Remote Sensing Essentials
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Lecture - 37
High Spatial Resolution Satellite Image and Limitations

Hello everyone and welcome to new discussion of this remote sensing essential course. And today we are going to discuss the advantages and disadvantage there are always some disadvantages with everything. So, we will be also discussing limitations of high spatial resolution satellite images. As you know that everyone many times is looking for high spatial resolution satellite images and but there are always some limitations.

With high spatial resolution satellite images, so first what we are going to discuss basically the advantages or benefits of going for high spatial resolution satellite images. And then we will see that what are the limitations and why I am seeing that it is disadvantages for certain type of applications. So, if we if we look the biggest advantages of high spatial resolution, remote sensing images or satellite images that it allows us for, you know, looking things in much more detail.

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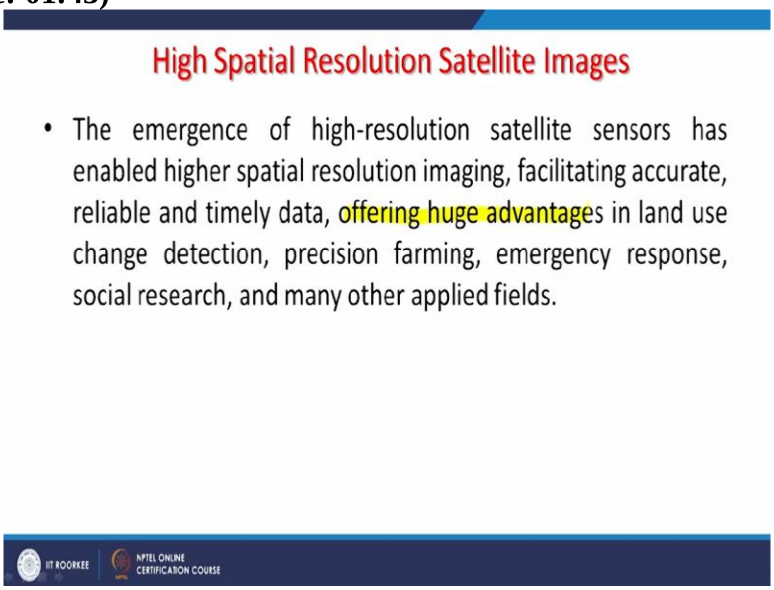

That is the advantage which we see they are offering huge advantage and in the study of land use change when we are having high spatial resolution images. precision farming is a new thing which is coming up including in India where not only high spatial resolution satellite images are being used, but also in precision farming for giving fertilizers or spreading the insecticide pesticides, and these drones are also being used along with the GNSS technology.

So, there also and these high resolution satellite images are very much required in emergency responses like if some earthquake has occurred or landslide or flooding. And then pinpointing you know the location where people have got affected or the house has got damage, and then providing the help. Providing emergency services to such locations is only possible through high spatial resolution images so it facilitate basically very accurate and reliable and sometimes also timely data.

And this point is timely data which we discuss further in terms of temporal resolution. And also for social researcher where house based such as required in detail based and required then high spatial resolution satellite images and becomes very advantageous, and also in many other applied fields and I would like to mention very recently, which has been an in which high space and resolution satellite images have been used

Is in when, you know, the in the defense, when targets are set to guided missiles, like it has happened in case of Balakot airstrike by India Indian Air Force, and they use very junior high spatial resolution satellite images. And these images have guided and these spy spices weapons or spices missiles to hit the target and wherever, because these were images, where of very high spatial resolution.

So, the target can be fixed, whether it is a corner of a building or a center of the roof top or whatever. So, to that extent, high spatial resolution satellite images can be used of course, it provides a lot of advantages in many disciplines, but not in all as we know that a spatial resolution plays along with all other resolutions play very important role for certain number of applications, and especially related to characterization of complex environment.

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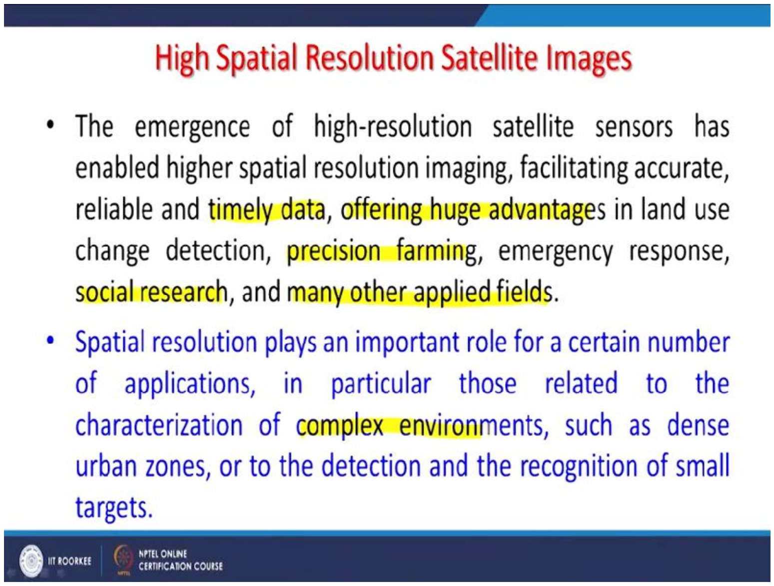

And that too, in urban situations, maybe in a dense urban Jones or to detection and recognition of small targets and that in that way, high space and resolution satellite images can play very important crucial role and in such a remote sensing products, that means high spatial resolution images can be very expensive. Sometimes and difficult to acquire and difficult to acquire a means of what happens that when you go for higher spatial resolution, satellite images.

The swath width but orbit produces and therefore, in order to cover a large area, you required you know many orbits data or many swath data. And therefore, it may become expensive in for certain applications. So, this also prohibits or reduces and they are using some applications. For example, I am seeing

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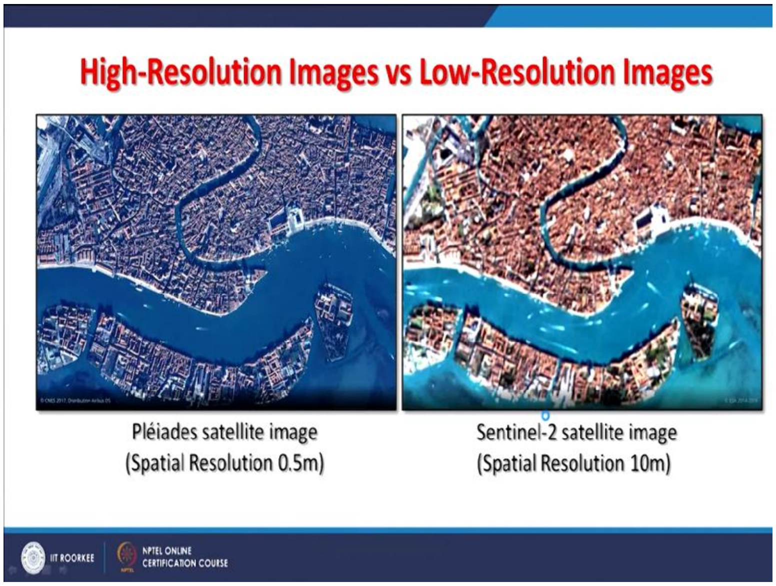

Relatively high spatial resolution satellite images versus low resolution satellite images on our on the right side what we are seeing a sentinel to satellite image having a spatial resolution of 10 meter and for the same area and this is a 50 centimeter spatial resolution that means 0.5 meter space civilization and satellite image from play you this satellite is there as you can then while comparing you can see that and play this satellite image provides a very detailed information or having detailed content as compared to sentinel to satellite image.

So, but if we compare the size of image in terms of computer memory, then definitely it will have many times requirement for size of memory and repeatability maybe also relatively less in case of high speeds and that means the temporal resolution nonetheless, that it is it provides the sharpness in the image which is provoked is un comparable with the even 10 meter or 5 meter satellite images. So, if applications which it really requires a very high resolution satellite images, then one has to use them.

