INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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Digital Image Processing of Remote Sensing Data

Lecture – 01
What is a Remote Sensing Image and How it is Represented?

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Hello everyone welcome to digital image processing of remote sensing data and we are going to discuss in 20 lectures different aspects of a digital image processing. But before that I would like to discuss what is exactly remote sensing image and how it is represented, so in this particular lecture we are going to discuss in detail about this digital image and especially digital image and rate it by remote sensors.

As you know that a picture tells 1000 words and satellite image can tell 10,000 words because not only you are seeing the satellite image but the interpretations and inferences which you make outdoor satellite image are much more important and more useful, so that is why it is said that a picture tells 1000 words or a map tells 1000 words.

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But a satellite image tells 10,000 words because of capabilities of one can perform interpretations as well as can take out some inferences. So what exactly an image is, so it be loop the definition an image is a pictorial representation of an object or a scene.

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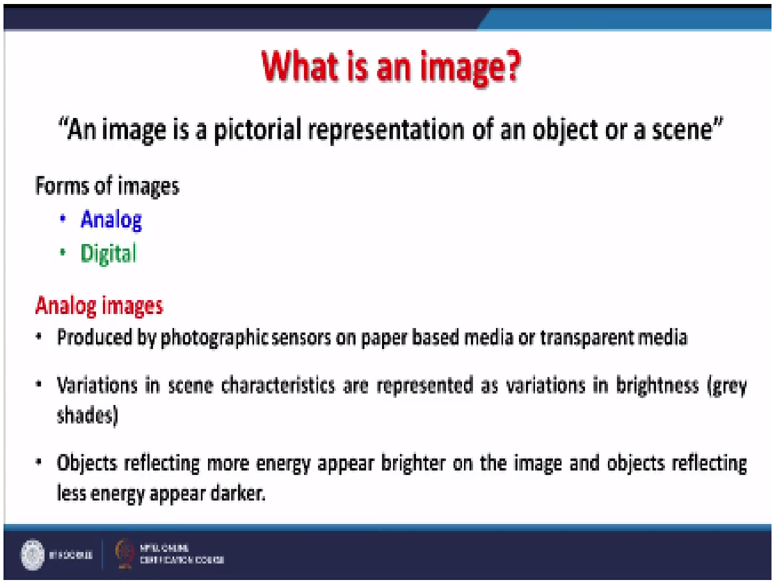

And when it is there are various ways of taking images as we know that nowadays most of us are having digital cameras in our mobile or otherwise DSLR and other cameras and all are collecting images in digital formats so they are all digital images, but the difference between these digital images which are taken by handled cameras or mobile cameras and satellite cameras are different and which we in due course of time we will be seeing the difference between these two.

And secondly earlier, this they are used to film cameras so we used to call a photograph so there is also some difference between an image and a photograph so those we will be also seeing. Earlier because the photographs we are on the films or negative films and then positive prints used to be taken out still some people like film cameras because of high special resolution but these are the analog not digital.

And digitalize you know that it will have a two dimensional matrices which we will see in detail, analog image is examples produced by photographic sensors on paper based on media or transparent media and that is typical example of film cameras and variations in scene characteristics are represented in variation in brightness or grey shades this is common characteristics both in analog images and digital images.

And the objects which reflects more energy appear brighter on the image and object reflecting less energy appears darker.

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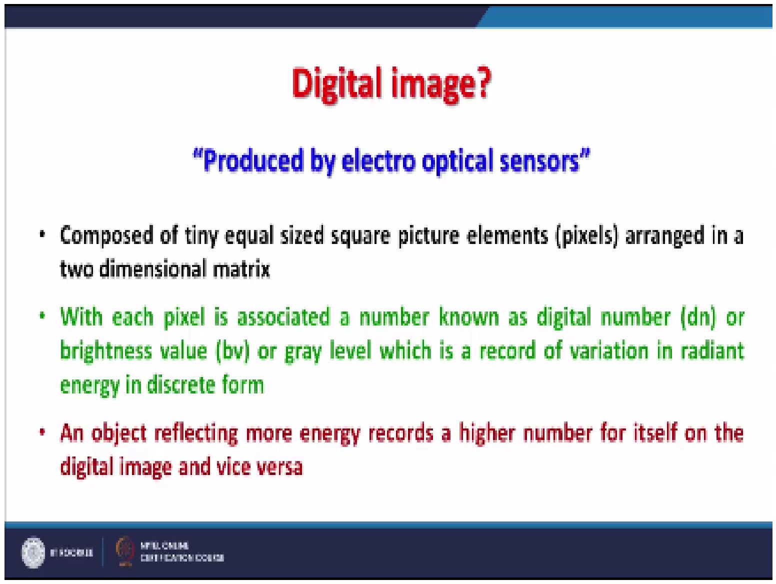

So these are the ways an image can be created analog or digital, now digital image which is produced by electro optical sensors so the image which has been created or data which has been created by such electro optical sensors then we call them digital images. And as you know the unit of an image is a pixel so which is arranged in a dimensional matrix so a digital image is nothing but a two dimensional matrix each cell or unit of this image digital image is a pixel, pixel is an abbreviation which is also called a picture element.

So smaller the size if pixel in an image that means the area which is representing the bv say high resolution and the high resolution otherwise we understand by number of rows and columns for the same area, so if I say 8 mega pixels and 12 mega pixels then 12 mega pixels is having high space resolution because number of rows and columns will increase and therefore number of pixels within an image will increase.

Thus, area which each pixel will cover would be less in high resolution images compared to relativity low resolution images and each pixel is associated with a number digital number or also brightness value or pixel value and if it is black and white that means say if suppose say 8 bit image then we can also record in gray levels or we can bring in color form as well.

So this is the unit is also very important one another important thing the unit is also square in shape which have been mentioned here that the equal size square pixel. Now it is one important thing here is the unit is square but overall size of an image can be either square or rectangle which we will see little later in much detail.

And as mentioned earlier that any object which is present on the surface of the earth now we are talking more from remote sensing point of view that an object reflecting more energy records a higher number of itself on the digital value so the pixel value would be higher and if an object which is darker on the surface of the earth will record a very low value and vice versa size also drawn.

