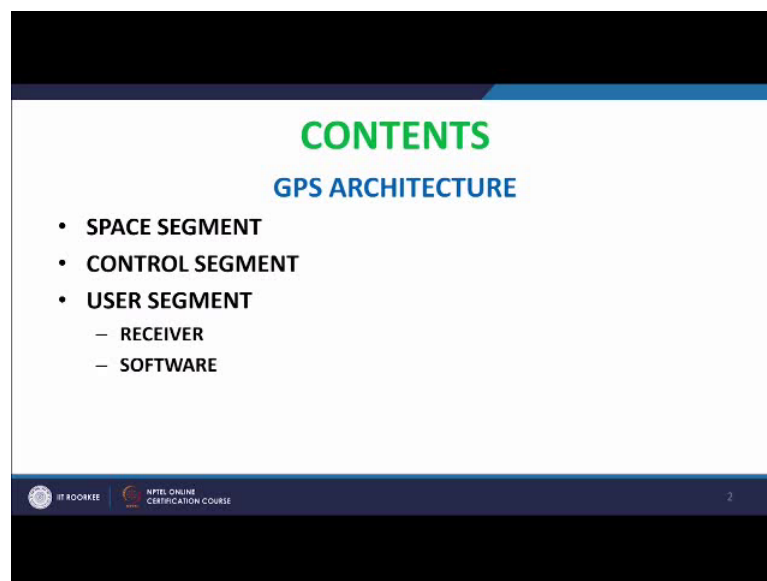**GPS Surveying**
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Lecture – 02
GPS System (Architecture)

Friends, welcome you to 2nd Lecture on GPS Surveying. In this class we will discuss on GPS System.

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Now the GPS system will be discussed under three broad heads; that space segment, control segment, and the user segment. And the user segment will be discussed on receiver as well as software. Now, let me first start with GPS architecture. A GPS system architecture consist of three segments; the space segment, the control segment and the user segment.
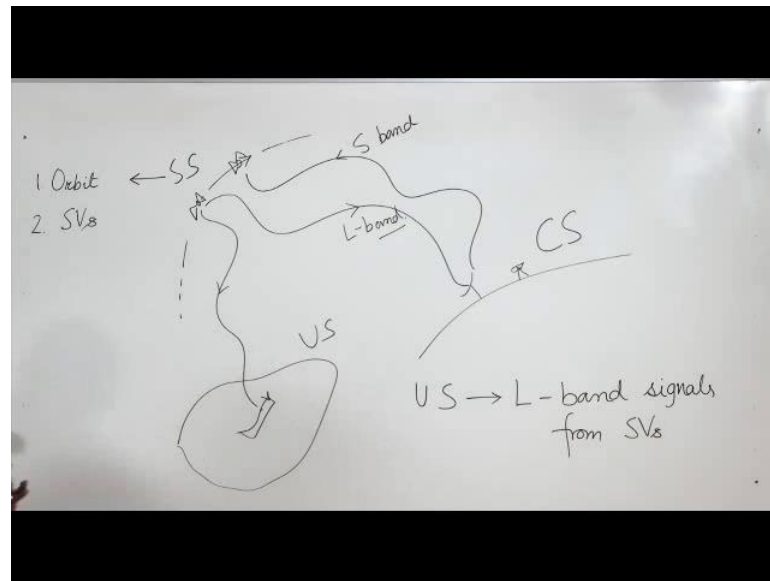
Now, these space segments actually consist of the satellites which are moving along some predefined orbit above the surface of the earth. And the control segment actually consists of some monitoring stations. And the user segments which belong to us it consist of some receiver as well as software. Now these space segments are linked to control segment and also it is linked to user segment by GPS signal which is being broadcast by satellite vehicles. From satellite vehicles one way ranging signals are coming and this is being control segment monitoring stations as well as user segment receivers.

