Photogeology in Terrain Evaluation (Part – 1)
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Lecture – 06
Photo-interpretation & Techniques

Welcome back.

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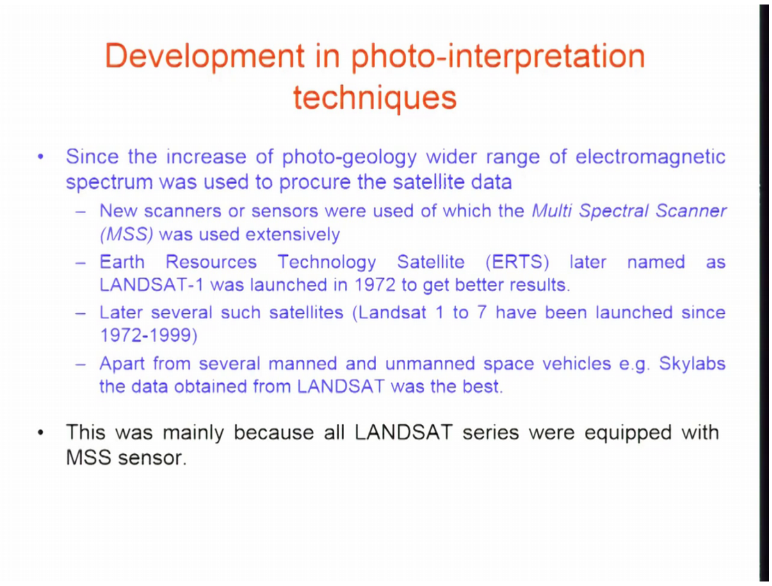

So, since the increase of photo geology, wider range of electromagnetic spectrum was used to produce the satellite data. New scanners or sensors were used, of which the multispectral scanner was used extensively, but now a days we are having hyper spectral scanners also which will have lot many different bands, not only restricted to 7, but you will have more spectral bands. So, I will just browse through very quickly the earth resources technology which came in and which was launched in 1972. So, we have an complete range of the launches which have been taken, which took place and last few couple of decades that you can refer in.

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TIMELINE OF ARTIFICIAL SATELLITES AND SPACE PROBES

Year	Origin	Name	Status	Description
1957	USSR	Sputnik 1	Success	The first satellite in space.
1957	USSR	Sputnik 2	Success	The first satellite to carry a living animal, a dog named Laika.
1957	USA	Vanguard TV3	Failed	
1958	USA	Explorer 1	Success	The first American satellite in space.
1958	USA	Vanguard 6.5in Satellite 2	Failed	
1958	USA	Explorer 2	Failed	
1958	USA	Vanguard 1	Success	The oldest man-made object in space, expected to remain in orbit until approximately 2200 AD.
1958	USA	Explorer 3	Success	
1958	USSR	ISZ D-1 No. 1	Failed	
1958	USA	Vanguard 20in X-ray 1	Failed	
May 15, 1958	USSR	Sputnik 3		

So, these are the timeline of artificial satellites and space probes, which started from 1957 which goes here. So, mostly you will find that many developed countries they launched, but India also came into the picture and that also you can look at that. Now we are having almost like around hundred satellites which are in the orbits.

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Year	Origin	Target	Status	Description
1990	USA/ Europe	Sun	Success	Ulysses solar flyby
1990	Japan	Moon	Success	Hiten probe, this was the first non-United States or USSR probe to reach the Moon
1990	USA/ Europe	Earth	Success	Launch of the Hubble Space Telescope
1990	Germany	Earth	Success	Launch of the ROSAT X-ray satellite to conduct the first imaging X-ray sky survey
1991	Japan	Sun	Success	Yohkoh solar probe
1991	USA	Earth	Success	Launch of the Compton Gamma-Ray Observatory satellite
1992	USA	Mars	Failure	Mars Observer orbiter
1993	Japan	Earth	Success	Launch of the ASCA (ASTRO-D) X-ray satellite
1994	USA	Moon	Success	Clementine orbiter mapped the surface of the Moon (resolution 125–150 m) and allowed the first accurate relief map of the Moon to be generated
1995	Mexico	Earth	Failed	Unamsat 1, First UNAM built orbiter

So, this is just for your reference information which you can look at.

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India has launched 101 Indian satellites as of 2nd September 2017 of many types since its first attempt in 1975.

NAME	LAUNCH DATE	LAUNCH VEHICLE	APPLICATION/ REMARKS
Aryabhata	19 April 1975	u-11 Interkosmos	Provided technological experience in building and operating a satellite system.
Bhaskara-I	7 June 1979	C-1 Interkosmos	First experimental remote sensing satellite. Carried TV and microwave cameras.
Rohini Technology Payload	10 August 1979	SLV-3	Intended for measuring in-flight performance of first experimental flight of SLV-3, the first Indian launch vehicle. Did not achieve orbit
Rohini RS-1	18 July 1980	SLV-3	Used for measuring in-flight performance of second experimental launch of SLV-3.
Rohini RS-D1	31 May 1981	SLV-3	Used for conducting some remote sensing technology studies using a landmark sensor payload.Launched by the first developmental launch of SLV-3.
Ariane Passenger Payload Experiment	19 June 1981	Ariane-1 (V-3)	First experimental communication satellite. Provided experience in building and operating a payload experiment three-axis stabilized communication satellite.
Bhaskara-II	20 November 1981	C-1 Intercosmos	Second experimental remote sensing satellite; similar to Bhaskara-1. Provided experience in building and operating a remote sensing satellite system on an end-to-end basis.
INSAT-1A	10 April 1982	Delta 3910 PAM-D	First operational multipurpose communication and meteorology satellite. Procured from USA. Worked for only six months.
Rohini RS-D2	17 April 1983	SLV-3	Identical to RS-D1. Launched by the second developmental launch of SLV-3.
INSAT-1B	30 August 1983	Shuttle [PAM-D]	Identical to INSAT-1A. Served for more than design life of seven years.
Stretched Rohini Satellite Series(SROSS-1)	21 March 1987	ASLV	Carried payload for launch vehicle performance monitoring and for gamma ray astronomy. Did not achieve orbit.

