Surveying
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Module - 12
Lecture - 3

Global Processing System

Welcome to this lecture on basic surveying. We are now talking about this module twelve and this module twelve is on GPS. Today is our lecture number three. We have already completed two lectures of this module.

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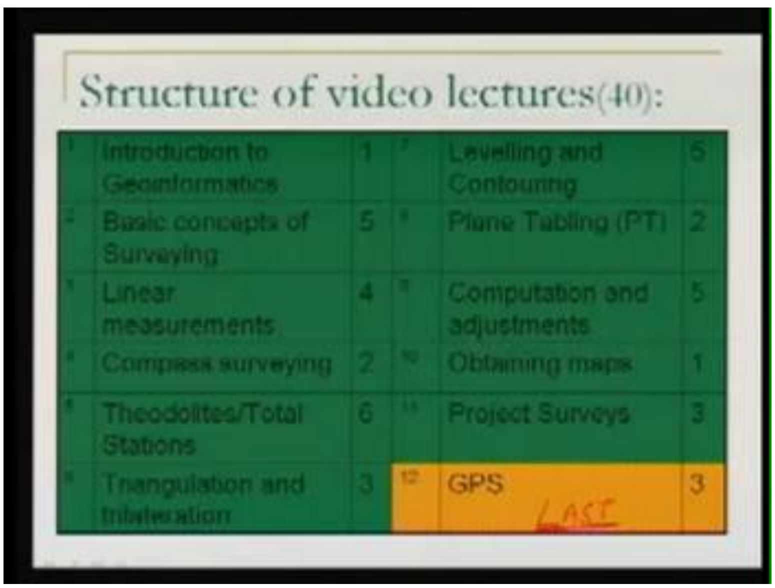

So this is our last lecture of this video lecture series. We have already completed this part which was the introduction to geoinformatics, basic concepts of surveying linear measurements, compass surveying theodolites and total stations, then these techniques of triangulation and trilateration levelling and contouring plane tabling; then how the observations can be adjusted. Finally how we can obtain the maps, then this is the setting out project surveys. We discuss how to set out the various projects and in this present module we are talking about the GPS and this is our last lecture now.

In our last lecture on this GPS that is lecture number two, we talked about applications of GPS. Then we saw the GPS errors. Also we saw how the errors can be eliminated by doing the differential positioning. Now in this lecture today we are going to talk about some measurement techniques, which are code and carrier based measurement techniques by the GPS. We will also have a glance at types of the receivers and how the various types of the receivers can be classified., then a little bit about GPS survey approaches; how actually the GPS survey is carried out in the field what are the various ways on that.

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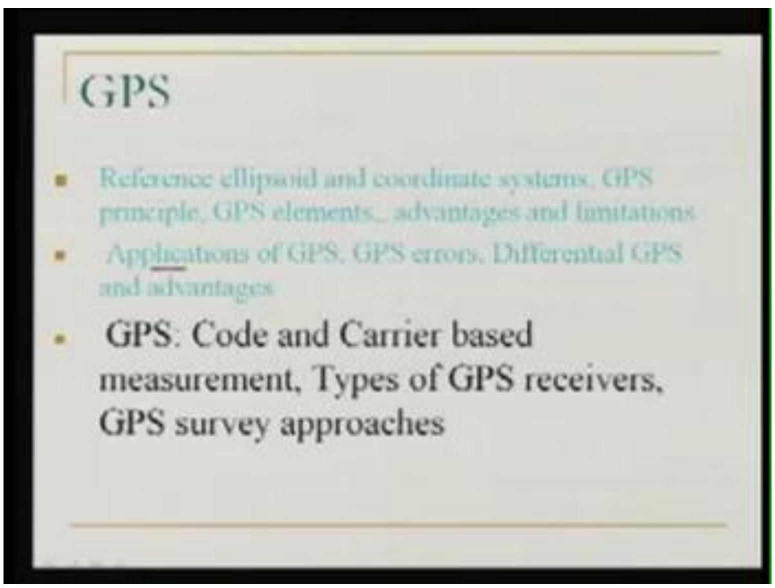

Okay so to begin with, we will start with GPS measurement techniques. We know we have already done a little bit about the code based techniques. When we are using the code you know you will recall that in our very first lecture we are talking about the pseudo random code, the code which is being generated by the satellite and is also being generated by the receiver and this code is same at one point of time. Now this code is being transmitted from the satellite and the same code is being generated by the receiver but by the time the code reaches the receiver and we compare the code that is coming from the satellite and the code of the receiver they will be displaced in time. So using this the time of travel of the signal from the satellite to the receiver was measured. So that was code based.

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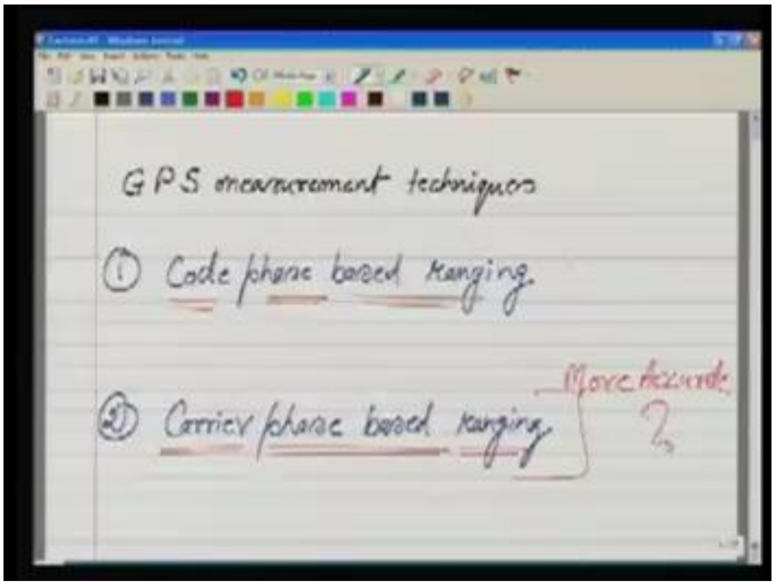

So very first way of doing this ranging is code based. There is one more way in which the ranging can be done which is the carrier phase based ranging and we will see this is more accurate. Why it is more accurate and how it is done? We will see that now.

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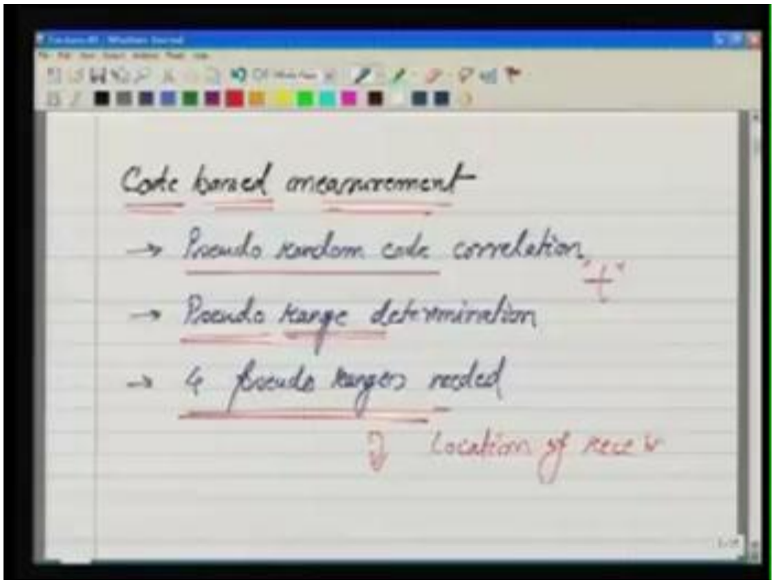

Well first a little bit about the code based measurement again. We are using the pseudo random code and we are determining the pseudo range using the time of travel measurement and we need four pseudo ranges in order to find the location of receiver.

