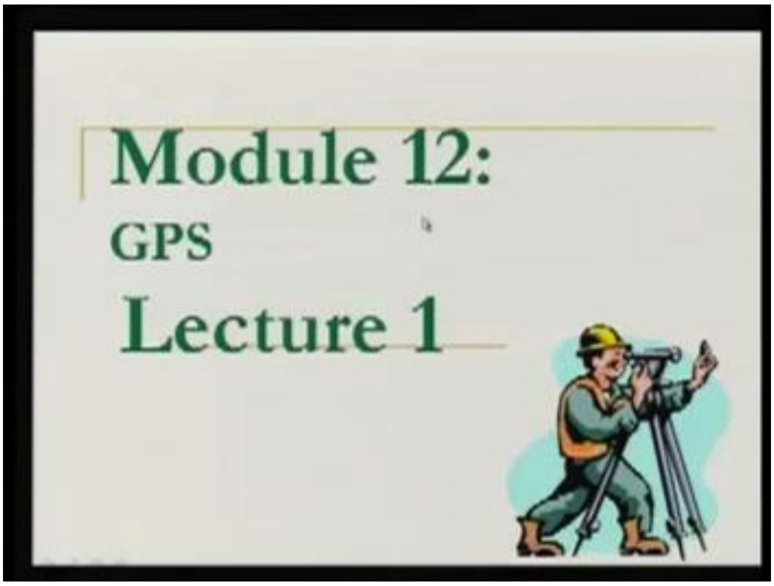
Surveying
Prof. Bharat Lohani
Department of Civil Engineering
Indian Institute of Technology, Kanpur

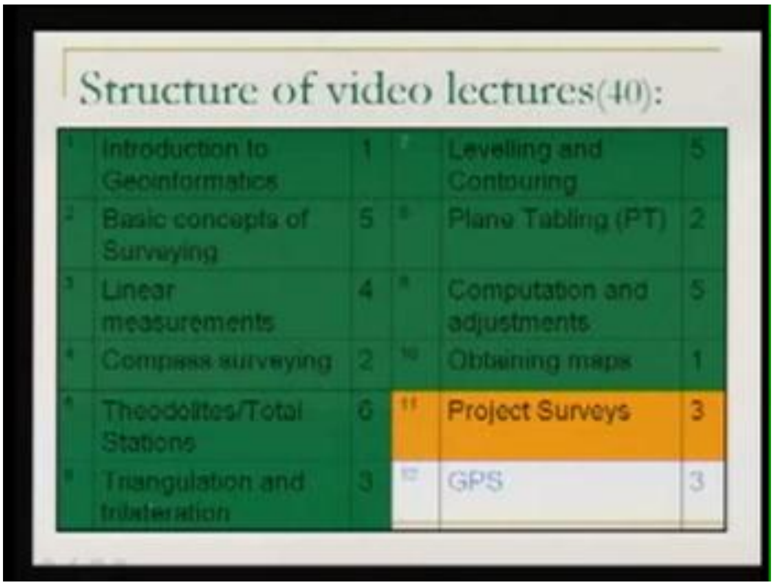
Module - 12
Lecture - 1
Global Positioning System

(Refer Slide Time: 00:20)



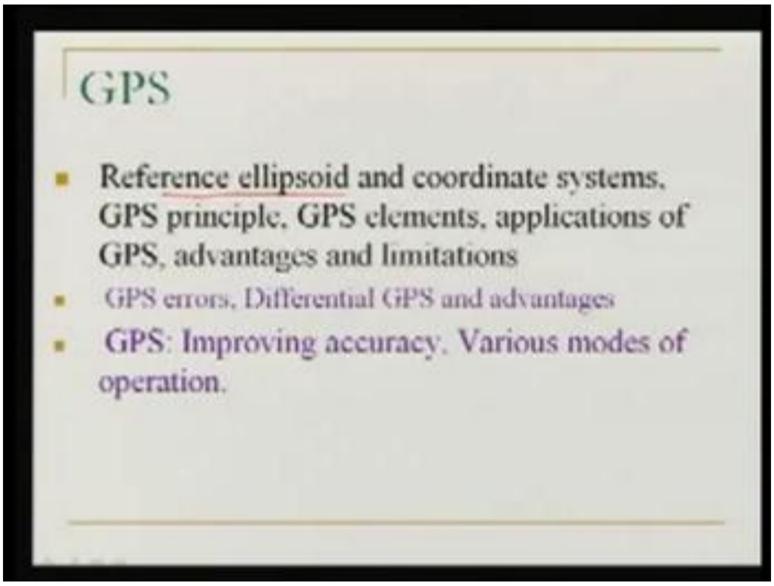
Welcome to this video lecture on basic surveying. Now, today we are in module 12. We are starting our new module now and this is the module on GPS. So, we begin with our lecture number 1.

(Refer Slide Time: 00:39)



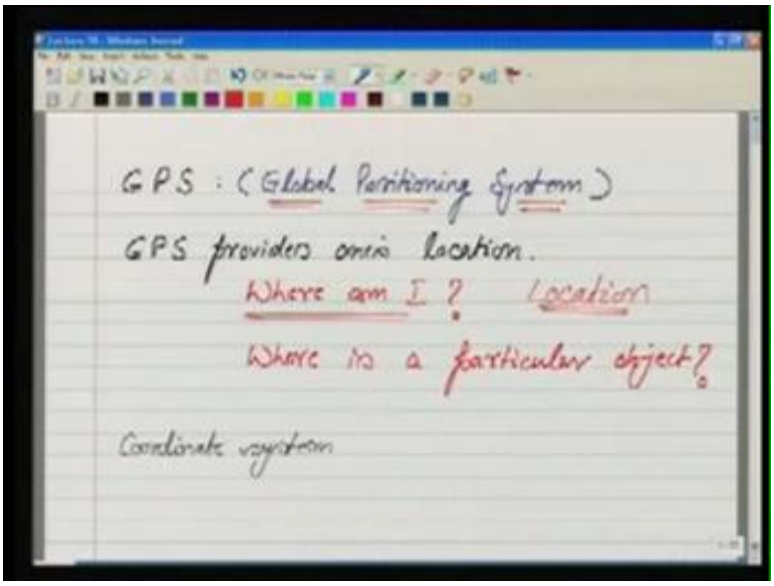
And, this is the entire course structure that we are talking here covered in this video lecture series. So, we have already completed project surveys, and also all these have been completed now. At the moment, we are in the last module of this and we will complete this module in 3 lectures.

(Refer Slide Time: 01:03)



Well, in GPS, in our first lecture today we will be talking about reference ellipsoid. Because in talking about the GPS we should know about the reference ellipsoid. Because the GPS observes or measures the coordinates using one ellipsoid and then a little bit about coordinate system. Then we will be looking in to the principle, the elements applications of GPS and advantages and disadvantages of it. So, we begin with the GPS now GPS stands for Global positioning system.

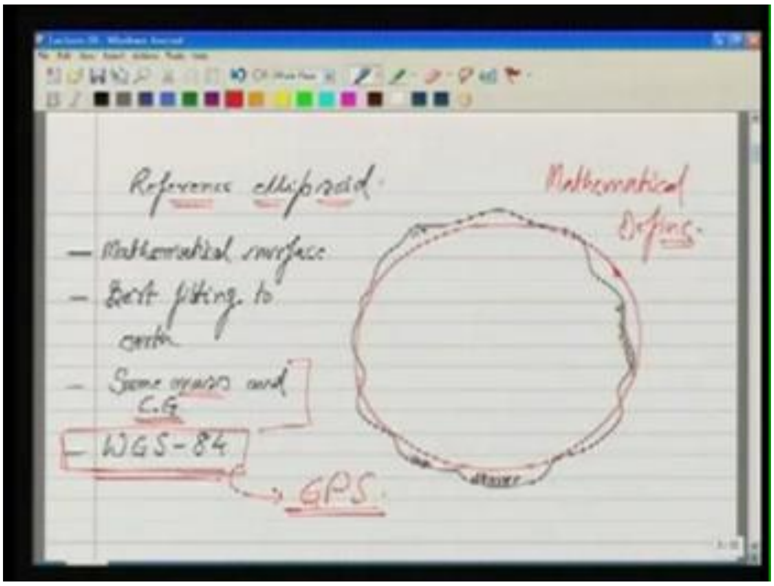
(Refer Slide Time: 01:46)



Now, if you look into this what is the meaning of this term global positioning system? It means, GPS can help us wherever we are over the globe to locate our position. Now, when we say position the meaning is with reference to something you know which need to define a coordinate system and is the position in that coordinate system. So, basically GPS makes use of satellites. And if this is our Earth the satellites are orbiting the Earth at certain altitude, and using these satellites which are spread over around the Earth. Anywhere wherever we can go there on the surface of the Earth we can know our position. So, this position is really very important, because this question the question that where am I the location.

