Introduction to Remote Sensing
Dr. Arun K Saraf
Department of Earth Sciences
Indian Institute of Technology Roorkee
Lecture 02
Development of Remote Sensing Technology & Advantages

Hello! This is second lecture on introduction to Remote Sensing. As you can see that now we are going to discuss in this particular topic the development of Remote Sensing technology and advantages. So we will look some history and we will see that why Remote Sensing is so useful that means the advantages. There are various advantages of Remote Sensing over conventional techniques and we will see all those details.

As I mentioned in the previous lecture that is the introduction to Remote Sensing first lecture that the current remote and sync is you know is not did not develop in just 1 day, it took you know centuries basically as you can see that the first time the Ariel photograph was taken from a hot air.

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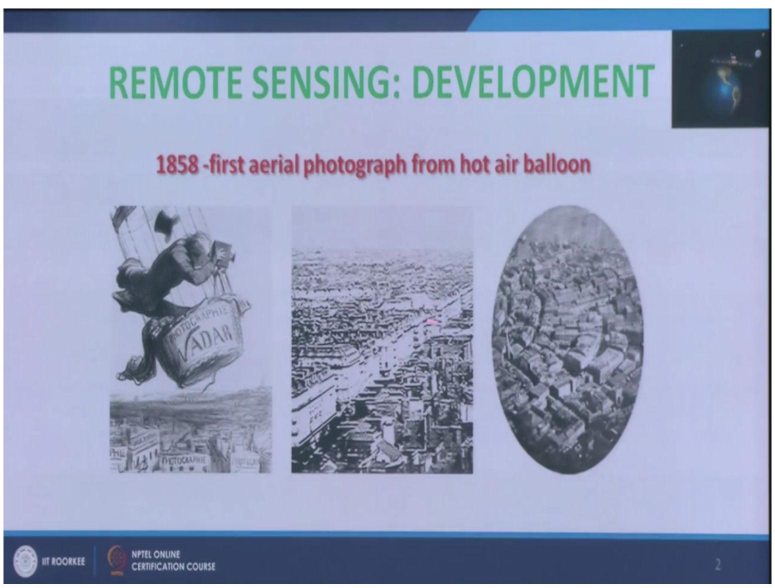

Hot air balloon in 1858 as a drawing shown here and the photo luckily these been preserved, so the photographs of uh through that camera which we have taken are also shown here. So remote basically that was also remote sensing which brought us to this current day remote sensing. So it is basically if you look the history of remote sensing and the development, the journey, the development journey of remote sensing basically we can put in 1858 and of course a later on in World War 2 specially there are lot of extensive use of remote sensing was done but before that also the you know that words were also used to put their the cameras and then flown over it.

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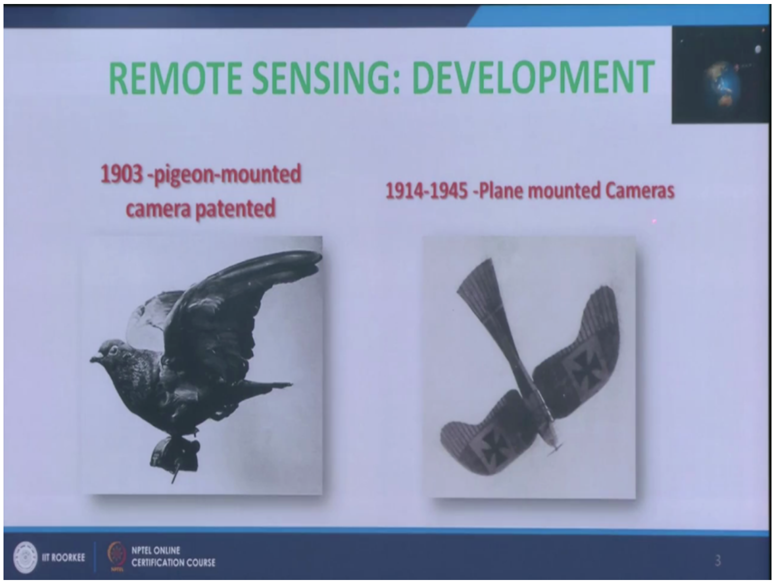

So in 1903 this kind of experiment was done, later on the plane mounted cameras were also used in 1914 45 when this World War second was going on.

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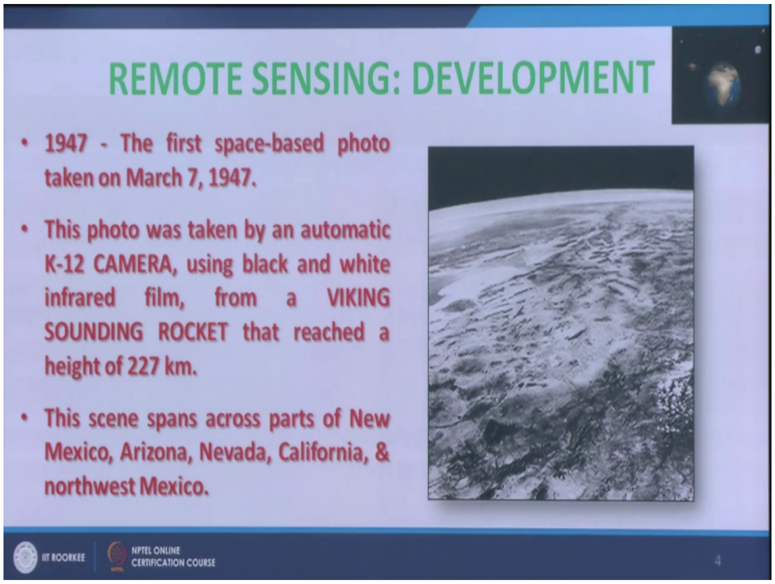

