Close range and Satellite photogrammetry.

1. Close Range photogrammetry

Close-range photogrammetry is generally used for terrestrial photographs with object distances up to about 300m.

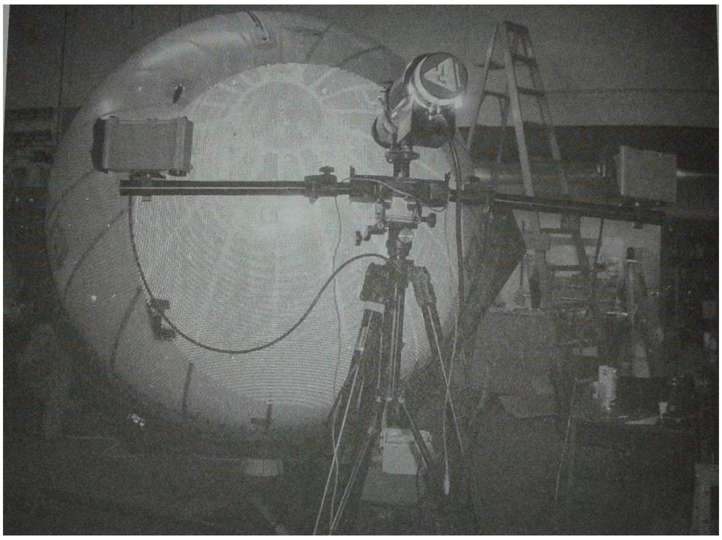
It deals with photographs taken with a camera located on the earth's surface or drones.

The camera may be handheld, mounted on a tripod, suspended from towers or other specially designed mounts.

1.1. Types of terrestrial photography:

- Statistic (photos of stationary objects), in this type, slow, high-resolution films or CCD with long exposure time are used to take images. Stereo pair can be obtained by using a single camera and making exposure at different locations.

- Dynamic (photos of moving objects) fast films and rapid shutter speeds are necessary. In addition, for the stereo pair, two cameras located at the ends of a baseline must make simultaneous exposures.



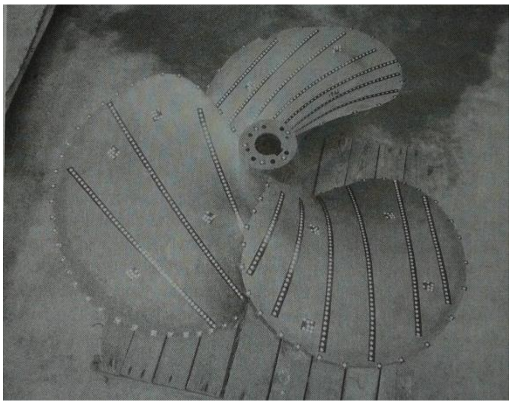
1.2. Applications of terrestrial and close-range photogrammetry

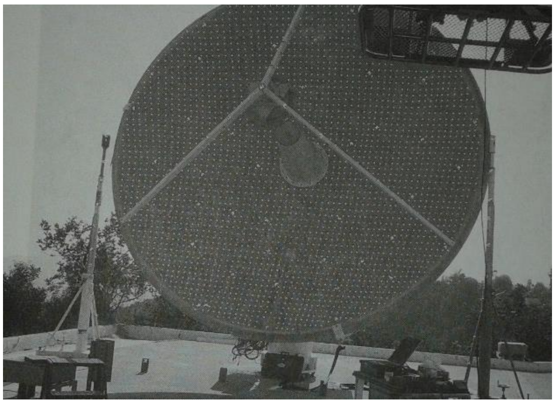
- Historically it has been found to produce topographical maps for rugged area, which was difficult to map by conventional filed-surveying methods.

- Mapping construction site, area of excavation, borrow pits, material stockpiles, etc..

- In medicine, X-ray photogrammetry has been utilized advantageously for measuring the sizes and shapes of body parts, recording tumour growth, studying the development of fetuses, locating foreign objects in the body, etc.

- The below figure shows an example of determining the precise shape of a parabolic antenna or using close-range photogrammetry to determine the dimension of ships propellers





- Also to be used in aircraft manufacture, shipbuilding, telecommunications, robotics, forestry, archaeology, anthropology, architecture, geology, engineering, mining, nuclear industry, criminology, oceanography, medicine, dentistry, and many more.