The best part here is nowadays even 50 centimeter, 40 centimeter and spatial resolution satellite images are available for almost all parts of the globe. And therefore, the options of using high spatial resolution satellite images for certain applications are available for us and we will be seeing some commonly used sensors and then end their comparison and with the spatial resolution and coarse resolution and we will see that what are the advantages and limitations simultaneously for example, if I take a relatively coarse resolution satellite image which is from the polder satellite which is having band be 1 to 9 minutes.

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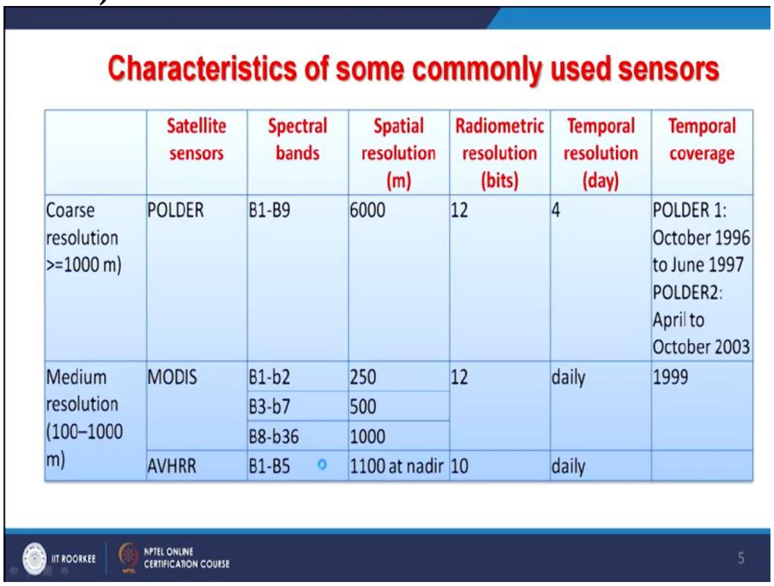

Characteristics of some commonly used sensors

	Satellite sensors	Spectral bands	Spatial resolution (m)	Radiometric resolution (bits)	Temporal resolution (day)	Temporal coverage
Coarse resolution >=1000 m)	POLDER	B1-B9	6000	12	4	POLDER 1: October 1996 to June 1997 POLDER2: April to October 2003
Medium resolution (100–1000 m)	MODIS	B1-b2	250	12	daily	1999
		B3-b7	500			
		B8-b36	1000			
	AVHRR	B1-B5	1100 at nadir	10	daily	

And then you are the spatial resolution here is 6 kilometer that means 6000 meter and the radiometric resolution of the data is 12 meter temporal resolution that means, it can come almost every 4th day and revisit the same area, but when we compare with Moderate Resolution satellite images, like from MODIS or AVHRR and because of polder and now we can call MODIS and AVHRR as coarse as Moderate Resolution if we because we talk in terms of a relative sense.

So, when we do not have the polder discuss and then we would be calling MODIS and AVHRR is of course resolution nonetheless and MODIS is having 36 channel data. So, when 1 2 and 2 are having digital channels which are 250 meter, then few channels are devoted for 500 meters of space and resolution and thermal channels are having 1000 meters that is 1 kilometer radiometric resolution remains same as compared to the polder and sensor.

But the advantage with MODIS is that the images are available on a daily basis so, that every day the same area can be visited, because there are 2 satellites in random and Terra and Aqua and which provides the advantage of reducing this temporal resolution and then therefore, it is possible to get the data for everyday of any part of the globe and then we are seeing AVHRR which is having 5 channels, 3 channels works in night time 2 channels works in daytime.

And it is about 1.1 kilometer and resolution at another because it is the Swath width about 2800 kilometer and therefore, it covers a very large area and therefore, the curvature of the earth also plays very important role that is why it has mentioned that at nadir and the center of the scene, the spatial resolution is 1.1 kilometer or 1100 meter and of course, they provide the data on daily basis and the data is 10 bits a radiometric resolution data is available from this. So, these are the examples of relatively coarse resolution and medium resolution.

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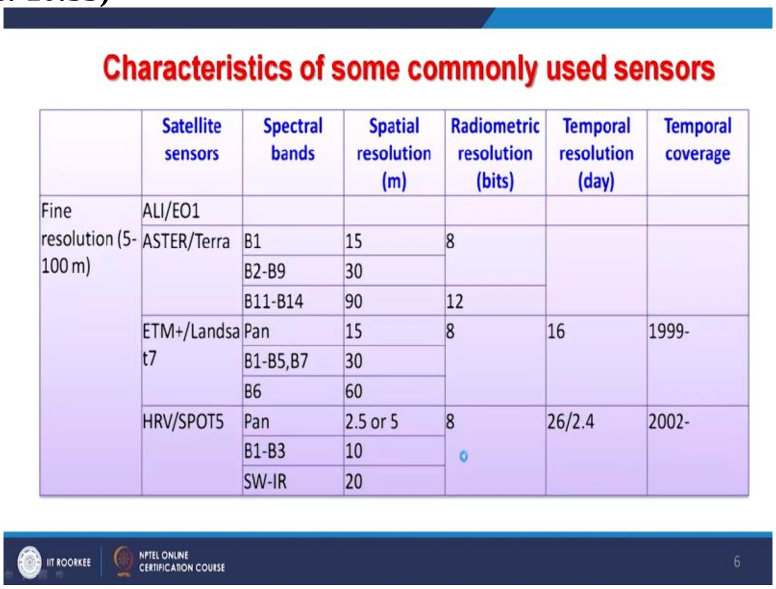

Characteristics of some commonly used sensors

	Satellite sensors	Spectral bands	Spatial resolution (m)	Radiometric resolution (bits)	Temporal resolution (day)	Temporal coverage
Fine resolution (5-100 m)	ALI/EO1					
	ASTER/Terra	B1	15	8		
		B2-B9	30			
		B11-B14	90	12		
	ETM+/Landsat7	Pan	15	8	16	1999-
		B1-B5,B7	30			
		B6	60			
	HRV/SPOT5	Pan	2.5 or 5	8	26/2.4	2002-
		B1-B3	10			
		SW-IR	20			

Now since we are discussing high spatial resolution satellite Images. So, we will have some examples of sensors and high spatial resolution and like a UI or ALI one or Terra or ASTER better known as the ASTER and the resolution is available for 1 channel B1 Pan 1 15 then 30 then 90. This is also becoming very common nowadays. That one platform that means, on one satellite, we are having you know a sensor, which is working at different displays of solutions against different part of EM spectrum.

For example, here in the visible part 15 meter which is possible, but in infrared or near infrared part we are having 30 meter and then when we go for the thermal infrared, then we are having a 90 meter, spatial resolution and the radiometric resolution in case of between B1 to B9. We are having 8 bits and whereas, when we go for maybe 11 to be 14, then we are having and I would say data. Generally this is also a common thing, that the when its spatial resolution is measurably closer the radiometric resolution is better.

Because in order to grab those kind of details by the sensor, now ETM plus that is on the lead set and 7 or ally in dance at 8, we are having the panchromatic channels are having 15 meter, then to B5 and 7 and that is excluding B6 is thermal channel where we are having 60 meter. So B1 to B5 and B7 30 meter. Parametric resolution is 8 bits which is most common radiometric resolution in most of the satellite images. But we are going for coarser resolution spatial resolution.

And then generally, this means up to even 12 then sport example is there again in Pan 2.5 to 5 meter B1 and to B3 10 meter and then shortwave infrared is 20 meter space and resolution, but this rudimentary resolution remains in throughout and that is 8 bit. These are since then what so, like spots since 2002 this data is available and the temporal resolution let we see for ETM and plus that means lens at 7 and in the temporal resolution by 16 days and, generally this is how the Landsat programs have been designed either in 16 or 18 days.

