Introduction to Remote Sensing
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Lecture 12
Remote Sensing Integration with GIS and GPS

Hello everyone and today in this introduction to remote sensing course, this is 12th lecture and we will be talking about how remote sensing can be integrated with the other 2 powerful technologies, GIS that is Geographic Information System and (gl) Global Navigation Systems, one of the example is GPS but we will discussing also some other navigation systems as well.

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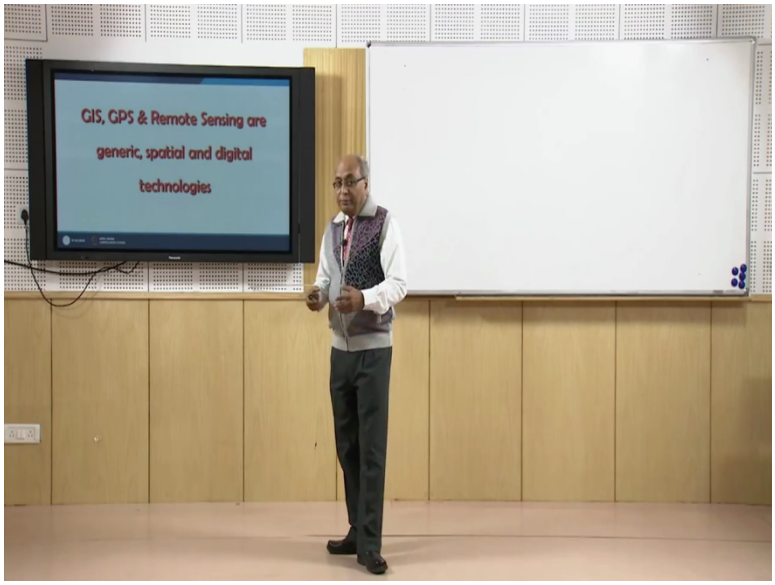

As you know that in earlier lectures also I have mentioned that GIS, GPS and remote sensing are having 3 common things in between that they are generic technologies, that means they can be applied to various areas, application areas and there are few areas still unexplored so in future we will be seeing the applications of these technologies either in a integrated fashion or may be individually or maybe 2 technologies together, maybe in some more new technologies may come in between but the 3 common things are generic so that they can be applied for various applications.

Spatial which are related with the location specific data because remote sensing images provides the data of a particular part of the earth so it is having location, same in your GPS, GPS provides

the geographic coordinates and GIS provides a platform to handle all kinds of spatial data so therefore these technologies, we put them as a spatial technologies as well and finally and the third common thing between these technologies is digital.

Digital means originally the remote sensing data is collected in digital form, transmitted in digital form and now there are digital platforms computer or image processing softwares are available so we can digitally process the data, interpret the data and analyze the data according to our requirements. Same with the GPS, GPS data is also available in digital format and GIS again the platform which provides to handle all kinds of remote sensing and GPS data so these 3 common commonalities between these 3 technologies have allowed us to create new types of applications, new types of products.

One of the very popular products which nowadays we are using is like Google Map or Google Earth which are using remote sensing technologies like Google Earth as well as digital elevation model which has been derived from remote sensing data and say on and you say custom design GIS software and if you are having GPS input collected from some location field surveys, especially for civil engineers then that too can be put on that one on Google Earth so it's a wonderful product which is a integrated product of GIS and (remo) remote sensing plus you can add the your input data from GPS as well during field surveys.

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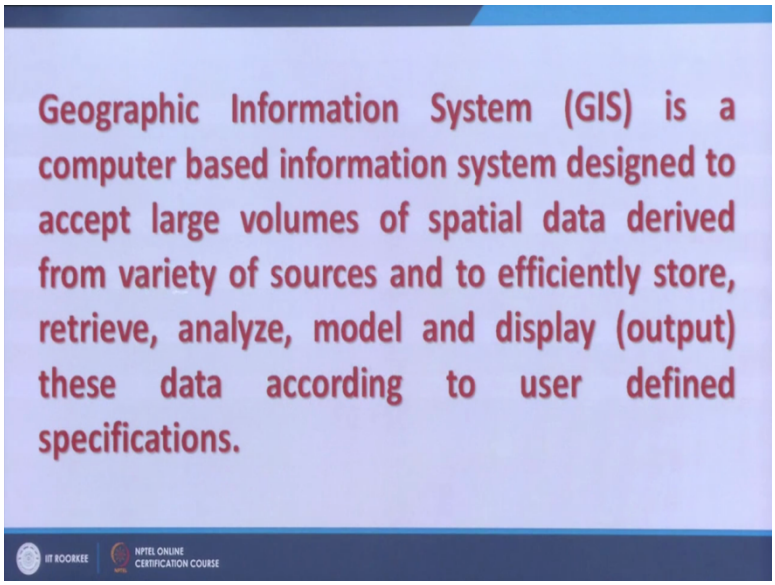

As you know that GIS because GIS has not been introduced in this course but there is a separate course which I have delivered GIS but just for completeness that I will bring the just definition of GIS which is a computer based information system designed to accept large volume of spatial data, spatial data means location specific data objects which are having geographic locations and that data might be coming from variety of sources and the purpose of GIS platforms are to efficiently store that spatial data and retrieve retrieve as per user requirements, analyze it and model it. So that we can we can analyze to that extent that we start predicting about some phenomena, some features or for for exploration purpose or any other purposes so model N then finally display or create outputs as per user defined specifications. So that's the purpose of GIS which allows us to handle all kinds of a spatial data on a digital platform.

