Satellite Communication Systems
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Lecture - 05
Orbit – 04

Welcome back. So, we were continuing your discussion on Orbit and in the last session we talked about how to rise the Orbits using thrusters at apogee and perigee and if it is not launched from the equator location then how to correct the inclination and ditch to Geostationary Orbits. Now at Geostationary Orbit also we have seen certain perturbation due to the other bodies and due to our assumptions which initially we had taken for Orbit and for that certain corrections are necessary.

Orbital corrections are necessary and satellite for that we have to spend some fuel and we have estimated at some fuel should be left that when the fuels are exhausted a electronics maybe be live and it will be communicating will disturb others and the Orbit will be slowly drifting in East, West and North, South. Therefore, it will have interference to other operating satellite therefore, it is d Orbited that is it is put in a different Orbit using that extra last amount of fuel and that is the end of the satellite life that is how we define though the electronics of satellite are routed.

Now, let us see at this Geostationary Orbit what are the effects that we have to consider for our communication.

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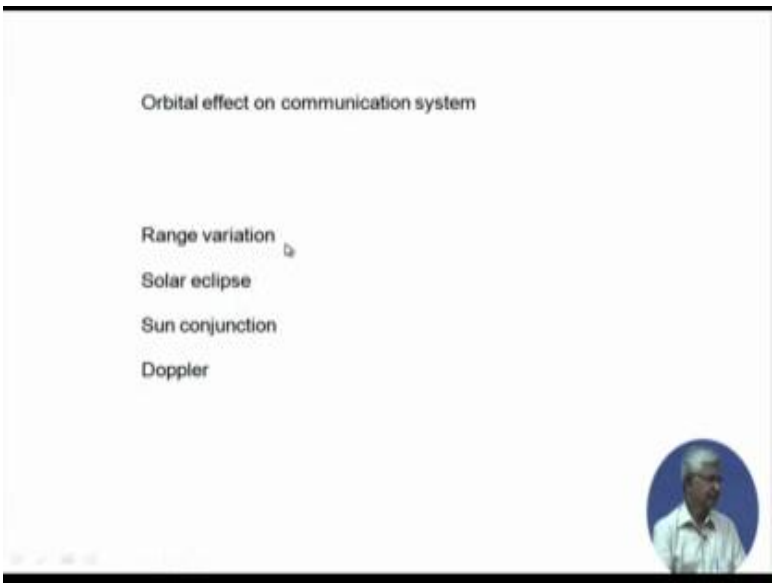

Let us look at these some of them I listed here that is effect on the communication system by tradition in the range that is the distance d on the observer is earth station to the satellite. There is some effect on the solar eclipse, there is some effect on some conjunction, some effect on the plan, many other it is four I have just picked up let us see each one.

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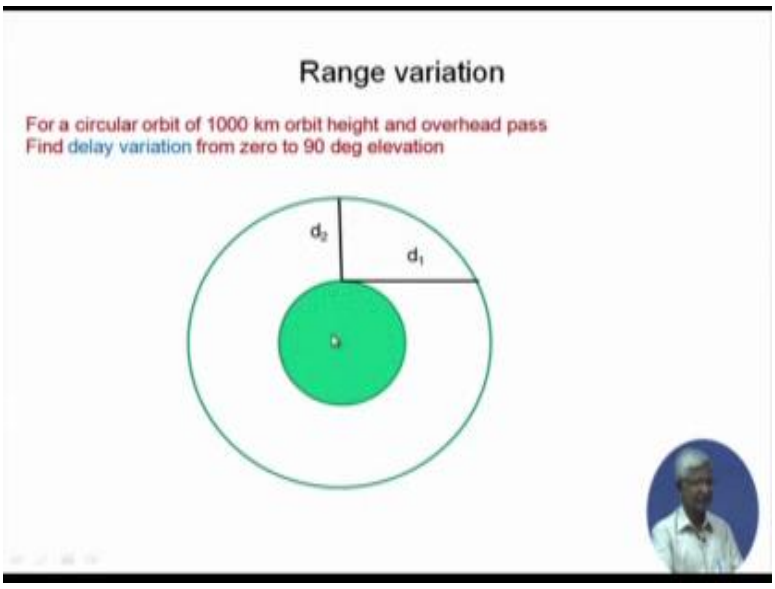

Simple geometry is a circular Orbit 1000 kilometer Orbit height and there is a overhead pass. You can find that for a observer here what will be the distance when the satellite's overhead or when the satellite is rising let us see its rising its going in this direction so; that means, 0 degree inclination elevation or 90 degree elevation. If it is 1000 kilometer Orbit height and assume earth as a sphere and as we were talking about 6378 kilometer as the earth has spherical radiation you can calculate what will be the distance.

