Global Navigation Satellite Systems and Applications
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Lecture - 06
Global Navigation Satellite Systems (GLONASS)

Hello everyone and welcome to this Global Navigation Satellite System; especially we will be talking in this one about the GLONASS which was developed almost same time when NAVSTAR GPS of US was being developed because as you know that these systems initially had the main purpose for the military and then later on now available to the civilian domain.

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So, GLONASS basically in Russia; it stands for "Global'naya Navigatsionnaya Sputnikovaya Sistema" and in English, we call as a Global Navigation Satellite System and not GNSS, but also it is called GLONASS.

So, GNSS is the general term and GLONASS when we say; it is specifically that is the Russian system and as we discussed that initial development of GPS started in 1970s. So, GLONASS was also developed by Soviet Union for mainly military communication systems and during 1970s. And, when this cold war ended between US and former Soviet Union then this Russia, Soviet Union realized that it has got lot of potential for commercial applications and the investment which has been made can be recovered to some extent. So, then the signals were made open for civilian public as well.

So, the first satellite of this constellation which is more or less almost same, but in detail we will be seeing except these numbers of orbits are less. So, this was launched in 1983 and system declared fully operational in 1995 whereas US GPS system was declared also in 1995, but it started by army in 1993. So, GLONASS went through a period of performance decline first it was launched, but then there were a lot of problems came.

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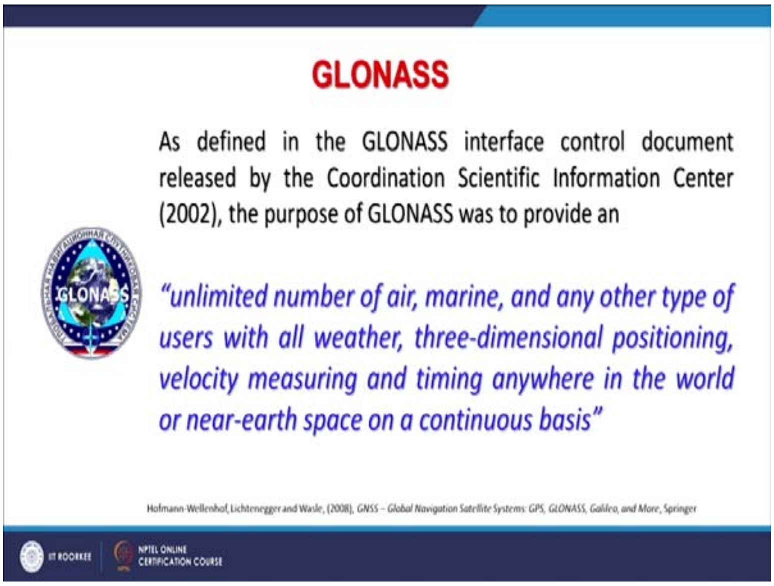

But now the signals are available even in India through even smart mobile or a handheld GPS receiver; one can definitely use these GLONASS signals as well. As defined in GLONASS interface control document that is released by coordination scientific information center in 2002, the main purpose of GLONASS; the aim as we have also seen in case of GPS, the aim.

So, here was also more or less same aim that unlimited number of air, marine and any other type of users with all weather, three dimensional positioning that is x y and z, velocity measuring and timing anywhere in the world or near earth space on a continuous basis. So, as the emphasis was of US GPS, almost same emphasis that in all weather conditions, the signals will be available on all over the world. So, this is also calling a global positioning system.

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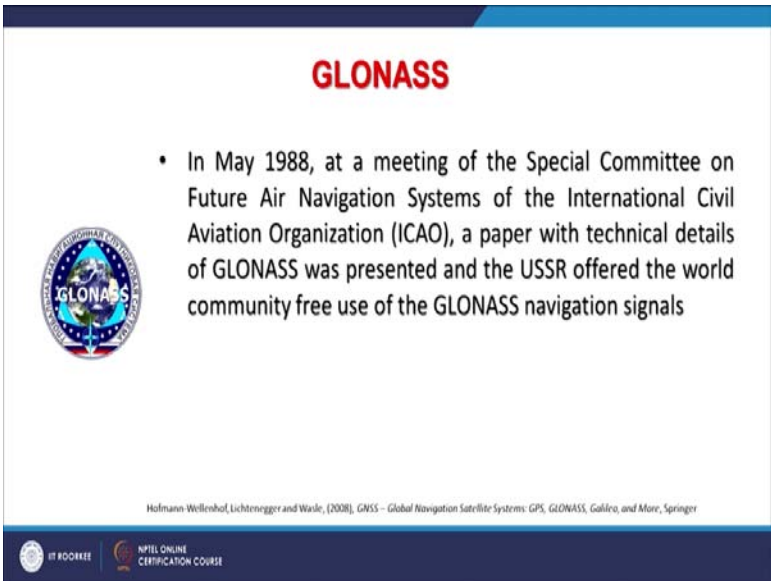