And whereas, since we have gone for relatively higher spatial resolution compared to Landsat, instead of 15 meter, now we are having 2.5 meter. And the point which I have mentioned and that If you go for higher spatial resolution, the temple of illusion reduces and therefore it has become 26 days. So, only a narrow swath, one would have an each orbit and therefore in order to revisit the same part, which will require many days to come back, so in this case 26 days.

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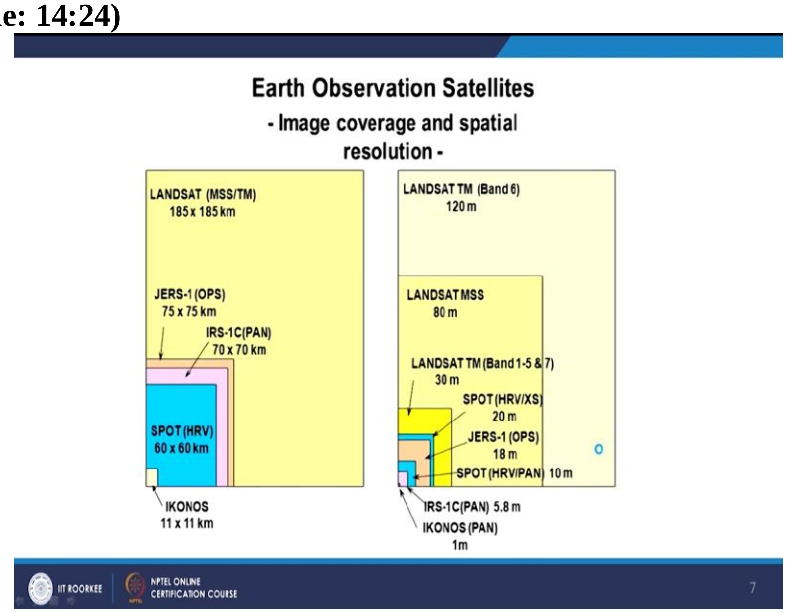

And if we bring everything but a spatial resolution versus image coverage or one can also say, is swath then let us take example of LANDSAT MSS, so, a LANDSAT MSS will cover in one go in one scene the other and 185 by 185 kilometer .So it is a quite large coverage by LANDSAT MSS or TM sensors. But when we go for a sport which we have just discussed, then the scene will cover only 60 kilometer by 60 kilometer. So, you can realize that it has on both extent or both directions it is one third roughly.

And therefore, the temporal resolution will reduce accordingly and that is what we have seen here that in case of land said it is when it is 16 days and that has gone to 26 days. So, higher the spatial resolution is smaller, that is swath width and therefore, and your temporal resolution is also very less if we are having high spatial resolution. So, this is what we can say the disadvantage of going for high spatial resolution.

See all the time for all the application It is not good to go for high spatial resolution if we work does not require that much of detailed information about the ground or surface on the earth Then one should not resort to high spatial resolution do the dataset might be available, because the data handling would be exponential. If my work can be done using say LANDSAT MSS or TM, then why I should go for a spot because then I have to handle more datasets in this case.

Maybe 9 times more and I end of the day that the results which I have to produce at a particular escape that it is not a large scale I have to produce on a smaller scale. Therefore, why I should go for high spatial resolution satellite imagery. So, all applications in all fields do not require high spatial resolution data. So, once you choose very judiciously if it is really required for that particular application, then definitely one should resort for high spatial resolution.

Otherwise, optimum is spatial solutions will be assessed that which one is most issue. They will and that because now choices are available from you know 6 kilometer to 60 centimeter the full range of spatial resolution satellite images are available. So, if I am covering a continent or a large part of the country, then I should have known go for very high spatial resolution images and if my study area is very small and I want very detailed information about my study.

Then obviously, I would go for high spatial resolution and we compare it with this LANDSET and a spot in between BC also the IRS- 1C so IRS- 1C covers, 1 scene will cover about 70 kilometer wide 70 kilometer area and there are some others like GRS also which will cover 75 / 75. So, the size of the scene that means the ground coverage would dictate end on the spatial resolution that means the higher the spatial resolution.

Lower the ground coverage that sensor would have and the lower the you know, and you relatively lower the space and resolution or coarser the spatial resolution, larger the ground coverage it would have one more point which we can bring about the IKONOS See, IKONOS is having a spatial resolution of 1 meter and therefore, and see compared to a LANDSAT which is covering a under 85 / 185 kilometer area IKONOS sensor will cover only 11 kilometer by 11.

So, the swath width is just 11 kilometer in case of LANDSAT MSS and TM the squad is 185 kilometer so almost 18.5 times coverage which is being provided by LANDSAT but if my work requires high spatial resolution satellite images, then I have to use, but my coverage area would be very little compared to LANDSAT Similarly, when we see for other bands or other sensors like for this is about the example of thermal image bands.

So, in case all LANDSAT TM band 6 which is thermal band, the spatial resolution is 120 meter. But when we go and for other bands like visible or near infrared in case of LANDSAT MSS then it is spatial resolution is 80 meter. But when we go for LANDSAT TM then 5 excluding band 7, band 640, thermal ben, then I am having a spatial resolution of 30 meter. So, the spatial resolution will also depend on the part on which part of EM is spectrum.

A band or range of bands are representing. Generally highest base of resolution satellite images are available only for visible part of the spectrum. But when we move towards say right direction and towards the thermal infrared part, then spatial resolution will reduce. And then this is the example here that in case of LANDSAT TM and these visible and infrared channels are providing spatial resolution 30 meter.

Whereas, a thermal channel is providing 120 meter and same with this IRS one see this is typical panchromatic sensor 5.8 meter spatial resolution and when we when IKONOS which just 1 meter resolution and then of course, the area of coverage is going to be less. So, what we observed at this stage that and coarser the spatial resolution, we can cover even thermal part of the spectrum but when we go for higher space of resolution then we are restricted mainly to the visible or near infrared part of human spectrum.

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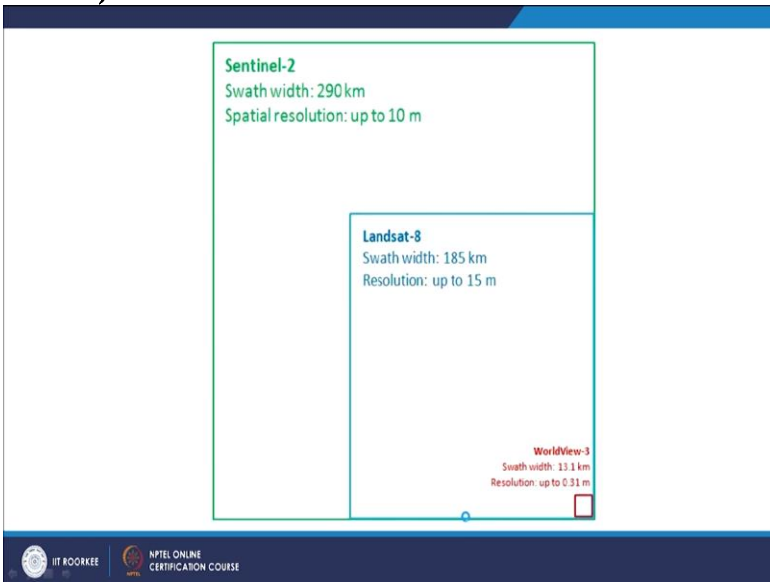

Just comparison of 3 sensors or 3 satellites a senses data from one is the Sentinel 2 another one is the Landsat 8 which is a new an OLI series it is also called OLI series and then worldview and worldview 3 is there that is the satellite. Now when we see the Swath width that the width of the scene if you wish to call then swath width is 290 kilometer in case of Sentinel 2 data and a spatial resolution is maximum up to 10 meter.

