Satellite Communication Systems
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Lecture – 22
Ground Segment – 1

Welcome. Today we will be starting a new topic that is Ground Segment. We have already discussed I would orbit, then the space segment and then the link budget, then the propagation channel through which the signal is coming through. And today will start on the earth that is on the ground segment.

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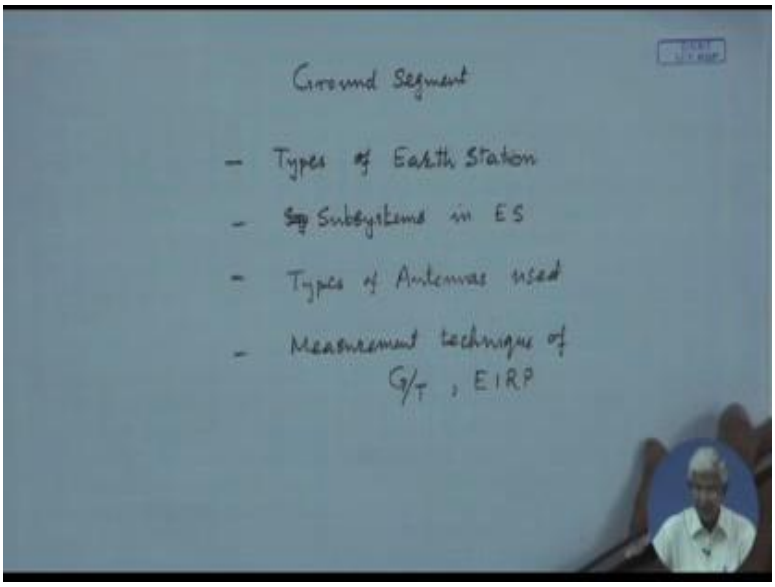

So, what will cover on the ground segment? We will cover the types of ground segment, and since it is on the earth not always on the ground so we will call earth station that is the terminology people use. And then of course, the sub systems insides the earth station and the types of antennas used in the station that is very important point will see. Of course, there is the measurement technique of two important parameters of the station we know already which is the receipt characteristics that is G by T and the transmit characteristics which is EIRP. So, these are the major topics inside that will see what else will understand inside.

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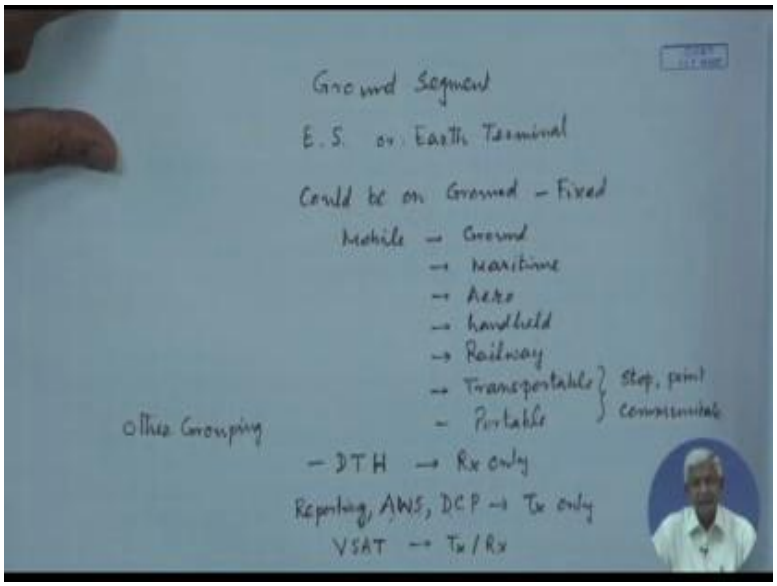

I will take another pen. So, the ground segment we call earth station or earth terminal which is very near to earth not may be always touching the earth. So it could be on the ground, it could be on ground surface or it could be mobile on the ground surface, it could be mobile on the ocean, marine or maritime, it could be mobile on the aero, it could be mobile on a another satellite. Then these types of mobile things can be a very small station which we can call hand held just like our cell phone. There is another type of ground mobile which is there which is recently being investigated and certain standards have come it is not come in the text book yet which is railway mobile.