So, if you take in terms of the Indian part, India has launched almost like 101 Indian satellites as on second September 2017 of many types since its first attempt in 1975. So, since then we are having almost 101 satellites. This for various applications has been given here ok.

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NAME	LAUNCH DATE	LAUNCH VEHICLE	APPLICATION/ REMARKS
INSAT-3DR	08-Sep-16	India GSLV-F05	An advanced meteorological satellite of India configured with an imaging System and an Atmospheric Sounder
Pratham	26-Sep-16	India PSLV-C35	A mini-satellite build by students and researchers at IIT, Mumbai to study electrical characteristics of the earth's atmosphere
PISat	26-Sep-16	India PSLV-C35	A micro-satellite designed and built by the students of PES Institute of Technology, Bengaluru at their Crucible of Research and Innovation Laboratory (CRIL) to develop remote sensing applications
ScatSat-1	26-Sep-16	India PSLV-C35	Miniature satellite to provide weather forecasting, cyclone prediction, and tracking services to India
GSAT-18	06-Oct-16	EuropeAriane-5 ECA	At 3.4 tons, this was the heaviest satellite being owned/operated by India at the time of its launch
ResourceSat-2A	07-Dec-16	India PSLV-C36	Its mission is identical to its predecessors (Resourcesat-1 and Resourcesat-2)
CartoSat-2D	15-Feb-17	India PSLV-C37	ISRO holds the world record for launching the highest number of satellites by a single launch vehicle (104 satellites, including the CartoSat-2D and 2 indigenously designed nano-satellites, INS-1A and INS-1B)
INS-1A (ISRO Nano-Satellite 1A)	15-Feb-17	India PSLV-C37	This is one of 2 nano-satellites designed and manufactured by SAC, ISRO, are part of the constellation of 104 satellites launched in a single go
INS-1B (ISRO Nano-Satellite 1B)	15-Feb-17	India PSLV-C37	This is one of 2 nano-satellites designed and manufactured by SAC, ISRO, are part of the constellation of 104 satellites launched in a single go
South Asia Satellite(GSAT-9)	05-May-17	India GSLV Mk.II	This satellite is being offered by India as a diplomatic initiative to its neighbouring countries (SAARC region) for communication, remote sensing, resource mapping and disaster management applications

So, in 2017, a lot many satellites were been launched.

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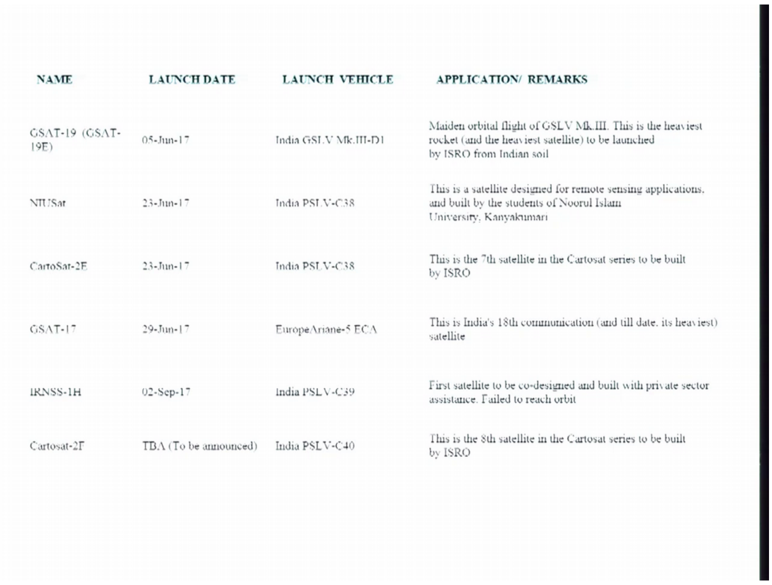

NAME	LAUNCH DATE	LAUNCH VEHICLE	APPLICATION/ REMARKS
GSAT-19 (GSAT-19E)	05-Jun-17	India GSLV Mk.III-D1	Maiden orbital flight of GSLV Mk.III. This is the heaviest rocket (and the heaviest satellite) to be launched by ISRO from Indian soil
NIUSat	23-Jun-17	India PSLV-C38	This is a satellite designed for remote sensing applications, and built by the students of Noorul Islam University, Kanyakumari
CartoSat-2E	23-Jun-17	India PSLV-C38	This is the 7th satellite in the Cartosat series to be built by ISRO
GSAT-17	29-Jun-17	EuropeAriane-5 ECA	This is India's 18th communication (and till date, its heaviest) satellite
IRNSS-1H	02-Sep-17	India PSLV-C39	First satellite to be co-designed and built with private sector assistance. Failed to reach orbit
Cartosat-2F	TBA (To be announced)	India PSLV-C40	This is the 8th satellite in the Cartosat series to be built by ISRO

And one which will make 102, that is cardosat is still to be announced ok.

