Global Navigation Satellite Systems and Applications
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Lecture – 08
Indian Regional Navigation Satellite System (IRNSS)

Hello, everyone and welcome to this 8th lecture which is of this Global Navigation Satellite Systems and Applications. And so far, we have discussed three main navigation systems, one is GPS, GLONASS and in the previous lecture, we have also discussed the Chinese one which is BeiDou.

Now very importantly, we will be discussing now our own Indian system which is Indian Regional Navigation Satellite System; this is what it is used to be called. Later on, it has been renamed as NAVIC and this system is again completely different than what Chinese have planned or it is different than GPS and GLONASS. So, all those details we will be seeing in this lecture.

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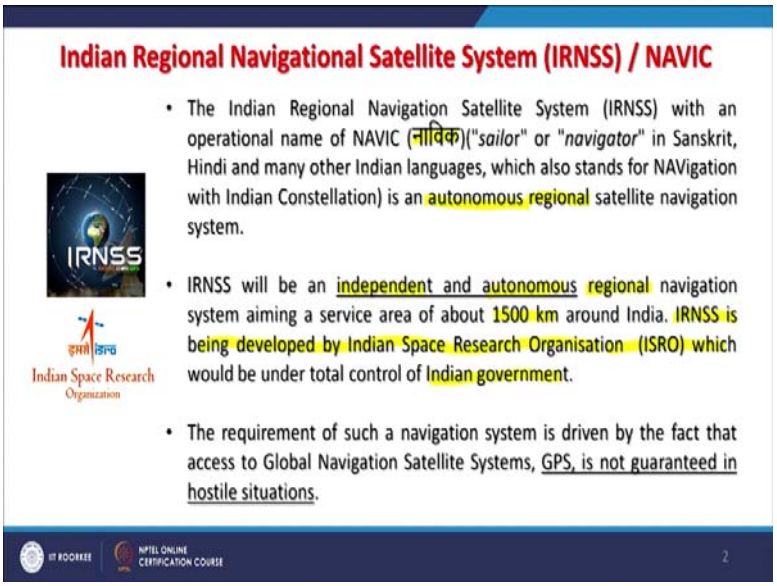

As you know that NAVIC means sailor or navigator in Sanskrit or in Hindi, also in some different languages is there. When I discuss the BeiDou, I also kept the name of by BeiDou in Mandarin. So, in the same way I am also giving NAVIC name in Hindi also and basically this NAVIC has been framed using this NAVigation with Indian Constellation that makes a NAVIC and which is again is an autonomous institute of

India; it is a regional and of course is completely satellite based system. So, it is a completely independent from all three systems which we have discussed GPS, GLONASS and BeiDou.

And, IRNSS will be is already mentioned independent and autonomous of course, regional navigation system aiming to have the service area around 1500 kilometer because it is a regional system so, we are focusing only in India and surrounding regions. IRNSS is or NAVIC is being developed by Indian Space Research Organization (ISRO) and would be completely under control of Indian government.

Now, what we see that basically when we are having three systems in place GPS, GLONASS and BeiDou and their signals are also available in India through our receivers, then why India is planning or having its own system?

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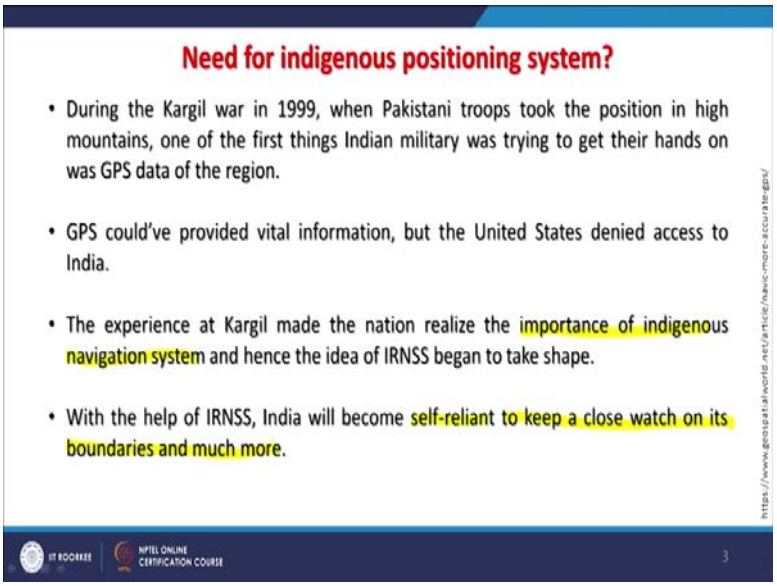

See this genesis of NAVIC or IRNSS started basically because of the Kargil war which happened in the year1999 and that time only one single system was existing which is GPS and US did not allow our army to have accurate signals or highly accurate signals and they introduced during that time the selective availability as well over the Indian part and that created problem for our army.

So, after this war, it was decided by India government to have our own system though it may be regional so that we can plan things, we can control things by our own be rather

than depending on GPS or GLONASS or BeiDou. So, that was the main purpose, Kargil war in that way was water shed and that compelled the Indian agency that is ISRO to develop the system.

And, as you know that GPS could have provided vital information during Kargil war, but the access was denied to India and that created hell of problems to Indian Air Force and other sections of army because of the poor signals quality which we were getting during those days.