The data might be coming from variety of sources, it also allows you to convert analog data into digital data to some extent in a semi automatic manner and then you finally integrate everything and start creating new products. The important point here that the these are the few terms we we use interchangeably sometimes anonymously but in fact if we start looking in details that these are all together different words, different terms have got different meanings.

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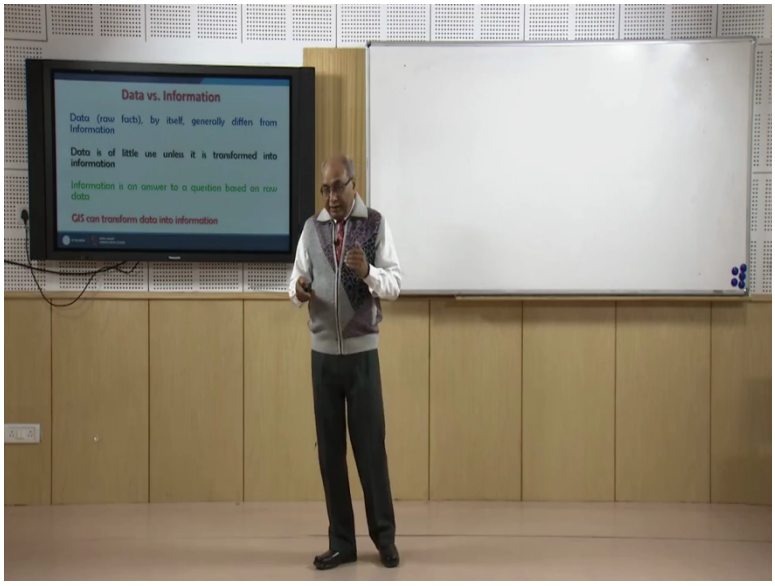

For example data and versus information. The data is basically about the raw facts, the data is nothing but a raw facts and by itself (gene) generally from the information and suppose

somebody has got the data about some surveys which has been done in the field and just fed in the say excel sheet. Now it till then it will remain the data, no analysis has been done, no other processing has been done but once I start doing some analysis, simple may be statistical analysis, may be some sorting things.

Suppose somebody has gone in the field, collected water sample data. Now, if he has collected 30 samples from different areas then I want to see the distribution so I will try to plot the map on the on GIS platform a form of map using geographic coordinates and this will start giving me the clustering information and other things whether the data has been collected uniformly or collected from only in a small area and so and so forth plus also that what is the highest value, that data which I have collected, what is the lowest value. Suppose value I talk about PH so where is the PH highest on the water and where is the less, so once you start analyzing these things on the raw facts that is the data then your data is converted to information.

But before that just collecting the data from the field and putting into say excel sheet or database, it doesn't become that information, it has to be analyzed, certain kind of operations, analytical operations, statistical operations have to be performed on that and once these are done then this data can be converted into information. So these are 2 terms, this we have taken completely differently. Data as I mentioned that data is itself little use unless it is transformed into information and the today is, the computer technology is allowing us to transform these raw facts the data into information quite easily and information is the answer based on raw data.

We create questions, once the data has been analyzed, it it is converted to information. Now when we raise the questions, for example, I can raise that where I have found the minimum PH value in the water samples, where I have found the maximum PH value, what is the average PH value or in which areas, if I have plotted this location then in which area I am getting higher PH value, in which area so all kinds of questions. Once the data has been converted to information can be answered various types of questions, may not be all kinds of questions so but the GIS goes on step forward, it converts your data in not only into information but also into the knowledge.

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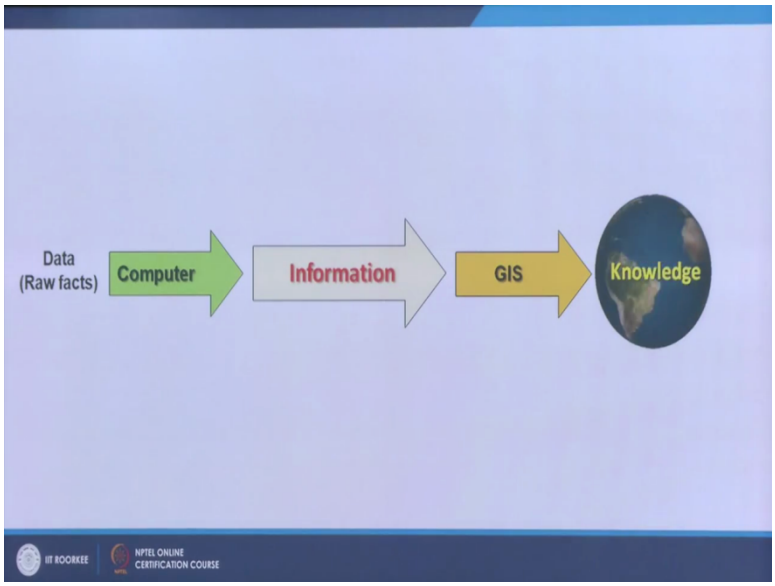