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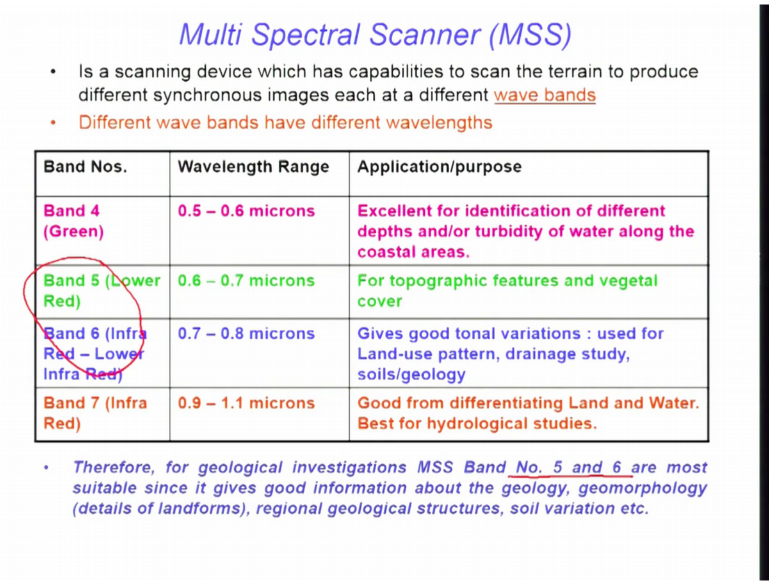

Multi Spectral Scanner (MSS)

- Is a scanning device which has capabilities to scan the terrain to produce different synchronous images each at a different wave bands
- Different wave bands have different wavelengths

Band Nos.	Wavelength Range	Application/purpose
Band 4 (Green)	0.5 – 0.6 microns	Excellent for identification of different depths and/or turbidity of water along the coastal areas.
Band 5 (Lower Red)	0.6 – 0.7 microns	For topographic features and vegetal cover
Band 6 (Infra Red – Lower Infra Red)	0.7 – 0.8 microns	Gives good tonal variations : used for Land-use pattern, drainage study, soils/geology
Band 7 (Infra Red)	0.9 – 1.1 microns	Good from differentiating Land and Water. Best for hydrological studies.

- *Therefore, for geological investigations MSS Band No. 5 and 6 are most suitable since it gives good information about the geology, geomorphology (details of landforms), regional geological structures, soil variation etc.*

Now, as we were talking about the multispectral scanner or the multispectral data. So, it is a scanning device, which has an capability to scan the terrain to produce different synchronous images each at different wave bands. So, different wave bands have different wavelengths.

For example, we are talking about 1 to 7, which we saw in the slide of these spectral reflectance curves, where we are talking about, that how the water will be absorbed and where and under which range the water will get absorbed or we will be able to see the reflectance and vegetation and for example, soids also. So, different wave bands have different wavelengths. So, depending on the application and purpose for example, you can pick up different bands.

Now, band 4 which is green, band 5 is red, band 6 infrared lower infrared and band 7 is infrared and they have their respective wavelength ranges here, 0.5, 0.6, 0.4, 0.6 to 0.7 for band 5, 0.7 to 0.8, band 6, 0.9 to 1.1, 4.7. So, if you look at the application, the band 4 is excellent for identification of different depths and or turbidity of the water along the coastal radius. So, if you are exclusively looking for the coastal zones and all that mapping in that area, you can straight away use band 4.

For band 5, for topographic features and vegetal covers, you will you can you should use band 5 and band 6 gives good tonal variation, which is used for land use pattern, drainage studies, soil etcetera and then band 7, good for differentiating land and water, best for hydrological studies. Therefore, for geological investigation, multispectral data if you want band 5 and band 6 are most suitable. So, band 5 and band 6 this both are most suitable one, since it gives good information about geology, geomorphology and regional geological structures, soil variation etcetera.

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Landsat Multispectral Scanner (MSS) images consist of four spectral bands with 60 meter spatial resolution. Approximate scene size is 170 km north-south by 185 km east-west (106 mi by 115 mi). Specific band designations differ from Landsat 1-3 to Landsat 4-5

Multispectral Scanner (MSS)	Landsat 1-3	Landsat 4-5	Wavelength (micrometers)	Resolution (meters)
	Band 4	Band 1	0.5-0.6	60*
	Band 5	Band 2	0.6-0.7	60*
	Band 6	Band 3	0.7-0.8	60*
	Band 7	Band 4	0.8-1.1	60*

* Original MSS pixel size was 79 x 57 meters; production systems now resample the data to 60 meters

Landsat Thematic Mapper (TM) images consist of seven spectral bands with a spatial resolution of 30 meters for Bands 1 to 5 and 7. Spatial resolution for Band 6 (thermal infrared) is 120 meters, but is resampled to 30-meter pixels. Approximate scene size is 170 km north-south by 183 km east-west (106 mi by 114 mi).

Thematic Mapper (TM)	Landsat 4-5	Wavelength (micrometers)	Resolution (meters)
	Band 1	0.45-0.52	30
	Band 2	0.52-0.60	30
	Band 3	0.63-0.69	30
	Band 4	0.76-0.90	30
	Band 5	1.55-1.75	30
	Band 6	10.40-12.50	120* (30)
	Band 7	2.08-2.35	30

* TM Band 6 was acquired at 120-meter resolution, but products are resampled to 30-meter pixels

Now, bands designated for landsat satellites mainly. So, you have multispectral scanner. So, you have from band 4 to band 7, band 1 to band 4 for landsat 1 2 3. So, we have multiple like several landsat satellites. Thus again I will not get into the details of this, but we can you can read out these again important. So, if you look at the thematic mapper landsat, then you have the range which is starting from 1 to7. So, this TM image is consists of 7 bands with spatial resolution of almost 30 meters for band 1 to 5 and 7.