So, this has made a basically the importance of indigenous navigation system which finally India has got now which we will see in few seconds the detail. It is of course, to become self-reliant and to keep a close watch on the boundaries and in the neighborhood as well.

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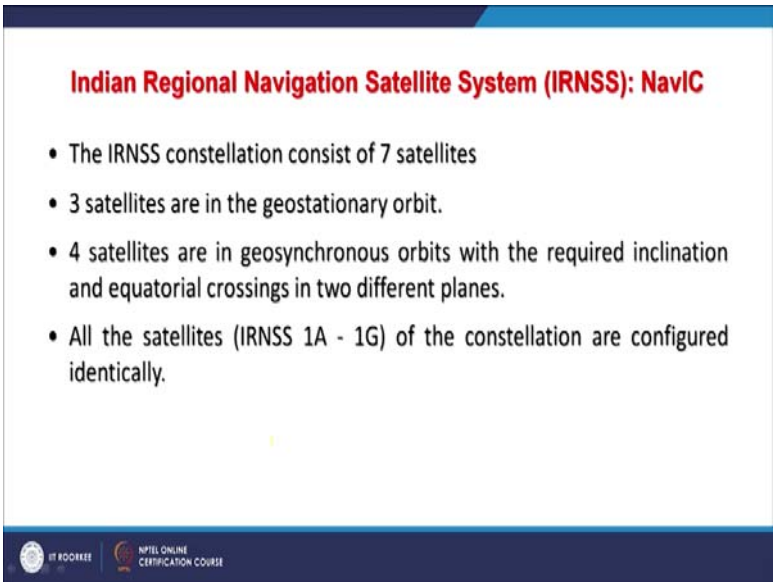

So, this NAVIC will have a 7 satellite constellation. It is not global. So, that is why limited number of satellite would be sufficient; 3 satellites in geostationary orbit. Geostationary orbit we have already discussed; the movement of satellite has been synchronized with the movement of the earth. So, as earth moves the satellite moves. So, in relative motion they are, you know stationary to each other and.

And, the remaining 4 satellites would be in the geosynchronous orbit which we also we have discussed in the previous lecture; what is geosynchronous and in which, the satellite

overpasses exactly and everyday same time and same location. So, with the required inclination and equatorial crossing in two different planes so, in two different planes, these geosynchronous satellites are there.

And, all the satellites starting from IRNSS 1A to 1G of the constellation are configured identically and especially the clock part that is most important thing.

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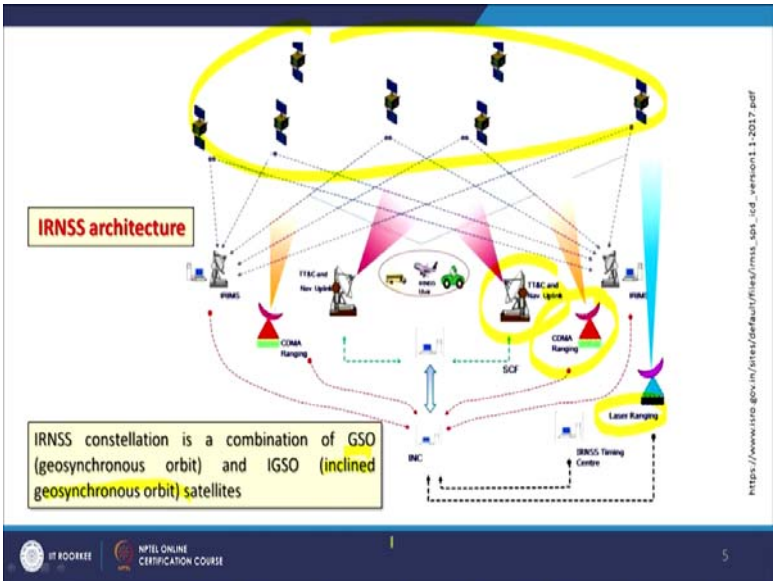

So, they are all having a synchronized clocks and now system is in place, only we are waiting for you know, encryptions or other things so that or de-encryption so that in our maybe mobiles or receivers very soon, we will be having signals from our NAVIC system as well. But, as I understand that Indian army is already having a accurate positioning through NAVIC as well. So it has already been open for army, but for civilian, I hope that it will be open very soon.

So, IRNSS constellation is a combination of GSO that is Geo Synchronous Orbit and IGSO that is Inclined Geo Synchronous Orbit of satellites are there and these seven satellites as we have mentioned are all here. And, the control segments and monitoring stations are also will have in these different components of IRNSS which we will have.

So, there is also some additional things are there like laser ranging and COMA ranging which is also in case of a BeiDou. And, then you are having Up-Linking from this

location and then you are having a Master Control Station and other things are there which makes this complete architecture of IRNSS.