That we will see here now that first is the (ro) the (ro) raw facts or data, using computers, we can convert this into the information but when when we use the GIS platform, along with some other information's, may be remote sensing data or maybe some other maps, may be soil map or a elevation map or some other thing then I can convert that into the knowledge and this becomes very (power) that is why GIS becomes a very powerful tool so that the raw data by its self analysis and further processing can directly be converted into knowledge and that makes a lot of utility of GIS otherwise simply using computers, maximum you can do, you can convert into information but using GIS, you can convert to knowledge.

Now the third technology, this is GPS, as we know that GPS was invented the early 90's or well it came in the civilian domain the early 90s when there were war between Kuwait and Iraq and American army entered in that war from the Kuwait side and what happened then they started because they were (wa) doing this or they were having war in a desert area and landmarks are very difficult to find so using just simple topographic sheets, it was very difficult. So why that but before that they developed this technology mainly for army purposes and that was the navigation system and they gave this name a Global Positioning System.

Earlier it used to called strategic defense initiative or (pa) it was part of Star Wars of Ronald Reagan. Parallelly also, when the Americans were developing GPS which is known as GPS,

parallelly Russians were also developing and that system is called Glonass and they both systems are Global Navigation Systems but GPS came first and it it was allowed by the to use by the civilians and therefore it became very popular. And still today, even in our mobiles, we are having GPS receivers, hand held GPS receivers and much more advanced versions of like (differ) a differential GPS are available today and in in civil engineering, especially in surveying extensively these things are being used.

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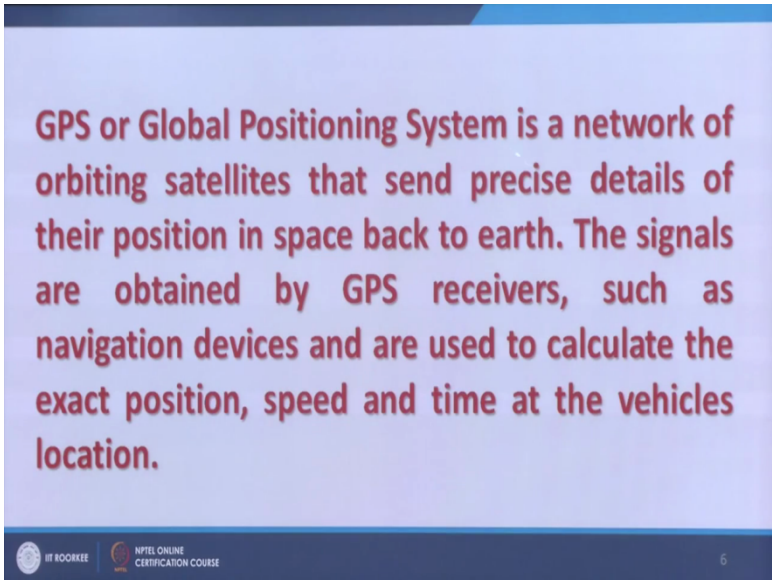

So basically if we look the definition of GPS or any navigation system, basically it's a network of orbiting satellites that sends précised details of their position in a space back to earth and these signals are obtained by GPS receivers such as navigation devices and are used to calculate the exact position, a speed, time and the vehicle locations. Concept wise it is simple. If you look the earlier surveying methods, we used to, if wanted to know where we I am located on a map then we what we used to do, we take, we used to take back bearing during our field service from 2 knows points which are which I can see from my naked eyes in the field itself and the same corresponding points I can also locate in my toposheet.

So then we used to take back bearing from these known 2 points which I which I am seeing and at the same time I am seeing in toposheet and then drawing these lines. So wherever these lines used to cut, we used to say that we probably we are located here in order to make certain that we

are there exactly where I have we have just seen through these 2 crossings of 2 back bearing lines. Then we used to take back bearing from third (po) point and if third point also, the back bearing line if also cuts at the same points where 2 lines earlier have cut then we are very um very much sure that we are on this particular location.

This concept of back bearing was on 2D. This (con) concept with the satellite technology especially with navigation systems, it became a 3D technology so (he) here what basically is happening that there is a constellation of satellites which we will see, which system is having where what type of constellation and then these satellites are at in each orbit, they are at say if I take the example of GPS then there are (si) 6 satellites are there, 6 six orbit are there and in each orbit, you are having 4 satellites and all these are having they are having in each orbit they are having at equal distance, each satellite is having its unique id.

So what each satellite is doing, also they are having synchronized atomic clock so what they are doing, they are sending the signals which is a times stamped, date stamped, location stamped signal and saying that I am in a space at this location and I am dispatching this signal at this moment so when a receiver receives this signal, I know that how much time it has taken because there is a time which is when signal was sent from there, it is there and so the time taken by that signal to reach to the receiver gives me the distance if I multiply by the speed of light and why is like in concept of back bearing, if I start getting signals by receiver from 3 such navigation satellites then I would know where exactly on globe my receiver is.