So it is, there are various types of data which we understand one is raster and other one vector or den as I have discuss in the other two courses one is in remote sensing introduction to remote sensing and introduction to GIS in which a raster vector and tin and other models I have been discussed so image is a raster.

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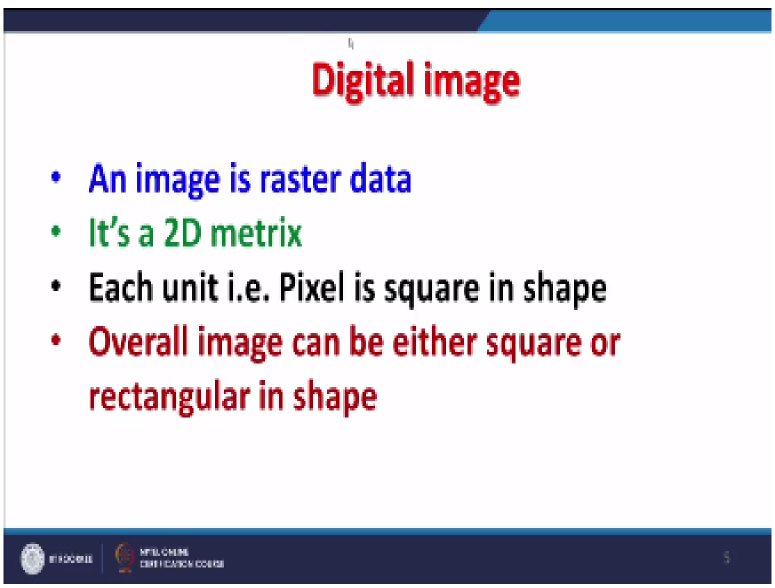

Because it is a two dimensional matrix and each cell here we call as pixel is a square in shape it is a two dimensional matrix and the unit is square and which we call as pixel as I have already mentioned that overall image can be either square or rectangular in shape.

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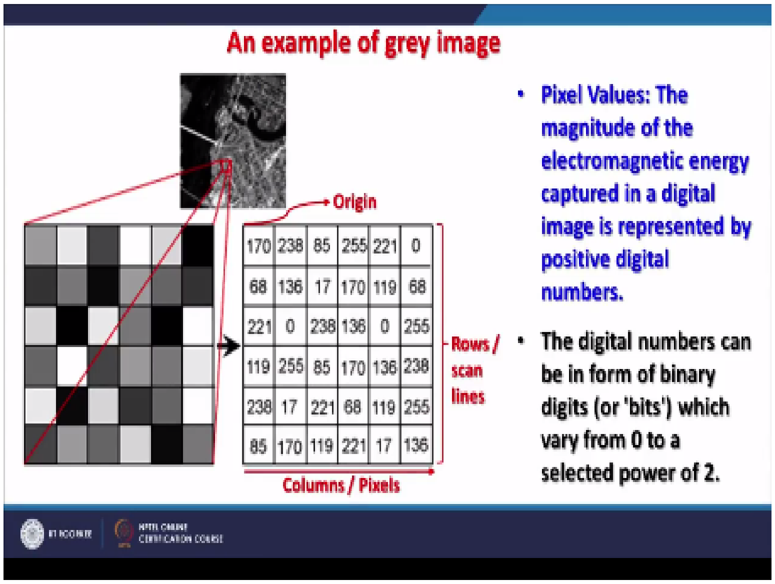

And now we are seeing one example of here, that let us take first this digital matrix here say two dimensional matrix and each cell here though line you know the blat lines and rows are shown here but in actual image these lines will not be there and you will have only the cells or pixels like this on the left hand side. So if we see here that a pixel value which is having very high pixel value 255 is the brightest pixel in a 8 bit or gray image.

Whereas a pixel value when it is equal to 0 then you end up with the black so these are black and white in a gray image and this example of 8 bit image so we have maximum 256 shades of gray if we are representing in gray color or gray shades and so the minimum value can be 0 maximum value can be 255 and rest of the values will fall in between, so both examples within this images giving that 0 representing the black color one extreme shade and 255 is representing the white which is another extreme.

And in rest of the values are in between if I take example of say 136 then 136 having dark gray and other thing, but because then we you know really zoom in then only we see indusial pixels. But if we do not zoom too much then we can see the overall image as example here and later some examples all, we will also we discuss. There are few more important fundamentals which I want to bring here now is the origin of an image is always on the top left corner.

Whereas if you recall in GIS course those who have gone through that or otherwise then in that like in maps the origin always in the bottom left so that is the difference and this play a very important role when we go for Jew referencing which we will be discussing in this course, so origin is Important, origin of an image is a raw image is always on the top left corner so this is the first pixel and likewise a number of columns and number of rows are there.

There are different terminology which are used so we for this we say rows or scan lien because by the central light sensors we scan individual lines so we call as a scan lines or these are the columns which you can see here and then also we say pixels, so either we call columns or pixels, rows or a scan line. A scan line this we are talking about the oriental lines, rows and if column or pixels we are talking vertical lines. And this is definitely two dimensional matrix.

So pixels values are magnitude of an electromagnetic energy captured in a digital image is represented by positive digital number, now pixel value has truly positive integer value is a whole number it cannot be in decimals so that means it cannot be floating point or real number and you cannot have negative value as well, so if pixel value is always is a positive integers and these are the requirements for a two dimensional matrix.

That has 2D remember in case of certain light images but who are all raster there are different types of raster in which the cell value no pixels the pixel value has to be always positive integer value but the cell value aware raster like a digital elevation model where value can be in negative or positive or value can be integer or real value so those values are possible but not an image whether it is image taken by camera on mobile or digital camera or a taken by certain light.

All the time the pixel value has to be a positive integer value, now if an image is just binary image then you are having two extreme values 0 and 1 so 0 you can assign in red color for 1 you can assign white color so that we also call as binary image.