But when we go for a Landsat 8, the swath width though it has been designed like this swath width is has reduced but it is spatial resolution has gone more closer. And when we go for the worldview the Swath width is quite close to your IKONOS which is 11 kilometer in this say worldview 3 case it is 13.1 kilometer and the resolution has gone up to 31 centimeter is spatial resolution means that you can record or you can see the variations on even on the rooftop.

So, if there is some layering or surface on the rooftop of a building, if there are very essential those very essence can also be recorded by the sensors if they are having dissolution of 0.31 meter that means the 31 centimeter a foot almost a foot and they do a in particular in a particular application, if those kinds of details are required, then once we resort, once would use such a high very high spatial resolution satellite images.

But if it is not required, then once would not go because otherwise, it will cover a very small swath or and the scene size is going to be just 13 kilometer. So, if I want to cover a say large city metro city like Delhi, then I would be requiring thousands of scenes to cover the entire Delhi weather my application required that kind of high resolution satellite media that kind of detailing, that means, I want to see when the variation in the each a rooftop then only I should go otherwise and that much is not required. One more comparison about the Swath width, we started for me the NOAA.

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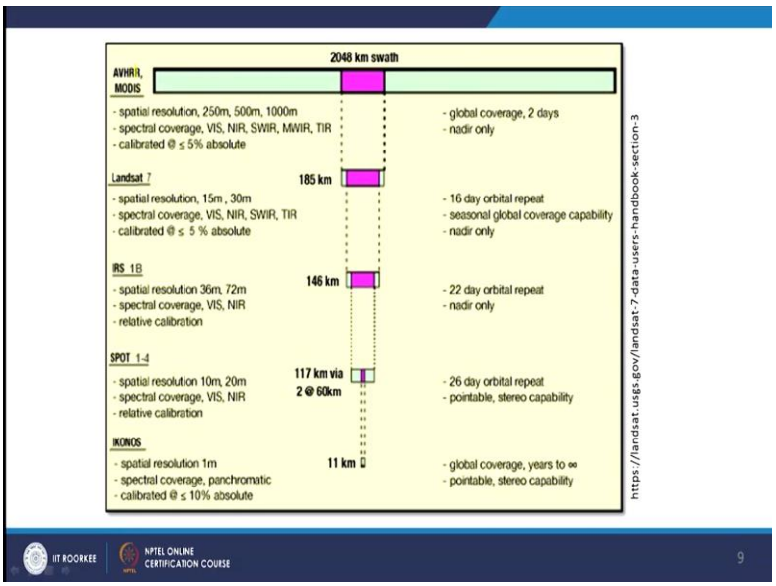

AVHRR or MODIS and NOAA AVHRR which is having about 2800 kilometers while width MODIS is having about 2048 kilometer in the Swath width, but of course spatial resolution in case of MODIS at different parts of EM spectrum or in different bands is 250 meter 500 meter and 1 kilometer, 1 kilometer that is in TIR and that is in thermal infrared. So, it covers a very large area in 1 orbit in 1 goal in 1 scene, but at a coarser resolution.

If come comparison to know AVHRR, if we go for the IKONOS, the spatial resolution is 1 meter, then you can realize that the swath width is just 11 and this is and this is not as per the scale which you are seeing from 2048 or 2800 kilometer to 11. This is not part of the scale but just representing and the Swath width and here it is just 11 crew so, compared to 2000 kilometer squad versus the full is a 10 kilometer swath width.

So, that means the more coverage many multiple types of scenes will be required if I want to cover that much of area and I using high spatial resolution satellite images say at one meter resolution and in between we are having lunch at 7 and which covers 185 kilometer Swath and then IRS which is very well designed and 146 kilometer and resolution is 36 meter and also a different sensor is having 72 that is LISS 2 and then of course we do not have a thermal channel here visible.

Infrared and near infrared and other elevations are other thing is spot if we look the spot a spot provides 10 meter and 20 meter resolution you move towards you know on the right side say on the EMI spectrum and for then we go for course on it and coarser is peaceful resolution and of course when we compare the temporal resolution in case of these satellites we may have daily and daily or in today's in Landsat 16 days in IRS 22 days.

Temporal resolution in a sport it is 26 days and I cannot send other things, many days are required maybe 40 days 48 days after that only. So, if 2 edges and scenes have to be Mosaic, then by the time the and you know the vegetation we saw some changes ground features me so, some changes and the mosaic king also and become very and difficult. Now, a in the in a different way we can also compare on the Y axis

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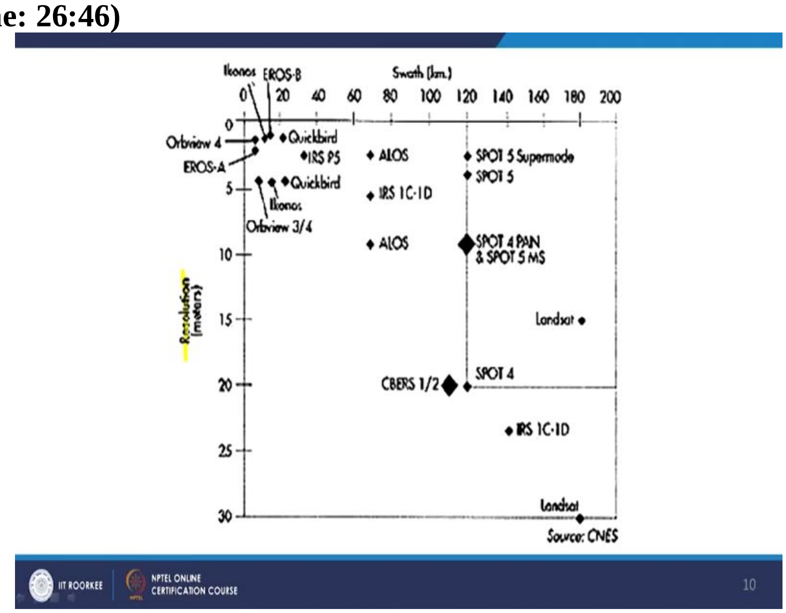

We are having the spatial resolution in meters and here we are having the Swath and that is in kilometers. So, LANDSAT is located here and that means the spatial resolution we are talking about LANDSAT TM of about 30 meter. And then if we compare with this is the quick word, we are a spatial resolution is about meter or even as 60 centimeter and so, even less than a meter It is about 60 centimeter and rest are in between including our IRSA P5 quick bird is also near and you know near 5 meters on here.

And IKONOS of course, 1 meter, quick bird is also in that then we are having ALOS pulsar IRS 1C 1D and a spot is also located here is SPOT 4 SPOT 5 and so on so for. So, more you go towards the top right in this figure and top left in this figure and you are finding newer and newer satellites are getting position there. That means they are going for higher and higher the spatial resolution.

But at the same time they are going for lower and lower Swath width and this is what this figure and basically depicts. So, he said basically, whenever some application is there in front of us be first assess what should be the optimum spatial resolution and what I want if it is Jane deception based a study or chin detection is study, then what a reputability I want and accordingly a satellite sensors would be chosen rather than just going for higher and higher spatial resolution satellite images.