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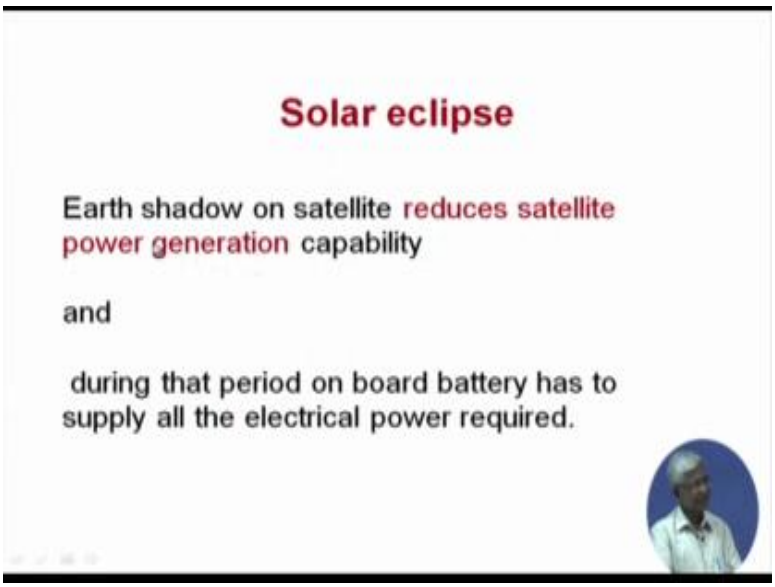

The other thing is solar eclipse that is earth shadow on the satellite that will reduce the satellite power generation and during the period the battery on board has to be used to supply all the power to the electrical circuits (Refer Time:03:43) circuits which are onboard.

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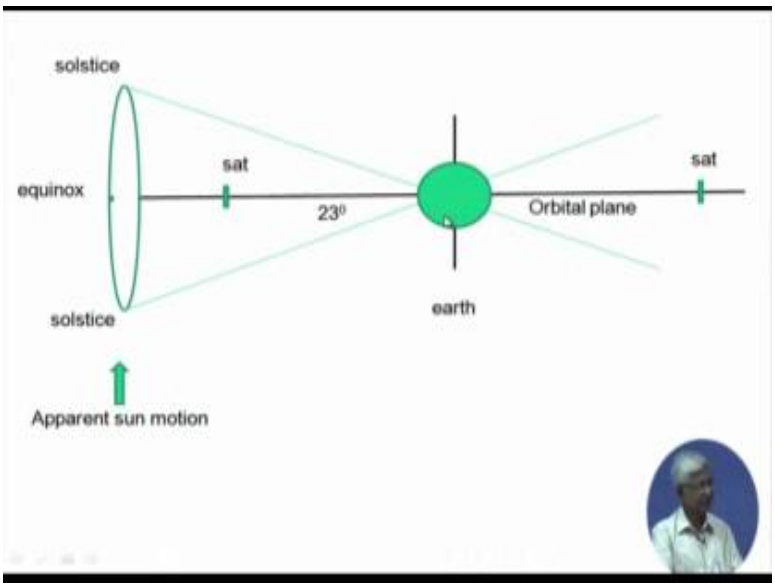

That is look at it, look at this geometry, that is assume that this is earth and though earth is rotating around the sun and this is the Orbital spin which is pictorial plane and satellite is here. We have seen that it makes 23 degree angle with the earth Orbiting plane on around the sun if we can draw it differently you can see that as if sun is apparently moving north and south over the year. So, wind is going to the extreme north is one summer solstice and extreme south winter solstice and when it is on the equator same plane it is called Equinox.