In May 1998 at a meeting of a special committee on future air navigation systems of International Civil Aviation Organization (ICAO) and a paper with the technical details of GLONASS was presented that is the first time it came with these details technical details into outside military domain and then USSR offered the world community free use of GLONASS navigation signals. So, this is a landmark from that point of view because two navigations signals became available to the civilian users; one from GPS US and next one was the GLONASS.

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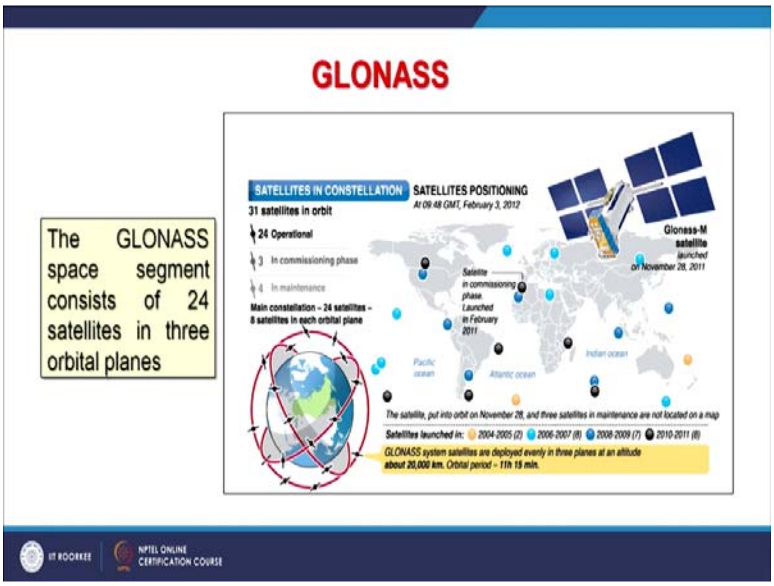

So, as compared to GPS has mentioned that the space segment is almost same. So, it is also having constellation of 24 satellites but number of orbits in case of GPS were 6 and each orbit, there were 4 satellites. Here, numbers of orbits are only 3. So, as you can see that these 31 satellites constellation is there, rests are in spares. 24 satellites are in operational, 3 in commission phase and 4 in maintenance currently.

And main constellation is 24 satellites in 3 orbital planes; that mean in each plane orbits, there are 8 satellites at equal distances. Not like GPS where 6 orbital planes and 4 satellites in each there. Now, similarly like if we see these control stations and other things, they are all spread over the globe to monitor and maintain this system. And, there are locations which are shown that different satellite when they were launched and how they have maintained these things.

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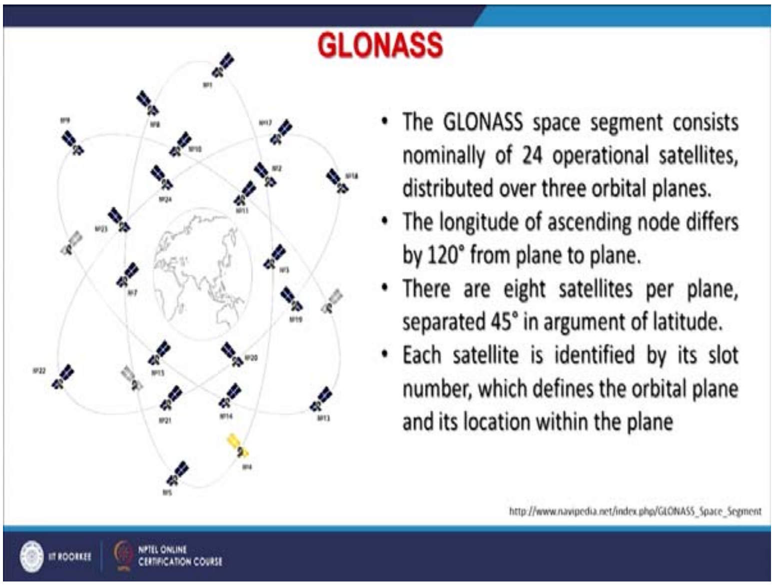

Now, as you can see that different satellites are having a constellation in three orbital planes, GLONASS space segment consists nominally of 24 satellites, distributed over 3 orbital planes. Longitude of ascending node differs by 120 degree from plane to plane and then there are eight satellites per plane separated 45 degree in argument of latitude.