And then in 1947 the first space based photo taken on 7th March 1947 and this photograph is shown like this but these were not scanners, these were not imaging system, these were the cameras and we took the snapshot, there is a large difference between these snapshots and scanning which we will see in later lectures. So this this was taken by an automatic camera K12 using black and white infrared film and from Viking sounding rocket that reached the height of 227 kilometre.

Nowadays these polar orbiting earth orbiting satellites are orbiting around 800 and plus, 850 minus few kilometres, they are orbiting, so much deeper in space the current day remote sensing is been done. But anyway this is how things developed, first through you know balloons and then you know space ball or space based photo taken and this is a New Mexico, Arizona, Nevada, California and New West Mexico was captured in 1947.

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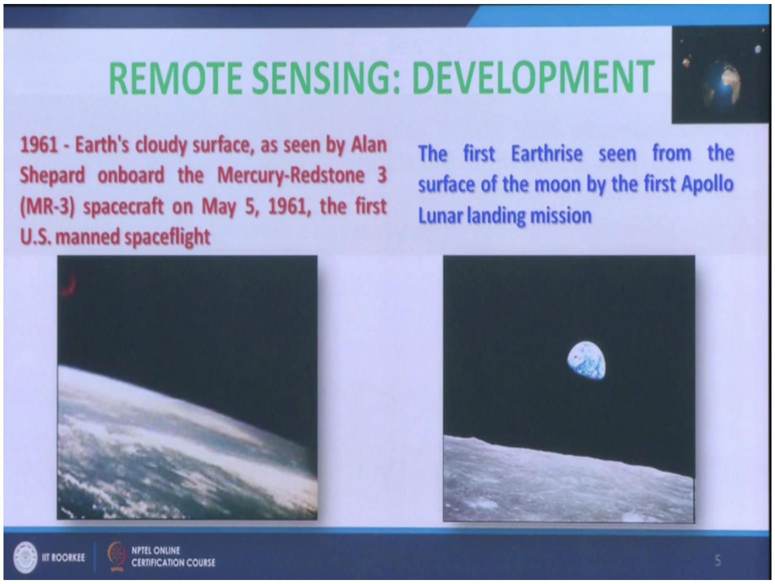

In a 1961 the earth this was taken by satellite which is Mercury-Redstone 3, spacecraft on 5th May 1961 and which was the first US man space flight, so this was a man in this space flight man was there and or astronaut was there and it has taken the photograph. Later on other in (alad) other missions also like Apollo, Lunar landing missions also the photographs not only of the earth were taken but also of the moon.

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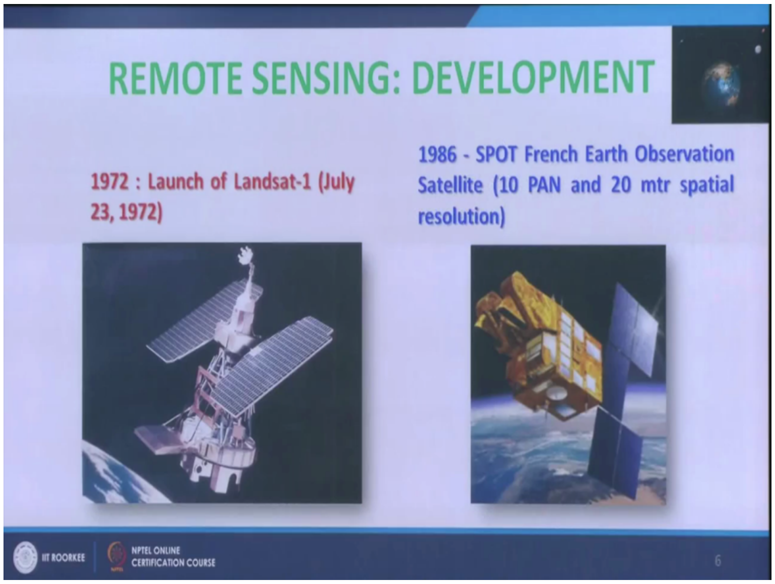

The real remote sensing, the boom in remote sensing really started since 1972 after the first launch of this series of satellite and the first one in that series was Landsat. Earlier if you open some older books you would find that the name of this satellite was ERTS, Earth Resources Technology Satellite, later on it was renamed as Landsat. So we started the real operational to the current remote sensing if since 1972 and the good part is that the most of the data which this satellite the series of Landsat have recorded are not available for us to use.