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Landsat 8 Operational Land Imager (OLI) and Thermal Infrared Sensor (TIRS) images consist of nine spectral bands with a spatial resolution of 30 meters for Bands 1 to 7 and 9. New band 1 (ultra-blue) is useful for coastal and aerosol studies. New band 9 is useful for cirrus cloud detection. The resolution for Band 8 (panchromatic) is 15 meters. Thermal bands 10 and 11 are useful in providing more accurate surface temperatures and are collected at 100 meters. Approximate scene size is 170 km north-south by 183 km east-west (106 mi by 114 mi).

Landsat 8 Operational Land Imager (OLI) and Thermal Infrared Sensor (TIRS)	Bands	Wavelength (micrometers)	Resolution (meters)
	Band 1 - Coastal aerosol	0.43 - 0.45	30
	Band 2 - Blue	0.45 - 0.51	30
	Band 3 - Green	0.53 - 0.59	30
	Band 4 - Red	0.64 - 0.67	30
	Band 5 - Near Infrared (NIR)	0.85 - 0.88	30
Launched February 11, 2013	Band 6 - SWIR 1	1.57 - 1.65	30
	Band 7 - SWIR 2	2.11 - 2.29	30
	Band 8 - Panchromatic	0.50 - 0.68	15
	Band 9 - Cirrus	1.36 - 1.38	30
	Band 10 - Thermal Infrared (TIRS) 1	10.60 - 11.19	100 * (30)
	Band 11 - Thermal Infrared (TIRS) 2	11.50 - 12.51	100 * (30)

* TIRS bands are acquired at 100 meter resolution, but are resampled to 30 meter in delivered data product

So, ETM; Enhanced Thematic Mapper which against a live almost like 8 bands and this was landsat 7 so, these are some of the important things which have been given, but anyways we will not be using this in our course, but you can have for your reference.

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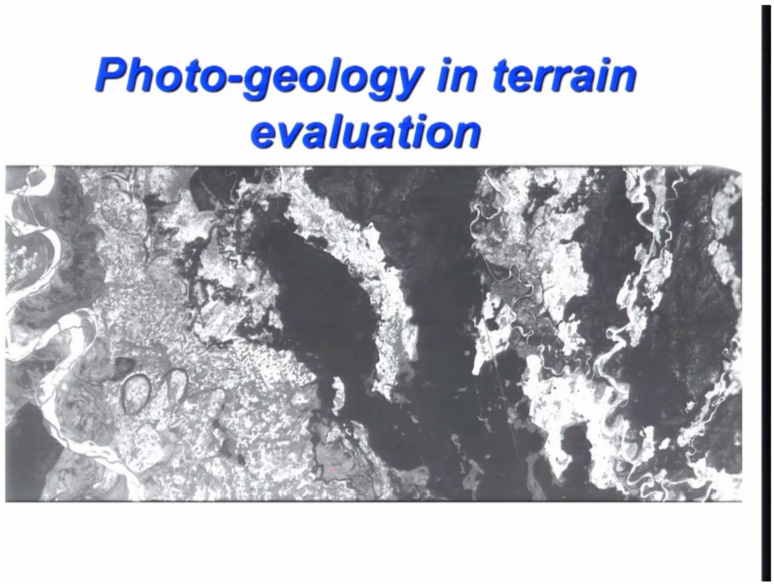

Now, this is and satellite photo, high resolution satellite photo and chromatic data. Corona, this is a Corona satellite photograph of indo Gangetic plain, which shows the darker colors here, could be related to the water bodies and you have the complete range of grey shades which are available here, which can help you and identifying the different features.

So, these are some of the cutoff channels here we are having like what we call the oxbow lakes and then this is your main channel. At the same time on the periphery of this one you can see migration of different channels and of course, one can also mark, which is which needs to have the ground conformation or ground to thing the older terraces or higher terraces or lower terraces also here.

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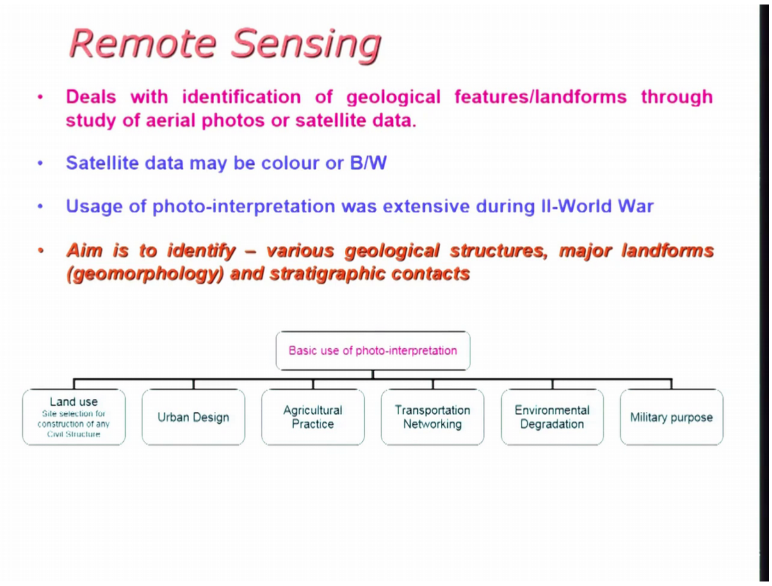

Now, coming to the remote sensing part here, if you look at or you can you can talk about the and why it is important, of the photo geology part deals with identification of geological features, landforms through study of aerial photos and satellite data. So, satellite data may be an form of color, images or black and white. Usage of photo interpretation was extensive during Second World War, aim is to identify radius, geological structure, major landforms that is what we call the Geomorphology and stratigraphic contacts.