1.3. Terrestrial Cameras

The cameras used in terrestrial photogrammetry is classified into two type metric and manufactured nonmetric.

Metric cameras it is manufactured expressly for photogrammetric applications. They have fiducial marks built into their focal plane or have calibrated CCD arrays. It is calibrated for focal length, principal point coordinates, and lens distortion.

Nonmetric cameras are manufactured for amateur or professional photography where pictorial quality is essential but geometric accuracy is not considered during manufacturing. It does not contain a fiducial mark. This type of camera can be calibrated to be used in terrestrial photogrammetric applications.

1.4. Self-calibration

Self-Calibration is a technique used in a block bundle adjustment to determine internal sensor model information on the basis of a sufficient number of GCPs.

The metric camera does not need calibration due to the stability of the parameters over long intervals of time.

For nonmetric cameras, the elements of interior orientations should be accounted for to make precise photogrammetric measurements. This should be achieved periodically even between the sessions, through a process known as analytical-self calibration.

The process of self-analytical calibration uses a Collinearity equation that has been augmented with additional terms to account for adjustment of the calibrated focal length, principal-point offset, and symmetric radial and decentering lens distortions. (In addition to that, the equation may include correction for atmospheric correction)

1.5. Planning close-range photogrammetry

The images used in terrestrial photogrammetry it is
- Amateur photographs were taken by different people or by a police officer for a crime scene accident. This type of photograph is specified to be not very well to be used in photogrammetry because they are not very well exposed or focused.
-Or, the photographs are taken by preliminary planning for the object by controlling the factors such as the type of camera, lighting, and camera orientations.

Pictorial quality is taken into consideration

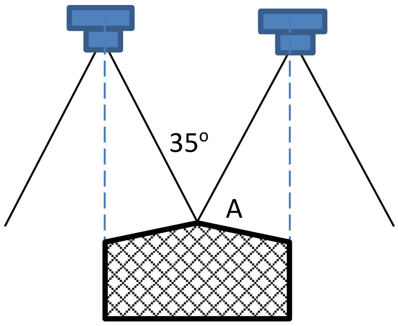
Three primary considerations should be considered: resolution, depth of field, and exposure.

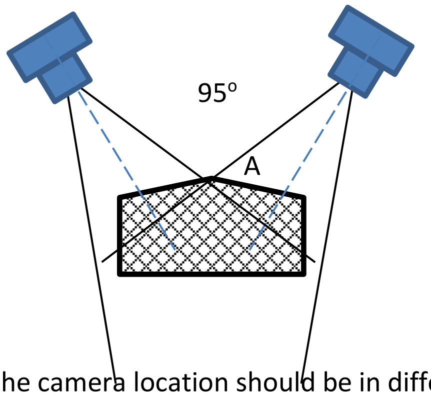
The physical constraint should be taken into consideration:

Object points should be visible on at least two or more images, physical space around the object.

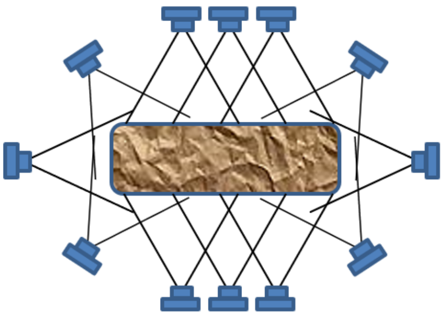
1.6. Geometric consideration,

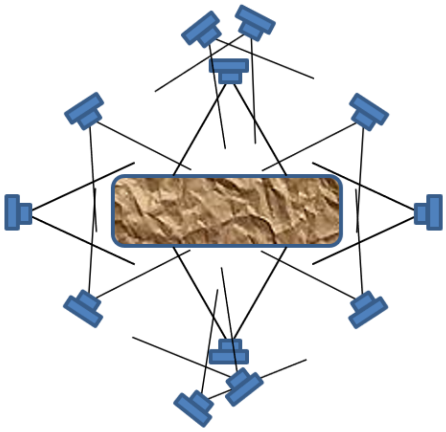
- It is necessary to consider the angular orientation of the camera exposure station.
- The accuracy of the analytical solution depends, to a large extent, upon the angles of the intersection between rays of light.
- The highest overall accuracy will be achieved when intersection angles are near 90°.
- In the left figure, the camera axis is parallel. Thus the obtained angle is around 35°
- In the correct figure, the camera is used to obtain a photo of point A by convergent images. The angle is around 90°. Therefore, the accuracy is higher in this type.