So more than 45 years of now, roughly 45 years of the data is available and therefore people are implying this data sets for long term studies specially in climate change or in environmental related studies. So that is the biggest advantage that the archive since 1972 after the Landsat 1 which was launched on 23rd July are now available almost free of cost for utilization, for different applications.

Then another boost came because the Landsat 1 was giving the data it has the sensor which is the multi spectral scanner MSS and it has resolution of 79 or roughly say 80 metre. Now this was improved, this special resolution was improved much much improved special resolution through this spot which was a French orbiting satellite in 1986 and it had the new sensors, very high resolution relatively at that time, very really high resolution that means it started providing data at 10 metre that was the panchromatic that means black and white and also 20 metre that is this multi spectral data though this spot, so that brought a major jump from special resolution, from roughly 80 metre to 10 metre and 20 metre, that was a great boost to remote sensing though this program of French earth observation satellite that is spot in 1986.

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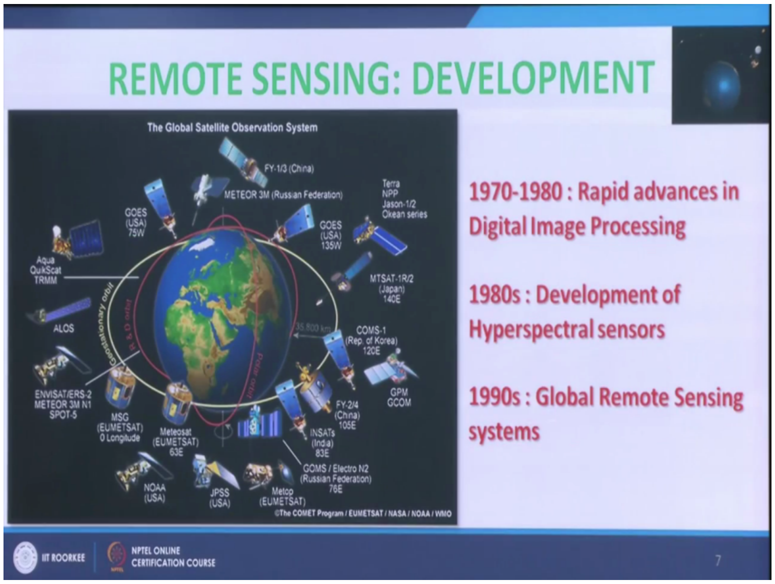

Nowadays many many countries, more than 12 countries are having their own satellites including India, including China, Japan and a even you know Dubai which is UAE Dubai is city of UAE which is a not a very big in that sense but they too are having their own satellite, so now many many countries are having satellite and that is why the earth is enveloped by many many types of satellite, many of them are working and some of them have lived their lives or have become defunct and they are though they are present in space.

So in 1970, 80 the repeated ones in digital image processing parallel also developed and that also basically brought impetus in the remote sensing technology because the data started coming, lot of data started coming from various satellite and the same time good digital image processing tools specially software tools were developed so that people can utilise, analyse the data make good interpretation and excellent applications.

In 1980's the development of hyper spectral sensors, like a Landsat MSS there were only 4 bands, people started looking more thinner bands, means narrow bands, and also many bands and that basically brought the development of hyper spectral sensors. Earlier these sensors where initially they were flown on aircraft tested and then later on they were on put on the satellite, like one of the example of Aviris which was developed by NASA and they had many channels, not 4 channels 10 channels or 36 channel like now days but they had like 200 channels, 155 channels or 255 channel.

So for for a very micro metre thick thick bands made available, so there is another large development which has taken place in remote sensing. Now there are satellites also in a (spec) hyper spectral range as well. Then in 1990's this global remote sensing system started coming that means we had we developed better communications so we can cover any part of the earth anytime and that kind of thing.

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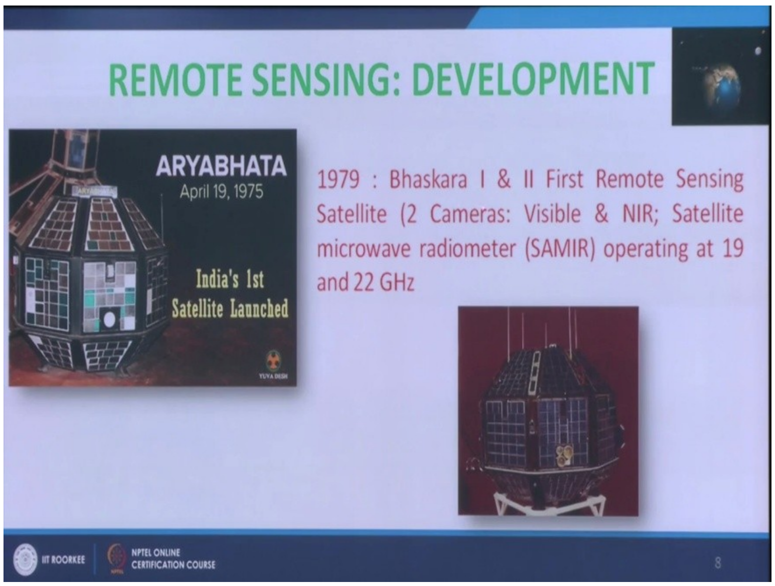

If we look the development of remote sensing in India so it started basically in 1975 when we had our first satellite launched that was named as Arya Bhatt and later on then we had the Bhaskara 1, Bhaskara 2 and they had some cameras visible near, near infrared camera and also some micro wave radio metres also at that time. Later on the the real as in case of word remote sensing the Landsat became the landmark development.