So, basic use of photo interpretations; land use, site selection for construction of any civil structures, urban design, agricultural practices, transportation network, environment degradation and for military purposes. So, in general we are looking at the aspect because the photo geology is part of the remote sensing only, a complete technique and which can be used for several purposes ok.

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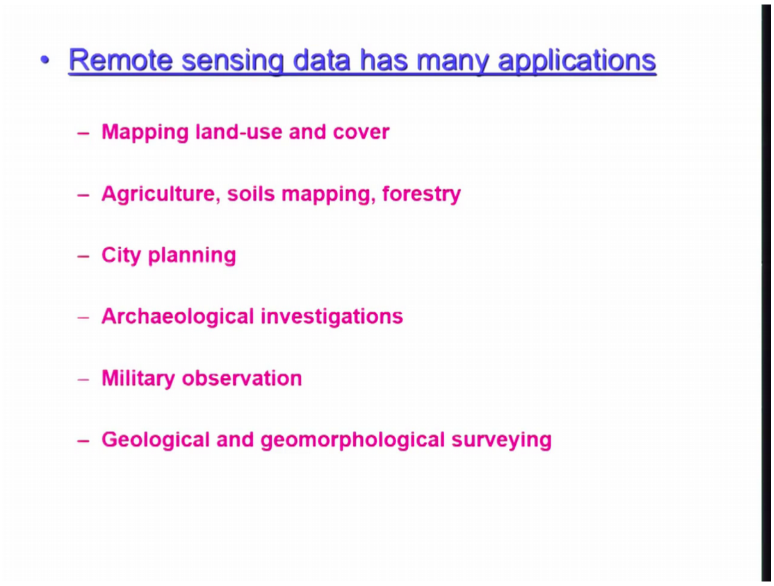

So, remote sensing data has many applications. Mapping land use and cover, agricultural soil mapping, city planning, archaeological investigations, military observations geological and geomorphological serving.

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Advantages and disadvantages of aerial photos; advantages, Time. If you use the aerial photographs and in particularly if you are using the high resolution a satellite data either it is aerial photograph or satellite images or satellite photographs. The time which you will consume in mapping the area will be drastically reduced, as you need not to go in the field and all that and why photographs are very good or important because they will give you and very high resolution information as compared to the satellite imageries, where you will have for example, 30 meter of resolution, absolute resolution.

Here you would, may have a resolution of 1 meter or even less, depending on that at what height you have flown. Then of course, the money part, because more when you fly for collecting the information for any area. That information can be passed on to multiple user. So, once the investment is done, the same data can be used by different users. So, for example, we were talking about again, you can have the information you can you would like to extract from this. Accuracy will be very high when we are talking about the ortho photographs or vertical photographs which have been taken by the aircrafts. Data form, either you have the data which is available in digital form which can be passed on to many users, multiple users and it is easy to use those or for the interpretations.

Disadvantages we have in terms of the scale because the fly flight will not stay at the same height every time because of several reasons either it is turbulence or maybe another reasons it will have some issues related to the tilt and all that. Either camera got tilted or the fly flying height was varying from while passing through that terrain. So, scale is one of the disadvantage in the aerial photographs. Only large features can be marked. Exact identification of rock is difficult sometime, I would say that it is something, but if you take of course, and very high resolution photographs. Then you will be able to also mark the smaller features also.

Exact identification is difficult because the photographs you will not be able to remove the vegetation and all that. So, you may have a disadvantage when you are having a very thick cover of vegetation. Only surface features can be identified, you cannot go to the deeper part as in terms of other satellite information or the data which is available. So, these are the advantages and disadvantages which we have, but most of the portion if you look at we have good amount of advantage using aerial photographs. These are just to show the two photographs of the same area in color and black and white or we can say the in the shade of the gray color ok.

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Importance of photo-interpretation in Civil Engineering

- Engineer should have indepth knowledge of the terrain on which the engineering structure is to be built
- Photo-interpretation provides information regarding rocks, drainage conditions, availability of construction material, slope stability etc.
- This helps in selection of suitable sites

Importance of photo interpretation in civil engineering mainly so, engineers should have in depth knowledge of terrain, on which the engineering structure is to be built. Photo interpretation provides information regarding rocks, drainage, availability of construction material, slope stability etcetera. This helps in selection of suitable sites. Therefore, the information which we are going to generate or extract from the satellite data or the satellite photos will play an important role in any urban development. So, we were discussing about not how it is how important it is to catalog the photographs to identify the line of flight ok.

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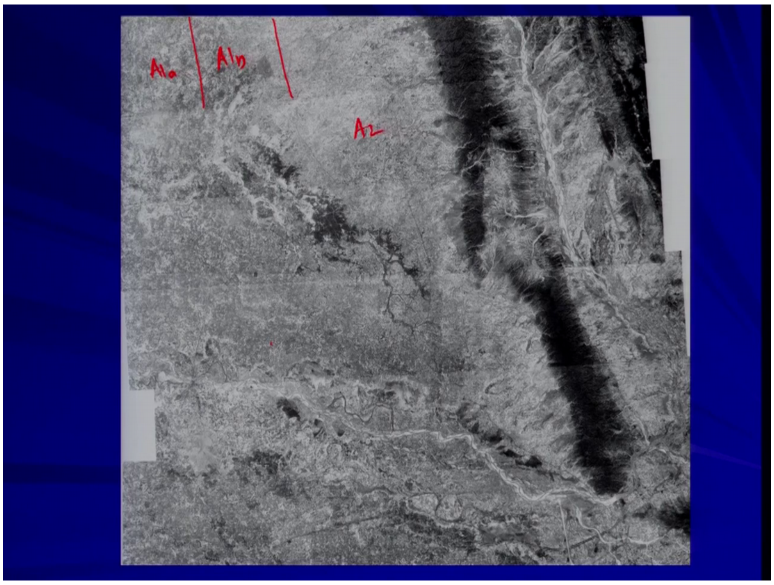