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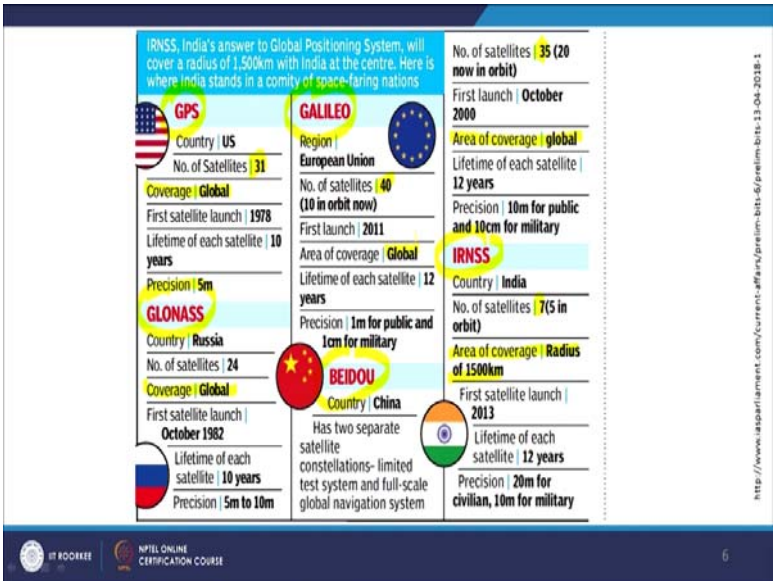

It is in comparison how where IRNSS stands and the major difference as already I have mentioned that three systems which we have discussed so far GPS, GALILEO and BeiDou which are, you know global system whereas IRNSS is regional system. Of course, when we compare these characteristics of these systems then number of satellites are reduced or less in case of IRNSS like a GALILEO; number of satellites 40, number of satellite in case of GPS minimum constellation is 24, but 31 are there; few are spheres. And, in case of Chinese; the total number of satellite would be 35 and there are 20 already in the orbit.

And, as you can see in case of India or IRNSS NAVIC system; 7 satellites, 5 are already in place and very soon, we will be having other satellites to complete the constellation over India. The coverage area as you can see it is 1500 kilometer radius whereas, in three other systems, coverage is global; in case of GPS it is also global and in case of BeiDou it is also a global one, GLONASS is also there. Now, GALILEO is though it is mentioned here the global, but currently it is regional, maybe in future it might become global but the main purpose this is what they have initially plant for regional system.

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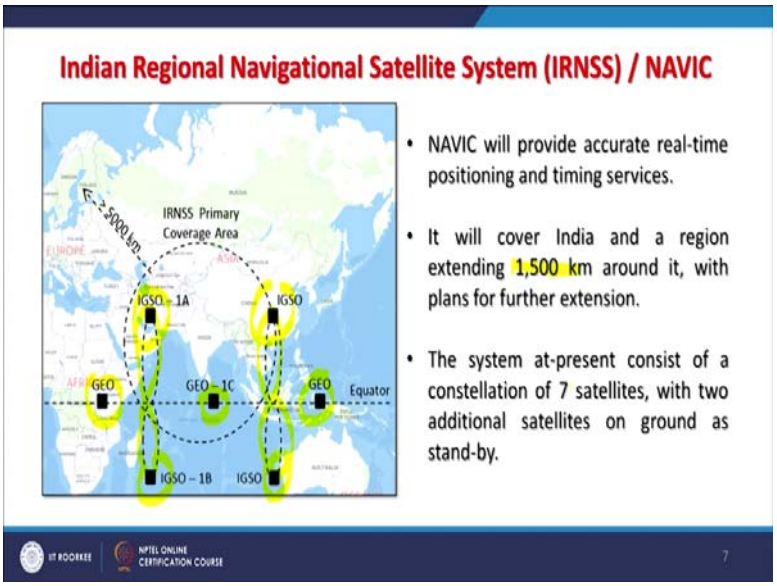

Now, our regional system, as the stations which you have seen in this slide different locations are there for monitoring Master Control Station and other thing. So, this IGSO is here in this part and these satellites at different locations are there. Some are with reference to the earth movement; they are stationery so all the time the signals would be available.

So, this Geo Synchronous Earth Orbit and Geostationary Earth Orbit satellites are located at different locations at 1, 2, 3, 4, 5, 6 and 7. So, the constellation here is completed. These GEO-1C and this one; they are all at the equator and this IGSO Inclined Geo Synchronous Orbits, they are at different and the orbit is something like this which you are seeing here.

So, with this arrangement of satellites India and surrounding countries will have the coverage or signals which will be receiving. So, we will provide the accurate real time positioning and timing services. This is what is expected. Very soon, civilian people will also have the data from IRNSS. As already mentioned it is going to cover 1500 kilometer radius area and currently the system constellation 7 satellites, two additional satellites on ground for standby are there.

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This is about a global perspective from GNSS point of view that which countries are having which operating systems as you can see that GPS belongs to the US, then GLONASS is Russian also shown here and then GALILEO is of course, European which you can see here and then BeiDou is a Chinese one and then IRNSS is for India and QZSS which we will be discussing in next lecture is about or maybe after that is, of Japan which is purely again a regional system.

But, as you can see that many systems are global. So, many-2 countries may not be developing their own system, but for security purposes or for army purposes, some countries might come up in future for their own systems.