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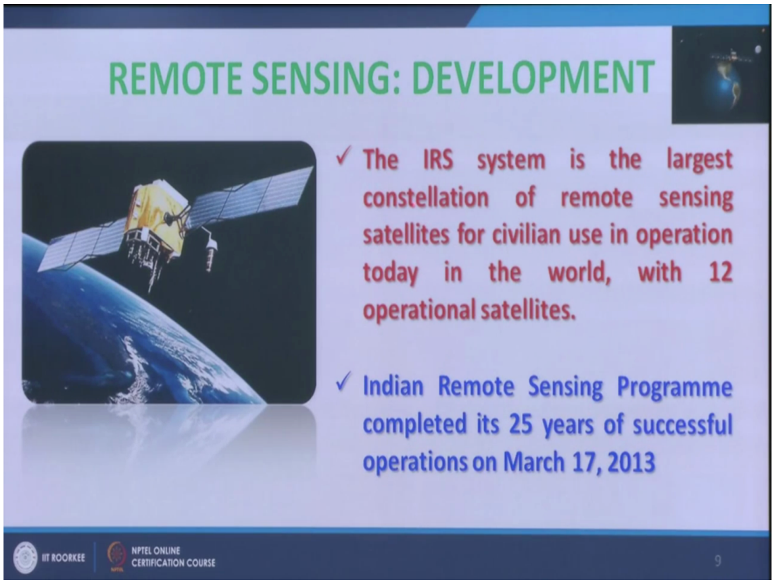

So in case of Indian remote sensing the IRS series became the landmark and basically it started in 1988 in March 1988 the IRS 1A a satellite which was launched we will see, go through a list of a Indian satellites and foreign satellites how the in the history we can put them and in a (chronical) chronological order that the IRS system is the largest constellation of remote sensing satellite for civilian use of operation today in the world with a 12 operational satellite.

So now we are left at series IRS 1A, 1B, 1C, 1D after that then we are having Cartosat source at very recently Cartosat 2 have also been launched and then this program of Indian remote sensing program continues and even we are launching the satellites only roughly 3 years back we have also completed 25 years of our successful remote sensing operations in a space.

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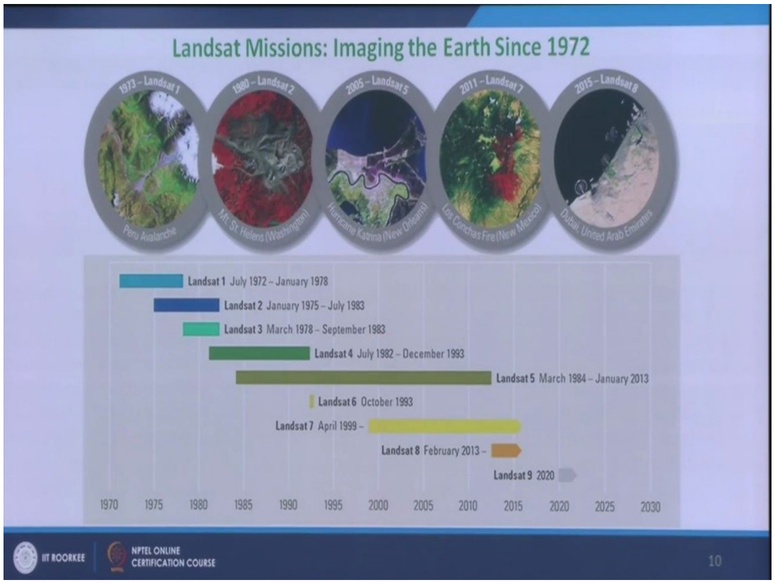

So they say this put the (pers) in perspective the landsat program as I mentioned earlier that is started in 1972 1st July 1972 and it lived a quite long life about about 5, more than 5 years though generally these uh type of satellites are designed for mainly 3 years but they if design part is good, launch is good then they may live even for 10 years. So this this was very successful mission than Landsat 2 came, Landsat 3 came, 4, 5 6 was very short lived satellite. Somehow there were some technological problems and then 7 and 8, 8 too has become very successful and this is for the future which we will see very soon.

The other important thing is which you, you should be able to notice is that there are overlapping all the time that it is not that which every the country who which are having long term remote sensing programs they always go for overlap and they say in Indian but like we are looking the Landsat case that see this roughly in the half time another satellite was launched, so for a few years we had a 2 satellites together in tandem, in space of Landsat series then, then when Landsat finished, then Landsat 2 and 3 were there in the space. There were some less overlap was there then a very longer overlap and similarly in case of our IRS series and other we also had this kind of overlap.