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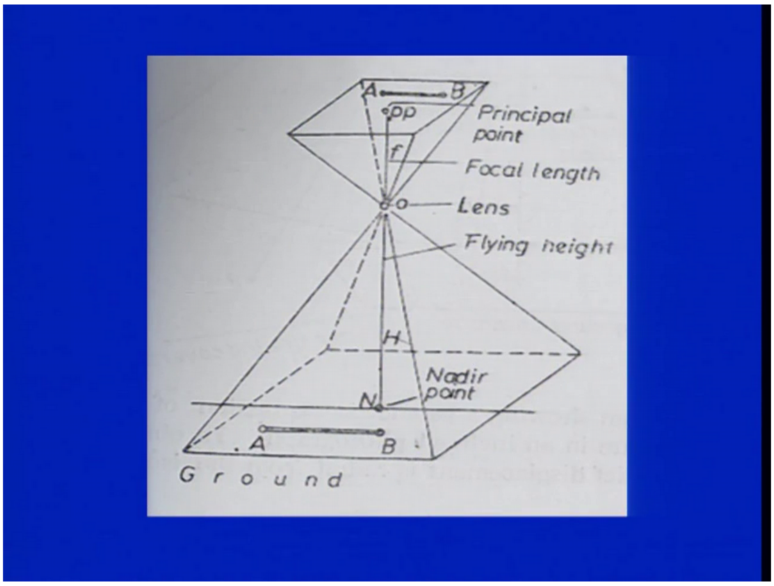

Now, further these are the few things which are important and in terms of the photograph which has been collected either it is vertical or oblique.

But mostly this parameters which we are talking about the principal point, then why it is important for us to know the focal length and then the height of the camera and what are they what is not the point and all that.

So, this sketch it shows not, in terms of if you are taking the area which has been covered by the photograph. So, this plane here is your the photograph and the point A and B for example, these are the two objects here on the photograph are represented here on the ground. So, this all information is important when we will be talking about more in detail in terms of the parallax, differential parallax or we are talking about the scale of the photograph, how to calculate the scale of the photograph.

So, let us get acquainted with few of the terminologies here we already talked about the fiducial marks and the principal point and the conjugate principle point they are extremely important to identify the line of flight and all that ok.

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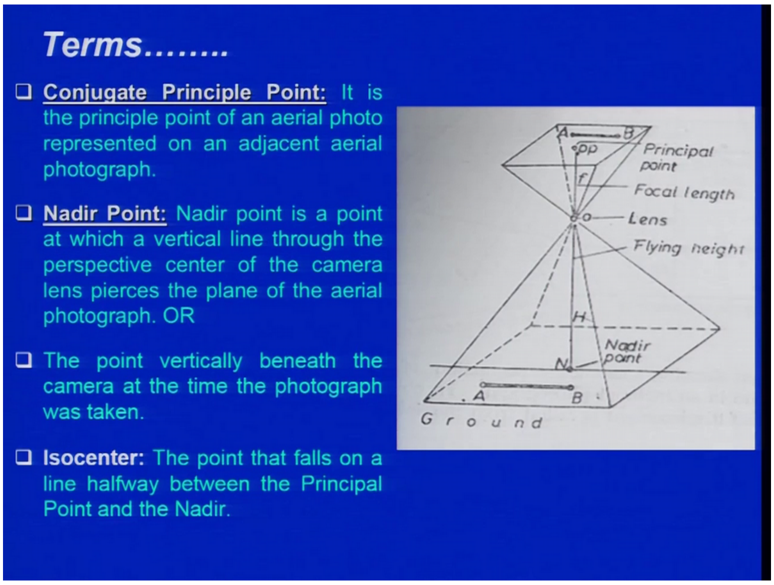

So, terms which we are using conjugate principle point we have already discussed, but we come down to the nadir point. So, nadir point is a point at which a vertical line through the prospective center of the camera lens pierces the plane of the aerial photograph or you can say the point vertically beneath the camera at the time of the photograph taken. So, you have this is the exactly vertical on the prospective center of the camera.

So, you have that is your nadir point. And then you have another isocenter. So, principle point if you are having vertical photograph, exactly vertical photograph then the principal point and nadir point will be the same, but if you are having slightly oblique then you will have the principal point will be different and the nadir point will be different.

