

**MODULE – 3 LECTURE NOTES – 1****GEOMETRIC CORRECTIONS****1. Introduction**

The flux radiance registered by a remote sensing system ideally represents the radiant energy leaving the surface of earth like vegetation, urban land, water bodies etc. Unfortunately, this energy flux is interspersed with errors, both internal and external which exist as noise within the data. The internal errors, also known as systematic errors are sensor created in nature and hence are systematic and quite predictable. The external errors are largely due to perturbations in the platform or atmospheric scene characteristics. Image preprocessing is the technique used to correct this degradation/noise created in the image, thereby to produce a corrected image which replicates the surface characteristics as closely as possible. The transformation of a remotely sensed image, so that it possesses the scale and projection properties of a given map projection, is called geometric correction or georeferencing. A related technique essential for georeferencing, known as registration that deals with fitting of coordinate system of one image to that of a second image, both of the same area.

**2. Systematic Errors**

The sources of systematic errors in a remote sensing system are explained below:

**a. Scan skew:**

Caused when the ground swath is not normal and is skewed due to the forward motion of the platform during the time of scan.

For example, image from Landsat satellites will usually be skewed with respect to the earth's N-S axis. The skew angle can be expressed as:

$$\theta = 90 - \cos^{-1} \frac{\sin(\theta_e)}{\cos(L)}$$

Where  $\theta_e$  = Direction of forward motion of the satellite

L = Latitude at which skew angle is to be determined

**b. Platform velocity:** Caused due to a change in speed of the platform resulting in along track scale distortion.

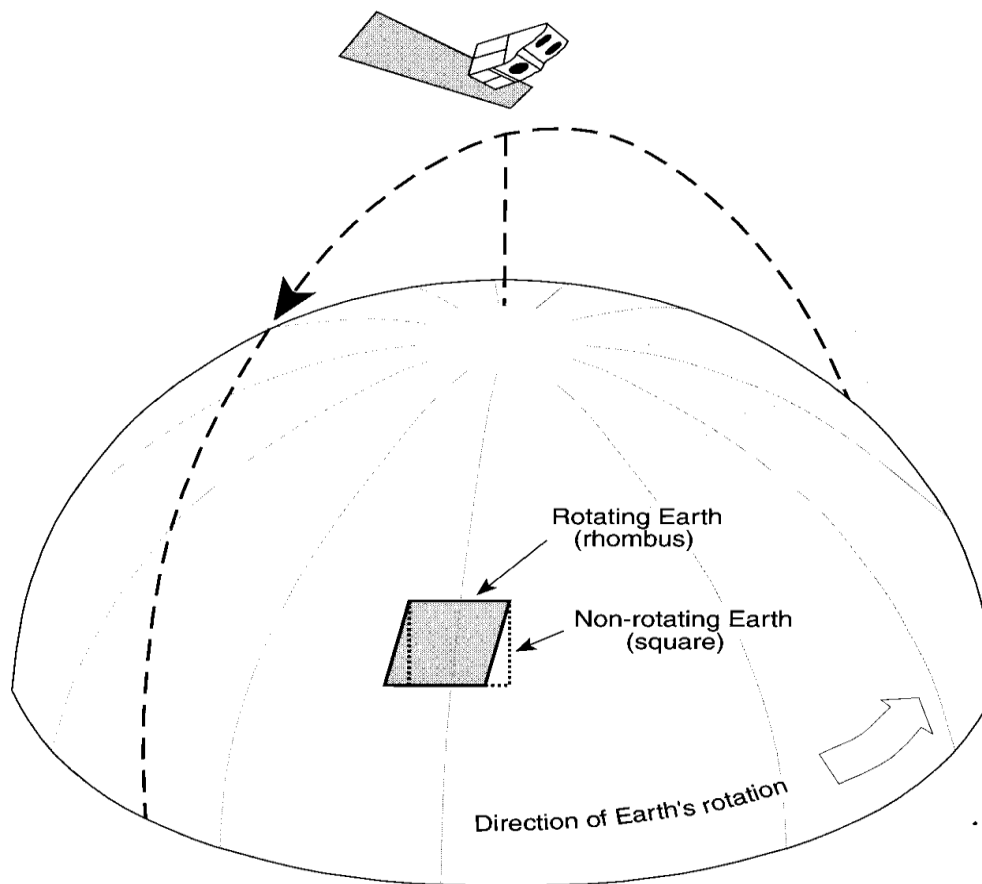
**c. Earth rotation:**

Caused due the rotation of earth during the scan period resulting in along scan distortion (Figure 1). When a satellite moving along its orbital track tries to scan the earth revolving with a surface velocity proportional to the latitude of the nadir, there occurs a shift in displacement of the last scan line in the image. This can be corrected provided we know the distance travelled by the satellite and its velocity.