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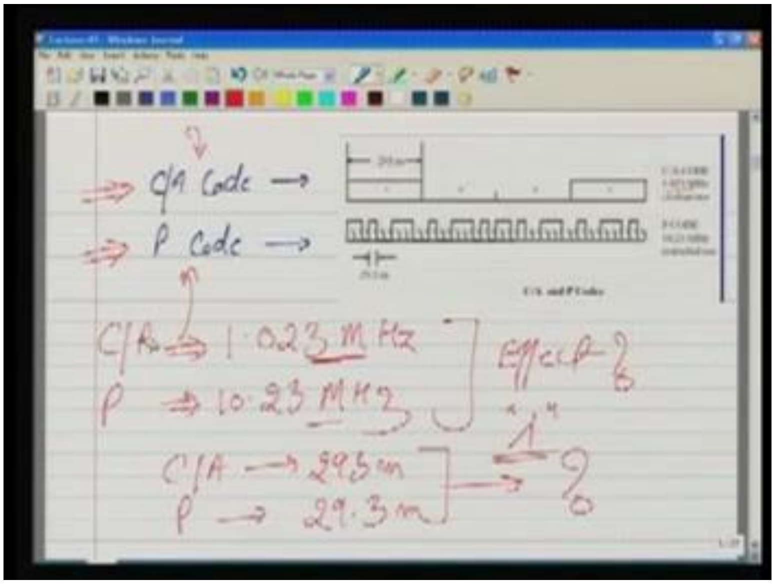

Well about the code? We have got two kinds of code. CA code. This is available to civilians while P code is available to the military. Now in the case of the CA code as we had seen previously also, the frequency of CA code is one point zero two three mega hertz. That is the CA code and the P code - it is frequency is ten point two three mega hertz. So what is the effect of this? If we convert these frequencies in corresponding wavelength we will find that the wavelength corresponding to CA is of order of two nine two three metre while for P it is twenty-nine point three metre. Well again what is the implication of this? What is the implication in each? It is something like as we can see because we are mainly making use of these codes in order to know our position. So what actually is happening there in this process?

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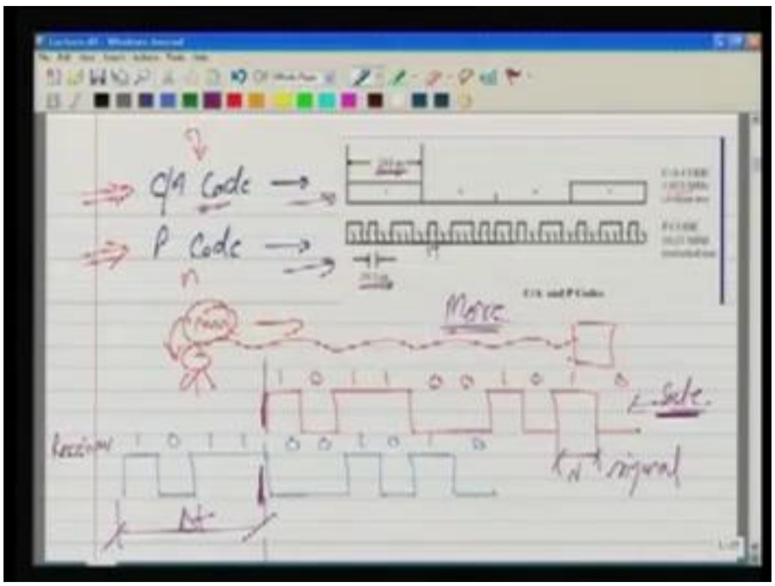

Let us say the signal which is coming from the satellite and that is the satellite which is sending the signal and the signal is being received there at the receiver. Receiver is also generating the same signal though it is not sending it to the satellite. It is generating internally and then these two signals are being compared. So what is happening there? If the signal which is being generated it is like this, how we will read this signal? We will read this signal as one naught one one naught naught one naught one and naught. That kind of signal. Now this is the signal let us say which is generated by satellite and the same signal is also being generated by the receiver but these two signals will be slightly displaced in time as we are trying to do here. Now here is the signal which is coming from satellite and here is the signal which is being generated by receiver. So what we see, these two signals are those same because what I did; I just copied it here so these two signals are same but the moment the signal from the satellite reaches the receiver the receiver is generating some other signal.

So this is the edge which has reached at the moment but at that at the same time our receiver is generating this particular point. So what we see there is a displacement. The displacement of the order of that is this much. So this is the displacement in time. So because of this displacement we observe this displacement and we convert it to the distance and this is how the pseudo range is computed. Now one thing, the accuracy of time measurement will depend upon what is the wavelength of the signal. If this wavelength is small we can have better time measurement and the accuracy of pseudo ranging will be better. Now if you understand this now we look at the signals for CA code and for P code. As in the P code the wavelength is very small twenty-nine point three in comparison to the CA code the accuracy of P code is more. It is more accurate than the CA code.

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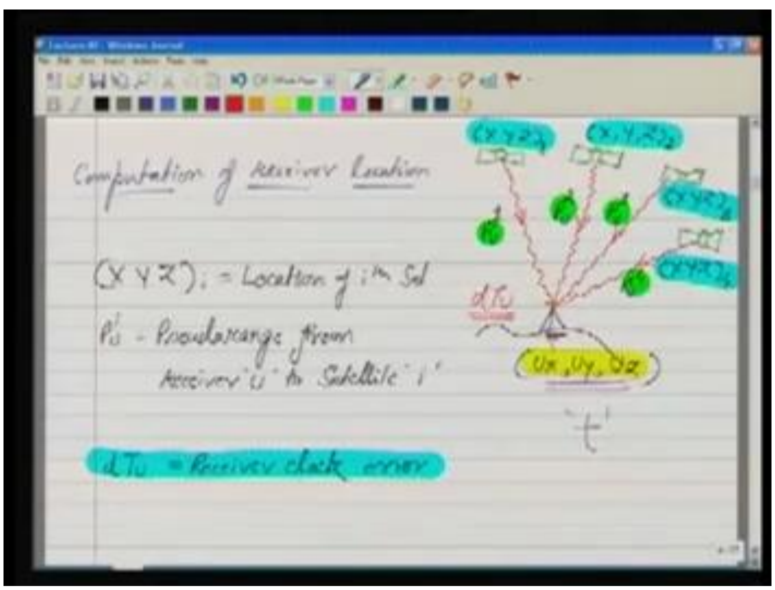

Now in the case of this code based ranging what is done? Over here it is desirable to determine the position over here let us say the coordinates are Ux, Uy and Uz. These are the coordinates of the point where our receiver is kept. At any time t the satellites are at x y z that means x1, y1, z1; x2, y2, z2; x3, y3, z3; x4, y4, z4. These are the locations of the satellite and our aim is to determine Ux, Uy and Uz. What we are observing? We are observing the pseudo ranges pu1, pu2, pu3 and pu4. This is what we are observing. Also let us say there is some error in the receiver which we are writing as dtu.. So dtu is the error in the receiver.

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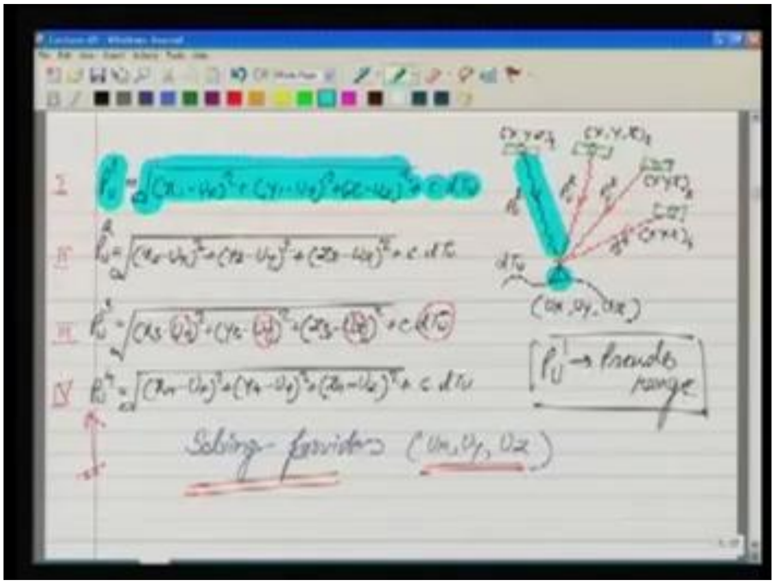

Considering all these we can write now as we can see here, I can write a relationship between the position Ux, Uy, Uz, the coordinate of the satellite and the range and as well as the time error which is there in the satellite. How I can relate these? I can relate them by this relationship. What is this? X1 minus Ux square plus y1 minus Uy square plus z1 minus Uz square and square root of that. It is basically the distance between these two points. Plus I am adding C is the velocity of light and dtu is the clock by us as at the receiver. .so this total is actually the range which is being observed this is the pseudo range.

This Pu1 is the pseudo range means, the range with error while this particular range this particular value is the correct value, but we are adding the error component to this. That is why Pu1 is the pseudo range. What we can do, we can write similarly for the second satellite, for the third satellite and for the fourth satellite. So what we see in these four equations, if you consider these four equations the unknowns here are Ux, Uy, Uz and dtu, while we know where the satellites are. So x1, x2, x3, x4, y1, y2, y3, y4, z1, z2, z3, z4 these are known as well as pseudo ranges are being measured and being observed. So we know also the pseudo ranges. So what we can do now, we have four equations and four unknown. We can solve it in order to determine Ux, Uy, Uz, mean the position here of the receiver.

