Remote Sensing Essentials
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Lecture-08
Various Remote Sensing Platforms

Hello everyone, and today in this course on remote sensing essentials, we are going to discuss on this various remote sensing platforms. Though in earlier discussions very briefly we have touched about various remote sensing platforms, but in this one and maybe in future also discussions we may go deep into individual satellites and their sensors in details and all intricacies associated with them.

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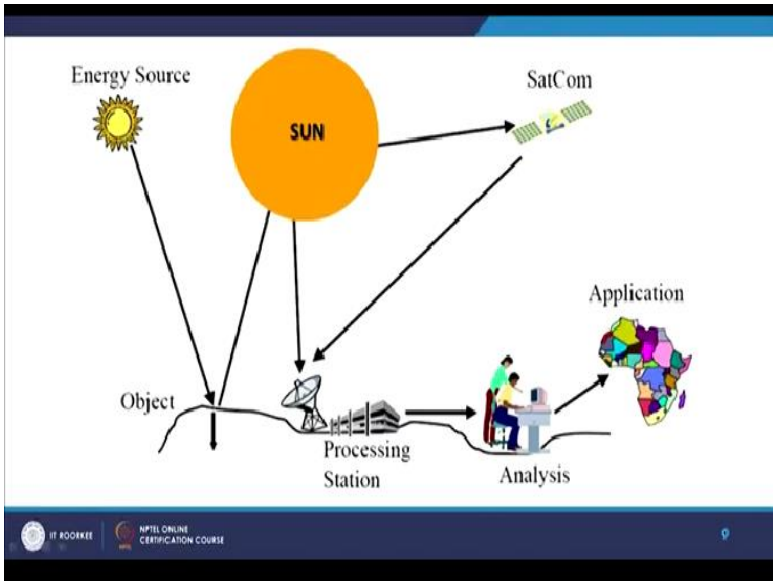

As you know that energy source is the sun in our case is basically I am talking about passive remote sensing and you are having satellites which are located in this space and then data collection, data acquisition data analysis and applications are there.

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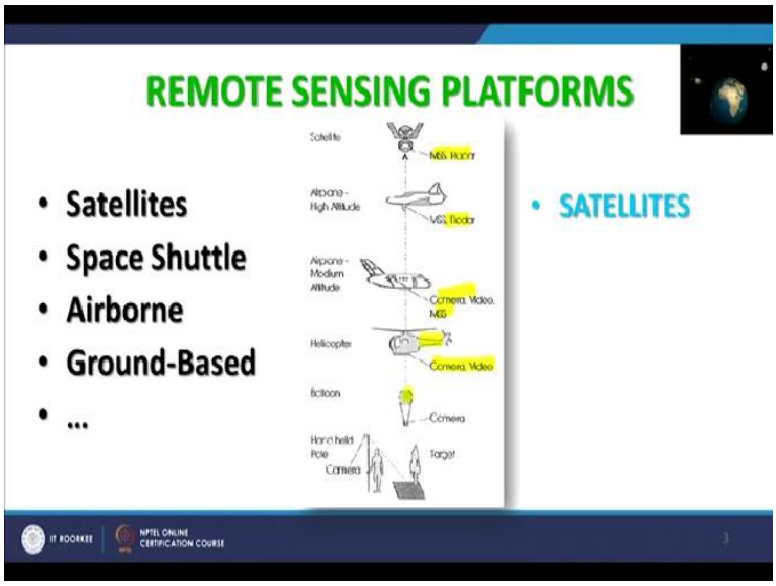

So, as we have also discussed that there are various platforms at different heights are possible starting from if you go from a ground so you starting from a human is having camera at some stand or standing, that can be also a remote sensing then you can go for balloon, then helicopters and then again on airborne things, maybe shuttle missions and then finally you end up with the satellites also.

So, you are having if we come from top to bottom then you are satellites though they are at a different depth in space or distance from earth and shuttle from there from satellite downward towards the earth, then you are having a space shuttles, airborne is also possible, then ground based remote sensing is also possible and in between nowadays we have also discussed a little bit about UAVs, which we will be having a complete discussion on that too.

So, you are having satellites, you are having airplanes, you are having helicopters, you are having balloons, you are having drones, and of course, you come to the ground, there are also. So let us take first the ground one.

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There are possibilities of using some cranes or some special platforms for collecting ground data like here one example shown is mobile hydraulic platform, which can go up to 15 meter height and you can have a payload on the top of this platform and then remote sensing can happen it is sometimes very useful in agricultural investigations or maybe investigation related with civil constructions also.

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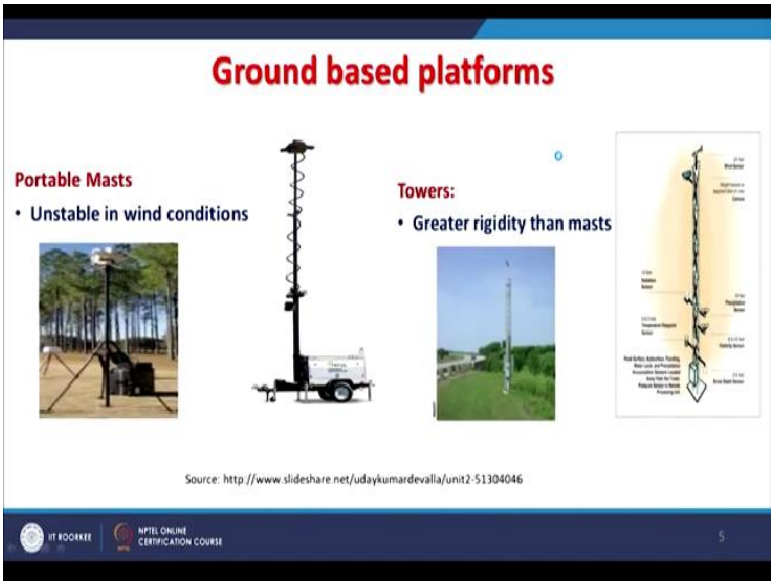

It is also possible to go for other kinds of platforms which are again ground based like these are portable masts are there, so there one some stand or tower. One example is also sewn here that this mast is with the setup here on the ground base setup, for varied height, you can have towers like these, the greater rigidly then mast and maybe for a very long time.

Generally these are used for whether data collection and other things but one can also have a camera sensor onboard of our top of the towers. So, it is possible this is one schematic of the towers is also shown. So, various instruments maybe at the lower heights you can have mythological instrument, but at top you can have some remote sensing payloads as well. So, these are mainly ground based platforms for very specific purposes they are installed and are being used world over.

