dynamic Effect (high frequency jittering)	< 0.2 pixel Pan LE99.7	
GEOMETRY – Rigorous/RPC Geometric Model accuracy without GCP: with ancillary data only		
Location accuracy	6.5m CE90 @ Nadir	With refined data
MS Registration	< 0.2 pixel MS CE99.7	
MS and Pan Co-registration	< 0.2 pixel MS CE99.7	
Global RPC vs. Rigorous Model	< 0.1 pixel PAN CE90	
GEOMETRY – Rigorous/RPC Geometric Model accuracy reset on (perfect) GCP and DEM auxiliary data		
Planimetric Accuracy (Panchromatic)	0.35m CE90	
Vertical accuracy (Pan) B/H=0.5 (absolute error)	0.8m LE90	Slopes < 20%
Vertical Accuracy (Pan) B/H=0.25 (absolute error)	1.2m LE90	Slopes < 20%

Image Quality Item	IQ Commitment	Remark
RADIOMETRY **Radiometric Model accuracy** **(DN conversion to Radiance) Known** **accuracy performance with pre-launch** **measurement**		
Absolute Calibration	Panchromatic: <5% Blue/Green: <5% Red/NIR: <5%	
Relative Cross-band Calibration Relative Multi-temporal Calibration	<5% 1%	
Cross-satellite calibration	2%	
RESOLUTION		
Satellite MTF (X/Y axis): Panchromatic	Pan: 0.16/0.15	
Satellite SNR: Panchromatic	Pan: 160	
IQF (MTF x SNR): Panchromatic	Pan: 25/24	
Restored MTF (target): Panchromatic	0.39	
Satellite MTF (X/Y axis): Multispectral	Blue: 0.3/0.25	
Satellite SNR: Multispectral	Blue: 150 Green: 155 Red: 155 NIR: 195	
IQF (MTF x SNR): Multispectral	Blue: 45/37 Green: 46.2/39 Red: 46/39 NIR:	

Table B.1: Commitments to image quality performances

B.2 Principle of Image Resampling

B.2.1 Introduction

CCD arrays working in Time Delay Integration (TDI) mode are used for Panchromatic detection. To acquire images over a field of view of 20 km, five arrays of 6000 pixels each are used, which give 30,000 columns.

The choice of TDI technology allows images to be obtained with a SNR that meets the system specifications.

Panchromatic images are acquired with a nadir resolution of 70 cm. Products prepared for users will be resampled to correct geometric distortions related to:

*   The instrument and the platform motion (Primary).

*   The terrain relief (Ortho).

The impact of the resampling on the image quality is carefully considered. The interpolation filter must guarantee that the information content of the raw image quality is preserved. Moreover, users often apply further processing on system products, and consequently resample the image. It is therefore important to generate system products (Primary or Ortho), robust with regard to further processing.

To satisfy the two above-mentioned criteria, the optimal solution chosen by CNES and demonstrated through experimentation, consists of applying a zooming factor, leading to a sampling distance of 50 cm on ground (Projected or Ortho). This zooming enhancement is effective thanks to a specific restoration method, developed and validated by CNES.

B.2.2 Why 50 cm?

B.2.2.1   Accessible Spatial Frequencies

Pléiades raw images are sampled in a way (70 cm) which is consistent with the value of the instrument MTF, at Nyquist frequency. Consequently, they are free of aliasing artifacts. However, higher spatial frequencies than the Nyquist frequency (line or column) do exist within the image.

Finer details correspond to contours and modulations at +/- 45° with respect to raw lines and columns, as shown in *Figure B.1* at the foot of the page.

It is therefore possible to identify on Pléiades images details rotated by 45°, corresponding to spatial frequency, i.e. 1m-1 for nadir viewing. This kind of object is quite common in industrial areas (networks, linear structures). More generally, 'diagonal' patterns are rendered thinner than vertical or horizontal patterns.

The following image is extracted from a Panchromatic Pléiades image, including a radial pattern. It illustrates the resolution variation along different directions.
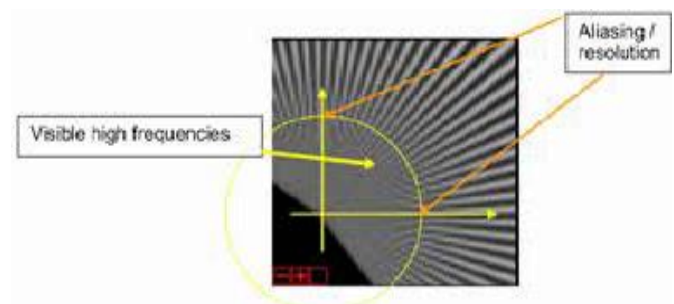
Figure B.2: Iso-frequency line

The yellow circle describes an iso-frequency line: on line and column axis, the pattern disappears quickly inside the circle, and is still visible around the diagonal direction (45°).

B.2.2.2   Restoration of the Panchromatic Band

The restoration processing includes a deconvolution. The raw Panchromatic image must be deconvoluted to compensate for the contrast reduction (Instrument MTF).
This restoration processing is followed by the application of a zooming factor on the Panchromatic band at the end of this process.

Spatial domain	Frequency domain
Sampling grid with p step	Inverse cell = square [-fe/2, fe/2]²

Figure B.1: Spatial Domain vs. Frequency Domain
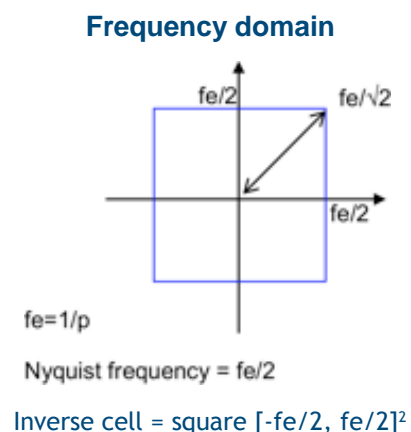
B.2.3 Zooming Before Interpolation

To preserve the raw image contents, it must be possible to rotate the inverse cell within the extended frequency domain. The zooming factor to be applied to the Primary image is therefore 1.414 (7/5), which gives a sampling distance of 50 cm at Projected or Ortho levels for Panchromatic Pléiades images.

In these conditions, the raw image spectrum is always included within the final inverse cell, for any rotation applied on the image during further processing. The 45° worst case scenario is shown in the following figure.
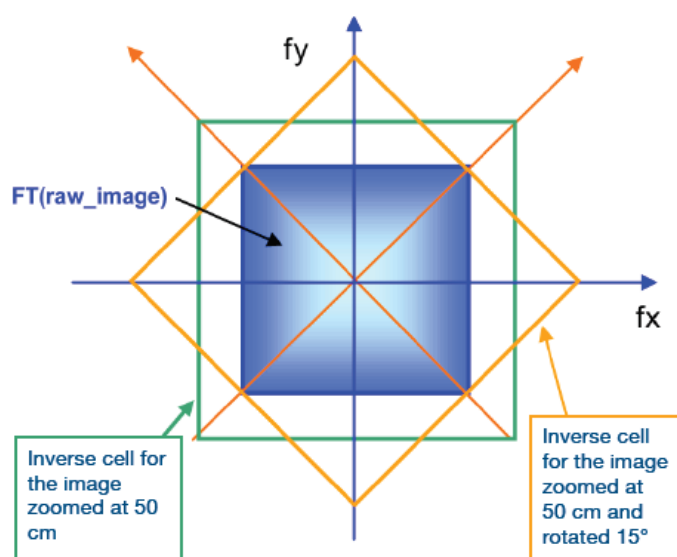
Figure B.3: Raw image and final inverse cell
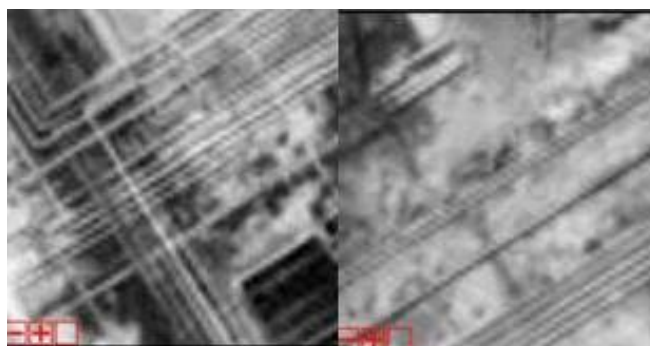
Figure B.4: Raw images resampled at 70 cm

The improvement brought by zooming to 50 cm is clearly demonstrated in the extracts shown in Figure B.5 at the foot of the page.

The first column shows images, 45° rotated, sampled with a 70 cm GSD.

The two last columns show 50 cm resampled images and then 45° rotated, zoomed using a spline 5 filter (column 2). Column 3 shows the result of a bicubic filter.

The benefits of the 50 cm zooming are significant and have been confirmed through experiments, notably by defence photo-interpreters:

- Images in the last two columns reflect a better image quality, in terms of information content.

- Further downstream processing applied by users on 50 cm images maintains the image quality (robustness) and are not impacted by the type of interpolation used.
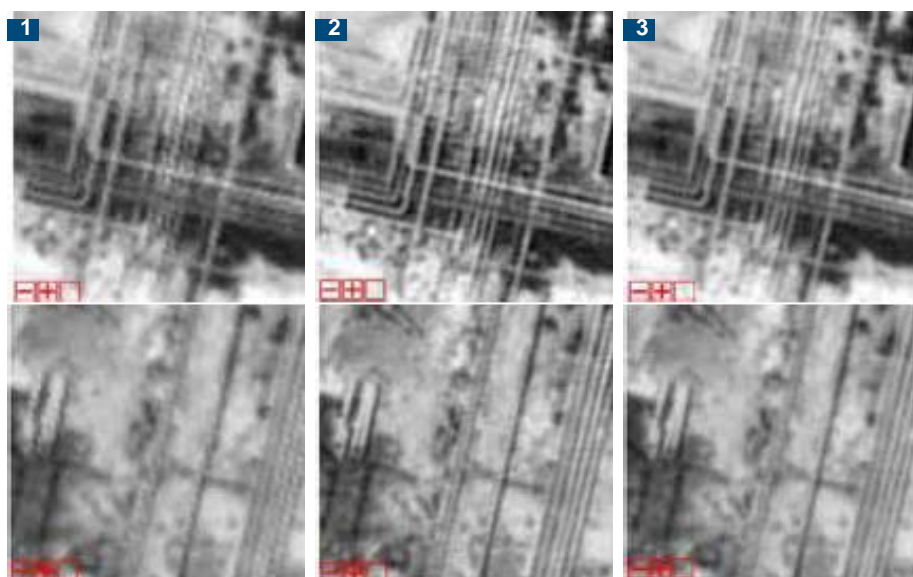
1 45° rotated – GSD = 70 cm bicubic resampling

2 45° rotated – GSD = 50 cm spline 5 resampling

3 45° rotated – GSD = 50 cm bicubic resampling

Figure B.5: Visual Enhancements Achieved Thanks to 50 cm Resampling

Appendix C: Geometric Modelling

The aim of geometric modelling is to describe the relationship between image and ground coordinates for a given sensor.

C.1 Geometry

Pléiades raw products are very complex and not user-friendly, due in particular to the complexity of the detector layout in the focal plane. For instance, the Panchromatic raw focal plane is composed of five slightly angled arrays. (See *Figure C.1* below.)

The Primary product has been designed to remove this complexity and offer end users a simple product with state- of-the-art geometric and radiometric accuracy. Technically, the Primary processing is also called Sensor, Perfect Sensor or Virtual Sensor.

The geometric reference frame for Primary imagery simulates the imaging geometry of a single pushbroom linear array, located very close to the raw Panchromatic TDI arrays. Besides, this ideal array is supposed to belong to a perfect instrument with no optical distortion and carried by a platform with no high attitude perturbations.
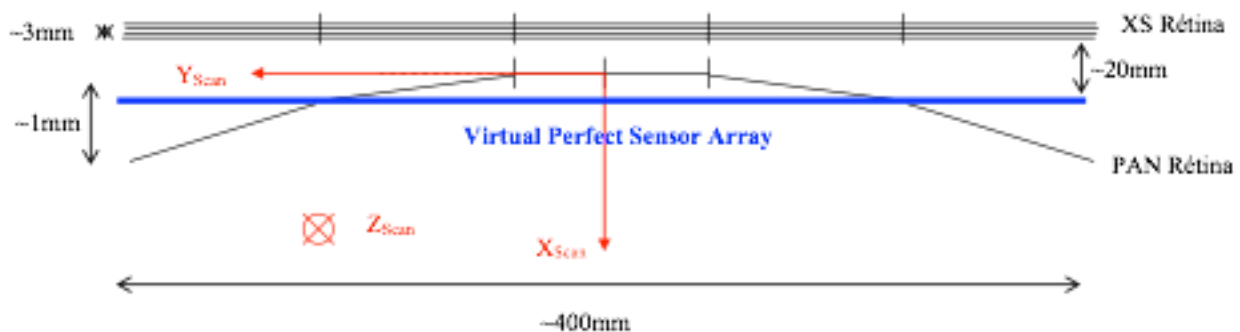
Figure C.1: Raw Focal Plane Layout and Location of Primary Virtual Array

Global viewing angle from satellite α (°)	PAN GSD (cm)	MS GSD (m)	SWATH (km) width	PAN GSDc (cm)	MS GSDc (m)	SWATHc (km) width	GSDc-GSD (cm)	GSD Error (%)
Please refer to part C.4.1 for more details	Without taking into the rotundity of the Earth			Taking into the rotundity of the Earth			-	-
-	70	2.8	20.0	70	2.8	20.0	0.0	0%
5	70	2.8	20.0	70	2.8	20.0	0.1	0%
10	72	2.9	20.6	72	2.9	20.6	0.4	1%
15	75	3.0	21.4	76	3.0	21.7	0.9	1%
20	79	3.2	22.6	81	3.2	23.1	1.8	2%
25	85	3.4	24.3	88	3.5	25.1	3.3	4%
30	93	3.7	26.6	99	3.9	28.3	5.6	6%
35	104	4.2	29.7	114	4.5	32.6	9.6	8%
40	119	4.8	34.0	135	5.4	38.6	16.5	12%
45	140	5.6	40.0	169	6.8	48.3	29.5	17%
47	150	6.0	42.9	188	7.5	53.7	37.8	20%

Table C.1: GSD vs viewing angle

This attitude variation correction (made with a polynomial fitting) allows for both simple attitude Modelling and more accurate precision of the imaging geometry by the rational functions sensor model.