So what, what it provides, that there is a continuity of the coverage by our own satellite or by a particular series of satellites and secondly that the repeativity is a suppose a once the the, the repeativity or we call as a temporal resolution is revisit time. Suppose a satellite having revisit time of 16 days, now if you are having 2 satellites in tandem really for whatever the time period we are having and if they are designed or put in space in a manner that a after every 8 days you will have 1 scene of 1 scene of the same part of the earth. So this is the advantage of having overlapping satellites in tandem.

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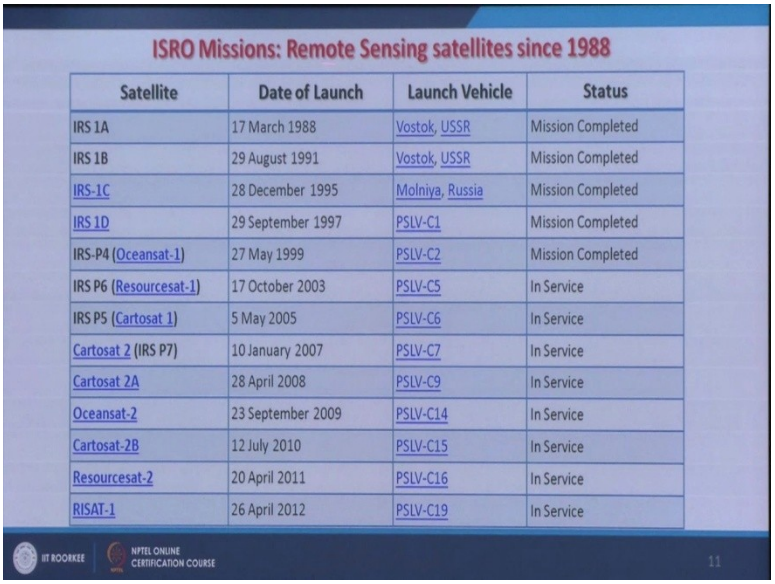

Satellite	Date of Launch	Launch Vehicle	Status
IRS 1A	17 March 1988	Vostok, USSR	Mission Completed
IRS 1B	29 August 1991	Vostok, USSR	Mission Completed
IRS-1C	28 December 1995	Molniya, Russia	Mission Completed
IRS 1D	29 September 1997	PSLV-C1	Mission Completed
IRS-P4 (Oceansat-1)	27 May 1999	PSLV-C2	Mission Completed
IRS P6 (Resourcesat-1)	17 October 2003	PSLV-C5	In Service
IRS P5 (Cartosat 1)	5 May 2005	PSLV-C6	In Service
Cartosat 2 (IRS P7)	10 January 2007	PSLV-C7	In Service
Cartosat 2A	28 April 2008	PSLV-C9	In Service
Oceansat-2	23 September 2009	PSLV-C14	In Service
Cartosat-2B	12 July 2010	PSLV-C15	In Service
Resourcesat-2	20 April 2011	PSLV-C16	In Service
RISAT-1	26 April 2012	PSLV-C19	In Service

Here is this our ISRO mission and we have we are only looking uh after this IRS that is March 1988 onward of, earlier we were using as you might be knowing that some foreign (sat) vehicles launching vehicles and but then the IRS 1D we started with our own PSLV series of our launching vehicles and since then we have been not only launching our own satellites but the foreign satellites of different countries even US, Russia and France and many other counties. Satellites are now being launched by the launching vehicles which is PSLV.

So IRS 1A and this series continued P, P4, P5, P6 then Cartosat, Cartosat 2 then Oceansat, Cartosat 2B and Resourcesat, RISAT, this is a different satellite, this is radar remote sensing satellite but that too have been launched in 2012, so many of them I are still in service, some have completed their missions and so on so forth. This is because each satellite has got some design life, many of them lived more than designed life, many because of some other reasons may not live even their design life but that is very rare thing.

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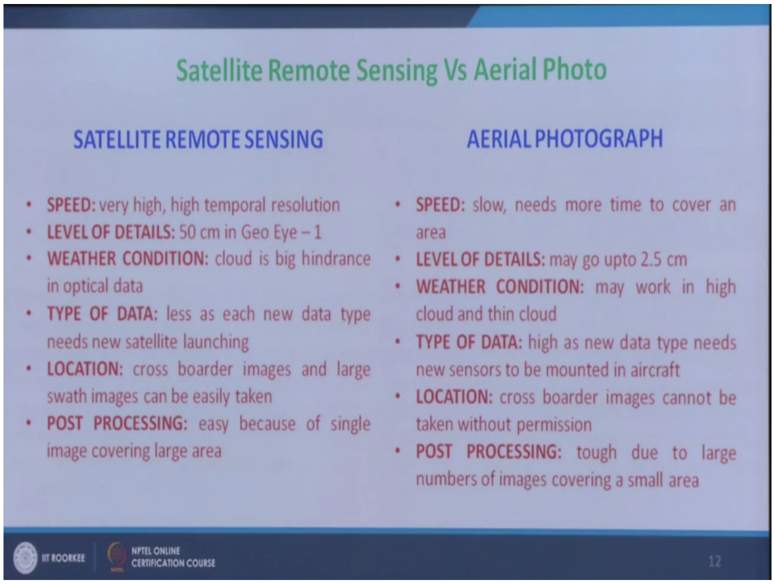

Now this this thing between the remote sensing which is available to us through sensors means imaging devices, scanners and the other side of the data is available through Ariel way, so we will see the difference point by point that what is the basically the difference between the normal remote sensing or Ariel photography which was a technology lasted for many years was quite useful. So what we see is that the current satellite remote sensing is having very high speed, high temporal resolutions like it depending on the special resolution if it is having relatively coarser (ap) special resolution it can provide the data of the same part of the earth, even 2 times or 4 times in a day.