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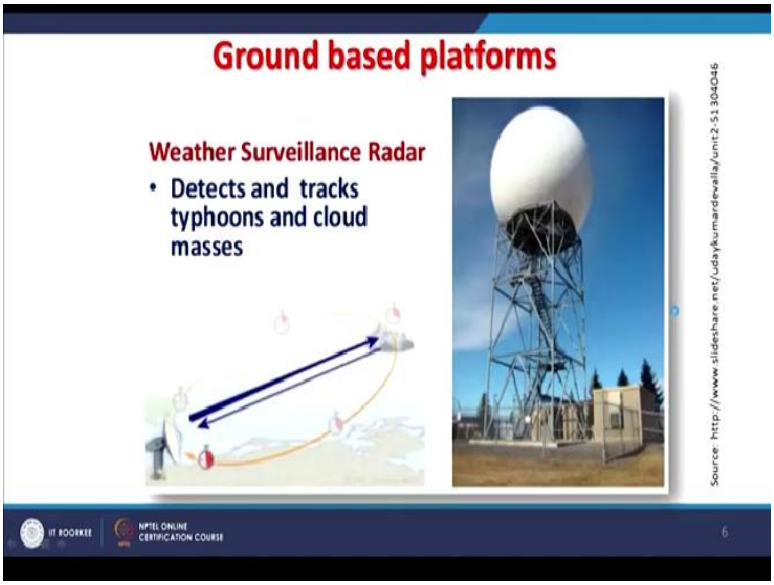

We can also have a ground based surveillance and namely this is radar and in this radar basically you are having you know sensors or maybe antenna to receive the data and in this particular example you can shown here that a spacecraft or any such a airborne platform is there and this antenna which is can be inside a radar is receiving the signal. So, that is also possible. But these radars are generally used for weather surveillance, radar.

And detects and tracks typhoons and cloud masses. Those are also quite common nowadays especially we see near the ADC, this airport control towers and they are also having radars.

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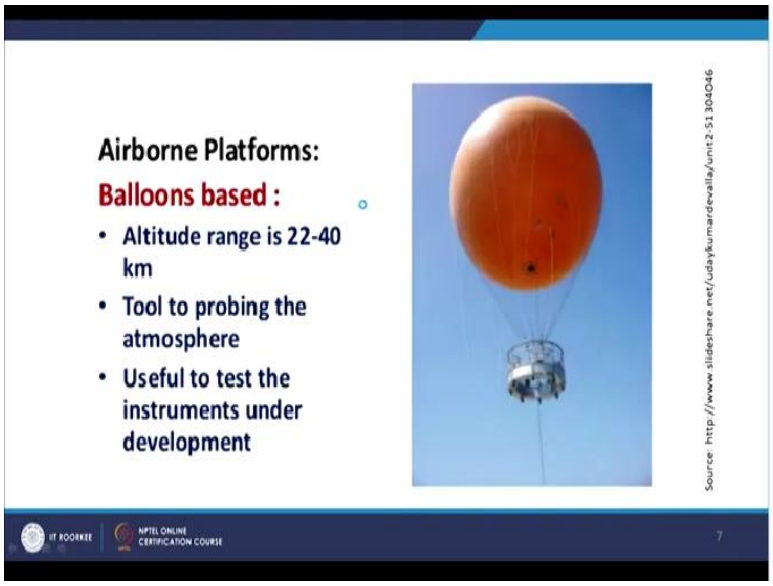

When we go a little higher from the ground, then we can have airborne platforms and starting with the balloons. So, balloons based very common, very old thing and it still it is being used that you can have a balloon, which can go up to 20 to 40 kilometer in height. And it can be used to probe the atmosphere different layers of atmosphere with different constitutes of the atmosphere depending on the what kind of sensors or payloads you are having.

And also useful for test the instruments under development. So, these things are balloons first, suppose somebody has developed a sensor and how it will perform in a space condition. So, before that a people test also in the using balloons, they also test in the airborne and then finally, these are launched with the satellite.

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Now, as mentioned earlier that nowadays a UAVs are also we call them drones. These have become very common, there are a few positive reasons with these devices or these platforms is that they are now very stable because the propellers maybe you know instead of 4 you can have 10 or all kinds of combinations are coming and they are becoming more powerful in the sense that they can have a greater or more payloads means these they can carry more heavy cameras or sensors as also soon here.

And they can go to different heights, they are quite stable platforms and for various kinds of remote sensing purposes these can be used not only here the example is shown for visible cameras, but one can have also you know infrared or thermal infrared camera and in case of natural disasters, flooding, earthquakes, dense lights or related with the you know, crowd management. These are being used very regularly.

So even now security people or police, they do have started using this kind of remote sensing. One example is on that mining induced wetland contamination. So that is being monitored can be monitored on a regular basis using drone. Another big advantage with drone is that they are equipped with the GPS and therefore the sorties or how they will travel in the air that can be planned.

And executed as per the given sorties or layout and therefore they can systematically cover an area giving a proper plan in geographic coordinates. So, that makes a very useful of UV that is why they are becoming very popular is also one here is a UAV based photograph shown of Australia wetland and you can have as I mentioned of different kinds of propellers here this a quad copter is shown.

There are also like one mosaic is also shown here, which you can see that after getting all cameras one can create a mosaic and complete coverage is also available and a lot of development is taking place if somebody is interested in more and such related aspects in this drone based remote sensing, then this is the area which is very much upcoming and one can use not only for taking images, not only in the visible but infrared thermal infrared.

And also one can use maybe for ultraviolet, because here they do not fly at very high height. So, that atmosphere effects on ultraviolet lights may not be there. So, in mineral exploration, it can be used and also people have started using creating very high resolution digital elevation models using drone based data, because overlapping or stereo pairs can be acquired with more systematic planning of sorties of drones.

And therefore then only the processing is required tools are available and therefore, it is possible it is becoming possible to prepare very high resolution digital elevation model of area, there might be some you know negative issues out there. So, when we will discuss in detail about this, we will also discuss some minus or demerits associated with the drones. Now, airborne platforms again has been there since very long time has also mentioned in world war II. And the airborne platforms **as we** have been used extensively.

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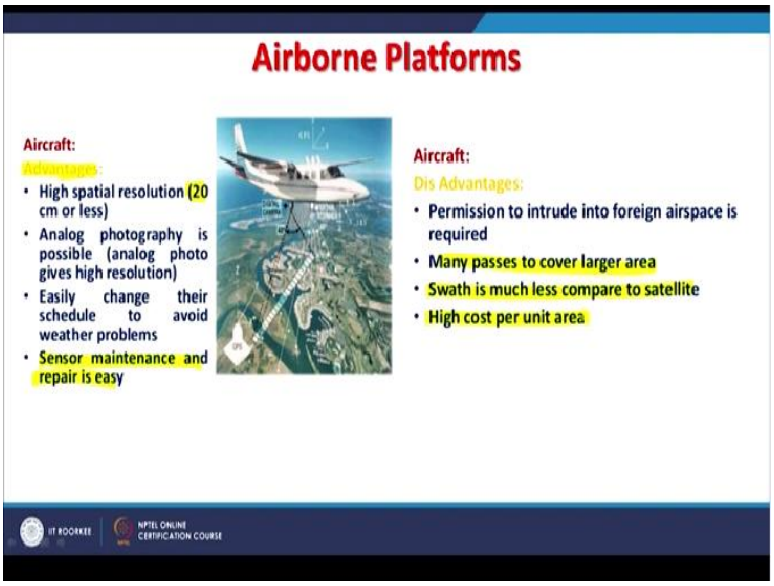

What are the advantages with the airborne remote sensing is that high spatial resolution is possible, maybe up to 20 centimeters, these are relative though relative terms and keep changing. So, today I am mentioning 20 centimetre today, tomorrow might be in 10 centimetre. Analog photography is possible because one earlier when we used to have aerial photography, which is not much common nowadays in India.