Location is now a very important parameter many of our modern applications. We will see later on what kind of applications we need the location, where I am or wherever we are going with the GPS it will give me that particular location. So, location means as we are saying the coordinate system. So, before we go into the principle of GPS. We would like to see about these coordinate systems. This is important unlike in the surveying, because in the case of the surveying and engineering surveying. So far we just discussed somewhere geodetic survey. But mostly in engineering surveys we can consider our coordinate system to be a local coordinate system. Unless the project is very large and in that local coordinate system we can carry out all our measurements all our setting out.

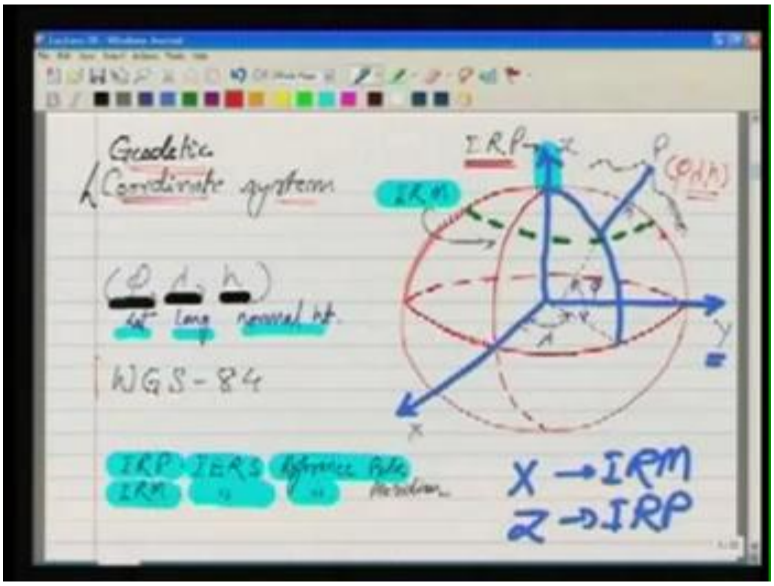
(Refer Slide Time: 03:54)



Over here in the case of the GPS for coordinate system, we would like to define a reference ellipsoid. Now, what is this? I will highlight the surface of the Earth of this brown colour is the surface of the Earth. And it is of course, we know undulating because it is undulating we cannot represent this mathematically. So, we cannot use this as a reference surface, because it is not a mathematical surface. And instead of this, what we do? We fit for example; here we fit an ellipsoid to the Earth, because Earth is slightly oblique. Oblique means it is not spherical from the poles it is slightly pressed, because it is pressed from the poles we say it is slightly oblique This is why we are using an ellipsoid in order to represent the earth.

So, what we are doing on that undulating Earth? We are fitting an ellipsoid, which is the best fitting ellipsoid to it. So, let us say this red line here is the ellipsoid. And we say this is the reference ellipsoid because this is an ellipsoid is a mathematical surface and we can define it using its parameters. Now, it is attempted that for this reference ellipsoid its mass and centre gravity are same as in the case of the earth. One similar ellipsoid is WGS 84 and this is the one, which is used by GPS for measuring the coordinates. Well, how this reference ellipsoid is helping in measuring the coordinates. Let us look at that.

(Refer Slide Time: 05:59)



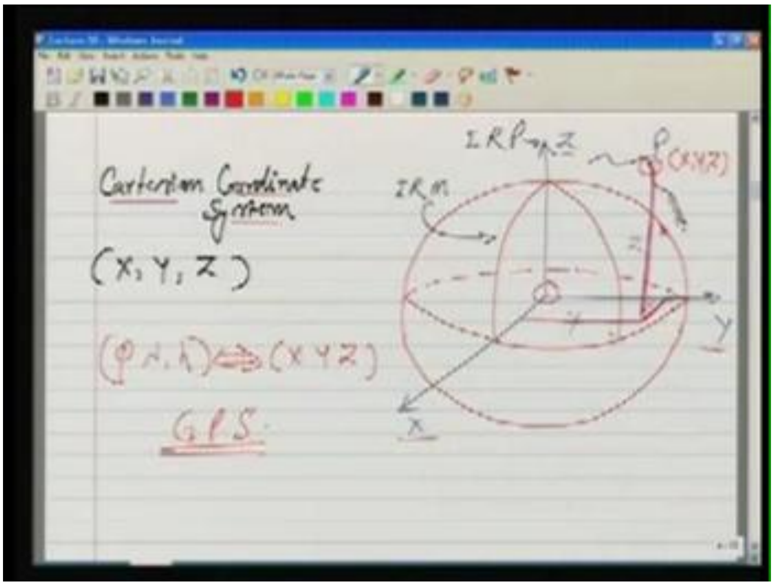
So, we are defining now a system which is called geodetic coordinate system. In this geodetic coordinate system the same ellipsoid what we saw in our last slide here over here the same ellipsoid I am showing now here and this is the surface of the earth. A point on the surface of the Earth can be represented in this reference ellipsoid in terms of as we have written over here phi, lambda and h. What are these? Phi, lambda and h are this is the latitude and this is longitude and this is the normal height. What is this? Let us define here now in the figure. So, if I on the reference ellipsoid this is reference ellipsoid and that is the equatorial plane. That is the equatorial plane of the reference ellipsoid and that is the other side and that is why shown by dots. Now, over here, this particular direction is we say IRP. IRP stands for IERS. IERS is International Earth Rotation Service reference pole.

So, you can consider this direction as a reference pole. A reference direction, which had been established by IERS also over here we have a meridian. If you look at this meridian and it will go further down, because it is a full circle now this meridian is also called IRM. IRM stands for again IERS Reference Meridian. So, this is also a fixed meridian this particular meridian is also fixed. So, what we are trying to do? We are trying to define the coordinate system and the coordinate system now which is being defined is first of all, I will draw it a bit thick in the same colour. So, that is the direction of IRP. IRP means the reference pole and there is another axis which is we say we say X Y and Z.

So, basically X is fixed it is IRM and Z is fixed, because it is along IRP. Then the position of Y is defined automatically because this is a right handed coordinate system. Now, in this any point P this is on the surface of the Earth from this point P we can draw a perpendicular or normal on to the surface of the ellipsoid. So, this we say normal. Now, corresponding to this point we will have a meridian. So, this is the meridian corresponding to that foot of the normal and this particular meridian will make some angle with the reference meridian. So, this angle we say lambda.

So, this lambda I have shown over here. So, this is the longitude at the same time this particular point P the foot of it we will make because we I can draw a latitude here. So, this angle is the latitude. So, this particular point the foot of the perpendicular is being defined now in terms of phi latitude and lambda is longitude as well as the point P the coordinates of point P can be written now as phi lambda and h. So, this is the way we represent geodetic coordinate system. So, we know our WGS 84 which is used by GPS is also a similar system and in case of WGS 84 we know the parameters of the reference ellipsoid and GPS makes use of this. So, one system of representing the coordinates is phi lambda h the another one is by Cartesian coordinate system.

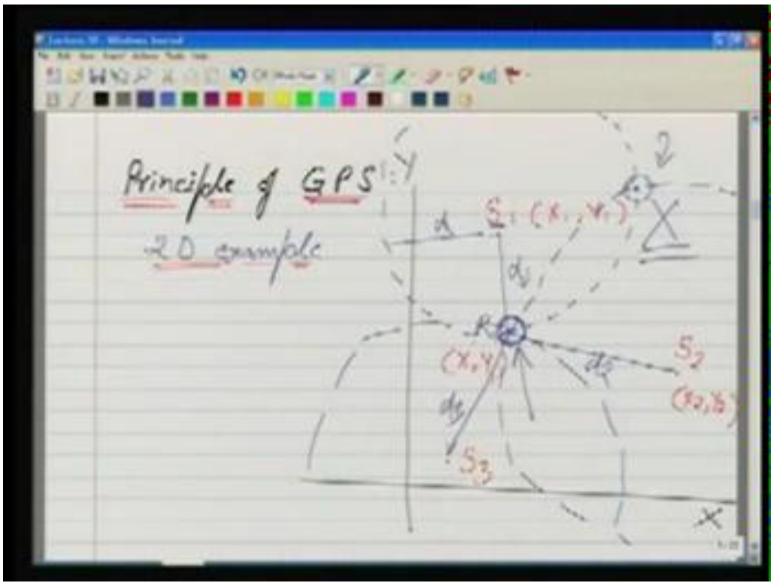
(Refer Slide Time: 11:20)



Now, what is there in this system again at the centre of this ellipsoid we have the horizon here. Now, similarly as we saw in our last slide we have defined X Y and Z. Now, for a point P we can also define the Cartesian coordinates as X Y Z while where X is this and this is Y and Z is the distance from equatorial plane that is the Z. Now, the phi lambda h and X Y Z we can determine one from the other. So, basically the GPS the very first measurement what the GPS will give us will be in the WGS 84 coordinate system. And the coordinate means with reference to this geocentric coordinate system either as X Y Z or as phi lambda and h. It gives me the coordinate of any point on the surface of the Earth.

