Geographic Information Systems
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Lecture – 29
GNSS and Applications

Hello namaste, welcome back to the course on geographic information systems. So as we were speaking about global positioning system. Now we have graduated into a stage where we have understood what do you mean by global positioning system? What are the different parts of a global positioning system?

Then we have looked at what are the other systems that are that can be used to find out to be more accurate in terms of whether we can use a DGPS system, we can use a wire system. We also looked at different signals that are there. Then how DGPS system can be used? What are different types of DGPS surveys that can be done? How a war system basically works architecture etc.?

Now when we look at the entire system of GPS, GPS was launched by U.S. and this actually managed by U.S. So similarly you have several other countries which have launched their own system for navigation and measurements. So various countries like Russia, China, India have launched and yes we are proud that India has launched our own systems though it is operational for a very small region.

But maybe in few years it will be operational for majority of the regions across the earths surface and once the integration has done from various systems it will be extremely useful in terms of navigations especially for Indian subcontinent and even closer to the east coast of Africa its east coast of Australia and also the east coast of Africa. I will explain to you in my further slides. But when we look at these systems having from different countries augmenting and using this system together has nothing but global navigation system.

So we would also learn about all of these systems today how it was introduced? What are different the satellite vehicles that are there? How many satellite vehicles are there? Where is a

control stations? For all of these systems other than GPS. So GPS we have understood but let us understand even all other aspects in terms of how this systems can be used and integrated for much better system?

For example, in your mobile when you actually buy your mobile you try to look at it specifications. So nowadays in your mobile they definitely mention you that whether you have an support for AGPS + GLONASS + BEIDOU or it has only AGPS or it has HPS and GLONASS. So you have some many more systems that have been used. Now very recently it has also been proposed that even a Indian system also can be used for the civilian purposes and navigation.

So probably in 2, 3 years down the lane we will see Indian system also put into applications. Now let us look at what we would look at in this particular class?

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I would like to speak on global navigation satellite systems what are different system? How these systems have evolved? What are the control facilities that are there? Where the facility is available? And how its integration done? Okay. So that is what we would cover in this particular class.

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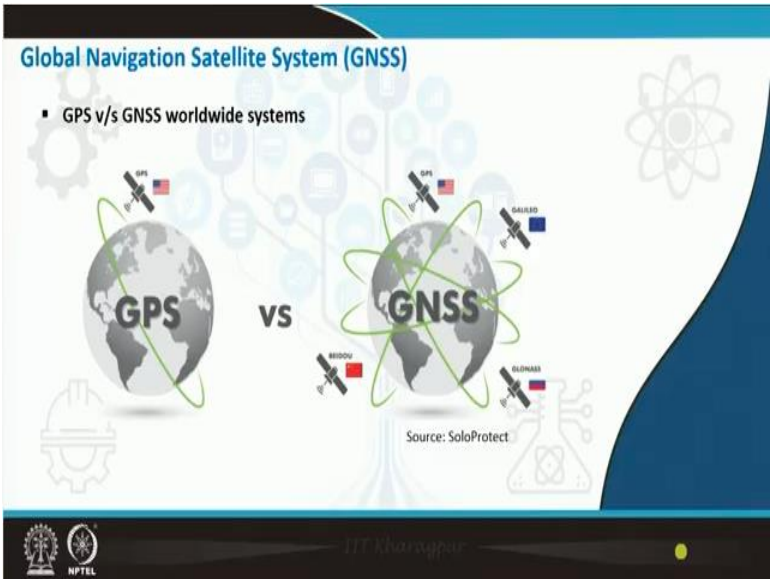

So when we look at the global navigation satellite system, we have until now we learnt about GPS GPSS from U.S. Department of Defence. Similarly, like GPS we have GALILEO, we have BEIDOU, we have GLONASS okay. So when you look at all of these okay it is a system that can be augmented okay. When it is augmented probably the navigation becomes extremely strong and extremely precise.

So that is what is meant by a global navigation satellite system. Now the researches on if you are looking at specific research that you can make these the research is now targeted in improving the user service or on ground user segments in terms of reception in terms of usage and applications of this GNS system. So if you are looking forward to work on such research area I would say this is one of the real research areas if you have some background in terms of electronics in terms of how you look at the signals and systems. So if you have that knowledge then this probably this is worth to look at as a research topic.

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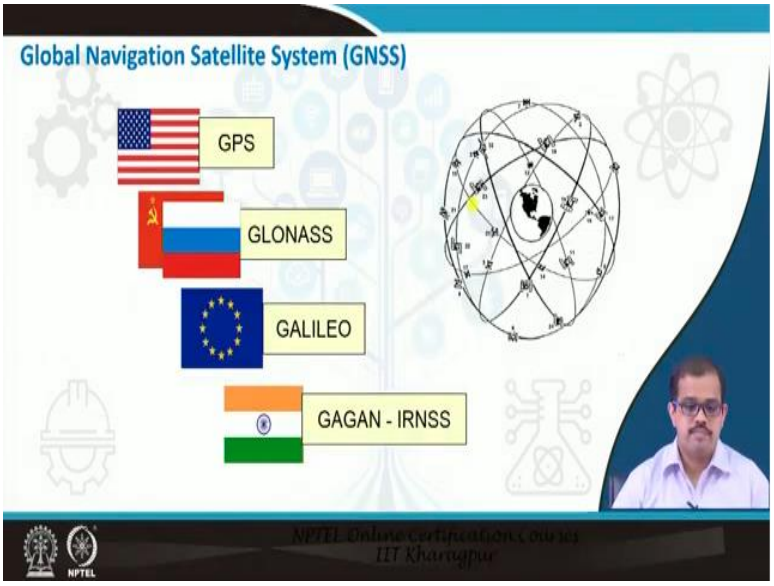

So when we look at global navigation satellite system we have GPS **because it is** already launched by the U.S. we have learnt about it then we have GLONASS. GLONASS is really be implemented in a bigger way. So GLONASS can be one of those systems which can be an alternative or can be the one which can augment with the GPS to provide better navigation especially with the in the South Asian or the Southeast Asian countries.