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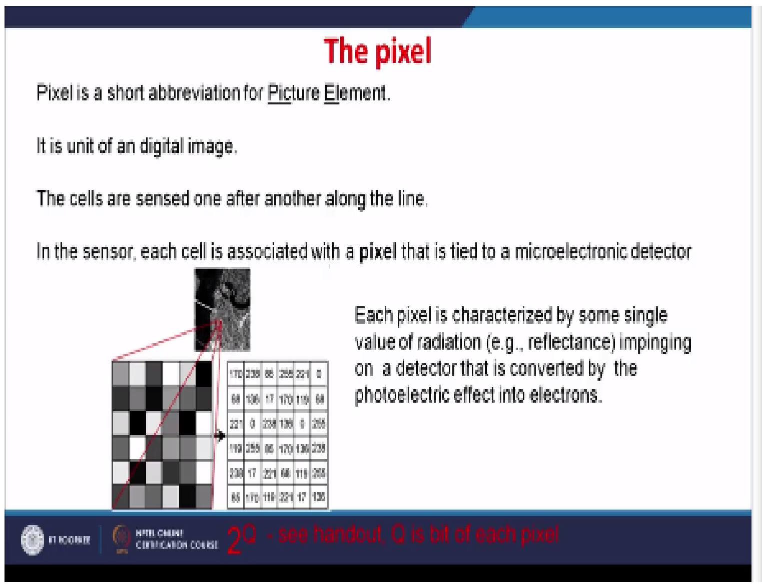

Now pixel is a short abbreviation for picture element and a this side we have already said I have also said that pixel is an unit of a digital image and cells are sensed one after another along the line so when this sensors on certain lines when they move they capture the data line by line pixel white pixel and record the whatever the brightness values in day time or in night time if they are having thermal sensors.

So whatever the miscibility any object about absolute 0 will emit energy and that can be recorded by thermal sensor on both of different certain lights all certain light all sensors they do not have thermal sensors in there but some certain lights like lenses DM or no IVHRR they are having thermal sensors they can even detect the you know the miscibility or which you can convert to brightness temperature and ultimately to less surface temperature.

And that is recorded that emissivity is recorded or brightness temperature so in the sensor each cell is associated with a pixel that is tied to microelectronic detector and each pixel is characterized by some single value of radiation may be reflection or may be emission sand depending on the type of sensor.

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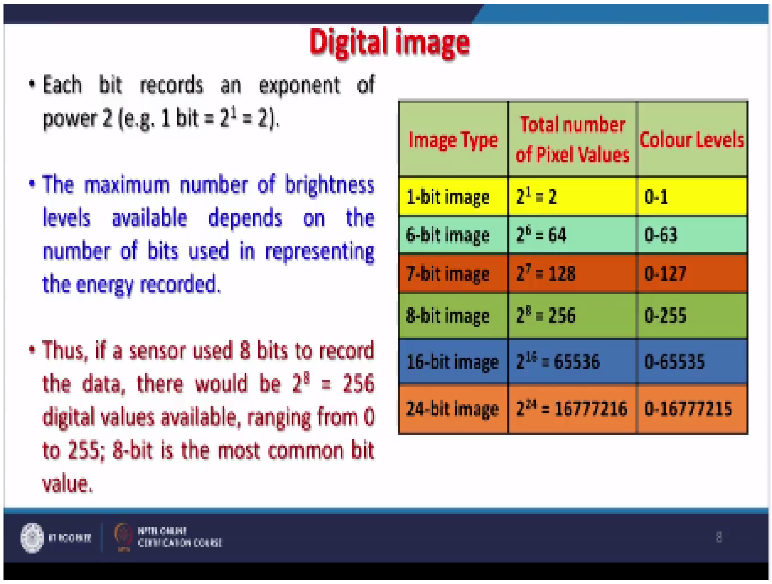

An I am taking one example here that like a one bit image so also we call binary image the total number of pixels we can have two that means variation in the pixel values either 1 or 0 so total 2 and the values can vary between 0 to 1, if we go for the 6 bit image like a IRS 1C pan, 1D pan sensors head the 6 bit images that means the values and 2^6 and total number of values 1 an image in that was the 64 that values can vary between 0 to 66, total number where we 64.

In 7 bit image like in list 3 image of IRSC or even IRSD then the total number of pixels values which can vary or total is 128 the values where varying between 0 to 127, generally lot of certain lights generally they acquire the data at 8 bits so this is the most common you can call as a format for image capturing 8 bit images total numbers are available 256, 2^8 and a values can vary between 0 to 255.

The example earlier I discussed was of 8 bit image now it is the requirements are increasing people are going for higher and higher radiometry absolution and therefore they are looking instead of just 8 bit they can go even for 16 bit or 24 bit or in-between 8 – 16 like no I reach or here which records the data at 11 bits so you will have a different total number of pixel values and range also.

Like in case of 16 2^{16} 65536 and the values can vary like this so as you go higher and higher in bits you the variability of total number off 6 or colors increases so the maximum number of brightness labels available depends on the number of bits used to represent the energy recorded, higher the bit it will give y0u the better clear picture lower the bits like in binary image you can have only black or white, not in-between values.

But if you are having 8 bit there are 256 bits can be used to represent an area or an image through an image so a sensor used 8 bit to record the data there would be $2^8 = 256$ digital values available and ranging from as mentioned 220 to 255, 8 bit is the most common bit value is noted of light images.

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One of the examples here and this has been this is not actual acquired but it is it has been stimulated or created just for understanding that thus the image the same area is been captured at a this is one bit, 1 bit means binary image so we are having values only wither black that is 0 pixel value or white that is pixel value = 1, whereas 2 then you know that we can have more number of pixel values.

And we are having example of 8 bits where the minimum value can be 0 maximum value can be 255 now visually you can compare at the quality of an image so obviously you compare to 1 bit binary or 2 bits or 4 bits 8 bit image looks much better if you would have for the same area say

16 bit image or 24 bits image the definitely that image would look much better, but that all the time just when dewing the bits is number of bits may not improve the quality of anything.

Quality of an image also depends on the space of distribution which we will be discussing in later lectures. Also as color sometimes we use that 256 colors or say so there has to be there has 2B also understood at this stage as you note that in order to make a colored images 3 primary color has to be added in case of certain light images what we do, we assign different color channels two different bands of a sensor.

Suppose I take the example of lens said MSS now Lens said MSS is having four channels out of these 4 channels I can use 3 channels which are having completely different you know signature of different objects which are present on the surface of that and assigned them three colors.

