Wildlife Conservation
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Lecture – 09
Radio-telemetry

[FL] In today's lecture we will have a look at Radio Telemetry, which is a technique to monitor individual animals or groups of them using radio waves.

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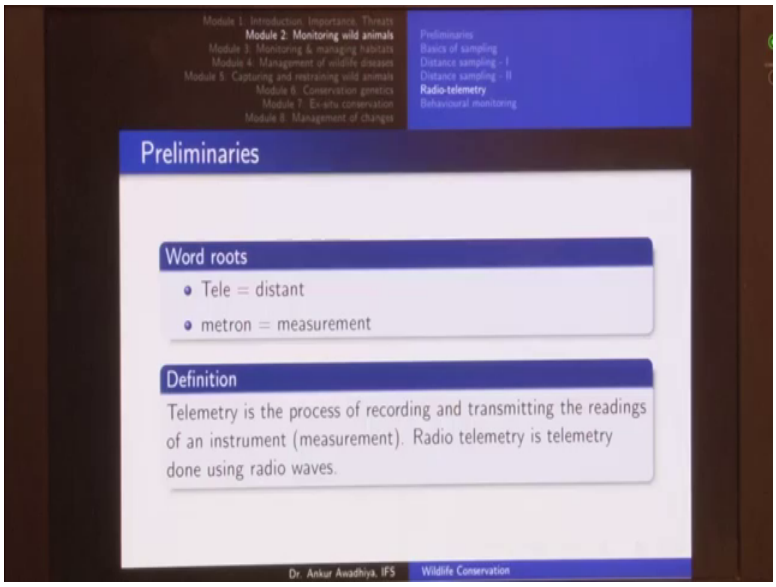

So, coming to the preliminaries radio telemetry, consists of this word telemetry.

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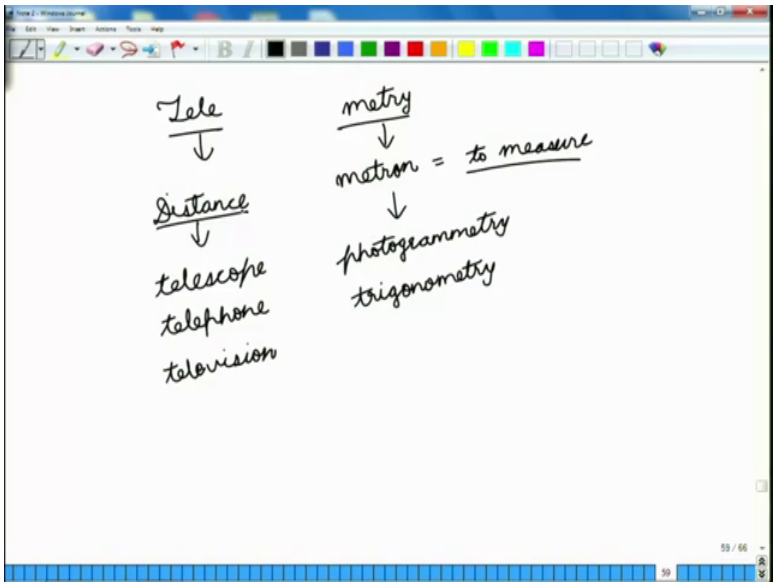

Tele means distance so, this is the same thing that goes in words like telescope which is looking at a distance telephone, which is talking at a distance television which is seeing at a distance and so, on. So, tele means distance then metry it comes from the word metron, which means to measure or measurement. So, metry would come in photogrammetry which is measurements using photographs or it can come in a trigonometry which is measurements using triangles and so on.

So, telemetry means to measure at a distance. So, coming back to the slides we have the word roots a distant and measurement. So, telemetry is the process of recording and transmitting the readings of an instrument which is measurement. So, we are measuring something with an instrument and you are recording and transmitting the readings of the instrument at a distance, and radio telemetry is telemetry that is done using radio waves.

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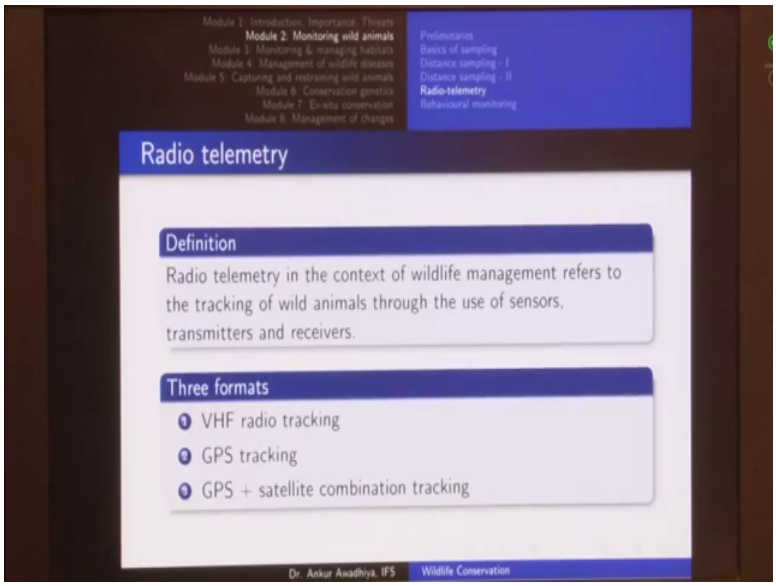

So, in the context of wildlife management radio telemetry refers to the tracking of wild animals, through use of sensors transmitters and receivers. So, we have a sensor that is placed with the animal a transmitter, which again is placed with the animal and then those signals that are given out by the transmitter are then received by us and we make use of that information.

So, there are three formats in which radio telemetry is classically done. So, the first is VHF radio tracking. So, VHF stands for very high frequency so, these are radio waves at very high frequency that we use to track the animals. The second is GPS tracking and the third is GPS plus satellite combination tracking.

Now, GPS stands for global positioning system so, this is a system that consists of a number of satellites that are revolving around the earth and we use this these satellites to get our position and that position can either be recorded inside the collar that is put to an animal in the case of GPS tracking, or this signal can be transmitted using satellite. So, that we can get the this these data points at a distance.

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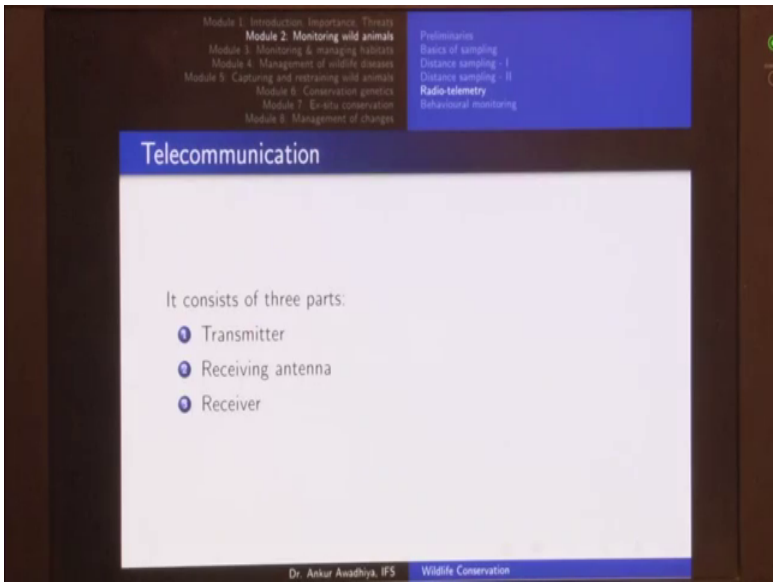

So, let us begin with telecommunication. Now, telecommunication in the case of radio telemetry it consists of three parts, we have a transmitter we have a receiving antenna and we have a receiver. So, when we look at a VHF transmitter.