And, each satellite is identified by its slot number which is also mentioned in this figure, that each satellite is having its own unique id which defines the orbital plane and its location with in plane. Now when two navigation systems are in operations; that mean that all these satellites combined GPS and GLONASS should have unique id and that is being maintained by international organization, we have just mentioned earlier.

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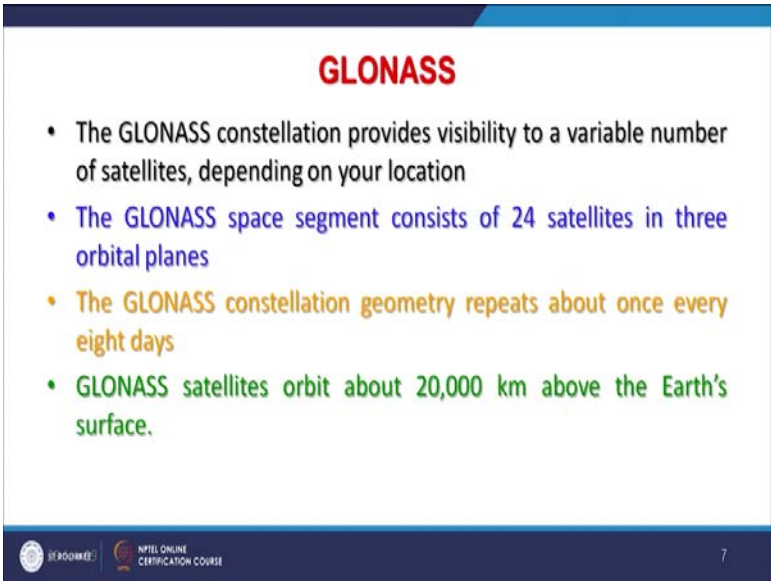

So, they basically assign these numbers so, that our receivers can identify separately. Now, GLONASS constellation provides visibility to a variable number of satellites depending on your location. GLONASS space segment consists of 24 satellites in 3 orbital planes. GLONASS constellation geometry repeats about once every 8 days. So, if today I am having excessive of certain number of satellites then after 8 days the same scenario from same satellites, I will have signals.

And, GLONASS satellites orbits about 20000 kilometer above the earth surface whereas, if you recall the GPS satellites, NAVSTAR satellites 20200. So, both these navigation systems are having about 200 kilometer distance or these envelopes of orbits are having 200 kilometer distance in a space.

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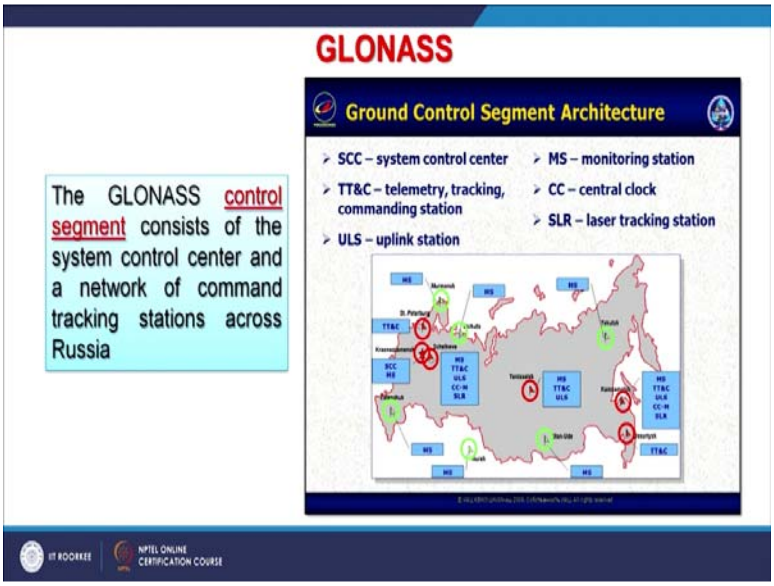

Now, ground segment as in case of GPS and most of these segments are within the USSR, former Soviet Union countries and they are all located with the different monitoring station, system control center, telemetry tracking and commanding station then ULS that is Up-Link Station and then CC, the Central Clock and SLR, Laser Tracking Stations.