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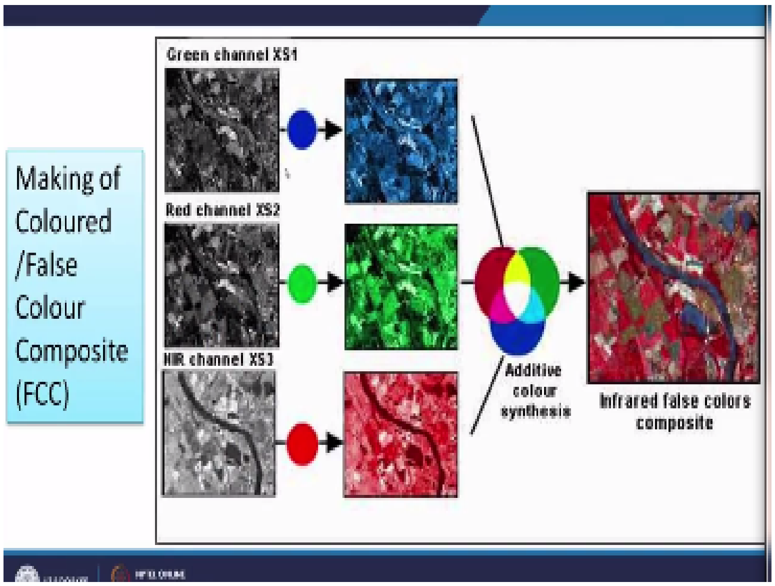

Red, green , blue and then when we assign these will be represented like this but when we use the additive color scheme and use this like soon here through 3 circles , then we can create colored image. Now here it is written that the infra red false colors composite, because we have used one channel which nri near infra red channel, in which the vegetation is having high reflect ants.

When we assign the red color to that channel then this false color composite vegetation healthy vegetation having high chlorophyll contains that will appear redder and therefore it is also called false color composite and that the vegetation will appear red. But in normal cases we do not assign we do not have the infrared range like in our in digital camera we do not have infrared channels.

Therefore you see the colors are near real colors we see from our own naked eyes but the census are capable of not only covering the entire part o spectrum we will see in much details, but also it covers infrared thermal infrared. Even in microwave reason itself. So when we want to combine and create color images we have to innovate in some other ways, because these are not true color images and why we want to it, because it will give us better interpolative of image and therefore better references can be taken out from these images.

That is why such schemes like false colored composite followed all over. This is the extent technique of creating a colored image from a satellite data one channel which is infrared which is representing infrared channel always a sign in red color.

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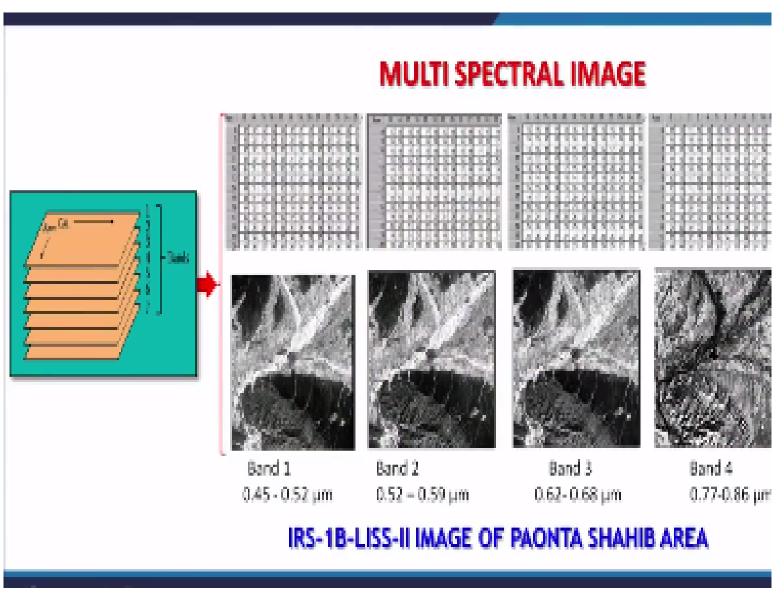

Now here the example from our IRS list 2 image by near to Paonta Shahib area which is near to Himachal which is bordering Uttarakhnad and you can see that these has band 1 and band 2 also given here and as that the different bands the image will look completely differently and June part from the corner of the image is also shown through this pixel values. Pixel values vary loads in different channels because the responses of the different objects which are present on the surface of the earth.

In different part of spectrum will have different responses and that is why there pixels value will also vary. Like in band 4which you are get we are going close to the infrared or near infrared there the appearances is completely different, so whatever the areas are appearing darker. In other images like in visible channel here they all are appearing very bright.

The vegetation as you sees here the vegetation appearing very dark here, the healthy vegetation but infrared little brighter than this image. This is how the cords the ray multi spectral random. Now resolutions I have already used the space resolution.

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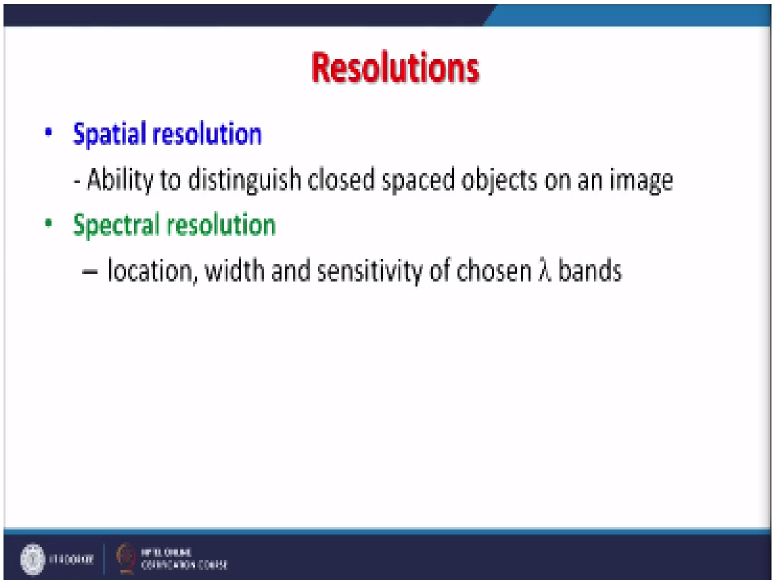

Completeness I have defined it. There are four resolutions one is space resolution, spatial resolution, temporal resolution and radio mated resolution, so all four we will discuss one by one very briefly. So first one is the spatial resolution ability to distinguished closed spaced objects on an image. Higher spatial resolution means larger the image size in terms of computer memory, but more clarity in the image. The clarity of image will always be better.

