GPS Surveying
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Lecture – 07
GPS Positioning (Principle and Methods)

Welcome friends. This is the 7th class on GPS Surveying. Today I am going to talk on GPS Positioning Principles and Methods. Their method of working GPS is very simple. In spite of that the different types of GPS positioning are available and we do adopt in the (Refer Time: 00:55) depending upon defined factors like what is the accuracy requirement, what really we are going to do in the (Refer Time: 01:04), what type of objects detail we like to cover etcetera.

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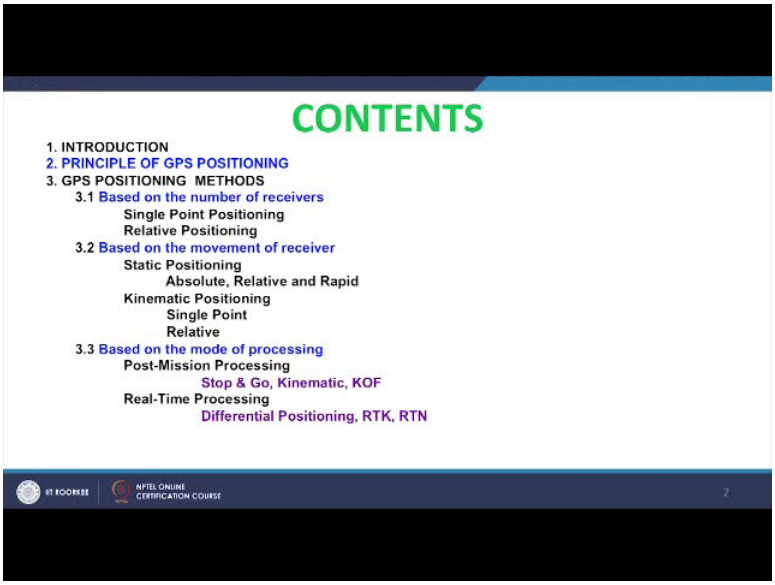

So, we need to know GPS basic principle of working as well as the different matters that is available which will be discussed in this class. This class we will talk on firstly principle of GPS positioning and followed by different GPS positioning methods. Now the methods are fundamentally may be divided into different categories, but in this course I have divided it on the basis of the number of receiver, based on the moment of the receiver, and also based on how the data will be processed.

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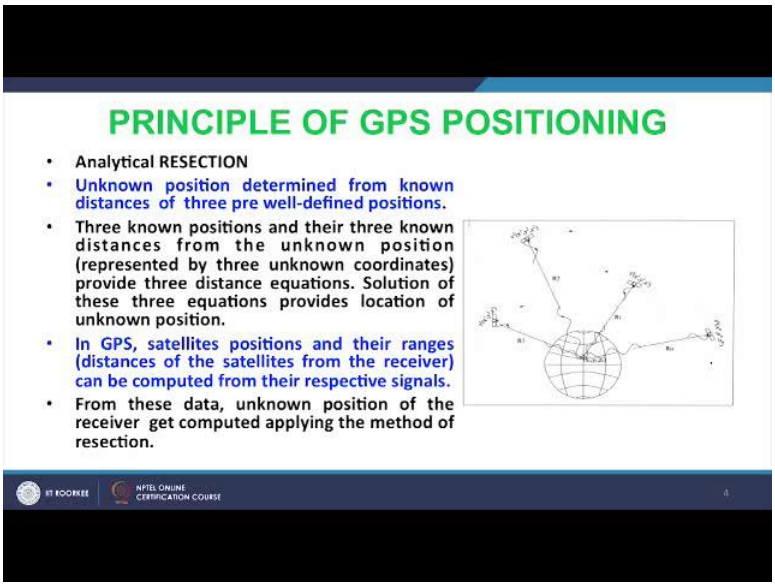

Now, what is the three principle of working of GPS? The principle of working of GPS is equivalent to what we learnt in our surveying course is resection.

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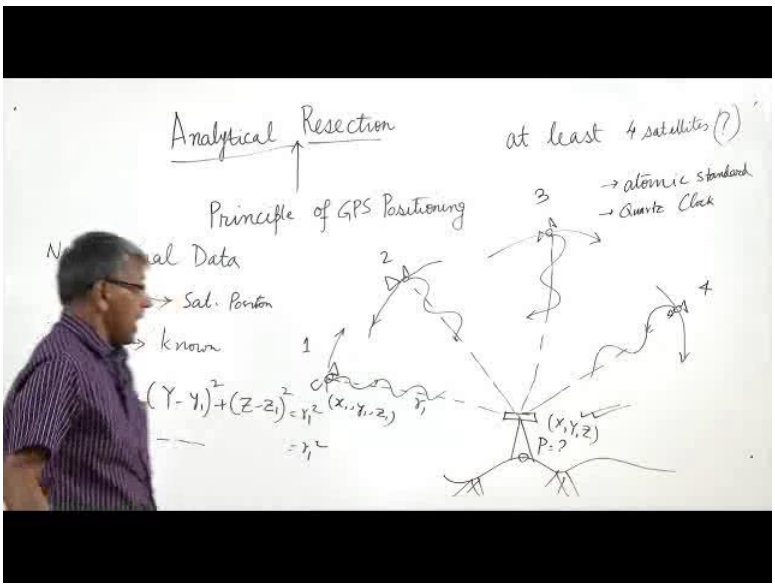