So, henceforth whenever we are talking about the position given by GPS we mean either of these 2. And these 2 are we can transform you know we can get the one from the other. So, in any format we can write the coordinate which is being given by the GPS. So, this is important in order to understand GPS we should keep in our mind that yes there is a coordinate system sitting at the centre of the Earth mass centre. And with reference to that particular coordinate system we know how we defined it Z was towards the IRP and X was towards the IRM and then it is a right handed coordinate system. This is how it has been defined well having done this. Now, we will go for principle of GPS.

(Refer Slide Time: 13:27)



How do the GPS work? Because so, far what we understand in the case of the GPS on the surface of the Earth we are standing somewhere with a receiver. What is a receiver? Receiver is a small device, which can receive signals from the satellites then we have several satellites which are orbiting the Earth. Now, this is receiver has you know the ability that can measure the distance. It is capable of measuring the distance from the satellite to the receiver we will see in a moment how. So, the receiver can measure the distance from itself to the satellite and not only one satellite. It can measure the distance to multiple satellites by making use of these distances. It is possible that we can determine this particular position, because in this coordinate system the coordinate system which we just defined in the same coordinate system our satellites are also positioned. At any moment we know where the satellite is exactly in that particular coordinate system. Well, having said that...

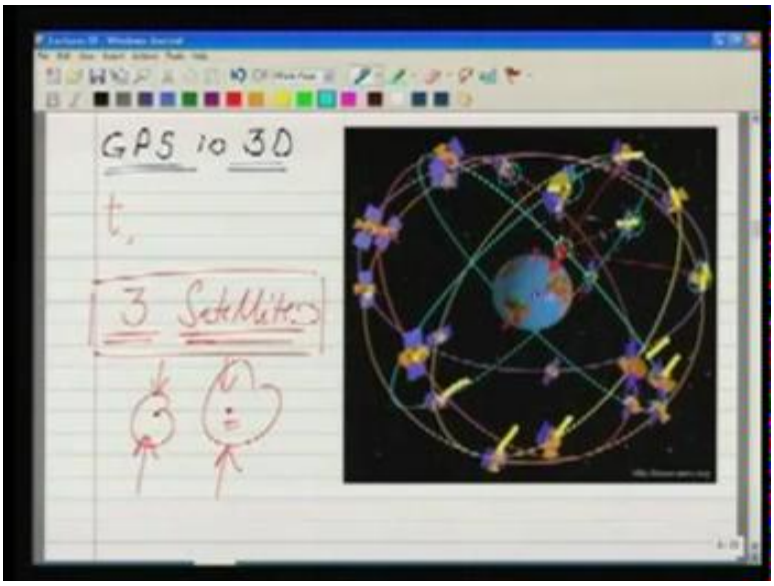
So, what is the principle? We will try to understand this by a 2 D example. Now, in the case of the 2 D let me draw a coordinate system here. This is X axis and this is Y axis, because we are only talking 2 D. I cannot draw in 3 D here and it is easier to understand this thing 2 D. Well, in this we have 2 known points let us say this is point S 1 and a point S 2 there is 1 unknown point. Let us say this is a point you said unknown. I say it is R S 1 and S 2 they are known means we know their coordinates. So, we know for this X 1 Y 1 and we know for this X 2 Y 2. Now, for R we want to determine, what are the coordinates of R? X and Y now, how should we do that how can we determine the coordinates.

Well, I said let us say this R is the receiver and this S 1 and S 2 are the satellites. Well, the receiver has the possibility that it can determine it is distance from the satellites. So, this receiver can measure the distance which we say as d 1. It can also measure the distance d 2. This distance is possible to be measured receiver can do it. So, if it can be done let us say if we have only one known point S 1 and the d 1 distance is measured. So, where all it is possible that our point R could be, because we know R is at a distance of d from S 1. So, all these positions this entire circle is the position where our R could be. So, we cannot really fix the position of R just by doing one measurement.

So, what we do? We are going for the second measurement d 2. The second distance and if it is. So, I can take again R here now. So, from d 2 satellite number 2 S 2 our point R could be anywhere along the circle. Well so, what we get we get 2 positions here now position number 1 and position number 2. So, our R could be at either of these 2 places. Now in order to find the solution for this problem if we know that one of these positions is not possible. For example if we take the problem to the 3 D now. What we have done so, far, we are trying to understand in 2 D 1 unknown point to know its position. We measure the distance to 2 known points and what we end up with we end up with by solved into right now I do it graphically, but it can be written mathematically also and we can solve it.

So, by solution we have 2 positions where it is possible that our receiver is. So, one of those positions if we know from some domain knowledge, domain means if we are on the surface of the Earth. We know we cannot be up there in the sky that kind of knowledge. So, one of those positions can be eliminated which is not possible. So, basically we are able to fix by these 2 distances this particular position. Now, what we can do in order to take a better measurement? We take one more satellite. We say S 3 and we also measure now the distance d 3. So, the moment we have measured the distance d 3. Now, the third point or rather this point is eliminated and we have fixed our position over here. What we will do?

(Refer Slide Time: 19:18)



We will extend this now to 3 D, because GPS is a 3D case. In the case of the GPS as we discussed there at the centre of the Earth. We have our coordinate system and it is possible. It is possible we will see in a moment how at any point of time at any time t all these locations where the satellites are wherever the satellites are we know all these locations. Everywhere these locations are known to us. Well, if we have a receiver there on the surface of the Earth there is a receiver here. This receiver is now measuring distances. So, what it is doing? It is measuring distance the receiver here is measuring the distance from satellite number 1 2 3 4 and so on. So, all these distances can be measured.

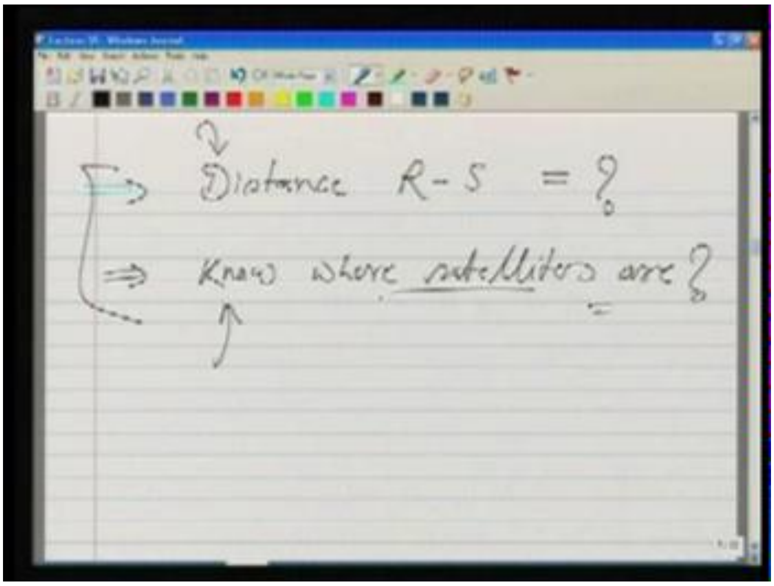
So, if we extend our this example here in this case we require 2 positions, you know 2 satellite positions S 1 and S 2 in order to locate our point, because we can eliminate one.

So, what we will need if we are going for a 3 D case? In case of a 3 D, we will need 3 satellites, because you can even think of it also you know if in a 3 dimensional case we have a satellite here we have a unknown point. So, this unknown point and the satellite, if we are able to measure this distance so, where all it is possible that this point could be. It is that everywhere in the sphere of this radius it is possible. So, what we do now in order to fix our position we take the distance of the satellite now from second sorry this reference receiver or this receiver from the second satellite. Then the sphere here and the sphere here they will intersect.