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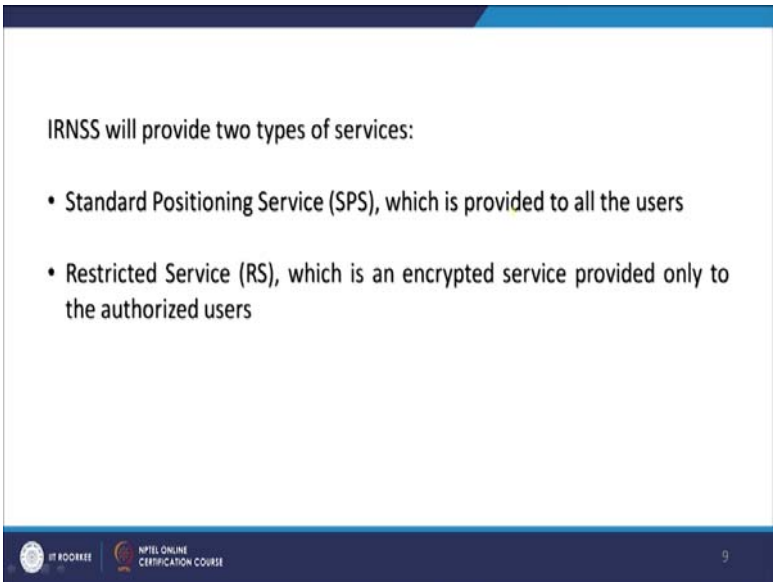

IRNSS will provide service again like other navigation systems. So, IRNSS will provide two types of services, SPS that is Standard Positioning Service which is provided to all the users including military and civilians. And, restricted service which has already started and which is in encrypted service provided only to authorize users that is mainly for Indian army people.

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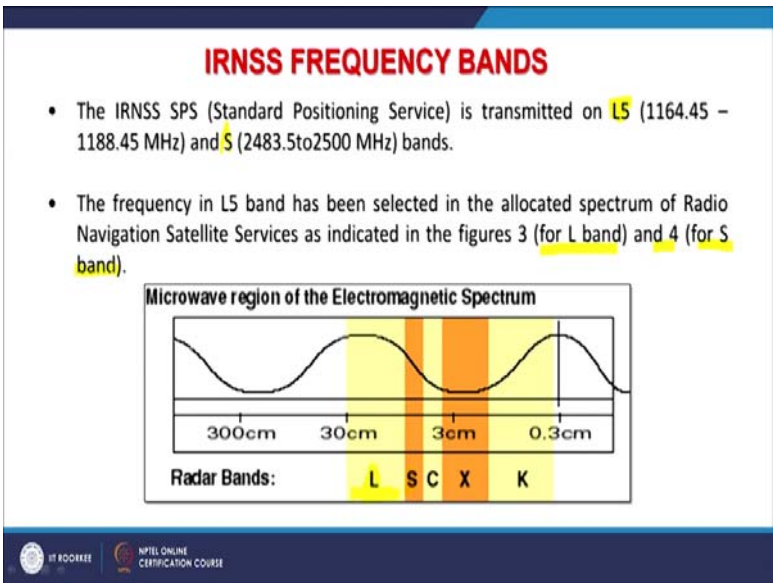

IRNSS frequencies if we see again, it comes in this part of EM spectrum where the L band is shown here and in this part, IRNSS will transmit the data in L5 that is 1164.5

Mega Hertz and 1188.45 Mega Hertz and also in the S band instead of not only focusing L band because now it is already occupied by other system. So, one more band is being used here that is the S band 2483 to 2500 Mega Hertz bands. So, these two bands L5 and S bands are going to be used by IRNSS for Standard Positioning Services.

And, this L5 band has been selected in the allocated spectrum Radio Navigation Satellite Services as indicated in this figure, for L band and for S band also, so that you can see it here.

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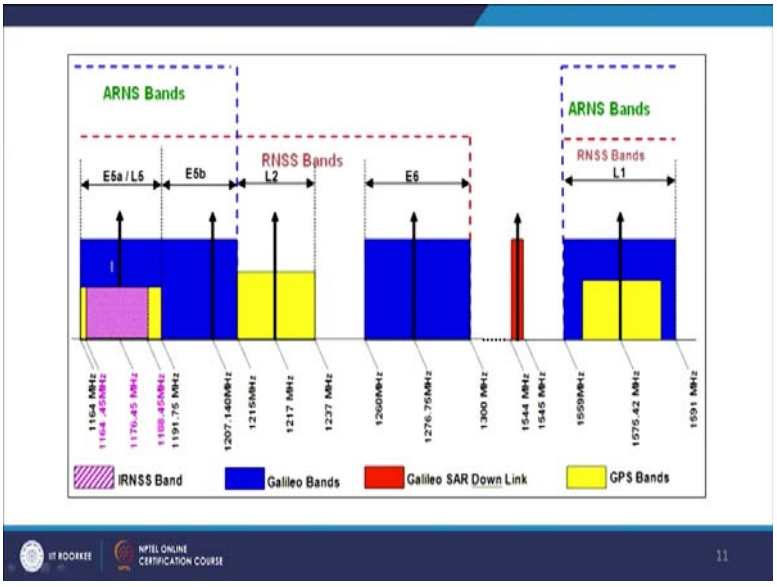

Now, if we compare with other systems then this is the location for IRNSS L5 band as see in the pink color and this is the range which is going to have IRNSS band are here, and then GALILEO band in blue color, GALILEO SAR Down Link in red color and GPS bands are in yellow color. So, also L1 might be used by India also but currently it has been planned mainly to use L5 and S band of microwave region of electromagnetic spectrum.