Now what the method of resection? If in the method resection we find that if we know the location of 3 objects, then form an unknown location if we can observe this and have a line of observation then the intersection of these 3 lines of observation will provide us the location of the point on which this unknown position is. In this way from 3 known objects and its orientation we can get the location of the unknown point.

Now in case of GPS we also apply the same principle, but in GPS we positioning we apply the method in analytical way. So, the basic principle of GPS positioning is analytical resection method. Now in case of GPS whole form we get the three objects as well as the direction of lines. In case of GPS it is the satellites whose positions we know from; so in case of GPS let us say there are 4 satellites; 1, 2, 3, 4 which is being absorbed from the surface of the earth and this is the point location whose position we want to determine. So at this point what we do, we place a GPS receiver. This receiver receives GPS signals from these satellites.

Now, as the GPS signal reaches to the receiver from satellites these signals contain navigational data and these data we may use to find out the location of the satellites. So, the satellite position gets known once the signal reaches receiver suppose the location of satellite 1 is x 1, y 1, z 1. And also from time of transmission of signal from satellite to the receiver the range between this satellite and the receiver at that instant of time is also known. So ranges, that is the distance between the satellite and the receiver also known once the signals gets received from the GPS satellites. Now, if x 1, y 1, z 1 is the location of the satellite number 1 and x y z is the unknown position now from distance equation we can write like this.

Similar to these for satellite number 2 we can write; in that way for 3 satellites we can write 3 equations and we have 3 unknowns solving these we can get the unknown location x y z. Now we know that in case of GPS it is not that 3 satellite signal, but signal should be available from at least 4 satellites. The reason one is that. In satellites the clocks or automatic standards use are of atomic standard and the time measurement devices that is used in our receiver is quartz clock. So, there lies a lot of discrepancy in measurement of time between the satellite system and the receiver system.

But one thing is that for all the satellites because it is being received by the same receiver the discrepancy in measurement of time will be identical for all the signals coming from all the satellites to the same receiver. So, you will have one more errors or unknowns that are associated with a particular receiver that is called time error or time measurement error or del t. So, that is taken is another parameter of measurement.

In case of GPS it is not the 3, but 4 parameters we need to measure. And so we need to have at least 4 satellites from which signal has to arrive at the receiver to determine the

position, because time is the primary parameter to the measure. As we can see in case of measurement of range it is the measurement of time which is required. So, the first parameter we need to measure is the time which is including this error in time. All these thing will be involved. And in case of GPS we say that it is at least 4 satellites. So, the more numbers of satellites signals from the more numbers of satellites the better it will be. So, this is in short about the basic principle of positioning of GPS.

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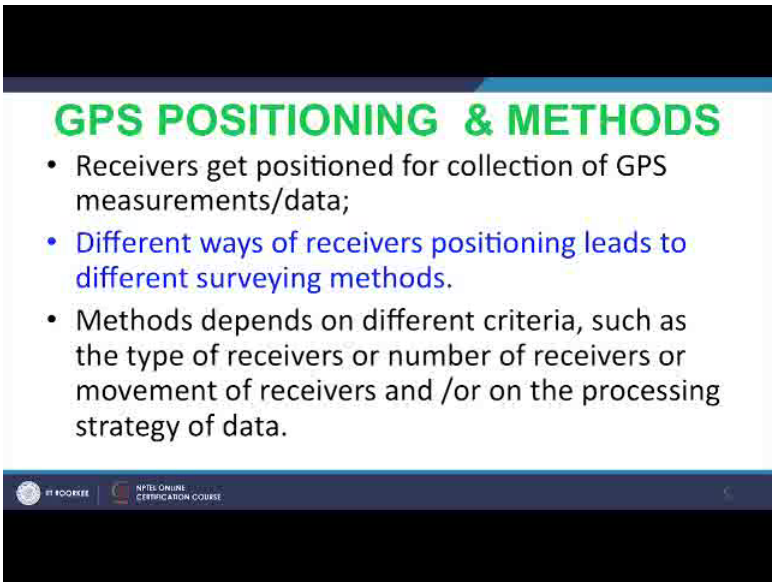

Now we will like to discuss on methods of GPS positioning. Now we can see from our principle of GPS that to carry out GPS serving we need to place our GPS server at any position for which we need to determine the position. So, GPS serving basically consists of replacing the GPS receiver. Now depending upon the field condition, depending upon the objects to be delineated or positions of object depending upon that part of object whose position object has to be determined, depending upon the accuracy requirement, these methods vary.