So it's like in back bearing, minimum back bearing readings were only 2 required but it's a 3D so minimum 3 are required to know X and Y position that is latitude and longitude but if I want to know the height or elevation of a point where receiver is kept then I have to need to have signal from 1 more satellite and that is the 4th and that will give you the 3D so 3 satellites will give you 2D, 4 satellites will give you 3D.

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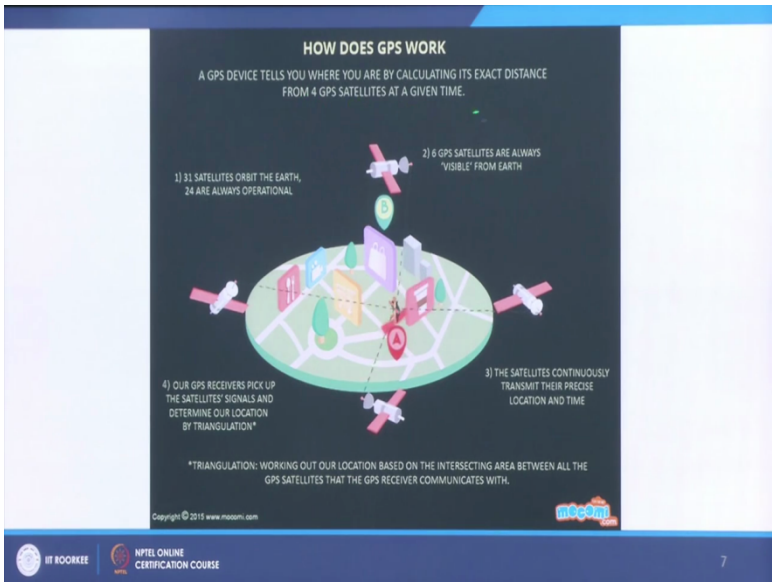

We will see all these things in little detail as well then how GPS works, the GPS devices tells you where are you and while calculating the exact distance from 4 GPS satellites at a given time, the first one, there are you know this thing, these figures keep changing because there are spare satellite but the in case of this US GPS, American GPS or navigation system which we call as GPS, a minimum constellation is the 24 satellites in 6 orbital planes.

6 orbital planes are there and so that at a time, minimum if you are in a open area, you should be able to get at least signals from 6 to 8 satellites at a time minimum and this then these satellites continuously transmit their precise location, every second they are sending a pulse, a signal from there towards the earth that I am here, at this moment, I am dispatching. Let me give you analogy.

Like if I post a letter from Roorkee to say Chennai so when I leave this letter into the letter box then in the post office it is stamped that in it is being posted from Roorkee on this data and this time. When it reaches to Chennai then again that post office will stamp so while looking these 2 posts 2 stamps, I can estimate that how much time it has taken to reach from Roorkee to Chennai. Almost similar concept that the it is in digital form, that signal once it received, the distance is calculated and direction is known so that this range is basically these are the ranges.

As you are seeing in this animation that as a person keeps moving that the he is getting the location because the 4 satellites are continuously communicating with his GPS receiver and that location is being calculated every second for that person or for that receiver so the GPS receivers pick up the satellite signals which are being transmitted by all these 24 satellites all the time every second and determine out location by a triangulation method so this is how this what is that triangulation that working out our location based on intersecting area between all the GPS satellites at the GPS receiver communication. The GPS receiver which are communicating with them.

Now think that if I am on the mountain on a hilltop, then I would be able to get may be even signals from 10 satellites and if I am say on Mount Everest, probably I might be able to get signals from 12 satellites because then hindrances are less so if if I want to have a good position then I I need to have a a very large open sky. If I am in a valley then I might be getting very less signals. From less number of satellites, signal quality might be also good, not good and therefore my position estimations might not be also good.

Nowadays when we use in our smart mobile, the Google Map, when we switch on, initially it will show a large blue circle and after some time you would realize that that blue circle has become a small blue circle so what it is basically indicating that now that initially the error margin was much larger, that means the estimation was very poor but once it starts getting the signals from various satellites GPS satellites then my position has improved, position estimations have improved and therefore the error circle which is blue has reduced and the so that sometimes by using some other application programs, you can know that what kind of accuracy you are getting.

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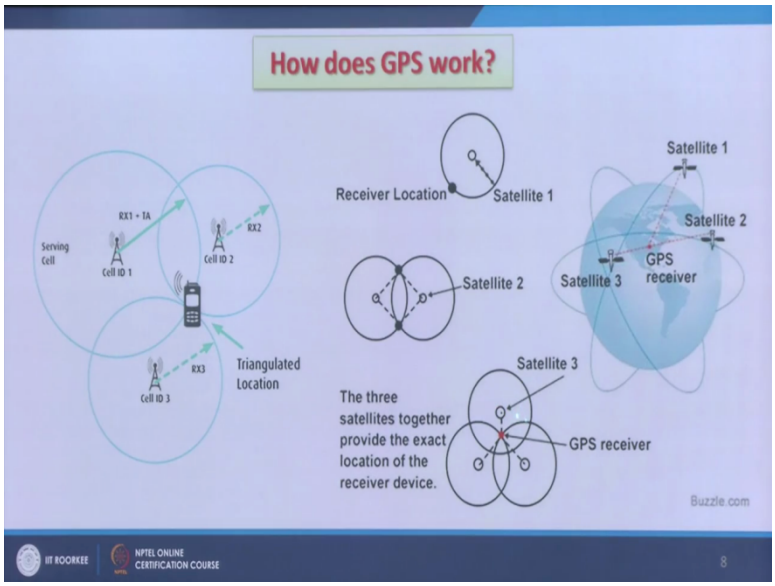