The geometry of the taking images of the project, the camera location should be in different positions and perpendicular to the object. It should be at the same location with different orientations





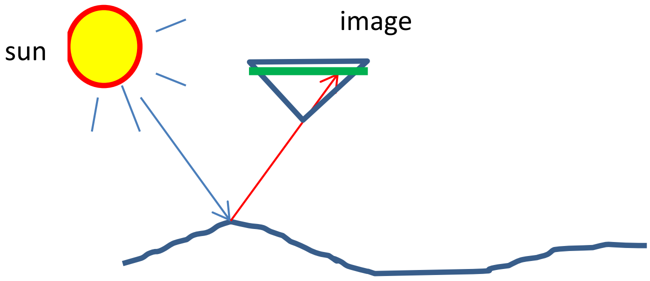
2. Satellite photogrammetry

For certain applications with low accuracy requirements, aerotriangulation from stellate images may be suitable. For example, for small-scale topographic mapping over mountain regions. Or for producing maps for the large area also for restricted areas.

The satellite image can be classified into two parts: passive sensor and active sensor

2.1. Passive sensor:

2.1. <u>Passive sensor:</u> photography is a passive method, the principal is based on energy reflected from the object and is recorded by photosensitive materials or elements or CCD. The type of camera is either a frame camera or a line camera.



The spectral range in the interval 0.3–15 μ m, typical of passive remote sensing, identified by the sensors:

– *panchromatic*: one band including the visible range and, in some cases, part of the near-infrared;
– *multispectral*: 2–9 spectral bands;
– *super-spectral*: 10–16 spectral bands;
– *hyperspectral*: more than 16 spectral bands;

<u>Classification of optical satellite imagery</u>

Low Resolution	≥ 30m and < 300m
Medium Resolution	≥ 5m and < 30m
High Resolution	≥ 1.0m and <5m
Very High Resolution	< 1.0 m

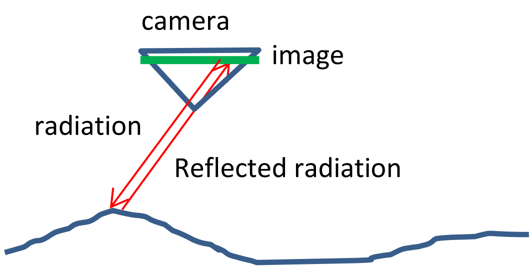
<u>The list of very high-resolution (VHR) optical satellite imagery,</u>

Satellite	Organization country	Bands Pan/MS	Res. Pan/MS(m)	Height(km)
WorldView-1	DigitalGlobe, USA	1/-	0.45/-	496
WorldView-2	DigitalGlobe USA	1/8	0.46/1.8	770
WorldView-3	DigitalGlobe USA	1/28	0.31/1.24	617
WorldView-4	DigitalGlobe USA	1/4	0.31/1.24	617
QuickBird	DigitalGlobe USA	1/4	0.61/2.44	450
IKONOS	DigitalGlobe USA	1/4	0.82/3.2	681
Pleiades-1A+ Pleiades-1B	Airbus Defense and Space France	1/4	0.7/2.8	694

2.2. <u>Active sensor:</u> Active sensors carry their own emitter of radiation that illuminates the sensed objects and causes reflections gathered by the active sensor receiver.