So, because in order to maintain these orbiting satellites of total number 31, but minimum requirement for complete constellation is 24, so, you need to have again monitoring stations, control stations and other stations to provide better maintenance and definitely better accuracy to the receivers. So, GLONASS control segment consist of system control center and a network of command tracking stations across the Russia.

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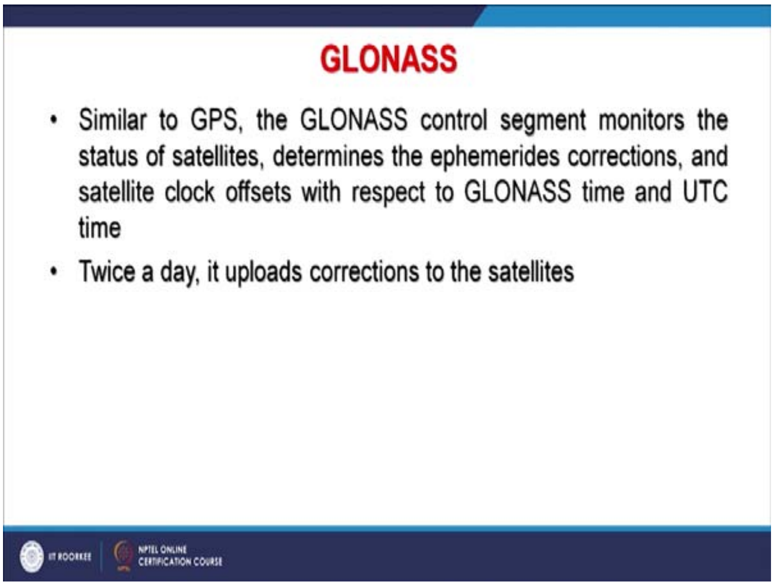

Now, as we keep discussing of other navigation systems, we will be keep comparing with other systems as well. So, that is why when we are discussing GLONASS, we also compare with the GPS which we have discussed in the previous lecture; that similar to GPS, GLONASS control segment monitors the status of satellites, health of satellite determine the ephemerides, corrections and satellite clock offset with respect to GLONASS time and UTC time. And twice a day, it uploads correction to the satellites.

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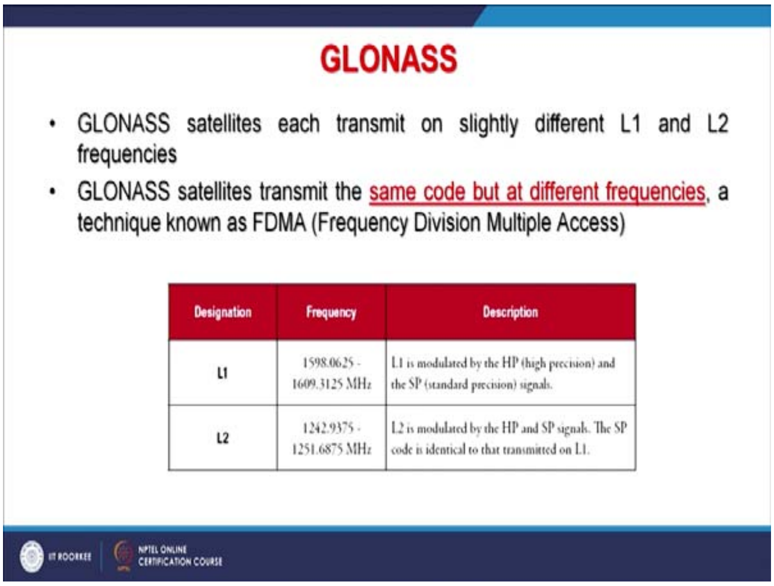

Designation	Frequency	Description
L1	1598.0625 - 1609.3125 MHz	L1 is modulated by the HP (high precision) and the SP (standard precision) signals.
L2	1242.9375 - 1251.6875 MHz	L2 is modulated by the HP and SP signals. The SP code is identical to that transmitted on L1.

So, if there is some deviation then twice a day, it is checked and if corrections are required, these are uploaded. Now, though the band-wise are same L 1 and L 2, but frequency wise, they are at different frequencies as compared to your GPS. So, there should not be any classes within frequency.