For example NOAA AVHRR data in there are satellites which can provide data even after 35 days like radar remote sensing data, so depending on their orbits and the resolutions this thing is there but for in case of Ariel photography it is slow, it has to be you know put in it has to go in the air and then take the photographs of a small part of the area whereas satellite keep scanning different parts of the earth continuously day time and night time if they are having thermal sensors, so that is the biggest advantage.

Say regular thing and we can say Ariel photography is not regular, once the satellite is launched and if it is is, it becomes operational then regularly it is scanning the part of the earth, whereas it is not true in case of Ariel photograph and levels of details. Nowadays like GUI satellite we can have even 50 centimetre special resolution data which is may not be possible with this sometimes with Ariel photographs will low flying air photographs we can have 2.5 centimetre but this very very rare and very expensive as well.

Weather conditions, cloud is a big hindrance in optical data, especially with the satellite data, so this is a sort of negative in case of present day remote sensing but in case of Ariel photograph you can avoid, if you know there are clouds the area which you are going to cover you will not fly the aircraft so that can be avoided. Then type of data, the less as each new data type needs new satellite launching, so type of data is also available, wide variety of data is available from satellite whereas the type of data high as new data types needs sensors to be mounted in aircraft.

Location, now there is another advantage, the as I mentioned that the big impetus came remote sensing in World War 2, so that the territory, across the territory people will wanted to have the information and therefore the at that time Ariel photography started and oblique, looking obliquely in other side across the border. So location cross border images and large swath images can easily be taken by the satellites which are doing regularly and the location here cross border images cannot be taken without permission generally but in case of war or some emergency situations these things are being done.

Now post processing is required in case of satellite data which but because of huge development in digital image processing and a very advance some semiautomatic or automatic image processing tools are available which makes us to process large amount of data which is being acquired by the satellite and then post processing it is tough though due to large number of images covering a small area because the Ariel photograph these are having fixed size and they becomes in very large number, they are mosaicking, they are processing becomes very very difficult because they suffer from lot of distortion because of the movement of the these Ariel photographs. So this brings the basically the major differences between satellite remote sensing and Ariel photography.

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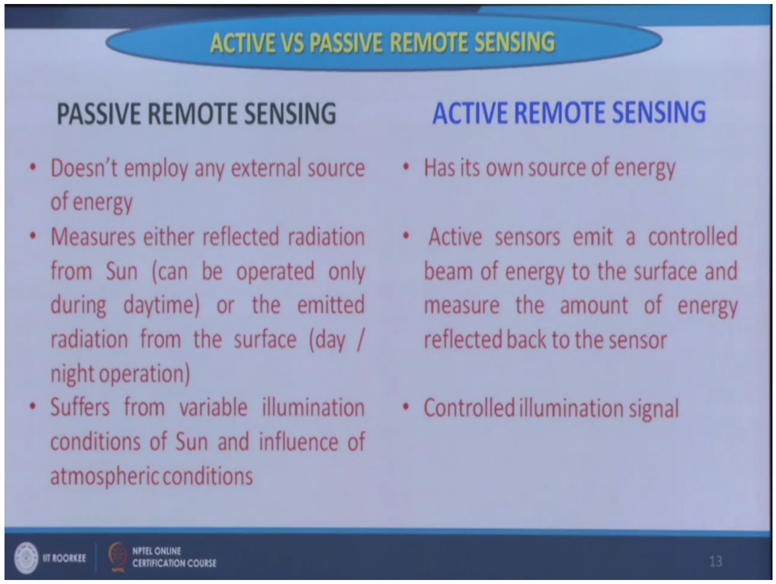

Now this current day remote sensing can be divided in 2 major parts basically, 1 is active remote sensing and another one is passive remote sensing. Passive remote sensing is very popular, active remote sensing is having limitations but now days it is becoming popular an especially with the development of this SAR Interferometry and many many countries are not having their own satellites or planning to have their satellites in active remote sensing but there are only few satellites in space in this domain.

Whereas the passive remote sensing is much easier and lot of satellites are there. Even in passive microwave regions they were some experiments were also done, so passive provides a lot of remote sensing data, so that is because passive does not employ any external source of energy and whereas in case of active remote sensing has it own source of energy. What does it mean? Basically it means that because for passive remote sensing either you are having solar radiation reflection reflective radiation which is available to the sensors, which can record the different objects of the earth especially in day time or a emitted energy can also be recorded, maybe in micro wave region as well.