You can see from northern hemisphere these are the summer period this is the winter periods the sun go south, but then the earth shadow also will be moving over the period that is year as sun goes to the earth shadow will be towards this plane which is away from the Orbital plane. So, therefore, earth shadow will not fall in the satellite, when the earth shadow will fall on the satellite, when it is near Equinox.

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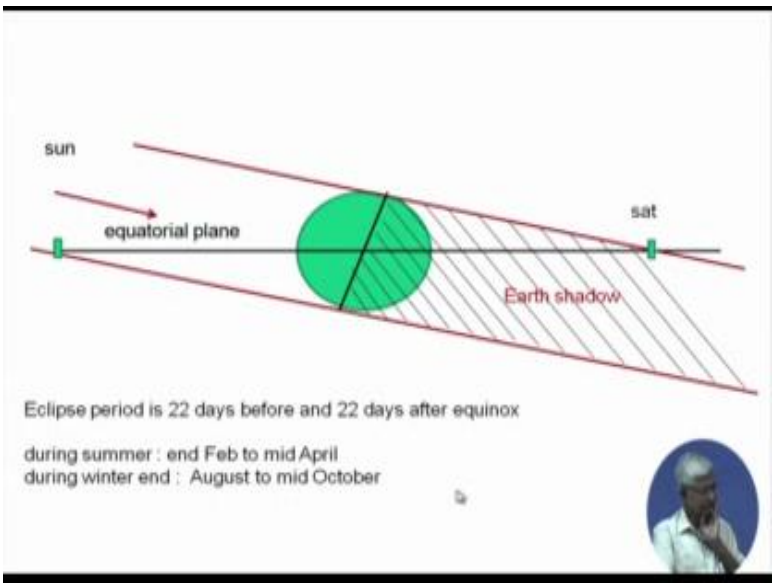

Let us add drawn another picture where the satellite is shown here and this is the equatorial plane and sun is come on the solstice coming towards equinox. At some points of the year, some day of the year the shadow of the earth will start falling on the satellite. And that will happen some times in the night is not it that is this side those who are communicating with the satellite for them this is the night and then sun is further going down and down. So, every day towards the night the satellite will be shadowed by earth for some period of time. It is been seen that this eclipse period the earth shadow falling on the satellite is 22 days before and 22 days after equinox roughly these are all rough numbers.

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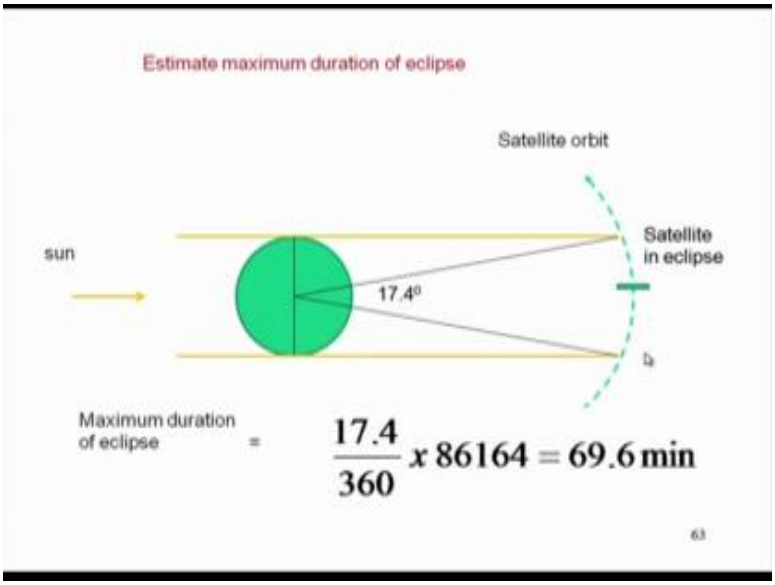

And it happens end of February to mid April during summer and during winter the other direction also seen nothing will happen August to mid October roughly and the at the middle of the time sun shadow as the earth shadow is fully covering the satellite at the mid of the night and how long this duration a shadow will remain on the satellite during the night. When the sun earth center and the satellite are on the same, same line you have seen the other session the calculation that is satellite to earth this angle visibility angle was 17.4 degree. By this figure u can make out that the same from the center of the earth same 17.4 degree will cover from here to here that is the shadow period.