Again these method will vary we how we place the receiver in the field.

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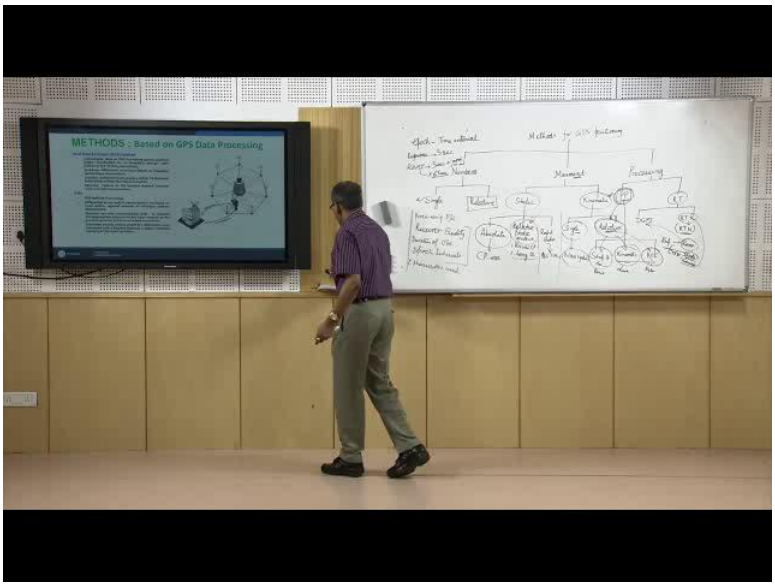

There are different methods are available for GPS positioning and they may be classified into different categories, but in my (Refer Time: 12:25) consider the all the methods under 3 categories. Now first category I want to consider on the basis of numbers of receivers that has been used in positioning. The second category I want to consider as what is the way means whether it is in a static condition or in movement depending upon the type of the movement of the receiver we can classify the positioning of the methods. And third on who are depending upon the processing time.

Now, on the basis of number of receivers there are basically 2 types; one is at if we make use of a single receiver that is called single point positioning or point positioning. And the other type is called relative positioning where we can we do use more than one, that means minimum two or it may be more than still two. Then, depending upon the movement again there may be 2 types; one is called static positioning, where the receivers will be in static condition. And another is called kinematic condition, where at least one of the receivers should be in a movement condition. And then our static type of again may be of 3 types; one is called absolute static positioning of GPS receiver, then will call static method of solving, and the third one is called rapid static.

And under kinematic there may be 2 types; one is called single kinematic, where a single receiver will be used and that will be in movement condition. And a relative kinematic

where there will be at least two receivers of which one will be in a static condition and other will be in kinematic condition

And then under processing again there may be 2 types; one is called post processing. That means, in this method of surveying the data that has been collected during surveying will be possessed much after it has been collected. The other one is called real time; that means, data will be processed simultaneously during it will be collected. Again this post processing will be there are 3 types of post processing; that is one is called stop and go, where the we will consecutively stop and take that reading and we will move forward to the next point. Another is called kinematic and a kinematic on fly; KOF.

So, these are the 3 methods of surveying and under real time there are 2 types depending upon holds what type of data it will be processed; one is called DGPS, differential positioning. Another is called RTK; Real Time kinematic. Nowadays one special variety of (Refer Time: 17:47) is also available and now it is called RTN; Real Time Networking.

So, this is in short the different types of search positioning methods that are available nowadays. Now, let me go one by one.

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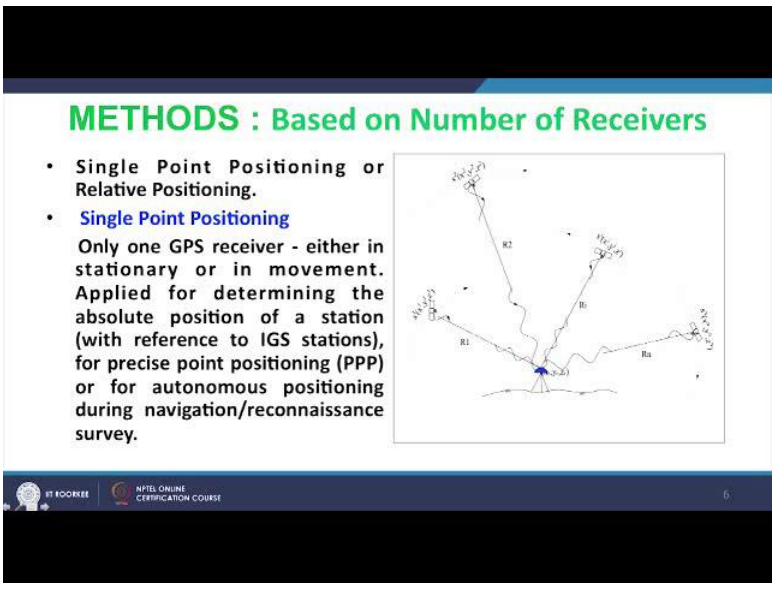