So, we have a circle, so anywhere on that circle it is possible that our receiver could be now in order to fix the point what we do we take the third satellite. So, again we have got one more sphere. So, this third sphere will cut this circle in 2 points. So, basically if you are using 3 satellites then finally, we end up with 2 points which are our solution points. And one of these points will be you know not practical solution for us, because from the domain knowledge we know this point has to be accurate. So, basically by taking this in to account it is possible that by three satellites we can determine our position.

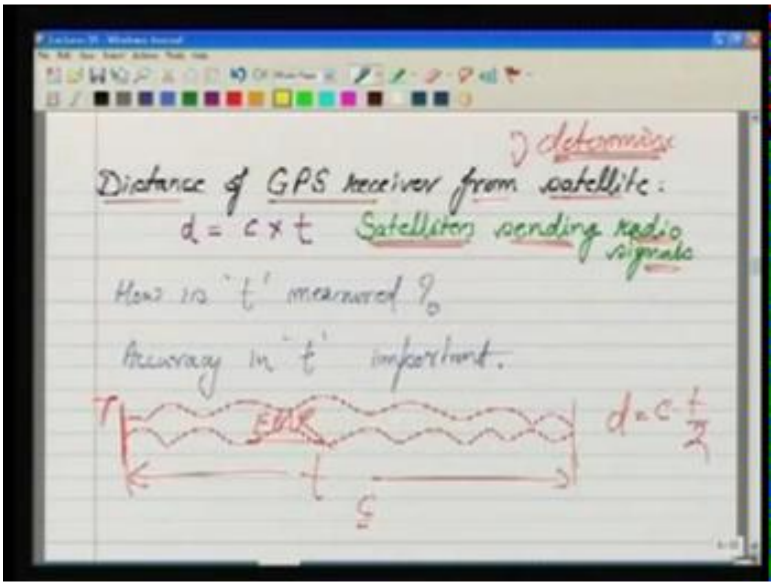
So, here in this coordinate system because we know the coordinates here we know the coordinates. And by measuring these distances and doing the solution the way we are doing we can determine this particular point. One more thing here though, because we can eliminate 1 point in that case though 3 satellites are good enough. But we would like to go for more number of satellites, because we know redundancies are always desirable. If for example, as in this figure we are able to see more number of satellites. So, what we will do? We will take all the satellites in to account we will measure the distance from receiver to all the satellites. And then we will put all these together in order to find the best possible solution which is coming by the least square as we saw also in the case of adjustment. Now, couple of questions here, 1 question is so far what we are doing?

(Refer Slide Time: 23:25)



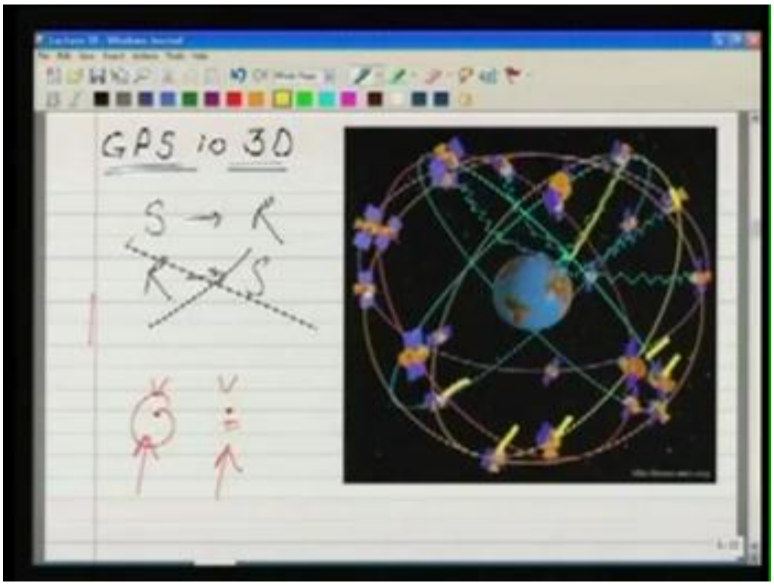
That we can measure the distance between the receiver and satellite, we would like to see how? Number 2; we were saying that we know where satellites are. So, that is the second question. Now, we would like to find the answer for this. How this distance can be determined and why do and how do we know the positions of the satellites? Where the satellites are at any point in time?

(Refer Slide Time: 24:10)



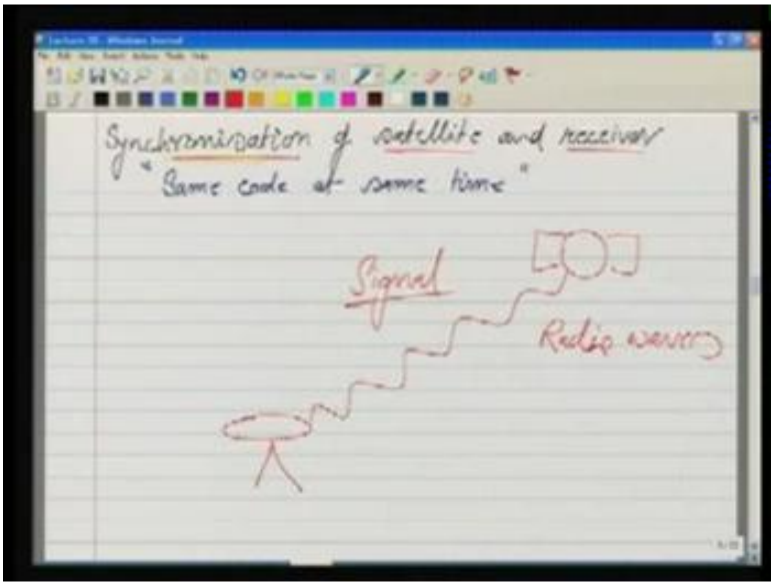
Well, first we will talk about the distance. So, distance of GPS receiver from satellite we were saying that this we can determine. Now, how we are determining this? What we are going to look in to now? Well, the satellites are sending radio signals this is what is there. So, in this case what is happening? In the case of the GPS if you remember EDMI, we have discussed in one of the modules the EDMI also? In the case of the EDMI what are the basic principles? The principle was a transmitter will transmit the electromagnetic radiation and then it will come back. So, by measuring the time of travel and by knowing the velocity of light it was possible to determine the distance. So, distance here was c into t by 2. We can do this by phase measurement or whatever,, but in this case our transmitter is sending the signal it is sending the electromagnetic radiation. However in the case of the satellite?

(Refer Slide Time: 25:31)



Or in the case of the GPS in the case of the GPS the way the signal is being transmitted. It is only from the satellite to the antenna here from this satellite also all the satellites are transmitting the signal. And there is no signal which is going from receiver to satellite. So, as far as the signal is concerned the signal is being transmitted from satellites to receiver not from receiver to satellite. So, this is not here as in the case of the EDMI. Well if this is so, we want to determine the distance. The distance means we want to determine this distance. So, how do we measure this distance? That is the question. Well a very clever trick is used in order to measure the distance.

(Refer Slide Time: 26:36)



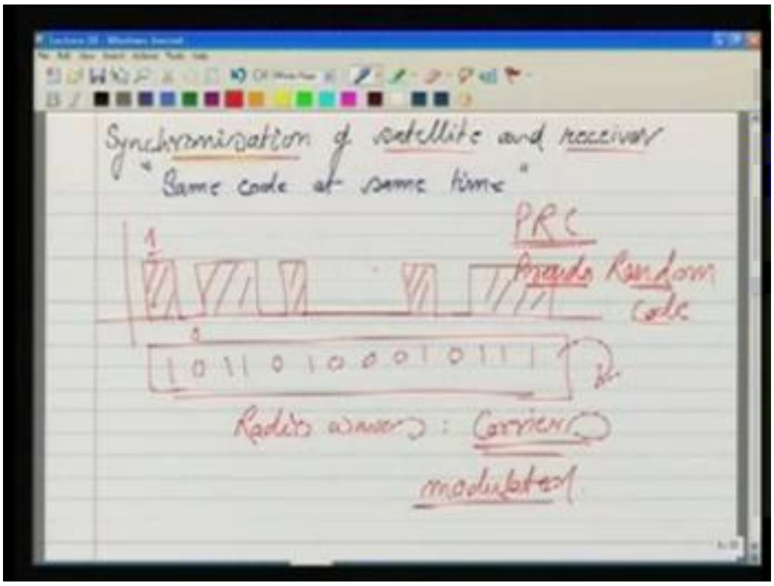
What is that trick? The trick is we synchronize the satellite and the receiver. What is the meaning of this? Basically the satellite is our receiver is kept here. Satellite is transmitting a signal. Again signal means these are the radio waves and these radio waves which are the carriers are carrying some signals. While the receiver is just receiving these signal. Now, the question is, because receiver is just receiving the signal which is coming from satellite. And just by you know capturing that it wants to determine, the distance it wants to determine. Because these are radio waves we know they travel at the velocity of a speed of light. We know that velocity of light, we know this thing.