So this is basically how in case of code based method the location is determined. By the observation, by the measurement of pseudo ranges. Now we are going for the other method. As we discussed that other method is the carrier based. Carrier? What is a carrier? Carrier is we have this code is being modulated on the carrier. There are two carrier ways L1 and L2 and incase of P code also and in case of CA code. Also this is modulated on the top of the carrier. In the case of carrier based method the idea is can we use the carrier signal in order to determine this range or the pseudo range. Again is it possible. Now how is it done? The principle is nearly same as the EDMI. In the case of the EDMI as we know we fire as we can see here.

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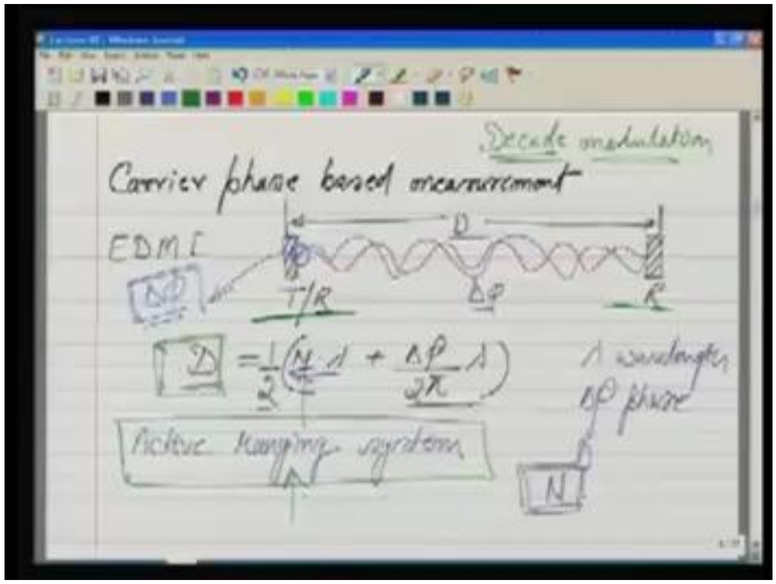

Now in case of a EDMI we fired the laser pulse or let us say it is a continuous wave. A continuous wave is fired which comes back after reflectance and over here we measure the phase difference of outgoing and incoming wave. So we measure the phase difference here delta phi. If we know the phase difference I can multiply that by the wavelength in order to convert it in to that partial distance. So how we can write the full distance D now? The full distance D between the transmitter and the reflector can be written as D is half of N into lambda plus delta phi by 2pi into lambda. Now what is N here? Of course we know lambda is the wavelength which is being used. Delta phi is the phase difference which will remain constant provided D is constant and D is the distance.

So we can guess it very easily here that N is equal to the full number of cycles in between transmitter reflector and receiver because the signal, it starts from the transmitter. Now they are one full wavelength, second full wavelength and so on. Now it reflects from here, one more full wavelength, another one, another one then at the end of it. It may be full wavelength or it may not be and that is what is the phase difference. So basically how we can write the distance? Distance we can write in terms of all the full wavelengths which are there in between as well as the partiaL1 at the end of it. So this N over here the N here represents full wavelengths in between this distance. So there are methods we know a method which is called decade modulation. So by this decade modulation in case of EDMI we can determine the distance between transmitter and the reflector. Now this kind of method where our transmitter is sending the signal or the continuous wave and again it is receiving the same. So the signal is starting from the transmitter it goes to the reflector and again it is coming back to the receiver here. So this kind of method we call active method or active ranging system.

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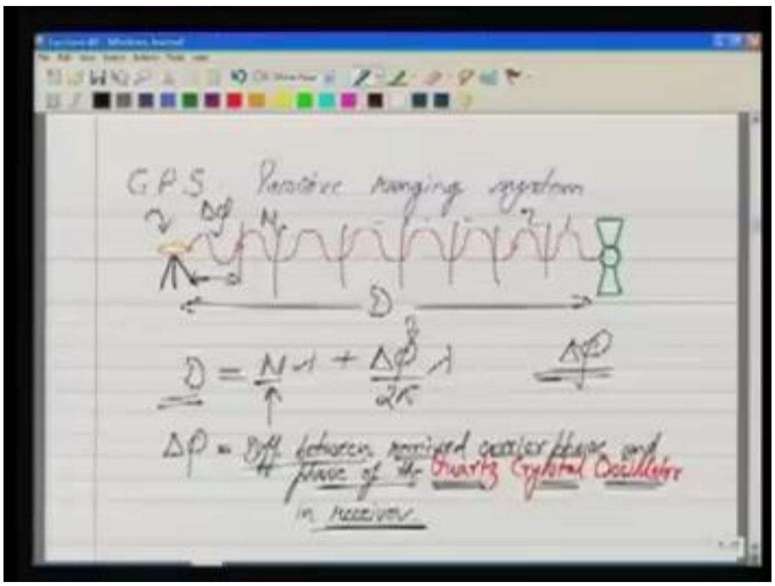

Now in the case of the GPS, as we know in the case of the GPS, the idea is we want to determine the range between the satellite and the receiver and we know only satellite is sending the signal. There is no signal which is being sent by the receiver. So the principle of EDMI though it is applicable here but cannot be used directly in the case of the GPS because unlike EDMI the receiver is not sending any signal towards the satellite. So in the case of the GPS when we are making use of the carrier phase what we will do? We will apply the passive ranging system. Now what is this passive ranging system? Well over here if this is our satellite that is the satellite and it is sending a signal. I have shown you by a continuous wave and the receiver receives this.

Our aim is we want to find the distance D between these two points or the range. So again we can write this D as N into lambda plus delta phi two pi by lambda. Now what is this over here? Delta phi is again the phase difference at receiver. What happens in this case, those receivers which can which have a facility to receive the carrier phase or rather to do the carrier phase ranging. Those receivers have got an oscillator there inside and this oscillator has the facility that it can measure the phase difference between it is phase and the phase of the wave which is coming. So the oscillator which is the quartz crystal oscillator which is sitting there in the receiver. Can you measure the distance between a received carrier phase and the phase of the oscillator? So basically now we are what we are doing we are measuring the phase at the oscillator or at the receiver by using the phase of the oscillator and the phase of the coming wave.

So this is the phase difference which we are observing. So we can write this phase difference over here but in order to know d we should again know the value of N, that how many full wavelengths are there. This is the N1, N2 and so on up to Nn and then the partiaL1. This is the partial wavelength which is corresponding to the phase difference. So again in this case we need to know n. Measurement of delta phi or the phase difference is possible and it can be done accurately also, it can be done with an accuracy of three to ten millimeter. Now one thing again why carrier is better than the code phase. We know in case of the code phase the frequency of this signal is approximately equal to one mega hertz, while in the case of the carrier it is approximately one thousand mega hertz. So these are the frequencies of the carrier and the C code signal or the pseudo random code. So what is the implication of this and how we can say that carrier is more accurate?

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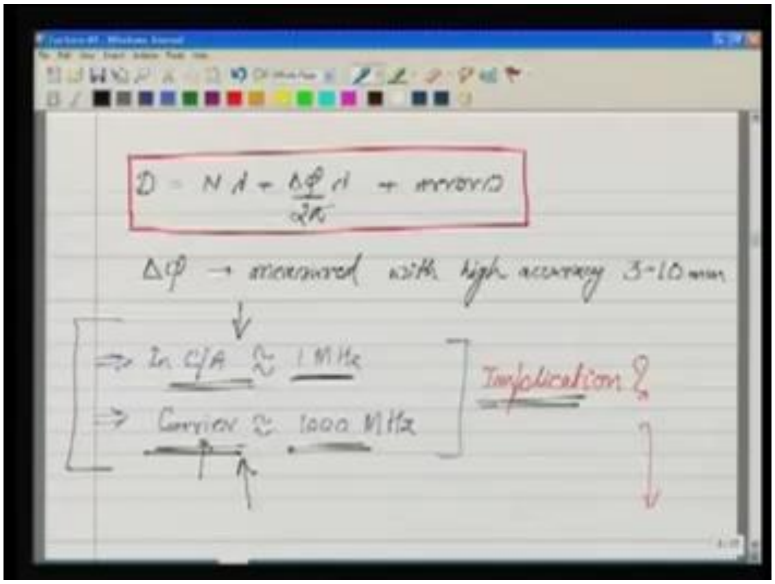