The Primary product GSD is related to the raw imagery resolution, which varies between 70 cm (at nadir) to ~1 m (30° viewing angle) for Panchromatic products, and 2.8 m (at nadir) to ~4 m (30° viewing angle) for Multispectral imagery (see *Table C.1*). To ensure perfect radiometric accuracy and image restoration, the end product is zoomed with an optimised ratio of 7/5.

Notes

$$GSD = h_{sat}.\tan(\alpha + IFOV) - h_{sat}.\tan(\alpha),$$

without taking into account the rotundity of the Earth (roundly the viewing angle)

$$GSD_c = R_E.\left[\frac{\left(1+\frac{h_{sat}}{R_E}\right).\cos(\alpha)}{\sqrt{1-\left(1+\frac{h_{sat}}{R_E}\right)^2.\sin^2(\alpha)}} - 1\right].IFOV$$

taking into account the rotundity of the Earth (roundly the incidence angle); with:

h$_{sat}$ (km)	695
PAN IFOV (rad)	1.00E-06
MS IFOV (rad)	4.00E-06
Earth	
Semi-major axis (km)	6378.14
Semi-minor axis (km)	6356.75
R_E (km) (mean)	6367.45

C.2 Using the Physical Model for the Primary Products

Two reference frames are used in the physical model for Primary products: image focal plane frame and geocentric Earth frame.
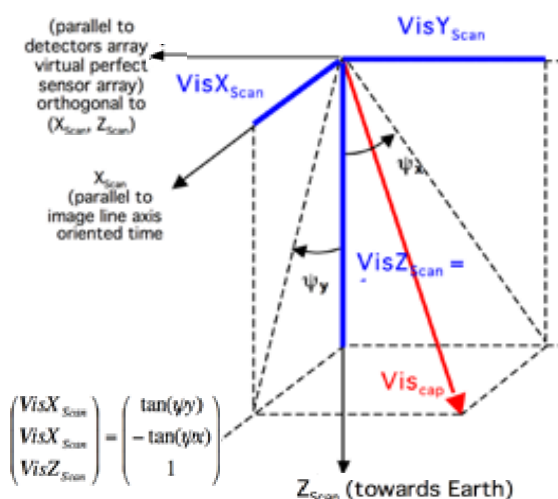
Figure C.2: Image focal plane frame
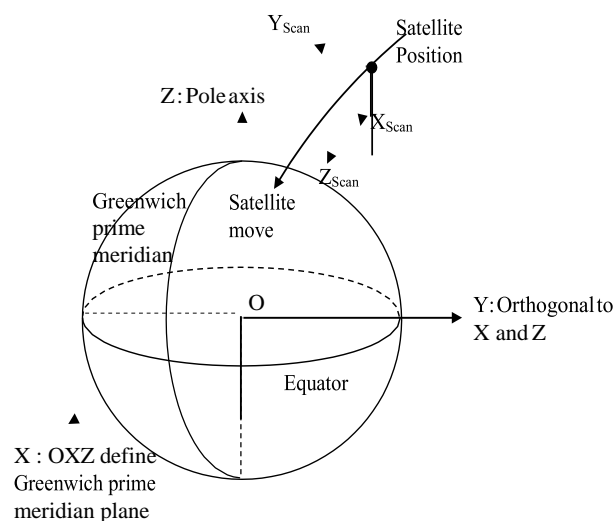
Figure C.3: Geocentric earth frame (WGS84)
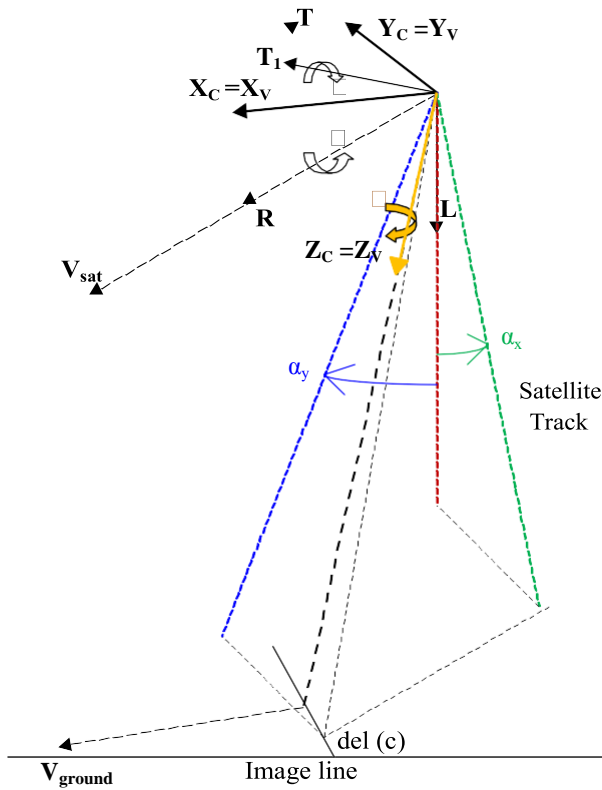
Figure C.4: Frames summary

C.2.1 Direct Localisation: Image to the Ground

Given image coordinates (col, lin) and altitude h, ground geographic coordinates (l, j) can be found by using physical model data. The ground coordinates may be calculated as followed:

Viewing time calculation for a given image line $t_{lin} = t_{ref}° + period* (lin – lin_{ref})$
Default value: $lin_{ref} = 1$

Calculation of viewing angle in image focal plane frame for a given column image (detector):

Apply the polynomial models:

$$TanPsiX = \sum_{i=0}^{n} CoeffPsiX_i * (col - col_{ref})^i$$

$$TanPsiY = \sum_{i=0}^{n} CoeffPsiY_i * (col - col_{ref})^i$$

Calculation of the viewing angle in the image focal plane frame:

$$\begin{pmatrix} VisX_{Scan} \\ VisY_{Scan} \\ VisZ_{Scan} \end{pmatrix} = \begin{pmatrix} TanPsiY \\ -TanPsiX \\ 1 \end{pmatrix}$$

Notes

- Image orientation and satellite track are different

- In case of Virtual Perfect Sensor Array, image focal plane frame (X_{Scan}, Y_{Scan}, Z_{Scan}) and frame to pilot (Xv, Yv, Zv) are identical

- A quaternion polynomial describes satellite attitude. At a given time, one can compute the quaternion and build directly the transformation matrix between image focal plane frame and geocentric earth frame (WGS84)

- All the data needed by the physical model is in the 'DIM_*.XML' metadata file under the node <Refined_ Model>

- All acquisitions times and dates are expressed in UTC

- All satellite locations are expressed in Cartesian coordinates (O, X, Y, Z) in the ECF frame WGS84

- In the dataset extent, ground coordinates of vertex are expressed in geographic coordinates (unit degrees). These values are computed at their estimated elevations. The centre value is an average of vertex values.

- All of these coordinates are related to the WGS84 geodetic system

$$\begin{pmatrix} VisX_{Scan} \\ VisX_{Scan} \\ VisZ_{Scan} \end{pmatrix} = \begin{pmatrix} tan(\psi y) \\ -tan(\psi x) \\ 1 \end{pmatrix}$$

Figure C.5: Viewing angle in image focal plane frame

Satellite location interpolation for a given time

Centring acquisition times and dates is recommended:

$$t_{mean} = \frac{\sum_{i=1}^{m} t_i}{m} \quad \text{and} \quad trel_i = t_i - t_{mean}$$

Each satellite location component (PosX, PosY, PosZ), is calculated by Lagrange interpolation with n samples:

$$PosX(t) = \sum_{i=1}^{n} \frac{\prod_{j=1, j \neq i}^{n}(trel - trel_j)}{\prod_{j=1, j \neq i}^{n}(trel_i - trel_j)} * PosX(t_i)$$

- n = 8 is recommended when time step between sample is 30 s.

The same formula is used to compute PosY(t) and PosZ(t).

In order to compute the viewing direction in the Earth geocentric frame, only the attitude quaternion is used (transformation between image focal plane frame and earth geocentric frame). Velocity data is not necessary for viewing direction orientation.

Velocity is used when the user would like to improve the model (computation of Orbital Local Frame Axis, which needs satellite inertial velocity in WGS84 ECF frame).

Satellite orientation interpolation for a given time

Centred normalised time value calculation:

$$t_{CN} = \frac{(t - offset)}{scale}$$

With: 'offset' = the UT time (in number of seconds from midnight) of the middle of image acquisition.

Apply polynomials for each quaternion component – Q0, Q1, Q2, and Q3:

$$Q0 = \sum_{i=0}^{n} CoeffQ0_i * t_{CN}^i$$

The same formula is used for Q1, Q2, and Q3.

Attitude quaternion normalisation and transfer matrix calculation between image focal plane frame and geocentric earth frame

Quaternion normalisation:

$$norme = \sqrt{Q0^2 + Q1^2 + Q2^2 + Q3^2}$$

$$\begin{pmatrix} w \\ x \\ y \\ z \end{pmatrix} = \begin{pmatrix} \dfrac{Q0}{norme} \\ \dfrac{Q1}{norme} \\ \dfrac{Q2}{norme} \\ \dfrac{Q3}{norme} \end{pmatrix}$$

Transformation matrix calculation between the image
focal plane frame and the geocentric Earth frame:

$$Mat_{PF \rightarrow Ter} = \begin{pmatrix} w^2 + x^2 - y^2 - z^2 & 2.*(x*y - w*z) & 2.*(x*z + w*y) \\ 2.*(x*y + w*z) & w^2 - x^2 + y^2 - z^2 & 2.*(y*z - w*x) \\ 2.*(x*z - w*y) & 2.*(y*z + w*x) & w^2 - x^2 - y^2 + z^2 \end{pmatrix}$$

Calculation of the viewing angle in the geocentric Earth frame

Apply the transformation matrix on the viewing angle in
the image focal plane frame:

$$\begin{pmatrix} VisX_{Ter} \\ VisY_{Ter} \\ VisZ_{Ter} \end{pmatrix} = Mat_{PF \rightarrow Ter} * \begin{pmatrix} VisX_{Scan} \\ VisY_{Scan} \\ VisZ_{Scan} \end{pmatrix}$$

Ground position computation given satellite location, viewing angle (in geocentric earth frame) and earth model (ellipsoid)

Given:

Satellite location at a given time:

$$\overrightarrow{Pos} = \begin{pmatrix} PosX(t) \\ PosY(t) \\ PosZ(t) \end{pmatrix}$$

Viewing angle in geocentric Earth frame:

$$\overrightarrow{Vis} = \begin{pmatrix} VisX_{Ter} \\ VisY_{Ter} \\ VisZ_{Ter} \end{pmatrix}$$

Earth model (ellipsoid) with two axes (a, b)

Find the point on the ground at height h above ellipsoid.

Note

Finding the intersection point between the viewing direction and an ellipsoid (a + h, b + h) is different than finding the point at height h (see Figure C.6 below).

The method is iterative in order to find the substitute ellipsoid (a + h + dh, b + h + dh), which gives the point at height h above ellipsoid.
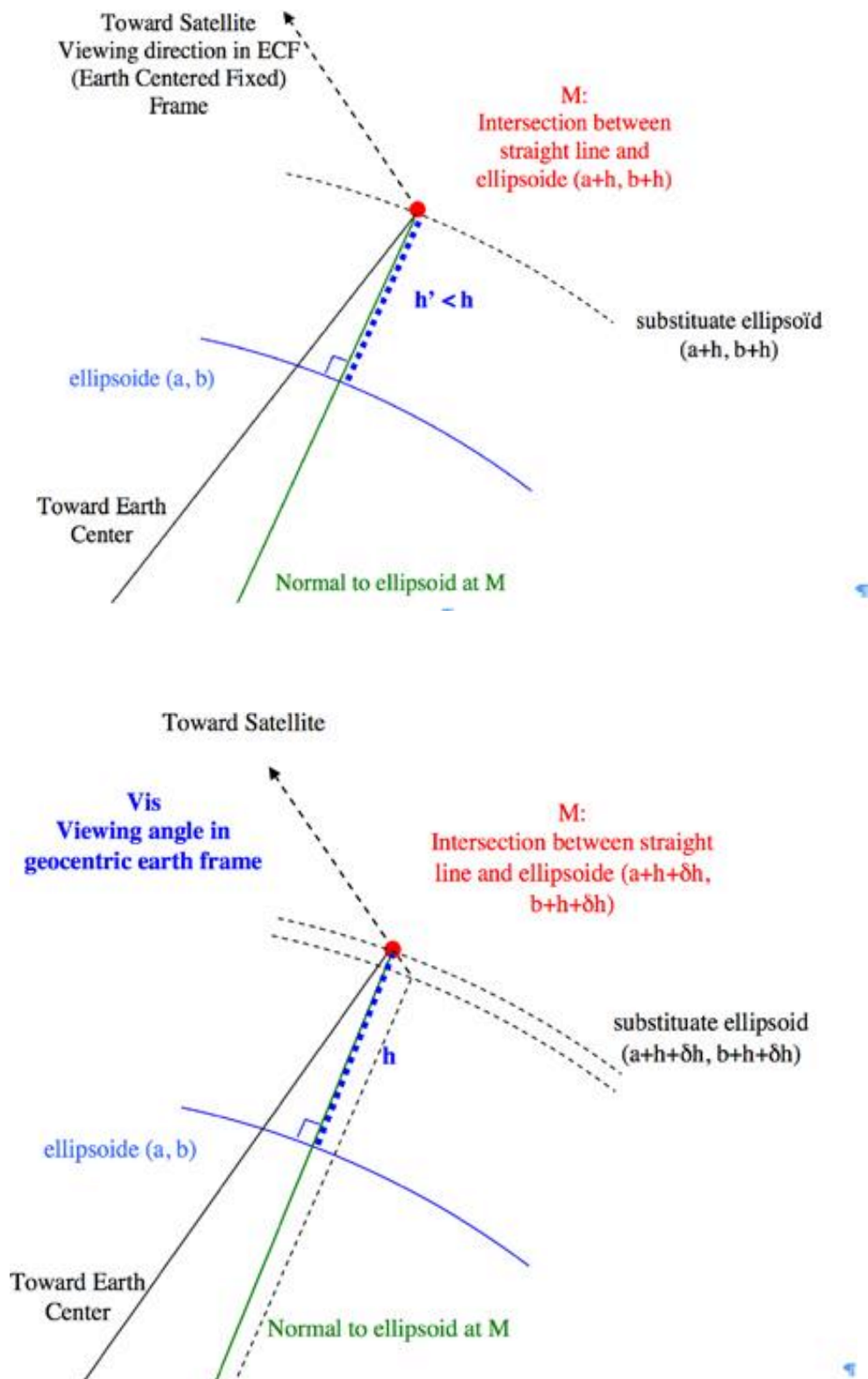
Figure C.6: Find the point on the ground at the right altitude H

Let's start with he = h.