But in other countries is still it is there why it is not common in India because we are already having very high resolution satellite images, which also provides a stereo pairs like from Cartosat and other and we can prepare a digital elevation model a relatively higher spatial resolution. So, airborne things which we do not go because there are certain disadvantages which we review also seeing soon.

And these easily change their schedule to a wide weather platforms that means that with the having a airborne if weather is weird, and then things can be planned accordingly when weather is clean, but in case of satellite orbits, orbits cannot be changed. So whatever the weather conditions are it has to it will overpass of that area and it will record whatever is available in atmosphere on the land with the satellite.

But in airborne it is possible to schedule according to clean weather and of course, the sensor maintenance and repair is easy something goes bad with the sensor. Then of course, whenever

aircraft will come on the ground, it can be checked, repair and all kinds of maintenance can also be done, but with platforms like satellite based platforms, once the sensor or the satellite as we launch sensor is onboard.

Then this maintenance or repair in does not big, it is not possible at all. So, what are the disadvantages with the aircraft, generally you require a permission to fly aircrafts. So, permission to intrude in foreign air space is also required not only in foreign aerospace but its own like in India one has to get the permission to fly airborne sensors and in any part of the India. So permissions are required and for if one is to cover a large area then many passes or many sorties would be required.

And but in case of satellite it provides much more synoptic view. So, a large area can be covered in one orbit rather than a airborne where you require many times passes to cover an entire area and because the swath is less compared to the satellite and because satellites are very far and these might be flying at 10 or 12 kilometer but satellites are in space in 850 kilometer and therefore, the swath even at the same resolution swath may be very large.

And of course the cost relatively satellite based remote sensing is my cheaper compared to airborne remote sensing. So, these are the disadvantages with airborne platforms.

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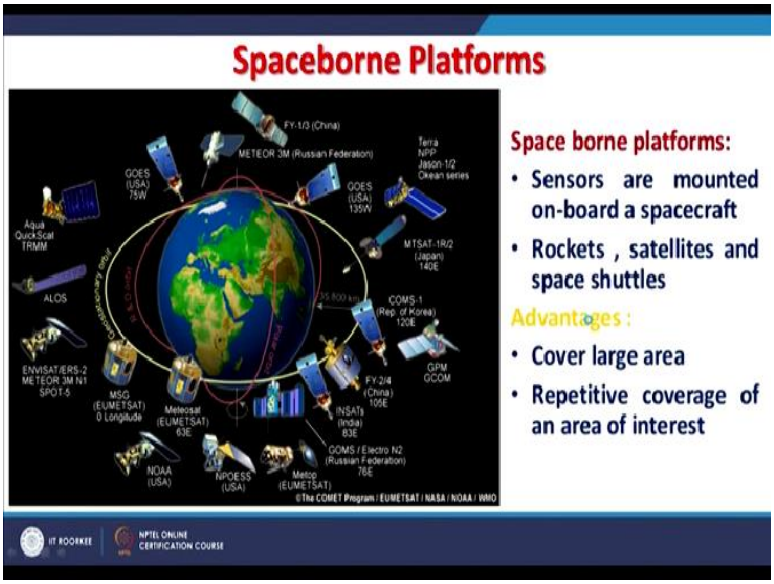

This figure we have already introduced in earlier discussions, but just for you know advantages and disadvantages point of view, I kept to this figure again here that when we go for a space burn platform, which is what actually and this is what real satellite remote sensing is. And this space well platforms as you know the sensors are mounted onboard of spacecraft and various sensors even one single spacecraft as possible.

It has been going on since very long time. And one rocket can also have many satellites. Remember that few months back or about 1 year back in India launched about you know, 104 satellites through 1 single launch vehicle. So, it is also possible to launch many satellites by a single rocket. And of course the space shuttles are also involved in that one, what are the bigger advantages the large area coverage the synoptic view.

It covers a large area and you are having a systematic repetitive coverage because you know each satellite will have a fixed orbit and therefore, repetivity is also known. So, we know that when the next orbit will come and so, the repetivity coverage of area of interest is much, much stable, reliable and one can have whereas in the airborne every time the sensor has to go in the airborne but in case of satellite it is already there.

And this repetivity coverage is not for 1 day, maybe for 5 years, 10 years. It depends on how robust and electronics and battery power and solar panels on a spacecraft. So, these are the biggest advantages with the space borne remote sensing. In between we have been discussing about different types of orbits in which satellites are put in a space, but I will have very specific discussion here.

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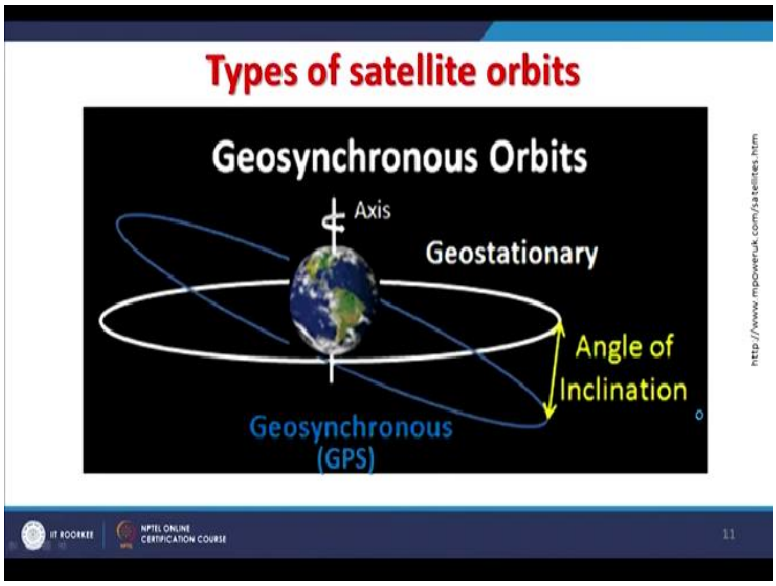

And because the remote sensing which we are talking is a polar orbiting satellite, that slide will come very soon, but before that there are different types of satellites are there and they too are providing some remote sensing data especially about the geostationary satellite. So, as name implies, we know very well that, as name implies that they are with reference to earth they are geostationary. That means as earth moves on own axis.