That single point positioning method where the single receiver is being launched and the signal will come from as many satellites in the (Refer Time: 18:17) from the receiver,

minimum for could be 4. And now these signal you can see here this in a single also absolute also single, so we can say that single receiver may be in a state of static condition that is called absolute static surveying. And if the single receiver is in kinematic condition then it is called autonomous GPS surveying. Most of us who are having our mobile with GPS generally we may use of our mobile for our navigation purpose, specifically in a city area or in an area where you do not know to or to move around. So, that is called Autonomous Positioning.

Now, these absolute again you can see that may be in a static means this is being used for very precise positioning. Specifically for control point establishment we go for this. So, the signal is also coming here and also coming here, this is called absolute positioning for control point establishment and this for navigation purpose.

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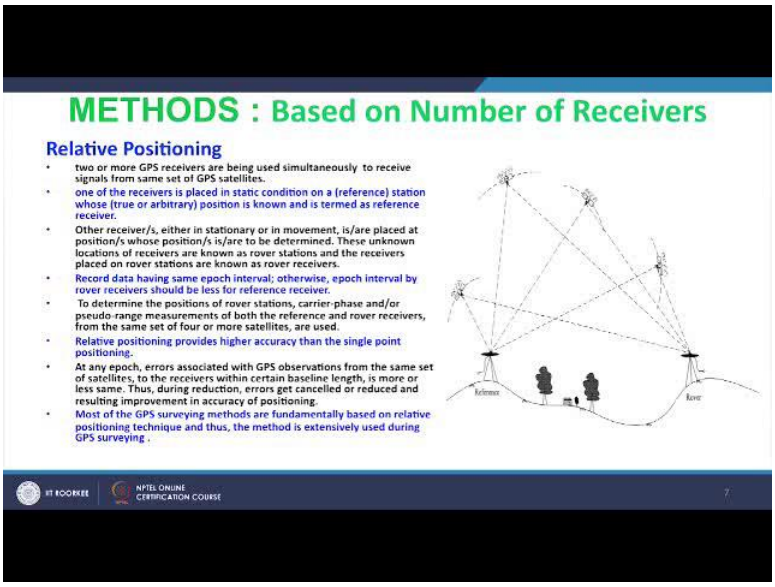

Next relative positioning, here also we can see that relative. In fact, this relative positioning is widely prevalent among all this, mostly this is then all these are relative positioning. Now what is relative positioning? In case of relative positioning there will be at least 2 receivers of which one will be on a reference station means, a station point whose location is known this is also called Control Point. And, other receiver will be placed at point whose position is to be determined that is called Rover Stations or Rover point, and the receiver is called rover receiver.

So, the condition is that the both reference and rover receivers should receive signals from 4 identical satellites, at least from 4 identical satellites. This is the condition which is to be prevailed for relative positioning, and the epoch of observation for the rover receiver should be equal to that of reference receiver or more than it. That means, what is epoch? Epoch means time interval in which the signal will be received. So, for references suppose the epoch is 1 second or 1 second suppose then the epoch of rover should be at least this could be one second or more that means 2 seconds 3 seconds etcetera.

Now, suppose the epoch of reference is suppose 5 seconds then the epoch of rover should be at least 5 seconds or more; that means, 10 seconds or something like that, it cannot be less than 5 second. So, that is what is called epoch of the rover receiver should be less equal to or more than what we have got the reference receiver. This is the very important consideration.

First important consideration is that both reference and rover receivers should receive signals from at least 4 identical satellites. Second condition important is that the epoch of observation of the reference receiver should be less or equal to what it is available for the rover receiver. Now after making the observation in a tips note we do classes the data from both reference as well as receiver together, and during as we do process the data together there is every possibility that the error in observation in the reference receiver and the error in observation in the rover receiver will be more or less identical. So, when we do process together then identical errors will cancel each other and that will lead as to better positioning accuracy. That is what the idea behind in the repositioning.

And so for any accurate say GPS surveying always we go for relative positioning. And relative positioning is widely prevalent among all the methods as I told you, so it is to be understood nicely.