And GALILEO is other one by the Russia. Russia the Galileo is extremely good in terms of navigation in the Russian region. But also you can find support in many other regions where it is available. Then you have GAGAN by India. So GAGAN as the entire system IRNSS Indian regional navigation support system is under aspect where India has integrated itself in providing the navigation support.

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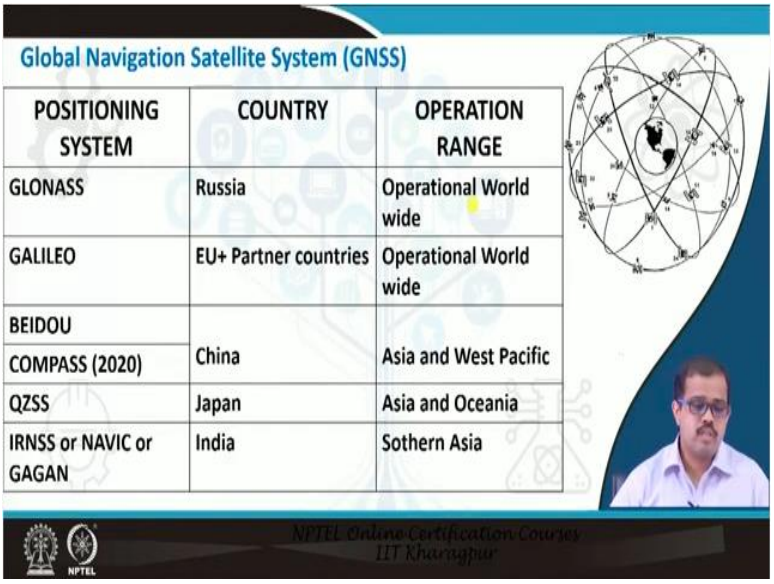

And when we look at the entire system here as I explained GLONASS is by Russia where normally the operation is worldwide. It can be found most of the places then you have GALILEO it has EU + partner countries operational basically by the worldwide. Then you have BEIDOU this is by China. It is also called as COMPASS. So it is targeted to be completely operational by 2020 specifically in Asia and West Pacific okay.

Then we have QZSS by Japan called QZSS okay. It is Japan and Asia and Oceaniac countries basically. So then you have IRNSS or NAVIC or called as GAGAN. It is basically called as NAVIC. The entire navigation system is called IRNSS. So it is by the countries India then you have this basically available in Southern Asia.

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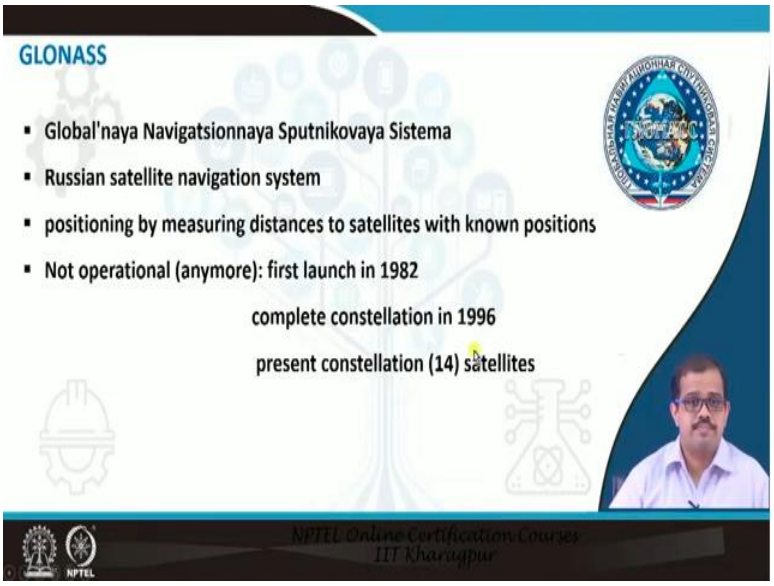

And when you look at GLONASS. GLONASS is Global naya Navigatsionnaya Sputnikovaya Sistema. So this particular thing as Russian satellite navigation system positioning by the measurement of distance to satellite with known positions. So this is how it has correcting the error. So normally it is nowadays it is not operational much. It was first launched in 1982 the completed a constellations 1996. The present constellation has only 14 satellites. So many of these may not provide the exact location on the ground. So GLONASS was extremely efficient in terms of locational measurement.

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So later they did a modernization plan that has they modernized the GLONASS-M with GLONASS-M and GLONASS-K the launch was 25th December 2005 with 3 satellites, 18

satellites were operational by 2007 intent to launch 21 satellite vehicles in 3 orbits 3 on-orbit squares spares. So which means that 3 18 operational vehicles will be there and 3 spares will be there 3 orbital planes separated at 120 degrees.

When you look at GPS at a 6 orbital plane separated at 60 degrees. Here it is 3 orbital planes separated at 120 degrees. Orbits most of these satellites are inclined at 65 degrees to the equator and orbital period is 11 hours 15 minutes. And when you look at this particular system this that is intended to be operational worldwide because of now 14 satellites you can find very less navigation capabilities that they have. But by 2000 maybe by 2020-25 this will have the entire constellation with the modernization that is happening.