Do {

Compute point M (X, Y, Z) in ECF frame: Intersection between viewing direction and substitute ellipsoid (a + he, b + he).

(X, Y, Z) coordinates are the solution of the
following equation system:

$$\begin{bmatrix} PosX_{(t)} - X \\ PosY_{(t)} - Y \\ PosY_{(t)} - Y \end{bmatrix} = a* \begin{bmatrix} VisX_{Ter} \\ VisX_{Ter} \\ VisX_{Ter} \end{bmatrix}, (1)$$

$$\frac{X^2 + Y^2}{(a + he)^2} + \frac{Z^2}{(b + he)^2} = 1 \quad , (2)$$

Equation (1) means that point M belongs to the viewing direction straight line: satellite location, viewing direction.

Equation (2) means that point M belongs to the substitute ellipsoid (a + he, b + he).

Finding the solution is equivalent to solve a quadratic equation (unknown α).

The solution is the smallest root.

Transform orthogonal coordinates (X, Y, Z) into geographic coordinates and height above ellipsoid (λ, φ, η').

See: http://geodesie.ign.fr/contenu/ fichiers/documentation/algorithmes/ notice/NTG_80.pdf

ALG0012 – Coordinate transformation: Cartesian coordinates ➔ Geographic coordinates

Calculate the height difference: $\delta h = h - h'$

Continue with he += δh

Metadata values for physical model are already corrected of light transmission delay and relativist effects.

The preceding algorithm is available for the first approximate localisation. Metadata values are not corrected of atmospheric refraction effect. The magnitude of this correction is a function of the viewing angle (null at nadir).
Theoretically the corresponding geolocation error will be around 2m at 15° viewing angle, but is not confirmed by experiment using such correction.

C.2.2 Inverse Localisation: Ground to Image

Given ground plane coordinates (λ, φ) and an altitude h, find the image coordinates (col, lin) by using the physical model.

First, it is necessary to calculate an inverse localisation predictor at different altitudes.

This may be calculated as follows:

Calculation of a direct localisation grid at different altitudes.

(col, lin) ➔ $(\lambda, \varphi)_{h1} (\lambda, \varphi)_{hi} (\lambda, \varphi)_{hn}$

For each altitude, compute an inverse localisation predictor by least-squares using grid samples (col, lin, l, j):

$col_{hi} = f_{hi} (\lambda, \varphi)$

$lin_{hi} = g_{hi} (\lambda, \varphi)$

Compute an approximation of the image position.

Apply the polynomial at different altitudes:

$col_{h1} = f_{h1}(\lambda, \varphi)$ $col_{hi} = f_{hi}(\lambda, \varphi)$ $.colhn = f_{hn}(\lambda, \varphi)$

$lin_{h1} = g_{h1}(\lambda, \varphi)$ $lin_{hi} = g_{hi}(\lambda, \varphi)$ $.linhn = g_{hn}(\lambda, \varphi)$

Interpolate the approximate image position at the given altitude h:

$col\_app_h = Interpolate (col_{h1}, \ldots col_{hi}, \ldots col_{hn})$

$lin\_app_h = Interpolate (lin_{h1}, \ldots lin_{hi}, \ldots lin_{hn})$

Let's start the iterative process with the approximate image position:

$col_{cur} = col\_app_h$

$lin_{cur} = lin\_app_h$

Do {

    Direct localisation function is applied on the current image position at altitude h in order to obtain the current ground position:

        DirLoc (col$_{cur}$, lin$_{cur}$, h) ➜ (λ_{cur}, φ_{cur})

    Calculate the difference between the current ground coordinates and the target ground coordinates:

        dλ = (λ – λ_{cur})

        dφ = (φ – φ_{cur})

    Calculate the image coordinates variation corresponding to the ground coordinates difference by using inverse partial derivatives:

$$\begin{pmatrix} dcol \\ dlin \end{pmatrix} = \begin{pmatrix} \dfrac{\partial \lambda}{\partial col} & \dfrac{\partial \lambda}{\partial lin} \\ \dfrac{\partial \varphi}{\partial col} & \dfrac{\partial \varphi}{\partial lin} \end{pmatrix}^{-1} * \begin{pmatrix} d\lambda \\ d\varphi \end{pmatrix}$$

    Apply the correction to the current image coordinates:

        col$_{cur}$ += dcol

        lin$_{cur}$ += dlin

}

The process iterates until image coordinates converge (image coordinates difference (dcol, dlin) less than a tolerance parameter).

C.3 Using the Analytical Model or the Rational Polynomial Coefficient (RPC) Model

All the data relative to the rational polynomial coefficient model (RPC) are in the RPC file (RPC_*.xml).

The polynomial coefficients order follows the NITF 2.1 norm (RPC00B model).

The rational polynomial coefficient (RPC) model is an analytical model which gives a relationship between:

- Image coordinates + altitude and ground coordinates (direct model: image ➜ ground)

- Ground coordinates + altitude and image coordinates (inverse model: ground ➜ image)

Ground coordinates used by inverse model or calculated by direct model are (longitude, latitude) in WGS84 geodetic system, the 'altitude' used is a height above ellipsoid.

As NITF has only documented inverse models, inverse model is the most popular method in COTS.

All coordinates must be centre-normalised.

Centre-normalised coordinates are calculated as

    followed: col$_{CN}$ = (col – SAMP_OFF) / SAMP_SCALE
    lin$_{CN}$ = (lin – LINE_OFF) / LINE_SCALE
    lon$_{CN}$ = (lon – LONG_OFF) / LONG_SCALE
    lat$_{CN}$ = (lat – LAT_OFF) / LAT_SCALE
    alt$_{CN}$ = (h$_{ground}$ – HEIGHT_OFF) / HEIGHT_SCALE

C.3.1 Direct Localisation Algorithm

When using direct model (image ➜ ground), users give image coordinates (col, lin) and an altitude (alt). The results of the application model are geographic coordinates (lon, lat).

Transform image coordinates into centre-normalised image coordinates:

    col$_{CN}$ = (col – SAMP_OFF) / SAMP_SCALE
    lin$_{CN}$ = (lin – LINE_OFF) / LINE_SCALE

Transform altitude coordinate into centre-normalised altitude coordinate:

    alt$_{CN}$ = (alt – HEIGHT_OFF) / HEIGHT_SCALE

For direct model, the rational function polynomial equations are defined as:

$$lon_{CN} = \frac{\sum\limits_{i=1}^{20} SAMP\_NUM\_COEFF_i \bullet \rho_i(lin_{CN}, col_{CN}, alt_{CN})}{\sum\limits_{i=1}^{20} SAMP\_DEN\_COEFF_i \bullet \rho_i(lin_{CN}, col_{CN}, alt_{CN})}$$

$$lat_{CN} = \frac{\sum\limits_{i=1}^{20} LINE\_NUM\_COEFF_i \bullet \rho_i(lin_{CN}, col_{CN}, alt_{CN})}{\sum\limits_{i=1}^{20} LINE\_DEN\_COEFF_i \bullet \rho_i(lin_{CN}, col_{CN}, alt_{CN})}$$

The rational function polynomial equation numerators and denominators are each 20-term cubic polynomial functions of the form:

$$\sum\limits_{i=1}^{20} C_i \bullet \rho_i(lin_{CN}, col_{CN}, alt_{CN}) =$$

$$C_1 \ldots\ldots\ldots + C_6 \bullet col_{CN} \bullet alt_{CN} + C_{11} \bullet lin_{CN} \bullet col_{CN} \bullet alt_{CN} + C_{16} \bullet lin_{CN}^3$$
$$+ C_2 \bullet col_{CN} \ldots\ldots + C_7 \bullet lin_{CN} \bullet alt_{CN} + C_{12} \bullet col_{CN}^3 \ldots\ldots\ldots + C_{17} \bullet lin_{CN} \bullet alt_{CN}^2$$
$$+ C_3 \bullet lin_{CN} \ldots\ldots + C_8 \bullet col_{CN}^2 \ldots\ldots + C_{13} \bullet col_{CN} \bullet lin_{CN}^2 \ldots\ldots + C_{18} \bullet col_{CN}^2 \bullet alt_{CN}$$
$$+ C_4 \bullet alt_{CN} \ldots\ldots + C_9 \bullet lin_{CN}^2 \ldots\ldots + C_{14} \bullet col_{CN} \bullet alt_{CN}^2 \ldots\ldots + C_{19} \bullet lin_{CN}^2 \bullet alt_{CN}$$
$$+ C_5 \bullet col_{CN} \bullet lin_{CN} + C_{10} \bullet alt_{CN}^2 \ldots\ldots + C_{15} \bullet col_{CN}^2 \bullet lin_{CN} \ldots\ldots + C_{20} \bullet alt_{CN}^3$$

Where coefficients C1..C20 represent the following sets of coefficients:

SAMP_NUM_COEF_n, SAMP_DEN_COEF_n, LINE_NUM_COEF_n, LINE_DEN_COEF_n, which can be found under the node 'Direct Model' in the RPC file.

Transform centre-normalised ground coordinates into ground coordinates:

lon = lonCN * LONG_SCALE + LONG_OFF

lat = latCN * LAT_SCALE + LAT_OFF

C.3.2 Inverse Localisation Algorithm

When using the inverse model (ground ➜ image), the user supplies geographic coordinates (lon, lat) and an
altitude (alt). The results of the application model are image coordinates (col, lin).

Transform ground coordinates into centre-normalised ground coordinates:

lonCN = (lon – LONG_OFF) / LONG_SCALE

latCN = (lat – LAT_OFF) / LAT_SCALE

Transform altitude coordinate into centre-normalised altitude coordinate:

altCN = (alt – HEIGHT_OFF) / HEIGHT_SCALE

For inverse model, the rational function polynomial equations are defined as:

$$col_{CN} = \frac{\sum_{i=1}^{20} SAMP\_NUM\_COEFF_i \bullet \rho_i(lat_{CN}, lon_{CN}, alt_{CN})}{\sum_{i=1}^{20} SAMP\_DEN\_COEFF_i \bullet \rho_i(lat_{CN}, lon_{CN}, alt_{CN})}$$

$$lin_{CN} = \frac{\sum_{i=1}^{20} LINE\_NUM\_COEFF_i \bullet \rho_i(lat_{CN}, lon_{CN}, alt_{CN})}{\sum_{i=1}^{20} LINE\_DEN\_COEFF_i \bullet \rho_i(lat_{CN}, lon_{CN}, alt_{CN})}$$

The rational function polynomial equation numerators and denominators are each 20-term cubic polynomial functions of the form:

$$\sum_{i=1}^{20} C_i \bullet \rho_i(lat_{CN}, lon_{CN}, alt_{CN}) =$$

$$C_1 \ldots\ldots + C_6 \bullet lon_{CN} \bullet alt_{CN} + C_{11} \bullet lat_{CN} \bullet lon_{CN} \bullet alt_{CN} + C_{16} \bullet lat_{CN}^3$$
$$+ C_2 \bullet lon_{CN} \ldots + C_7 \bullet lat_{CN} \bullet alt_{CN} + C_{12} \bullet lon_{CN}^3 \ldots\ldots + C_{17} \bullet lat_{CN} \bullet alt_{CN}^2$$
$$+ C_3 \bullet lat_{CN} \ldots + C_8 \bullet lon_{CN}^2 \ldots + C_{13} \bullet lon_{CN} \bullet lat_{CN}^2 \ldots + C_{18} \bullet lon_{CN}^2 \bullet alt_{CN}$$
$$+ C_4 \bullet alt_{CN} \ldots + C_9 \bullet lat_{CN}^2 \ldots + C_{14} \bullet lon_{CN} \bullet alt_{CN}^2 \ldots + C_{19} \bullet lat_{CN}^2 \bullet alt_{CN}$$
$$+ C_5 \bullet lon_{CN} \bullet lat_{CN} + C_{10} \bullet alt_{CN}^2 \ldots + C_{15} \bullet lon_{CN}^2 \bullet lat_{CN} \ldots + C_{20} \bullet alt_{CN}^3$$

Where coefficients C1...C20 represent the following sets of coefficients:

SAMP_NUM_COEF_n, SAMP_DEN_COEF_n, LINE_ NUM_COEF_n, LINE_DEN_COEF_n, which can be found under the node 'Inverse Model' in the RPC file.

Transform centre-normalised image coordinates into image coordinates

col = col$_{CN}$ * SAMP_SCALE + SAMP_OFF
lin = lin$_{CN}$ * LINE_SCALE + LINE_OFF

C.3.3 Global or Partial RFM and Estimated Accuracy

The term 'Global_RFM' means that the RPC model is available in the whole image. This global RFM model is always computed.

When the acquisition duration is more than a threshold (nominally 4 seconds), partial RFMs are automatically computed, each one addressing a subset of the image (its validity domain).

Partial_RFM has a better accuracy than Global_RFM, because domain validity is reduced. In the case of Global_ RFM, the least squares method is applied on samples located in the whole image, thus the RMS error is more important.

Important

Partial RFM must be applied inside the validity domain, otherwise functions diverge and the result would be completely wrong. There is no continuity between partial RFM unlike global RFM.

An error corresponding to 3* standard deviation is given for each model (99.7% of evaluation samples).