For example, consider the case when the line joining centres of first and last scan lines to be aligned along a line of longitude and not skewed (as observed in the case of SPOT, Terra and all sun synchronous satellites). Landsat satellites take 103.27 minutes for one full revolution. Expressing the distance and velocity in angular units, we have the satellite's angular velocity to be  $\frac{2\pi}{(103.27 * 60)}$  radians/sec. If the angular distance moved by a Landsat satellite during capture of one image be 0.029 radians, the time required for satellite to traverse this distance can be calculated as

$$\frac{0.029 * (103.27 * 60)}{2\pi} = 28.6 \text{ seconds.}$$

Once we know the relative time difference, the aim is to determine the distance traversed by the centre of last scan line during this time (28.6 seconds). Earth takes 23 hours, 56 minutes and 4 seconds to complete one full rotation; therefore its angular velocity can be obtained similarly as  $\frac{2\pi}{867164}$  radians/sec. The surface velocity of earth can be estimated to be 292.7 m/sec (for  $51^\circ$  N). Hence, the distance traversed can be finalized as  $292.7 * 28.6 = 8371$  m.



**Figure 1: Figure showing distortion due to earth's rotation**

- d. **Mirror scan velocity:** Caused when the rate of scanning is not constant resulting in along scan geometric distortion.
- e. **Aspect ratio:**

Sensors like MSS of Landsat produce images whose pixels are not square. The instantaneous field of view of MSS is 79m, while the spacing between pixels along each scan line is 56m. This results in the creation of pixels which are not square due to over sampling in the across track direction. For image processing purposes, square/rectangular pixels are preferred. Therefore we make use of a transformation matrix so that the final aspect ratio becomes 1:1. In the case of MSS, the transformation matrix will be as given below:

$$A = \begin{pmatrix} 0.0 & 1.41 \\ 1.0 & 0.00 \end{pmatrix}$$

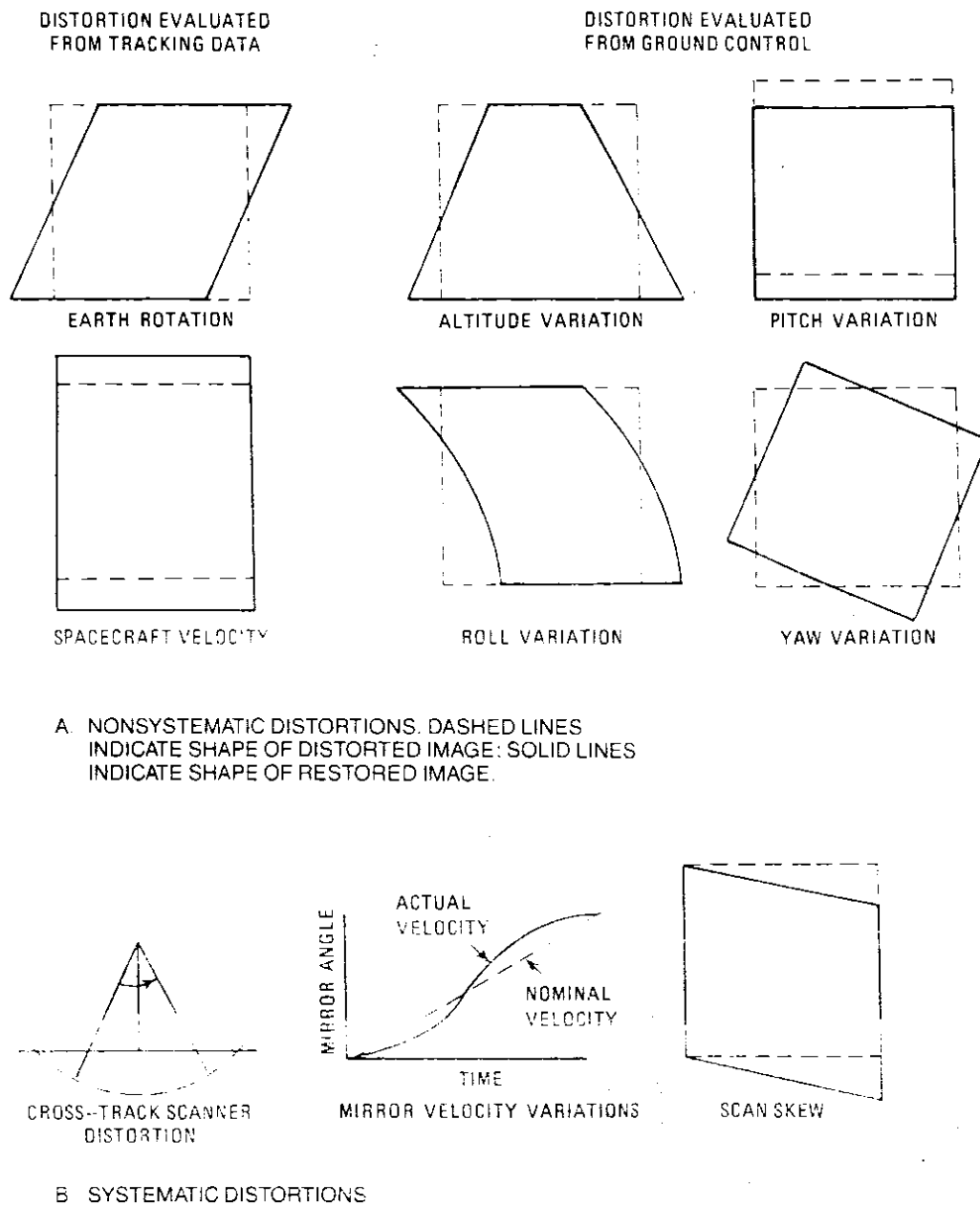
This is because the Landsat MSS scan lines are nominally 79 m apart and the pixels along the scan line are spaced at a distance of 56 m. Due to the general user tendency to choose square pixels rather than rectangular ones, we can either go with 79m or 56 m to remove the issue of unequal scale in both x and y direction. In this case, with Landsat MSS, the across scan direction will be over sampled and therefore it will be much more reasonable to choose 79 m square pixels. Then, the aspect ratio will become the ratio of x:y dimensions which is 56:79 that amounts to 1:1.41.