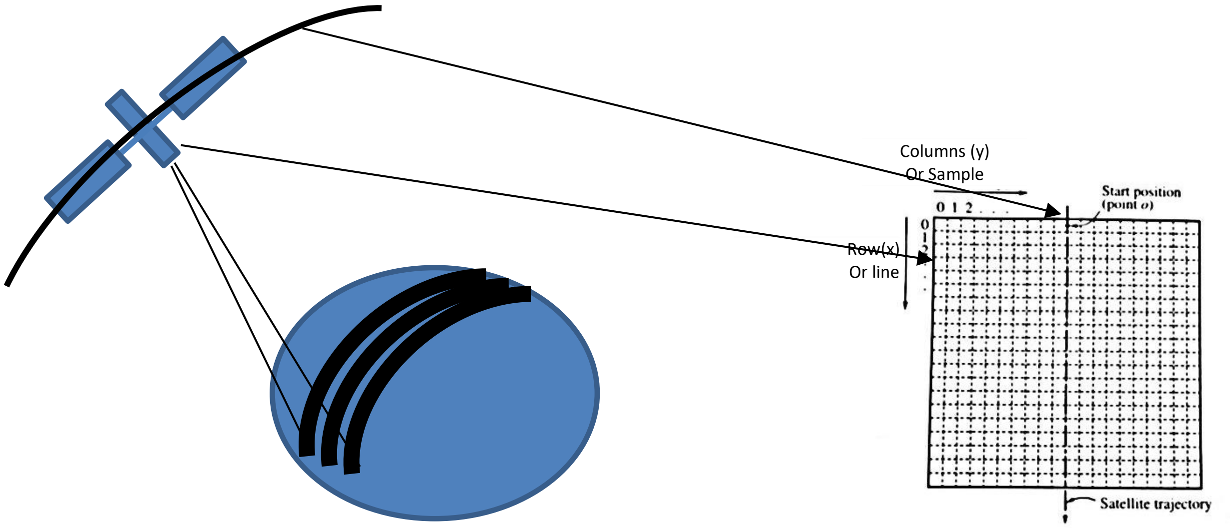
The most important active sensor types are radio detection and ranging (RADAR) and light detection and ranging (LIDAR).

Such technology allows operation independent of natural radiation, mostly reflections of sunlight, e.g., at night.



***<u>RADAR</u>*:** microwaves ranging from 1 mm to 1 m, typical active remote sensing tool, that can operate, with single or multi-polarization and with single or multiple incidence angles, in:
– single frequency;
– multi-frequency.

2.3. Satellite imaging



The satellite is highly stable during the acquisition of the image. Therefore, the exterior orientation parameter can be assumed to vary systematically, as shown in the above figure.

From the start position (point o-centre of row) on the ground with known $\omega o, \phi o, \kappa o, X_{Lo}, , Y_{Lo}, Z_{Lo}$. These parameters can be assumed to vary systematically as functional of x coordinate (row in which image appears). Hence, the function used to represent systematic variations:

$$\omega_x = \omega_o + a_1 x$$

$$\phi_x = \phi_o + a_2 x$$

$$\kappa_x = \kappa_o + a_3 x$$

$$X_{Lx} = X_{Lo} + a_4 x$$

$$Y_{Lx} = Y_{Lo} + a_5 x$$

$$Z_{Lx} = Z_{Lo} + a_6 x + a_7 x^2$$

Coefficients a_1 through a_7 describe the systematic variation.

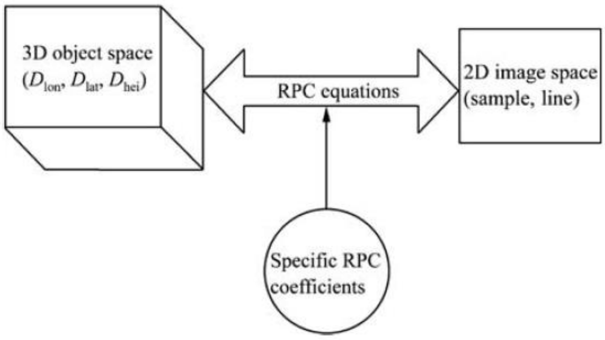
All equations are linear except Z_L is second order due to the curved path of the satellite.

The Collinearity equation used to derive the point of a is:

$$0 = -f.\left[\frac{m_{11x}(X_A - X_{LX}) + m_{21x}(Y_A - Y_{LX}) + m_{31x}(Z_A - Z_{LX})}{m_{31x}(X_A - X_{LX}) + m_{32x}(Y_A - Y_{LX}) + m_{33x}(Z_A - Z_{LX})}\right]$$

$$y_a = y_o - f.\left[\frac{m_{21}x(X_A - X_{LX}) + m_{22x}(Y_A - Y_{LX}) + m_{23x}(Z_A - Z_{LX})}{m_{31x}(X_A - X_{LX}) + m_{32x}(Y_A - Y_{LX}) + m_{33x}(Z_A - Z_{LX})}\right]$$