So, in order to determine the distance we need to know how much time it took for that signal to leave the satellite and reach the receiver. If we can determine that this at particular signal took. So, much nanosecond in order to start from satellite and reach the receiver we can determine the distance between these two. Now, how do we know the time? So, for that this synchronisation is done. Now, what is this synchronisation in the case of the synchronisation? The receiver and the satellites both are generating same code at same time. Well what is the meaning of this? The meaning of this is, code here means we will see the definition of code in a moment.

But right now, let us say for example, I say the satellite and the receiver both start counting 1 2 3 4 5 together. So, they are counting 1 2 3 4 5 together; that means, if the satellite if the receiver is counting 1 satellite is also counting 1 and then it is counting 2. So, this is also counting 2 and then 3 then 3. So, basically the signal is synchronised. Now, the receiver here because the moment it counts 1 then 2 then 3. So, this one is travelling then 2 is travelling then 3 is travelling. So, what will happen? After sometime, when it was counting 4 the receiver is counting 4 it will hear the 1 which was counted by the satellite.

So, the one of satellite is reaching the receiver when the receiver is counting 4. Why, because this one took some time to reach from the space to the receiver. So, now, the receiver can determine the difference in its counting which is 4 and the counting which is received here which is 1 so, by finding this difference which is 3. So, 3 could be 3 seconds or whatever. So, what? What it is able to do? It is able to determine how long did it take for this one which was which was started by the satellite to reach finally, the receiver. So, this is how basically the time is measured.

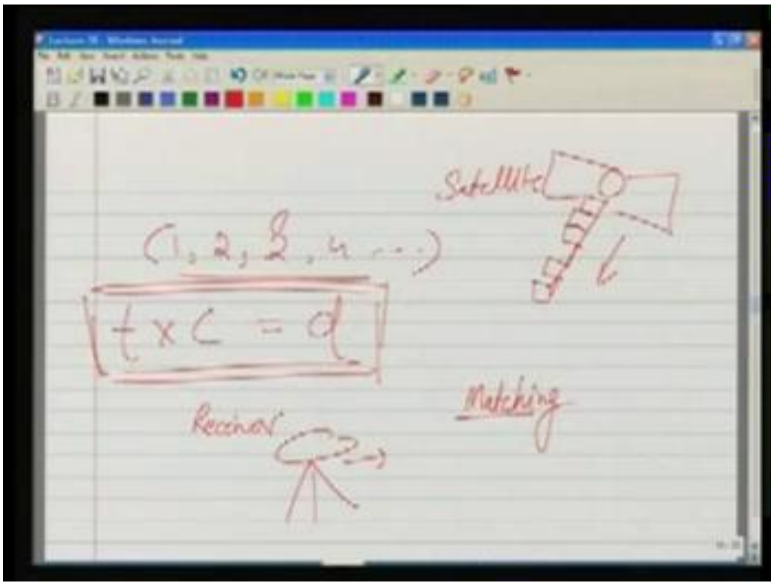
(Refer Slide Time: 30:07)



Now, in actual practice both receiver and the satellite they make use of a code we say this as pseudo random code now, why it is called pseudo because it looks like random though it is not random. So, that is why it is pseudo random code, because it is something which is being generated by our program we have written the program and it is being generated. So, that code may look like or whatever. So, this is let us say 1 and naught. So, we can read the code as 1 naught 11 naught 1 naught naught naught1 naught

1 1 1. So, basically over the carrier, because as we were saying the satellite is transmitting the radio waves which are the carriers over these carriers this particular signal has been modulated. And the same signal is also being generated by our receiver.

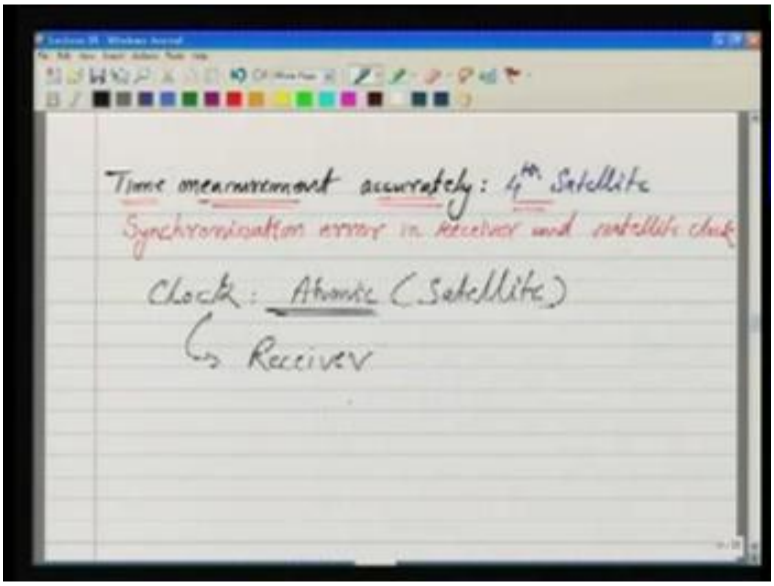
(Refer Slide Time: 31:34)



So, our satellite is transmitting this signal. And the receiver there is also generating the same signal at the same time so, by matching the signal which is being generated by the receiver and the satellite as we saw in the case of our example of counting 1 2 3 4 and so on. So, what we are doing there? We are matching the count of satellite by the count of the receiver. So, similarly here also by matching the signal, which is being generated by the receiver and the signal, which is reaching the, from the satellite. So, basically by doing that it is possible that receiver will determine the time of travel of the signal from satellite to itself.

So, in this time of travel determined well it is very easy. We can then multiply with the velocity of light in order to determine the distance. So, this is the clever trick by which distance from satellite to the receiver is determined at the same time. We were saying that we know the positions of the satellite and these distances are measured to 3 satellites 4satellites 5satellites. You know any number of satellites which are visible to the GPS receiver and the position where the receiver is can be computed. So, this is one way when we are making use of pseudo random code in order to determine the distance. There are some other ways also now, one more important thing here.

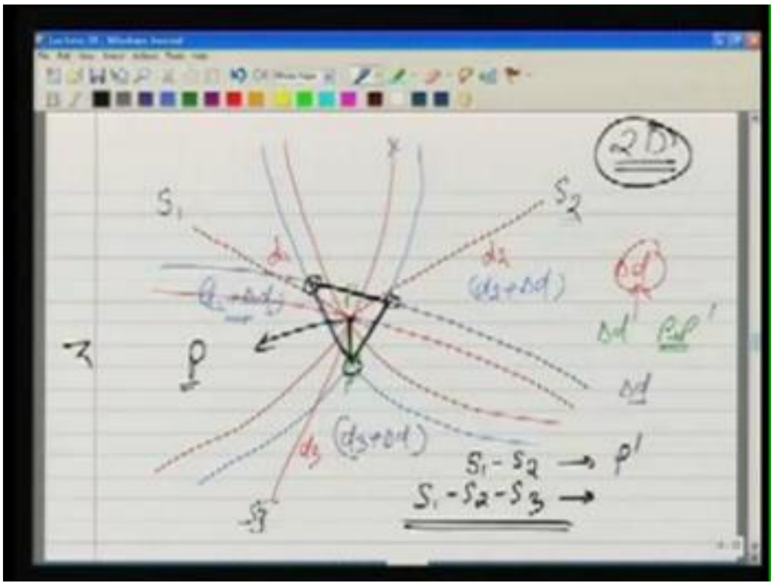
(Refer Slide Time: 33:31)



So far we were saying that we will need 3satellites for positioning. That is okay theoretically, because one of the points can be eliminated, but in GPS we need 4satellites for positioning. Now, why 4? The answer is the clock, which is being used in the GPS in the satellite it is atomic clock. We have 4 number of clocks there, because once the satellite has been launched in order to ensure redundancy in order to ensure accuracy the atomic clocks are put there. So, these are the very precise clocks, but this is for satellite, but here in the ground for receiver we cannot put an atomic clock here. The clock, which is being put in to the receiver is not that costly is not that precise. So, naturally there will be some synchronisation error, because our assumption. So, far was the GPS signal, because why the clock is important? The signal is being generated as per the clock the time is important.