On the other hand the control segment can also communicate with this space segment through again one way ranging signal, but these signals are in S band this in L-band. So, in the GPS architecture that space segment can communicate with the control segment as well as it can communicate to user segment by one way L-band ranging signals. And the control segment can communicate with the space segment by again another one way ranging signal in S band. But the user segment cannot communicate, it can only receive and that too from space segment only. So, user segment only it receives L-band signals from satellite vehicles.

Now let me discuss in length about the space segment. Now the space segments actually it consist of two parts; first one you can say the orbit part and the second one is that satellite vehicles. That means a constellation satellite vehicle at present which revolves

around the earth along some pre-specified pre-design orbits. And these orbits are designed in such a way, and the satellite vehicles are placed in those orbits in such a way that at any point on the surface of the earth at any instant of time a user will receive signals from at least 4 satellite. Now this is the beauty or this is what is the design can constrain that has been achieved.

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Now, satellite orbits these are pre-designed luminary circular in shape which has been designed and around the surface of the earth over the approximately 26,600 kilometer above the center of mass of the earth.

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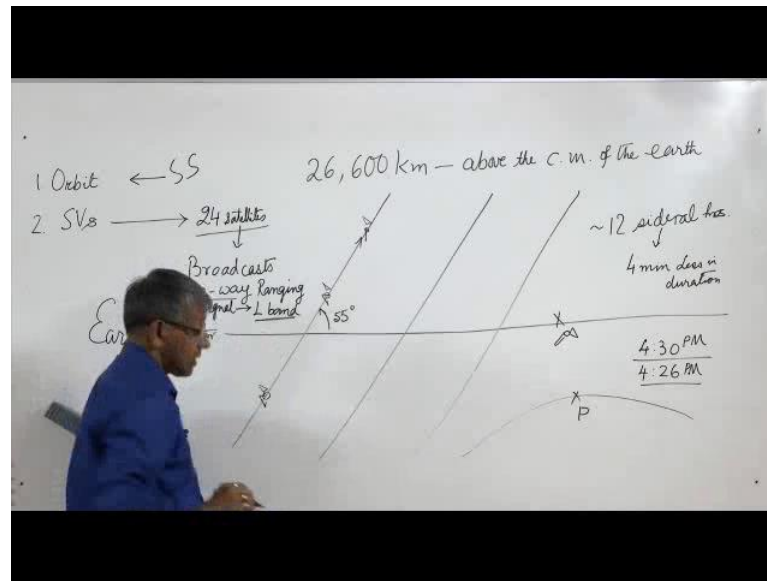
So, orbits are about 26,600 kilometer above the center of mass of the earth which is a about to 20,000 kilometer from the surface of the earth.

And these are nominally circular in shape and they are well spaced. And they are inclined in such a way that if we assume this line as the earth's equator then the orbital planes of the satellites will look like this and these orbital planes are approximately 55 degree inclined to the equatorial plane. Further, these orbits are designed in such a way that its foot print on the surface of the earth is along some stationery line. Now this satellite constellation, actually the satellite constellations are designed in such a way so that there are at least 4 satellites that will be available along each orbital plane and more or less they will be equally spaced.

And thus, there are at least twenty 4 satellites that will be available in the satellite constellation of GPS system. And these satellites revolve around the earth and the orbital period is about 12 sidereal hours. So, each satellite any places the same satellite X will busy two times in a sidereal day. Now the sidereal day differs from solar day which we generally follow and the sidereal day is 4 minute less in duration then solar day. Suppose X on position P is appeared at 4:30 pm today that same satellite will be available on the place P tomorrow again, but that will appear at 4:26 pm.

This information is very important when we want to carry out the repetitive study with respect to some satellite on some other thing. So, 12 sidereal hours is the orbital period

of the satellite around the earth. And these satellites actually broadcasts one way ranging signal. Broadcast one way because that is only satellites broadcasts the signal and receivers in the user segment as well as in the control segment receives that signal, and that is called Ranging Signal. Ranging signal and these signals are in L-band in radio range.