C.4 Other Informative Geometric Data

The other geometric data associated to the image area are under the node:

> <Dimap_Document><Geometric_Data>
> <Use_Area><Located_Geometric_Values>

These data are given for information only. These data are given at the beginning, the middle and the end of image acquisition.

C.4.1 Acquisition Angles

C.4.1.1 Incidence and viewing angles

$$\beta = \sin^{-1}\left[\frac{R_E + h_{sat}}{R_E} * \sin(\alpha)\right] \geq 0$$
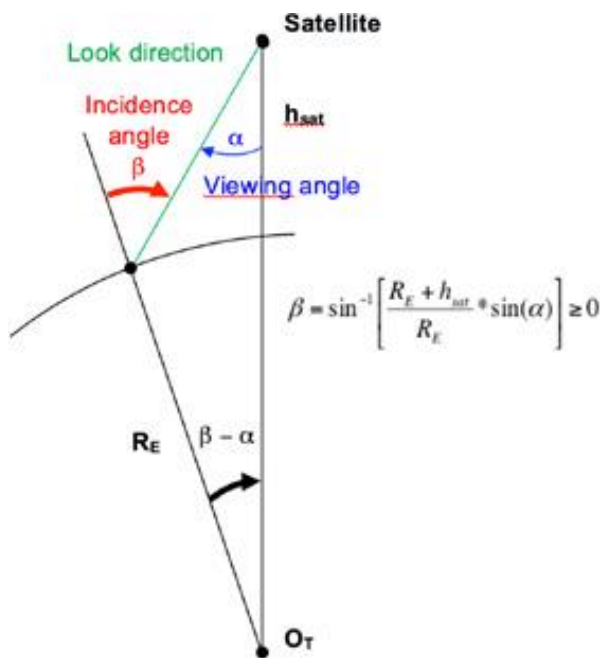
Figure C.7: Relation between incidence angle and viewing angle

The incidence angle β (INCIDENCE_ANGLE in DIMAP format) is the angle between the ground normal and look direction from satellite: in other words the angle affecting the Earth surface. For Pléiades, the range for the incidence angle is nominally [0, 33.6 degrees]. It can be raised to higher values, for instance to increase a revisit over a target.

The look direction from the satellite on the ground may be projected on two planes: (normal to the ground, Scan Axis) and (normal to the ground, OrthoScan axis). Thus, incidence may be measured in both planes:

- INCIDENCE_ANGLE_ACROSS_TRACK (βX): Incidence in the OrthoScan axis direction

- INCIDENCE_ANGLE_ALONG_TRACK (βY): Incidence in the Scan axis direction (image line axis on the ground)
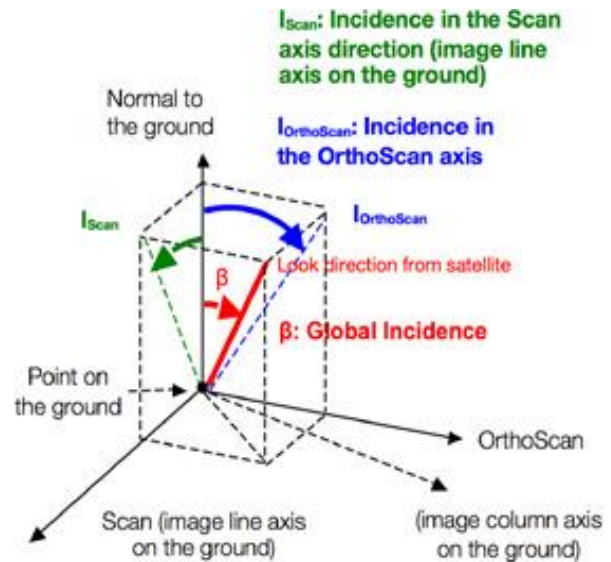
Figure C.8: Incidence angle projected on two planes

The incidence angle is calculated on the ground. The viewing angle from the satellite α (also named VIEWING_ANGLE in DIMAP format) is the angle between look direction from the satellite and nadir. For Pléiades, the range for the viewing angle is nominally [0, 30 degrees] – but can be opened to raise revisit frequency over a given target.

Look direction angle from the satellite may be projected onto two planes defined in the local orbital frame: (yaw axis, pitch axis) and (yaw axis, roll axis) – see *Figure C.9*. Thus, viewing may be measured in both planes:

- VIEWING_ANGLE_ACROSS_TRACK (aX): viewing angle in the across-track axis direction (roll)

- VIEWING_ANGLE_ALONG_TRACK (aY): viewing angle in the along-track axis direction (pitch)
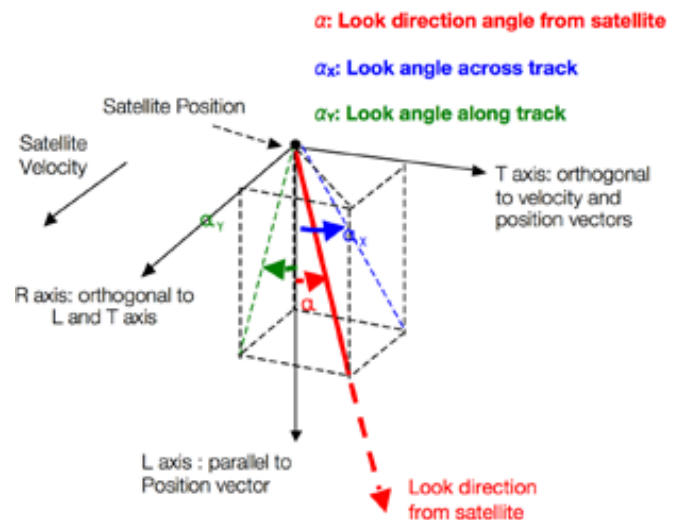
Figure C.9: Viewing angle along and across track

C.4.1.2 Azimuth angles

Scan line azimuth angle (image orientation):

The scan line azimuth angle Az_i (also called image orientation or image cap), is the angle between geographic north and the image line direction on the ground (also called Scan Axis). The range for the scan line is [0, 360 degrees], clockwise positive. As shown below in *Figure C.10*.
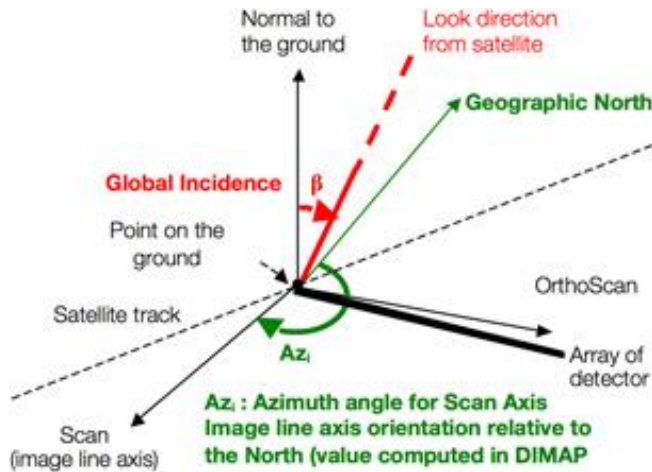
Figure C.10: Incidence angle and scan line azimuth (image orientation)

> AZIMUTH_ANGLE (AZ_i) = Scan line azimuth angle (image orientation)

Satellite azimuth angle

The satellite azimuth angle Az_{sat} is the angle between the meridian indicating the north passing through an image point and the line passing through this image point and the satellite nadir point. The range for the satellite azimuth angle is [0, 360 degrees], clockwise positive. As shown below in *Figure C.11*.
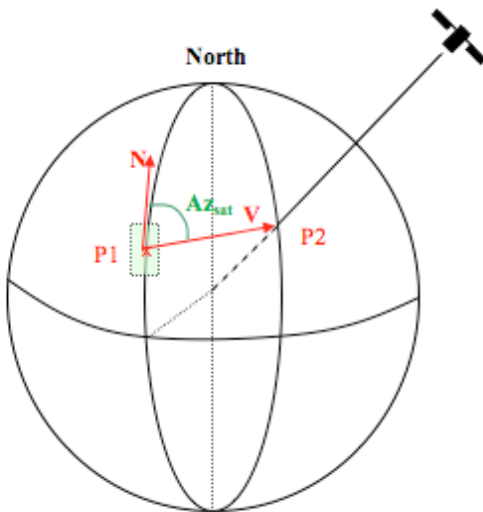
Figure C.11: Satellite azimuth angle

- **P1** is the position of the image point.

- **N** is the north direction for this point.

- **P2** is the satellite nadir point.

- **V** is the direction between nadir point P2 and image point P1.

- Direct angle between **N** and **V** is the satellite

azimuth. The satellite azimuth angle is not yet

computed in the
metadata file. It can be thus easily done at one of the located geometric values using the following formulae:

> Az_{sat} = MODULO(AZ_i – (ATAN2(tan(β_Y) ; tan(β_X)))) ;
>
> 360)

Numeric example:

> $AZ_i = 180°$, $\beta_Y = -11°$, $\beta_X = 15°$; $Az_{sat} = 215.95°$

C.4.2 Solar Angles

The following angles (see Figure 45) are calculated in a local Earth frame (Normal to the ground, North, East):

- SUN_AZIMUTH (Az_{sun})

- SUN_ELEVATION (El_{sun})
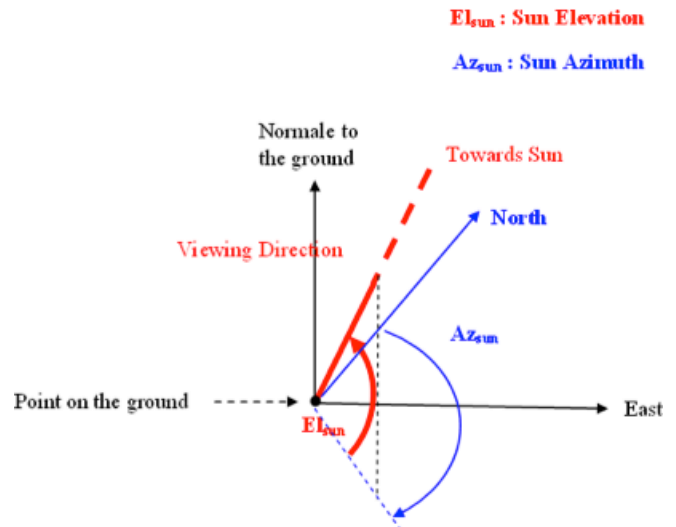
Figure C.12: Solar incidences

Info: Sun zenith angle (θs) = 90° – SUN_ELEVATION (El_{sun})

C.4.3 Ground Sample Distance (GSD)

Ground Sample Distance (GSD) is the Ground distance in meters viewed on board by two consecutive pixels along both directions: image line direction and image column direction at acquisition.

> GSD_ACROSS_TRACK: pixel size along image column direction

> GSD_ALONG_TRACK: pixel size along image line direction

Appendix D: Spectral Modelling and Rendering

D.1 Pléiades Spectral Bands

Pléiades acquires images in five spectral bands. *Table 1* below provides the spectral domain for each band, according to the standard expression, Full Width at Half Maximum (FWHM). The band range, corresponding to a rejection of 1%, is also indicated.

Spectral bands	λmin 1%	λmin FWHM	λmin FWHM	λmin 1%
Panchromatic	0.47 mm	0.49 mm	0.81 mm	0.83 mm
B0 – Blue	0.43 mm	0.46 mm	0.53 mm	0.55 mm
B1 – Green	0.50 mm	0.52 mm	0.60 mm	0.62 mm
B2 – Red	0.59 mm	0.61 mm	0.69 mm	0.71 mm
B3 – Near Infrared	0.74 mm	0.77 mm	0.89 mm	0.94 mm

Table D.1: Pléiades spectral bands

D.2 Spectral Responses of the Pléiades Sensor

The spectral response at a particular wavelength is the ratio of light power measured in the sensor band to the light power input at the telescope entrance. The spectral normalised responses are shown in *Figures D.1* and *D.2* below for each of the Pléiades satellites (Pléiades 1A and Pléiades 1B). Normalisation per band is relative to its maximum spectral response value.

For applications requiring really accurate response profiles, tabulated values can be provided upon request by submitting an email to: technicalsupport@intelligence-airbusds.com.

Figure D.1: Spectral normalised responses of the Pléiades1A
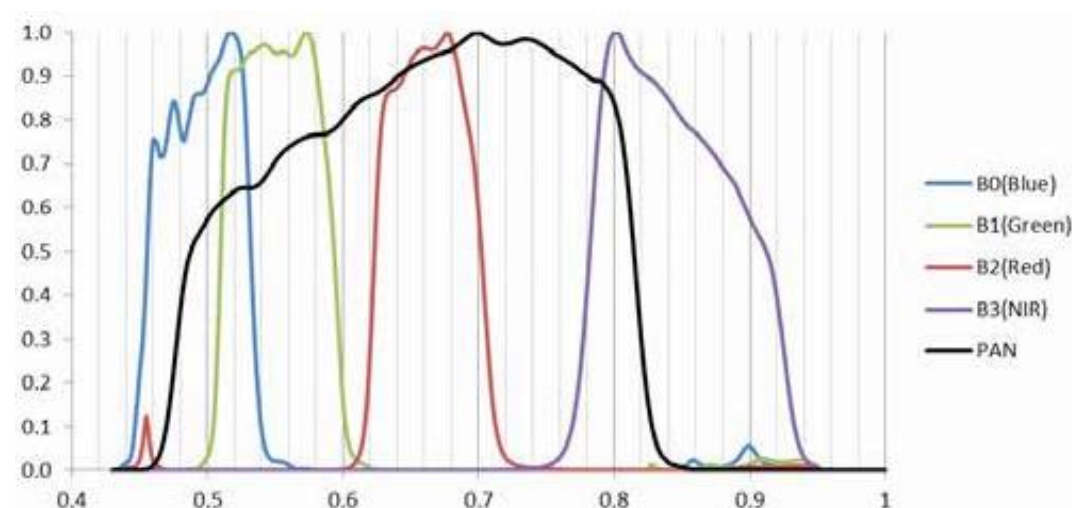
Figure D.2: Spectral normalised responses of the Pléiades 1B

D.3 Standard Radiometric Options

Applications based on advanced spectral analysis need to convert image raw Digital Numbers (DNs) to physical information such as spectral radiance, reflectance or albedo.