The satellite also moves along this equator. And so as you can see that it is white orbit which is shown is for the geostationary satellites. So, India is also having its own geostationary satellites. Now, the main purpose of geostationary satellite used to be for communication purpose for telephone, for data transmission or for TV channels and other things. But nowadays they are also being used to capture you know images or snapshots of part of the earth are we call as a disk.

So, suppose if a geostationary satellite has been you know geostationary with reference to India, then it will cover the India surrounding countries means Indian subcontinent and in a form of disk because a snapshot are not typical remote sensing images, but for various purposes they are being used especially for weather monitoring , in cyclone studies, cyclone forecasting and other things extensively these are being used.

Because every you can program you can have an every half an hour one image or every 15 minute image also in future India is planning, I understand that we will have you in video images

of continuously images will be coming in for more videos of the India and surrounding countries very, very useful in case of weather related studies and there is a another orbit which is quite similar to the geostationary orbit which is called geosynchronous orbit.

And which is as you can see, this angle of inclination is there, depending on the country where it is because sometimes if they are far from equator then they do not like this geostationary satellite for communication and other purposes. So, one can have geosynchronous as well. And also nowadays for a navigation systems a geosynchronous satellites are also being used, here in bracket it is written in GPS for GPS, but GPS is one part of the GNSS that is Global Navigation Satellite System.

India is also having NAVIC or IRNSS in this category and we are also having some satellites in geosynchronous orbit we are also having and geostationary orbit. So, this is geosynchronous and geostationary orbits are there.

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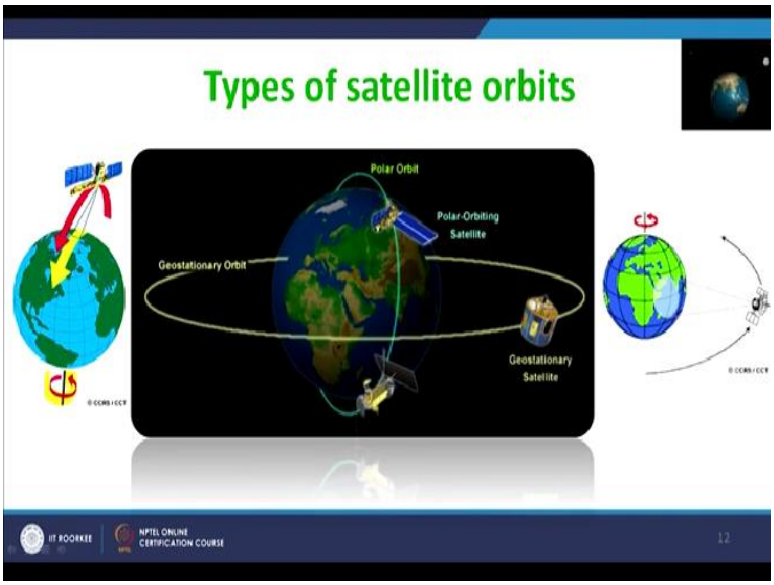

Now, the main, the remote sensing which we use these satellite or orbits that is the polar orbit or near polar orbit. We also call a sun synchronous satellites or orbits because sun synchronous means local time they will pass and exactly in the same time every time whenever they come. So, that is why they are sun synchronous, they are not pole to pole but little inclination is there. So that is why they are also called near polar orbiting satellites.

All your remote sensing satellites starting from Landsat and to your Envisat and Sentinel or Indian satellite like IRS, Cartosat, Resourcesat all are polar orbiting or near polar orbiting sun synchronous satellites with referenced because they are relatively quite close to the earth around 850 kilometer whereas geostationary satellites are at 3600 kilometer quite far and of course, geosynchronous satellites are 20,200 kilometer plus minus few 100 kilometer depth in the space.

So, and the purposes are different, therefore, designs of the satellite or orbits are also different, but here in this is passive remote sensing which we will be this we are discussing in this course and further we will be discussing in this course, all we are talking about the polar orbiting satellites or near polar orbiting satellites, also called sun synchronous satellites. And this is again the similar thing is soon for some synchronous satellites as earth moves you know on this axis or rotates these satellites keep moving in their orbit and in between the within that orbit, the earth also rotate.

I briefly mentioned earlier about the geosynchronous satellites orbits and they are having some inclination and, of course, the distance is much more.

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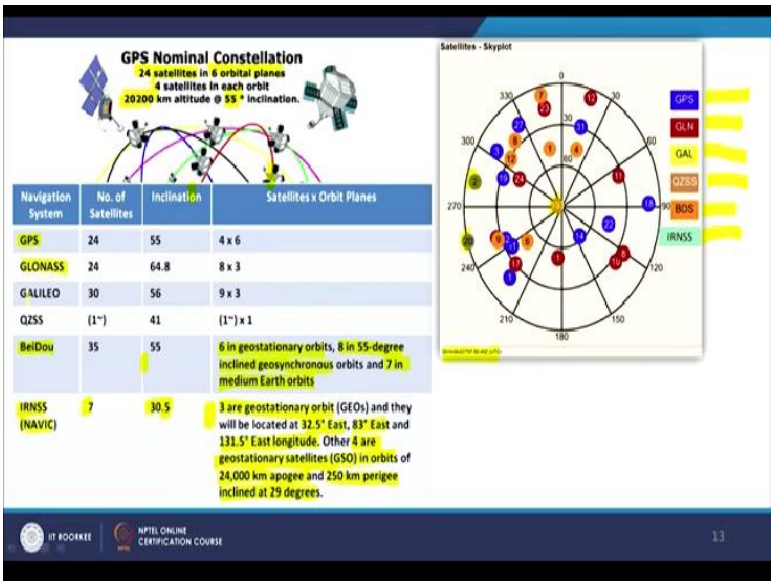

So this example is about the GPS which is American Navistar navigation system. As you can see that there are 6 orbital planes are there. So, 6 types of orbits having the 24 satellites total, 4

satellites in each orbit. So, 6 multiply by 424 and you are having the distance or altitude of the satellite is 20,200 kilometer and they are having inclination at 55 degree with each other. So, likewise these orbits are there in 6 orbital planes in each orbit plane they are 4 satellite at equal distance.

So, if I take as a this red one, so 1 satellite here, 1 satellite here another must be this one and another is this one and the distance wise and they are having the same. So, these are the geosynchronous satellites are there one example also shown that not only the GPS which American system you are having Glonass, you are having Galileo which is European system, Mellowness is a Russian system Qzss SS is Japanese, BDS that is BeiDou is Chinese and of course, then IRNSS, which is Indian system.

So, this is the skyplot showing for that instant where these different kinds of ah satellites we are located, here the examples of GPS is shown example of BDS is shown and Glonass is also there in this dark red color or a dark brown color. You are also having one satellite which is BDS 193 probably, and sometimes some other satellite or so. So these 2 are not you know so far has got any color. So they are probably not being used for that instant, the time and date everything is mentioned here.