So, in the case of the receiver the clock, which is put is not that precise why it is? So, because we want the receiver to be very you know inexpensive one. So, that it can put in the watches it can be put in the mobile phones it can be put in a car it can be put everywhere. So, the receiver clock has to be very cheap, because it is cheap it is not precise if it is not precise it will have some synchronisation error then. Synchronisation error means as I was saying it is counting 1 it is also counting 1 2 2. If they are not synchronised it is counting while this was counting 2 then it counts 3 it counts 2. So, there is a synchronisation of 1 second. So, if there is synchronisation problem can we eliminate it what will be its effect. That is what we are going to see now.

(Refer Slide Time: 35:58)



Let us say our satellite number 1 is here and that is our satellite number 2. What we will do? We will again discuss this in 2D, because 2 D is easier to understand. Any unknown point let us say there is an unknown point here. If there is no error in distance measurement we will measure the distance and we will measure the distance. So, this point is being located. So, basically what is happening now? This point could be anywhere because of this distance d 1 and this point could be anywhere here also, because of the distance d 2. Now, if we have an error of let us say in distance some delta d is the error. Because if there is synchronisation problem in the clock the time measurement will be an error if there is time measurement error it will result in the error in the distance.

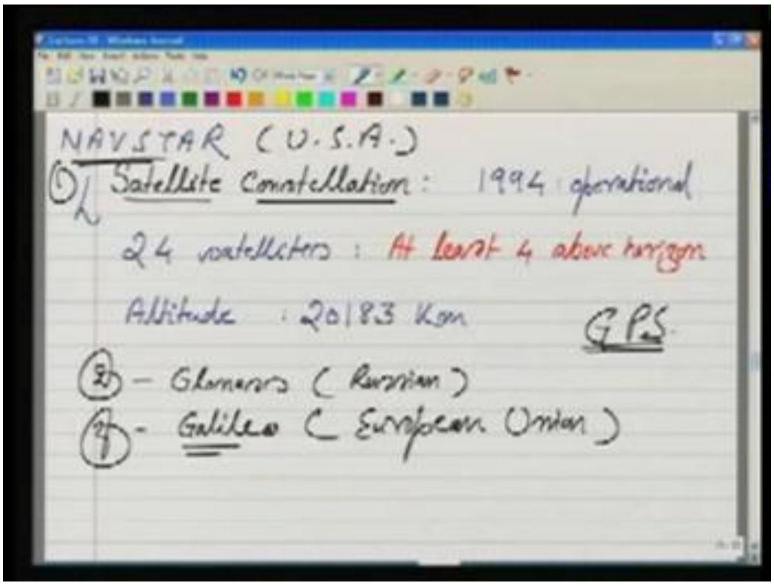
So, if the distance has some error let us say delta d is the error. So, what will happen? Because of that now we are measuring d1 plus delta d. If you are measuring this let us say delta d is positive; that means, we should be somewhere along the circle not on this one. Because of we are measuring a distance, which is d 1 plus delta d. Now, from the second satellite also we are measuring d 2 plus delta d; that means, we should be somewhere along this circle from S 2. Now, what does it do? It will shift my position from the actual position by this amount. So, that is the shift. So, the point P has been shifted to P dash. So, this is the effect of the error. So, my delta d has shifted my point from P to P dash that is the effect of the error.

Now, the question is can we eliminate it? Well in order to eliminate it what we do? We take a third satellite here a third point here if you take the third satellite and if there was no error in the case of the third satellite. Let us say the third satellite is somewhere here S 1 or S 3 there is no error in distance measurement. So, this distance d 3 will be measured like this and we will have our arc like this and these three intersect at this point if there is no error where is the case when there is no error. But when there is error delta d as we are saying. So, we will measure now, d 3 plus delta d if it is. So, we will be positioned somewhere along this arc. Now, what it does in case of only 2 satellites S 1 and S 2? In that case we are able to determine our position as B dash and we know that this B dash has error, because it was shifted.

Now, when we are using S 1 S 2 and S 3 are we getting any single position? No, because what we are getting as the position is now this triangle which we say triangle of error. So, we are getting this triangle; that means, our point has to be somewhere in between this triangle. Now, if you observe this triangle we will find the actual position is the centroid of this triangle. So, that is the actual position which is the centroid of the triangle. So, we get the triangle we get the coordinates of these 3 points and we get the triangle and we find the centroid and centroid is the point P. So, what is the meaning of this? The meaning is even if our receiver has synchronisation error which will be there, because receiver clocks are not very expensive they are not very precise.

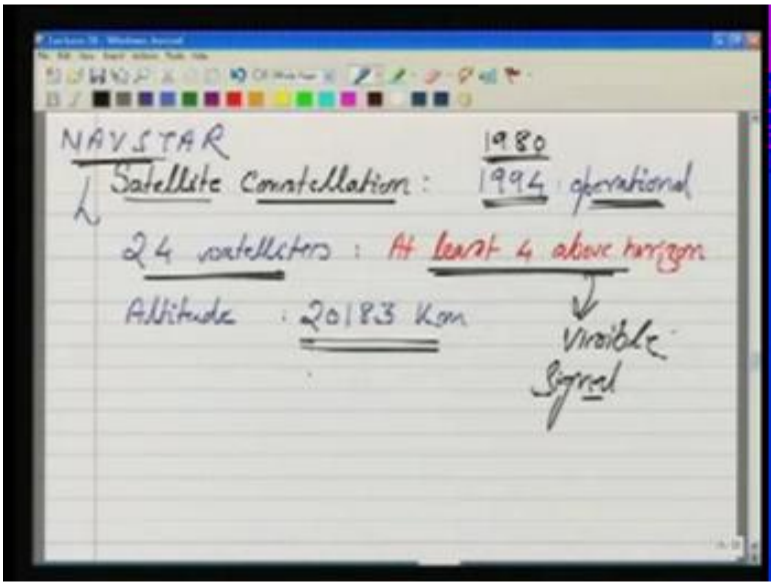
So, because of the synchronisation error in the receiver still it is possible to determine the coordinate of the point accurately. Because we are making use of now 3 points which we are saying here, because the example which we just discussed is in 2 D, but when we take it actually to the GPS. In the case of the GPS has 3 dimensional problem. So, we will have to add one more satellites. The meaning is in the case of the GPS even if there is error in the receiver its effect can be eliminated by observing distances to 4 satellites. Because in the case of the 2 D example we saw the 3 satellites can solve the problem. So, in the case of the 3 D problem we will have to have 4 satellites.

(Refer Slide Time: 41:38)



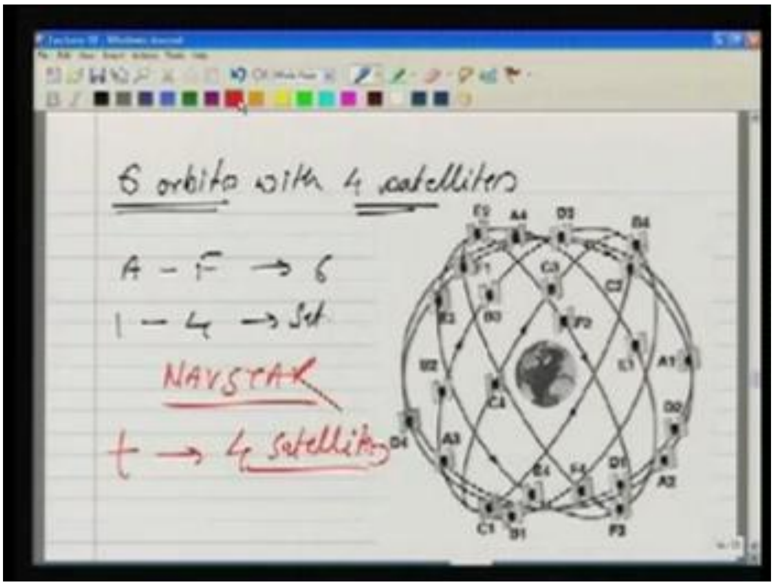
A little bit about the information this is basically more of information and a lot of this can be get from the internet also when we say GPS. Mostly we use it as a synonym of NAVSTAR satellite constellation or NAVSTAR this is a United State system. So, basically the GPS is the generic name while the GPS which is being used mostly at the moment around the world is the NAVSTAR. In addition to this NAVSTAR there is also Glonass this is an Russian system it is being used, but not that often not as NAVSTAR that as well as a new system which is coming up is Galileo and that is by European union. So, they are coming with a system which is called Galileo. So, we have we can say it three systems 1 is the NAVSTAR 2 and the third and all of these are called GPS. So, GPS is basically the generic name. So, the information which I am giving you right now is about NAVSTAR.