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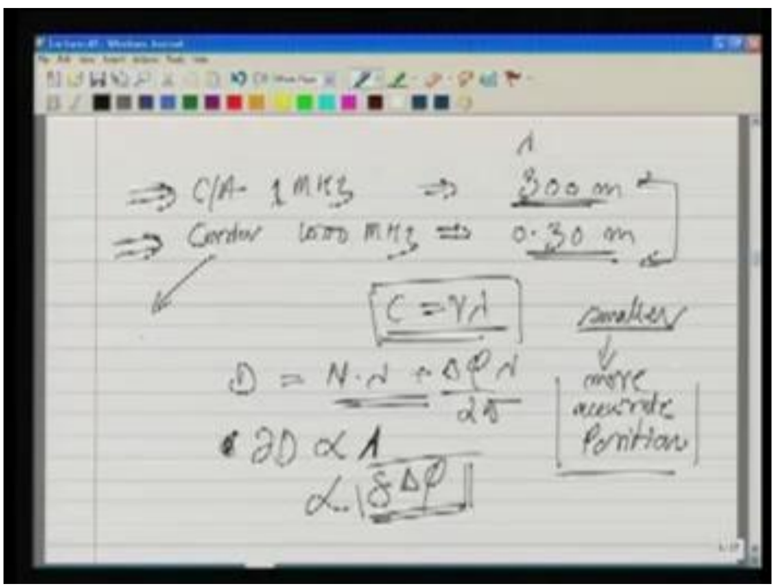

Well for this CA one mega hertz and for carrier one thousand mega hertz, if you convert these in corresponding wavelengths; so to convert it this wavelength we will come out around thirty centimeter, point three zero metre. While this wavelength it comes out to be three hundred metre we just saw it. So we can do this computation because we know the relationship between lambda. C is mu lambda, by using this we can do this computation. Now what do we observe here? Our accuracy of D is N then lambda delta phi lambda by2 phi. So the accuracy of D if you see over here is proportional to lambda as well as proportional to the delta phi. How precisely we can observe this phase difference: so accuracy of D will be governed by this as well as accuracy of D is governed by the wavelength.

What is the meaning of this? If we are going for a smaller wavelength we will have more accurate position. Well the wavelength in case the of CA is three hundred metre while in case the case of carrier it is only thirty centimeter. So what we see? We see a big jump in terms of the accuracy when we are using the carrier. So this is why as we are seeing earlier also in case of the code based GPS the positions are not accurate when we compare them with the carrier based. In case of carrier of course there are some disadvantages but the carrier based GPS positioning is very accurate. Well still there is a problem in case of the carrier.

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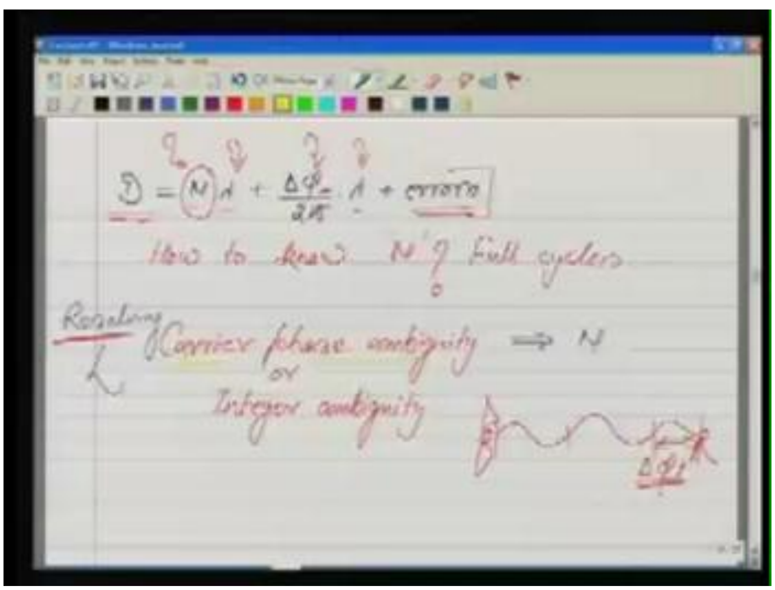

This is being measured at the receiver and this is how you know we can write the full equation. The range or the pseudo range now because we are adding the errors here is N lambda delta phi by2 into lambda. We know lambda because we know what carrier wave we are using. We know delta phi because this is being observed and we can model the errors but still we do not know anything about n. How to determine the N? What is N? The signal from the satellite here the signal is going to the receiver over there we have got one full wavelength second full length and then some part which is corresponding to delta phi, but how to know that how many full cycles are there from satellite to the receiver? That is the major question.

In case of EDMI we are using the decade modulation and there it was possible because the system was active system but here the ranging is passive system, but still we would like to know number of integer you know, that is the integer quantity: how many full cycles are of the wavelength in between satellite and the receiver. Delta phi or that partiaL1 is being measured . Now if the answer of that is we say resolving carrier phase ambiguity and also this is called integer ambiguity. So basically we go for the method of resolving integer ambiguity. How it is done?

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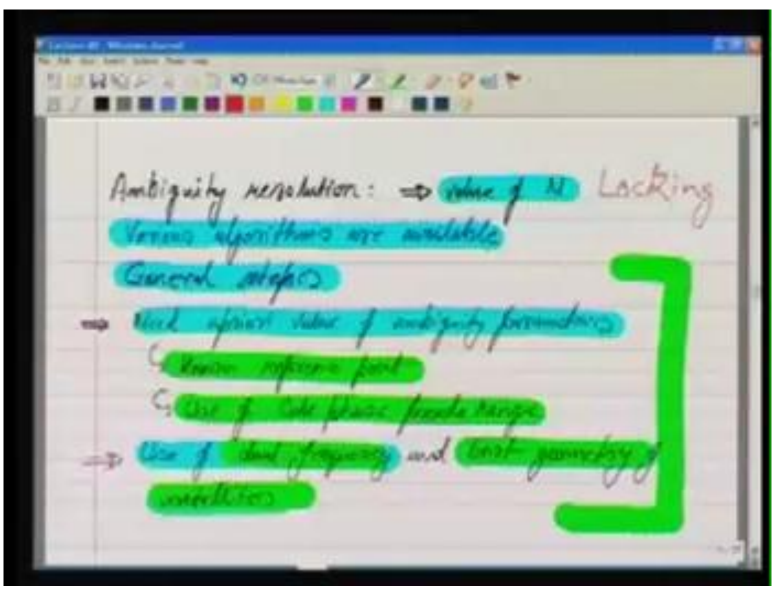

This value of N we want to determine this there are various algorithms in fact but the general steps most of these are we need to provide apriori value of ambiguity parameters. Now what is the meaning of this? To the algorithm which is trying to resolve the ambiguity we give some initial value. The initial value could be the location where we are standing. For example there is a location which we know which we have some idea about not accurate but we have some idea about that location. So we input that initial value so the algorithm will make use of the initial value and then it will resolve the ambiguity. We will find the value of N or may be we start with the CA code or the P code because we we have a way in which we can still find the pseudo ranges and the location by using the CA code or the P code. Though there are errors but the range which is given by the CA code or the P code is the initial value for us. Now that initial value goes into the algorithm and using that the ambiguity is resolved. Also there are ways in which dual frequency and best geometry of satellite is used, so basically by using initial values known reference point or the code phase pseudo range as well as in dual frequency and the best geometry mode.

There are algorithms which we are not discussing here which can resolve ambiguity. Okay. Once the ambiguity has been resolved, now what is happening here? We have a receiver. It is now locked. We say a term called lock. I will write that term here. Locking of a receiver with the satellite. Now what is the meaning of this? The receiver here and the satellite the moment they are locked, means the receiver is observing delta phi the phase difference as well as it has now determined the ambiguity. So once this operation is complete we say the receiver is locked with the satellite. Now we would like to observe at this point for some long duration in order to get an accurate position but in between what is happening now? The satellite is moving. As the satellite is moving this number of n or the full cycles will not remain same. We keep observing the delta phi the phase difference because this is being done here at the receiver. So this phase difference can be measured continuously but what about n which is changing now? So basically there is again a possibility as we can see here.