So we will be we will we will go on further on this how GPS works basically as I have been saying that this the this like in case of towers, mobile towers, how they get the concept of a GPS, how they get the signal, that each tower, if each tower keeps transmitting its location as well apart from signals then wherever these 3 (sig) you know the range of these towers that means these circles, 3 circles will cut that is the position where I am standing.

This is how a GPS works. Think that instead of 2 dimension on plain area on a surface of the earth, if I consider these as spheres and instead of towers I consider them a satellites, in the same way, when these spheres will cut, that would be going to be my position of my receiver so this triangulation location or triangulation concept is, here it is in 2D but in case of satellite it becomes a 3D. So satellite 1 whenever this range is available, I know radius of my sphere.

So one satellite will give me the one (sa) one is sphere, another satellite once I get, start getting signal, I find the distance between receiver in satellite then another sphere will come. Now then there will be 3 spheres. Suppose I am getting signals minimum from the 32 satellites so wherever these all 3 satellites will cut, these spheres will cut in circles, it is looking only 1 points but in case of a spheres, there will be 2 points, so 1 would be very far from surface of the earth therefore the other point which is close to the surface of the earth is going to be location of the receiver, so the 3 satellites together provide the exact location of the receiver.

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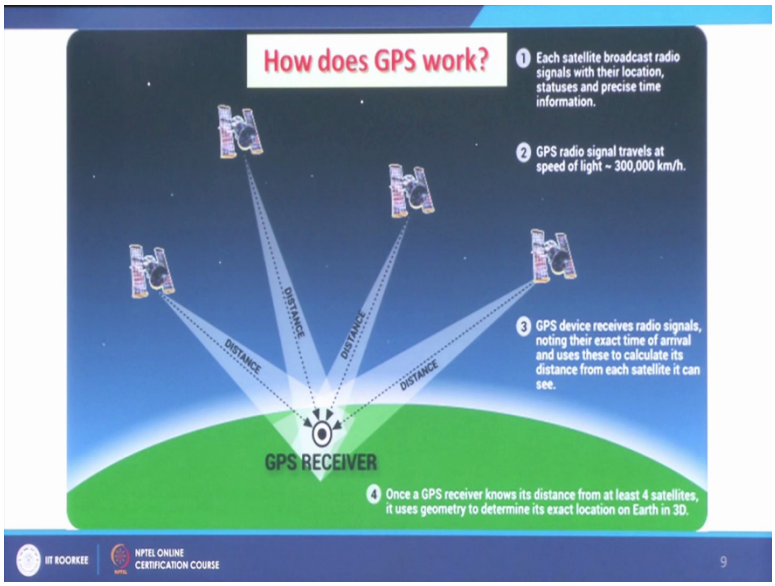

And now as I mentioned that each satellite broadcasts radio signals with their location status and precise time information. This is very important to note that each satellite every second is sending signals and these are in the radio frequencies and that means that in all weather conditions, day and night, 24 hours, we can receive signals from the constellation of 1 navigation system for example here, a GPS which is American one and once the time is calculated, the dispatch time, receiving time then distance is (go) available.

Now 1 is sphere for this satellite, one is sphere for this, one is sphere for this and one is sphere for this and likewise, GPS radio signals travels at a speed of this 300000 kilometer per hour and GPS receiver device receives radio signals noting their exact time of arrival and uses this calculate the distance from each satellite. Basically the distance, once distance becomes available then this imaginary sphere which we I am emphasizing can be calculated or can be drawn by the receiver itself or calculations about or estimations about positions can be done.

So once a GC, a GPS receiver and knows its distance from at least 4 satellites, it uses the geometry to determine this exact rotation of the earth in 3D. If I am only interested in 2D then um minimum 3 satellites are sufficient but if I am, I want to know not only X and Y but elevation as well then I need to have the signals at least from 4 satellites.

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As I have mentioned that when US was developing their (Nav) Navstar system that is the GPS or Navstar satellites, that is the GPS, the (simil) same time, the Russians were also developing a system which is called Glonass. Later on some regional systems have also come which is the European countries have also developed Galileo, BeiDou, India has also developed, I will discuss little later but why there are requirements, once a global navigation system became available in somewhere 1990s, earlier it was accuracy part was not as good as today but at least it was there and it was globally available to anyone who is having appropriate receiver so why other countries started developing?