And then another type of mobile which is mobile which is called transportable or a simply portable, these two types are the types of earth stations or earth terminal when you are moving that time you are not communicating. That means, you move stop and then point to the satellite and communicate. So, there are fixed type of earth terminal that is could be on the ground which is fixed and could be mobile which could be on the ground that is on a vehicle, it can be on a road, it can be on railway, it can be on boats or ships which in maritime, it could be on aero.

While walking you can talk that is hand held and there are two other types of shadow mobile things available which are called transportable or portable. That means, you carry the terminal to a place and then stop where the event is occurring or where you want to communicate and then point your antenna to the satellite and communicate. The different

types of packaging is done different types of environment when your hand held a portable it package is very small, when you are on the ground package may be large, when you are on the railway your packaging is different. So, there a different types of packaging.

There are other groupings possible which I can say how it is communicating based on that other type of grouping. That means, say let us say you are trying to receive only which is very common you have seen that the TV broadcast what we receive in our television it is coming directly from satellite and many people in cities and villages they are using a direct satellite receiver which is called direct to home; DTH. This is a fixed terminal may be maintained on a window on the roof top, while moving you are not using direct to home but this is direct to home, home is not moving. Therefore, it is a fixed station, but this is receives only. Through this DTH you do not do a two way communication you receive only.

There are some programs goes on in TV where interacting with the studio is taking place from a person and studio things are getting broadcasted, the events happening in the studio. Those interactions are done in telephone mode not through DTH, through other means of communication may not be always through satellite; so DTH is receive only. There could be something like I should say you are not very familiar it is called reporting or we can call automatic weather station or data collection platform, you can understand from the names.

Automatic weather station at different locations it may be inhabited or need not be inhabited. They say Himalayan places where the glaciers to be monitored or somewhere in the desert you are measuring some temperature, somewhere in a sea you measuring some other parameters or simply in different villages our meteorological department they have placed many such terminal which automatically measured, pressure, temperature, relative humidity, wind speed, wind direction, many other parameters. So, they are collected and reported to a central station may be at Indian Meteorological Department building at New Delhi. So, these terminals are AWS or data collection platform automatic weather station or data collection. It is one way, it is transmit only, some form of a reporting the data.

Generally other things which are they are that is our VSAT; very small aperture terminal which is there in our ATM, bank ATM's very near to bank ATM's I have mentioned earlier. So, this VSAT is very common which is transmitted and receive both way it transmits and receive. Similarly, the corresponding to VSAT larger stations are there which are Hub which are also transmit and receive. So, depending on the type of transmission whether receive only, transmit receive or transmit only are the types of groping can be made. Of course, that also will change the characteristic and the sizing of the earth station. If is receive only station DTH there is no transmit chain, so half the electronics is not there, `fire amplifier is not there, up convertor is not there, there is no uplink it is receive only. Whereas, in transmit only the receive chain is missing, so definitely the electronics is much simpler. And transmit receipt system has full ability to communicate so both transmit chain and receipt chain is there.

So, accordingly the sizing of the station its power a capability, the antenna sizing, the number of bits it is carry all this things will be wearing. Based on various ways you can define the ground station either in which environment and for what purpose it is being used and which way it is communicating that way.