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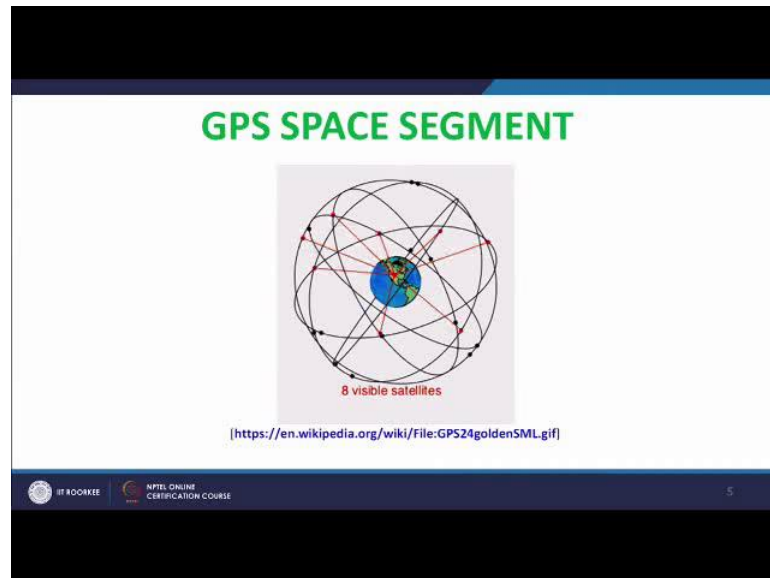
Now here we can see a simulation of the space segment. You can see here that the black colors are shown the orbital dot of the satellites with black color and this earth is shown by these blue and green colors.

Now at any point on the surface of the earth at an instant of time you can see that the numbers signals coming from the satellites are more than 4. So, the signal that is arriving at any point on the surface of the earth at any point instant talk time will be more than 4 satellites. So, this is a simulated figure of GPS space segment.

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Next control segment.

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The control segment of a GPS system consists of 1 master control station and 1 standby master control station. 16 monitoring station and 12 ground antennas From the name itself we can say master control station is actually the station which fundamentally controls all the activities, but the activity of master control station depends on the working of monitoring stations as well as ground antennas. The information's are

received from monitoring stations and master control station process the information and provide some information to ground antennas which it uploads to the satellite vehicles.

Now you can see here in this figure the distribution of different control stations over the earth, you can see the red stars are shown which shows the location of master control stations actually this is the primary master control station and this is the secondary permanent master control station, this is at Colorado USA. And then you are black spherical circular balls these are monitoring stations. And if we observe we can see that most of this monitoring stations are placed along the equatorial plane or by the side of equatorial plane at equal distance for about twenty third and a half degree.

And that triangular black figure shows the location of the ground antennas. Mostly they are present by the side of the monitoring stations. And these stations are spread over the whole earth. Now the monitoring stations actually what happens whenever a satellite passes over a monitoring stations then the receiver at the monitoring station captures the data that caused by the satellite and from that data it calculates the position of the satellite, the velocity of the satellite, the altitude of the satellite, the health of the satellites and from those measurements it find outs the condition of the satellite.

Not only that it also computed the ranging than it also compute clear out the atmospheric data, gravity measurements and their variations, and those information's the monitoring station sends it to master control station. So, master control station get receives information from 16 monitoring stations. And for the same satellite when it will pass over different monitoring stations from time to time it will provide monitoring control station information for the same satellite at different for time in a single day. That means, suppose this X this is the X satellite then monitoring station 1, 2, 3, 4. Suppose it is 1, this is 2, this is 3, and like that I have 16.

Now as the orbital period of this satellite is 12 hours so within 12 hours about this satellite this master control station will get information about these satellite 16 sets of information it will at different period of time. So, in a single day the master control station will receive 32 sets of information about the same satellites over a period of day. So, that temporal information about a single satellite over a day like, every day. Similarly for all satellites, all these information's are coming to master control stations and this

master control station will subsequently process this data to find out the exact location of the satellite vehicles.