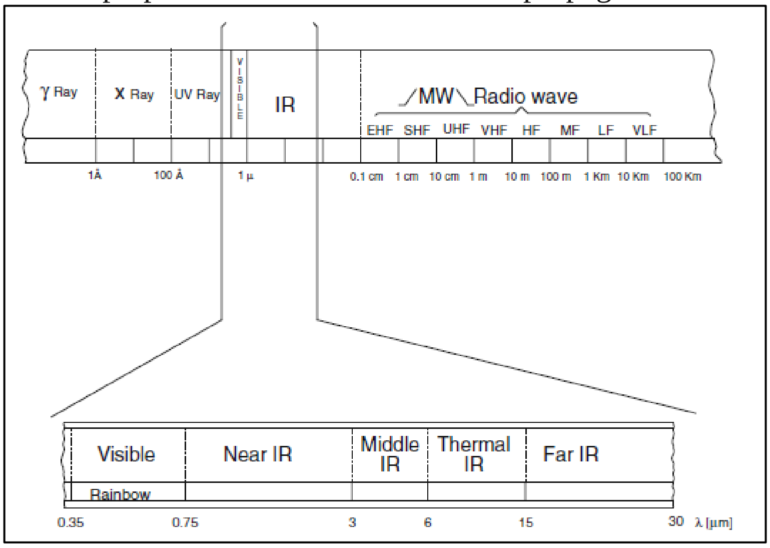
Rational Polynomial Coefficients (RPC) is a model that relates 3D object space to 2D image space through a set of equations for various sensors with different RPC coefficients. It is considered a replacement for the actual physical characteristics and orientation of the sensor concerning the image coordinates of the ground point.



The RPC delivered with the image. Similarly to the Collinearity equation, the RPC can be used to **derive** different products such as DEM generation, orthorectification, and feature **extraction**.

2.4. Electromagnetic Spectrum

- Electromagnetic radiation consists of an electrical field (E) that varies in magnitude along a direction perpendicular to the direction of propagation. As shown below:



- *Visible light*, so defined as its range, is within the interval of the human eye's spectral sensibility, as shown in the below figure:

Table 6.8 SPOT satellites series: instruments, spectral bands and geometric resolutions

Satellite	Sensor	Spectral bands (μm)	Resolution (m)
SPOT 1, 2 and 3	HRV- P	0.51–0.73 panchromatic	10
	HRV -XS	0.50–0.59 green	20
		0.61–0.68 red	
		0.79–0.89 near infrared	

The introduction of the panchromatic band is the most important innovation, covering the visible range (0.5–0.7 μ m) and part of the near-infrared.

<u>Synthetic aperture radar (SAR),</u> is widely used to acquire images. Images acquired by SAR are very sensitive to terrain variation. This is the basis for three types of techniques, that is:

- **<u>SAR Radargrammetry</u>** acquires DTM data through the measurement of parallax. It is based on the following key issues:
  1. determining the sensor–object stereo model
  2. searching for corresponding pixels from two overlapping SAR images using image-matching Techniques
  3. determining 3-D coordinates by solving the intersection problem.

- **<u>SAR Interferometry</u> <u>(inSAR)</u>** acquires DTM data by determining phase shifts between two echoes.

- **<u>SAR Radarclinometry</u>** acquires DTM data through shape from shading. However, radarclinometry uses a single image, and the height information is not accurate enough for DTM.

- **<u>AIRBORNE LASER SCANNING (LIDAR)</u>** ALS is a complex integrated system consisting of a laser range finder (LRF), a computer system to control the online data acquisition, a storage medium, a scanner,
- and a GPS/INS system for determining the position and orientation of the system.