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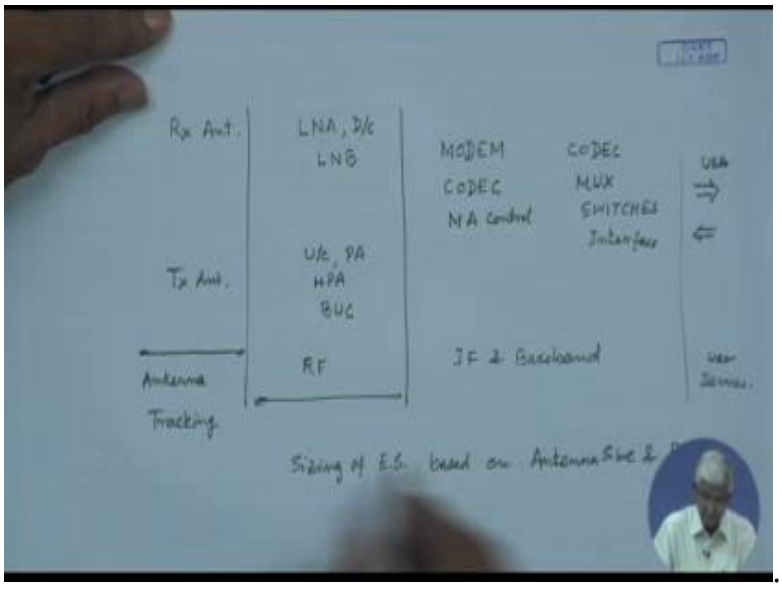

Let us go into little more inside the station; that is the electronics in the station. Obliviously, there is antenna so let us call there is a receive antenna. And then this receive antenna will go in to the RF section. So, first will be low noise amplifier we have

discussed earlier, then they are down conversion or combination of these two are called low noise block converter; LNB is another terminology they are using. Now after conversion you are in IF so at the IF level you do demodulation, so I will simply call modem. And of course there will be certain error correction, so there will be codec that is for error channel error correction. Then if there are multiple people are using so there could be multiple access control. And then after getting all the bits then if it was baseband compressed or decompressed like in TV it is done in (Refer Time: 11:35) it is done.

So, there are other types of codec which is the baseband coding and decoding which is compression and decompression takes place. And then there may be multiplex de-multiplex. There may be switches and the interface to the user, and it goes to the user terminal, it can be a TV, it can a simply a speaker, it can be a computer terminal, it can be a storage of computer or it can be connected to a land.

So, in similarly in the transmit side you have the other part that is the switches which are coming and then interfacing to the user and then you have this modulation, the coding, multiple access control etcetera. This side I can call baseband side and this side after this modulation you have the up converter and then power amplifier, in some cases it is high power amplifier depending on how much power you are transmitting. So, these are sometimes combined like LNA down concertize combined called LNB here it is called block up converter; BUC is another terminology. And then it goes to transmit antenna.

If we keep this antenna part separate though it is falling under RF we call this is the RF part and this is I can call IF and the baseband. If you come down to intermediate frequency or directly it can be demodulated. So, there we have the antenna. And in some of the case for geosynchronous satellite it may not be always required, but for other positions of the satellite or if you want to change from your operation from one satellite to another satellite you will have to move the antenna. So, there may be having some arrangement for tracking in some of the station is tracking is important you track. And if it is a low earth orbit satellite definitely you may have to track the antenna defending on what type of gain in the antenna is used.

So the antenna is a separate part, RF is a separate part, and IF and baseband is separate part and then it goes to the user devices. Now these sizing of the earth station is based, I

can call it a large station or small station based on the antenna size and the power amplifier size. Because, if I have to transmit a larger power the power amplifier is a diamantine unit out of all these things it draws heavy current. And all other things are electronically nowadays realize within a very very small area and small packages are used. Particularly these IF and baseband now a days are people are using processors GSB and sometimes defending on different applications are capacity they may use FEGA fascist. People use different form, but these are processor side using processor you can do all these things. And here the RF part you have to use separate. Nowadays even people are trying, but RF IC app started coming in but we can for the time we can assume that they are having separate transistors in power amplifier you will have sometimes higher power required then you go to tubes, it is STW treys are used and then the antenna.