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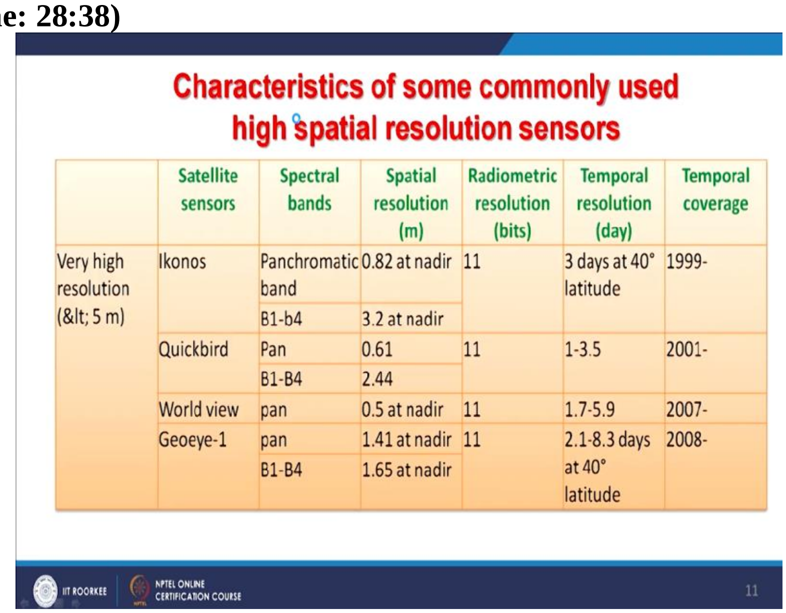

	Satellite sensors	Spectral bands	Spatial resolution (m)	Radiometric resolution (bits)	Temporal resolution (day)	Temporal coverage
Very high resolution (< 5 m)	Ikonos	Panchromatic band	0.82 at nadir	11	3 days at 40° latitude	1999-
		B1-b4	3.2 at nadir			
	Quickbird	Pan	0.61	11	1-3.5	2001-
		B1-B4	2.44			
	World view	pan	0.5 at nadir	11	1.7-5.9	2007-
	Geoeye-1	pan	1.41 at nadir	11	2.1-8.3 days at 40° latitude	2008-
		B1-B4	1.65 at nadir			

Now, there are some other characteristics which be like a quick word which we have just seen that it provides a 60 centimeter or 61 centimeter spatial resolution and for some bands it also as I mentioned that generally in the panchromatic event, can provide higher spatial resolution as In case of IKONOS 0.8 or roughly the same 1 meter, worldview 0.5 meter and then Geoeye is having 1.4 meter 1.6 meter higher spatial resolution.

So, these are quite close to each other and lot of options from IKONOS quick bird Worldview 1 to 3 and Geoeye are all available, repeated or temporal resolution and 3 days 1 to 3.5 days 1 to 1.7 to 5.9 days and 2.1 to 8.3 days. So, it would be makes integer values then 3 days 1day 1 to 3 days and roughly 2 days or 3 days and so on so for. And since when the data is available, that information is also here. So, like Geoeye 1 only from 2008 onward, we are having the data in

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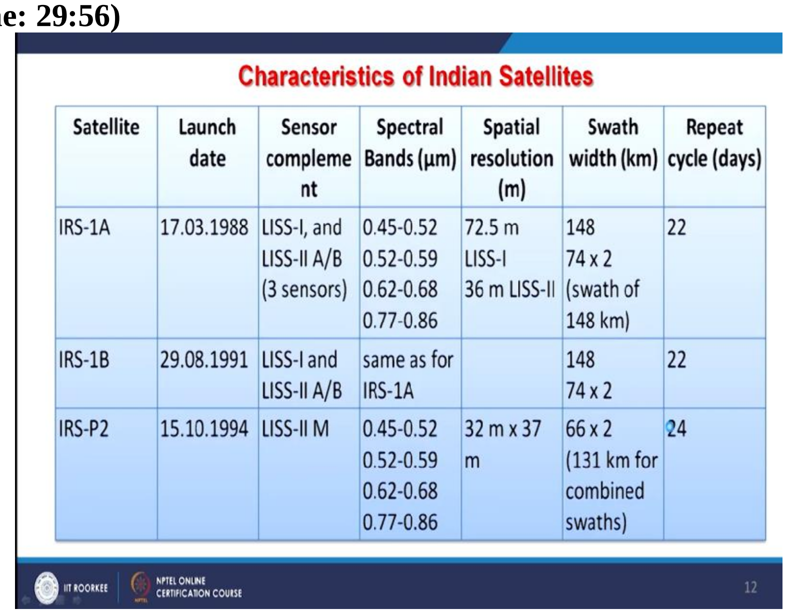

Characteristics of Indian Satellites

Satellite	Launch date	Sensor compleme nt	Spectral Bands (μm)	Spatial resolution (m)	Swath width (km)	Repeat cycle (days)
IRS-1A	17.03.1988	LISS-I, and LISS-II A/B (3 sensors)	0.45-0.52 0.52-0.59 0.62-0.68 0.77-0.86	72.5 m LISS-I 36 m LISS-II	148 74 x 2 (swath of 148 km)	22
IRS-1B	29.08.1991	LISS-I and LISS-II A/B	same as for IRS-1A		148 74 x 2	22
IRS-P2	15.10.1994	LISS-II M	0.45-0.52 0.52-0.59 0.62-0.68 0.77-0.86	32 m x 37 m	66 x 2 (131 km for combined swaths)	24

We see now, our own program that is Indians Satellites program. Of course, the Indian remote sensing satellite program and started (( ))(30:08) back. But the real operational satellites started with or the data became available since 17th of March to 1988 after the launch of IRS 18, and so we will be comparing our one program against different satellites of ISRO so if I see IRS 1A and 1B of course, both had the same characteristics.

So first IRSA IRS 1A was launched and when it became very successful, then the duplicate which we had on the earth, was also sent in after 3 years in 1991. And it also worked in the same day. So the temporary resolution in IRS 1A and 1B because the sensors satellite everything were seen. So it was 22 days, how were they were for long time attend them. That means the spatial resolution reduced to even 11 days.

So that way it was designed and launched and it worked for several years in tandem also 2 satellites in tandem. The swath width in case of IRS 1A and 1B was 148 and kilometer and then we came into another series that is IRS P2 series and that was launched in 1994. And though the satellites IRS 1A 1B worked for longer time. So we had a overlapping periods between IRS 1A 1B and P2 IRS.

This has the sensor LISS 2 IRS 1A 1B had a sensor LISS 1 and LISS 2 We had only the LISS 2 and there were 4 bands just like IRSA 1A LISS 1 and this spatial resolution was about 32 meter and the Swath width they was very less compared to IRS 1A 1B that is 66 kilometer and repeat cycle was also less it was 24 because when you go for higher spatial resolution obviously

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Characteristics of Indian Satellites

Satellite	Launch date	Sensor complement	Spectral Bands (μm)	Spatial resolution (m)	Swath width (km)	Repeat cycle (days)
IRS-1C	28.12.1995	LISS-III	0.52-0.59 0.62-0.68 0.77-0.86 1.55-1.70	23.5 23.5 23.5 70	142 142 142 148	24
		PAN	0.50-0.75	5.8	70	24 (5)
		WiFS	0.62-0.68 0.77-0.86	188	804	5

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And repeat cycle or temporary resolution will reduce accordingly. If we look the IRS 1C program then it was launched in December 1995 it has a new sensor which is LISS 3 became very popular sensor and provided data 23.5 meter resolution for a very long time of course it has the panchromatic sensor that was providing data as 5.8 meter resolution but that is in the visible part of EM spectrum swath width 70 meter there is the LISS 3 had the swath width of 142 kilometer to 1.48 kilometer.

And repeat cycle of (( ))(31:14) 24 days and it also had one more sensor and that WiFS sensor and that had the swath of 804 kilometer, but the same time spectrum spatial resolution was 188 kilometer and therefore, the repeat cycle was only 5 days. So, as you can again see here that if a spatial resolution is poor, swath width is very large repeat repeatability with your temporal resolution is very small.