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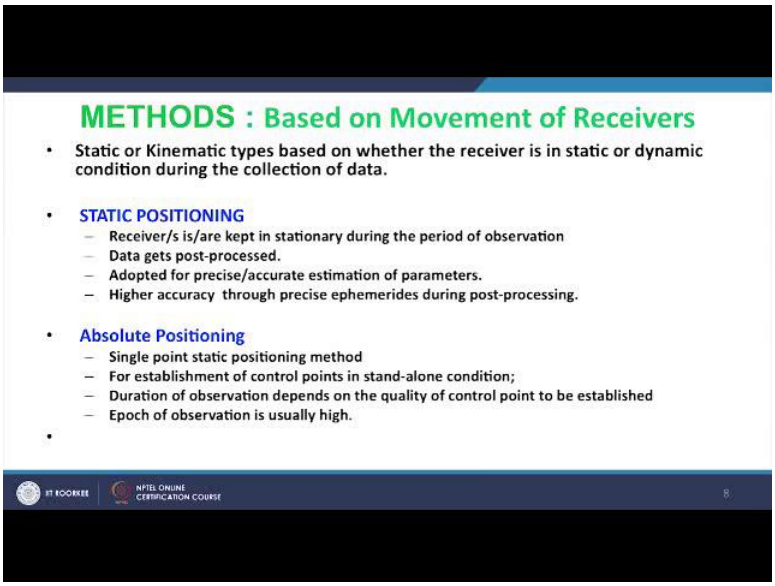

Next let us take into movement consideration. As I told you that receiver may be in a static condition when it is not moving and kinematic condition when it is moving. And again static condition it may be absolute, that means if we take a single receiver in a static condition and taking observation that is called absolute positioning and that is used when there is no reference available around, and while we up to start our work without having any known position. In this case we need to take observation for long duration as well as you should take the epoch of observation high like, 15 second, 20 second like that.

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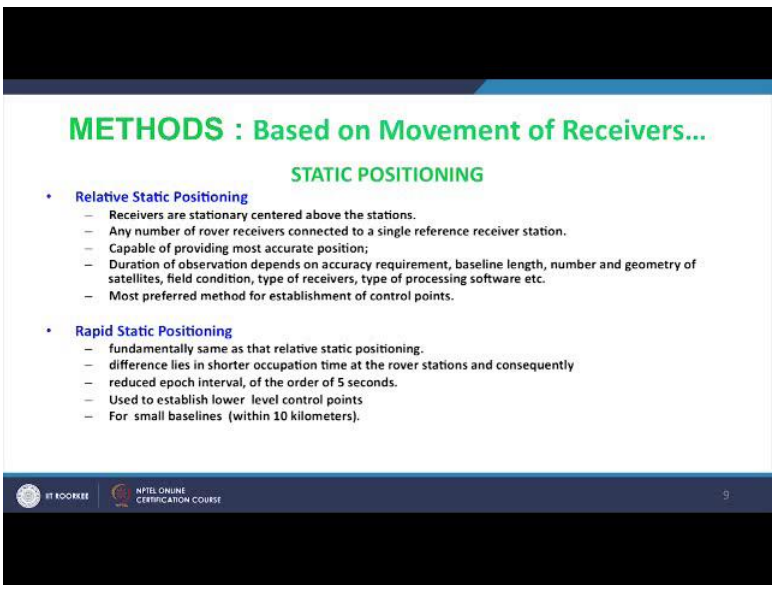

Next our relative static position, there is call relative static method. As I told you in relative method there will be two or more of this; one will be at least reference and one will be second or third fourth all will be rover. Because it is a static so all these receivers will be in a static condition over the point for which I need to take the position. Later we will download the data from both the receivers, all the receivers and will process together and the position of the reference receiver is known with respect to that other location of other receivers will be determined.

And for very accurate positioning we go for this, but in that case we should make use of precise ephemerides. Now what are ephemerides? Is nothing but navigational data precise ephemerides means precise navigational data which will be available in the internet site after different suppose 3 days or 7 days or 15 days. So, if I take the precise ephemerides after 15 days then that is the most accurate ephemerides or navigational data about the satellites. If you make use of that to the relative static positioning then that will lead us to most accurate positioning. And this of method and this epoch is used for establishment of best control points or when the based on length very high.

So for long based on length or very precise control point positioning we do go for relative positioning; for precise control points and long base lines. Now if the control points are of less important means less accurate control point is need to be established of the based on lengths of not that high, it means less than 10 kilometre or 20 kilometre; if the baseline length is 10 less than 20 kilometre, then instead of relative static positioning will go for rapid static positioning.

Now, rapid static positioning is same as relative static positioning, only thing is that in case of rapid static method will do take observation for smaller duration as well as our epoch interval also more. Sometimes we make use of lower quality of GPS receiver. So, it is the receiver quality receiver. Quality means that quality of the data then your time of observation or duration of observation, then epoch interval. These are the important considerations about the accuracy. And then ephemerides used for processing, then processing software. So, these are the things which need to be considered to arrive at more accurate GPS position.