This measurement performed by the satellite can be first converted to a radiance value, thanks to sensor calibration, then to 'Top-Of-Atmosphere' (TOA) reflectance expressing the fact this is exoatmospheric reflectance as measured from space, thus considering measurement at terrestrial level filtered by the atmosphere.

It may be then further corrected from the transfer through the atmosphere down to the ground level to obtain direct spectral information. A simple illustration of such correction steps is given in *Figure D.3.*

Ultimately, for the visual exploitation of the image product, some optimised image rendering can be applied to the reflectance image to provide a reliable true colour image in the visible domain (RGB) for direct display.

Three standard spectral options are proposed. One of the following radiometric processing options is selected at order placement:

- BASIC
- REFLECTANCE
- DISPLAY

The radiometric selection appears in the product metadata file (DIMAP) under the RADIOMETRIC_PROCESSING tag. It also includes two additional values:

- LINEAR_STRETCH: relates to the BASIC option at 8-bit depth.

- SEAMLESS: relates to the mosaic option. In this case, the spectral properties cannot be retrieved since the initial images have undergone several radiometric adjustments for aesthetic rendering.

D.3.1 BASIC option

RADIOMETRIC_PROCESSING tag = 'BASIC' or 'LINEAR_STRETCH' (8-bit depth)

In the BASIC radiometric option, the imagery values are digital numbers (DN) quantifying the energy recorded by the detector corrected relative to the other detectors to avoid non-uniformity noise.

Raw count
- Pixel digital number (DN)
  - Energy as measured by the sensor (CCD) with equalization

BASIC

Spectral Radiance TOA(tmosphere)
- Pixel DN converted to light power = radiance ($W/m^2.sr.\mu m$)
  - Taking into account sensor calibration (metadata), converted to equivalent scene radiance at telescope entrance

In space corrections

Reflectance TOA(tmosphere)
- Radiance converted to apparent reflectance (ρ) (ρ – standard range 0 - 1)
  - Taking into account Sun illumination variation

Atmosphere and atmospheric corrections

Reflectance: correction of static effects
- Reflectance corrected from atmosphere systematic contributions
  - Taking into account scattering effects from the sky (molecular = Rayleigh) and related loss of transmission down to the ground

REFLECTANCE

Clear sky

Atmospheric veils corrections

Reflectance: correction of dynamic effects
- Reflectance corrected for the whole atmospheric column including dynamic contributions of low atmosphere if any
  - Taking into account semi-transparent clouds or aerosols: haze, cloud thin veils, dust, pollution

Surface reflectance (ground environment)

TOA: Top-Of-Atmosphere

User interest: space observation refined up ground observation

Figure D.3: Sensor to ground physical spectral corrections

D.3.1.1 Processing

Different radiometric artefacts may affect the raw image on-board. The main ones are high frequency noise due to the differential sensitivities between detectors (pixel equalisation) and low frequency variations in the field of view (vignetting, etc.). After correction of the detector PRNU (Photo Response Non-Uniformity) the dark signal and relative gain of each detector are fully characterised and monitored at regular intervals throughout the satellite's life to maintain
a fine equalisation according to the nominal TDI level or electronic gain. This 'relative' correction is performed on-board.

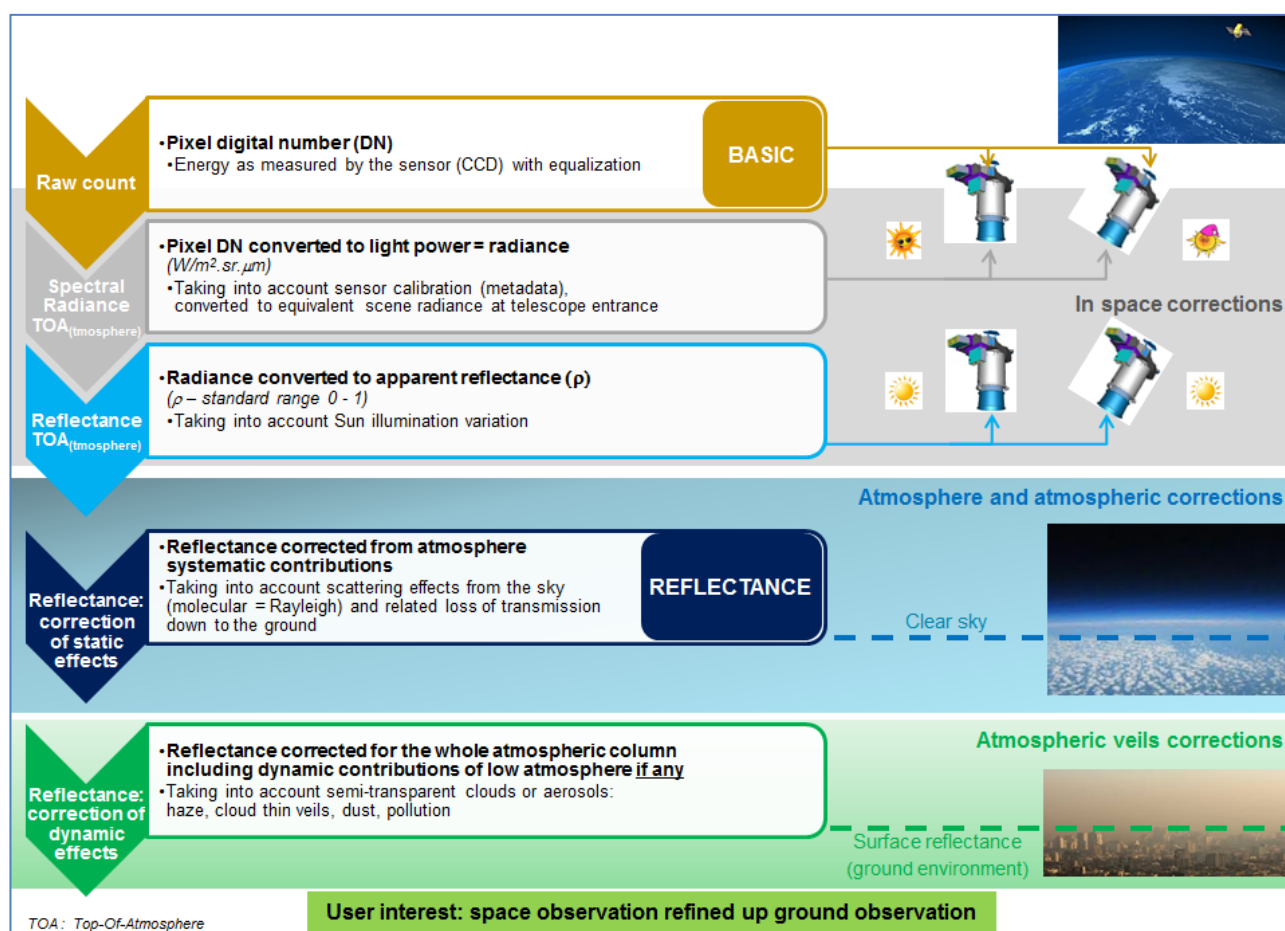Other radiometric corrections can be performed on-ground such as crosstalk correction, defective pixel (none identified), and restoration for panchromatic band (deconvolution).

A DN value does not account for the light power in the space environment at the time of input at telescope entrance. In fact, part of the light power is lost during transmission at different stages of the acquisition chain (optic, filters, etc.). Basically, the loss is homogeneous on each sensor band with an evolution during the satellite life. Thus the related correction is simply modeled by a linear function on each band. This 'absolute' calibration or sensor calibration includes an offset and a gain for each band, updated at regular intervals throughout the satellite's life to maintain a fine restitution of the light power.

The absolute calibration aims to turn back the DN value into a radiance value at the input of the camera (TOA). Absolute calibration coefficients are updated periodically, typically four times per year.

The BASIC radiometric option is the most untouched from a sensor point of view. Thus, the absolute calibration is not applied to the image bands, and the linear coefficients are provided in the DIMAP metadata file (see section D.4.1.1 From BASIC). The BASIC option ensures spectral corrections from space to ground.

D.3.1.2 Encoding

Quantisation performed at sensor level is 12 bit-depth. Thus source DN values have range 1–4095 and are coded as 16 bits integer in the image file, in particular, for storage in GeoTIFF format. RADIOMETRIC_PROCESSING tag is set to 'BASIC'.

In order to minimise the image file volume, the user can order BASIC in 8 bit-depth. The conversion to 8 bits coding (range 1–255) is performed by a linear stretch on the effective histogram of the source image. RADIOMETRIC_ PROCESSING tag is set to 'LINEAR_STRETCH'.

D.3.2 REFLECTANCE option

RADIOMETRIC_PROCESSING tag = 'REFLECTANCE'

In the REFLECTANCE radiometric option, the imagery values are corrected from radiometric sensor calibration and systematic effects of the atmosphere (molecular or Rayleigh diffusion and given in reflectance physical unit).

D.3.2.1 Processing

The reflectance (ρ) for a given spectral band (ρ_b) is the ratio of reflected light to the incident Sun illumination (or irradiance). A value 0 represents full absorption (black), and a value of 1 represents full reflection (perfect white). Apparent reflectance may exceed a value of 1 on specular targets or on slopes facing towards the Sun.

Absolute calibration coefficients, as obtained from the sensor regular absolute calibration, are applied to the DN values to convert into radiance (light power) information. This is referred as TOA radiance (see section *D.4.1.1 From BASIC*).

In general, in-situ measurements of the atmosphere are unavailable to process the satellite imagery, so determining the best atmospheric correction is a complex matter.
Various methodologies are discussed in the scientific community; debate will go beyond the scope of this document. The aim of the REFLECTANCE option is a universal atmospheric correction addressing the most common user needs and allowing the users to locally refine the correction:

(a) To revert without loss to the source DN image (BASIC) and TOA radiance

(b) To further correct reflectance down to the ground level.

Atmospheric correction may address two factor categories:

- **The systematic contribution of the atmosphere, corresponding to the sky effect as observed from ground:** This part is rather predictable and results from the gaseous nature of atmosphere at its different layers as a consequence of the molecular (or Rayleigh) scattering and corresponding loss of Sun illumination. The first order effect is the Rayleigh scattering, in inverse relation with the wavelength (law in $1/\lambda 4$) responsible for the bluish rendering in TOA imagery. Spatially, the static contribution is nearly uniform over the whole image scene and can be physically computed from
an atmospheric model, e.g. the LOWTRAN family (MODTRAN, ATCOR, etc.) or the 5S-6S (SMAC, etc.).

- **Various dynamic factors affecting the low atmosphere:** This part consists in various phenomena that are much more unstable, such as the presence of aerosols (haze) of different types and with varying load, and the presence of cloud thin veils. The correction is only relevant for semi-transparent phenomena; opaque clouds obviously cannot be corrected. This contribution is never homogeneous

over the whole image scene and the knowledge of this optical thickness is often investigated on the pixel level rather than physical approaches.

In order to meet user needs as referred to in (a), the REFLECTANCE product does not implement any correction of the dynamic atmospheric phenomena in the image (considered in a future product).

The systematic contribution of the atmospheric effects is corrected by the REFLECTANCE processing. Whereas, no auxiliary data is available (i.e. in-situ measurements), the atmospheric model is estimated with a priori average parameters as standard pressure and at image level mean terrestrial altitude, average sun illumination and satellite viewing. The nearly homogeneous contribution resulting from these effects is represented by a linear correction in each spectral band. With respect to the condition (a), this linear formulation is reversible without loss with the opportunity to refine the model if accurate auxiliary data becomes available (see section D.4.1.2 From REFLECTANCE).

In clear sky conditions (no veils), the reflectance value given by the REFLECTANCE product can be directly assimilate to the ground surface reflectance.

In conclusion, REFLECTANCE is more straightforward and easier to use than BASIC for spectral analysis and a number of image processing techniques. Both have the same spectral capability.

D.3.2.2 Encoding

The reflectance values are encoded into integer values by a fixed scale factor of 10000, thus image values are given in 1/10 000 reflectance. The scale factor can be found in the DIMAP metadata file:

> Radiometric_Data/Radiometric_Calibration/Instrument_
> Calibration/Band_Measurement_List/Band_Reflectance/ GAIN + BIAS (respectively 10000 and 0).

The BIAS and GAIN formula given in section *D.4.1 Top-Of-Atmosphere (TOA) Spectral Radiance* is appropriate to turn back the reflectance values scaled in integer to the reflectance range values in real number.

The 1/10 000 unit sets a standard range of 0–10000. The upper limit is not predictable, notably on specular conditions. For byte-oriented format as GeoTIFF the storage is onto 16-bit integer. A quantisation on 8 bit would revoke the benefit of a direct readable count in physical unit and is not proposed.

In addition to the imagery data, REFLECTANCE option provides a Look-Up Table (LUT) for each band that properly retrieves the true colour from sensor calibration and atmospheric correction processing for RGB rendering. The LUT is optimised for the display by an adaptive stretching

to 8-bit range per RGB channel. The user is able to achieve DISPLAY rendering (see section D.5.2).

The LUT is common for bands in the visible domain, Red (B2), Green (B1), Blue (B0) and Panchromatic (PAN), to ensure RGB visualisation. The NIR band (B4) has its own LUT for NIR composite rendering (false colour).

D.3.3 DISPLAY option

In the DISPLAY radiometric option, the imagery values are 8-bit numbers optimised for a direct rendering on the screen. The scene true colour in the visible domain is properly retrieved from sensor calibration and correction of systematic effects of the atmosphere. The values are not reversible to spectral physical unit.

D.3.3.1 Processing

The aim of the DISPLAY option is to provide imagery that has been spectrally corrected and that is easy to display in true colour in their software applications. The imagery is intended for visualisation purposes rather than spectral applications.

The DISPLAY processing consists of the application of the LUTs computed for REFLECTANCE to the imagery file. Therefore, imagery values are stretched to RGB values, and are no longer reversible to physical values (reflectance, radiance), so spectral information is not stated in the DIMAP metadata file.

D.3.3.2 Encoding

The image values are encoded in 8-bit depth, addressing the 16.78 million colours of RGB space plus an extra channel for 4-band delivery. A larger encoding would not have extra values for display purposes.