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Then it evaluates the health of these satellite vehicles from that data, and then it generates the navigational data, master control station. From this temporal information from computes the position of the satellite vehicles then health of the satellite vehicles. Then generates the navigational data; NAV data.

Now if at such particular point of time if the master control station finds that something is going wrong with some particular satellite, then between send message to ground control antenna to upload required information or required signal to the particular satellite. So, through ground antennas master control station provides the necessary control information commands then upload navigational messages. That is what about the control segment. And then ground antenna; what ground antenna does?

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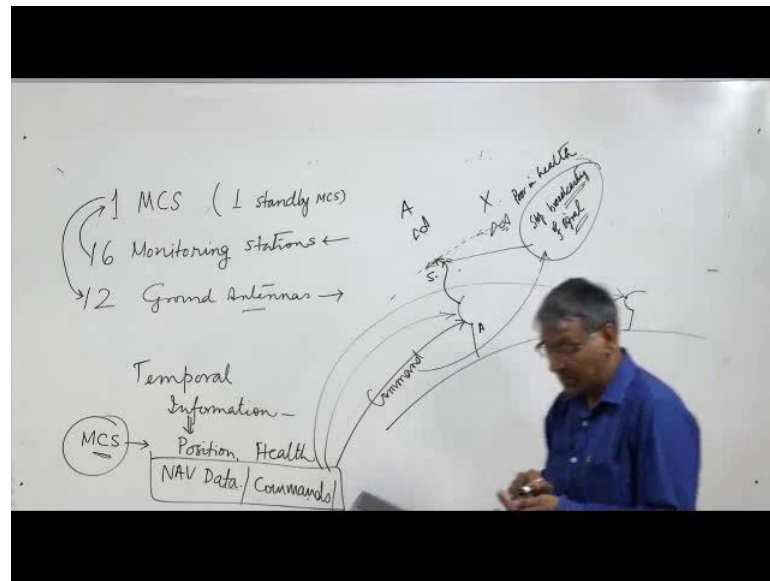
Suppose there are 12 ground antennas, now master control station after preparing the navigational data and if it needs to send some commands or some other information to certain satellite this data and commands it will send it to the ground antennas. Ground antenna will store it and whenever some satellites are coming it will track the satellite and way it will find out whether some information is waiting for, whether it had stored some information for this particular satellite or not. If it can identify, suppose satellite A; for satellite A this is ground antenna has some information which has been communicated by the master controls station. Then it will send this to the satellite through S band signal.

So, the ground antenna tracks the satellites it is passing over it and if it finds that for particular satellite some information is being stored by master control station to it then it will communicate that information to the satellite. This is the way suppose some satellite X is poor in health so for this satellite master control station has given information that it needs to send some command to satellite X to stop send broadcast message; stop broadcasting of signal.

Suppose this is the information, this is the command that has been stored in antenna A for this satellite X. So, now when this satellite will be moving like this at one point of term it will come here then it will send the signal command this command it will send to this and after it will pass through here it will stop broadcasting its signal. In that way

master control station provides commands through ground antenna to the particular satellite particular message.

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Next it is the user segment. Actually as a user this is the most important for us because neither space segment nor control segment is of any we cannot do any direct interaction. Space segment for the space segment only we can receive the GPS signal that is what about the space segment, we have no control over the functioning of control segment or space segment. We have only controlled in user segment.