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And when we look at the GLONASS control segment the control segment is basically located in Russia and not worldwide. If you see they have 4 basically 4 different control segments each of these control segments are acting as a backbone in correcting the GLONASS services and providing it to the user. And many of the mobile phones use GLONASS today Russian services are and with the 14 satellite there is a good number of services available to Indian subcontinent also.

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And when you look at GALILEO. GALILEO was officially launched in 26 March 2002. This is the EU and other countries. European Union + the partner countries. Then GALILEO system test bed was delivered in 2004 which means that it was the first set of satellites. Then implementation of GALILEO ground segment using the GPS satellites was done bit later and then when we started with integrating with the GPS satellite.

It had 10x better signals than the GPS systems alone. The first experimental satellite in 2005 was launched with GTSTB-V2. So this started with first test bed then the experimental satellite in 2005. Then the later it was later set was launched in 28 December 2005. That is for as an experimental satellite then the first of the 4 operational satellites. So once it was experimented then the operational satellites was launched between 2006 and 2007 okay.

Then we had it was operational between 2009 and 2010 officially. Officially it is said to be operational by 2008 but when we look at the data and the signal reception it was in 2009 and 10. Then we had ignores that is GPS and GLONASS integrity services on geostationary satellites. Ignores was operational in 2005 was supposed to be operational in 2005 but slightly it was delayed and started its operations in 2006. Nevertheless, then ignores integrated with GALILEOs started giving us the signals by 2008 and GEO services are available until April 2015.

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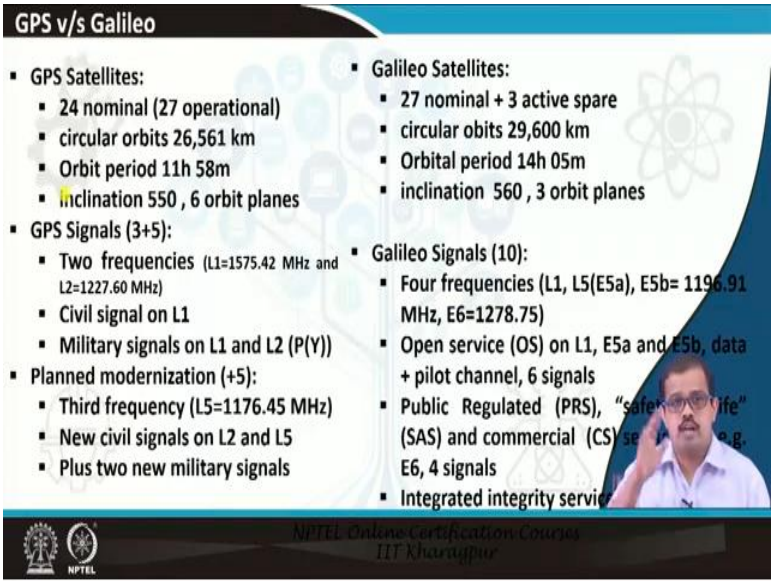

So this is how the GALILEO has evolved over a period of time. When we compare both of these systems the GPS systems and the GALILEO system, GPS system satellites were 24 nominal satellites though 27 is operational. We have 24 nominal satellites, circular orbits at 26,561 kilometers, orbital period is 11 hour 58 meters inclination is 550 with six orbital planes it is 55 degrees and 6 orbital planes.

Whereas GALILEO satellites are 27 nominal satellites and they have 3 active spares okay. So in case there is some issues so these active spares are used and you have circular orbits at 29,600 kilometers, orbital period is 14 hours and 5 meters, inclination at 56 degrees with 3 orbital planes. So that is the basic difference between GPS satellite. So 24 satellites and 27 satellites with 3 active spares. Circular orbits at 26,000+ kilometers and 29,000+ kilometers.

Inclination it is inclined. GPS is inclined at 55 degrees whereas GALILEO satellites are inclined at 56 degrees, 6 orbital planes and here it has 3 orbital planes specifically 3 orbital planes are stationed in such a way that 120 degrees is each orbital plane. So GPS signals normally 3 + 5 in a ratio that has 2 frequencies L1 and L2. Civilians, normally civilian services are through L1, military services are both with L1 and L2 with extreme precise positioning system.

Whereas when you look at GALILEO signals they have 4 frequency L1, L5 which has also an E5a, E5b then E6. So these are different frequencies if electronic guys you can understand these

frequencies by this is particularly used. It is basically an open service rather than selective services on as such in terms of GPS signals on L1, E5a, E5b + pilot channel and 6 signals that has together.

Public regulated so it has different services like public regulated certain amount of regulation of service signals whereas it has safety of life signals on SAS and commercial signals these are different prescient signals that they have services normally on E6 and these are 4 signals that are used. And integrated integrity services is another kind of service that GALILEO can provide okay. But GPS both of them have a planned modernization whereas GPS has third frequency that is L5 that is being introduced.

New civil signals will be on both L2 and L5 okay + 2 new military signals are being introduced maybe in some years down the lane probably you will see that GPS has more modernized and planned signals that can give you more precise information on the earths surface okay.