So, as the earth rotates the satellite also rotates like this. So, what is this duration that is the fraction of 360 degree 17.4 degree fraction of 360 degree. So, maximum duration of the eclipse is 17.4 by 360 and the earth is revolving one sidereal day 86164 seconds in terms of minute it be roughly about seventy minutes. So, for 17 minutes period in the night of during those days when the sun earth shadow full falls on satellite, this is the duration during which the satellite will not get sun and solar panels will not able to generate electricity during this period it has to operate on battery. So, power system and satellite will come into picture.

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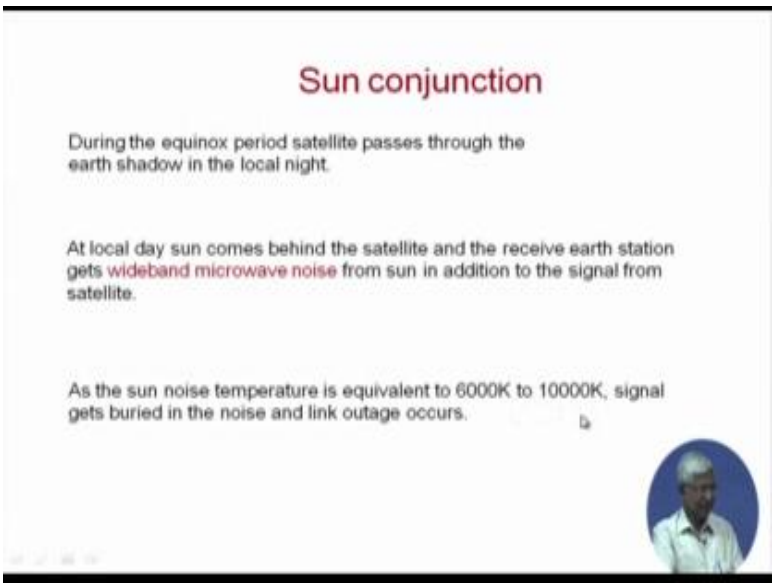

The other side that is when the day time this sun is behind the satellite just imagine, this was earth was between satellite and the sun. And in the day time in the same period of the year the sun conjunction takes place, which is that local day sun comes behind the satellite and the receive earth station gets a very wide band microwave noise which is generated by the sun in addition to the signal generated by the satellite. So, that noise will vary the signal this sun noise temperature is roughly about 6000K to 10000K rough numbers, single gets buried in the noise now this can be calculated how much it is.

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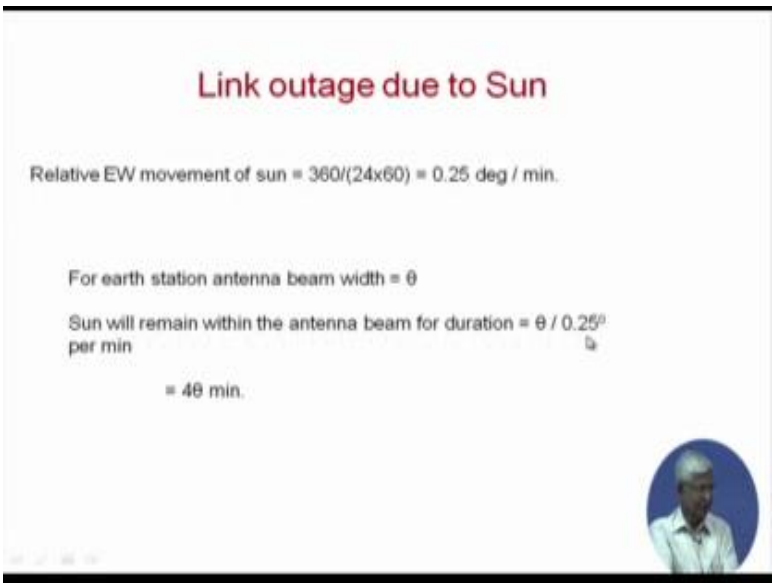

And during that time the link will be out. What is the time? It is relative movement that is east west movement of sun is 360 degree by 24 hours 60 minutes which is 0.25 degree per minutes as if sun is moving actually earth is moving. And if the satellite earth station antennas beam width is theta. So, sun will remain within the antenna beam for the duration theta by 0.25 degree per minutes and that is 4 theta minute.