D.4 Radiometric and Atmospheric Corrections

D.4.1 Top-Of-Atmosphere (TOA) Spectral Radiance

BASIC or REFLECTANCE radiometric options provide information for converting the pixel values X(p) into TOA spectral radiance values (L). The formulation is linear for each band (b) set with coefficients GAIN and BIAS. The GAIN and BIAS values are posted in the DIMAP metadata file.

For each band b the formula is:

$$L_b(p) = \frac{X(p)}{GAIN(b)} + BIAS(b)$$

The physical unit of TOA spectral radiance

is $W \cdot sr^{-1} \cdot m^{-2} \cdot \mu m^{-1}$

TOA spectral radiance for Pléiades 1A and 1B imagery are similar in same acquisition conditions. Users looking for very accurate spectral information should consider the respective spectral responses aboard Pléiades 1A and 1B sensors.

D.4.1.1 From Basic

The pixel values $X(\rho)$ are DN values. The GAIN and BIAS are the absolute radiometric coefficients of the sensor calibration routinely performed during the satellite life cycle. The absolute calibration recovers the spectral response into TOA radiance unit (*D.3.1.1 Processing*). Inputs are as follows:

X= DN pixel values (band image file)

GAIN: Radiometric_Data/Radiometric_Calibration/ Instrument_Calibration/Band_Measurement_List/Ban d_ Radiance/GAIN (DIMAP metadata file)

BIAS: Radiometric_Data/Radiometric_Calibration/ Instrument_Calibration/Band_Measurement_List/Ban d_ Radiance/BIAS (DIMAP metadata file)

Note that products in the sensor native radiometric range (12-bit Quantisation) have a BIAS value set to zero. For 8-bit products, the image DNs are reduced to the 8-bit range, which means a non-zero BIAS value.

D.4.1.2 From Reflectance

The pixel values $X(\rho)$ are reflectance values (ρ). The GAIN and BIAS are the coefficients of the linear law to reverse the atmospheric correction back to TOA radiance unit. Inputs are as follows:

X = reflectance (ρ) pixel values (band image file)

GAIN: Radiometric_Data/Radiometric_Calibration/ Instrument_Calibration/Band_Measurement_List/Ban d_ Radiance/GAIN (DIMAP metadata file)

BIAS: Radiometric_Data/Radiometric_Calibration/ Instrument_Calibration/Band_Measurement_List/Ban d_ Radiance/BIAS (DIMAP metadata file)

This conversion may be used to initiate an atmospheric model with user-defined parametre values, for instance in- situ measurements in capacity to refine the standard ones.

D.4.2 Converting TOA Radiance to TOA Reflectance

TOA radiance of the acquired scene will directly vary with the Sun illumination, i.e. with the local elevation of the

Sun at the time of image acquisition. Converting to TOA reflectance minimises this dependency.

The TOA reflectance (ρ) for a given spectral band (ρ_b) is the ratio of reflected light filtered by the atmosphere to the incident Sun illumination. A value 0 represents full absorption (black), and a value of 1 full reflection (perfect white). Apparent reflectance may exceed the 1 value on specular targets or on slopes facing towards to the Sun.

TOA spectral radiance L_b (p) can be converted to TOA spectral reflectance ρ_b (p) with the following formula:

$$\rho_b(p) = \frac{\pi . L_b(p)}{E_0(b). d. \cos(\theta_s)}$$

Where:

- E_0 (b) is the solar spectral irradiance in the considered band

- θs is the Sun zenith angle.

- d is a correction coefficient with respect to mean Earth-Sun distance

The DIMAP metadata file provides parametre values for the solar irradiance given per spectral band $E_o(\beta)$, and the Sun elevation angle (EL$_{sun}$). Sun zenith angle qs is 90°-El$_{sun}$ (user can choose by default the value indicated at the centre of the product).

The correction coefficient of the Earth-Sun distance (d) can be computed from formulas available in the literature, or may be approximated to 1 (varies a few % along the year).

D.4.3 Atmospheric corrections

Some spectral image data analyses may be performed on TOA spectral reflectance, for example, if using only bands on which atmosphere has limited impact (e.g. Red and NIR bands). However, in many cases, in order to properly retrieve the scene true colour in the visible domain, there is the need to apply further atmospheric corrections. Please refer to section *D.3.2.1 Processing* for more information.

D.4.3.1 Correction of the atmosphere stable contribution

To initialise atmospheric models the DIMAP metadata file provides the following parameters:

Sun parameters as Sun elevation (EL$_{sun}$) and azimuth (AZ$_{sun}$) angles

Viewing parameters as acquisition incidence angle (a). See section C.4.1.2 to compute the satellite azimuth angle (AZ$_{sat}$).

Atmosphere composition, local altitude values, etc. are typically auxiliary data or set to average values.

D.4.3.2 *Correction of variable phenomena in the low atmosphere*

In contrast with the stable contribution (Rayleigh scattering, etc.), correction of other atmospheric effects cannot be uniform as they may vary rapidly in the image. Atmospheric models include modelling of aerosols haze and clouds, and related parameters are difficult to assess. Many dehazing approaches use relationships between spectral bands to locally estimate these parameters from the image data, by reference to what should be the pixel reflectance in clear sky conditions (e.g. the Dark Dense Vegetation – DDV – method) and apply some spatial filtering to generalise this correction to the whole image. This correction will recover reflectance over hazy areas. Please refer also to section D.3.2.1 Processing for more information.

D.5 Image Rendering

D.5.1 Basic Option

As discussed at section *D.3.1.1 Processing,* the colours are not calibrated and would need substantial effort to achieve a pleasant colour rendering with a manual stretch. First we recommend converting the DN pixel values in TOA radiance (*D.4.1.1 From BASIC*), especially for 8-bit- products. Then a threshold at histogram base plus a stretch per band can simulate an empiric correction of atmospheric effects.

D.5.2 Reflectance Option

We recommend using the Look-Up Table for each band posted in the XML LUT file under the tag LUT:

> Raster_Data/Raster_Index_List/Raster_Index/L
> UT

The LUT has the same syntax of VRT files (Raster Virtual format) adopted by GDAL or MapServer. Both are internally supported by many software.

All bands of visible domain have the same LUT: Red, Green, Blue and Panchromatic bands. The LUT for the NIR band is adapted for false colour.

The rendering will be exactly the same as the DISPLAY option and remains neutral for the imagery values themselves. The rendering can partially absorb homogeneous haze effects.

D.5.3 Display Option

The image is immediately usable with optimised visual rendering. In Commercial off-the-shelf software (COTS), we recommend switching the automatic stretching tools off.

The brightness is a function of the reflectance value at ground level. For scenes acquired in low luminosity conditions or with low reflected objects, the luminosity level can be slightly increased at a same magnitude of the three RGB channels. Keep in mind that the colour balance may be a subjective notion, as well as dependent on the calibration of the monitor.

Appendix E: Schematic overview of processing

E1   Radiometric Processing Options

Radiometric processing

Primary - Projected - Ortho
Pan-sharpened - Panchromatic - Multispectral - Bundle

Radiometric processing	

Basic **Reflectance** **Display**

Imagery values

| 12 bit-depth (4096, native) | 8 bit-depth (255, compact) | 0-10000 (*) (physical, with 0.001 scale factor) | 8 bit-depth (255, rendering) |

Format: GeoTIFF / JP2
(optimized or regular)

8 or 16 bits encoding   *8 bits encoding*

Metadata values

Conversion formulas DN/radiance ⮕reflectance   LUTs applied to reflectance

Format: DIMAP
XML encoding

Achievable on user's side (COTS SW)

Spectral applications   **Visual applications**

(*) >10000 when reflectance values over standard range 0-1 (specular   reflections)

Formats also available: NITF (Basic), ISO 19115 add-on DIMAP

E2 Geometric Processing Options

PRIMARY level

Image in the geometry of acquisition synthesized on
a perfect single and linear push-broom sensor,
at satellite position and orientation in space

PRIMARY:
Image at sensor level

Ground topography or
elevation surface
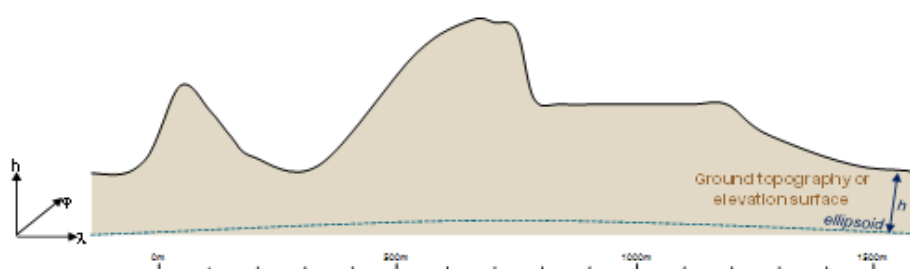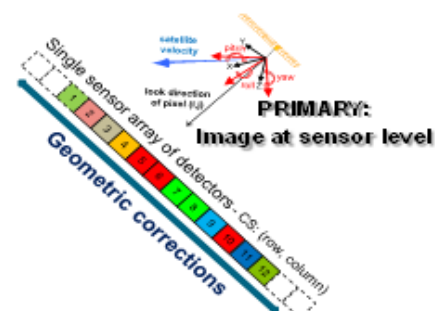
Overlay with maps ? NO

AIRBUS

From PRIMARY to PROJECTED level

Image as viewed from a constant terrestrial altitude
(i.e. mean over the area of interest),
projected onto an Earth mapping system

Internal + external image orientations from space :
detectors look directions of acquisition intersecting
a constant altitude over ellipsoid surface
(default is mean altitude value over AOI)

Geometric modeling
Rigorous sensor
(RPC also available)

input
PRIMARY

Corrections

Constant altitude
surface (mean)

Terrestrial topography or
elevation surface

output
PROJECTED

CRS:
(λ, φ) or (E,N)

Relief effects not corrected
(Positioning error mainly relates to (hTrue − hConstant) altitudes)

PROJECTED:
geodetic datum
+ Map projection

Overlay with maps ? YES but not superimposable

AIRBUS

From PRIMARY to **ORTHO level**

Image corrected from off-nadir and relief effects (rectified as nadir position) and possibly improved with GCP, projected onto an Earth mapping system

Single sensor array of detectors - CS (row, column)

input
PRIMARY

Internal + external image orientations from space: detectors look directions of acquisition intersecting the variation of terrestrial altitudes (or DTM/DSM)

Geometric modeling
Rigorous sensor
(RPC also available)

h
φ
λ
H
geoid

True altitude or Digital Terrain/Surface Model
ellipsoid
h

CRS:
(λ,φ) or (E,N)

0m   500m   1000m   1500m

Relief effects corrected
(Positioning error mainly relates to accuracy of the true relief knowledge)

Overlay with maps ? YES superimposable

Corrections

output

ORTHO:
geodetic datum
[+ addition of GCP]
+ Map projection

AIRBUS

From PROJECTED to **ORTHO level**

Image corrected from off-nadir and relief effects (rectified as nadir position) and possibly improved with GCP, projected onto an Earth mapping system

Pixels at constant altitude (mean) intersecting the variation of terrestrial altitudes (or DTM/DSM) along look directions of image acquisition

input
PROJECTED

Geometric modeling
RPC model

Constant altitude surface (mean)

h
φ
λ
H
geoid

True altitude or Digital Terrain/Surface Model
ellipsoid
h

CRS:
(λ,φ) or (E,N)

0m   500m   1000m   1500m

Relief effects corrected
(Positioning error mainly relates to accuracy of the true relief knowledge)

Overlay with maps ? YES superimposable

Corrections

output

ORTHO:
geodetic datum
[+ addition of GCP]
+ Map projection

AIRBUS

Abbreviations, Acronyms and Terms

Area Of Interest (AOI): The abbreviation for area of interest. An AOI outlines a particular region by panel, shape, preset values, or by a defined line and sample. An AOI is used for clipping an image area or for processing a subset of image data.

Figure E.1: Stereoscopic – B/H

Attitude: The angular orientation of a spacecraft as determined by the relationship between its axes and a reference line or plane or a fixed system of axes. Usually, '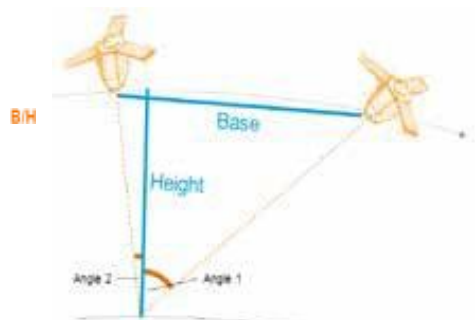Y' is used for the axis that defines the direction of flight, 'X' for the 'cross-track' axis perpendicular to the direction of flight, and 'Z' for the vertical axis. Roll is the deviation from the vertical axis (the angle between the Z axis of the vehicle and the vertical axis, or angular rotation around the Y axis). Pitch is the angular rotation around the X axis. Yaw is rotation around the Z axis.

Azimuth: The arc of the horizon measured clockwise from the north point to the point referenced, expressed in degrees. Azimuth indicates direction, and not location.

B/H: The Base-over-Height ratio of a stereo pair. This parametre characterises the stereoscopic capacity of a couple (see *Figure E.1*), given that the 'Height' value is constant and equals the altitude of the satellite, the larger the base, the larger the angle). Thus, the Base-over-Height ratio reflects the angular difference between the two images. It should be high for rather flat areas and low for urban or mountainous areas. See page 39 for more details about how to select the right B/H ratio.

CE90: Circular Error with a confidence level of 90% (positioning accuracy on both axes). It indicates that the actual location of an object is represented on the image within the standard accuracy for 90% of the points. See also Geolocation accuracy, RMSE.

Map Scale	1:2,400	1:4,800	1:12,000	1:24,000	1:50,000
CE90	2m	4m	10m	12m	25m
RMSE	1m	2m	5m	6m	15m

Table E.1: Approx mapscale equivalencies based on US NMAS

CMGs – Control Moment Gyros: The CMG principle relies on the gyroscopic effect to rapidly and instantaneously generate an important output torque by using the spin axis' rotation of a momentum wheel thanks to a cardan gimbaled mechanism. The CMGs are used both for the manoeuvre guidance to ensure transitions between image acquisitions and for the acquisition guidance in order to guarantee the image quality. See section *1.1 Flexibility, Agility and Availability* for benefits of CMGs.