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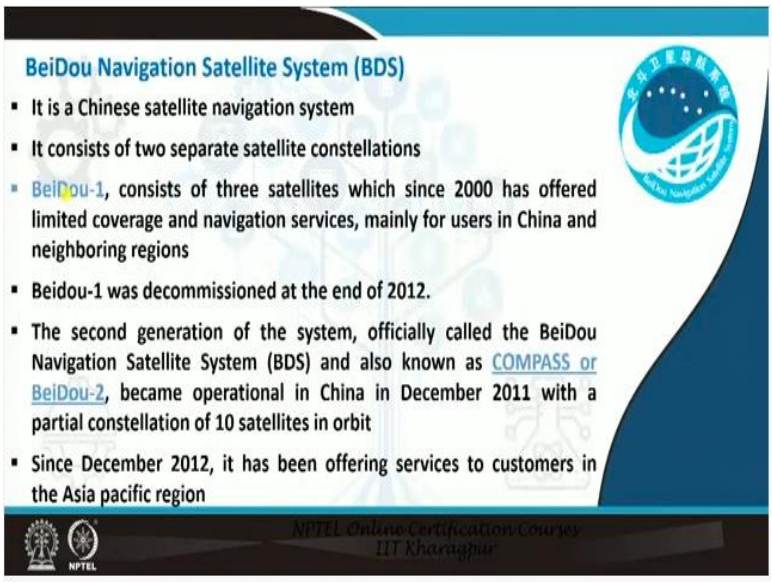

So that is about GPS and GALILEO. Now let us look at BeiDou, BeiDou is an navigation Chinese satellite navigation system okay. It consists of 2 separate satellite constellations BeiDou-1 and BeiDou-2. BeiDou-1 consists of 3 satellites basically okay only 3 satellites which since 2000 has offered limited coverage and navigation services mainly for users in China and neighboring regions basically Southeast Asian regions and to an extent of Pacific region.

Otherwise this is not existent in many of many of the other places. BeiDou-1 was decommissioned by the year end of 2012 okay. It means it stopped its operations by 2012. The second generation of systems it is officially called as BeiDou navigation system or BeiDou-2 are also very famously called as COMPASS systems okay. It became operational in 2011 okay with a partial constellation of 10 satellites.

They have 10 satellites and since December 2012 it has been offering services across the entire Asia Pacific region okay. But it is yet there is a lot of planned modernization in terms of BeiDou services probably by 2025 we have huge constellation of this BeiDou satellites and extreme services and exact services in Asia Pacific region.

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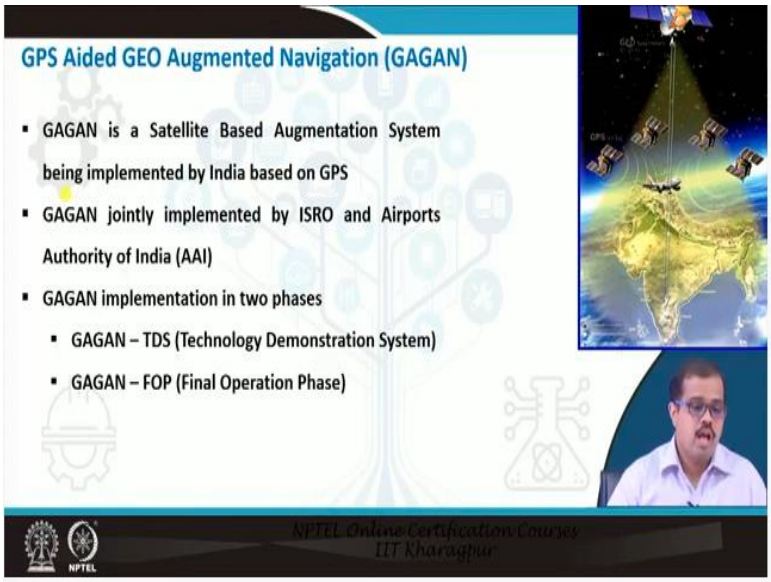

And compared to this there is another set offered by the Indian subcontinent which is called as GAGAN. So this is GPS aided GEO augmented navigation. So if you can understand it is GEO augmented navigation GPS aided GEO augmented navigation. So GAGAN is a satellite based augmented system being implemented by India based on the GPS system okay. So GAGAN jointly implemented by ISRO and Airport Authority of India.

It has basically covering the Indian subcontinent and till the west coast of till the east coast of Australia and other signals in the other part of the African Eastern coast. Then you have

GAGAN implementation is in 2 phase that has been planned. GAGAN TDS that is a technology demonstration system and GAGAN FOP that is the final operation and phase. As per the plan this has been successfully integrated into the system.

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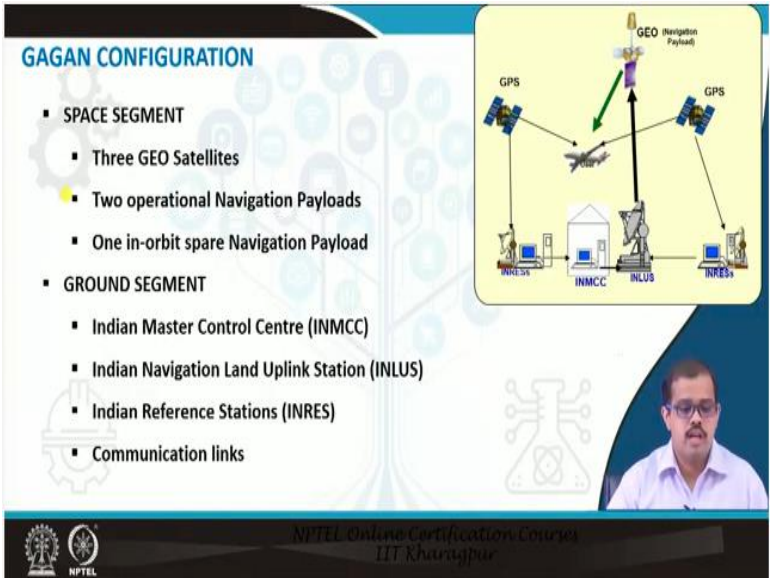

Now GAGAN also has different segments, first one is a space segment this has 3 GEO satellites, 2 operational navigational payloads okay, 1 in-orbit spared navigational payload. So 2 satellites are used for navigational payload. There is one more operational navigate which is used as a spare okay. Then there is a ground segment where you have Indian master control center then you have a Indian navigational land uplink station.