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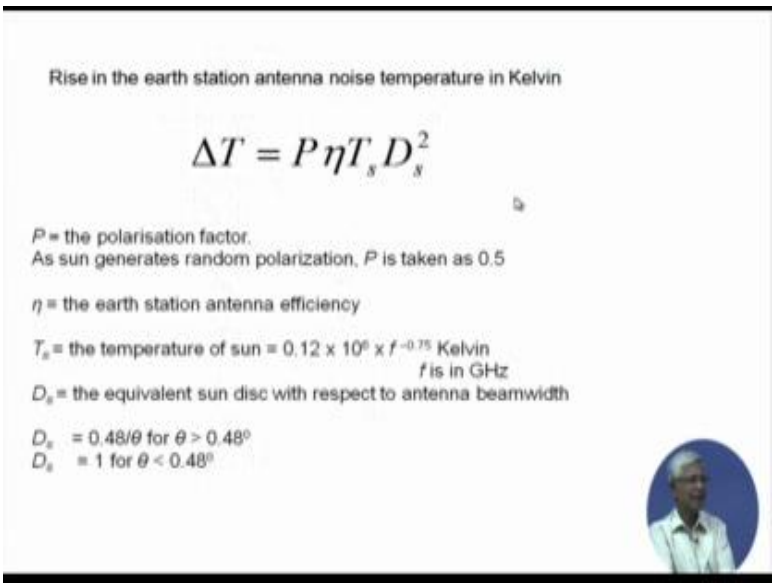

And the temperature is expressed in a formula like this that is delta T is equal to pn theta and Ts and Ds square each is expended, p is a polarization factor.

Now, this is a new terminology polarization those who are familiar with the RF they will know what is polarization. Is the electrical field vector and since this is generated in randomly an antenna is pointing to one particular electrical field vector. This is assumed that 0.5 values is taken, it may not be aligned with the noise which is coming. So, 0.5 value is taken it has the efficiency of the antenna. And Ts is the temperature of the sun which is depending on different frequency, roughly a model is given 0.12 will deliver 6 f to the power minus 0.75, where f is in gigahertz and Ds is the equivalent sun disc with respect to antenna beam width theta that is Ds is 0.48 by theta for theta is equal to greater than 0.48 degree and 1 for theta equal to less than 0.48 degree. These are some rough numbers. So, on this basis some calculation of the temperature can be made.

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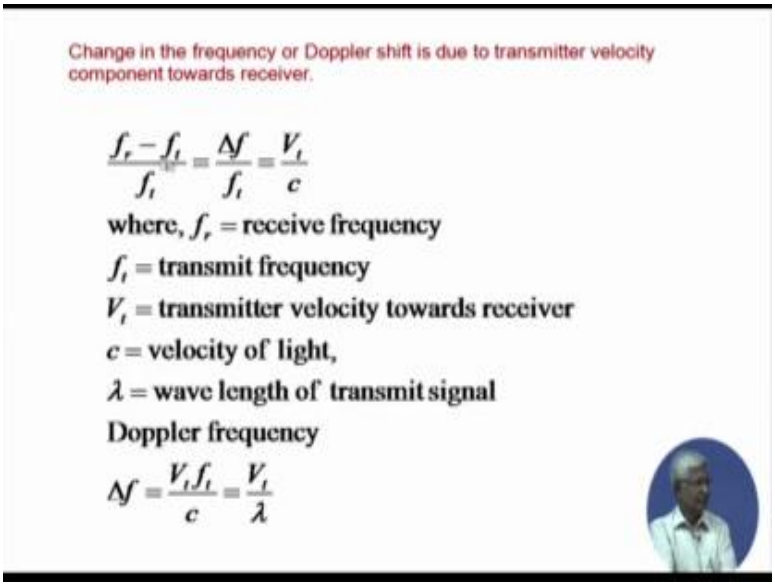

There is another phenomena which is called the frequency or Doppler shift. That is due to transmitter velocity component towards the receiver. All of us know that is the difference of the frequency that is transmit frequency and a the actually the change in frequency that is delta f by the transmit frequency is a velocity towards the receiver,

transmitter velocity towards the receiver by the velocity of light, and you can put it in terms of lambda also that is the delta f is Vt, ft by c or Vt by lambda.