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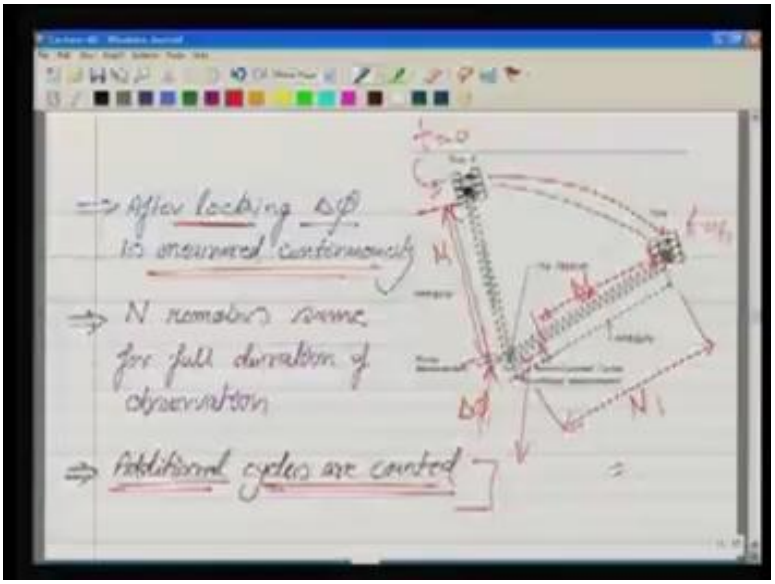

After locking, delta phi is being measured continuously. What do we do? That is the initial point, at time t is equal to zero. The receiver here has measured now delta phi1 and this ambiguity means n has been resolved. So that means the lock has been established now. From here the time is t equal to t1 the satellites moves to a new position. If it is moving the number of full cycles, let us say this is now n1, so n will not be equal to n1. Rather there will be some extra. Extra could be positive or negative both. There will be some extra cycles here. So after resolving the ambiguity, this ambiguity parameter or this n remains constant but the receiver also keeps counting these extra cycles. So what is happening? How the position is being determined? The receiver keeps counting the extra cycles. That is also possible.

So now once the ambiguity has been resolved the receiver is locked with the satellite. Now any movement of the satellite till there is no obstruction till the signals are reaching the receiver the receiver will keep determining the range accurately because it has resolved the ambiguity that means it knows the n. It is measuring the delta phi phase difference. It is also counting the extra cycles which are being introduced there now that was n1 minus n. So by doing this the receiver is able to determine the accurate range.

Well now we have seen both the methods. The code based and the carrier based. What we will try to do? We will try to compare them.

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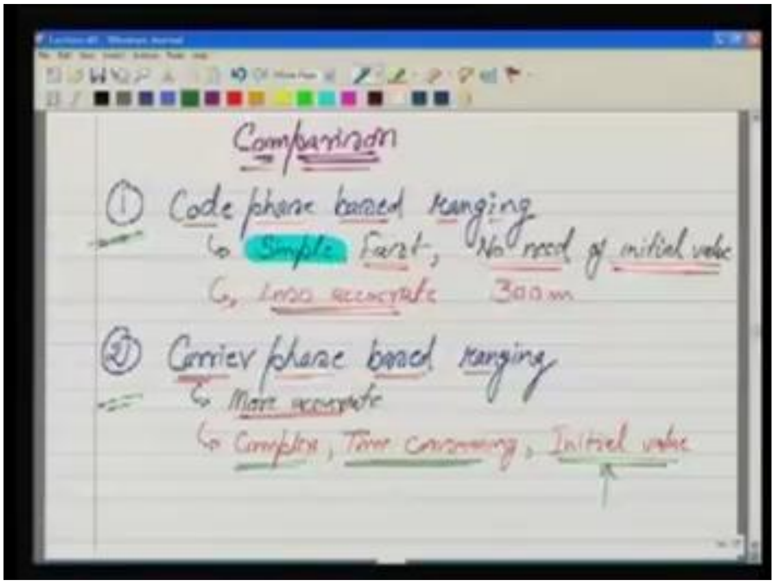

Now here in the comparison, first the code based methods which is also called code phase based ranging. The important thing about this is it is simple. Also these methods are fast because there is no question of resolving the ambiguity here. There is no need of initial value again because there is we need not to resolve the ambiguity here. However these are less accurate we have already seen why they are less accurate. For this CA code the wavelength was corresponding to three hundred metre so because of this reason these are less accurate when we compare it with the carrier based. Now in carrier phase this ranging a carrier phase GPS this is of course more accurate. We will see this accuracy values also in a while what can be achieved by GPS but at the same time these are complex. Complex means now we have to take in to account the phase difference we have to take in to account the ambiguity so these are very very complex.

Also in order to resolve the ambiguity we have to wait so we have these are the time consuming methods and anywhere in between if the lock of the receiver is broken from the satellite again we will have to restart the process. So again that ambiguity will not need to be resolved in some the methods. Then also we need an idea about the initial value so this is briefly the comparison of code phase GPS and carrier phase GPS.

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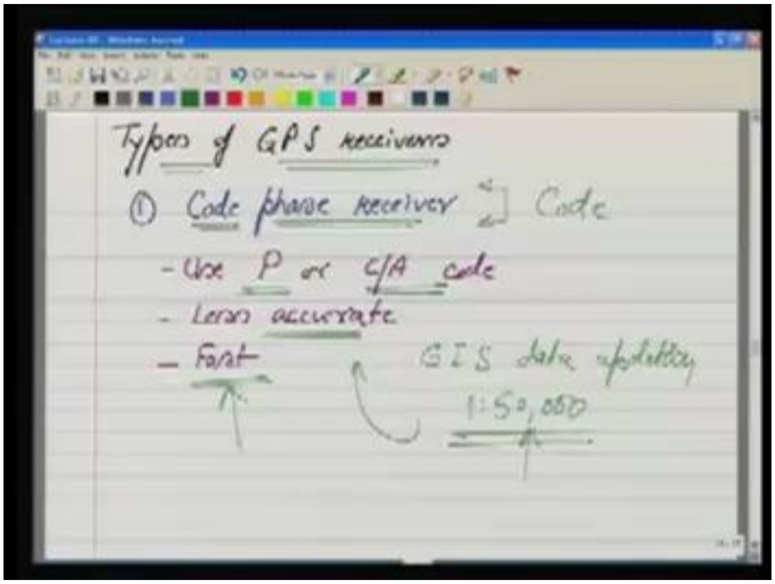

Now we would like to see what are the kinds of GPS receivers, how we can classify them. When we go to the market to purchase GPS receivers, you will find the GPS receivers which are so small so cheap that you can put them in your watch also. Some receivers may cost only ten to fifteen thousand rupees while at the other end there are receivers which are larger in size which are more complex in operation which are very costly. You will have to pay around fifteen lakh rupees for one receiver. So there are varieties of receivers which are available in the market. How we classify them, because this classification is important depending upon your application. What application you are using in your GPS for, accordingly you will take a decision. Okay. So what is the classification? How we can categorize them? For number one is the code phase receiver, means those receivers which are only for code signal. These may be either for P code or for CA code.

Of course, we know from the code phase GPS that now these receivers will be less accurate but the surveying will be faster. So if you are just doing a GIS data updation at one is to fifty thousand scale, we would like to go for a receiver like this because we do not need a good accuracy of the data here at this scale and we can carry out our work very fast.

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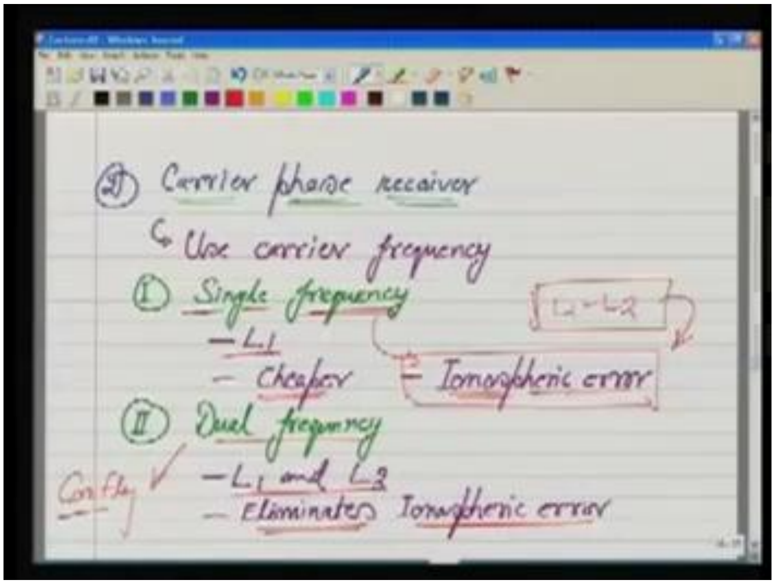

The other category of the receivers is the carrier phase those receivers which are making use of carrier signal. Now carrier means these could be those which can use either single frequency or may be dual frequency. Now those with the single frequency they use L1 they are again in comparison to the dual frequency they are cheaper but we know why we use L1 and L2 together. By observing their relative delay it is possible to eliminate ionospheric error. If you are using only single frequency the ionospheric error cannot be eliminated here. However in case of dual frequency both L1 and L2 frequencies are being used and this can now eliminate also the ionospheric error. Of course the dual frequency ones are expensive.