### 3. Non- Systematic Errors

A schematic showing systematic and non systematic errors are presented in Fig. 2. The sources of nonsystematic errors are explained below:

- a. Altitude: Caused due the departure of sensor altitude resulting in change of scale.
- b. Attitude:

Errors due to attitude variations can be attributed to the roll, pitch and yaw of satellite. Schematic showing roll, attitude distortions pertaining to an aircraft is depicted in Fig. 3. Some of these errors can be corrected having knowledge about the platform ephemeris, ground control point, sensor characteristics and spacecraft velocity.



**Figure 2: Schematic representation of the systematic and non systematic distortions**

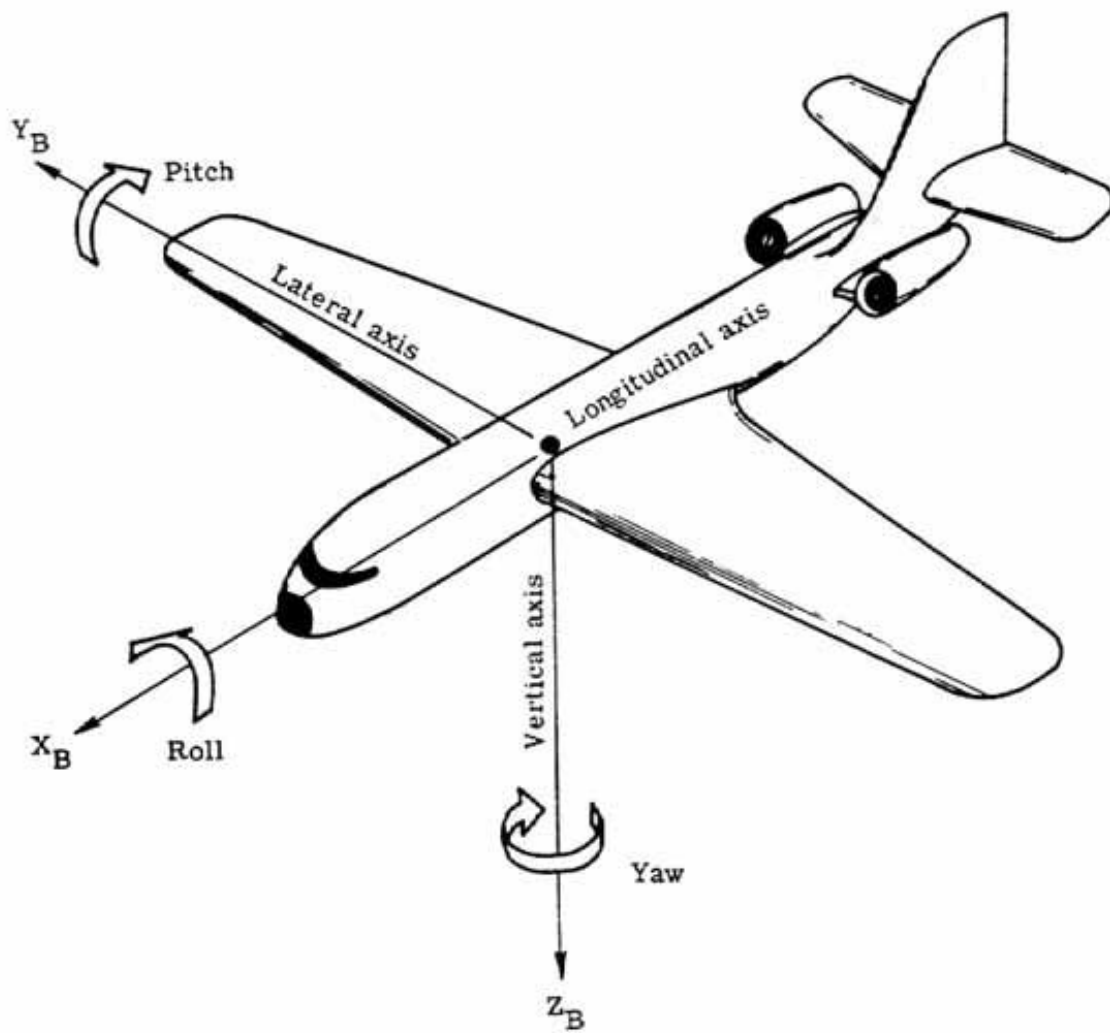


Figure 3: Attitude Distortions of an aircraft