So, with this static is over now kinematic condition. Now let us go to kinematic method of GPS serving. As I told you in this case at least one of the receivers will be in a

movement and already I have discussed about the single receiver kinematic positioning. Now in case of relative kinematic positioning one of the receivers will be in a reference station in a static condition and the other will be more than one may be walk as a rover and will be in a kinematic condition.

Now, which is important is that actually this is the method which we again see available with these methods, so will discuss on the post processing methods. Now depending upon the processing time, when we pass that GPS data either immediately after the collection of that data or afterwards that in the basis of that we do classify into post processing. In post processing GPS data is get possessed well after its gets connected.

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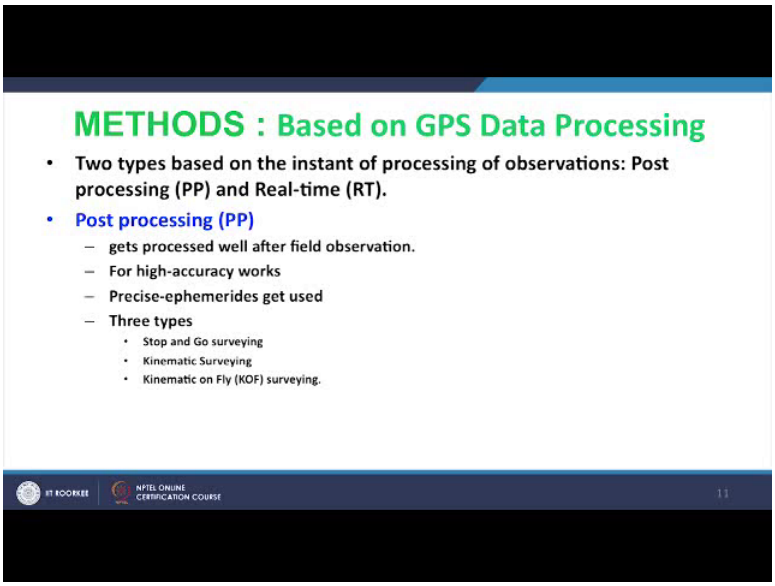

And this is the method which we generally used for most accurate purpose. As I told you that relative static position that is also post processing type and in the relative kinematic are post processing, relative post processing and relative kinematic. That means, is step on the kinematic and kinematic on flag.

Now, in this case stop and let us discuss with this stop and go.

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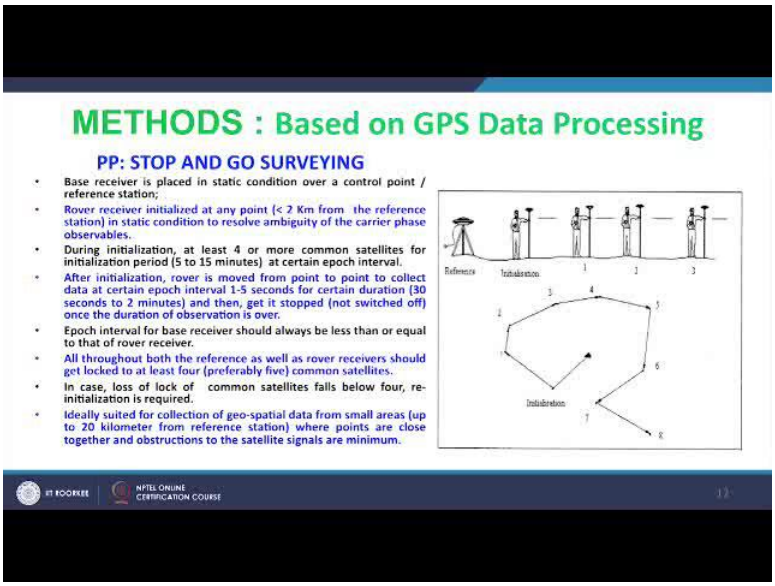

In the stop and go method of GPS surveying we need to place a reference in a static manner and then the kinematic one first we should place at any point, it may be any point but only thing is that it should be within the 2 kilometre from the reference station so that both of them have the signal from at least 4 identical satellites; preferably it should be 5 and more. And then for few minutes, that means may be 5 to 15 minutes depending upon the strength of the project nature of the project the they should take signal from identical satellites having at least 5 identical satellites. That is this process is known as initialization. Once it is being done then the rover receiver is kept points of whose position which need to be determined.

Now, what you will do after initialization the receiver has to be kept on the first point. Once it is taken to that point then we will make it placed on that point and data has to be collected and once the data collection is over, then it will be making a stop and then we have to take it second position that is stop and go; go means it will be removing from one to other and stop during the stopping process it will take the observation at the station.