But in the same time it is trade of that means requires the more space to be stored and definitely tin the normal digital cameras like an now we are going for higher in higher a space resolution so it made up mega pixel we talk 14 mega pixel 18 mega pixel so you go higher the value here in mega pixels we are talking a higher space evolution because for the same area in earlier of two mega pixel you might be hearing one pixel to depended the large area now we might be are in 16/16 pixel to represent the same area in a large higher mega pixel images so special resolution will definitely.

Into the quality of the image but as I mention there is a trade of you require more a space to store these images either when your flash card or hard disk or any storing device the second resolution which is spectral resolution that is the, the width location and sensitivity of chosen λ bands so this is the band width where it is there so if I go back two one pre or slide here the band width are given here like for band 1 in case a list to wire is so when we list to mean what sense and the bandwidth will 0.45 – 2.52 there as here the bandwidth is different.

So this is what I am discussing the and narrow are the bandwidth higher the spectral resolution and broad the band width lower the spectral resolution so here it is little, little different than a spectral resolution and then especial resolution so here the where it is look it how what is the width and the sensitivity of chosen λ bands so in the visible or in near we forward the band a band width are different for different sensors.

In thermal, thermal in florid generally band widths are quite wide compare to visible and in florid because the sensitivity in that part of A spectrum that is electromagnetic spectrum of mutual objects is not S grade as in case of this similar in Florida so there in order to cover that area or in order to record those variations which are present on the objects natural objects then band width is to be increase and therefore compare to visible channels we can say it has got over spectral resolution depending on which sensor you are using or which is on board on different satellites.

The band width always indicates the spectral resolution so never the band width higher the spectral resolution in vice versa. That a broad the band width lower the spectral resolution now temporal resolution means time between observations how frequently your satellite is re visiting the same area again and again so suppose you satellite your passes on day one and then day 16 there is an another satellite passes on day one and day 8th so the one which is passing on day 8th again there is having higher temporal resolution so that again there is a trade of very interestingly then like move or NHAR sensor.

It is covering almost the same area twice a day because the special resolution they are is 1.1km so if you are having more special resolution then temporal resolution can be improved so there is a inverse relation higher special resolution lower temporal resolution there is lower special resolution higher and temporal resolution for example if a sensor is having and capabilities of providing data in 1m resolution like ICO satellite then the re setting or temporal resolution is going to recover very less because it covers a very smallest.

In case of no I which RR it covers a about 2800km wide sat of part of the earth whereas this icon was having inter revolution wide just 11 kilometer so it say 20 hundred was in the 11 kilometer so but the temperature revolution in case of the move always higher space revolution is lower per in the case of icon was the temper was revolution is very poor but the spacer revolution is very high so there is a relation between the spacer revolution and the temper revolution and the last one is the.

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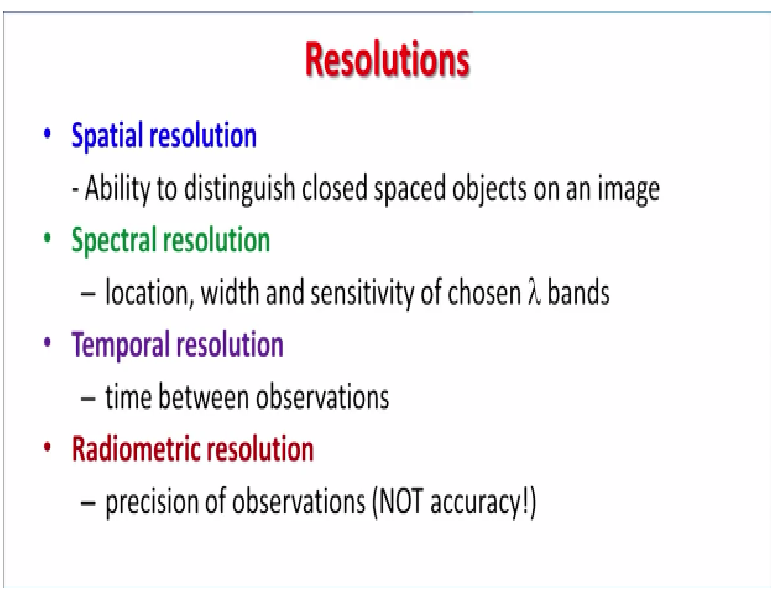

The radio matriculation that is the precession of the observations and that we have talked one bed or eight bed our sixteen bed so the higher the beds it will provide this is will also called in some congestion so this if it is in six bit and eight bits definitely eight bit image will have high radio matriculation revolution then you are six bit image the six bit image can have the maximum values between the 0 to 63 the total number of values are precisions will have only 64 bin case of 8 bits the total number is available to 256but the these are not accuracy.

These are basically in the statically term so do not greet confused with this is the higher space of revolution can higher radiometric revolution will improve the quality of pure image.
That is more important because the quality of and image will always be alpha in interpolation and in the interpolation is good we will have I am in eye confident in then I can make better inferences out of this.

Now we will go little detail in the space revolution some specific examples as well in the remote sensing the revolution men’s resolve.