Then we can have another classification of the receivers, which is based on data use. Now there may be some receivers which are using only CA code. There may be some which are using CA code as well as L1 or the carrier phase carrier wave. There could be some which are using CA code, L1 carrier as well as L2 carrier. Also there may be a few which are using CA code, P code as well as L1 and L2. So depending what kind of facility is there the receivers are classified and this is how the receivers are available in the market.

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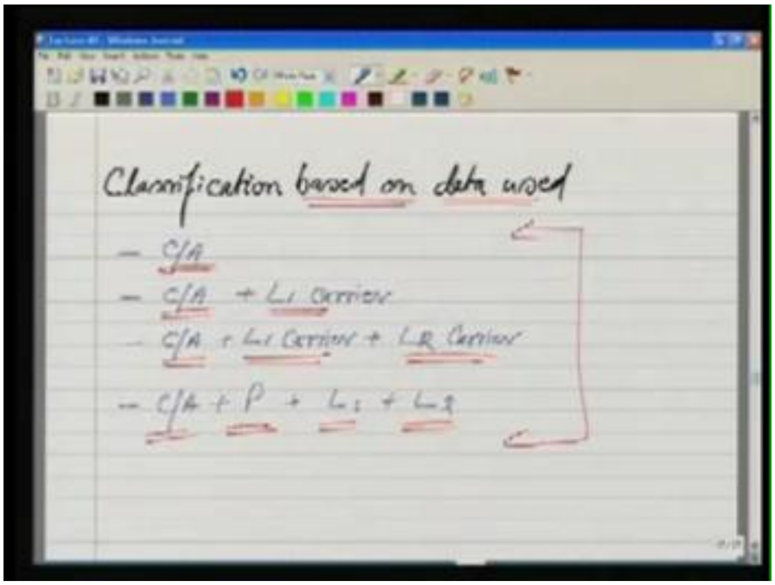

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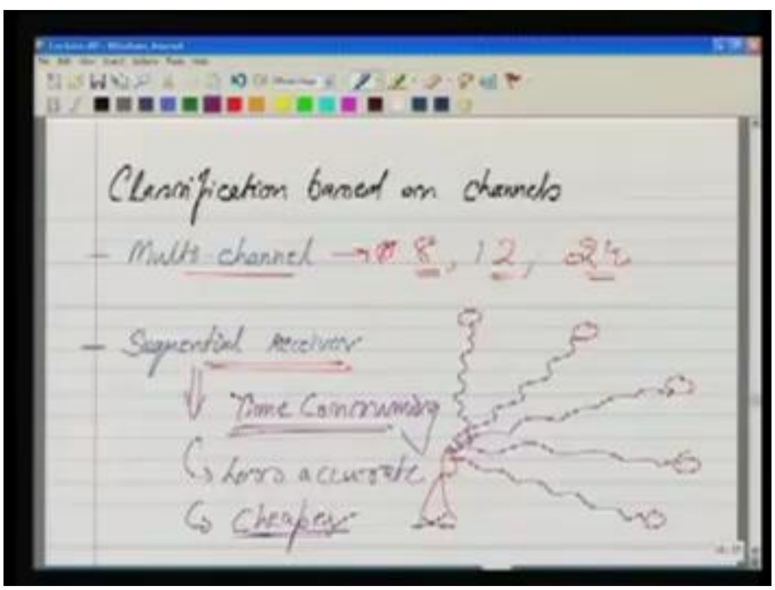

One more classification and this is based on the channel. Now what is channel? Actually for a receiver once it looks or it gets locked with the satellites, satellite is standing at a signal so we have, at any time, there is a signal coming from all the satellites. Those satellites which are visible to us, which are visible to the receiver. Now the question is does the electronic of the receiver supports simultaneous observations of all these signals or not? There are some receivers which can observe or which can capture all these signals which are coming from the satellites. There are few which have only one channel. So accordingly we can classify the receivers as multi channels.

You know they may have eight number of channels, twelve number of channels, twenty-four number of channels so they can simultaneously lock with all these satellites and collect their data simultaneously. However we may have some receivers which are sequential. Sequential receivers means they are; if there are five number of satellites so this receiver will capture the signal from these in a sequential mode one by one and then it computes it is location. Of course if it is sequential it will be time consuming, means we will need to give more time in order to compute the position as well as the position will be less accurate but the receiver will be cheaper.

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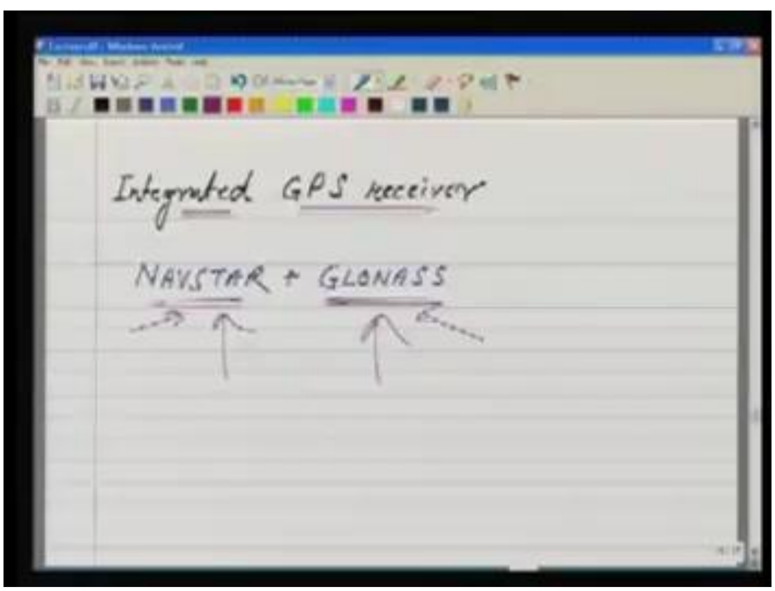

One more classification which is possible, it is of Integrated GPS receiver. Now what is the meaning of integrated? Now in market there are GPS receivers which are coming, like a GPS receiver can only collect the data from NAVSTAR. There could be another GPS which can collect the data from NAVSTAR as well as the GLONASS. There will be now because more GPS receiver some GPS receivers are already coming in to the markets which have the facility to collect the data from Galileo as well. So how or to what all GPS systems the receiver can collect the data or can collect the signal in order to compute the location depending on these GPS systems, we can again classify the GPS receivers.

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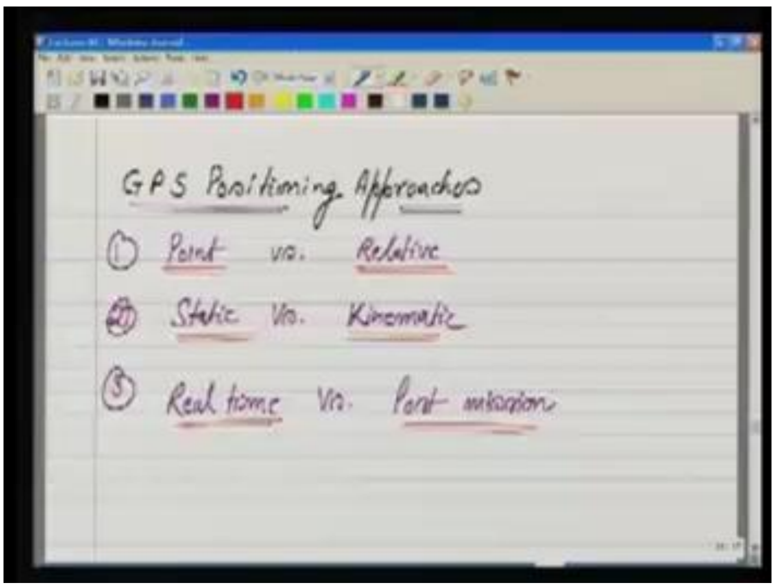

Next after knowing about the GPS receivers, their types, we would like to see about the GPS positioning approaches. Now so far we have understood broadly the methods which the GPS users in order to compute the location. We have also seen how the differential GPS is carried out and how it can improve the accuracy. Now we would like to see in field when we are using the GPS, actually what are the various possible modes. Again the list which I am giving you here is not a very wide list. It is not exhaustive, only some ideas about the various modes in which the GPS can be used there in the field. Okay out of those modes we can use the GPS for point positioning or for relative positioning, for static positioning or for kinematic positioning or also for real time positioning or the post mission positioning, mission positioning.