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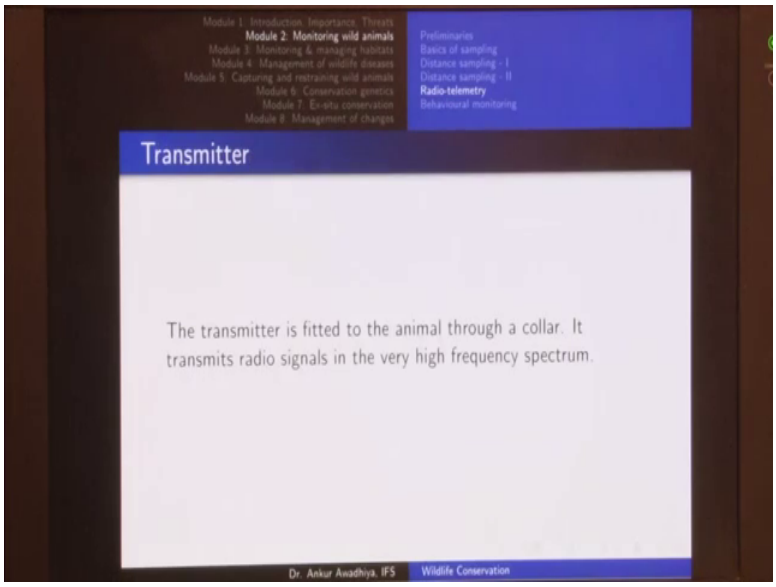

So, the transmitter is fitted to the animals through a collar. And it transmits radio signals at in the very high frequency spectrum.

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So, what is the collar so, this is a tiger that we saw in Patna and this is the head of the tiger, this is the body of the tiger, this is the neck of the tiger. And on this neck we can see this black colored strip which is collar. Now, a collar is a device that is used to harness our equipments to the animal.

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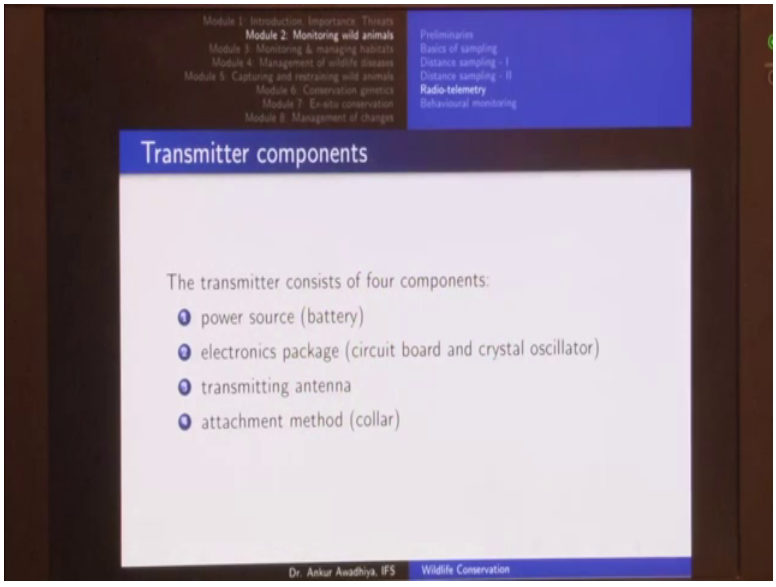

So, this is our transmitter so, this collar consists of a transmitter and a transmitter essentially consists of four components. So, one component as we have seen is the attachment method, which is the collar, then this transmitter requires a power source

which is a battery, then it consists of an electronics package consisting of a circuit board and crystal oscillators and it also consists of a transmitting antenna. So, these four things put together forms are transmitter. So, essentially we said that in the case of transmission we had three things.

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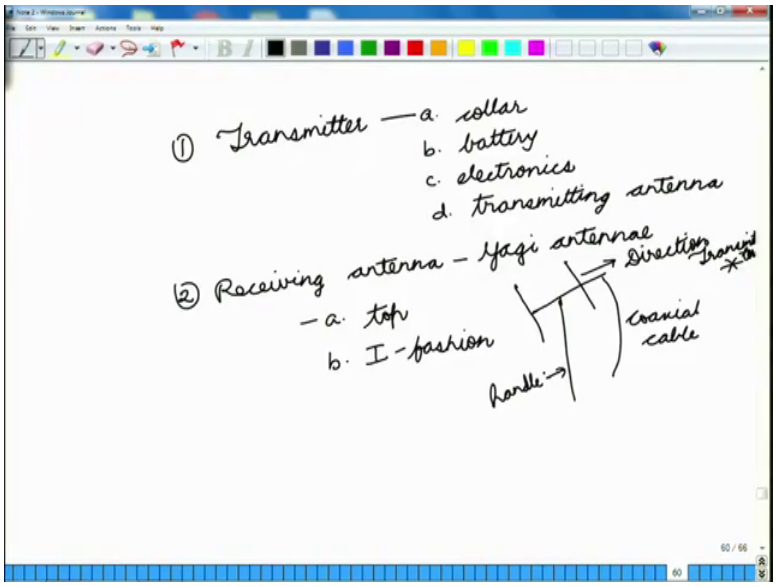

One is a transmitter, now a transmitter consists of four parts we have a collar that is used to attach it to the animal, we have a battery, we have electronics and we have a transmitting antenna. So, this is our transmitter. The next component is our receiving antenna, now in the case of receiving antenna coming back to the slides.

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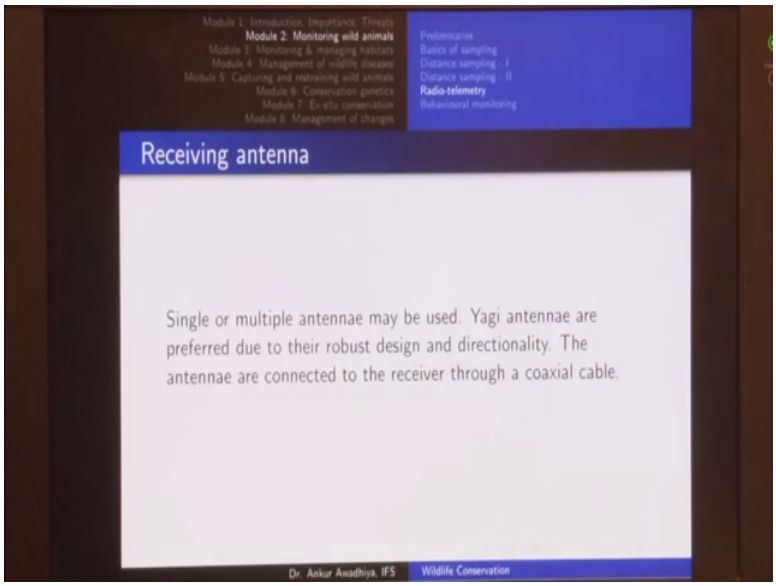

So, single or multiple antenna can may be used, when we are receiving the signals that have been transmitted by the transmitter section Yagi antenna are preferred due to their robust design and directionality. So, we will come to Yagi antenna in a short while the antenna are connected to the receiver through a coaxial cable.