Figure E.2: A control moment gyro

Conflict: Two (or more) tasking requests are said to conflict when the satellite is not in a position to image the two (or more) areas during the same orbit. These two tasking requests are also said to be in competition. When there are different priority levels attached to each tasking request, the satellite will image the tasking request with the highest priority level first.

Coordinate Reference System (CRS): A coordinate system related to the Earth through one datum. This definition includes coordinate systems based on geodetic or Cartesian coordinates and coordinate systems based on map projections.

DEM – Digital Elevation Model (or DSM – Digital Surface Model): A digital 3D ground model, including the maximum altitude in every point: with human superstructures and canopy.
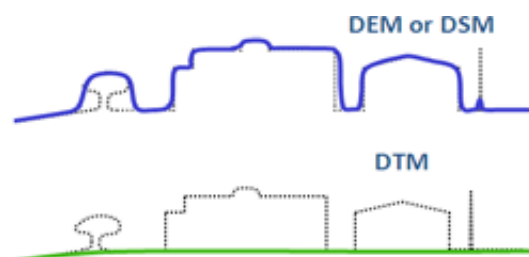

Figure E.3: DEM vs. DTM

DRS – Direct Receiving Station: An antenna and a terminal enabling a given partner to receive Pléiades telemetry directly at their facility. For more details about Pléiades DRS, please feel free to contact us.

DTM – Digital Terrain Model: A digital natural ground (bare Earth) model, meaning without human superstructures or canopy. See DEM.

	Level 0	Level 1	Level 2	Level 3
Posting	30 arc sec.	3 arc sec.	1 arc sec.	0.4 arc sec.
At Equator	± 900 m	± 90 m	± 30 m	± 12 m
At 45˚ latitude	± 630 m	± 63 m	± 21 m	± 9 m
Posting values decrease towards the poles to cope with meridian convergence.				
Absolute horizontal		50 m CE90	23 m CE90	10 m CE90
Absolute vertical		30 m CE90	18 m CE90	10 m CE90
Relative horizontal		-	-	3-10 m CE90
Relative vertical		20 m CE90	12-15m CE90	1-3 m CE90

Table E.2: DTED Classes

DTED – Digital Terrain Elevation Data Level: A uniform gridded matrix of ground elevation. It is a standard used to classify DEMs upon their precision and posting. DTED standards encompass several levels of accuracy, from DTED level 0 to DTED level 3. Level 0 content is equivalent to the elevation information of a 1,000,000-scale map (more or less equivalent to GTOPO30, or GLOBE), DTED level 1 to a 250,000-scale map (SRTM public data), and DTED level 2 to a 1:50,000 map.

ECF or ECEF – Earth Centred Earth Fixed coordinates: The Earth Centred Earth Fixed or conventional terrestrial coordinate system rotates with the Earth and has its origin at the centre of the Earth. The X axis passes through the equator at the prime meridian. The Z axis passes through the North Pole but it does not exactly coincide with the instantaneous Earth rotational axis. The Y axis can be determined by the right-hand rule to be passing through the equator at 90˚ longitude. For more information: metadata. dod.mil/mdr/ns/GSIP/crs/WGS84C_3D

FOR – Field Of Regard: The area covered by the detector of the system when pointing to all mechanically possible positions.

Geometric Modelling: The relationship between image and ground coordinates for a given sensor.

GeoTIFF – Geographic Tagged Image File Format: GeoTIFF is a public domain metadata standard which allows georeferencing information to be embedded within a TIFF file. The potential additional information includes map projection, coordinate systems, ellipsoids, datums, and everything else necessary to establish the exact spatial reference for the file.

GIS – Geographic Information System: A geographic information system is a system designed to capture, store, manipulate, analyse, edit, manage, and present all types of geographical data.

Ground Control Point (GCP): A geographic feature of a known location (e.g. corner of a building, rock reflector…) that is recognisable on an image and can be used to determine geometric corrections to improve the geolocation accuracy of the image.

Ground Sampling Distance (GSD): The Ground Sampling Distance is the distance at ground view by two consecutive pixels (in meters) along both directions: image line direction and image column direction. See IFOV and *Figure E.4*.
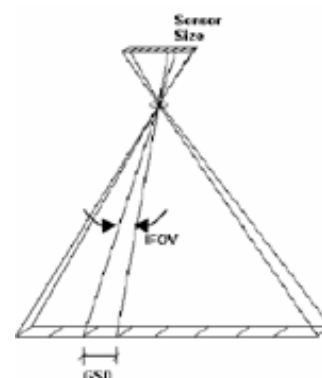

Figure E.4: IFOV and GSD

HR – High Resolution: Imagery with a resolution between 1-10 m.

Incidence Angle: See Viewing angle.

Instantaneous Field Of View (IFOV): (1) In a scanning system, this refers to the solid angle subtended by the detector when the scanning motion is stopped.
Instantaneous field of view is commonly expressed in milliradians or picoradians. (2) The ground area covered by this solid angle. See GSD.

JPEG 2000: An image compression standard and coding system. It is the default image format for Pléiades products. See section *2.5 Product and Image Format* for more information about JPEG 2000 benefits.

KML – Keyhole Markup Language: An XML notation for expressing geographic annotation and visualisation within internet-based, two-dimensional maps and three- dimensional Earth browsers. KML was developed for use with Google Earth, which was originally named Keyhole Earth Viewer. It was created by Keyhole Inc, which was acquired by Google in 2004. KML is an international standard of the Open Geospatial Consortium.

LE90: A linear error with a confidence level of 90% (positioning/vertical accuracy on one axis). It indicates that the actual elevation of an object is represented within the stated accuracy for at least 90% of the elevation posts.

Linear Adjustment: An algorithm used to rescale bit-depth from 12 to 8 bits. It does not affect the properties of the image histogram (linear transformation) in order to preserve the initial radiometric quality of the imagery. It is activated each time a customer orders 8-bit products, either with automatic values or custom values.

Location Accuracy: Location accuracy means positional accuracy using satellite ancillary data only. It is a measure of the possible difference between the locations of features in the data versus their actual location on the ground. It is usually expressed in units plus or minus some distance (e.g. + or - 50 m) from the actual ground position in either the horizontal or vertical plane. To exclude local terrain effects the specification is asset globally on Ellipsoid. See also CE90, RMSE.

Monoscopic: Acquisition mode which has been obtained by imaging a precise area from a single viewpoint on the orbit.

Mosaic: A mosaic is the end result of combining multiple smaller images into one larger, cohesive image.
Geographically, a mosaic is a raster data set composed of multiple raster datasets merged together.

MTF – Modulation Transfer Function: a measure of the image sharpness (the spatial frequencies) of a camera and/ or image.

Multispectral (MS): Generally denotes remote sensing in two or more spectral bands (and less than 20 bands), such as visible and infrared. Multispectral capacity enables a sensor to deliver colour images.

Nadir: The point on the ground vertically beneath the sensor.

Near Infra-Red (NIR): The preferred term for the shorter wavelengths in the infrared region (the entire infrared region extends from about 0.7 μm, visible red, to about 3 μm).

Orthogonal: Having three right angles.

Orthorectified: Describes an image which has had the displacements due to tilt and relief removed. The resulting image can be virtually overlaid on a map.

Pan-sharpening: The practice of using the highest resolution Panchromatic band in conjunction with the other lower resolution multispectral bands to increase the apparent spatial resolution of a multi-band (colour) product.

Panchromatic (PAN): Detectors that are sensitive to visible colours of the spectrum. Pléiades has a Panchromatic band that extends into the near-IR and covers the spectral region between 0.47–0.83 μm.

Pitch: The rotation of a spacecraft about the horizontal axis normal to its longitudinal axis (in the along-track direction) so as to cause a nose-up or nose-down attitude. The pitch axis is referred to as the X axis. See Attitude.

Planimetric Accuracy: The positional accuracy of the image projected on an Earth mapping system and reset with a DEM (vertical reset) and possibly with GCPs (horizontal reset). Unlike Location Accuracy, the Planimetric Accuracy depends on the intrinsic accuracy of the external data (DEM and GCP). Planimetric Accuracy is dedicated for georeferenced products like ortho images.

Priority: A hierarchal system for different tasking requests. In areas of high competition, priority service requests are served first, so customers will see a shorter collection window for priority service requests than for standard service requests.

Pushbroom: The pushbroom scanner, otherwise known as the linear array sensor, is a scanner without a mechanical scanning mirror, or moving parts. Instead, it has a linear array of sensors with one sensor for each area sampled on the ground. Charge-coupled devices (CCDs) are usually used for the sensors. This enables the pushbroom scanner to record one line of an image simultaneously, with this line being perpendicular to the flight direction. As with mechanical scanners, forward motion is achieved through the flight direction of the platform. See figure below.
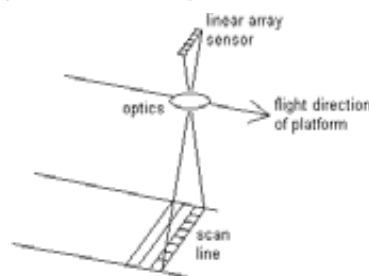

Figure E.5: Pushbroom sensor

Quicklook: Sometimes called a browse image. A quicklook provides an overview of the product with a degraded resolution to make browsing an image catalogue quicker and easier. It gives an immediate understanding of the image quality and cloud cover. Quicklooks of images are, for instance, the images that are used and displayed in the GeoStore catalogue. Basically, the quicklook is a subsampled image. It is compressed and dynamically stretched (by default 2%). Typically, the quicklook image is subsampled by a ratio of 32 vs. the original Panchromatic image sampling (approximately 22 m).

Radiance: A measure of radiant intensity per unit of a projected source area in a specified direction. The unit is the rate of transfer of energy (Watt, W) at sensor input, per square metre on the ground, for one steradian (solid angle from a point on Earth's surface to the sensor), per unit wavelength being measured.

Reference3D®: A database that has been designed to take advantage of highly accurate SPOT 5 stereoscopic images. It consists of three information layers: SPOT DEM (30 m resolution, uniform grid of terrain elevation values of the area of interest), Orthoimage (5 m resolution, orthorectified images from the DEM stereo pairs) and Quality Masks; with a specification of circular planimetric accuracy between 6–10 m for 90% of the points, depending on the location, and an elevation accuracy better than 10 m for 90% of the points, depending on the steepness of the slopes. The average is 5 m. For more information: http://www.intelligence-airbusds.com/elevation-models/#elevation30.

Refined attitude data: The attitude data is a main element for geolocation accuracy without GCP. It provides information about the attitude/orientation of the satellite and it is measured by the satellite sensors for each acquired image. The refined attitude data is the average of attitude data gathered on various consecutive orbits. It allows minimising individual attitude data errors (improve geolocation). It is calculated twice per day and automatically re-integrated in the processing chain. It is not available in the case of rush production of a recently acquired image (< 12h). It is neutral if on-board attitude data are already accurate. This automatic processing secures Pléiades' geolocation and is nominally integrated in Direct Receiving Stations ground processing chains.

Reflectance: The ratio of the reflected radiance divided by the incoming radiance. Reflectance provides a standardised measure, which is directly comparable between images. Reflectance is unitless and thus is measured on a scale from 0 to 1 (or 0–100%). Top-of-Atmosphere (TOA) reflectance does not attempt to account for atmospheric effects and has a directional aspect. Surface reflectance attempts to correct for the atmosphere while also converting to reflectance.

Resolution (spatial resolution): A measure of the smallest angular or linear separation between two objects that can be resolved by the sensor.

There is a relationship between the size of the feature to be sensed and the spatial resolution of the optical system. It is simply the dimension in meters of the ground-projected instantaneous field of view (IFOV).

RFC: Rational Function Coefficients (from RPC).

RFM: Rational Function Model (with RPC).

RMSE (root mean squared error): Commonly used for quoting and validating geodetic image registration accuracy. A RMSE value is a single summary statistic that describes the square root of the mean horizontal distance between all photo-identifiable GCPs and their respective twin counterparts acquired in an independent geodetic survey. See also CE90.

Roll: The rotation of a spacecraft about its longitudinal axis (in the along-track direction), so as to cause a side-up or side-down attitude. The roll axis is referred to as the Y axis. See Attitude.

RPC (rational polynomial coefficient): A mathematical model of the image geometry, in the form of a set of rational polynomial coefficients, that one can use to orthorectify the image. This procedure also requires a DEM (Digital Elevation Model). One can often improve the fit of the rational polynomial model to a particular image by re-georeferencing the image using accurate 3D ground control points. See Orthorectified.

Sensor model: A sensor model is a physical representation of a sensor in its state at the time of image collection. The algorithm accounts for refraction, position, orientation, velocity, and viewing directions along the sensor array through the camera. It calculates the transformation between 3-D ground space and image line and sample coordinate points, and vice versa. Every image has unique sensor model parameters that reflect the location and orientation of the sensor at the time the image was collected. The sensor model is native to the image's support measurement functions with ground surface.

Scan line: The ground trace of a narrow strip that is recorded by the instantaneous field of view of a detector in a scanner system.

SHP (shapefile): A popular geospatial vector data format for Geographic Information Systems software. It is developed and regulated by ESRI as a (mostly) open specification for data interoperability among ESRI and other software products.

Shapefiles spatially describe vector geometries: points, polylines, and polygons. These, for example, could represent water wells, rivers, and lakes, respectively. Each item may also have attributes that describe the items, such as the name or temperature.

SNR (signal to noise ratio): SNR measures the radiometric accuracy of an image.

Spectral band: An interval in the electromagnetic spectrum defined by two wavelengths, frequencies, or wave numbers (e.g. Pléiades' blue band covers an area between 0.43–0.55 µm).

Stereo(scopic): Acquisition mode which has been obtained by imaging from two viewpoints on the same orbit.

Sun-synchronous: An Earth satellite orbit in which the orbital plane remains at a fixed angle with respect to the Sun, precessing through 360° during the period of one year. The Pléiades satellites are in a near-polar orbit of this type and maintain an orbital altitude, such that each pass over a given latitude on the Earth's surface occurs at the same mean Sun time every day.