(Refer Slide Time: 43:11)



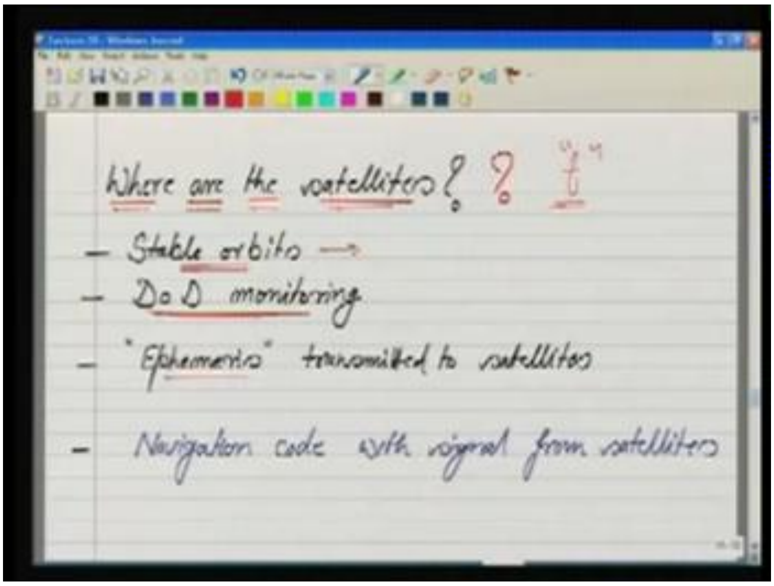
It was started in 1980. Of course, the thoughts were before that, but the process was started and in 1994 it became fully operational. The principle is that we should have some 24 satellites. So, that at least 4 are above horizon means they are visible. Visible means we receive signals from these satellites and these satellites are put at an altitude of 20183.

(Refer Slide Time: 43:45)



Now, here is the orbit and satellite positions these satellites are put in 6 orbits with 4 satellites in each as you can see here A to F. This represents 6 orbits and the numbers 1 to 4 they represent the satellite. So, for example, a particular B 3 here B three means is in the B orbit and this is a third satellite. So, we will have B 1 B 2 B 3 B 4. So, this is the constellation of the GPS satellites again when I say GPS I mean NAVSTAR here. And as we are seeing why these satellites are positioned this way? Why this orbits are given this way? Why this one? Why not an orbit like this? The basic idea is the satellites are positioned in such a way and their locations at any point of time t, we should be able to see 4 satellites or we should be able to receive the signals from 4 satellites. Of course, when we actually work in the field we will find that very often you have more number of satellites. Which are visible to you 8 satellites, 9 satellites, 12 satellites which are actually visible to you from where you can receive the signal?

(Refer Slide Time: 45:18)



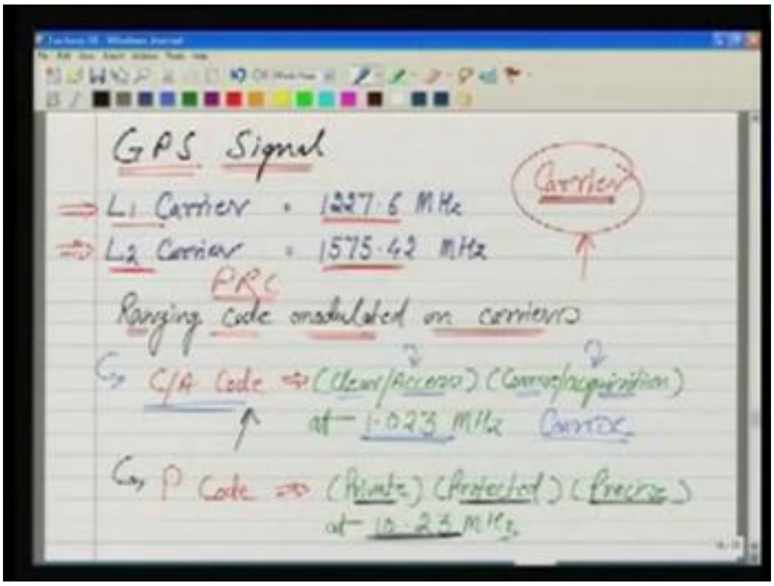
Another question, which we left there was, where are the satellites, because we need this positions. We need the position of the satellites here wherever the satellites are we need their position, because while we are standing there on the Earth with the receiver. And we are measuring these distances from 4 satellites I need to know their coordinates, because if I know their coordinates then only I can compute the coordinate of the point here at the receiver. Now, how do we know these coordinates? So, that is the question where are the satellites at any point time t. Number 1 number 1 point which is important here. The satellites are put in stable orbits stable orbits means the satellite we can predict in advance, because the satellites had been put there by the Department of Defence of

United States. They know where exactly the satellites are they know at what altitude they have put the satellite. So, they can do the computation for that.

So, this Department of Defence is monitoring also. So, in addition to the parameters of the orbit using which the satellite position can be determined and these positions are being computed in the same coordinate system, which we have talked about in the beginning. At the same time there may be perturbations also in the satellite orbit, because of perturbations the satellite will change its positions from its computed positions. So, from the ground station the satellites are being monitored. So, whenever there is any perturbation that perturbation is being recorded. And that is being recorded by Department of Defence and this information is called Ephemeris. So, this Ephemeris is transmitted back to the satellite. So, the precise positions of the satellite which is their which is being monitored is sent back to the satellite again. Why it is sent back to the satellite?

Because once the satellite is transmitting the signal the signal which we make use of for measuring distances. At the same time along with the signal we have also the navigation signal which has information about the Ephemeris; that means, what are the perturbations in the satellite orbit. So, basic idea is by knowing that they are in a stable orbit we can compute the positions as well as by observing from the ground. We can know the perturbations in the satellite orbit combining these 2. It is possible that the user will have precise position of the satellite. So, the receiver will have the precise positions of the satellite by reading this navigation message and as well as by the ((refer time: 48:25)) another information. So, once we know the precise positions of the satellite the accurate positions of the satellite. We will apply the distances which we are observing in order to know the coordinate of the point where we are standing. Next thing about the GPS signal

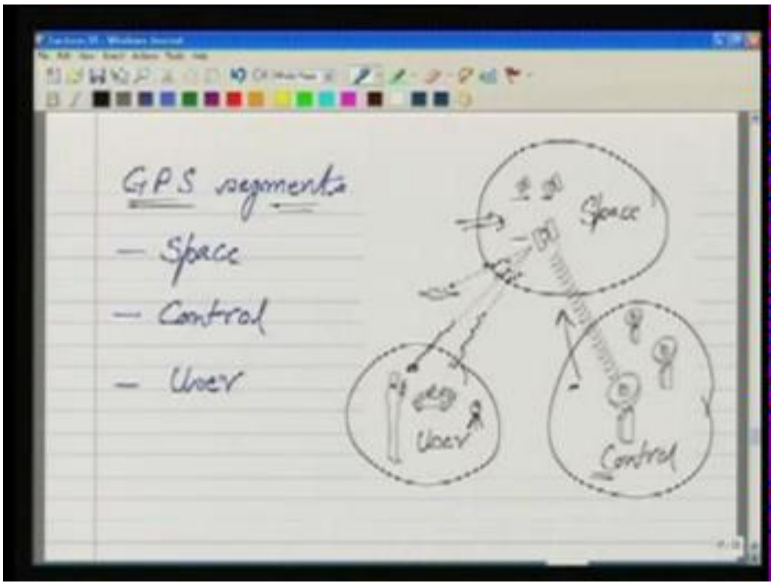
(Refer Slide Time: 48:45)



Because so, far we are saying radio waves and carrier basically we have 2 bands which are being used as the carrier here. Now, what is the 2 band means 1 band is working at this frequency and other band is working at this frequency. We say them as L 1 and L 2 and they are carriers. Now, why these 2 are used why not 1? It helps later on we may see in eliminating the ionospheric error. Then this carrier is modulated we also discussed that. So, ranging code, ranging code means as we talked about pseudo random code is modulated on carriers.

And the code is of 2 types 1 code we say CA code the CA stands for clear access; that means, it is free anybody can access this code also. It is called coarse acquisition means it is not precise and this modulation is done at 1.023 mega hertz frequency it is not precise is coarse. Well the other one the other code is P code this code is available to the Civilian users CA code it is freely available. However the P code is the precise code or also protected also private. It is modulated at 1.023 mega hertz at a higher frequency that is why it is precise. And this code is not available to the civilian users rather this code is designed for the military. Because initially when the GPS is started they were started keeping the military applications in mind. So, this code is a kind of protected code now, a little information about the GPS segments.