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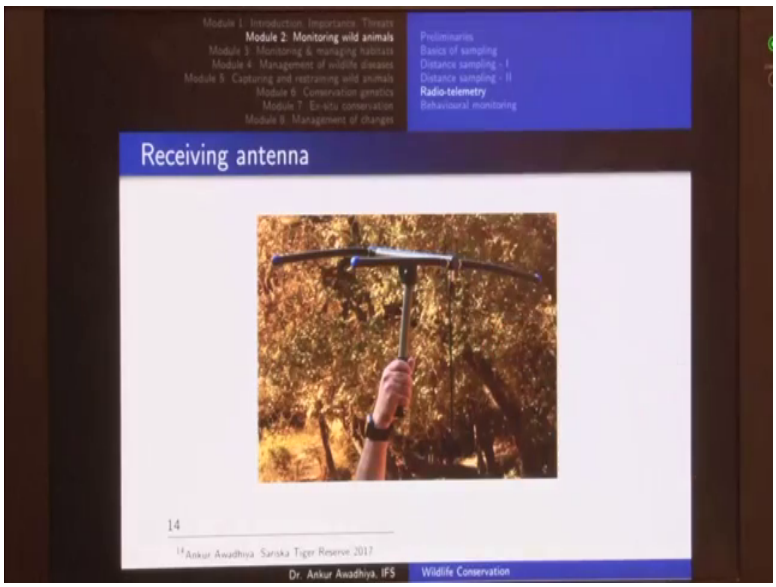

So, this is how a receiving antenna looks like so, we have this antenna, which is a directional antenna and we hold it like this. So, that on the top there is a pole and this

pole can give us the direction. So, essentially you have an antenna like this and the direction is given by the direction of this top rod.

So, here we have this top rod that gives us the direction, this cable that we can see here is the coaxial cable. So, this antenna is connected to the receiver using this coaxial cable, this is the direction of the antenna and these horizontal bars give us extra sensitivity.

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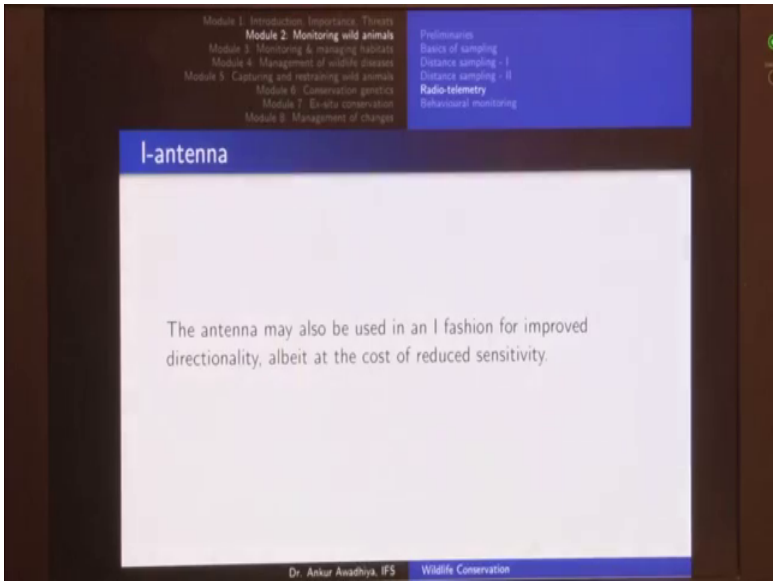

So, the antenna can be used in two fashions so, receiving antenna we generally have Yagi antenna. So, these are the most common antenna, but we can also go for some other antenna and these can be used in two fashions, one is a top mode and the second is in I fashion. So, in the top mode you have this top and then we have this antenna, and here we have the coaxial cable and this gives us the direction. So, the direction tells us the position of the transmitter and this is our handle.

Now, in the I fashion coming back to the slides the antenna may also be used in an I fashion, for improved directionality at the cost of reduced sensitivity. So, essentially what it says is that when you are at a distance from the animal.

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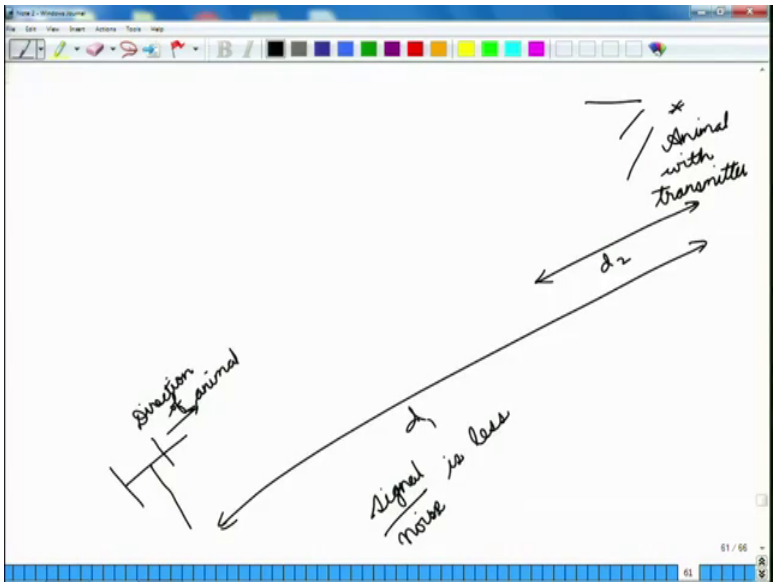

So, essentially you are here this is the animal with the transmitter. So, when you are at a great distance, you will use your antenna like this. So, this will give you the direction of animal, but because at a large distance your at this distance of d your signal is less. So, you have signal is to noise is less.

So, essentially we want a greater sensitivity, even at the cost of directionality we want a greater sensitivity, because we want to detect that animal and we want to have an approximate location or an approximate direction of that animal. So, we increase the gain in the equipment. So, gain is essentially a digital amplification of the signal by and also reduction of noise, but once you have come close to the animal. So, say at this distance of d 2. So, at this distance the amount of signals that you are getting from the transmitter is large. So, at this distance you will put your antenna in an I fashion.

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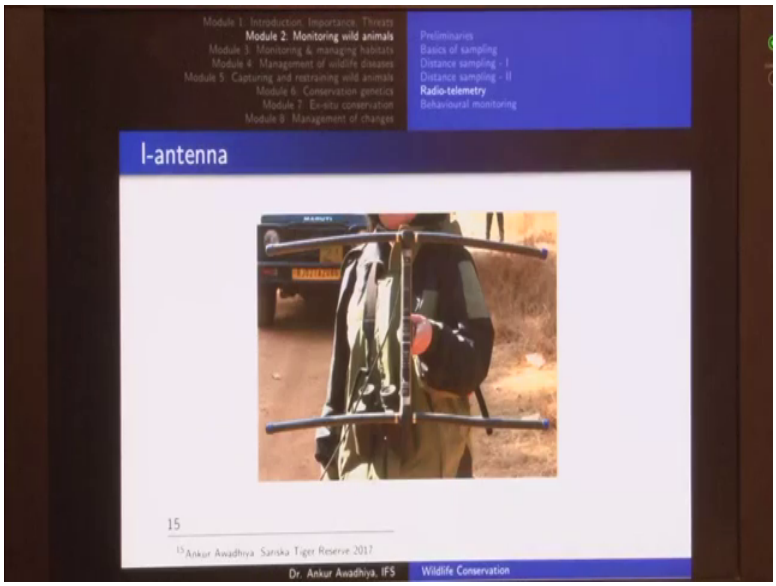

So, this is the I fashion so, this looks like our alphabet I so, at this point and this is our coaxial cable. So, in this fashion when the antenna is used, then it does not have a high sensitivity, because we do not require a high sensitivity, because as such the level of signal is very high because of our closeness to the animals, but the directionality is improved a lot. So, essentially you can very easily pinpoint the direction of the animal at the closer distances, now the next thing is a receiver.