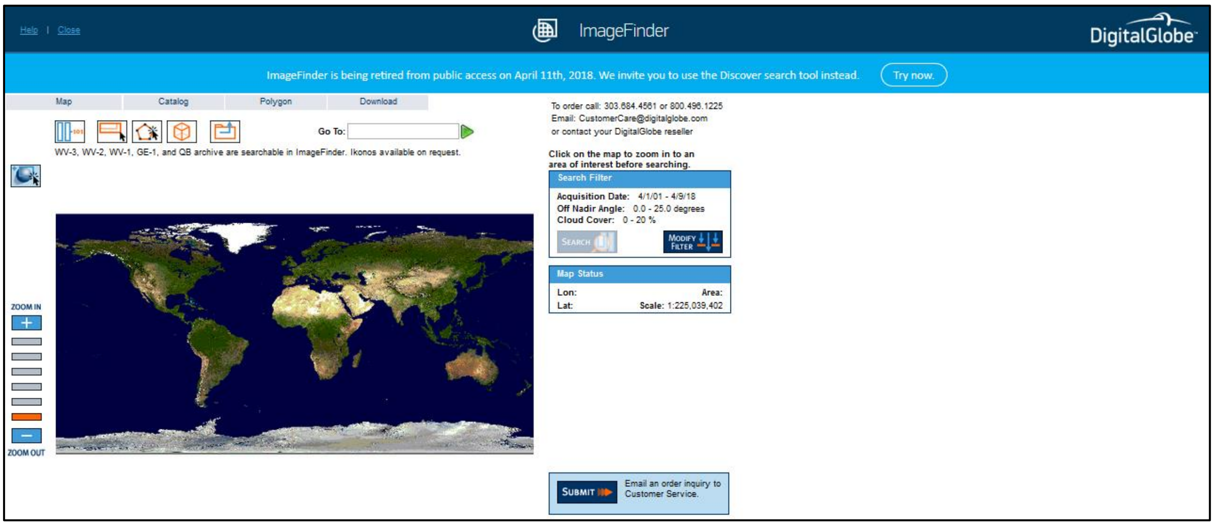
2.5. Ordering satellite imagery

Before ordering the satellite images, it is possible to browse the available imagery and check some properties, such as angles and dates.

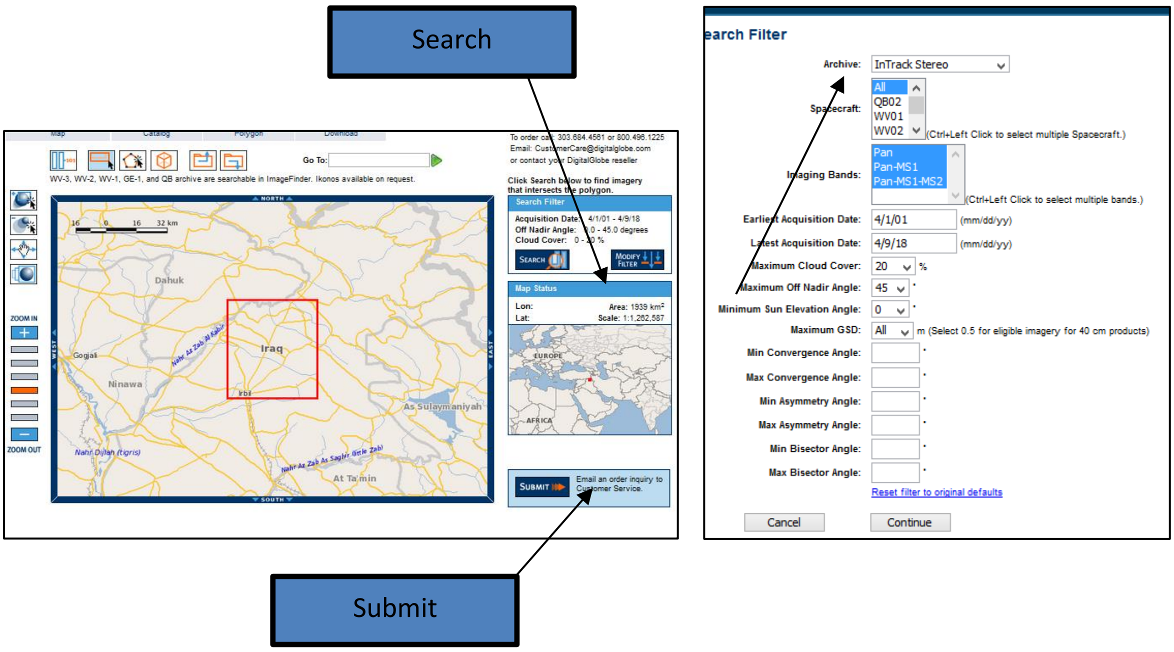
Commercial websites make their sample images available online, such as DigitalGlobe, and Pleiades,. ….