Now, the most important thing to be noted is that in this process we have to do initialization process. Second point is that during whole of the surveying at least 4 or preferably 5 or more satellites should be identical in nature for both the receiver. That means, signals from 4, 5 or more satellites identical satellites should come in both

reference and rover receiver. And the epoch of observation of reference should be equal to or less than the rover receiver.

And in case during this observation there is any loss of lock between these satellites; that means, some common satellites are not coming, that means if there are less than 4 satellites which are not coming then we have to re initialize the process. And this method of surveying is to be done when we are needed to capture data from point absorbs which will be coming repeatedly in any area of survey.

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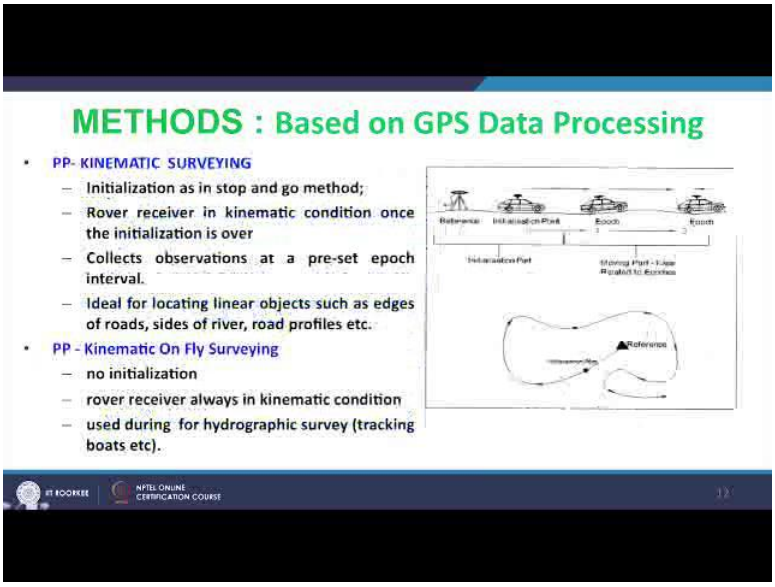

Then in kinematic survey actually it is the same as; that means, here also we have to do that initialization process as we did in stop and go method, but here after initialization the receiver will be in continues kinematic mode. Generally for linear type of objects like the corner of the roads or seashore like that we can go for kinematic surveying. Then third one is that kinematic under fly in which (Refer Time: 35:01) will be done once you will start the rover will start moving in a kinematic condition. Like this type of method is applied for hydroelectric surveying. So, kinematic on fly is hydroelectric surveying. This is for linear objects and this is for point objects; point object line object or linear object and this is for hydroelectric surveying.

Another way it is which is now popular very much is the real time GPS surveying. Now in case of real time surveying the errors are sent from reference to rover and rover makes connections in real time and provides position in real time.

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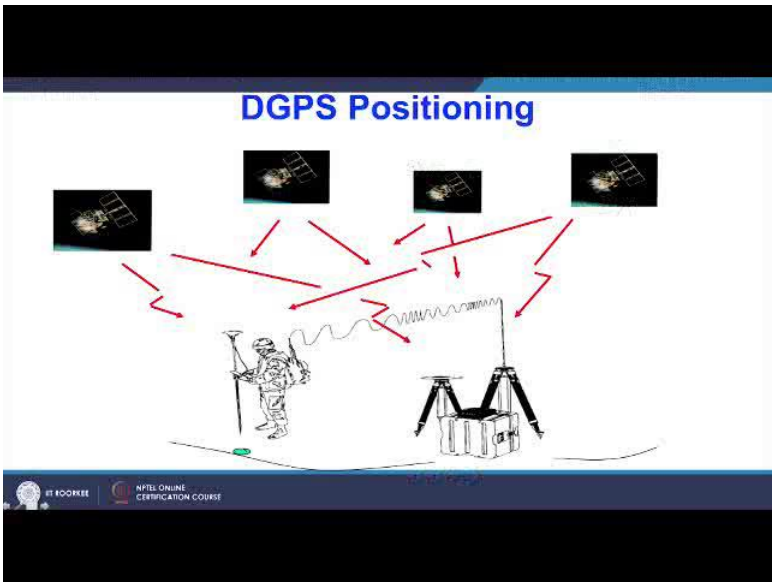

So, in this case there is an essential arrangement that is required to have; you can see here that there is a reference receiver which is placed on a point whose position is known and this is the rover receiver and this is a radio communication and this is connected with a reference receiver.

So, the basic idea is that the errors that will be available in this will be also available same as this rover receiver. Now as the point known, so as the signals are coming it will compute the position of this. And already known position and computed position that is the difference the difference is the error that error and some other parameters these radio communication it will communicated to the rover. It is assumed that the error that is available with the reference position is also will be same as that of rover and the rover will complete this position and make this correction and give the position in real time.