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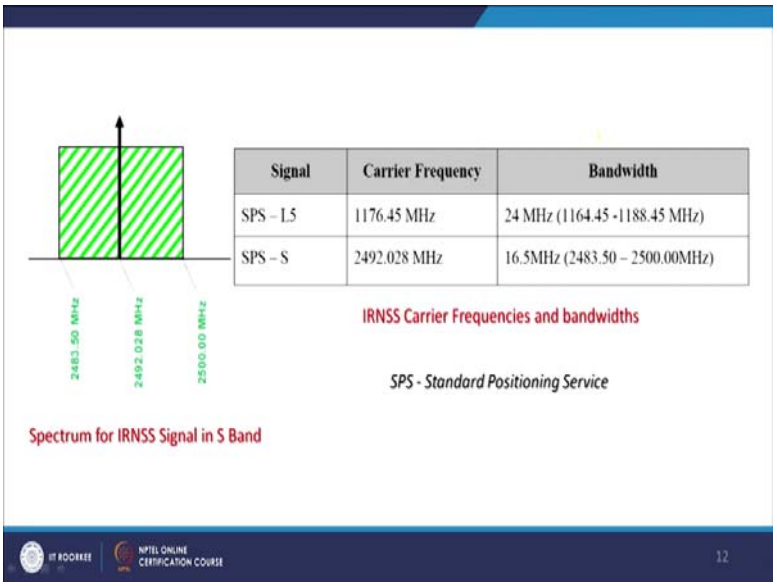

Now, these Standard Positioning Services will be using two bands as already we have discuss, of these carrier frequencies and bandwidth is going to be 24 Mega Hertz, L5 is quite broad in that sense and then here 16.5 Mega Hertz band for the S band. And this for Standard Positioning Service; this is what we are going to have and these spectrum of S band is also shown here; the ranges are here. In between, the frequency has also been allotted. So, this is that frequency which is going to be transmitted signals from the IRNSS.

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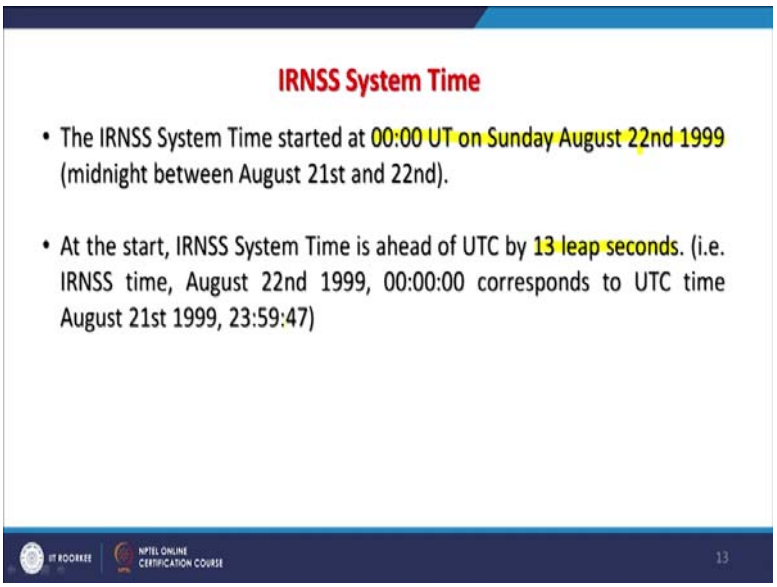

IRNSS system difference time is there. So, 00 Sunday August 22nd 1999. Each system navigation or GNSS systems are having their own sort of start or reference time and that is midnight between August 21st and 22nd, we started 00 hours that our system clock.

And, for calibration purpose in IRNSS system, time is ahead of UTC by 13 leap seconds. So, like in case of BeiDou it was 100 nanoseconds, but here we are having 13 leap seconds that IRNSS time August 22nd when we started 1999 corresponding to UTC time of 21st because UTC is behind in that sense 21st, 23:59:47 hours. So, this is the difference between UTC.

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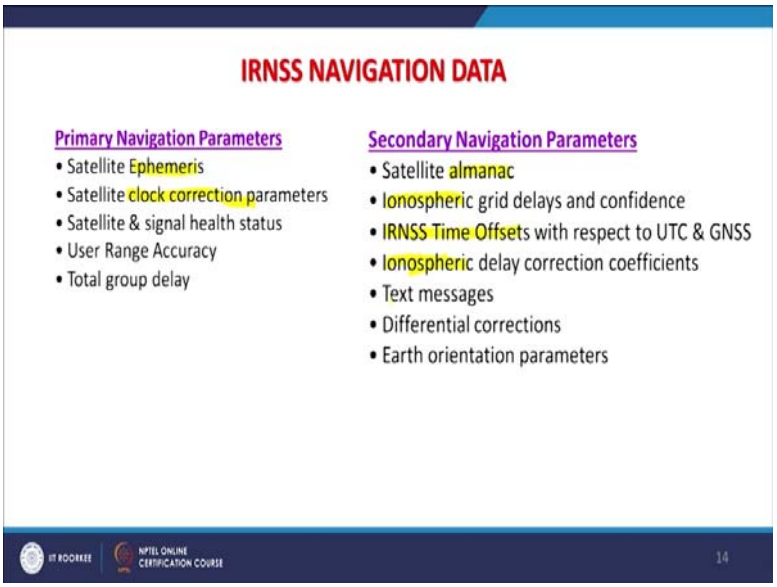

But, in civilian domain may not be much important but for army purposes and some for very accurate positioning estimations these things will matter. And, if somebody is exploiting 3 – 4 systems through their receivers, then during the calculation or these things have to be maintained or corrected timing so that we get the correct estimation. Of course, these things can be done through the installed programs with these receivers or maybe through the post processing .These correction can be performed over the signals coming from different GNSS system.