(Refer Slide Time: 51:12)

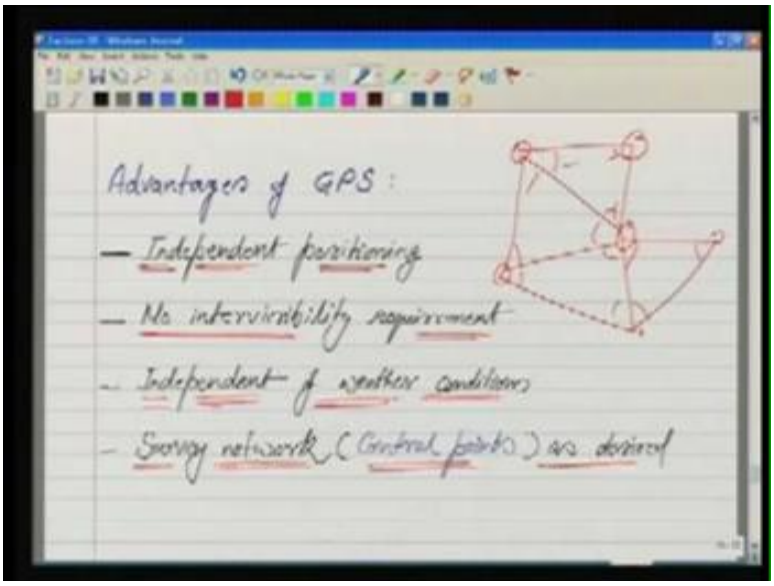


Of course, we know by this time GPS has 3 segments; one is space; space means we have the satellites we have their signals and we have the orbit and other things. This is all part of the space segments. Then in the case of the control segment, the monitoring of the satellites, recording of the Ephemeris, transmitting the Ephemeris to the satellites all these are part of the control segment. Then finally, the user segment well the user is receiving the signals on his receiver. The receiver could be hand held could be on a car could be on a tripod. And the user is doing all the computations in order to arrive at its location.

(Refer Slide Time: 52:05)

These are the examples of the GPS. Now, in these examples, the GPS can be used by keeping the antenna. This is the antenna; antenna means something, which is receiving the signal. And over here we have the battery and other parts. It can be used in combination with a total station. Also this is the like a GPS, which is used for geodetic surveying or it is called geodetic receiver. Geodetic means, because it is very accurate. While the GPS data can be put in to a PDA and this PDA can be connected to another receiver, which is hand held. And we can carry out mapping as we can see over here over GIS data over the existing data the additional things can be added with the GPS. So, this is just an example of various kinds of GPS which can be hand held can be very precise. We will put on the tripod can be put on your bag and can be used with total station and others.

(Refer Slide Time: 53:32)

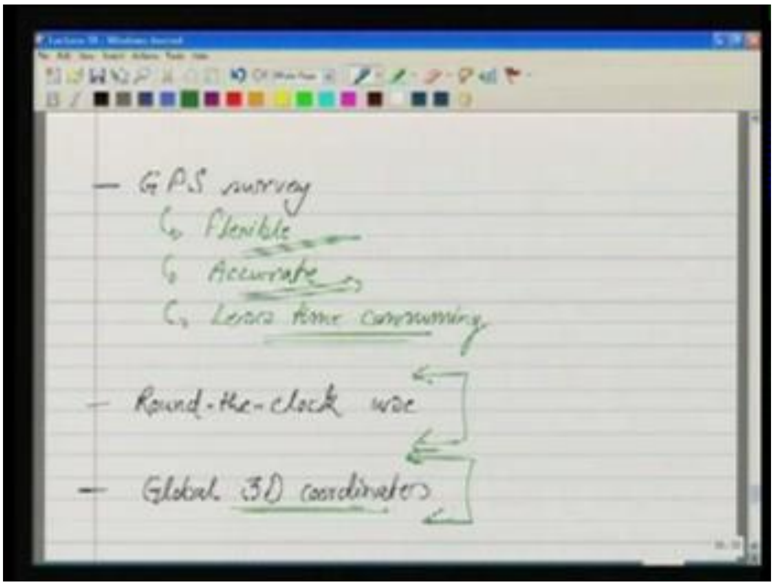


Having discussed all these now, we would like to see rather we will compare the GPS with the adjusting techniques. Now, we will compare GPS with the traditional techniques of mapping or traditional techniques of location generation or determination of the location. We have understood about this surveying in our previous video lectures. We know also a bit about the GPS now. Now, what are the advantages of the GPS? One very important one is it is independent positioning. Independent means you stand anywhere and your position is being determined without any bearing on the previous position unlike our traverse or triangulation. In case of traverse in case of triangulation, we have a dependency on the previous position.

So, error may propagate here or error may accumulate, but here in this case each and every point is independent this is very important. Then we do not have any inter visibility requirement here. If you are using GPS for survey wherever you go the only requirement is from the GPS, you should be able to see the satellites. It is not that you need to see the other stations as in the case of again traverse or triangulation. We can use GPS in most of the weather conditions provided you can go out and survey unlike our land survey. Because in the case of the land survey if it is raining or if it is too much foggy if the visibility is very poor or in the night we cannot use the land survey.

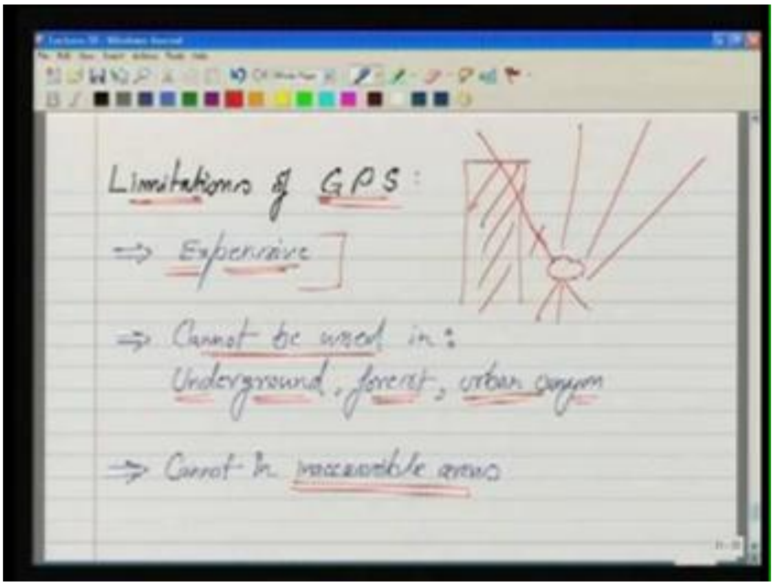
Then, the survey network is designed as per the desire. Now, what is the meaning of this? In the case of triangulation as we discussed our network is also governed by the computations which we carry out. If our angles are not well conditioned the error propagation will be more. So, what we want; we want the triangulation network to have a particular shape or these angles to have some values. Because of that the positions of the triangulation stations are determined, but in the case of the GPS, we fix the position not as per the, this requirement rather as per the requirement of our survey where we want our positions.

(Refer Slide Time: 56:09)



So, we can see the GPS offers a lot of flexibilities and also it is accurate if you go for long term observations. That GPS gives you very accurate position the operation is less time consuming as we discussed round the clock we can use the GPS. One more important thing the coordinates which we are getting are the global 3 D coordinates it is not a local coordinate system. So, any time the survey, which we have done with the GPS can be related can be you know compared with any global survey.

(Refer Slide Time: 56:51)



Well, at the same time we should also see some limitations of the GPS 1 it is expensive. If you are going for very accurate GPS, we need to go for the geodetic positioning or the geodetic receivers. And the geodetic receivers will cost highly while there are receivers which will cost only 10000 15000 rupees, but the geodetic receivers will cost above 1000000 rupees. Now, another thing, in the case of the GPS it is important that our antenna should receive the signals if there is a building here. So, the signal is not being received. So, we cannot receive the signal here. So, because of that if the signal is not being received. For example, in underground in forest area thick forest or in urban area in that case the GPS cannot be used. Also GPS can be used only in those positions where we can actually go and occupy.

For example, if we have to measure the trajectory of the ((Refer Time: 58:04)) of a power line the transmission line. It is required sometime we cannot use GPS to measure it, because we need to occupy the point. They are some other methods like ((Refer Time: 58:15)) or photogrammetric which can be used for inaccessible areas. So, what we saw today? We saw the principle of GPS. How do we know the positions where the satellites are? How do we measure the time of travel and then how all these can be put together in order to determine the position? Then also one question was there that we need 4 satellites why, because the receiver synchronisation error can be accounted for that way. Then we saw the advantages and disadvantages of GPS.

Thank you.