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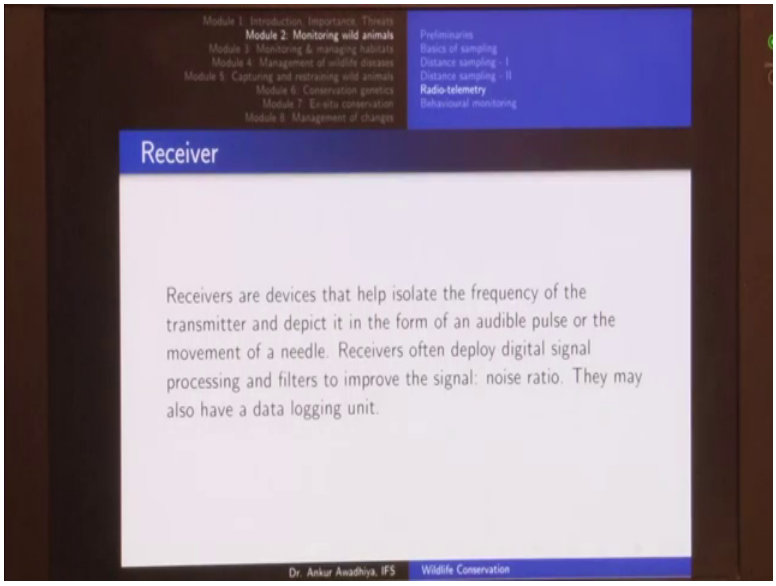

Now, receivers are devices that help isolate the frequency of the transmitter, and depict it in the form of an audible pulse, or the moment of a needle. Receivers often deployed digital signal processing, and filter to improve the signal to noise ratio, they may also have a data logging unit.

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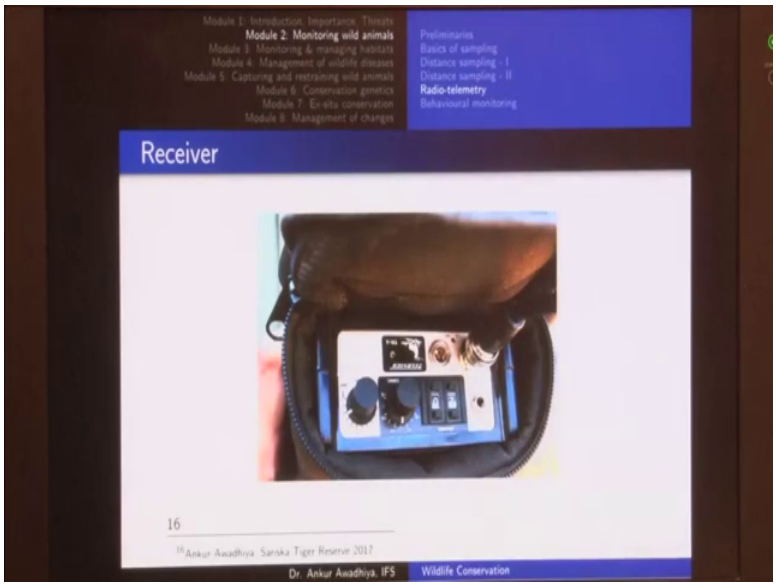

So, this is how a receiver looks like so, we had an antenna to which a coaxial cable was connected and this cable is then connected to the receiver. Now, this receiver would be having some set frequencies which we can select using these numbers. So, these are some preset frequencies, because we have a number of animals in the field. So, every animal can be given a different collar which gives out a different frequency. And we can select those frequencies by these numbers.

Now, there is a tuning knob through which we can fine tune the signal. So, say if it is giving out at a frequency of say x hertz, so this x hertz can be increased by can be increased or decreased by very small values. So, that we can pinpoint the exact frequency that is given out by the transmitter and then we also have a knob for gain.

So, again is essentially your digital amplification of the signal. So, when you increase this gain to a higher value, we will be able to hear a loud pulse when you decrease it you will be able to hear a very moderate pulse.

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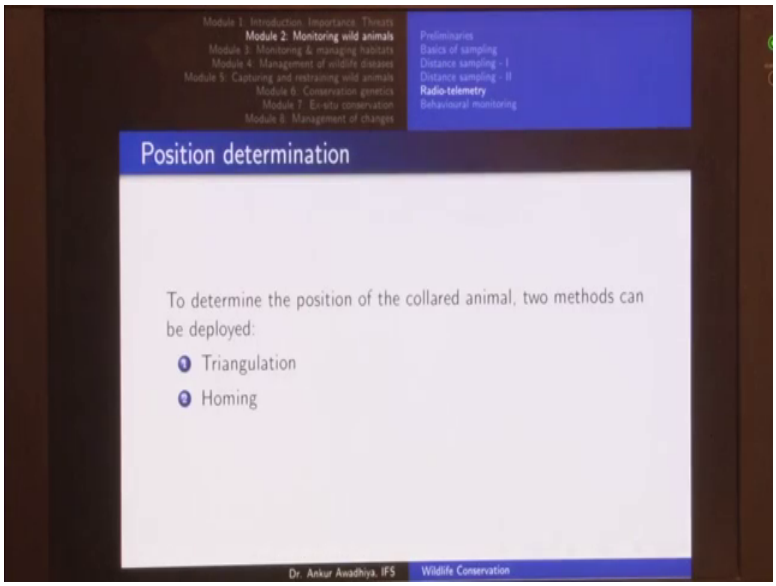

Now, how do we use this device to locate the animal in the field. So, you have a tiger which is wearing a collar, this collar is giving out some set frequencies. And now you have your antenna and you your receiver and you want to locate where this tiger is. To determine the position of the collared animal two methods can be deployed, one is called triangulation. And the second is called homing.

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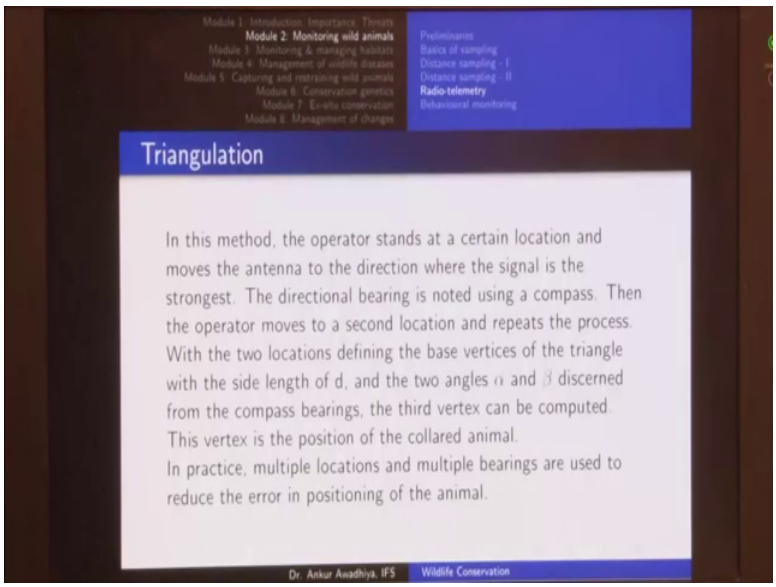

Now, in the method of triangulation the operator stands at a certain location and moves the antenna to the direction, where the signal is the strongest. This directional bearing is

noted using a compass, then the operator moves to a second location and repeats the process, with the two locations defining the base vertices of the triangle, with the side length of d and the two angles alpha and beta discerned from the compass bearings, the third vertex can be computed. This vertex is the position of the collared animal and in practice multiple locations and multiple bearings are used, to reduce the error in positioning of the animal.