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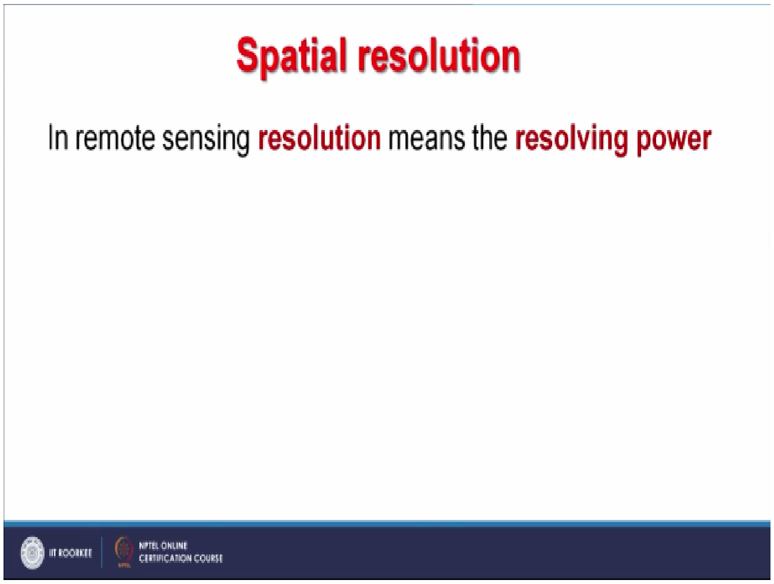

Capability the identify power the presence of the two object the two adjacent object if they are present eye will two identify so then you will the capability to identify the properties of two objects each when we giving the brighter signature as well as we are giving and signature and the image we are source finally derived so to final revolution compare the source we complete is so we say we were the relative terms because when we had you had a lenses analysis reality the analysis is revolution at that time it was very high revolution just comparing with one, one, one kilometer but in today we are talking thirty centimeter so relatively.

You have now much final revolution then lenses image so the time we are reducing the which as been covered more number of eyes and we used to cover the same area and for moving higher and higher specie; revolution in the some applications always the higher special revolution are month helpful because I mentioned the higher revolution images and will cover a very small of area or a very small educated worth and that means in the order to a adjacent the I have to wait for the longer so there are always in to a trade you gain something you lose something here a special revolution.

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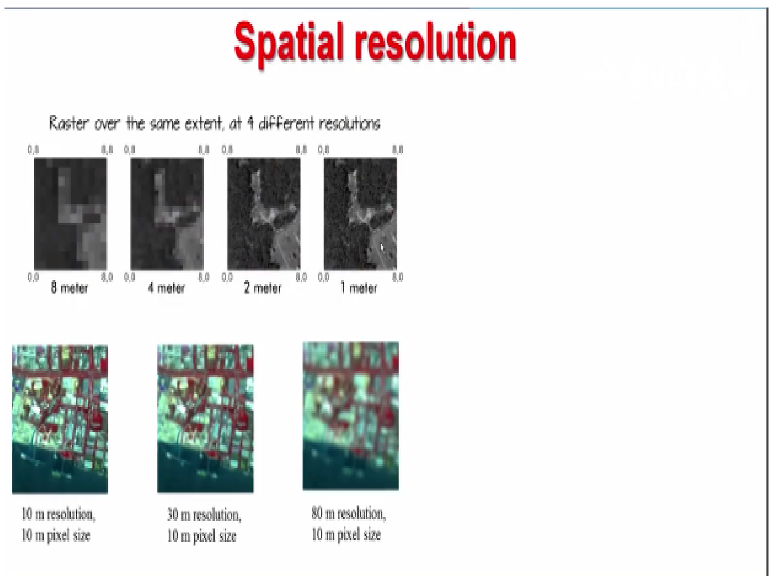

There are many examples are dialer then I am having a special revolution eight meter in the image might look this for the same area of this example for the two meter and one meter and here ten meter thirty meter eighty meter revolution examples are shown so we compare to eighty meter revolution we shown the real of when we compare to the ten meter it shows very poor quality the eighty meter.

but if you have not seen at the ten metered in you must might be happy with the thirty meter so this is not we happen so size also we happening so the smallest dimension over which and in the dependent the major can be made by the sensor that is the space energy revolution when the size pixel in the ground and the meter control by the instant measly fields and the topic and the in the same thread angle is the radiant's is a angular cone of visibility of sensor.

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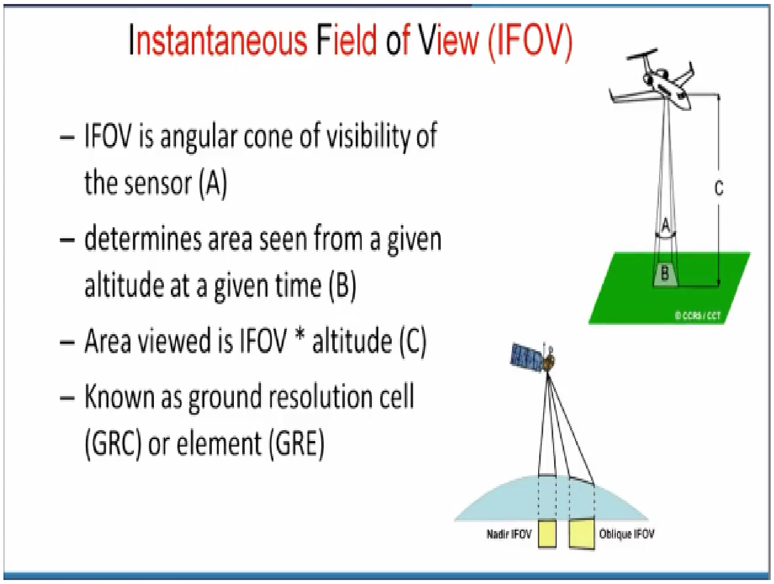

Determine the area seen in heaven attitude and by the air craft or the air sensor and the IFOV and the dependent on the attitude and it depend we are taking so if its other viewing then IFOV is having this angle having in the both the cases but the pixel here is more to comparing so this is further illustration fib or the field of the view.