Now, other primary navigation parameters of NAVIC system is the satellite ephemeris, satellite clock correction parameters and satellite signal health status and then the last one is the user accuracy and maybe total group delay is there.

Now, under this category of secondary navigation parameters, we will be having satellite almanac and then ionospheric grid delays and confidence that will be again based on some modelling and then IRNSS time offset with respect to UTC which we have just discuss. There is a slight difference in these timings between IRNSS and UTC and ionospheric delay correction coefficients, those will be also applied in the secondary navigation parameters.

So, first primarily will ephemeris where secondary will have almanac. Then primary will have clock corrections, here the main important part is the ionospheric delays, corrections and then time offset in the secondary parameter. Others are signal health status, user range accuracy and total group delay; those data will be coming to a receiver and it maybe some text messages in the secondary navigation parameters, differential corrections might be there, earth orientation parameters will also be there.

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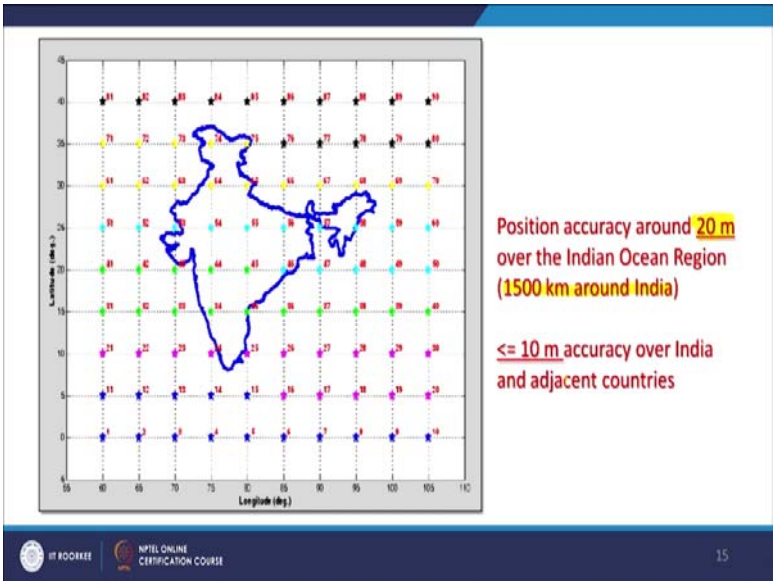

So, the position accuracy as we see because it's a regional system so, we talk in civilian domain. This is going to be the 20 meter over Indian Ocean region, 1500 kilometer around India as shown here at different location; the accuracy may vary that is why they are there. So, less than 10 meter accuracy over India, and adjacent countries might be there, but if you go quite far then there will be different accuracies because the entire focus of this IRNSS or NAVIC is over Indian subcontinent; India and neighboring countries.

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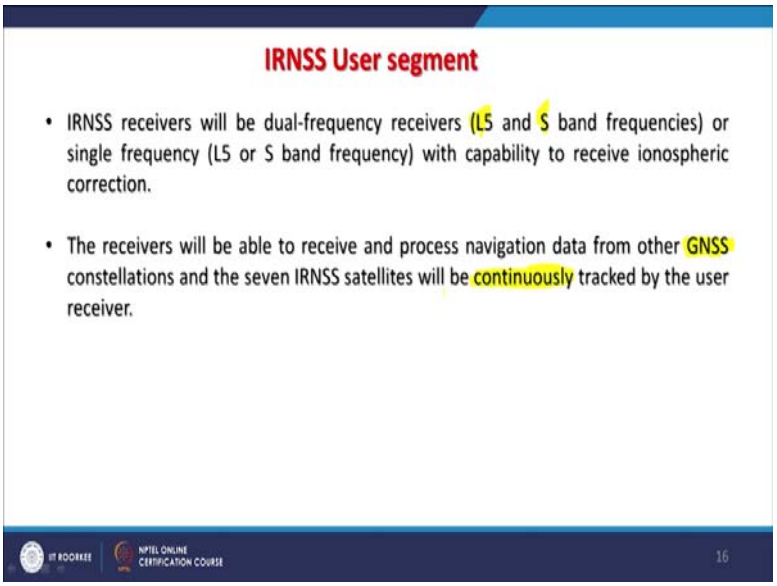

IRNS receiver will be dual frequency because L5 frequencies being used and S Band frequency are also being used and or maybe a single frequency either it will have a L5 or S band with capability of receiving this ionospheric corrections, so that our position estimations becomes much better.

And, receivers will be able to receive and process navigation data from other GNSS systems or constellations. And, the seven IRNSS satellites that is the complete constellation of IRNSS which has been planned will be continuously tracked by the user receiver. It is because you know, many of the satellites orbits have designed in a manner that at from almost from all locations. If we somebody is in open area, will have access to all these seven satellites and that is why sometimes you may get better accuracy estimation or position estimations then compared to other systems.