So, GLONASS satellite is transmitted on slightly different L 1 and L 2 frequency compared to GPS. And GLONASS satellites transmit the same code, but a different frequency, a technique known as FDMA which is Frequency Division Multiple Access rather than CDMA. This is now FDMA frequency division multiple access, there were the code division multiple access; here we are having frequency division multiple access and these two frequencies little different from GPS.

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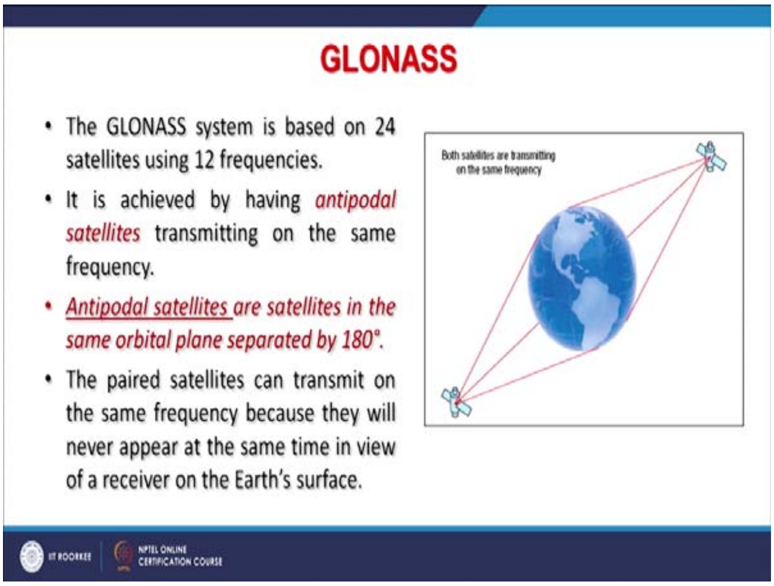

So, GLONASS system is based on as we have seen 24 satellites using 12 frequencies, and these satellites are transmitting on the same frequency, but they are antipodal satellites; that means they are completely opposite in the direction. So, though they are transmitting on the same frequency, but there cannot be any place on the world, where you can receive the signals from these two satellites together. So, there cannot be any problem.

So, antipodal satellites are satellites in same orbital planes separated by 180 degree and these paired satellites can transmit on the same frequency because they will never appear on the same time in view of a receiver on the earth surface. So, rather than using different frequencies for different satellites, it is also possible to have antipodal satellite arrangement.

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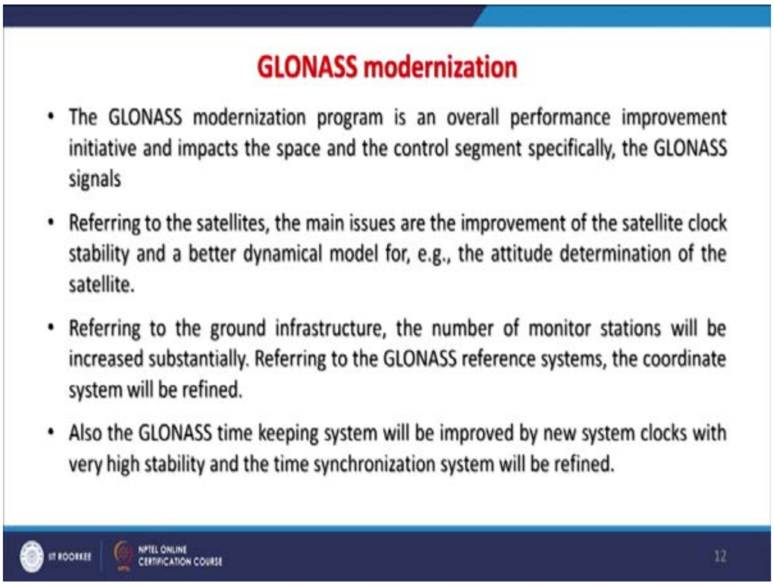

Now, modernization plan of GLONASS is; GLONASS modernization program is an overall performance improvement initiative and impacts the space and control segment especially the GLONASS signals. And referring to the satellite; the main issue are the improvements of satellite, clock stability and a better dynamical model for example attitude determination of satellites. As I have been mentioning that these are orbiting vehicles in space and therefore their stability is big issue because they sometimes deviate from their expected or designed orbit and therefore, attitude of these satellites have to be maintained. So, that we get a better performance of the receivers for position estimation.