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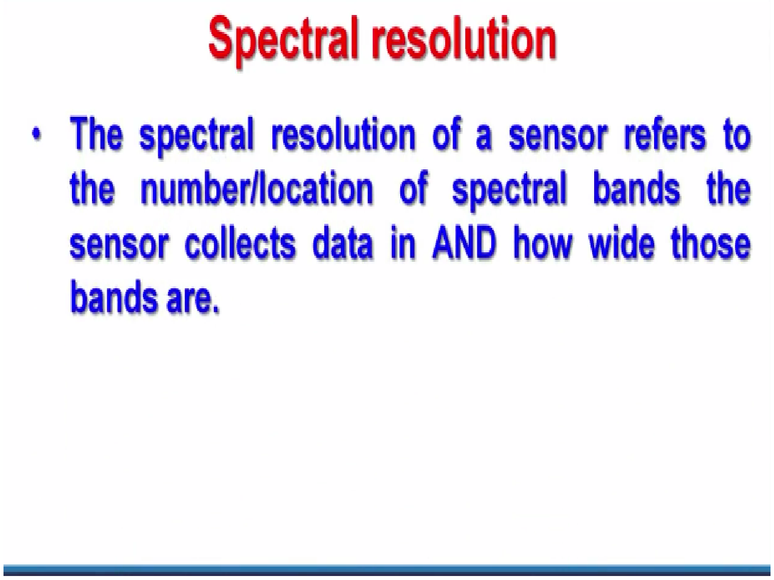

This is very quickly and in the sensor and the location and in the senor collects the data and how wide those bends are a good analogism may be how many cairns in the colorings box do you eight are sixty four of course sixty four is better that one day if we see the real example with the different séance on the different satellites we find like here.

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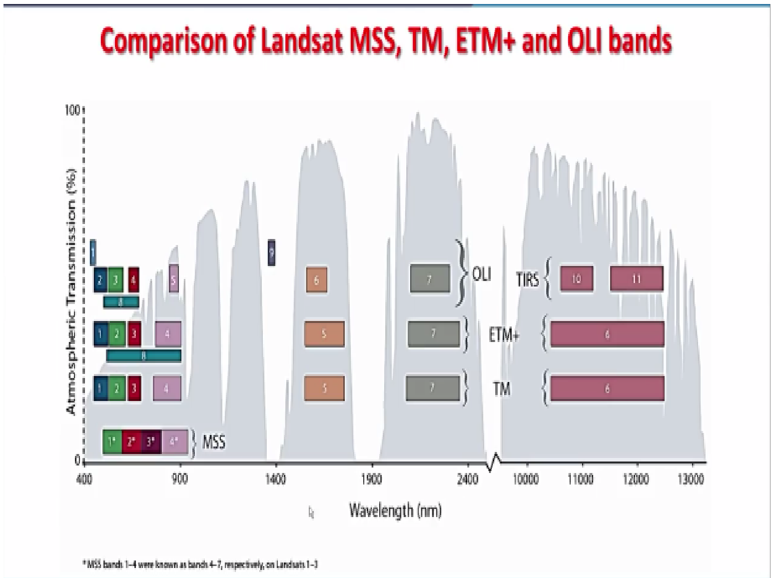

In the massage case of area in the elm and not only in the president here sand the bends are narrow and wide never here and I have high respective revolution and compare tm and in the spectral revolution in the same senses are giving normally wide we are recover this much part of this island se now we are talking all spectrum we will covering a continuously in the spectrum and in the new one after and other so the broad band were the narrow bend and the advantage of the broad band its is collected

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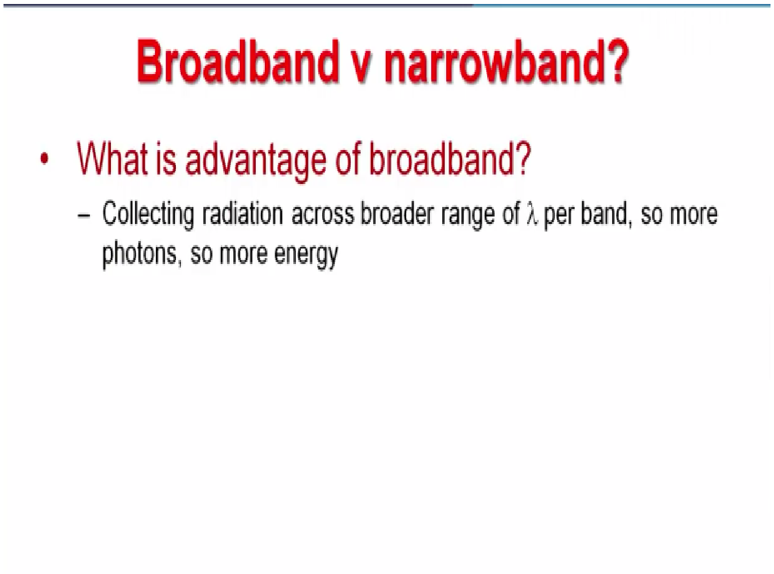

Reduction in the border range of lamed upper and so more photos and in more energy and I give the energy example in the case of thermal senses because the energy is less and that is why the bends are broad where the energy is more in the narrow bends so the narrow bends gives.

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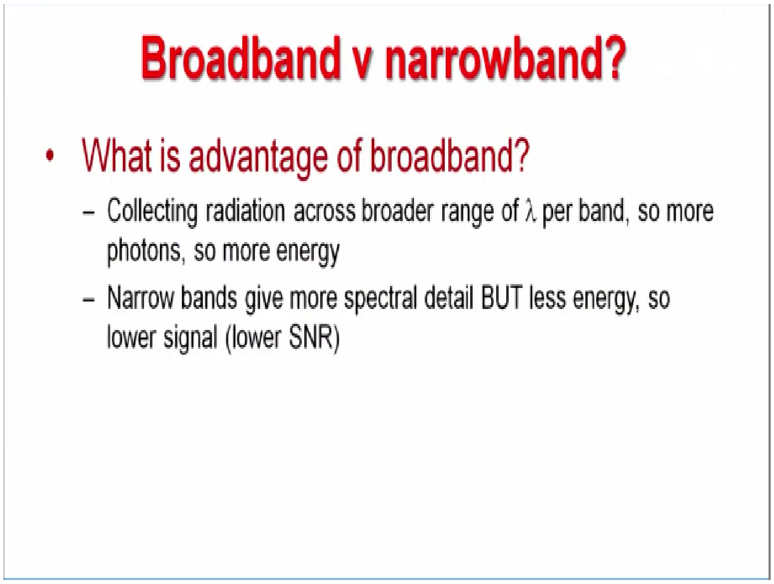

So the more respectively daily but has less energy so the lower signals is the lower in to the noise ratio and the more bends are more possible such situations, but more bands enables discrimination of more spectral details that is the advantage. So if you are having more bands our interpretations becomes much earlier but there is always trade of, trade of in sense computer memory processing time consuming and other things appear now temporal resolution that we have already discussed the time between observations revisit time over an area.