So this is what is important in terms of having a station where you have both master and both uplink station in the same region and then you have a Indian reference stations where which gives you exact reference point or the ground control points. Then you have communication links that are built in. This is this becomes an entire ground station. And when you look at the Indian system as I said you have the GEO which has the satellite system here.

So now once you have a satellite system based on these 2 GPS systems you have an input to INRESS okay or INRRES okay. This is then processed using because this is an reference station it starts processing the reference points. Then you have a master control unit which actually

controls the entire positioning service of this system. Then once the entire thing gets corrected then it is uploaded using the land uplink Indian navigation land uplink that is there here.

So once it is uploaded, it is uploaded into the satellite system which is then disseminated into the any of the user services that may be your aircraft, naval systems or in any of the user systems. Once it is and it can be used for variety of applications as required.

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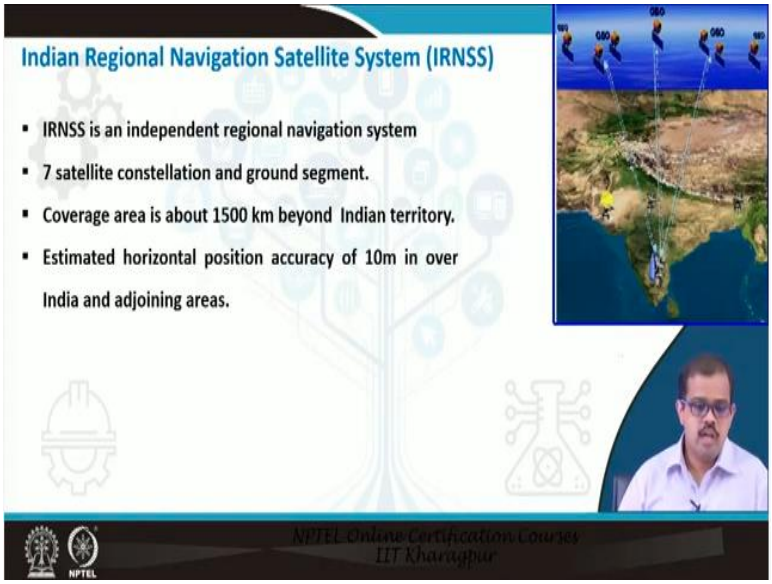

Then Indian regional navigation satellite system is completely an independent regional navigation system. So now I am very specific on this if you think about this it is a regional navigation system you have 7 satellites constellations and the ground segment. Covered area is about 1,500 kilometers beyond the Indian territory. Estimated horizontal position accuracy of about 10 meters can be achieved in over India and adjoining areas.

So 10 meters when you compare to GPS signal so we can acquire almost closer to 10 meter accuracy which is extremely good.

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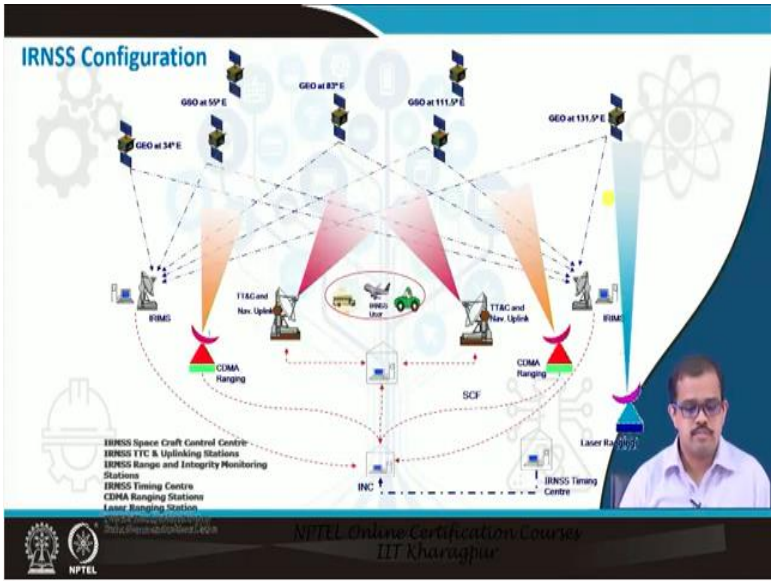

So when we look at the entire IRNSS satellite system if you see these are different GEOs at that are position as I spoke about it before and then you have IRIMS station here which has receiving station which we know exact location. Then you have a master control facility then you have the timing center which actually gives you an input about the timing and then you have the CDMA ranging which also which is playing a very important role in terms of corrections and network coverage.

So with this there is an upload link which uploads it to the satellites. Once it uploads to the satellite all those signals are corrected and the corrected signals are then beamed into the user segments for any applications. So this gives you the this slide gives you the entire configuration of how the IRNSS works and how it is being implemented over different regions across India and its neighboring countries.