Because if we start depending everything on the GPS, for all kinds of navigations whether for aircraft operations or for taxi fleet operations or for the railway engines operations then it it would it would have been a complete a monopoly of US and then whenever they wanted, they could have switched off and all navigation system would have gone completely haywire. So in order to you know not to depend completely on American navigation system that is GPS, Russians also developed. Basically it was originally Navstar or GPS was developed to for the missile technology but it it became much more popular equally in our day to day life.

Then Glonass was again it is also a (navi) a Global Navigation System and even in nowadays in not very expensive a smart mobiles, their receivers are capable, GPS receivers are capable of

receiving signals from Navstar that is US GS GPS as well as from Glonass so in instead of getting from 1 navigation system, signals from 1 navigation system, it is possible to receive signals from many navigation systems and so know these receivers, small tiny receivers are coming with smart mobiles or hand held GPS receivers that they can receive signals from various navigation systems.

So Russians also developed parallel to the system and almost same time, the third system as I mentioned by the European countries that is the Galileo but Galileo is not truly a global system, Galileo is a regional system. Then Chinese also came because they too never wanted to depend themselves on GPS that is Navstar or Glonass so they too came with their own navigation system and design wise, constellation wise, it is completely different than typical GPS system or Glonass system. This BeiDou navigation system of China is having all together different constellation.

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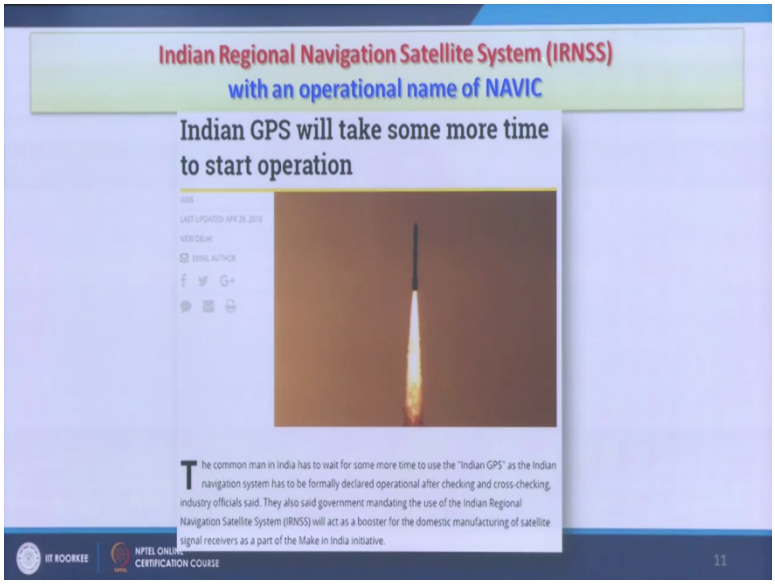

Same time also, when India realized that we need to also develop our system (be) not only for missile technology but also for day to day life in the civilian world for all kinds of navigation so we went with this kind of initially it used to called IRNSS and then later on it was renamed as Navic and say though it has not become fully operational but I am sure that very soon our mobiles will have a receiver which might be receiving signals not only from a GPS that is

Navstar, Galileo and BeiDou because BeiDou also provides, it's a global navigation system, it also provides data free of course and may be when if I am using such receivers in India I might be also getting signals from Navic as well.

If I get from even in a valley, if I get signals from 10-15 satellites of different navigation system, definitely my position estimations are going to be very very accurate. If I compare just or if I get signals only from 1 navigation system so that is the advantage for us going to be that if we start getting signals from many navigation systems of the worlds then our position estimations are going to be very accurate. Generally we get with the simple these smart mobiles we get say position estimation, there is a error margin, may be 5 meter or 10 meter sometimes but if I am getting signal from 3, 4, 5 navigation systems that accuracy might be improved within 1 meter which is very good for many applications.

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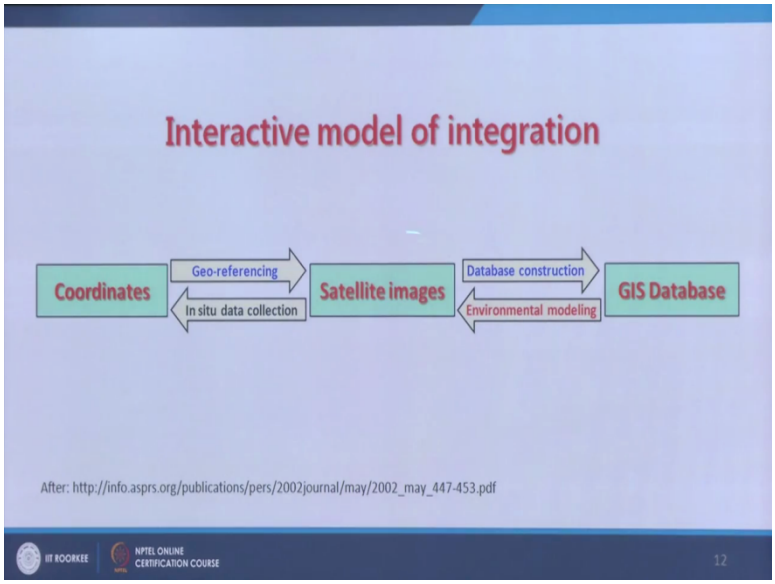

Now this whole I have so far introduced a very briefly what is GIS also very briefly about the GPS and remote sensing, we have been anyway discussing so now this main purpose of this lecture was to have this how to integrate all these technologies so that we get a very nice product. So there are different models which we can think that is one is the interactive model of integration which is very popular, very commonly used. As I have said all the data which is

either remote sensing data or data from coming from GPS or your GIS platform, they all handle the geographic data, that is means special data and the that is the advantage.