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So, applications of IRNSS as we know that all GNSS systems will have almost same type of applications; Terrestrial, Aerial, Marine Navigation, in Disaster Management; at that time it plays a very important role, Vehicle tracking, fleet management, Integration with mobile phones. Of course, mobile phones are coming with lot of apps and map and other facilities are there. Of course, Precise Timing is one of the key applications for various purposes are there, various applications and then Mapping and Geodetic data capture where one can also exploit the IRNSS system. Terrestrial navigation for hikers, travelers and you know other people and Visual and voice navigation for drivers that might be also there.

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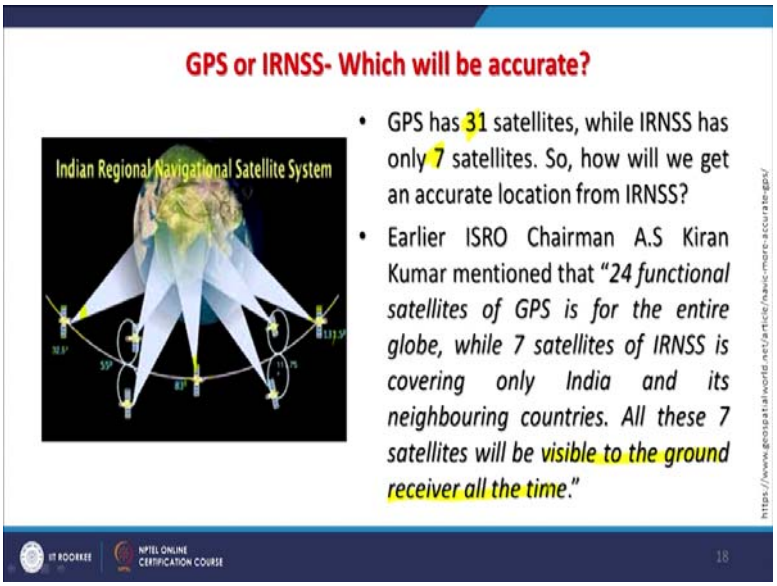

So, now let us talk little bit about the accuracy part and with comparison to the GPS as you can see that all these 7 satellites been shown here and 3 are in the geostationary orbit and rest are in the IGSO Inclined Geo Synchronous Orbit. So, this GPS as you know that having 31 satellites constellation whereas IRNSS will have only 7 constellations. GPS is global IRNSS is regional. So, it is fine.

And so, how we will get an accurate location from IRNSS because earlier it has been mentioned by then chairman ISRO Kiran Kumar that 24 functional satellites of GPS is for the entire globe, while 7 satellites of IRNSS is covering only India and its neighboring countries. So, all the 7 satellites will be visible to ground receiver all the time. This is most important thing.

In case of GPS if you use only the signals from GPS all the 7 satellites or any 7 satellites out of 24 will not be available. But, in case of IRNSS at every location in India, one will have access of all these 7 satellites signals. That is most important part of IRNSS being focused over India and being regional system.

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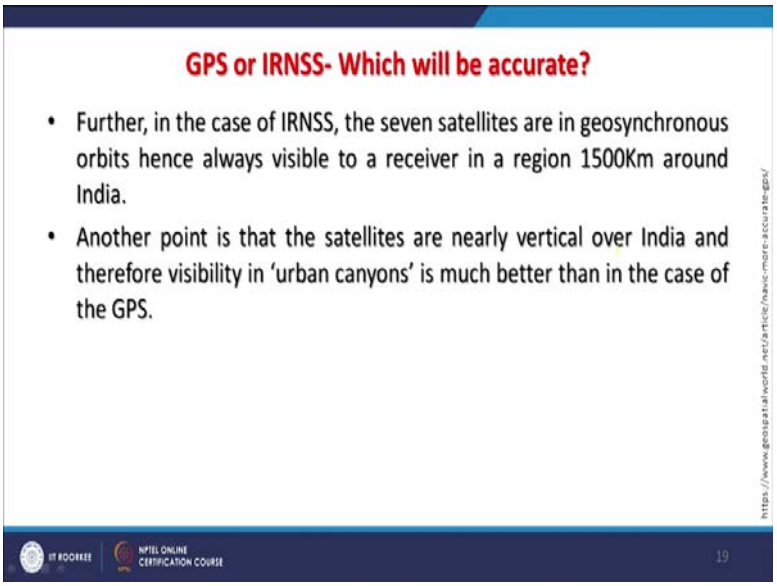

Further in case of IRNSS, the 7 satellites are in Geo Synchronous Orbits hence always visible to a receiver in a region which is 1500 kilometer around India. Another point is that the satellites are nearly vertical over India and therefore, visibility in urban canyons which much better than in case of GPS. Because these are deep in a space, but if you say connect trajectory then what you will see that even if you are surrounded by buildings or you know mountains that signals are coming vertically downward rather than from Inclined Orbiting Satellites. And, therefore the signal quality is going to be much better in position estimation. This is what it is expected.