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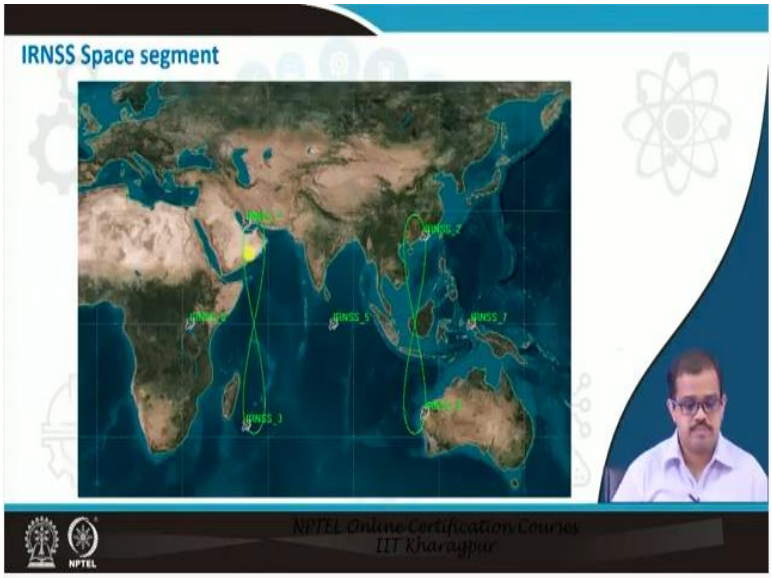

So when we look at the entire space segment IRNSS is available in this particular segment specifically. So these are the 2 segments where it is available I am sorry I spoke about Eastern it is not Eastern Australia it is Western Australia basically. So you have over this region you have the entire capability of acquiring the signals and this region you have another acquisition of the signals. So this is about the space segment and 2 space vehicles and 1 spare vehicles have been used in terms of acquiring the signals or sending out the signals.

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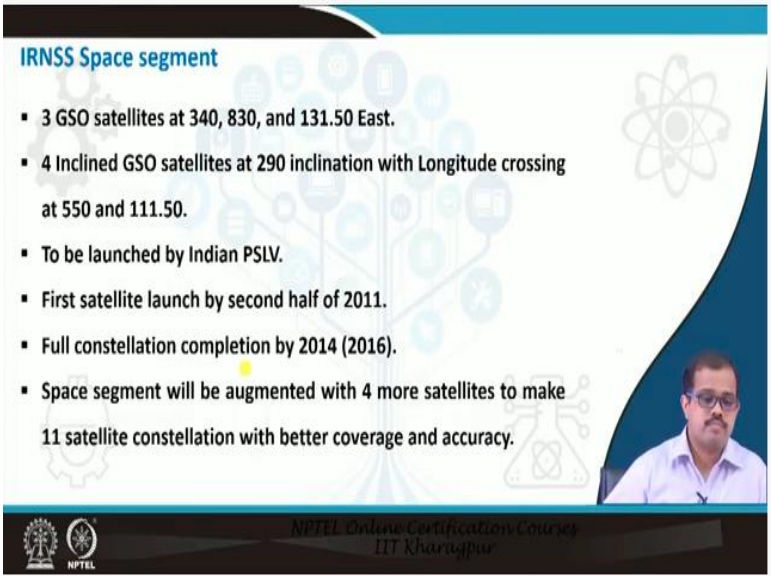

So 3 GSOS as I said the geostationary operational satellites at 334 degree and 83 degree and 31.50 East so these are where the satellite is actually positioned, 4 inclined GEO source at 29 degree inclination with a longitudinal crossing at 55 degrees and 111.5 degrees. So to be

launched by Indian PSLV some of this is already launched and to be exact. But first satellite launched by half of 2011.

Full constellation was supposed to be completed by 2016 and but it happened by 2018. Space segment will be augmented with 4 more satellites to make about 11 satellite constellation with better coverage and accuracy by the end of 2021 and 22 when the entire segment is complete. So 11 we will have 11 satellites for better accuracy.

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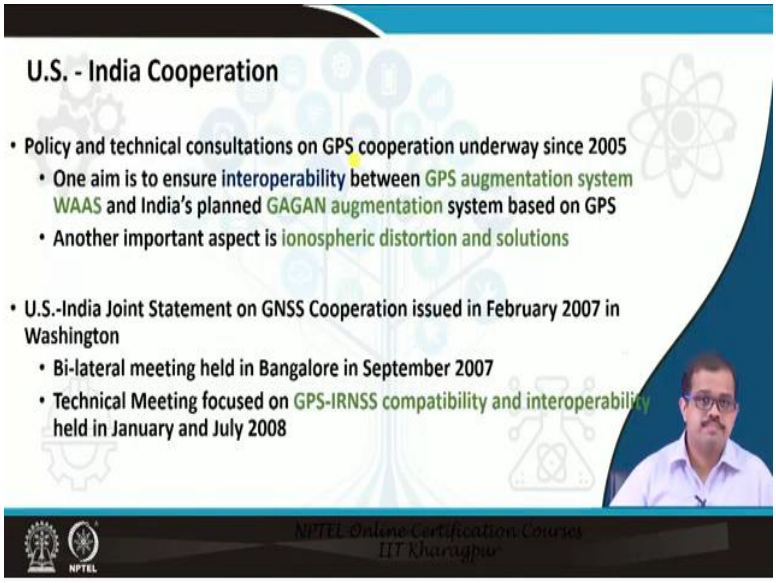

And when we look at it when I spoke about GNSS, GNSS about augmenting all the systems together in order to improve the navigation capability. In this terms has been a huge leap after introduction of IRNSS or GAGAN. This has come up with the U.S.-India cooperation on augmenting the GPS signals with the IRNSS signals. So we have started with the policy and technical consultation of GPS corporation that is underway since 2005.