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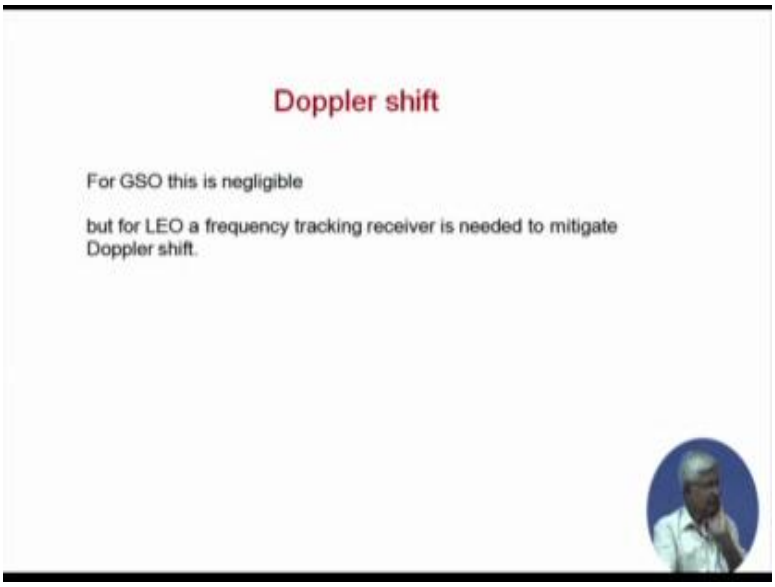

Now, this Doppler shift is for GSO it is negligible for low watt Orbit satellite frequency tracking receiver is needed to mitigate this Doppler shift. So, with the very briefly speaking .We have seen there is for different Orbital the different Orbital effect all communication system can be listed like this that is the range variation (Refer Time: 13:00) which will affect the time it is important in the communication system when we talk about the multiple access particularly time division multiple excess that is many people are trying to access the satellite resource and each persons. So, that they should not interfere with each other allotted different times and; that means, their signal should reach the satellite at the allotted time.

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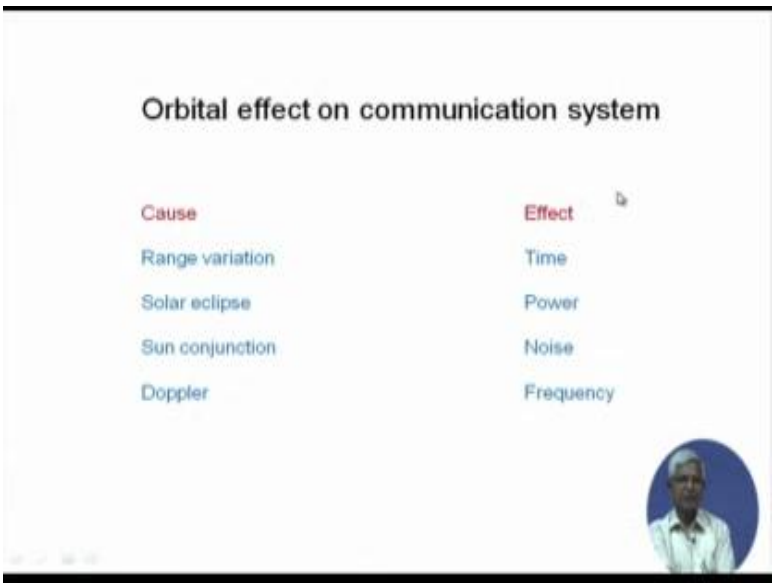

Now, as the distance from the transmitting stations to the satellite varies, the signal will reach may not able to reach in the allotted time. So, that adjustment is very very important. Also we will see much later that this physical variation of the time can create the delay in the reception of the signal and whether the signal is received correctly or not will be seen by the acknowledgment of the signal from the receiver and as this delay varies there is technique called re transmission on positive acknowledgment on non reception of positive acknowledgment.

So, that re transmission time varies we will see in the satellite channel effect or higher layer there is on TCP layer. This range variation can create a major problems will do the calculations later. So, you see the range variation to the effected which is effecting as a time is in terms of TDMA and higher layer effect that will come.