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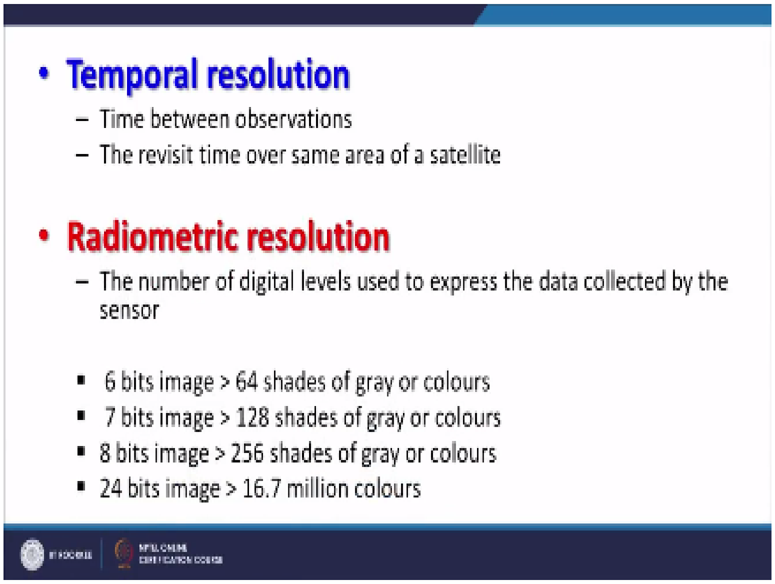

And last then the series of resolution is radiometric resolution the number of digital levels used to express the data collected while, so 6 bit means 64, 7 bits means 128, 8 bits 256 and it is 2 power $a2^{7,6}$ likewise. Then we go and create color images using three 8 bits images that means we are going for 24 bits and we can have any color out a palate of 16.7 million color and that is why the colored images are always much better than black and white image.

In case of 8 bits image scenario there we will have only 256 shades of gray. Example this says just repetition of the same thing.

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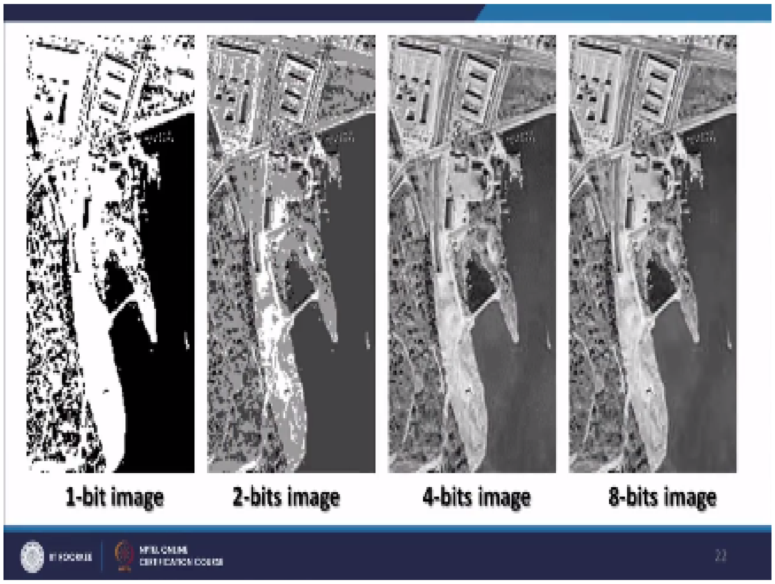

That 1-bit, 2-bit, 4 bit how would they looks.

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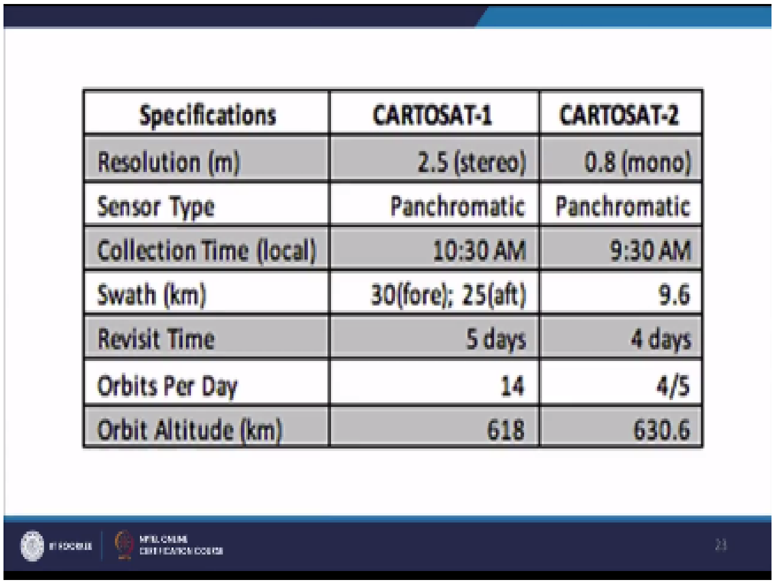

Specifications	CARTOSAT-1	CARTOSAT-2
Resolution (m)	2.5 (stereo)	0.8 (mono)
Sensor Type	Panchromatic	Panchromatic
Collection Time (local)	10:30 AM	9:30 AM
Swath (km)	30(fore); 25(aft)	9.6
Revisit Time	5 days	4 days
Orbits Per Day	14	4/5
Orbit Altitude (km)	618	630.6

And different sensors like in cartosat-2 or cartosat-1 I am taking example thus resolution is here space resolution is 2.5m here space resolution is 0.8 that means high spacer resolution now we are talking and the swath this will control our temporal resolution swath this is 30 and forward and backward but here the swath is 9.6 so you say narrow swath that means the poor temporal resolution as you can see that revisit time here is 5 days it is 4 days.

Orbits per day 14 orbits per day of the entire earth here 4 or 5 orbits and of course the altitude can also bring variations in all these, so this brings to end of the first lecture and the series and thank you very much.

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