Swath: The width of an image. Pléiades' swath is 20 km at nadir. The swath increases proportionally with the angle.

TDI (time delay integration): A time delay integration charge-coupled device (CCD) is widely used for observation of high-speed moving objects undetectable by classic CCD. This technique senses charge patterns and shifts them across the charge-coupled device (CCD) array in sync with the movement of the image, to integrate more light from the scene.

UTC: Universal time coordinated.

UTM – universal transverse mercator: A projection system that divides the Earth into sixty zones, each a six- degree band of longitude, and uses a secant transverse Mercator projection in each zone.

VHR – very high resolution: Imagery with a resolution below 1 m.

Viewing angle: The angle from the instrument point of view. It represents the angle between the look direction from the satellite and nadir, combining the pitch and roll angles. It is different from the incidence angle.
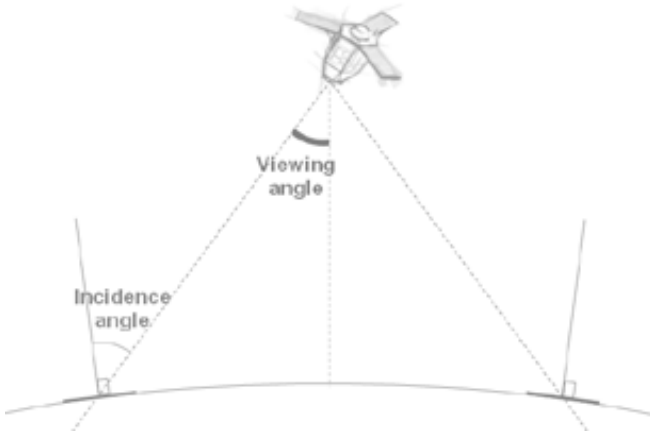

Figure E.6: Viewing angle

Yaw: The rotation of a spacecraft about its vertical axis so as to cause the spacecraft's longitudinal axis to deviate left or right from the direction of flight. The yaw axis is referred to as the 'Z' axis. See Attitude.

Zenith: The point in the celestial sphere that is exactly overhead. The opposite of nadir.

Table of symbols and values location in DIMAP V2

This section defines all the symbols (mathematical or specific to Pléiades) involved within at least one of the equations of this document.

Symbol	Description
	<Location of values in DIMAP V2 format>
Az_i	Scan line azimuth angle of the image line axis between the geographic north and the scan line direction (image orientation). Unit in degree (°). <Geometrice_Data><Use_Area><Located_Geometric_Values><Acquisition_Angles><AZIMUTH_ANGLE>
Az_{sat}	Satellite azimuth angle between the geographic north and the satellite track on ground. Unit in degree (°). Azsat = MODULO(AZi – (ATAN2(tan(ßY) ;tan(ßX)))) ; 360)
Az_{sun}	The sun azimuth angle (°). <Geometric_Data><Use_Area><Located_Geometric_Values><Solar_Incidences><SUN_AZIMUTH>
B	Spectral band identifier. Examples P, B0, B1, B2, B3 = Resp. Panchromatic, Blue, Green, Red and Near Infrared bands. <Band_Measurement_List><Band_Radiance><BAND_ID><GAIN>
BIAS	A bias value. <Band_Measurement_List><Band_Radiance><BAND_ID><BIAS>
C	Light speed.
CoeffPsiX(i)	Polynomial model coefficients: TanPsiX = f(col –colref). <Geometric_Data><Refined_Model><Geometric_Calibration><Instrument_Calibration><Polynomial_Look_Angles><XLOS_(i)>
CoeffPsiY(i)	Polynomial model coefficients: TanPsiY = g(col –colref). <Geometric_Data><Refined_Model><Geometric_Calibration><Instrument_Calibration><Polynomial_Look_Angles><YLOS_(i)>
$CoeffQ0_{(i)}$	Polynomial coefficients: Q0 = f(tCN). <Geometric_Data><Refined_Model><Attitudes><Q0>
$CoeffQ1_{(i)}$	Polynomial coefficients: Q1 = g(tCN). <Geometric_Data><Refined_Model><Attitudes><Q1>
$CoeffQ2_{(i)}$	Polynomial coefficients: Q2 = h(tCN). <Geometric_Data><Refined_Model><Attitudes><Q2>
$CoeffQ3_{(i)}$	Polynomial coefficients: Q3 = k(tCN). <Geometric_Data><Refined_Model><Attitudes><Q3>
Col	Image column coordinate.
col_{ref}	Reference column for polynomial models. <Geometric_Data><Refined_Model><Geometric_Calibration><Instrument_Calibration><Swath_Range><FIRST_COL>
del(c)	Elementary detector.
$E_o(b)$	Eo(b) is the mean Top of Atmosphere (TOA) solar irradiance for the band (b) in W/m^2/micrometer. <Band_Measurement_List><Band_Solar_Irradiance><BAND_ID><VALUE>
El_{sun}	The sun elevation angle <Geometric_Data><Use_Area><Located_Geometric_Values><Solar_Incidences><SUN_ELEVATION>
ERR_BIAS_X	Error at 99.7% (corresponding to 3 * standard deviation) for the longitude (unit meter) between RPC model and physical model. <ERR_BIAS_X>
ERR_BIAS_Y	Error at 99.7% (corresponding to 3 * standard deviation) for the latitude (unit meter) between RPC model and physical model. <ERR_BIAS_Y>
ERR_BIAS_COL	Error at 99.7% (corresponding to 3 * standard deviation) for the column (sample) (unit pixel) between RPC model and physical model. <ERR_BIAS_COL>

Term	Description
ERR_BIAS_ ROW	Error at 99.7% (corresponding to 3 * standard deviation) for the line (sample) (unit pixel) between RPC model and physical model. <ERR_BIAS_ROW>
FIRST_COL LAST_COL	Validity domain for column image coordinate (sample) available for Global RFM or partial RFM. <Rational_Function_Model><Global_RFM> or <Partial_RFM><RFM_Validity><Direct_Model_Validity_Domain><…>
FIRST_ ROW LAST_ROW	Validity domain for line image coordinate (row) available for Global RFM or partial RFM. <Rational_Function_Model><Global_RFM> or <Partial_RFM><RFM_Validity><Direct_Model_Validity_Domain><…>
FIRST_LAT LAST_LAT	Validity domain for latitude coordinate available for Global RFM or partial RFM. <Rational_Function_Model><Global_RFM> or <Partial_RFM><RFM_Validity><Inverse_Model_Validity_Domain><…>
FIRST_LON LAST_LON	Validity domain for longitude coordinate available for Global RFM or partial RFM. <Rational_Function_Model><Global_RFM> or <Partial_RFM><RFM_Validity><Inverse_Model_Validity_Domain><…>
GAIN	A gain value. <Band_Measurement_List><Band_Radiance><BAND_ID><GAIN>
H	Altitude.
h_{ground}	Ground altitude.
h_{sat}	Altitude of satellite.
HEIGHT_ OFF	Altitude offset used in RPC model. <Rational_Function_Model><Global_RFM><RFM_Validity><HEIGHT_OFF >
HEIGHT_ SCALE	Altitude scale factor used in RPC model. <Rational_Function_Model><Global_RFM><RFM_Validity><HEIGHT_SCALE >
I	Viewing incidence.
Lin	Image line coordinate.
lin_{ref}	Reference line to line-timing model.
lat, long	Geographic coordinates.
LAT_OFF	Latitude offset used in RPC model. <Rational_Function_Model><Global
LAT_SCALE	Latitude scale factor used in RPC model. <Rational_Function_Model><Global_RFM><RFM_Validity><LAT_SCALE>
LINE_DEN_ COEFF_i	Polynomial coefficients used to calculate the denominator (Q) in order to obtain centre-normalised latitude (i from 1 until 20). Direct model: <Rational_Function_Model><Global_RFM><Direct_Model><LINE_DEN_COEFF_i> Inverse model: <Rational_Function_Model><Global_RFM><Inverse_Model><LINE_DEN_COEFF_i>
LINE_NUM_ COEFF_i	Polynomial coefficients used to calculate the numerator (P) in order to obtain centre-normalised latitude (i from 1 until 20). Direct model: <Rational_Function_Model><Global_RFM><Direct_Model><LINE_NUM_COEFF_ i> Inverse model: <Rational_Function_Model><Global_RFM><Inverse_Model><LINE_NUM_COEFF_i>
LINE_OFF	Line offset used in RPC model. <Rational_Function_Model><Global_RFM><RFM_Validity><LINE_OFF>
LINE_ SCALE	Line scale factor used in RPC model. <Rational_Function_Model><Global_RFM><RFM_Validity><LINE_SCALE>
LONG_OFF	Longitude offset used in RPC model. <Rational_Function_Model><Global_RFM><RFM_Validity><LONG_OFF>
LONG_ SCALE	Longitude scale factor used in RPC model. <Rational_Function_Model><Global_RFM><RFM_Validity><LONG_SCALE>
M	Number of time stamp samples found in the product.
(O, X, Y, Z)	Terrestrial Cartesian Coordinate.
O	Earth gravity centre.

Y	Y orthogonal to X and Z.
Z	Pole axis.
OS	Satellite gravity centre.
(OS, T, R, L)	Local Orbit Frame.
T	Pitch axis:
R	Roll axis: $\vec{R} = \vec{T} \wedge \vec{L}$
L	Yaw axis (build with Satellite Position:
(OG, X_v, Y_v, Z_v)	Steering frame (or viewing frame).
X_v	Parallel to scan line direction.
Y_v	Parallel to detector array.
Z_v	Towards Earth.
(OG, X_c, Y_c, Z_c)	'Pointing' frame. (X_c, Y_c, Z_c) = (X_v, Y_v, Z_v) when attitude control is perfect.
Offset	Offset used in Centred normalised time value calculation. <Geometric_Data><Refined_Model><Attitudes><Polynomial_ Quaternions>< OFFSET>
Period	Line period (in ms). <Geometric_Data><Refined_Model><Time><Time_Stamp><LINE_ PERIOD>
PosX(t) PosY(t) PosZ(t)	Satellite location at the given time.
PosX(t_i) PosY(t_i) PosZ(t_i)	Satellite locations at different times ti. <Geometric_Data><Refined_Model><Ephemeris><Point_List><Point(i)> < LOCATION_XYZ>
R_E	Mean Earth Radius ($R_E \approx 6367{,}45$km).
S_b	The spectral sensor sensitivity of b band.

SAMP_OFF	Column (sample) offset used in RPC model. <Rational_Function_Model><Global_ RFM><RFM_Validity><SAMP_OFF>
SAMP_SCALE	Column (sample) scale factor used in RPC model. <Rational_Function_Model><Global_ RFM><RFM_Validity><SAMP_SCALE>
SAMP_DEN_COEFF_i	Polynomial coefficients used to calculate the denominator (Q) in order to obtain centre-normalised longitude (i from 1 until 20). Direct model: <Rational_Function_Model><Global_ RFM><Direct_Model><SAMP_DEN_COEFF_ i> Inverse model: <Rational_Function_Model><Global_ RFM><Inverse_Model><SAMP_DEN_ COEFF_i>
SAMP_NUM_COEFF_i	Polynomial coefficients used to calculate the numerator (P) in order to obtain centre-normalised longitude (i from 1 until 20). Direct model: <Rational_Function_Model><Global_ RFM><Direct_Model><SAMP_NUM_COEFF_i> Inverse model: <Rational_Function_Model><Global_ RFM><Inverse_Model><SAMP_NUM_COEFF_i>
Scale	Scale factor used in Centred normalised time value calculation. <Geometric_Data><Refined_Model><Attitudes><Polynomial_ Quaternions>< SCALE>
T	Viewing time computed for a given line.
t_{CN}	Centred normalised time value.
t_i	Ephemeris point times. <Geometric_Data><Refined_Model><Ephemeris><Point_List><Point><TIME>
t_{mean}	Absolute mean time computed with ephemeris point times.
$trel_i$	Ephemeris point times relative to mean

Symbol	Description
t_{ref}	Reference time corresponding to reference line (see linref). <Geometric_Data><Refined_Model><Time><Time_Range><START>
V_{ground}	Image orientation on the ground.
V_{sat}	Satellite velocity.
Vis_{Scan}	Viewing angle in image focal plane frame.
$VisX_{Scan}$	X coordinate of Vis_{Scan}
$VisY_{Scan}$	Y coordinate of Vis_{Scan}
$VisZ_{Scan}$	Z coordinate of Vis_{Scan}
X_{Scan}	Parallel vector to image line axis.
Y_{Scan}	Parallel vector to detector array.
Z_{Scan}	Vector towards Earth.
α	Incidence angle (°). <Geometric_Data><Use_Area><Located_Geometric_Values><Acquisition_Angles><VIEWING_ANGLE>
αx	Viewing angle in the across-track axis direction (roll). <Geometric_Data><Use_Area><Located_Geometric_Values><Acquisition_Angles><VIEWING_ANGLE_ACROSS_ TRACK>
αy	Viewing angle in the along-track axis direction (pitch). <Geometric_Data><Use_Area><Located_Geometric_Values><Acquisition_Angles><VIEWING_ANGLE_ALONG_ TRACK>
β	Incidence angle (°). <Geometric_Data><Use_Area><Located_Geometric_Values><Acquisition_Angles><INCIDENCE_ANGLE>
βx	Incidence angle in the OrthoScan axis direction. <Geometric_Data><Use_Area><Located_Geometric_Values><Acquisition_Angles><INCIDENCE_ANGLE_ACROSS_ TRACK>
βy	Incidence angle in the Scan axis direction (image line axis on the ground). <Geometric_Data><Use_Area><Located_Geometric_Values><Acquisition_Angles><INCIDENCE_ANGLE_ALONG_ TRACK>
θ_s	The sun zenith angle (sun zenith angle = 90° – sun elevation angle)
θ	Pitch angle.
ρ	Reflectance
φ	Roll angle.
ψ	Yaw angle.
ψx	Viewing direction angle in the YScan direction (parallel to detector array).
ψy	Viewing direction angle in the XScan direction (parallel to image line axis).
Ω	Earth rotation angular speed.

Document Control and Data Sheet

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