And this ground infrastructure, the number of monitoring stations will increase substantially. The same is also being done in case of GPS and with a special reference to the GLONASS reference systems, the coordinate system will be also redefined because later on, it was realized that the current coordination system which is being used by GLONASS require some improvements. Then also GLONASS timekeeping system will be improved further by new system clocks with very high stability and time synchronization system will be redefined.

So that in future, when new satellites in the same constellation will be added because some satellites keep become nonfunctional after maybe 10 years, 15 years. So, they have to be replaced by new satellites. So, when these new satellites are being sent in order to maintain that minimum constellation, then these new satellites will have a new system clocks on them which is again will have a very high stability and better time synchronization.

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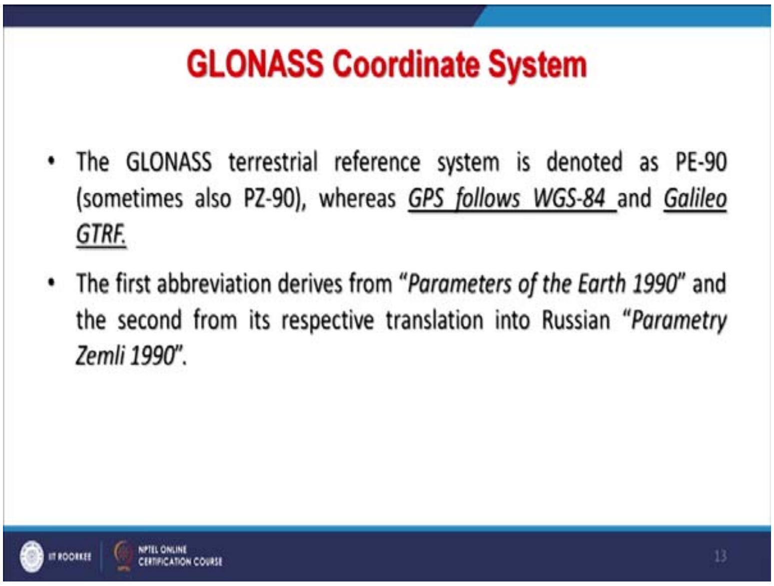

Now, as we have just touched earlier that coordinate system. So which coordinate system basically, the GLONASS using? GLONASS using this terrestrial reference system that is denoted as P-90 also sometimes called PZ-90 whereas, GPS follows WGS-84 and Galileo GTRF that is reference. So, there is a difference but nowadays, our receivers with the software inbuilt in them, are capable of using these data and capable of estimating better accuracy using signals from two systems.

So, this parameters of the earth 1990 that is the abbreviation for that PE or PZ and the second form is respective translation into the Russian that the Parametry Zemli 1990. So, this PZ word comes for coordinate systems.

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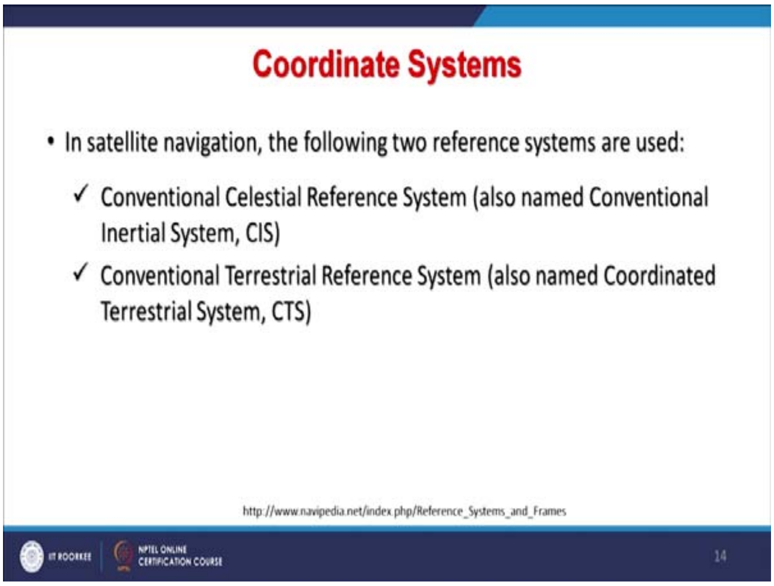

In satellite navigation, the following two reference systems are used; first one is the Conventional Celestial Reference System also named Conventional Inertial System or CIS, another one is the CTS that is Conventional Terrestrial Reference System also called Coordinated Terrestrial System. So, these two systems are used by these navigation satellites.