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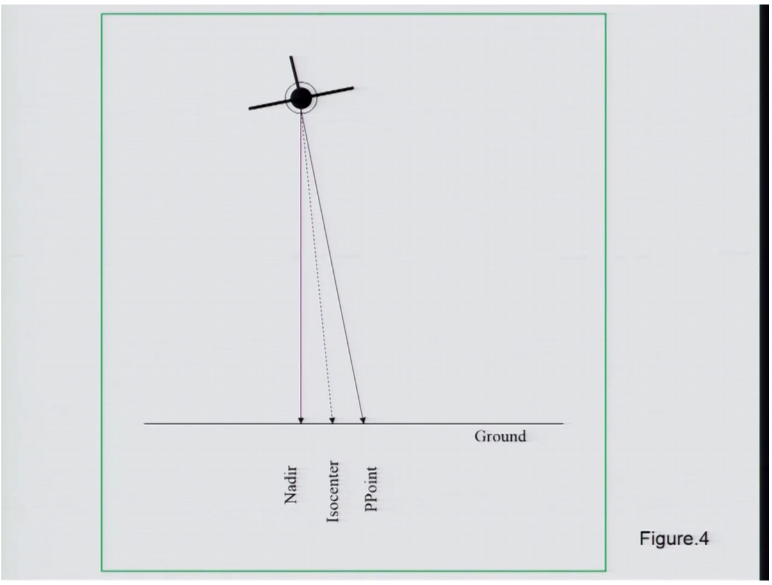

So, this is what we see. So, we have the nadir point will be exactly vertical, but this will be perpendicular to that. So, you have principal point and the nadir point and the center of this two will be termed as isocenter.

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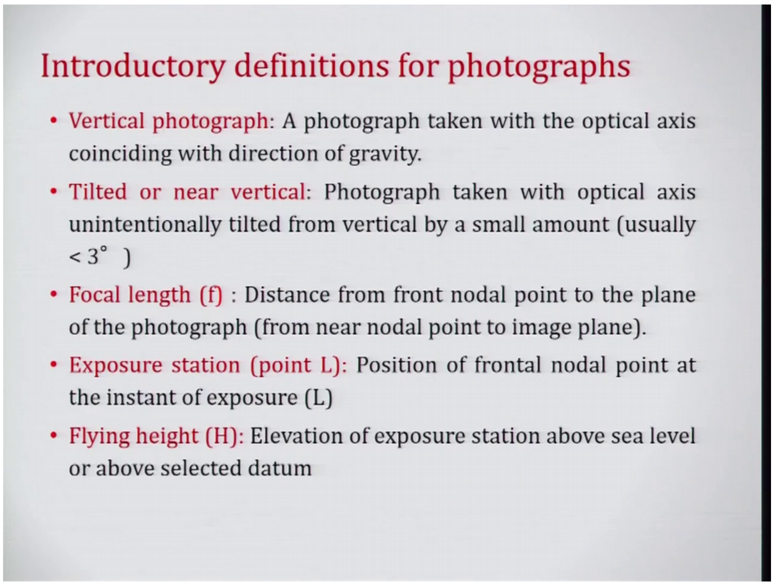

So, definition of the photographs if you take vertical photographs, this we have already talked about. A focal length, a distance from the front nodal point to the plane of the photograph, from near nodal point to image plane this is termed as focal length. This is also important because when we are trying to calculate the scale of the photograph this will play an important role. Then we are having exposure station position of the frontal nodal point at the instant of exposure. Then you are having flying height which is again important, the elevation of the exposure station there is the camera lens above sea level or above mean sea level or any selected datum ok.

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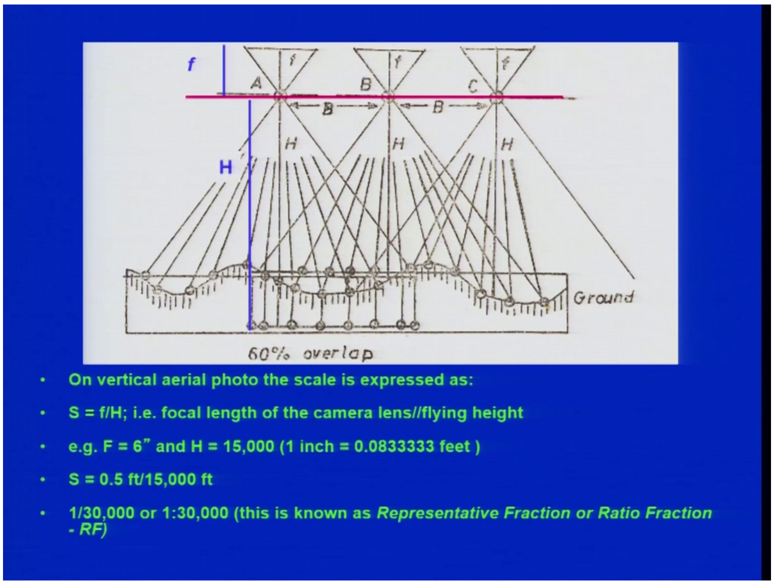

So, for example, you are having this is the datum here and you are having a ground level which is not flat it is undulating. So, you will have the variation here in terms of the height and this is your focal length of the camera and this is your height. So, on vertically the photograph, the scale is expressed as S equal to F, that is your focal length by height that is a flying height here. So, example if you are having the focal length is around 6 inches and height is around almost like 15000. Then the scale which will be given is will be in terms of the representative fraction or ratio fraction that is RF.

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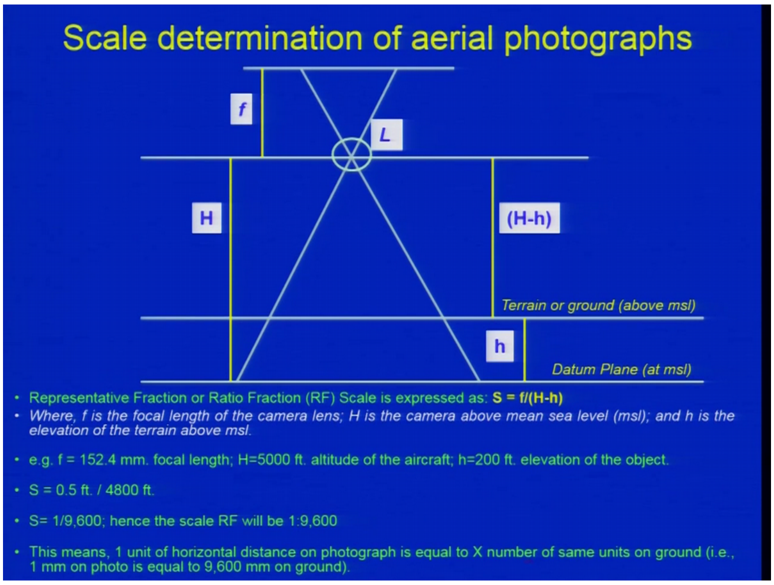