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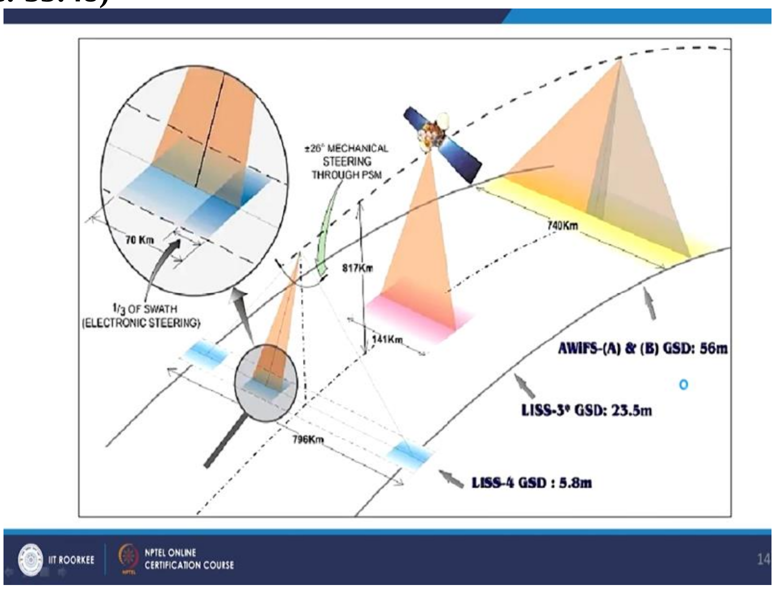

So, this is what it describes here. Again, there are examples of our Indian program that LISS 4 is also their LISS 3 example in their AWIFS Also there and the corresponding swath width is based on the resolutions have been mentioned like and here AWIFS 56 meters, this is LISS 3 23.5 meter and LISS 4 had 5.8 meters if we compared see the LISS 4 which was covering a very small swath of high resolution.

And like here, then in case of AWIFS it was covering a very large area of this much Swath so, this is Swath of a LISS 4 and this is the Swath of AWIFS definitely it covers a large area and the LISS 3 was covering a swath width of 141 kilometer

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Characteristics of Indian Satellites

Satellite	Launch date	Sensor compleme nt	Spectral Bands (µm)	Spatial resolution (m)	Swath width (km)	Repeat cycle (days)
IRS-P3	21.03.1996	WiFS	0.62-0.68 0.77-0.86 1.55-1.70	188	804	5
		MOS-A MOS-B MOS-C	0.75-0.77 0.41-1.01 1.595-1.605	1500 520 550	195 200 192	Ocean surface
		IXAE	Indian X-ray Astronomy Experiment			

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And there were a few more satellites after IRS P3 P2 and that is P3 is also there. And 96 it was launched then things keep changing like here the resolution 188 kilometer Swath width 804 kilometer repeat cycle was 5 and there were 3 sensors on IRS P3 and some new type of sensors. The X- ray Astronomy Experiment was also conducted through this satellite that is IRSA and P3 and for also dedicated sensor was there that was MOS-A B C.

Were there and for Ocean surface so far which you do not require very high spatial resolution data, so 1500 meters space and 520 and 550 different bands against different bands? We are available from IRS P3.

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Characteristics of Indian Satellites

Satellite	Launch date	Sensor compleme nt	Spectral Bands (µm)	Spatial resolution (m)	Swath width (km)	Repeat cycle (days)
IRS-P4 (OceanSat-1)	26.05.1999	OCM MSMR	0.4-0.9 6.6, 10.65, 18, 21 GHz (frequencies)	360 x 236 105x68, 66x43, 40x26, 34x22 (km for frequency sequence)	1420 1360	2 2

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Then we go for IRS P4 that is also called the OceanSat-1. It was launched in 99. And this was basically dedicated for studies related with the Oceans or seas or water and therefore, and the swath width was much higher, much bigger the spatial resolution about the relatively coarser and therefore you also had repeat cycle. So, every second day the purpose of the satellite, the design of the satellite was that, that it should provide data or alternate day. So, therefore, there will compromise with the spatial resolution and by if you compromise your goal for coarser space of resolution, you get the,

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Characteristics of Indian Satellites

Satellite	Launch date	Sensor complement	Spectral Bands (µm)	Spatial resolution (m)	Swath width (km)	Repeat cycle (days)
IRS-P6 ResourceSat-1	17.10.2003	LISS-IV	0.52-0.59 0.62-0.68 0.77-0.86	5.8 5.8 5.8	70	24 (5)
		LISS-III*	0.52-0.59 0.62-0.68 0.77-0.86 1.55-1.70	23.5 23.5 23.5 23.5	140	24
		AWiFS	0.62-0.68 0.77-0.86 1.55-1.70	70 70 70	740	5

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You know broad swath width if we go for IRS P6 also called as resource set one, it was launched in 2003. It has 3 sensors LISS 4 LISS 3 and AWiFS and the swath width we see 70 kilometer 140 kilometer and 740 kilometer whereas the resolution spatial resolution is just in the universe that is in LISS 4 we had 5.8 meter resolution and multispectral bends against metric spectral bands in LISS 3 23.5 meters illusion for 4 bands and AWiFS was 70 meter and when we compare the repeatability.

Of course, when you are having high coarser spatial resolution, the temporal resolution was much higher that is 5 days in case of a AWiFS and when we go for higher spatial resolution that means 5.8 meter in against the list for then repeatability or temporal resolution past 24 days and it was possible to steer them, so, it can be quiet after 5 days also. So, in that way there is then also IRS P5 that is all called CartoSat-1 very high spatial resolution 2.5 meter.

Swath width is reduces further and say repeated we see 2 lines stereo camera was and there and then CartoSat-2 Carter OceanSat-2 we are also launched and these values kept changing in that one.

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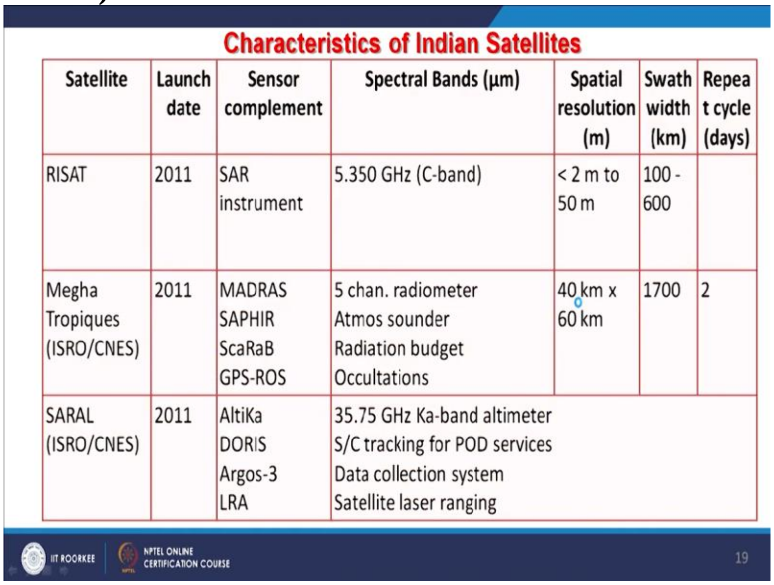

Characteristics of Indian Satellites

Satellite	Launch date	Sensor complement	Spectral Bands (μm)	Spatial resolution (m)	Swath width (km)	Repeat cycle (days)
RISAT	2011	SAR instrument	5.350 GHz (C-band)	< 2 m to 50 m	100 - 600	
Megha Tropiques (ISRO/CNES)	2011	MADRAS SAPHIR ScaRaB GPS-ROS	5 chan. radiometer Atmos sounder Radiation budget Occultations	40 km x 60 km	1700	2
SARAL (ISRO/CNES)	2011	AltiKa DORIS Argos-3 LRA	35.75 GHz Ka-band altimeter S/C tracking for POD services Data collection system Satellite laser ranging			

And there are some other sensors which we quickly we will cover here. One is the which was the radar the SAR instruments 30 aperture was there in case of RISAT and the spectral bands of course, it worked only on the C-band generally satellites will work on a single band either on C-band or X-band and spatial resolution ranges between point above 2 meter to 50 meter and Swath width was 100 meter to 600 meter because it is not there been in that sense.