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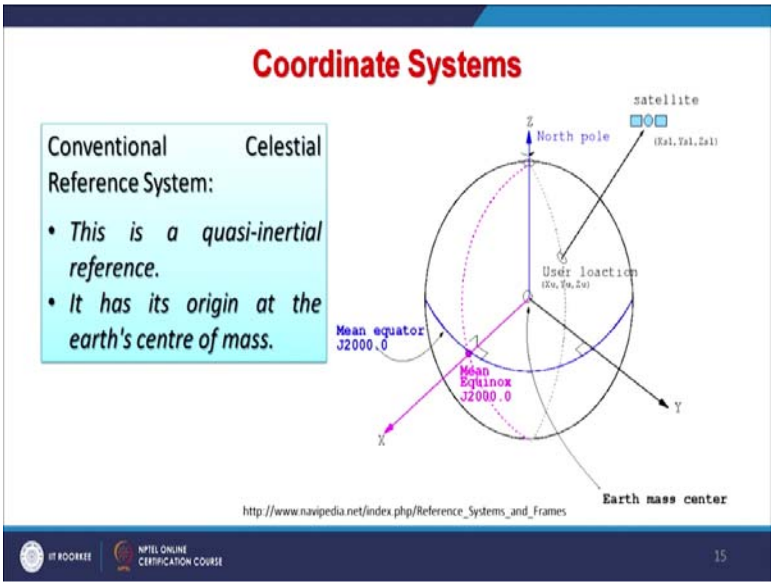

If we go in detail about these systems then what we find this coordinate system that lets take example of this Conventional Celestial Reference System, this is a quasi-inertial reference and it has its own origin at the earth center of mass which is shown here also. The main problem is because as you know that earth is not perfect spheroid and therefore different coordination system exist and different countries is start using different coordination system which is convenient for them or which may be accurate for them.

And therefore, when someone is using a system or a receiver which is capable of receiving signals from different navigation systems, which are using different coordination systems then it is necessary to understand these intricacies in order to exploit and get the best results of positioning from multiple navigation systems.

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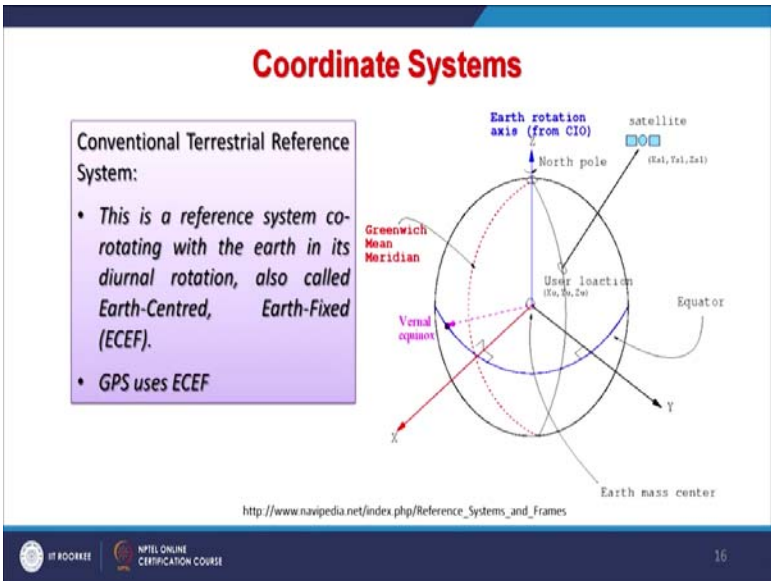

So again in coordinate system, the Conventional Terrestrial Reference System. This is reference system co-rotating with the earth in its diurnal rotation and also called Earth Centre Earth Fixed (ECEF) system. So, this is also used by the GPS; ECEF Earth Centered Earth Fixed system.