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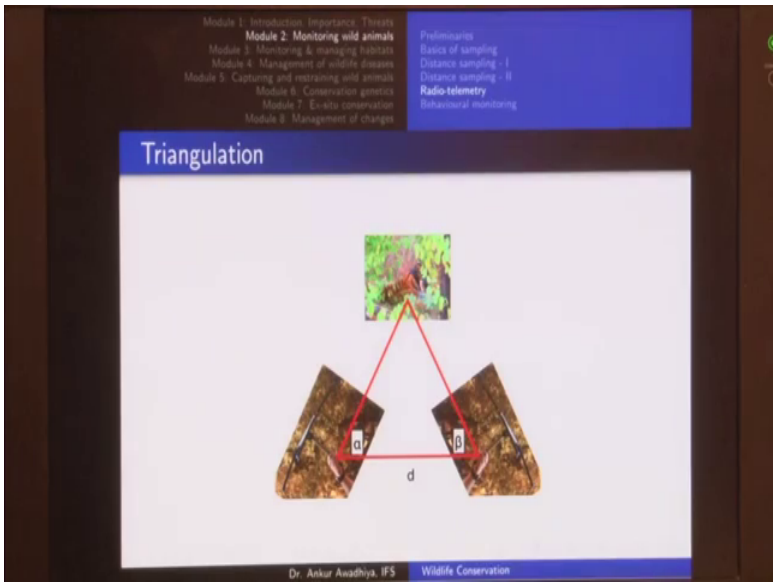

So, this is how it looks in the field so, there is an animal somewhere out there. So, you stand at one position you take you move your antenna, to a direction at which the level of the signal that is received from the transmitter is the highest. So, you are getting a very loud sized pulse like beep beep beep. So, at that direction you note the bearing of this antenna using our compass. And then you go to another location and repeat the process.

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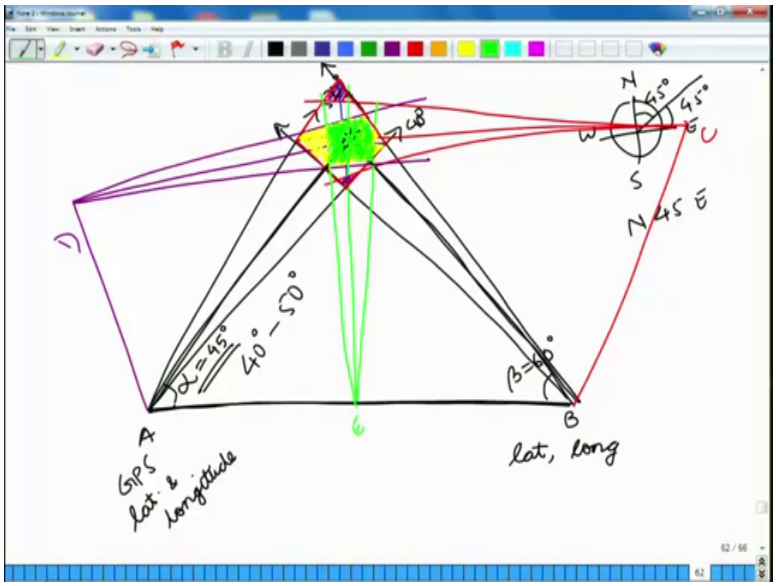

So, essentially what we are doing here is that you have an animal somewhere here, you are standing at location A, at this location you moved your antenna to the direction where you have the highest signal. So, you get this angle alpha so, this angle is generally taken in the form of a bearing so, a bearing means that when you have a compass. So, you have north south east and west so, if you are getting this angle you will write it as say north 45 east, which means that you are talking about this angle and from this angle. So, this is your 45 degrees from this angle, you can compute this angle very easily. So, this again will be 45 degrees and you are getting the value of alpha is 45 degrees.

Then you move to another location B and at this location you again find out the direction of the annual from this location. And here you get an angle of beta say beta is equal to 60 degrees. Now, you come back you plot your locations. So, you can have a GPS training reading, a GPS reading will give us the latitude and longitude of point A. And similarly a lat long for point B, once you have these lat longs you can come back and plot both of these locations on a map.

Once you have plotted them out you can draw a straight line and then on this straight line, you can draw these two lines, with the same angles alpha and beta. And once you have done the point, where these two intersect is the location of the animal. Now, it is easy to see it in theory, but in practice remember that this triangulation is being done at large distances. Now at large distances when you are using your antenna in this fashion

you are holding it up. So, you have a high sensitivity of the antenna, but directionality is not that good.

So, essentially when we are seeing an angle of 45 degrees, this could be say 40 degrees or this could be as much as 50 degrees. So, in that case you can draw two lines so, one is for 40 degrees and one is for 50 degrees. So, here you have these two rays, similarly at position B, you have these two rays; just because your directionality is not that good.

So, in that case your animal can be anywhere, within this quadrilateral. Now, to know the exact location of the animal we can employ two techniques, one is that we can just draw these two lines joining the opposite vertices so, or the two diagonals. And then we will say that that this point, where both these diagonals are meeting is our location of the animal. But then this is just an approximate location, to get a better location what we can do is in place of taking just two points we also take a third point.

So, this point is C now at this point, again we noted the bearing of the animal again there will be level of uncertainty, but what it has done is that in place of using this whole of the whole of this quadrilateral we have removed these locations. So, these two locations are now gone. So, we only have this smaller polygon from which we need to get the which represents the location of the animal.

Then we can take another point say this point D and this point again we have a bearing, but there is an error involved. So, now, we have reduced our polygon even further so, essentially now our animal is somewhere within this smaller polygon. So, by taking more and more points we reduce the errors that are there in the location of this animal, if we took another point say somewhere here point E. Then we would be able to reduce it even further so, at each step we are removing some portions of the polygon to get a another smaller polygon which gives us the location of the animal. So, this is an iterative process which can go again and again till we will reach a level of accuracy that is good enough for us.