So, GPS as you know, having 24 satellites in geosynchronous orbit, Glonass is having 24 again, Galileo is having 30, Qzss is having 01 because they have to cover only Japan is not a global system. And BeiDou is of course global system they are having 35 satellites 6 in geostationary orbits, 8 in 55 degree inclined, geosynchronous orbit like GPS orbits, and 7 in medium earth Meo medium earth orbits.

And let us discuss in detail about the NAVIC system. In NAVIC system 7 satellites are total in constellations, and inclination is 30.5 degree, 3 or geostationary orbit. Remember these geostationary satellites are multipurpose satellites. So they are being used for communication, telecommunication. TV also broadcasting and also for weather monitoring another thing. But the same time now, India is also having one more duty for the satellites for the navigation also.

So, navigation is also becoming possible they are out of 7 the 3 are important from geostationary and they are located at different locations as soon here and 4 are geostationary satellites in orbits of very deep in this one 24,000 kilometer away from there. And of course 250 kilometer perigee inclined at 29 degree. So, they come very when in the orbit time they also come quite close to the earth as well or you can say quite close to India as well.

The design is like this. So instead because our system is IRNSS or NOVIC is not global system whereas GPS, Glonass and BeiDou, these are global system understand in future Galileo will also become global system but for time being it is definitely a European system only to cover Europe.

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Now various are observing satellites. And this we are talking about the mainly the passive satellites which are working in visible infrared, thermal infrared part of EM spectrum and + 1 microwave which is passive microwave not active microwave, passive microwave. So, the first example is NOAA AVHRR, NOAA is the name of the satellite AVHRR is the advance very high resolution radiometer, which is the sensor onboard of NOAA series of satellites.

It started with NOAA-1 now we are having NOAA-19. So, in between, you know all these satellites where there 18 and 19 are still working and we will have more discussion on AVHRR and then of course in 1972 on board AVHRR NOAA came much earlier but the purpose was

mainly for weather monitoring for NOAA but land set came for earth monitoring or terrestrial monitoring.

That is we initially used to call earth resources satellite and so Landsat-1 now we are having Landsat-8 latest, so in between lot of land said satellites came with different sensors. We started with Landsat MSS multispectral scanner, then thematic member and the TM ET then ETM, ETM + and OLI series now the latest. Of course the French also had their series which is a SPOT satellite say an abbreviation but difficult to pronounce.

IRS or course the Indian remote sensing satellite, so we started with the series with IRS-1A 1 B 1 C 1D and then we had also after that the Cartosat and Ikonos for IRS-1 after 1D in between also some other names also came and of course then Cartosat, Ikonos, sea waves, GOES, and Meteosat. Meteosat is like your geostationary satellite and Terra EOS satellites. These are very, very popular data of the satellite is very popular.

It is being used extensively have NOAA data as well as Terra require 2 satellites are in tandem. So their MODIS sensor is very, very popular and for all kinds of studies. Because it covers the globe data is freely available and it is being used extensively for climate studies, climate changes studies and other things, it is possible.

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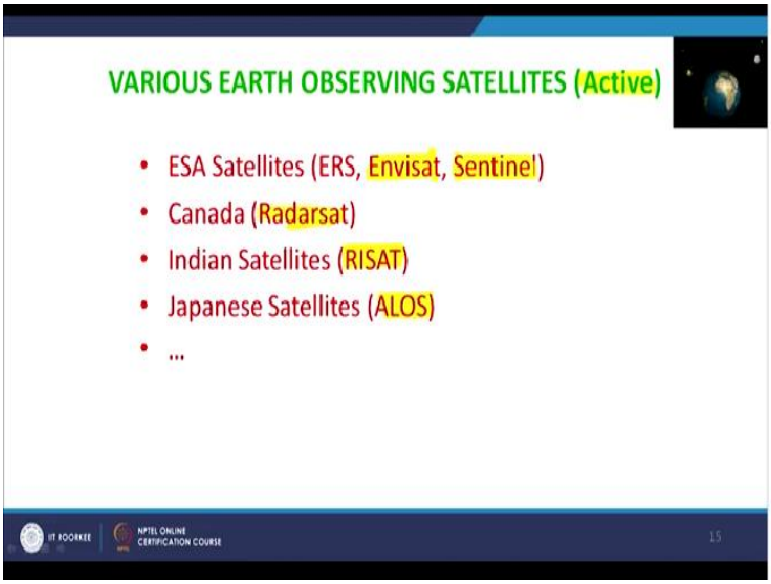

Now, we will see that like ESA the European Space Agency satellites, they earlier had ERS of course, this was the active now we are having and Envisat also had active sensors ESR and others and they were providing interferometry data at very low cost for educational institutes. And now Envisat is no more functional. So, now we are having Sentinel 1 and 2 and Sentinel 1 also provides active microwave remote sensing data.

And also interferometric data very useful data for changes studies especially induced by earthquakes, flooding and landslides, all kinds of such studies and very useful within 35 days, you get a pair and interferometry, a technique can be used and a minute ground deformations can be monitored and grounded formations as I mentioned maybe because of landslides, maybe because of earthquakes or maybe mining activities or maybe because of over exploitation of groundwater.

So, lot of applications are there data is free and very, very useful data. Then Canada also had the Radarsat data, which is again active microwave data, Indian satellite among Indian or a slow had RISAT data and then Japanese have a ALOS data, RISAT-2 is also planned maybe next year we will have then ALOS it has the sensor PULSAR very popular satellite again. The one which I would like to emphasize about the Sentinel, currently data is available and data is free interferometry data is available and it is really very good.

And processing tools are also available that means the software. So, one can quickly learn this active remote sensing and start applying for the studies related with wrong deformations as I just mentioned induced by various reasons.

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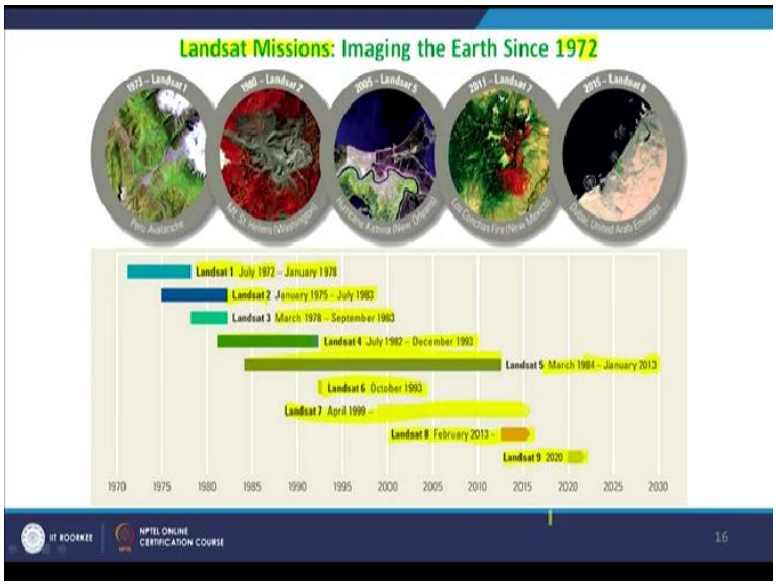

Now, in very brief way we will be also see the landsat missions starting since 1972 like Landsat-1 which is started in July 72. It remained in space for about 6 years, 5 and a half years. Then the Landsat-2 which was launched in after 3 years of Landsdat-1 because earlier the age of satellite was estimated about 3 years But now because things have improved in terms of electronics, in terms of battery, in terms of solar powers.