And then there are some other programs Megha Tropiques send SARAL and they were there which never became as popular as our IRS series or CartoSat series.

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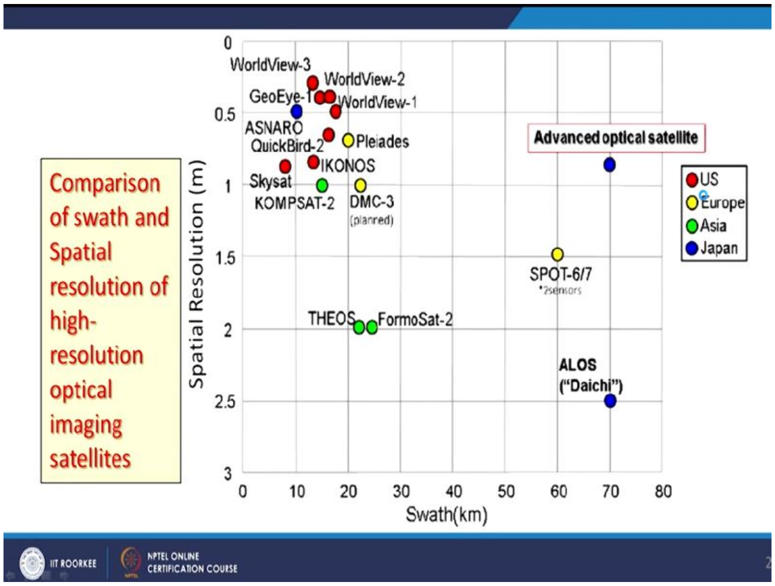

It be bring most of these satellites together and on this sort of X by plot spatial resolution versus Swath width, and then we what we see that in case of ALOS also is a Japanese satellite also called Daichi and then you are Swath width is 70 kilometer, but the spatial resolution is 2.5 below and 2.5 meter and when go for say a worldview 3 and then worldview 3 or worldview 2, then you are having Swath width is allowed 11 to 12 kilometer.

And whereas, the spatial resolution is less than half meter that means about 30 centimeter. So, here we had in this one we are talking about spatial resolution 2.5 meters to you know 0.3 meter or 31.31 meter. So, again a lot of satellites apply this we have discussed IKONOS we have discussed and there are some other quick bird we have discussed worldview 1 2 3 Geoeye, all these are there and many such satellites are getting concentrated in this top part or in the left corner where the Swath width is getting reduced and high spatial resolution.

So, on the spatial resolution front it is gaining but on the Swath width it is losing may one important point also here and though against different countries they are shown but it is not necessarily like it is shown for US. That does not mean that it is these all are being have been launched or are being maintained by NASA. In there are no private companies are also coming like a space imaging or other companies which have launched their own satellite space imaging loans IKONOS and then quick birds and others.

So, there are now private companies which are moving towards higher and higher spatial resolution satellite images, but the very costly if we compare with this a IRS data and maybe LISS 3V or LISS 4 5.6 meter spatial resolution data, but comparing the cost the enormous difference is there with satellites which will be launched by private companies of the say US or some other countries. And when we compare with this again like Pleiades is here

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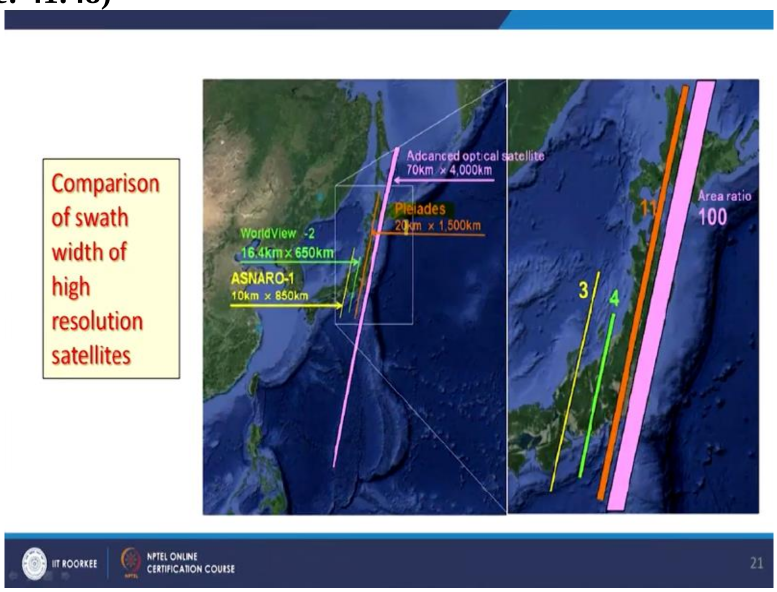

20 kilometer swath width and by 1.5 kilometers so 20 kilometer in the length or that the and the Swath and the width is just 1.5kilometer, where is it provides high spatial resolution data same be worldview than advanced optical sensors and there are many such as sensors are there, which covers the data.

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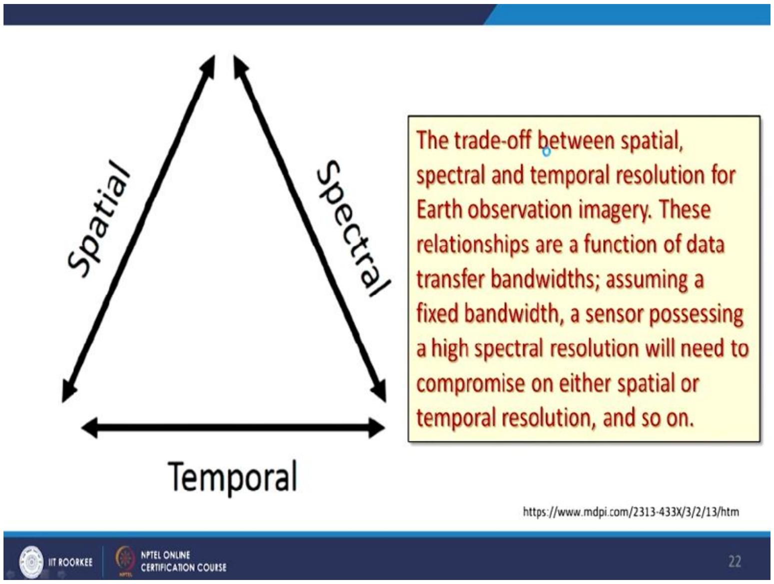

Now, as we have seen that there are trade-off between spatial resolution spectral resolution and temporal resolution among the satellite images and these there are relationships one can one we must have realized by now and that are a function of data and transfer bandwidth because ultimately we are acquiring data at a very high spatial resolution and the satellite remain in contact with the ground station for very little time then the transfer data transponder and bandwidth has to be accordingly or read has to be accordingly and you know it fixed bandwidth.

And then a lot of other things have to be compromised or handled. And that may be on the front office spatial resolution or that may be on the front of temporal resolution. So, this left figure on one axis, this is a triangle trade-off between spatially spectral and temporal resolution. So, we when we go for high spatial resolution, and we go for you know, and, lower bandwidth and MB more go towards the visual part of EM spectrum. And therefore, you know that you reach only in mainly in the panchromatic sensors, but when you go for course or a specific solution.

Then you can cover a large part of your EM spectrum including your thermal power TIR. So, this is greater between spatial resolution and a spectral resolution, but when we see the 3 spatial resolution, the spectral resolution and temporal resolution, then what we will see that if I go for very high spatial resolution, my temporal resolution reduces, but if I go for Lewis spatial resolution, my temporal resolution that means, even I can have images on every day and daily basis is possible with relatively courser space and resolution.