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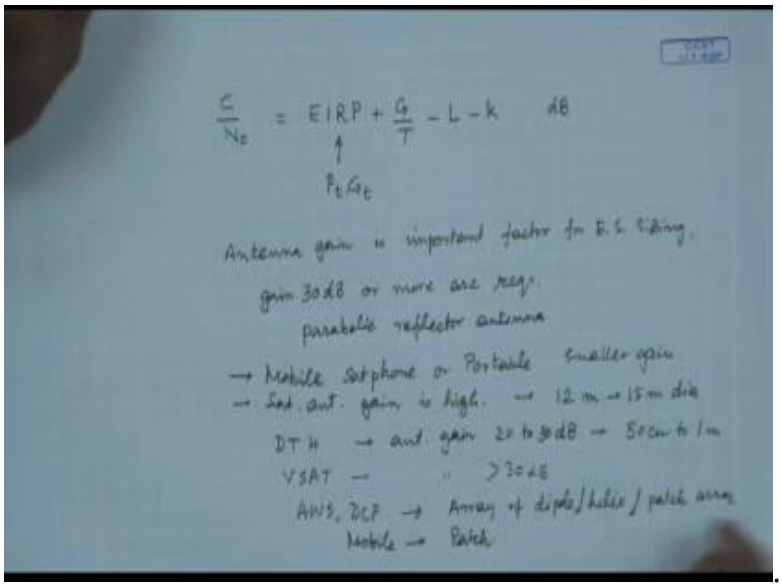

Now, will spend some time on the sizing of the antenna and how he comes to that. Let us go back to our original transmission equation that is C by N naught in dB is EIRP plus G by T minus the loses majority is the loss in the path minus the Boltzmann constant; this is in dB. Now this form of equation is true for uplink and downlink. When you are on the uplink from the ground station that is from earth to space when you are going then the C by N naught uplink will be defending on EIRP of the earth station.

What is EIRP? This is nothing but P t into G t, that power amplifier output including the freedom loss and then the gain of the transmitting antenna; G t is the gain of the transmitting antenna. And in case of uplink these G by T is for the satellite and uplink path loss and k. Similarly for the downlink these EIRP is the EIRP from the satellite and this G by T is G by T of the ground station.

Now you see in both uplink and downlink, the satellite as well as ground station have antenna that is being used. Now satellite antenna whether it is transmitting or receiving you cannot make it very large. Normally, there are two reasons; one is very large antenna if you try to deploy obviously, the way to live more so your launch cost is more is much more complex. So therefore, at this type of frequency like 10 gigahertz, 3 gigahertz and above people are using small or relatively smaller antenna of the dimension of about a meter and half diameter like that.

And then another reason is there. Depending on what type of business your satellite proprietor is doing; say yes all over India it is to be covered, so all over India if you want to cover with one single beam then the gain will be relatively less instead of focusing a beam over a particular region of India. So therefore, if the gain is less antenna diameter will be smaller. So, for defending on the service requirement as well as the cost requirement the satellite antennas are selected and generally it is of the order of 1.1 meter, 21.5 meter maximum 2 meter at these macro frequencies.

Since, the satellite antenna is gains both transmit and receive is relatively smaller. So, it becomes critical for the ground antenna because when you are having a G by T of the satellite these G is a satellite antenna gain which let us say it is relatively lower. So, the ground antenna EIRP or ground terminal EIRP which include the ground antenna G t its gain as to be high, similarly when it is receiving the gain of the ground antenna has to be higher to have a better G by T. So, the antenna gain is important factor for a station sizing.

Now generally it has been seemed when we do the link calculation we have done some of the link calculation and we have seen of the order of gain of order of 30 dB or more are required. At this type of frequency of operation 30 dB or more you need parabolic reflected antenna. It can be realized with array antenna or many other combination, but cost wise and handling wise it is become popular so parabolic reflected antenna.

Wherever we are drawing the sketches we might have seen we are drawing a small parabola. For satellite communication parabolic antenna is very very popular antenna.