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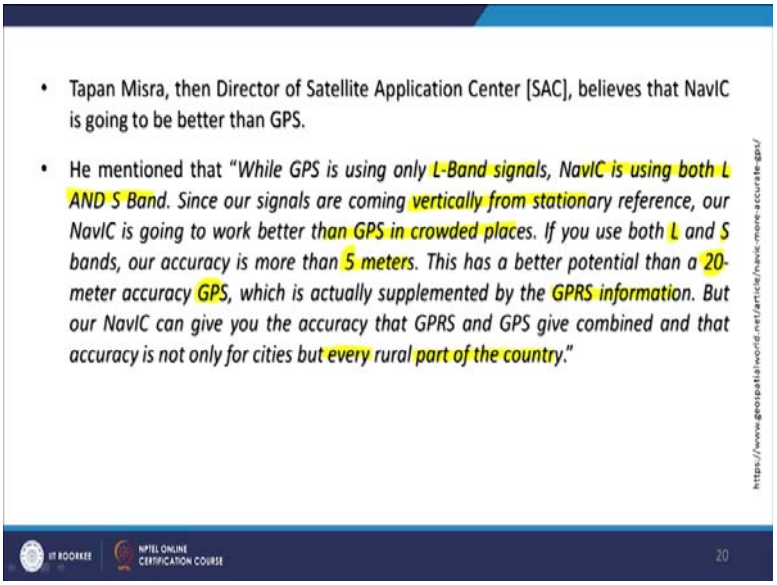

Further, the Tapan Mishra, who was then Director of Satellite Application Centre SAC, Ahmedabad. He said that NAVIC is going to be better than GPS while GPS is using L band signals, NAVIC is going to be used both L band and S band. These two bands, it is going to use since our signals are coming vertically; this is important vertically downward from stationary reference; with reference to the earth, they are stationary. our NAVIC is going to work better than GPS in crowded places. If we use L and S bands, our accuracy is more than 5 meters and this has a better potential then a 20 meter accuracy of GPS.

Well, sometime if you are in open area, you may get a better accuracy from GPS and when this IRNSS signals would be available, when we will go in open area, we may have again better accuracy than even 5 meters. Nonetheless, so, currently an average accuracy is around 20 meters in case of GPS which is actually supplemented by GPRS information that is augmented or assisted GPS. So, our IRNSS can also be assisted and then accuracy can be improved. But, our NAVIC can give you accuracy that GPRS and GPS give combined and that accuracy is not only for cities, but every rural part of the country. Almost every part of the country will have better quality signals and better position estimations.

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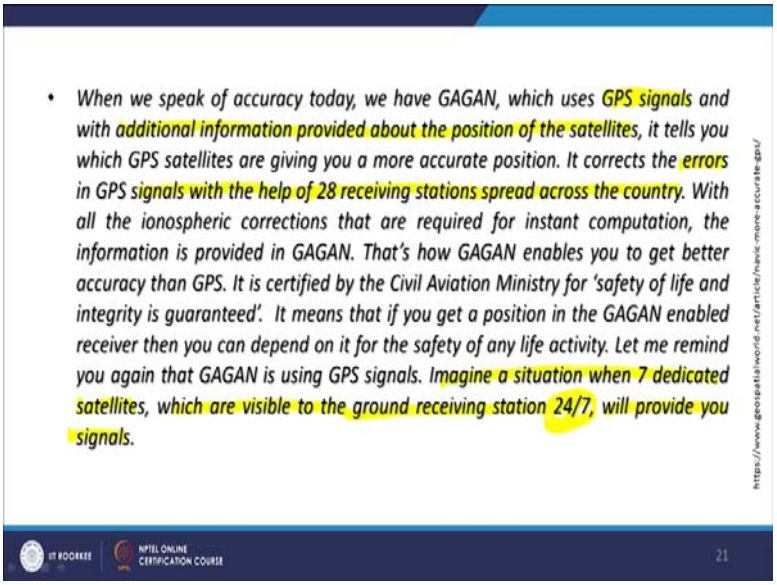

And, further he mentioned that when we speak about accuracy today we have GAGAN, which is the Ground Augmented Navigation System which India developed earlier which

uses GPS signals. Because we did not have our own IRNSS signal and additional information provided about the position of these satellites. And then it tells you with GPS satellites are giving you a more accurate position and it corrects the errors of GPS because basically the error part is being communicated from ground stations to a receiver.

So, therefore, it correct the errors in GPS signal with the help of 24 receiving stations spread across the country. With all these ionospheric corrections that are required for instant computation, the information is provided in GAGAN. So, that is how GAGAN enables you to get better accuracy than GPS but the disadvantage with GAGAN is a Ground Augmentation System.

And, now we are talking Space Augmentation System which comes under the category of SBAS and in future lectures, we will be touching these parts also; the SBAS of or similar technologies by different countries which are these Augmentation that means the error part is being transmitted not from ground stations, but by space based or satellites.

So, it is certified by the Civil Aviation Ministry for safety of life and integrity is guaranteed. For the GAGAN it means that if you get any position in the GAGAN enabled receiver then you can depend on it for the safety of any life activity and these aircrafts, they are using the signals from the GAGAN as well.

And, further he mentioned that GAGAN is a using GPS signals whereas when we will have our own signals, the same GAGAN system can be upgraded. So, we will have much better accuracies. So, imagine a situation when 7 dedicated satellites which are visible to the ground receiving station 24/7 will provide signals, it is going to be definitely much-2 better.

So, it brings to end of this discussion on IRNSS and in future we will be discussing over about the GALILEO and then QZSS and also we will be discussing about SBAS or Space Based Augmentation Systems. We will not be focusing in this course about the Ground Based Augmentation System but some details we will be having about the GAGAN as well because it is our own Indian systems. So, as usual I am leaving with a cartoon for your fun.

Thank you very much.