It started with the first dialogue on policy and technical consultation. One aim was to ensure interoperability this was missing when we were trying to set up different systems. So they started with interoperability between the GPS augmentation system was and Indias planned GAGAN augmentation system based on GPS. So now all the 3 systems which is already there. GPS was and Indian system which has GAGAN augmentation all these 3 are there.

And this is going to be augmented and they have a same platform where interoperability of all of these signals when I say interoperability it is how I mean 1 signal can be used by other systems and also to improve its capability. So that is what is called as interoperability. So when you have data it is different format. When you have signals it is usage by different systems okay. Another important aspect is ionosphere distortion which are supposed to be removed.

And based if we have regionals satellite systems that are communicating across each other and their augmenting their systems then probably the ionosphere distortion would reduce in a much larger way. Then we had an U.S.-India joint statement on GNSS corporation in February 2007 which was held in Washington. It was a bilateral meeting that was held then the bilateral meeting was held in 2007 in September 2007.

This technical meeting focused on how do we actually look at compatibility of GPS and IRNSS system and interoperability. This was held in January and July 2008 also so which really proved in a way helpful in developing the entire system.

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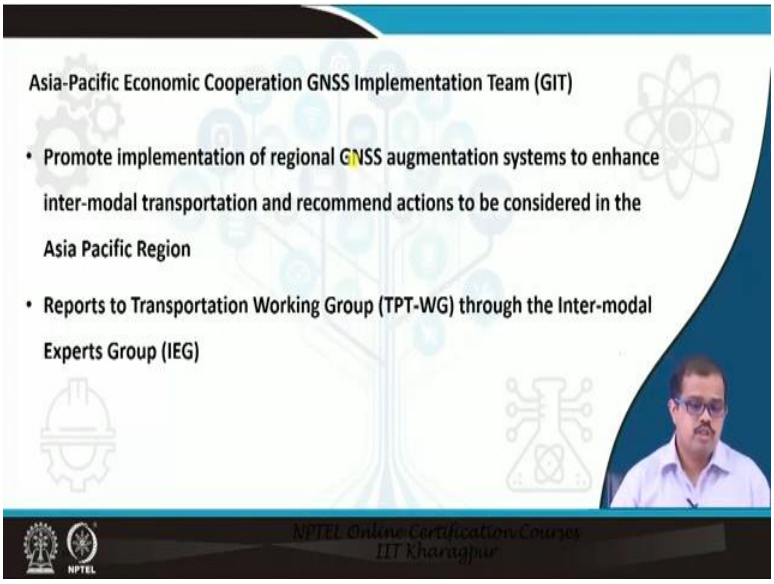

So then after that we have been in operating with Asia-Pacific economic cooperation GNS implementation team which is actually looking at augmentation of these different systems. So what why this is specifically necessary is that it promotes the implementation of regional GNSS

augmentation system to enhance inter-modal transportation and recommended actions to be considered in the Asia Pacific region.

It also reports to transportation working group okay which is also called as TPT-WG through the inter-modal expert group which actually is developing the entire system. The system are what are the different standards? How it should communicate? What is the interoperability standards? All of this list is looked at by the intermodal expert group.

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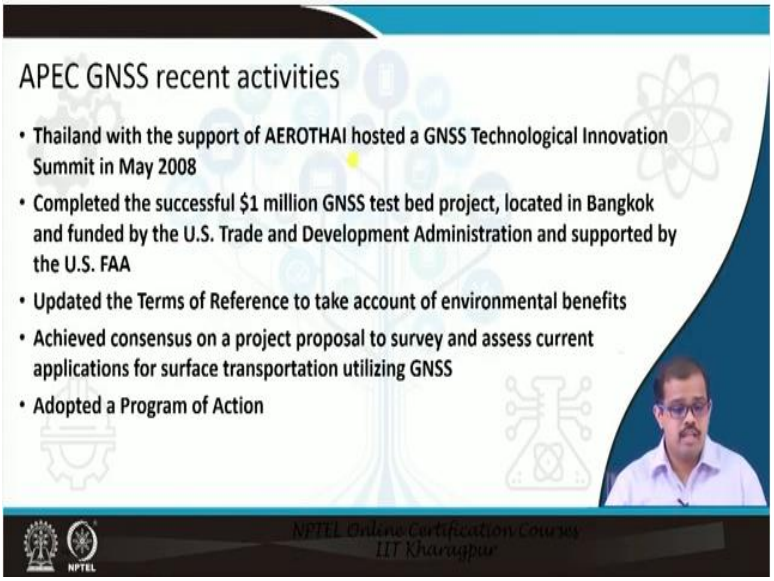

So this intermodal expert group has been meeting over years. So for example when we look at the recent activities Thailand hosted and GNSS technological innovation summit in May 2008. This marked as one of the years where the technological summit focused extensively on developing the interoperability standards.

Then it completed the successful dollar 1 million GNSS test bed project located in Bangkok and was funded by U.S. trade and development administration and supported by the U.S. FAA. So they started looking at how can we look at the GNSS test bed this was complete now and then the updated terms of reference has also been come out. This also takes in the account the environmental benefits that this particular system may have okay.

Then there is because there are lot of stakeholders you need to have a consensus between the project proposal to survey and access current applications for surface transportation utilizing all of these systems augmented as a GNSS term probably by 2025 or 2030 most of you when you buy your mobile phones when you buy your navigation systems you will rather than seeing it as GPS, BEIDOU etc.

You would see it has GNSS enabled systems which means it is augmented system that are there. So they adopted a program of actions that has to be done in next 10-15 years. So that this entire system is in place.