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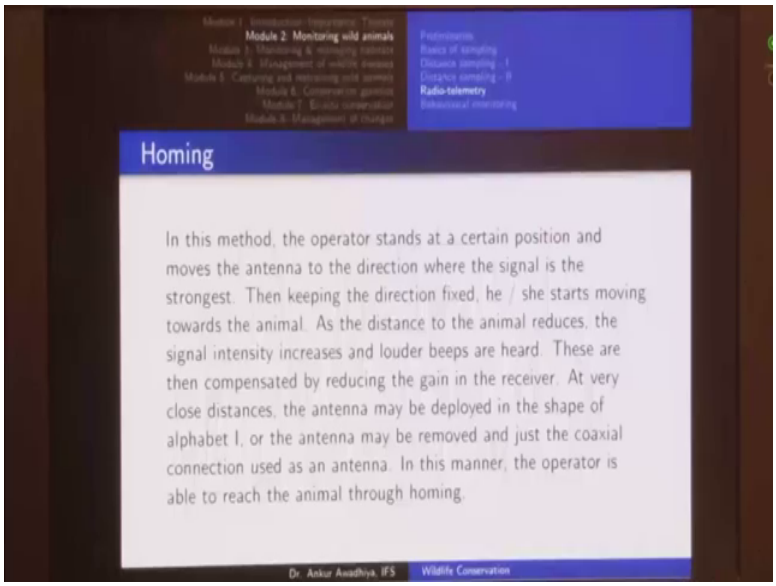

The second way in which we look at the animal is through homing. Now, in this method the operator stands at a certain position and moves the antenna to the direction where the signal is the strongest, then keeping the direction fixed he or she starts moving towards the animal.

As the distance to the animal reduces the signal intensity increases and louder beeps are heard, these are then compensated by reducing the gain in the receiver, at very close distances the antenna may be deployed in the shape of alphabet I which is the I shaped fashion or the antenna may be removed and just the coaxial connection used as an antenna. In this manner the operator is able to reach the animal through homing.

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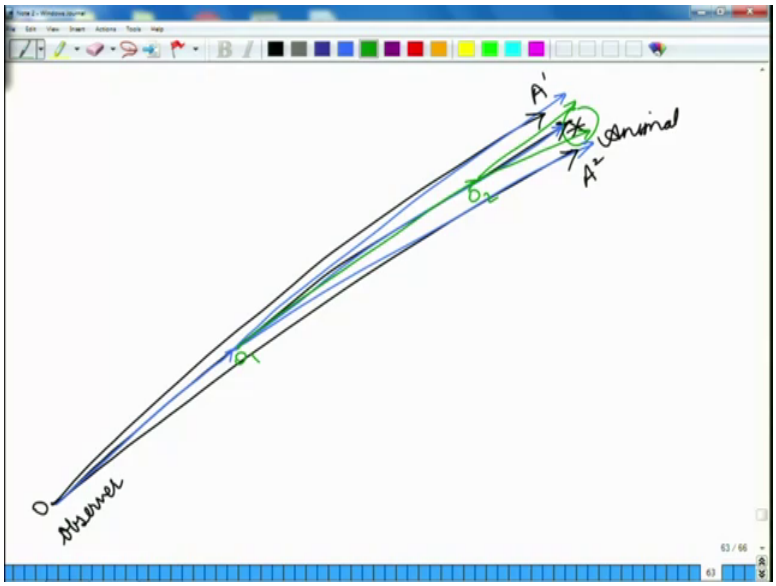

Now, what we are doing in this case is that we have this animal here, so, this is our location of the animal we are at this location so, this is the position of the observer. So, we used our antenna in the vertical fashion. So, we hold our antenna like this and then we turn it around. So, we get an approximate directionality at which the our beeps are the loudest.

So, suppose we got it as so, this is our actual directionality which should come, but because of the errors we make this assumption that our animal is somewhere between these two lines. So, between these two rays let us call it O A 1 and O A 2. So, our animal is somewhere between these two lines O A 1 and A 2.

So, now what we do is we move closer to the animal. So, we start moving along this line, then at this point we repeat the process. So, at this point we again get this bearing and then somewhere r with our errors, it is goes something like this. Then we repeat the process we get to another point. Now, once we have moved from the position O to O 1 and then 2 O 2.

Now, at this position O 2 the signals that are coming from our animal are very high because of our closeness to the animal. So, at point o two probably our beeps are very loud. So, they are beep beep beep so, in that situation we reduce the gain, then we go on repeating this process.

So, after a while we have reached so, close to the animal that even the antenna is not required. So, we take out the antenna we just use the coaxial cable. So, we hold it in our hands like this and then we try to figure out what is the direction of the animal, or else we can use our antenna in the I fashion. So, in the I fashion we hold it like this horizontally so, it does not have a very high sensitivity, but it has a very good directionality.

So, once we have done that so, we are able to pinpoint the location in with very less error. And just by repeating this process again and again and again we will be able to reach the animal which is the position of the animal. Now, you might think that this is a tiger which is wearing our collars. So, how can somebody go so, close to the animal.

Now of course, when you are doing an exercise in homing you do not walk on foot most of the times when you are having an animal like tiger that you are trying to home into you move on an elephant back. So, that you are safe, but in the case of other animals because these collars are not just specific to tigers you can also put it on a Barasingha, or you can put it on a chital or on a Sambar.

So, once you have these herbivores it is very easy to go very close to the animal now why do you why would you want to go so, close to the animal. Now, in certain circumstances it might be required to immobilize this animal. So, basically you have you have put this collar this collar has a battery and everybody has a battery life. So, suppose this collar has a battery life of 3 years and you have already 2 and a half years.

So, now you think that in the next 6 months my collar will go off so, why not change the battery. So, when you want to change this battery you will have to go back to the animal, you will have to dart it. So, darting and immobilization is something that we will cover in another module, but essentially you are immobilizing this animal. So, you shoot it with a chemical hidden dart, it becomes unconscious you go there you remove the collar replace the battery or put another collar and then put it on the animal.

So, with in those circumstances homing is extremely crucial. Otherwise in the case of tiger reserves, we also use homing in situations when some tourist has told us that one of your tigers and has clicked a picture that one of your tigers, which has a collar has become hurt, because of say fighting with another tiger a territorial fight.

Now, in such a circumstance it becomes very much essential to go to that tiger and its level of hurt. So, you will take a veterinarian to the tiger who will analyze it is situation. And then take our decision whether these wounds are going to heal on by themselves, or whether we need to perform some veterinary operations.

So, probably we would need to immobilize this tiger, then put some antibiotics or antiseptics clean up the wound or maybe even stitch it in at times. So, for those circumstances also homing becomes extremely crucial so, coming back to the slides.

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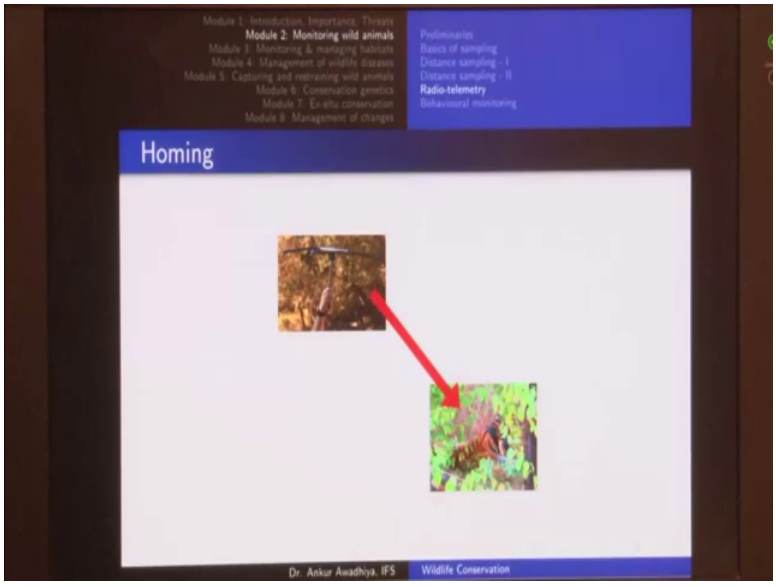

This is how a homing operation would look like. So, you have an antenna you are at a distance this antenna gives you the direction of the animal, you take this antenna and you start moving towards the animal till you reach animal. Now, all these were regarding our VHF collars.