And therefore, you would see slowly that their life is much more as compared to that, see here it is about 5 and a half years and see here it was launched in 1975, January and it is July 1983. So, about 8 years and the Landsat-3, again it is stayed about for 5 years, Landsat-4 see about 11 years. So, things have improved, the technology has improved and therefore the life for these satellites have also improved.

Landsat-5 again, March 84 and 2013 very long service. Though originally these are designed only for you know, 3 years generally it is but sometimes it is not a normal common thing that they will last at least 5 years. But the examples are of 11 years, same with the NOAA series of 6 October, but sometimes they are some mishaps also, and because this is a highly risky technology in that sense, and Landsat-6 was almost a failure.

Then came Landsat-7 and that was also working. I think currently it is no more, Landsat-8 is of course, was launched in 2013 is still working, Landsat-9 is expected next year that is in 2020. So

life of these satellites as you are seeing these horizontal bars, some they have increased quite lot in recent years because of a lot of improvements.

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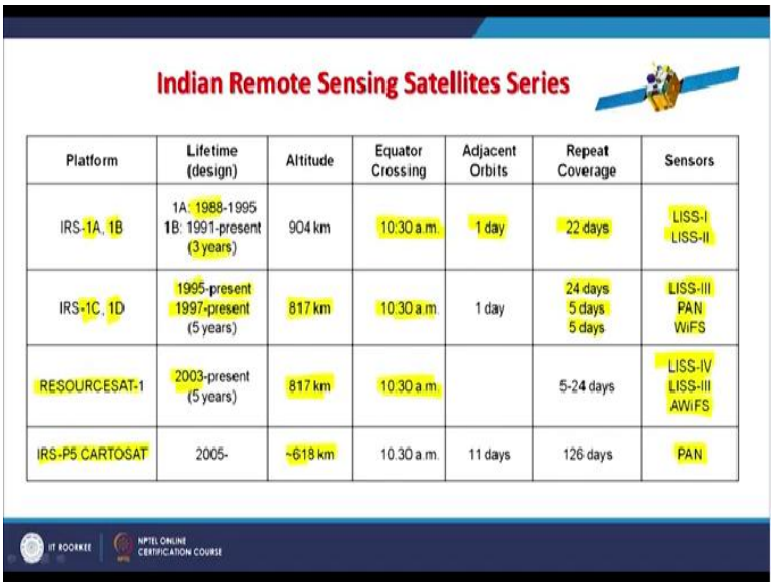

Now we will see our own remote sensing satellites very successful mission were there are these satellites starting with IRS-1A and later IRS-1B, IRS-1B was launched in March 1988. And it gave these were also designed for 3 years, but they serve a lot the IRS-1A 1 B both had the identical platforms or identical sensors also LISS 1 and LISS 2 the repeat coverage, what 22 days and the steering capabilities was there, because the sensors had the mirror camera.

So, it was possible to change the angle of camera and therefore the adjustment orbits data could be required after just after the wind 1 day, so that was also possible with these one and a local crossing time. That is equator crossing time or local time was 10:30 A.M. IRSA next series was IRS-1C 1D why next series because instead of LISS 1, LISS 2, it has LISS 3 sensor much more improved the sensor.

Of course it has the pan sensor that panchromatic camera. And web sensors it has wide angle and field scanner also. Now it was launched in 1995. Of course, it is no more working but it has to be updated and in 1997 the IRS-1D was launched and IRS-1D had some problems. But anyway the coverage was designed for 24 days of course the repeat coverage because of steering capabilities. And if you are having 2 satellites in tandem, you can have repeat coverage even in 5 days.

This is what it was done in IRS-1C 1D, again local time, or the equatorial crossing time was 10:30 and as you can see that because IRS LISS 1 and LISS 2 sensors had relatively lower spatial resolution and therefore, their swath was much more as compared to LISS 3 which had a higher spatial resolution. So, as you know that when we move towards higher spatial resolution, the swath width that reduces.

And this is what you are seeing here. And then a complete new series which is Resourcesat in launched in 2003 and it has at LISS 4 sensor, LISS 3 was very popular sensors it was repeated on this platform as well and advance AVF sensor was also there, again local across time or equator across time 10:30, it is same altitude and this P 5 IRS-P5 or a popularly known as Cartosat very, very useful because it had panchromatic capabilities.

And stereo pairs acquired and we can create spatial resolution DM 5 meter spatial resolution DM using Cartosat. So, that was very popular and I think still it is working. Since then of course a because of higher spatial resolution the altitude was less and swath will also is less compared to LISS 1 LISS 2 or LISS 3.

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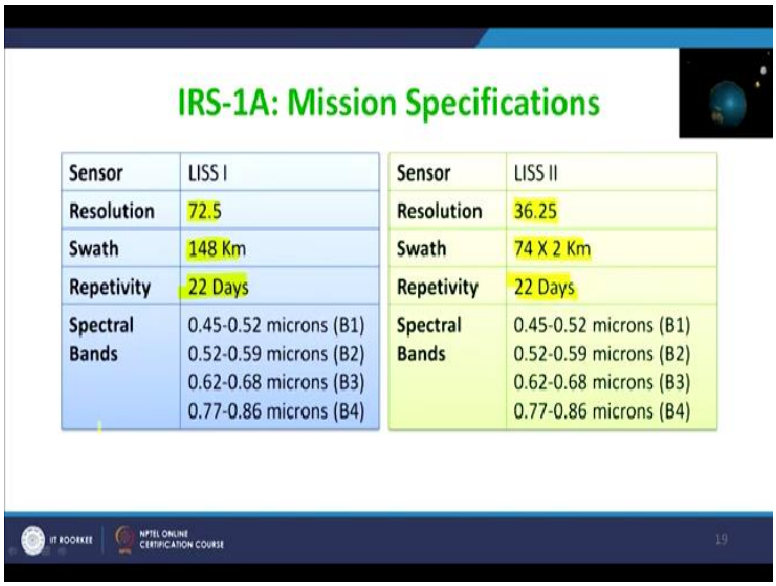

Different dates and other further details are here about like IRS-1A, IRS missions, LISS 1 had the resolution of 7.25, LISS 2 had the resolution of 36.45. So, as you go higher in the spatial

resolution as I was mentioning, the swath size reduces here it is 148 but here 74 multiply by 2 because you can cover much more, but still it is not in 2 strips or something like that. Then you are having 22 days repetivity was same because it is on the same platform. And channel wise also it was means spectral bands were on LISS 1 LISS 2 were the same.