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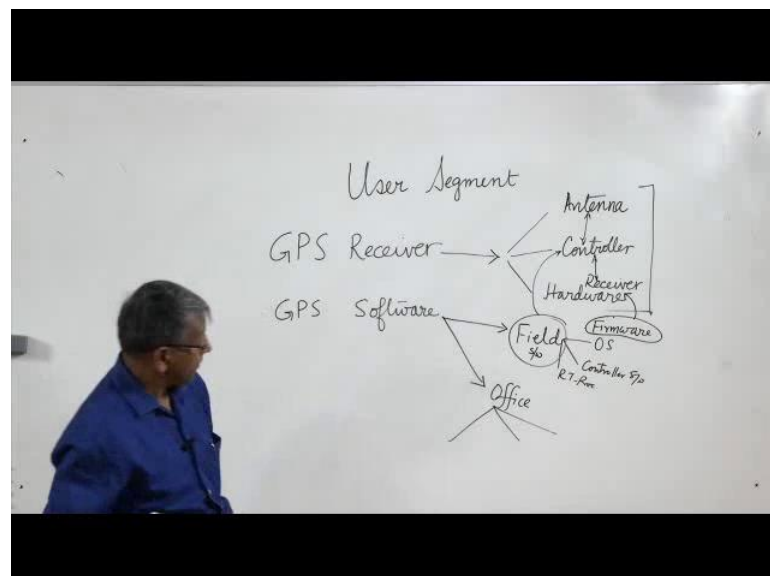
Now, what is user segment? User segment consists of two parts; one is that GPS receiver and the other part is GPS software. Now, GPS receiver is an electronic device to receive the GPS signal from satellite space segment, and it has three primary components; that is your antenna, controller, and hardware or receiver hardware. Now these three components constitute a GPS receiver. Now these three components maybe available as in a single unit or it is available as independent unit, if it is independent unit then they are connected to each other.

Now here you can see a GPS receiver. This is the antenna of the GPS receiver and this is the controller of the GPS receiver and this is our receiver hardware. And they are connected with each other through these connectors. Now as the receiver is kept for open sky under open sky so signals from GPS satellite will come to this and this antenna will gather this information which will pass through this connector to the receiver.

Now how this antenna will start work, that will depend on what is the command or what is the control statement that has been given by the controller to the antenna. That means controller is the part of the instrument which controls the functioning of antenna as well as hardware receiver. Now how does it do? It does it through software. Actually there are two types of GPS software that is available and that is required for GPS surveying; one is called field software and other is called office software.

Now under field software there are different types of field softwares like, firmware, operating system, then controller software, and then your real time processing software. Again under office software there are different types; however, this field software these are available within the controller. So, controller make use of field software to control the antenna as well as receiver hardware which will be firmware is available within the hardware receiver, other than firmware all are available in the controller, also some software also available in the controller.

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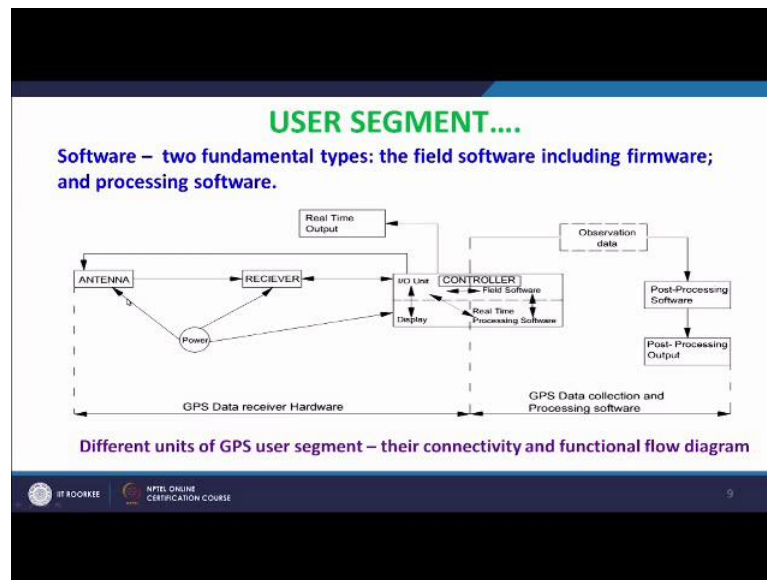
So, the functioning of user segment can be depicted through this flow diagram here you can see that there is an antenna and this is the receiver hardware and this is the controller. And these controllers has the connectivity with the receiver as well as it has the connectivity with the antenna, that means the controller has to control both the receiver. And the antenna and all these are connected to some power.