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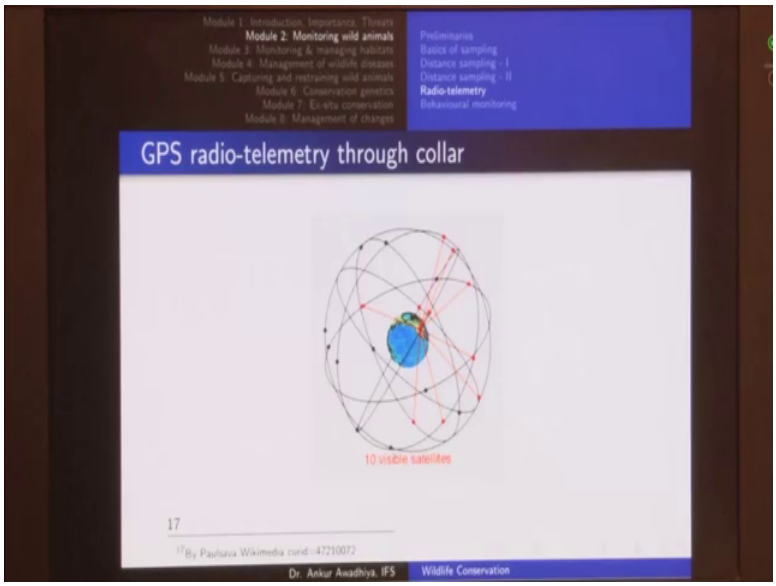

Another kind of collar is GPS radio telemetry through collaring. Now, what is GPS? GPS stands for global positioning system. Now, this system consists of a number of satellites and at any location on the earth, we can get signals from a number of these satellites.

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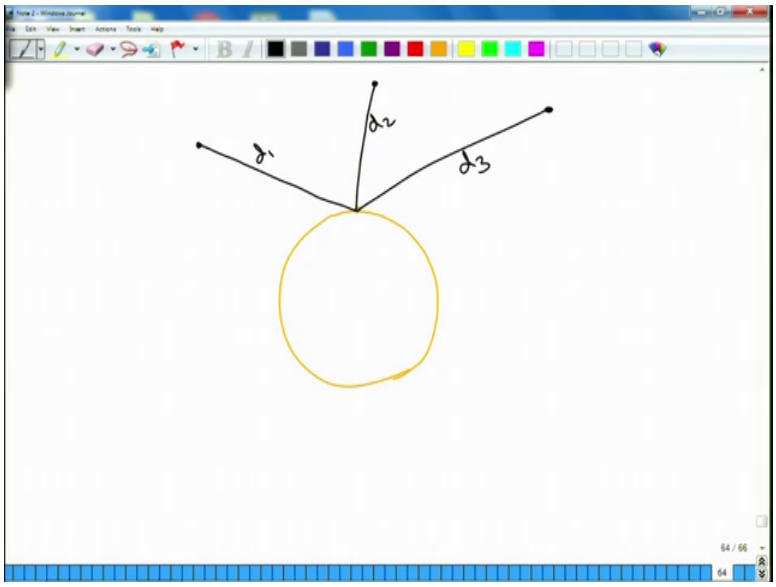

So, what we are trying to do in this case is suppose we are there on the earth. So, suppose this is our location and, this these are the four satellites that we are getting these are the three satellites that we are getting our signals from. So, we can measure our distances from all these three satellites. So, let us call it d 1 d 2 and d 3. So, we know the positions

of these satellites, because they move in certain specific orbits. And once we have these three locations what we are trying to do is.

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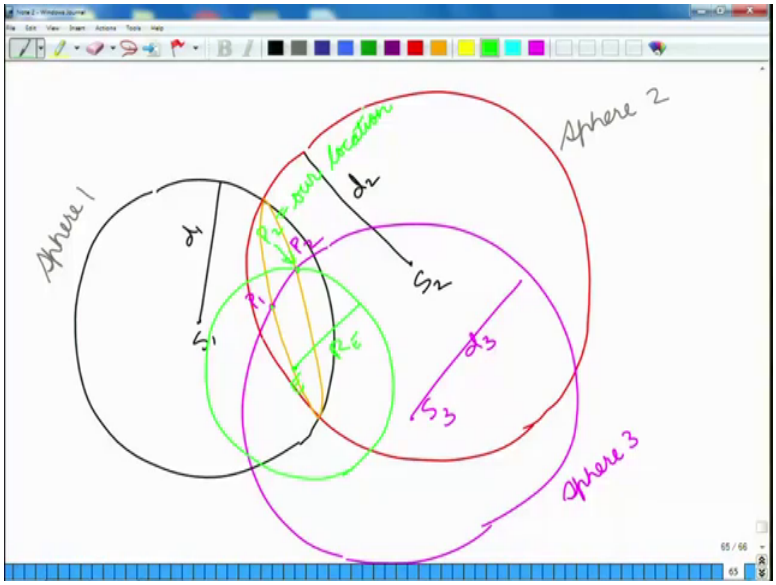

Suppose this is our first satellite, and we are at a distance of d 1 from it. So, we are at a distance of d 1 from satellite S 1. So, our position with respect to the satellite is given by this sphere on which we would be there. Now, if we have a second satellite and we are at a distance of d 2 from the second satellite S 2. So, our location would be given by this second sphere. So, let us make it in red so, by using two satellites. So, we are on this sphere as sphere 1 S 1, or let us call it sphere 1. So, we are somewhere on the surface of sphere 1 and we are somewhere on the surface of sphere 2, which would give us that our location is somewhere on this circle, that is formed by the intersection of these two spheres.

Now, if we have a third satellite. So, let us have this third satellite S 3. And we are at a certain distance from this third satellite given by a value of d 3. So, now, these satellite the sphere that is formed by the satellite. So, we are on the surface of sphere 1 sphere 2 and sphere 3. So, now an intersection of 2 spheres would give us a circle. Now, this third sphere is going to cut the circle at two points. So, this is point P 1 and this is point P 2. So, we are at either point P 1 or we are at point P 2. Now, because we are on the surface of the earth so, suppose this is the surface of the earth. So, this is another sphere and now

this is the center of the earth. So, let us call it E and the radius of the earth is given by R E.

So, now this also forms another fourth sphere. Now, this is fear is going to intersect either this point P 2 or it is going to intersect point P 1. The other point will either be away from the sphere, or it is going to be inside this sphere. So, by using these four spheres we can very accurately pinpoint that our location is P 2. So, a GPS satellite essentially when we are using a GPS satellite, we are finding out our distances from different satellites and by knowing the positions of these satellites, we are drawing a number of spheres and the intersection of those spheres and in the intersection of the earth gives us our location in the three dimensional space.

Now, GPS tracking is being deployed these days on the animals. So, when we do that we can use it in two modes. So, we can have an animal which has a collar, that collar has a GPS receiving device. And that collar will find out the location of the animal and will go on recording it in a data logger. And then later on we can move to the animal we can dart it, or we can program our collar in a way that after a certain while this collar drops off by itself. So, once this collar has come out of the animal, we can go there we can retrieve it back and then we can take out the data, from the GPS device which was there in the collar. So, before proceeding further let me show you how one of these GPS devices works.