The other one is the solar eclipse we have seen that earth shadows falls on the satellite. So, the power generation is reduced it is not only the power generation, the thermal imbalance also takes place when the satellite is one side is exposed to the sun that side is having some temperature. Other side is having much more temperature. Temperature gradient is different; when the shadow falls the temperature also changes. So, there is a double effect one is the battery has to take over during that time and second is the

thermal imbalance, the solar eclipse creates a problem and of course, initial days satellite which were not able to carry highly efficient and large amount of battery. Many of the amplifiers used to be switched off. Fortunately these was happens during the midnight time around midnight time. Earlier days television and maybe other communication were not taken at the local mid night time, but nowadays is all 24 hour service. So, therefore, this is very important and larger sizes of battery are launched along with the satellite to take care about this solar eclipse.

The opposite effect is in the same time of the year, the day time, moon time the noise falls on the on the receiver if it is in line with the with the satellite and sun. Moon time it depends on the time period and again deploy at I have tried a different sizing of the antenna because it depends on the beam width of the antenna. If it is a large station beam width is smaller you we have seen that effect will be more it can be calculated using that formula, what I say I shown you that with different beam width of the antenna how the noise there is quite particular frequency range.

Then of course, the Doppler that for Geostationary satellite the Doppler effect is much less. Though we have seen that for station keeping within the station keeping box the satellite moves here and there, and for very high bit rate communication where the bit duration is less than micro second, let us see 100 mega bits per second or 120,150 mega bits per second when its being communicated bit duration is very small. So, therefore, that drifts of the satellite that has some effect on synchronization. So, that is in GSO, though it is not much effecting because very few communications takes place at very high bit rate, but for low earth bit satellite this is important because the Doppler has a some effect off course it depends on the frequency we you should able to do some calculation on based on different frequency and different Orbital height of that in the text books like in the practice on the calculations are given there.

So, these are very briefly some of the Orbital effect on the communication system. So, till now let us recollect what are the things we have seen, what was covered is from the beginning in this four sessions we have covered the Orbital period, the velocity and the Orbit height, their relations in the circular Orbit in the electrical Orbit and also how to find the location of the satellite and based on very commonly used term for

geosynchronous satellite defining that latitude longitude as a sub satellite point as a satellite location. Though in actual coordinated will be much different, the visibility of the satellite from the earth station is calculated and we have seen that how to calculate that elevation and azimuth angle and also we have seen how to calculate the distance from the earth station to the satellite, which is very important to us.

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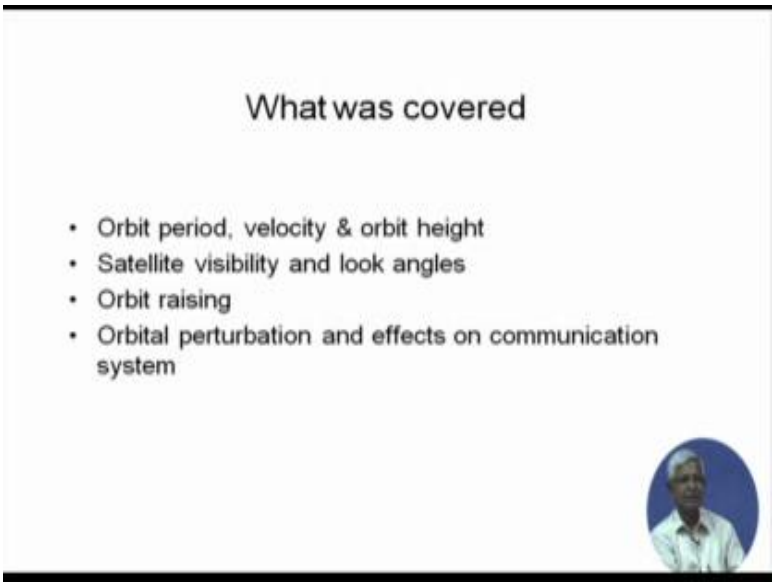

We have all seen that how this Geostationary Orbit is achieved by initially putting into parking Orbit and by giving different thrust to put from parking Orbit to Geosynchronous Transfer Orbit and then from Geosynchronous Transfer Orbit to the geosynchronous Transfer which is electrical Orbit at to Geostationary or Geosynchronous Orbit which is a circular Orbit. So, these incremental velocities we have done with a rough I mean with some rough calculation.