So, this is the fundamentals and depending upon these errors may be computed from court or from career. If the error messages is computed from court then it is called DGPS; Differential GPS. And if the error messages are being prepare from career phase then it is called Real Time Kinematic.

As you can see from this that the real time kinematic will provide us more accurate position because these error messages are computed from the career phase of the signal. And still more accurate method has come up that is called real time network. In this case

what happens there is more than one reference stations there are be network of reference stations.

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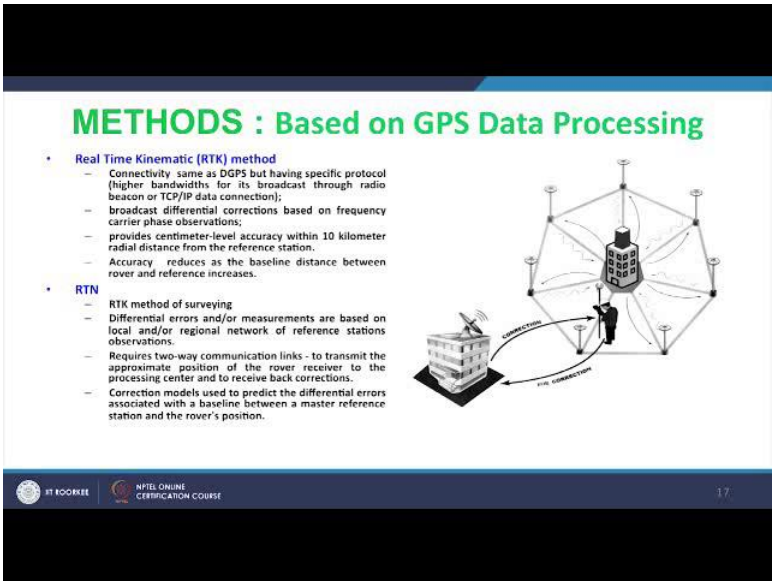

And from this reference station there will be a central server that the signal will be coming and error messages will be produced there. And the rover position is there, it will also provide this position data and all these thing for correction. And all these information will go to the central server and central server will process all the data and it will provide the real time correction message to the rover position. So, this is called real time kinematic in network mode, and this perhaps the best most accurate real time positioning.

So, with this I like to conclude to this class.

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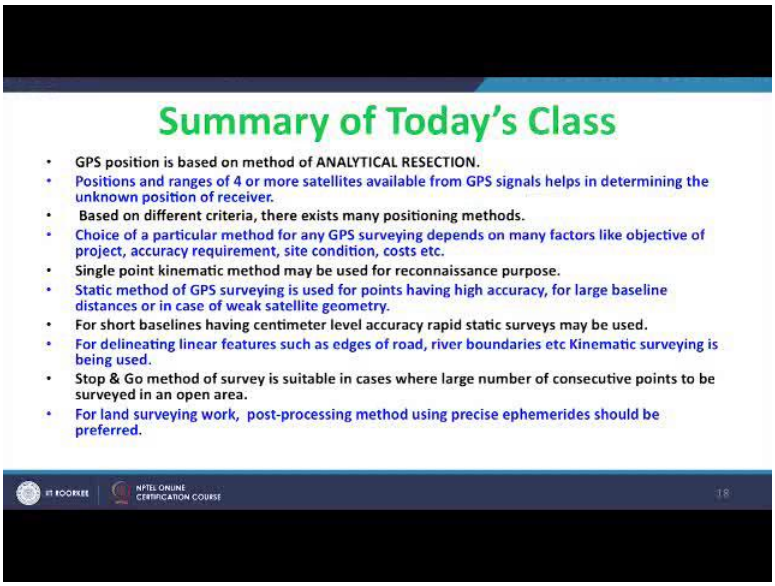

However, before concluding let me summarize that it is the analytical research and method which is being basics or which is the behind GPS positioning. For GPS positioning we need at least 4 satellites and preferably 5. And based on different criteria there are different methods that are available nowadays.

Of this the single, autonomous, kinematic mode is for our recognizing survey. We can go for autonomous positioning method to establish our control point we should go for relative static method. And if we want to long base line also we will go for relative static method, but if you want to establish lower order control point or smaller base line we will go for rapid static method.

If we want to go for positioning of point objects then we should go for stop and go method. If we want to go for line objects like the road or rover line we should go for kinematic method. And for land surveying work it is always advisable to go for post processing mode of GPS surveying. And if we want to end up with the very accurate, we should go for post processing GPS surveying method along with precise ephemerides.

Thank you very much. See you again in the next class. Next class will be on demonstration of some of these methods that will be done in the field.

Thank you.