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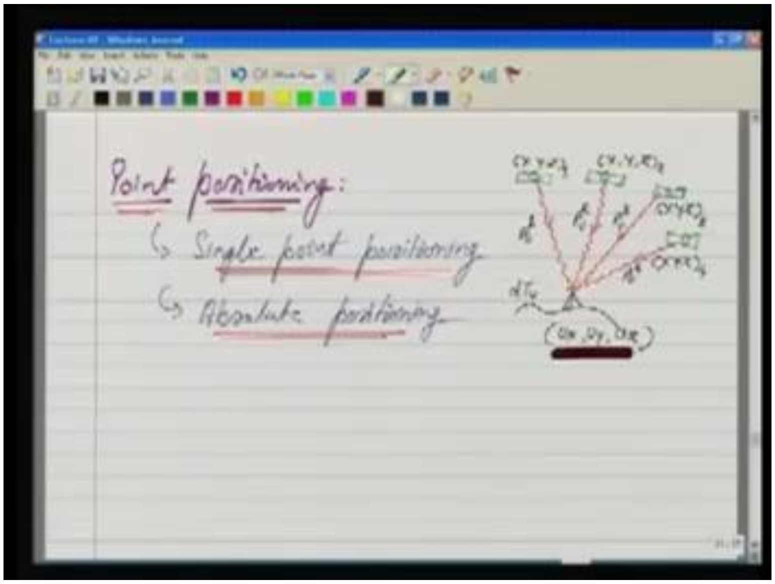

What are these in point positioning? This is also called single point positioning or absolute positioning. Now what is this? We have already discussed this principle by observing the ranges the pseudo ranges or may be in the carrier way also. This point positioning can be done either way either in the carrier phase or in the code phase. So basically what we are doing we are observing these ranges and we know the locations of the satellites and we can compute the coordinates of a single point. In the case of the relative positioning we can now eliminate the error.

We can eliminate now the error. So in case of relative positioning what is being done? We have a known location here for this known location. We know it is coordinates x, y, z in our coordinate system. There is a position here for which we want to compute the coordinates and as we saw earlier we were saying it as rover so for this location we want to compute the coordinates here. So what we do? We do the relative positioning. Relative means at the reference receiver. Also we are receiving the signal and from here we are computing the correction. So this correction is being computed for all the satellites and then this correction is being transmitted to the rover of the other receiver where we want to compute the position and the rover is basically observing the times t1, t2, t3 and t4 for the signals which are coming from these four satellites and then it applies the correction as it should be: t4, t3, t2 and this is t1 here. So this is how the corrections are being applied in the times which are being observed. So by knowing these correct times the position over here can be determined. So this is how we did the DGPS also and this kind of positioning we say relative positioning, where the positions are being determined of an unknown point with respect to receiver at a known point. So this is the relative positioning

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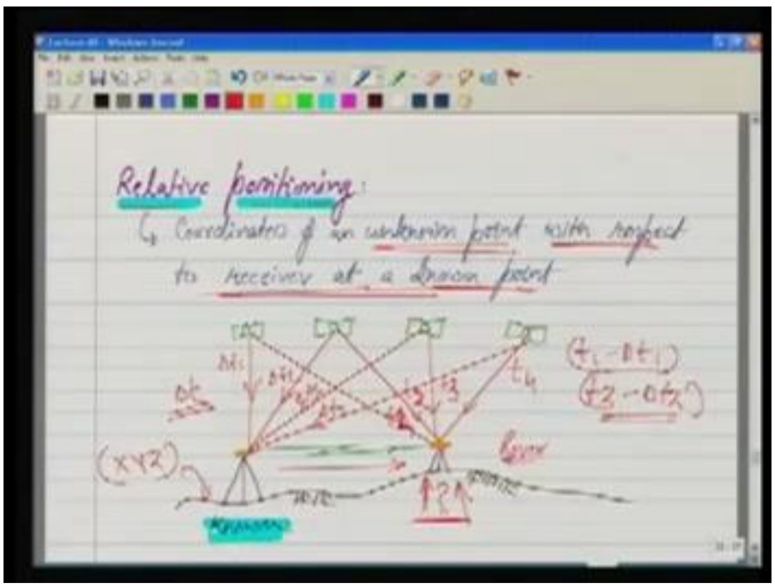

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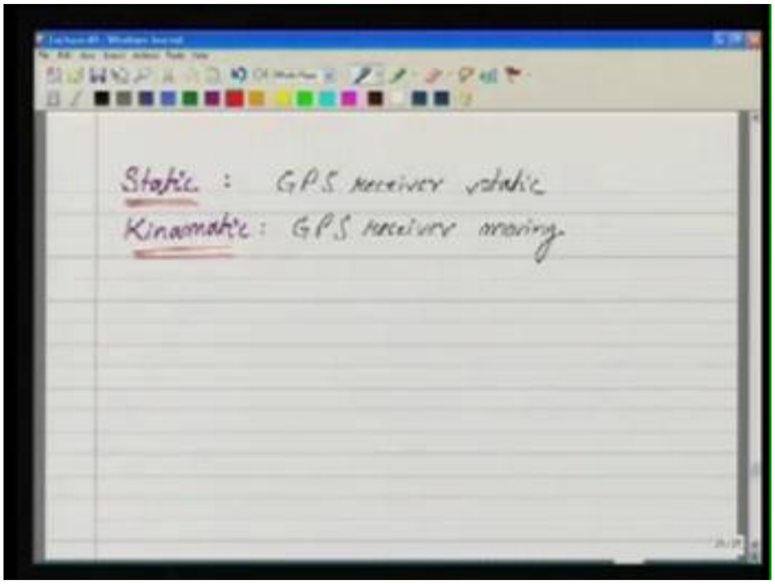

Another way is we can say the static or Kinematic. Static means our GPS receiver is a stationary. It is not moving. We keep it here for half an hour for five minutes for ten minutes and we determine the position here but some applications will demand that the GPS receiver should move. For example if the receiver is fitted in an aircraft or the GPS receiver is fitted in a car or the GPS receiver is with an individual was moving. In all these cases the positions which is being determined for the receiver is the kinematic.

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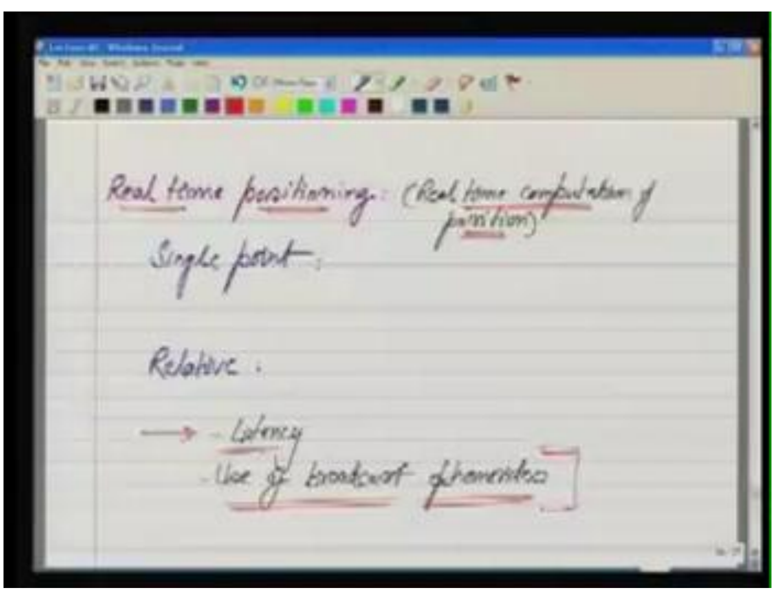

Another way of positioning we have already discussed. This, it is the real time positioning, means we are computing the position in real time. Now it could be for single point positioning also for relative positioning. If we have a single point positioning means we have a our receiver here and the moment these signals are reaching from the satellite, at the same time I am computing the position of the receiver. So this is the real time. In case of differential positioning or the relative positioning we know the point. We know the coordinate here. This is the reference receiver and the this reference receiver is computing the corrections and these corrections are being transmitted to the rover and the rover makes use of these corrections and then compute it is position there in the field itself in real time. So this is the real time relative positioning.