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So, we observed how using our handheld devices, we can get our positions in the form of latitudes longitudes as well as elevation. Now, when we deploy a GPS device in the form of a collar, we tune our device in such a way that these values of latitude longitude and elevation, are continuously logged in a data logger that is connected with that device. So, once we have deployed our collar for a specified period of time as it is required, we can then again go back to the animal using the using the process of homing.

Now, all these GPS collars also have a VHF transmitter attached to them. So, we can always home into these animals along with getting these GPS signals. Once we have gone to these animals we can use a mechanism in which when we press a button on our device, then it signals this collar to detach itself from the animal. So, the collar will just drop off its called the drop of collar.

Once that is done we can go retrieve that collar and then from its data logger we can get all the coordinates, which are recorded at a specific time intervals. So, we know that at all these different time points, this animal had visited all these different locations. So, that is one way of getting the location of the animal using GPS collars.

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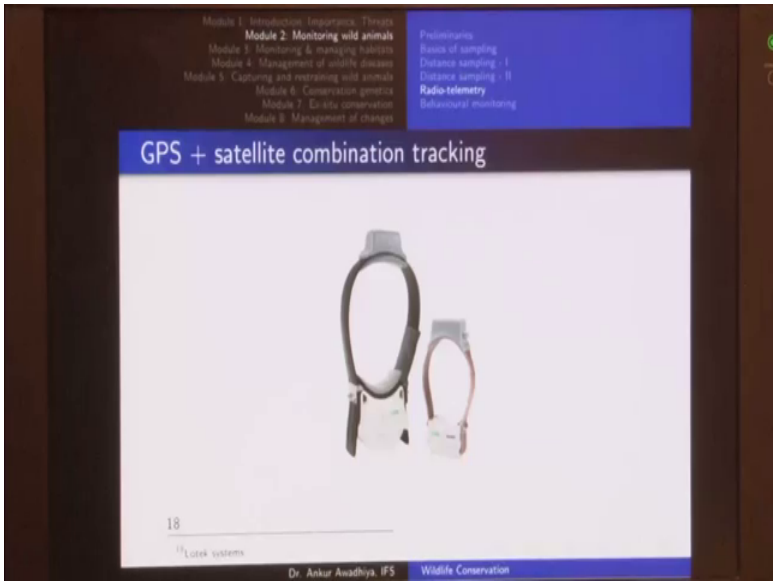

The second way is using a GPS plus satellite combination tracking. So, these collars are GPS plus satellite combinations. So, what they do is that they have a GPS receiver inside so, they know the latitude longitude and elevation of that place, but they also have

transmitted that can transmit signals back to the satellites. And these are different satellites than the GPS satellites.

So, these are telecommunication satellites. So, once this device has logged latitude longitude and elevation locations or data points for a specific time frame, it will then transmit this data to the satellites. And then from those satellites will get these data back at our control stations. So, in this way you do not have to go back to the animal to retrieve your data points.

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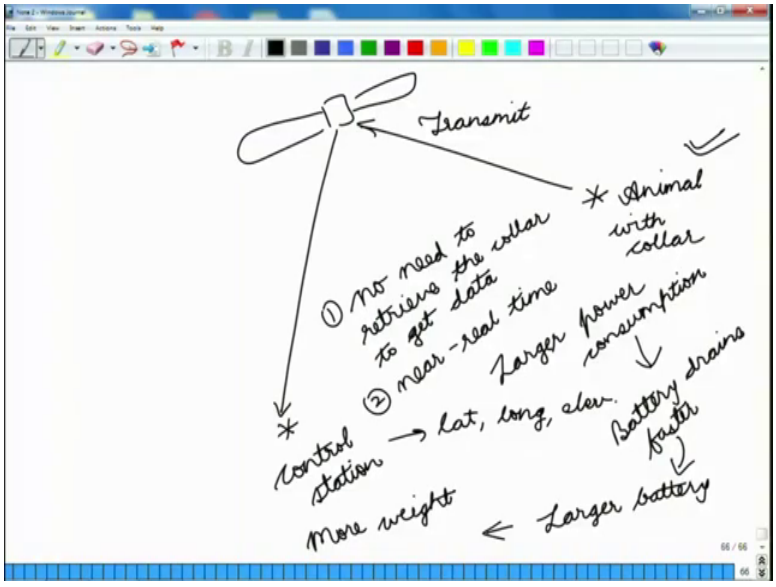

But, essentially what we are doing in this case is that we have an animal with the collar, then there is a telecommunication satellite that is going somewhere on top of us. And suppose this is our control station. So, this collar after getting GPS coordinates and the elevation will then transmit the signal to the satellite, which will then relay it back to the control station. From this control station will directly get the lat long and elevation. Now, the benefit of using a GPS collar with satellite combination tracking is two folds, one you do not we have no need to retrieve the collar to get data.

Because this data is continuously being received at the control station, and two is that it is near real time; because this collar is continuously transmitting the lat long and elevation data to our control station. So, we can know within say 20 or 30 minutes where this animal has been. The minus point or the drawback of using this GPS plus satellite combination collar is that, because of an extra transmitter which is the satellite

transmitter and remember that this transmitter needs to have such a large amount of power that it should be able to transmit the signals right up to the satellites.

So, essentially it has larger power consumption, which also means that the battery drains faster. Now, to circumvent the problem of battery draining faster, because if a battery drains faster, then it means that you can deploy, this satellite this collar for a very small period of time so, to compensate for that you have a larger sized battery.

So, to compensate you have a larger battery, now a larger battery in turn means more weight. Now, more weight reduces our options of putting this satellite collar this GPS plus satellite collar onto the animals, because typically for any animal the weight of the collar that can be used with this animal is typically less than 3 percent of its body weight. The maximum you can go is close to around five percent of the body weight, because if the collar is too heavy, then it will restrict the movement of the animal and will restrict the normal natural activities of the animal.

So, we typically have to have a weight cutoff of around 3 percent of the body weight. Now, if your collar is very big, then you cannot deploy it on smaller animals. So, this also becomes a drawback with these collars. So, in this lecture we looked at radio telemetry we looked at different kinds or different ways in which we performed radio telemetry, we can do it using a VHF collar which is a very high frequency collar, we can use it with a GPS collar in which these GPS data are logged into a data logger and then we can retrieve it back.

Third we can go for a GPS plus satellite combination tracking, in which we can get a real time location of the animal, but with a drawback of having more weight in the collar which reduces our options of deploying it. Then in the case of VHF collar we saw that we can locate our animal using two ways, one is triangulation and second is homing. In the case of triangulation we take multiple readings multiple bearings at different locations, then we draw lines to that location and where those lines intersect is where we have our animal.

In the case of homing we will we get the direction of the animal using our antenna, then we move closer. So, that its signal intensity is greater, in that case we deploy our antenna in an I fashion or we only make use of the coaxial cable to get even finer location or finer bearing of the animal and, then we move closer and we actually get to the animal.

So, radio telemetry is these days a very important technique for monitoring of animals, for monitoring individual animals as well as for monitoring of a pack of animals. So, we get data about say in the case of tigers. If these tigers are our holy resident in our forest or whether they are going outside whether they are migrating.

If they are migrating what migration routes are they taking, if they are dispersing what dispersal routes they are taking, at what times do these animals rest at what times do these animals move; whether they are moving in the daytime, whether they are moving in the night time and data such as these. So, this is a very important technique and that is all for today.

Thank you for your attention, jai hind.