Maybe I when I go for this, my spectrum resolution maybe or my spectral resolution or bands which are available may be much higher. So, there is a trade-off between spatial resolution spectrum distortion, temporal illusion, but basically it indicates what is the basically outcome of this discussion is dead the lot of choices of satellite data is now available to us. And these choices are if depends on our applications.

If I am looking for high temporal resolution data that means I want data from satellites on daily basis, then I cannot go for high spatial resolution satellite images, because the Swath width is very little with the high spatial resolution, but courser spatial resolution data swath width is very high maybe 2800 kilometer and therefore, it is possible to acquire data not even every day, but twice in a day 1 in nighttime and 1 in daytime.

But when we go in nighttime, then we have to use only and the infrared part or thermal infrared part and therefore, the space and resolution may further reduce. So, these are the compromises one has to make why you choosing the satellite data, higher spatial resolution is not the solution. For all the applications, this is the main point which I want to bring here. So, in conclusion almost what we see the limitations in directly we had that but in to for completeness and we will go one by one.

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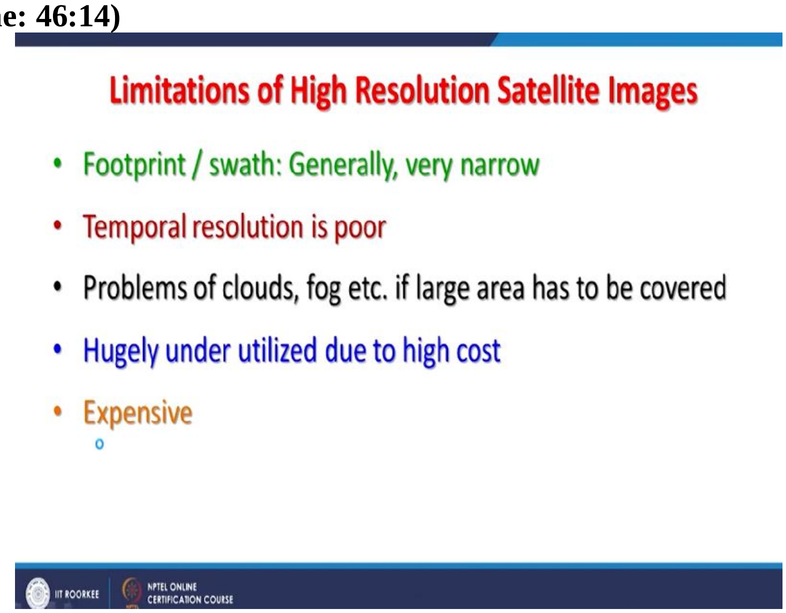

The limitation of high spatial resolution and data is that the footprint the Swath generally is very narrow and a temporal resolution is also poor, but of course, as a trade-off so, you get a high spatial resolution images. So, Swath width reduces temporal resolution reduces, but you gain on front of spatial resolution problems of cloud forget sector if large area has to be covered this example I have given that.

If I am using say IKONOS data my Swath width is just 11 kilometer and my cover area is a 200 kilometer that means I have to use several orbit and date hours for several you know orbits data and that means that I am during that time because the repeatability is poor and temporal resolution is poor. So, by the time it comes to the next day descent scene or next scene, I would might be having that area might be having and see different atmospheric conditions clouds fog or other things.

And therefore, making music or high spatial resolution data is equally very challenging. So, one has to remember this part and this is again usually underutilized due to high cost. And once I had interaction with the space imaging executive, and I asked a question in a conference, and that how much data which you are acquiring to your sensor is being utilized or being purchased by the people borrower and answer by the executive path only roughly 2%.

So, 98% of the data in highest spatial resolution satellite images is going just in archives, because the cost is enormous, when we go for very high resolution say 31 centimeter data and that means say use cost and therefore, use underutilized data because of high cost and of course, expensive and if I have to cover a large area, then it requires a lot of resources to cover that area. So, as I have been saying the best thing is first assess what the output I am intending or envisaged what is going to be the detail or a scale of my outputs.

And accordingly, appropriate datasets will be choosing appropriate satellite datasets would be chosen of a particular resolution so that I struck optimization between high spatial resolution and cost and other things. And if there is a lot of gap between 2 adjacent scenes in case of high spatial resolution data, which is highly possible, which is a regular case, then the shadow that means, the solar elevation angle may also change into adjacencies and therefore, and the mosaic king of such images becomes very difficult.

So, that is settled over other objects also creates in highest spatial resolution data that also creates a big problem. If you are having big building along with a small building then big building may cover many buildings of smaller hides in under the shadow. So, that is another and some other the limitations of high spatial resolution satellite images difficult to acquire sometimes.

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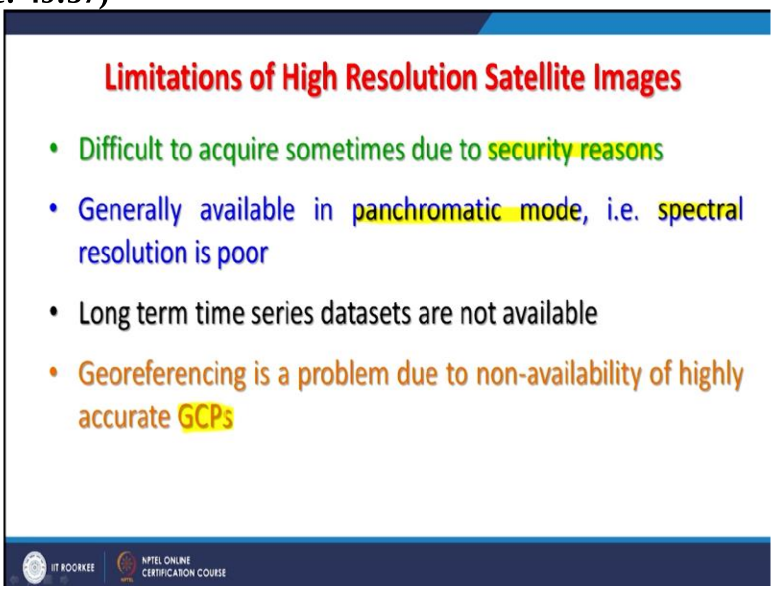

Due to security reasons this agencies are the company is regularly collecting or acquiring data from satellite and putting in archive, but when we want to buy or acquire from a purchase from these agencies or companies, then we find difficult because they are not allowed to sell the data just like that, because of high spatial resolution. So, security reasons will prevail and it will it will be basically block and block the acquisition of such high spatial resolution data.

This is a big issue in including in India, when we go for high spatial resolution data. So, that is another limitation. Another constraint with higher is a spatial resolution data and generally as I have been also mentioning, that generally very high spatial resolution and datasets are available in panchromatic mode and mainly representing the Brazilian visual part of the spectrum and you know like a 0.4 micro meter and 2.6.7 micro meter only in that part of the spectrum and the bandwidth available or data will be available.

So, there is a compromise with the spectral resolution is well the bandwidth of panchromatic bands are much wider as compared to multispectral bands and long term time series datasets are not available and because the highest spatial resolution satellites generally they may not be at a 850 kilometer and depth in a space they may be at a lower depth and therefore, the life cycle of such satellite may be less and therefore, there is no continuities available.

So, if I am looking for a long term time series data for change attacks and studies, then it may not work and Georeferencing is a problem of high spatial resolution data due to non availability of highly accurate and ground control points. And if I am I have to Georeference a very high spatial resolution say 31 or even 1 meter spatial resolution on satellite to me, then I require very accurate ground control points and these I mean very accurate ground control points that means, they have to come through differential and GNSS campaign and that means, again cost. So, it will add further in costs.

So, this brings to the end of this discussion about high speed advantages with high spatial resolution and satellite datasets up their availability. And of course, in last, we have also discussed in detail about the limitations of high spatial resolution satellite images to this brings to the end of this discussion. Thank you very much.