Well what we can do? All these computations we can do later on. For example the single receiver here it is collecting the data. It is not doing any computations. It is not computing its position. Rather later on we go to the office and then we compute the position. Similarly in the case of the relative also it is collecting all the data and this is also collecting all the data. Data means the signals and all the computations means the ranges the time corrections and applying these time corrections at the receiver all these are being done in the office. So that is the post mission. Now in the case of real time there is one problem. We saw that problem earlier also that was called the latency. But more than that one more problem is there in the case of real time. This is the real time positioning will use the broadcast ephemerides. What is this broadcast ephemerides?

We know in order to locate or in order to do the GPS we need to know exactly where these satellites are located. This can be predicted by knowing the orbital characteristics but there are perturbations. So what is being done? The ground control station is observing the satellites and keeps measuring those perturbations. So right now for example the navigation data which is coming from the satellite has got the predicted position as well as the perturbation. It is there but that is the broadcast ephemerides broadcast means it is not the actual it is rather the predicted one. Using the past data how the perturbations are there the ground control is extrapolating the positions, okay? Today at this particular time where the satellites are these particular position is a predicted one based on the past twenty-four hours or forty-eight hours of the data above the satellite actual position.

So this predicted one is being transmitted through the satellite along with the signal. So this is the broadcast ephemerides. So obviously the broadcast ephemerides is not the actual perturbation there in the satellite position, so this is not accurate. So in the case of the real time GPSwe are using the broadcast ephemerides so there are chances that there will be error, but however in the case of the post mission processing, now we have come back to the laboratory you log on to a site and from that website we can download the actual or which we say the precise ephemerides.

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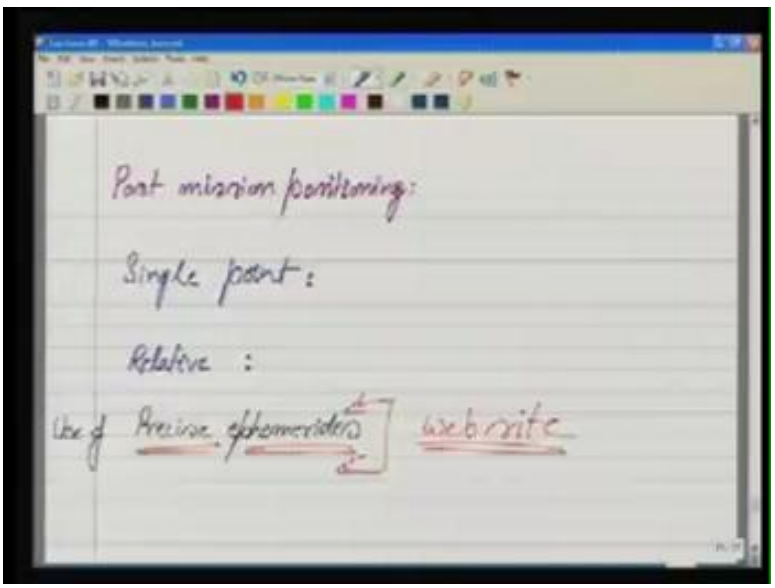

So these precise ephemerides are available from the website. What I can do, I had done the GPS surveying field five days back. Now after a week I log on to the site and in the site the precise location of the satellite at that point of time are given. So what we can do, we are downloading the correct positions, the actual positions of the satellite so these are more accurate obviously. So in the case of the post processing our locations which we are determining are more accurate

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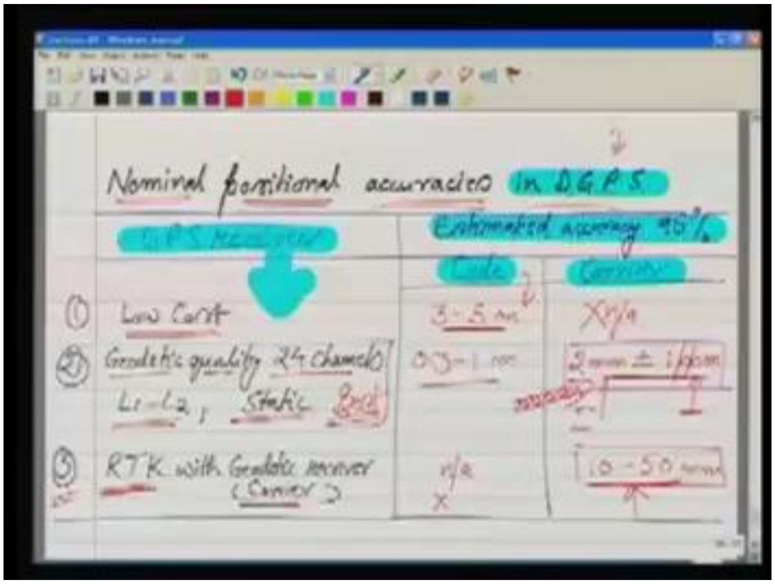

Finally as we can see here, we are trying to give now some nominal positional accuracies in DGPS. So please mind it now we are not using a single GPS, rather these accuracies are for DGPS mode. Now in this DGPS how we are writing these accuracies. We are first writing about the receivers. What are the types of receivers and then this is accuracy at ninety-five percent and we are giving the accuracies for code based and as well as for carrier based. First of all if we have a low cost GPS so naturally the low cost GPS will not support carrier so it will not support this. So in case of carrier there is no accuracy value here but with the low cost GPS if we are doing the DGPS in code phase, the accuracy which we can get is three to five metre.

This is quite good accuracy in order to update GIS data base at middle level scales. Well if you have a geodetic quality GPS means it has twenty-four channels. It has got the frequency L1 L2 and we are doing the static observations. If you are doing this static observation with this geodetic quality GPS, this is the best possible way and if you are using only code based this is the accuracy which we can get zero - point three two one metre. Now the most important one of them now over here this is the best possible case which can be there. What this case is, we are using a geodetic quality GPS which has

twenty-four channels or large number of channels. It is using dual frequency, both the frequencies so the ionospheric errors can be eliminated.
We are working in static mode, we are not moving. So static means we are observing for long duration of time. So we have better accuracy again. Then again we are using the carrier phase. So this is best possible combination which we can say dual frequency carrier phase static observation with large number of channels. So best possible case and the accuracy which we can achieve is 2 mm plus-minus 1 ppm. Now what we are indicating by this accuracy the way we have written it here? We know already when we are talking about EDMI, we discussed how this is the way of writing the accuracy. Over here two mm is because of the instrument. So the instrument results in this two mm accuracy while this one ppm it means one per part million is related to the base line distance. The base line distance means we are doing the DGPS.

Of course, see the carrier phase dual frequency multi-channel static and relative positioning there is the best possible combination. So, once we are doing the relative positioning we have a base between these two reference and the Rover. So this 1 part per million means we will have an accuracy of 1 in one million base line. So, whatever the length you know one kilometre one millimeter. So, that is the second part of this accuracy. So, that is the best possible accuracy which we can achieve. Well, third, we are doing the real time kinematic - it can be done. Real time kinematic is a survey which can be done only in the carrier phase so this is not applicable here. So what is the meaning of this real time kinematic? Real time kinematic is a relative positioning. We are computing the position in real time and we are using the carrier phase. We are using the geodetic quality receivers. So now the movement is possible. It is not a static for those applications where movement is there. In this case the position can be determined with 10 to 15 millimetre accuracy and this is important.

If you are putting this kind of GPS on an aircraft the location of the aircraft can be determined with you know two centimeter, three centimeter, that kind of accuracy and this is highly useful for air borne surveys. Then we are using the camera put on in an aircraft or some other sensors put on the aircraft. We need to know their location of the aircraft so the GPS in RTK mode is helping us. And of course in these cases we are doing the post processing not the because in this case basically in this case we are doing the post processing not the real time processing. So what we have seen in this lecture, now we talked about what are the methods of measurement in the GPS: code based and the phase based.

We saw some formulation in the case of a code based and also now in case of the carrier phase. In the case of the carrier phase GPSwe measure the phase difference at the receiver but there was a problem of ambiguity, that was the integer ambiguity and there are methods by which this integer ambiguity can be resolved. We found that the carrier phase is more accurate than the code based, then we saw the various kinds of receivers the receivers which are available in the market. Receivers can be classified depending how many channels are there, depending the kind of the signal which they can process, which they can receive. Then finally we saw some ca based methods, you know the static versus kinematic, real time versus post mission processing. So we saw some methods which are actually used once we are doing the survey in the field. So we end our this video lecture here. Thank you.