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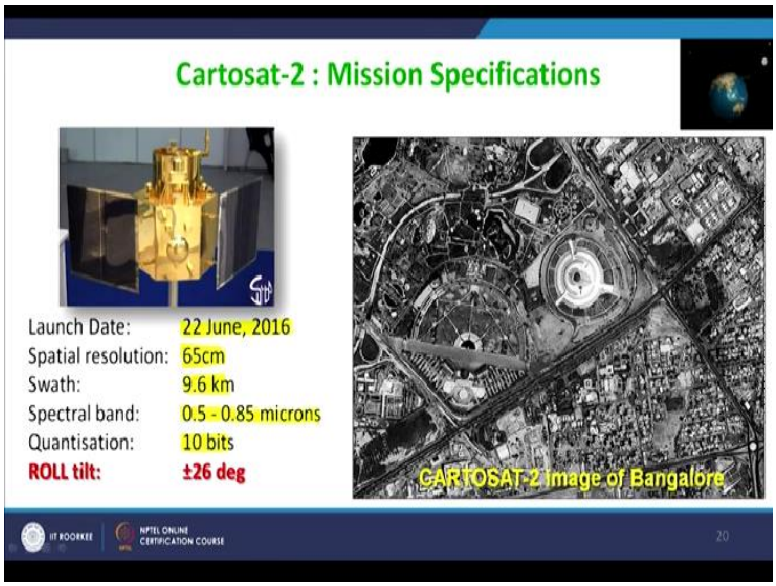

A very popular recent one is the Cartosat mission. It was launched in 22nd June 2016. And these details are also there, the swath just noticed the swath because just 9.6 kilometer, so very narrow swath, but the spatial resolution 65 centimetre. So, with Cartosat images, it is possible to acquire images of 65 meter resolution. However, the swath is 9.6. So if you are going to cover a large area then you are having you need to acquire many swath data.

If it is a small area to be covered then not a big issue and of course, panchromatic data but at 10 bits rather than conventional like IRS-1 D, we had panchromatic sensor, but it was working at 6 buts, now it is 10 bits. So you know the radiometric resolution in case of Cartosat-2 is very good. And spectral band is of course part of visibility spectrum.

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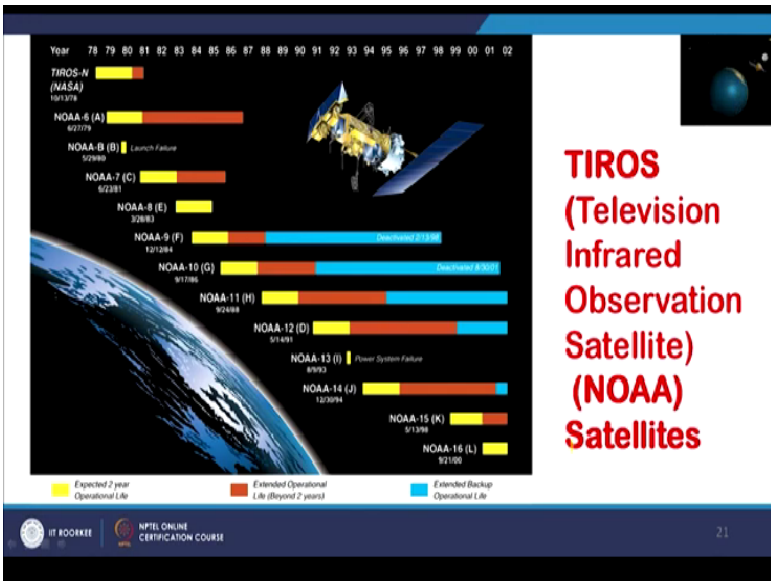

And NOAA series of satellites again very popular is still going on and the NOAA 19 is there, it is missing here but I know that NOAA 18 and 19 are working and this can be updated and see that earlier this was TIROS series. Then NOAA 6, NOAA-B, NOAA-7, 8, 9, 10 and 19 they were there.

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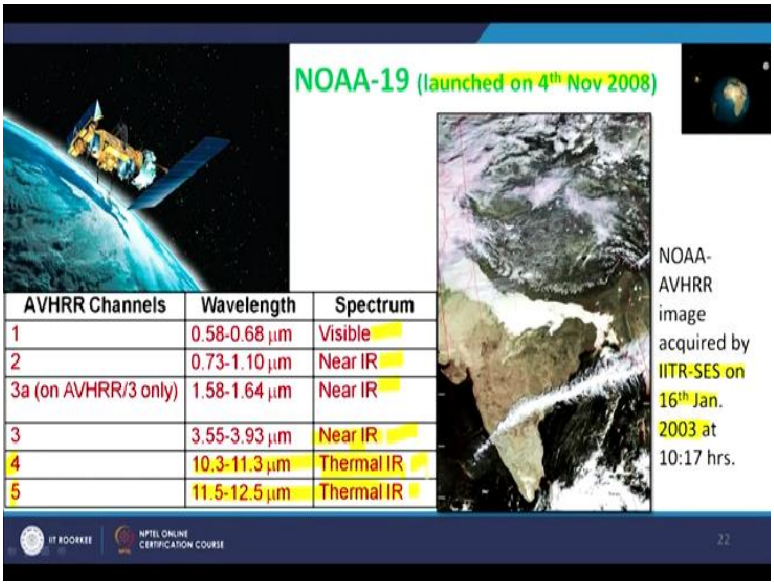

And NOAA 19 as I just mentioned, that it was launched on 4th November 2008 is still working and there are 5 channels in daytime and nighttime 3 channels works because visible and near infrared channel will not work it is mainly the passive sensor. And one example are shown by the data acquired by our own satellite earth station which is working since October 2002. And every

day 4 times in a day, by each satellite, the data is being acquired 2 times in daytime 2 times in nighttime.

By nighttime is possible because we are having 2 devoted channels one NOAA AVHRR which is channel 4 and 5 in thermal infrared part of EM spectrum. And as you know for thermal images to in order to acquire thermal images, you do not require that direct sunlight or illumination source that whatever the emitance or emissions which are coming out of the earth can be recorded by the sensors.

So, these 3 channels works very well in nighttime, whereas, these 5 channels, thermal channels will always work. So, 1 channel, 1 channel, this channel, this channel and this channel, this channel and this channel works in daytime also.