Now, if you take this. But I have slightly simplified it. So, you are having the camera lens here and this is the plane of film and the star the two points which are also on these are on the photograph and these are on the ground here and this is your terrain. So, you are having datum plane at mean sea level for example, you take or any reference plane you take with respect to that you are having the terrain here.

So, here we are showing the, that the terrain is almost flat, which is above mean sea level. So, if you are taking taken the datum as mean sea level and this is above mean sea level. So, you have F here, you have H and that is your datum from the point of the lens and this is your a difference between the datum and the terrain elevation and this one is your small h that is above (Refer Time: 22:15) height of the terrain or any location. So, your having is your lens. So, representative fraction of fraction array, the ratio fraction scale is expressed as we have discussed here. So, if you are having this information you have you can talk about.

So, capital H minus small h that is your height here and you are having the elevation of the third, where F is the focal length of the camera, H is the camera above mean sea level and small h is the elevation of the terrain above mean sea level. For example, if you are having the focal length is 152.4 millimeters and height that is an altitude of the aircraft is around 5000 feets and 2000 feet is the elevation of the object. So, you can have an scale like this, these are in feeds and finally, you can refer this ratio fraction as 1 is to 9600.

So, this means 1 unit of horizontal distance on photograph is equal to x number of same unit on ground that is 1 mm on photograph is equal to 9600 mm on ground.

So, you can calculate the scale based on this, if you are having almost vertical photograph.

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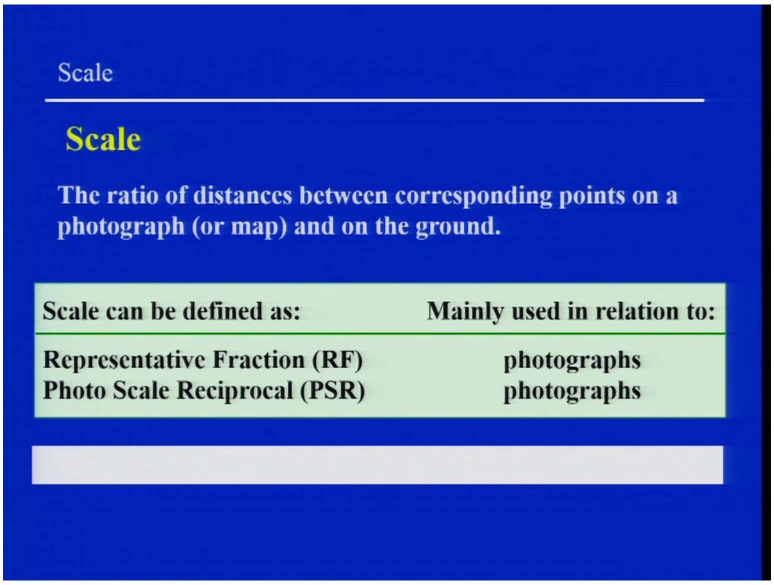

Further you can have different representations also, in terms of the scale or the photo scale.

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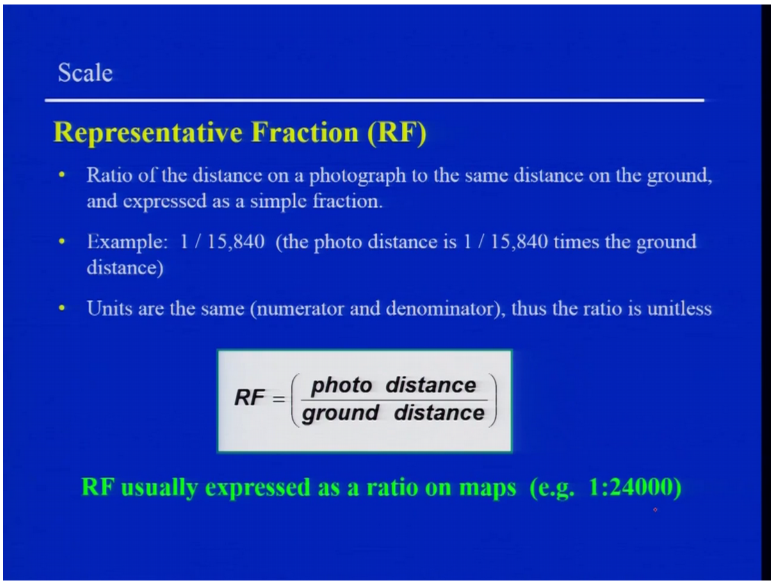

So, representative fraction, the ratio of the distance on a photograph to the same distance on the ground and is expressed as a simpler fraction as we were talking about in the previous slide it is one is to, for example, 15840. So, what we are looking at the photo distance and the ground distance we are taking. So, whatever has been measured on the photograph, it will be reflected same on or it depend on the ratio what we are taking here. So, it is usually referred as either for example, one is to 24000 or so.

So, this we will continue in the next lecture using the topographic maps and all that, but before that we will have more and a few of the labs in which we will discuss more on the how to calculate the height and the and the distance and all that.

Thank you so much.