But that does not means that smaller antennas cannot be used like, mobile, satellite phones, or portable phones, portable satellite terminals they have a smaller gain let us say of the order of it will much much smaller of the order of 15 dB or 20 dB or even sometimes much smaller than that. Now, for this purpose the satellite antenna gains as to be high. Therefore, if you remember in our introductory class I have shown some of the pictures of the large antenna deployed system of the order of 12 meter to 15 meter dia antenna by inverse (Refer Time: 22:02) their couple of pictures that was shown. So those are very large antenna, very specific purpose mainly to provide the service to ground system which as very small antenna gains. But generally we are talking about DTH and VSAT where the for the terminal say let us say DTH antenna gain is much lower of the order of 20 to 30 dB so the sizing is 50 centimeter to 1 meter; sometimes lower than 50 centimeter is available.

For the other group that is VSAT; very small aperture terminal the antenna gain is of the order of 30 dB or greater than 30 dB. Of course, there are other antennas which are used by AWS and DCP they do not parabola they use array of dipole or helix or sometime micro script patchary. For sat for mobiles is simply patch antenna; simply patch sometimes it is used. So, these are the different types of small antennas and sizing of the antenna that comes because of our C by N relation where the antenna gain is important factor.

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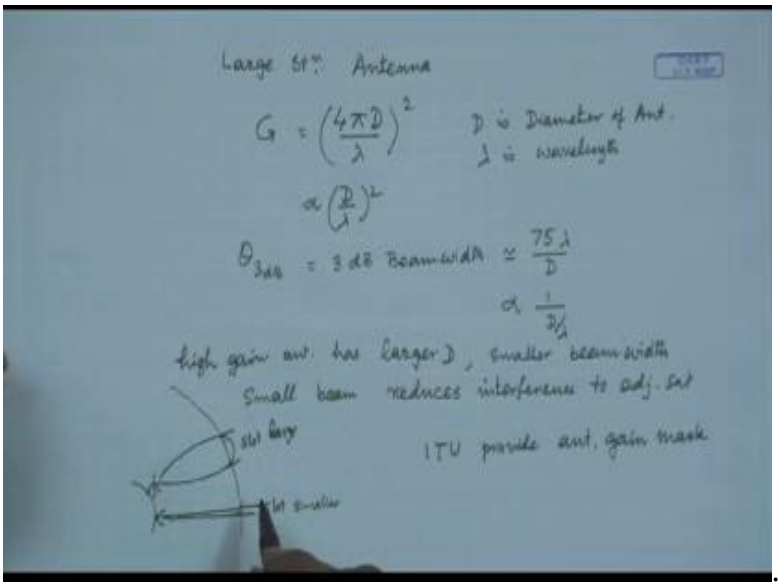

Now, let us look at the larger station antenna. We remember these relation gain is 4 pi D by lambda square. Where, D is diameter of parabolic antenna and lambda is wavelength for that particular frequency of operation. That means, you can say it is proportional to D by lambda whole square. Then there is something which is the beam width, we called theta 3 dB that is 3 dB beam width which approximately we stated that it is 75 lambda by D or I can say it is proportional to 1 by D by lambda. One interesting thing what we see that high gain antenna has larger D diameter and smaller beam width. And then one thing is important the small beam how it comes as a advantage, small beam that is smaller theta 3 dB has reduces the interference to adjacent satellite. Like you have the ground on that you have antenna and you have the geosynchronous arc on which you have a beam like this. So your satellite slot, the orbital slot is this many degree. Otherwise if you put another satellite it will start interfering if it is operating on the same bandwidth.

Let us say another antenna is larger antenna it is having a smaller beam width so the operating slot is smaller, this slot is larger. So therefore, the beam width decides how much interference that can take place. For this reason international telecommunication union as provide the antenna gain mask that has to be use so that the number of satellites can be increased in these 360 degree arc.

So, let us stop here will continue our discussion in the next period on this ground segment particularly the ground segment antenna.

Thank you.