So for that you don't require any external source of energy whereas here in case of active remote sensing the satellite of the sensor itself has to send some signals energy and then that is a attenuated, reflected back and then collected later, so that is why it is less common but it is becoming very powerful tool of remote sensing, that is active remote sensing especially SAT Interferometry which we will see little later.

Now the passive what passive remote sensing is doing as mentioned earlier the measures either reflected radiation from the sun can be operated only during day time or the emitted radiation from the surface day and night time, so if you are having thermal sensors you can record the data even in night time like in case of Landsat after Landsat 4 till Landsat 8 all these are having thermal sensors and therefore even in night time you can record the emitted energy through these thermal channels, same with the NOAA AVHRR data.

So no AVHRR sensor on board of this NOAA satellites are also having 2 channels in thermal, thermal band and therefore we can also record the data in night time as well. Though they are also having visible and near infrared and infrared channels as well, so that is the advantage of having this kind of passive remote sensing. Active sensors emit a control beam of energy to the surface of the earth and then whatever is reflected back it is recorded and this is how these images of microwave basically, microwave remote sensing images are formed.

Then passive remote sensing, so first from variable illumination conditions of the sun because you know that uhh the sun having the you know varied illuminations depending on the season because of clouds and so on. So that might create some problem in our passive remote sensing and may influence the atmospheric conditions as well that we have also discussed little earlier, we will see in much detail what are the atmospheric distortions and how these quickly can be corrected in some cases.

And here what we are having because the satellite or sensor itself is sending the energy and therefore it is controlled illumination signal, so that question of atmosphere and other things will not come because here the wavelength is larger and then that atmosphere present between sensor and the earth does not create much problem here. These operations in active remote sensing can be done day time or night time, there is hardly any difference because the, the source of energy from satellite itself, sensor itself.

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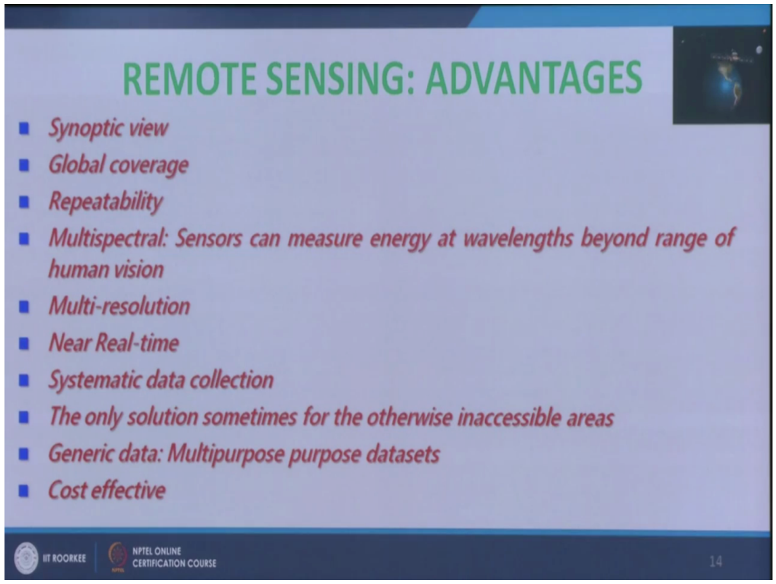

Then what are the advantages, this is this is the B point basically which brings the usage of remote sensing or why it has become very popular in the last 30 40 years. First of all it is, it provides the synoptic view, what does it mean, synoptic view means here that in a, in a when it is satellite is orbiting it may cover a very large part of the earth and another very important thing which that point might come later in the slides is that it records the unbiased, in a unbiased manner, so whatever the recording which is available there is no human interventions directly the sensors is recording, so it provides a unbiased recording and a synoptic view.

A large part is covered by these and another advantage it is a global coverage, most of the satellites, these satellites are covering entire globe though somebody might not be recording that the data or somebody may not be having the earth stations in different counties of all satellites but the satellite itself might be transmitting the data or directly broadcasting the data towards that and covering the different parts of the or all parts of the earth, so that is another very good advantage with remote sensing global covering.

Repeatability, it keeps covering same part of the earth depending on the resolution and the orbit so some satellite as I mentioned that like NOAA AVHRR sensor they can cover even 4 times in a day, 2 times in day time, 2 times in night time whereas some satellites may come after 12 days, 16 days, 18 day depending on the their resolution, swath, width and so other things.

Now multi, multi spectral sensors can another advantage with remote sensing that not only you are recording in panchromatic but you are also doing a multi spectral sensor so can that can also be that can be recorded wavelength beyond range of human reason, as mentioned in the the first lecture that our eyes are only sensitive in visible part of the earth whereas the sensors we can design which can sense the earth or scan the earth, not only in visible part but near infrared, infrared, thermal infrared even in passive microwave regions, so multi spectral sensors are available through remote sensing which is otherwise not possible.

Multi resolutions data even on 1 same satellite, we can have different sensors having different resolutions example came about spot, so it has panchromatic camera 10 metre resolution, it has 20 metre resolution multi spectral data, same example started coming with our own IRS satellites we had once a this (pan) panchromatic camera at 5.8 metre resolution and then we had the les 3 sensors like 23.5 metre resolution, so same satellite can have different sensors of different resolutions, so that is another advantage for the same day you are having different resolution data from the same satellite, so that the atmospheric conditions are constant throughout these sensors.