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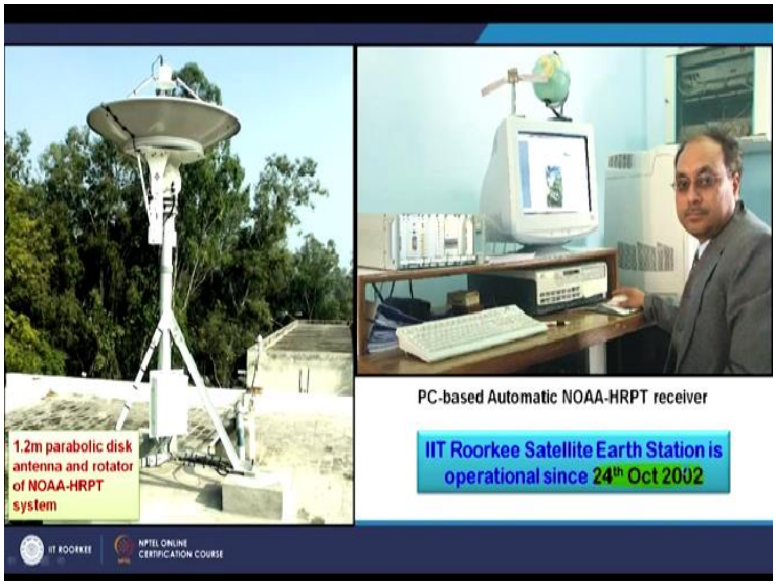

And this is the simple setup which we are having running and still data is being acquired this is external part which is a rotating or tracking here is a PC based system. And as mentioned it is working since October 2002.

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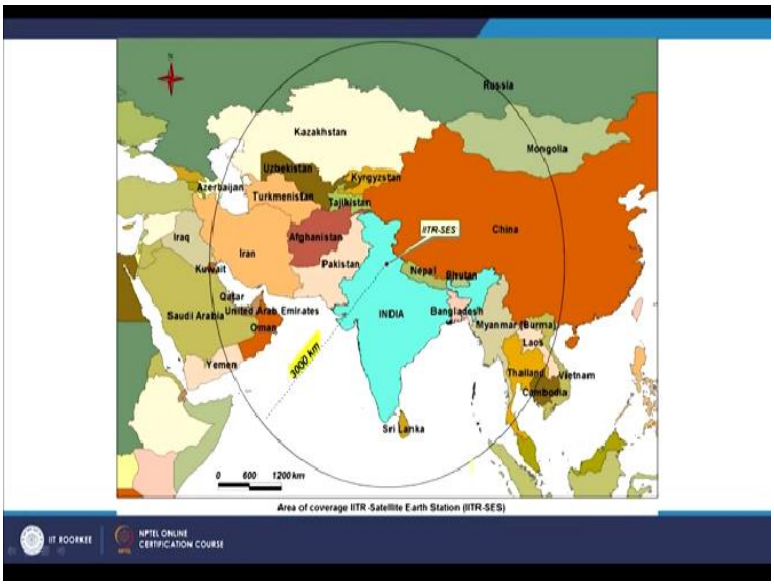

And because the spatial resolution relatively is a course, it is 1.1 kilometer and the AVHRR sensor and therefore it covers a very large area. So, it covers a 2800 kilometer width of the area I have shown the image here. So, in one go it can cover the entire India and some neighbouring countries as well, because of coarse, or spatial resolution and this shows that whenever these NOAA series of satellite within the range of this circle in a space, which is about 3000 kilometer radius.

Then we can acquire for our this earth station, which is called IITR and satellite of the station can acquire the data from the satellites can whatever the transmission the satellite will make our earth station can record that one. So, that is why this circle is there you can see that, you know, 80% or 90% of Iran and Turkmenistan, Afghanistan, Pakistan and many large part of more than half part of China, Russia.

All these countries are covered and we are acquiring data. Of course, the purpose is different which is I am not going to discuss them.

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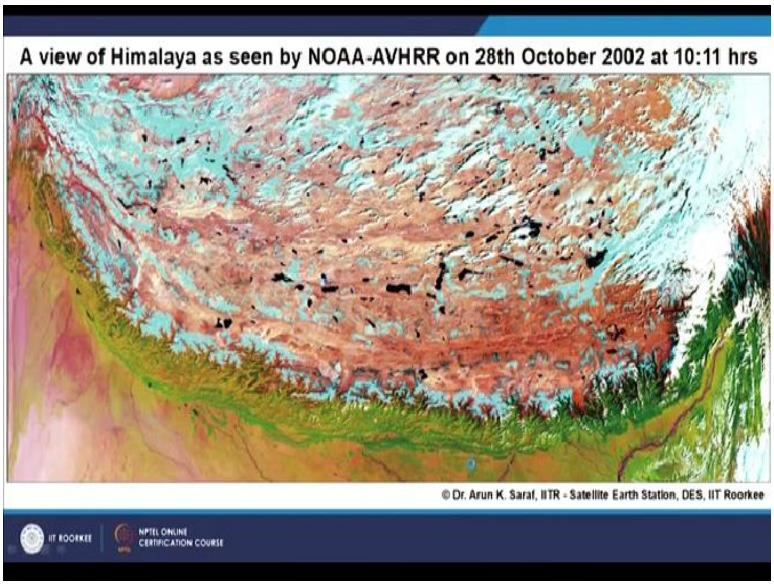

This is one of the examples that entire Himalaya in one set this is not a mosaic, but just in one swath in one go one orbit the entire Himalaya has been covered.

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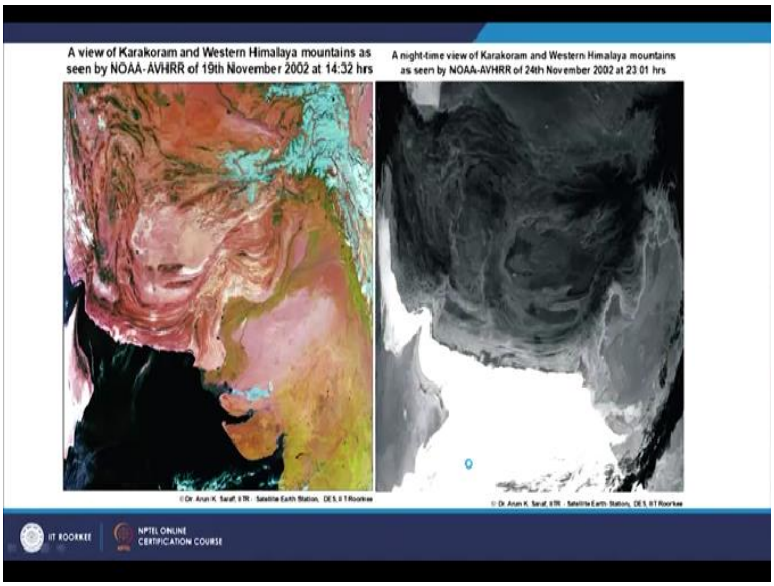

In nighttime example also given for the daytime example is here on the right side, this is what how you see in the nighttime in thermal images, something like x-ray of the earth. So, this brings to end of this discussion, especially about the different platforms main focus of this discussion was on space based platforms. We have taken some examples of Landsat, our own Indian IRS C Ds, and of course, finally, NOAA series of satellites. Thank you very much.