And then also we have seen that as Geostationary Orbit is supposed to be zero inclination with Orbital plane with the pictorial plane and in real life may not able to launch from the equatorial plane the launch sites are at though they are near equator, they are away from the equator. So, this launch latitude and their azimuth angle of the launch. These are related to put into different inclination of the satellite Orbit and how to correct that

inclination to the GEO stationary Orbit inclination that expression we have derived and we have seen that.

Then subsequently we have seen what are the different perturbation that takes place in the GEO stationary Orbit particularly and lower the Orbit in some cases. That is basis of the assumption what we had initially the earth is a sphere and there is no other body around forces acting are on then accept earth and satellite nothing else is there. Though in real life earth is not sphere its density is not same and it has a different gravitation force at different location. So, therefore, certain stable and unstable points are there in the Geostationary Orbit and the effect of this perturbation any perturbation on the Geostationary Orbit will trip the satellite in East West direction which needs to be corrected.

Similarly, sun and the moon is also not in line with the earth equatorial plane where Geostationary satellites are put. So, therefore, the gravitational force acting on the satellite by moon and sun varies depending on the day on the particular time therefore, the effect of that on the Geostationary Orbit is northward or southward pull of the satellite. So, these called North South movement and this perturbation is to be corrected otherwise many satellites are possible to place in Geostationary Orbit which will start drifting and the signals will start interfering. Remember that they may not physically collide because the distance is there are very large in kilometers and satellite size is very small few meters square, but the signals will collide.

So, therefore, there will be lot of interference to avoid the interference the international bodies like international telecommunication union, they have defined that satellites to be kept within a particular area or particular volume which is called Station Keeping box. Brief descriptions on the station keeping box for different frequencies are given, why different frequencies, at difference frequencies difference lambda will be there. So, it is given in terms of angles you can calculate the distances of that, but these are very approximates and the operator satellite operators they try to keep within the station keeping box for that particular satellite, allotted satellite and for that they have to based on east west and north south movement of the satellite they correct by firing from the opposite direction the thrusters and keep the satellite within that.

And if the satellite in the low earth Orbit then there will be lot of perturbation on the satellite because of the atmospheric drag, I forgot to mention that there is a solar radiation pressure that comes under satellite in addition to the generation of the electricity provide the pressure on the surface which is facing to the to the sun particular to the larger surface which is solar panel. So, because of that there will be there are some movements and we will see during the space craft discussion the solar panels are north south oriented with respect to earth.

So, therefore, say north south tilt will be there and that also has to be corrected, for a new earth Orbit satellite the atmosphere will start effecting, though the satellite are not Orbited in dense atmosphere that is roughly about 800 kilometer. So, satellites are kept normally at higher than that that is 1000 kilometer, but lower or Orbit satellites lower then that can create hit over the satellite and on the satellite and burn. So, therefore, this atmosphere drag they change the satellite Orbit height and slowly it drifts down.

In addition to that that movement of the satellite we have seen that there are many communication effects on the communication system on the satellite. All of them is delayed, depending on the position of the satellite for GEO station satellite delay will be same for a fixed station for low earth Orbit satellite it will be varying, but for mobile station of course, the delay will be varying both the cases and then there is a this power generation problem, when the shadow of the earth comes on the satellite then there is a noise problem when the sound is behind the satellite is happens at particular time of the year and of course, for a low earth Orbit satellite because of its movement speed with respect to the observer or the user on the earth will be some Doppler effect and that is to be corrected for our communication system.

So, these are briefly we have talked about during our Orbit a topics. In the books referred books like (Refer Time: 27:00) and many others at there - Orbital much more details are there derivations are available you can go through them. Our interest is for you to know the knowledge of the communication system effect on the Orbit.

With this we close this particular topic and we will go into next session into the space segment what is there inside the inside the satellite that we will discus and mostly we will concentrate on the communication part of this Space Segment.

Thank you very much for listening, I will give you some assignments and based on whatever we have discussed here, use your intelligence and try to answer to this assignments.

Thank you very much.