Now these antennas used to gather the GPS signal out of the atmosphere, actually these atmospheres full of so many electromagnetic waves. Of this only we are interested in GPS signal. And this antenna can gather those GPS signal and this will stop gathering it will transform it to the receiver. Now receiver what it will do? It will receive the signal from antenna then it will carry out many preprocessing and processing operations inside it as par the instruction given by the controller and under the framework of its firmware. So, firmware will be the guiding criteria how a receiver will work. And what is specifically it will do, it will that would depend on what commands controllers provides it through field software.
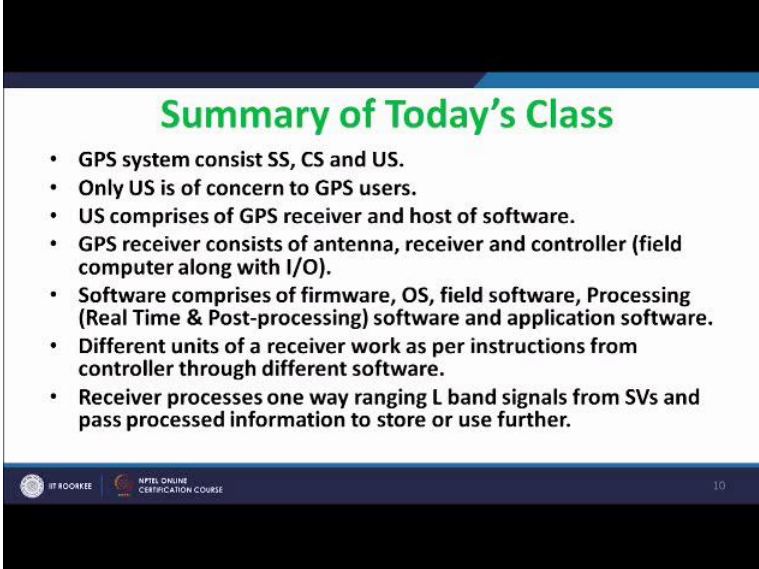
Now after the receiver receives the signal from antenna it will preprocess as well as it will process the data. And after processing the data either it will store itself or it may send the process data to controller. Now the controller if it contains some real time processing software then it will process the data received from receiver through the real time processing software and it will provide the real time output. And the real time

output may be in the form of files which will be stored within the controller or also it may be some pictorial presentation or data which may be displayed in the controller, because controller has also displaying unit.

And it may also store the data either the form it has been received from the receiver or it may store the data as it has processed inside it. Later these data will be taken out through office software to processing software and processing software will process the data received from controller or from receiver and to provide the processing output.

So, this is in short how the whole of GPS user segment works. So, after processing the data from GPS signal we get the necessary information like position and many other parameters which we are looking for as par done by the processing software. And this is in short about the user segment.

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So, that is all about today's class. Let me summarize today's class that means, GPS system is having architecture of three segments; space segment, control segment and user segment. Of this only the user segment is of our concerned as a user. However, user segment receives the signals from space segment that is a one way broadcast signal in the L-band of electromagnetic wave.

The user segment primarily consist of two parts; one is that GPS receiver another is that GPS software. The GPS receiver is composed of three electronic units; that antenna,

controller, and the receiver hardware. Of which antenna gathers the GPS signal transfers it to the GPS hardware receiver, receiver GPS hardware receivers receives the signal from antenna and it passes as per the instruction given by that controller. And after processing the information it stores the data either inside it or it transfer it to the controller. Then controller may process this data using the real time processing software or it may transfer it data. And the whole of controller works on the basis of the field supporters uploaded inside it. And finally, after processing the data we get the desired parameters which we are looking for our surveying or any other application activity.

That is all about today's class. Thank you very much see you again for the next class which will be on GPS signal, because as you have seen GPS signal is the primary element for which we derived the desired information.

Thank you.