So the the coordinates basically or the you know like if you are having a satellite image after doing georeferencing or rectifications, image rectification, you get the coordinates for the image and satellite image so that becomes your georeferenced satellite image, and this this is 2 way because sometimes standard, a georeferenced image can also be used to georeference another image which is not yet in geographic domain, it might be in geometric domain or may not be yet georeferenced to that is why it is 2 way. Nowadays for like for let me give you analogy, like nowadays for very high resolution images, if we want to do a georeferencing, that means we want to convert from geographic coordinate to (geomet) from geometric coordinate to geographic coordinate then we are also using the (coord) coordinates in the for GCPs, our ground control points using even Google Earth.

So a registered or georeferenced a satellite image can also become a master image for another image which is not yet georeferenced so that is why is it in 2 direction. Same day once I have got the georeferenced data, satellite images then I get the database construction on a GIS platform which will provide not only the satellite data information, the output from the satellite data information and data images but also data from other like digital elevation models may be a soil map, may be a land use map, may be a forest cover map and so and so forth, because GIS is capable of handling all kinds of information especially the spatial information on a digital platform.

And then I might perform some kind of modeling on a GIS platform that can go again back to my satellite images to see like people are doing nowadays that whatever the product they are creating on a GIS platform after doing all kinds of analysis on satellite images and along with other datasets, they put directly on Google Earth and then see that how it fits there with the surrounding so (the) that is why this is another arrow is there. That once I have done the modeling, I can put again on the Google Earth and see things along with the surrounding as well as I can transmit to some others who can also see once they double click on the Google Earth so that's the advantage so it's a interactive model of data integration and this concept is given here.

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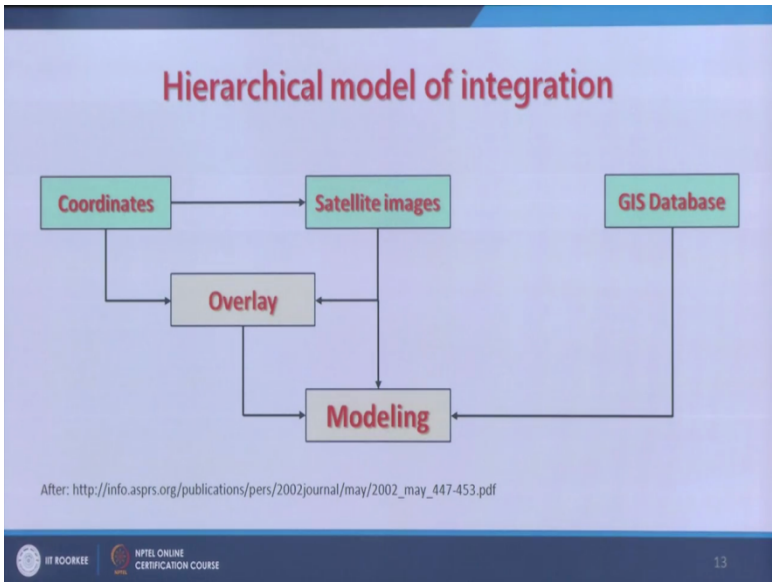

Then there is a another model we can think of which is a hierarchical model of data integration that we are having coordinates, coordinates might be coming from survey toposheets coordinates might be coming from GPS or coordinates might come from standard products from Google Earth, Google so they they go here for my data, georeferencing of satellite images and again for overlaying with the other maps on a GIS platform, I might be having a GIS database separately which is again georeference having geographic coordinates and then I can integrate again do the modeling and can create some products.

Modeling here means suppose I am working you know for landslide hazard zonation so for that purpose, I need lot of information, not only about the slope but the land use and the road network, maybe some you know geological structures, faults and other things so all these things, once I am available, I may assign certain weights or I may employ some known models for that particular area and can create a map, an output, a model which will show that where, if these conditions remain like this then where the slope will fail first and which are the slopes, which are most vulnerable and the next and next so that is basically modeling predicting about the future.