1-To check the DigitalGlobe website, check the following link: https://browse.digitalglobe.com/

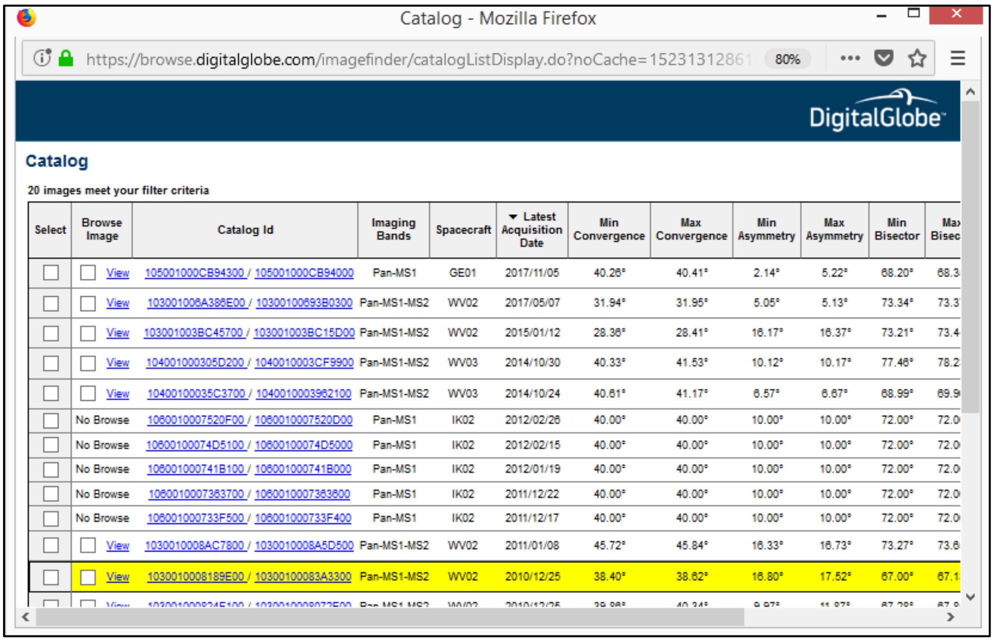
the below image will appear



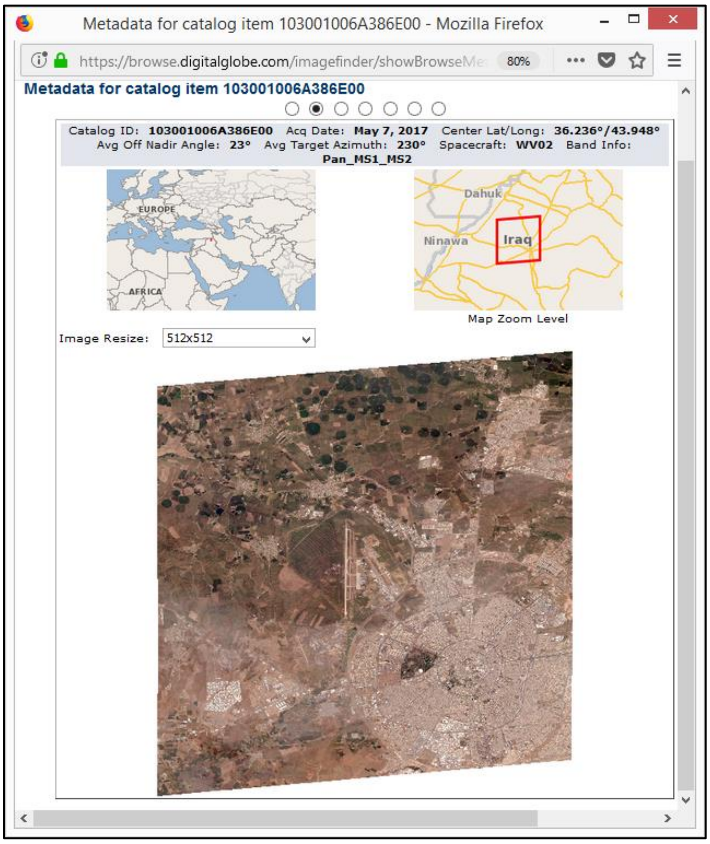
2-specify the location by specifying a polygon, and click on the "modify filter" to select the properties of the search such as in track stereo, the sensor and others… when finished, click on Continue



3-click on the search button to start the search. When finished, it will show a list with all available images. You can sort them based on the date or sensor type.



4-To view any image, click on the catalogue id.



5-if you are satisfied with the image, click on select that shown in item 3 and then click on submit, shown in item 2.