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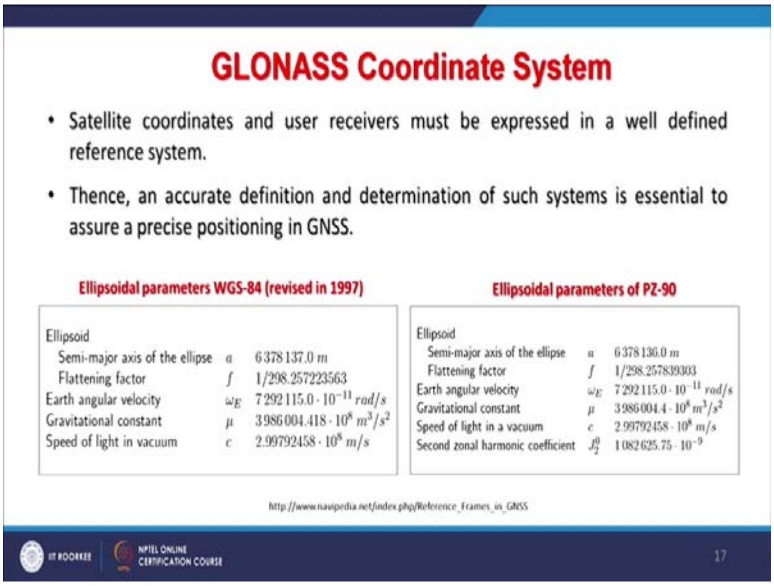

And this coordinate system or these satellites coordinates and user receivers must be expressed in the well-defined reference system. Because if satellite is giving data in different systems, our default setting or settings in a GPS receiver is different then we may not get that accurate positioning. So, these cares have to be taken while. And then an accurate definition and determination of such system is essential to assure a precise positioning in GNSS.

Now, just to compare these two systems; one is the WGS ellipsoid parameters as you can see on the left side and ellipsoid parameters of PZ that is a Russian. So, the left one, first one, WGS 84 used by the GPS. Another one you used by the GLONASS as you can see different values are there; for example semi major axis of the ellipse which is being used in equation that is a and here, there is a slight difference in the value in the last digit instead of 136 in the WGS 84 (Refer Time: 19:10),it is 137.

And, then flattening factor is also different. Earth angular velocity in WGS 84 is same, but gravitational constant is completely different, than a speed of light in vacuum. There are different units are used. So, that is why, this sort of coordination of coordinate system by a receiver has to be done in order to get better results. And this brings to end of this brief discussion on GLONASS systems, not meant much details are available because initially the system was kept very secret and only recently details have started coming.

So, with the GLONASS as compared to GPS we do not have much detail available. Nonetheless signals are available, which are freely available round the clock, globally and our receivers now are capable of receiving these signals from GLONASS simultaneously with GPS. And, some other navigation systems which we will be discussing in due course of time and receivers are capable of. you know integrating these signals and getting a better position than based on an individual system.

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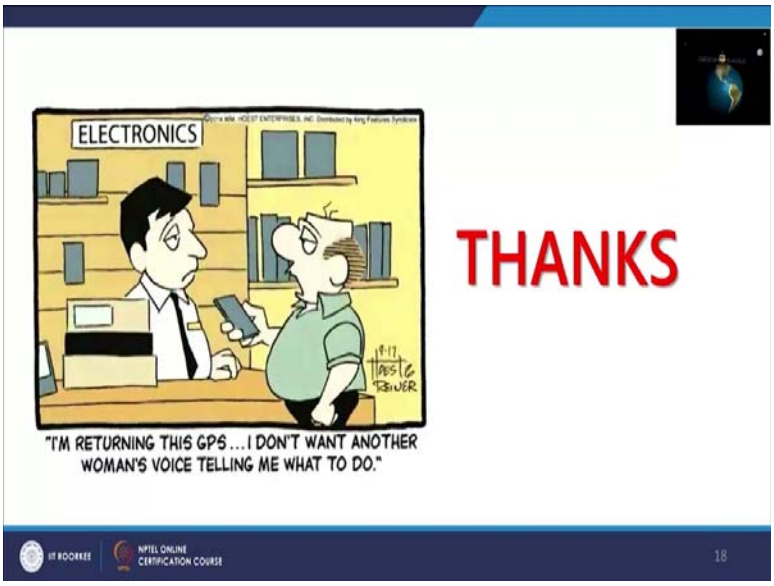

I am leaving again as usual with a cartoon. It says that I am returning this GPS because I do not want another woman's voice telling me what to do because when you are having voice with the GPS generally ladies voice are kept and that person is annoyed with that lady voice. So, he said that my wife voice is sufficient rather than one more voice is given by GPS. So, this is just for humor.

Thank you very much.