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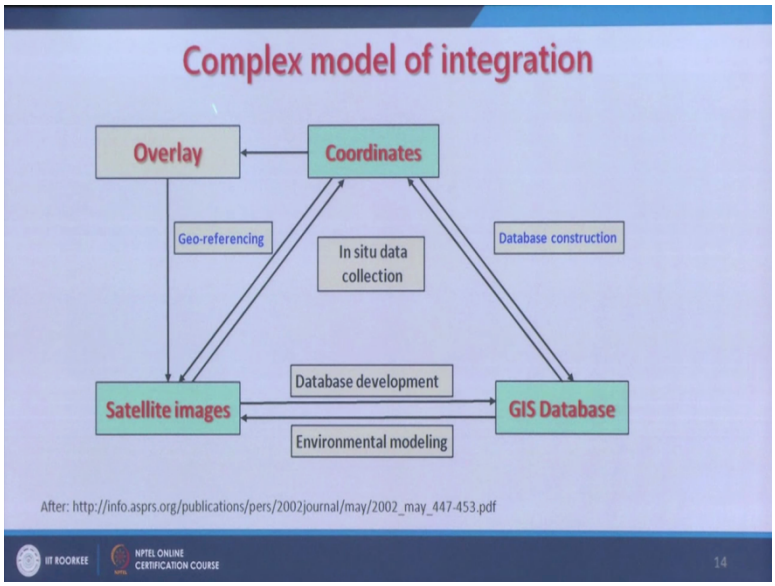

The third type of integration model is the complex model so (ra) rather than having interacting or hierarchical model, a complex model of integration can also be thought here. That again the coordinates, the special information becomes the key so coordinates are there overlays are there on a GIS platform and then you may have to have a database construction instituted our collection that means going in the field, collecting the data, collecting the samples, analyzing the sample, putting into the database, coming into GIS and then again creating such models, environmental model or any other model like may be soil erosion model or some other models may be putting on a GIS, a satellite images.

Today I am (us) suppose I have used the satellite images of 2010, now I have (us) I have also seen in 2015, now what would happen after 5 years, I may project, I may model and then when 2020 comes I will be able to see that how accurate model was because the satellite images can provide the time series data so all these things are possible to do it even if you one goes for complex model of data integration so all kinds of models are being implemented to integrate data specially on GIS platform data coming from satellite images data, coming from GPS data, coming from variety of sources, that is the spatial data and field data, survey data and all these are going on a GIS platform and then you create a final product, a model a predication and other (prod) as per user defined.

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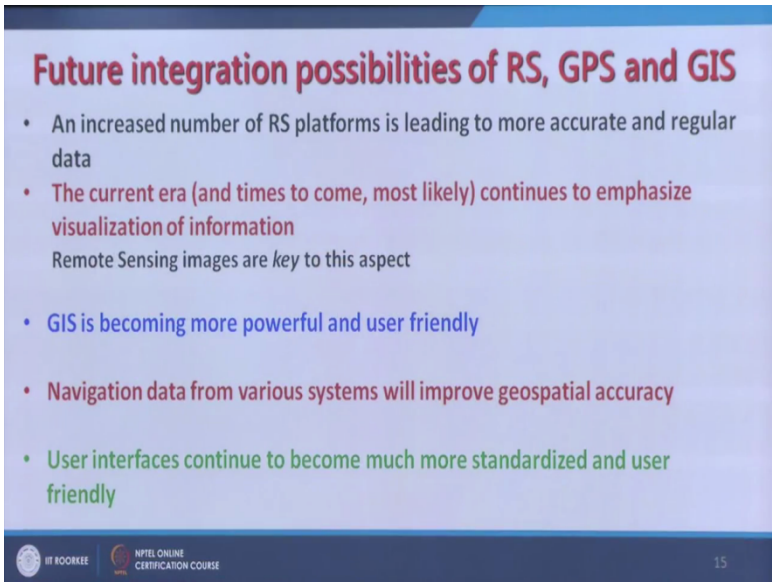

So what are the what is the possibilities of the future, future integration possibilities with RSGIS and GPS just as a as a thought, things may work little differently because we may have more powerful, more useful images, more powerful GIS technology, more better GPS signals or navigation signals, may be some technology might be coming but if we think that whatever the (possi) whatever the technologies which are present then how these things will be integrated, that what we are going to see an increased number of remote sensing platforms that is more number of remote sensing satellites leading for more accurate and regular data.

Higher spatial resolution data, higher radiometric (spa) resolution data, higher temporal resolution data and on regular basis, that is one very real possibility. Then the current era that is times to come and most likely continues to emphasize visualization of information because I said, you remember in other previous lectures, I have mentioned that a picture tells 10000 a picture tells 1000 words whereas a map or model can, especially a map can tell 10000 words. So this visualization a satellite image will give you more information than a simple picture and if it's a GIS product then it may give you much more information even in the simple satellite image so that kind of emphasis on visualization will continue.

Remote sensing images will be the key input for all kinds of analysis and of course GIS is going to be powerful and more user friendly so that person who doesn't have much knowledge of a a

computer computer science programming can also use GIS very easily so more this is what the future. Navigation data coming from variety of systems, 5, 4 or 5 systems I have discussed. 1 more from Japanese side are also available so all these might get in only 1 receiver so it means 1 in near future, we might be having a receiver which is kind which is going to be kind of a kind of a universal receiver.

So it can receive signals from all type of navigation systems whichever are presently or in future such a open system might come, a universal system might come and our accuracy estimations will improve say to just few centimeters as nowadays we are it is possible only through differential GPS but not with simple GPS navigation system so that is the geo spatial accuracy definitely is improving, it is going to improve very soon on this front. And the last one here is that user interfaces is to continue become much more standardized and user friendly so all these technologies are going to become user friendly in near future so this brings to end of this special topic of discussion. Thank you very much.