Near real time it is possible when because when the satellite is over passing generally these are also directly broadcasting or transmitting data towards that. If a uhh these data is not incorrupted one can even have their own satellite earth station like an IIT Rudkin department of earth science, since 2002 we are operating NOAA AVHRR earth station because NOAA is directly broadcasting so we don’t have to have a license or encrypting code or any other thing we can just record the data, whenever the satellite is over passing our earth station.

So in near real time the data is coming, there is another advantage especially in disaster related applications that provides the very big advantage. systematic data collection because these the orbits are fixed when the satellite will come we know in advance even 7 days 8 days before we know then when satellite will overpassing a particular part of the earth, so lot of things can be designed accordingly, lot of missions can be designed and therefore the data collection is very systematic through remote sensing and this is the only solution sometimes for otherwise inaccessible areas.

Especially like in high mountain terrains like Himalaya where highly rugged all parts cannot be reached very easily by the humans or by other means but remote sensing can reach so that is the very big advantage. Same thing also happens in case of any natural or manmade disasters that the first thing people start looking remote sensing because it can acquire the data, there might be some satellite at that time might be flying over of that part of the earth where a natural disaster has occurred and therefore you can get the data and analyse and can see how things developed or this has happened.

And I have a very important point which I mentioned about these 3 technologies that is remote sensing GIS and GPS that these are the generic technologies and therefore their applications are you know many, several and some still we don't know, people are developing, so the generic the remote sensing data is generic and therefore it has got multipurpose application, so it can be applied for various things from climate change to natural disaster to civil engineering to mineral exploration, to Isle exploration, whatever where ever one can think can now a days can apply.

Metrological applications are there and therefore weather forecasting it is now extensively being used this technologies in integrated manner. And of course it is cost effective because once the satellite is launched it may last may live for 5 years 6 years sometimes they live for even 10 years and keep providing data continuously and therefore the initial cost is much more and later on only the some operational cost recording of the data making archive and of course analysis interpretations those things are there but even then overall of you see it is highly cost effective technology compared to other conventional methods and specially ground surveys and other things.

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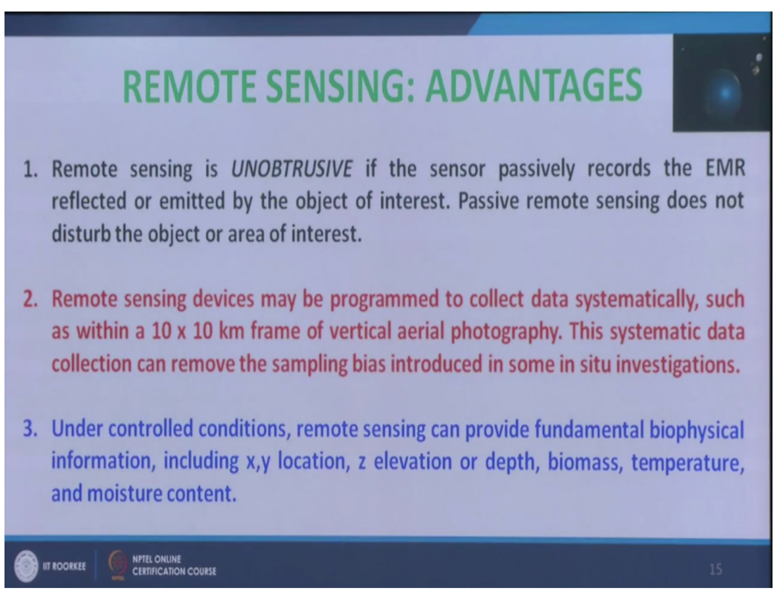

So this brings this in a large perspective we can see that the remote sensing is unobtrusive if the sensor passively record the EMR that is the Electro Magnetic Radiation Reflected or emitted by the object of interest, passive remote sensing does not disturb the object or area of interest. So whatever is being done it untouched by any sensor and the remote sensing devices may be programmed to collect data systematically such as within a 10 kilometre by 10 kilometre frame or vertically photography, this systematic data can collection can remove the sampling bias introduce in some of the because this term I have used the remote sensing provides completely unbiased recordings of the any any event which is happening on the earth, anything which is happening on the earth.

For example there might be forest fire, for example there might be earthquake and ground (defo) associated ground deformation and might be flooding so on and so forth, so this is completely unbiased recording is also available. Under control condition remote (cansing) remote sensing can provide fundamental biophysical information including location, elevation, daft biomass temperature, moisture content because if we integrate the GPS then we get the location.

If we integrate or put on GIS platform we can expect few more things that temperature is being driven from remote sensing through this thermal sensors and there are different algorithms by which we can estimate the temperature of the earth or even sea surface temperature or a temperature over a volcano, temperature over a forest fire or coal fire, coal mine fire those things can also be done and of course moisture content and other thing people have developed application not only in this infrared or other parts but also in microwave remote sensing. So this brings to the end of this second lecture on introduction to remote sensing. Thank you very much.