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So with this as I said they are supposed to report to ICG, ICG is International Committee on global navigation system satellite systems. ICG was emerged from the third UN conference on exploration and peaceful uses of outer space. So this was in 1999 they promote the use of GNSS and integration into infrastructure particularly in developing countries that is very important particularly in developing countries encourage compatibility interoperability among global and regional systems.

So it is not only those systems which are in place but also it should be used by all other countries where these systems are inaccessible. So when you look at the entire member of this ICG you have GNSS providers like U.S. U.S. has its own GPS system the EU which has GLONASS then

Russia has its own system the GALELIO and GLONASS. Then you have China, China has its BEIDOU or COMPASS.

Then India has its own system and you have Japan. So all of these together are the members of this particular committee then other members States of the United Nations or also its members okay. International organization associations which are actually working on GNSS integration and infrastructure building are also the members of this particular committee.

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So the first the second ICG-2 was held in September 2007 in India. So it established a providers forum. This was the first of its kind where it was addressing even the common issues of providers and application users. So they started looking at the implementation of this work plan which established working they established 4 different working groups. These working groups were responsible for different aspects of implementation of GNSS.

The first working group looked at interoperability and compatibility issues what may be there? How these signals are being sent? How if you have 2 signals augmented what kind of interrogatory issues can have compatibility issues can be there? Then it looked at enhancement of performance of GNS services. How it can be enhanced and how it can be performed using all the systems together?

Information destination especially in terms of education and outreach and coordination that is what I said. Research has been extremely main focus in terms of GNSS. If someone wants to perceive research in GNSS looking at GNSS signals and systems this is excellent opportunity for all of you today. Then interactions with monitoring and reference station network organizations are also being done.

So these are 4 different groups that are working, 13th meeting was organized by China in 2018 and in the previous annual meeting was held in Bangalore by 8 to 13 December 2019 that is organized by ISRO on behalf of Government of India. So this is how it has been growing the GNSS activities has been growing.

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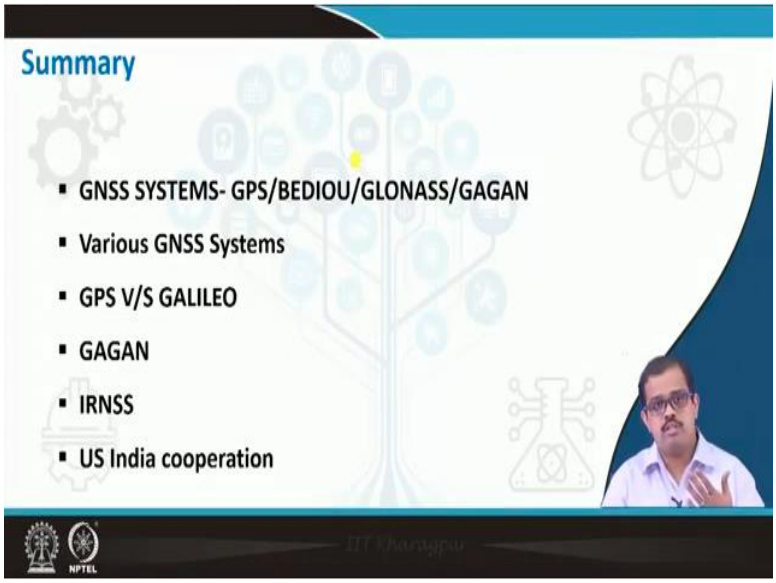

Probably maybe in 2025 or 2030 we will see extreme growth of this and also the applications of every nook and corner can be expected with development of the entire GNSS system. So we as a summary to this class we looked at the entire GNSS system which included GPS, BEIDOU, or COMPASS. Then we looked at GLONASS, we looked at GALILEO, we looked at GAGAN okay or IRNSS.

And we also looked at what are how its control segments and how is its space segments located. We looked at different systems aspects in a positive and negative way. We also looked at the GPS versus GALILEO. How GPS is placed? How the GALILEO is placed? Its orbital period it

is how it is inclined? And how many satellite vehicles are there? We also compared both of these things and if there is some improvisation program that is planned also we looked at it.

Then we looked at how GAGAN the Indian owned program is being planned and how it is already being operated. Then we looked at how U.S. India corporation then all the stakeholder's corporation that is trying to develop the entire GNSS system which should be interoperable and compatible in almost every receivers that is being used. So probably this will be in place in few years down the lane.

And also we have set up lot of committees and UN monitored committee that is actually looking at implementation of this entire system and maybe in some years down the lane this may be an real aspect in usage for the public and also to any of the civilian aspects. So with this I would end this particular class I would the next so I have finished the entire GPS theory. This is to introduce you to the GPS system and the GNSS system.

This is just a basics of it. If someone is interested, please go back and the entire the GPS course is also online in NPTEL otherwise you can look at the GPS system as subject itself. It is a subject of about 40 hours course. So please look at in case you are very interested look at its basics its mathematics very interesting aspects in to learn. And if the next thing that we would now start looking at this the application part of GIS.

So in the next session probably I will introduce you to one of my research scholar also the (()) (35:02) of this course Mr. Prakash PS who would take on with the quantum GIS. So he would introduce you to a software called quantum GIS. I had asked you guys to download the software and look at it but he would give you a brief overview of how this software started? What are the where do you download this particular software?

And what are the different options that are there in that particular software for you to or the tools that are there and the science behind those tools if possible. So he would speak about all of these in next 25-30 minutes in the next class that is following. So till then have a nice time thank you very much.