Introduction to Industry 4.0 and Industrial Internet of things

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Lecture – 57
IIOT Applications: UAVs in Industries

In this module on Applications, I have included a special lecture on the use of UAVs. UAV as you know the full form of UAV is Unmanned Aerial Vehicle. So, you UAVs drones for example, which most of you have heard of are good examples of UAVs. So, UAVs have become very popular.

So, consequently there are so, many different initiatives happening worldwide, which are basically targeting the use of these autonomous unmanned vehicles to conduct, to carry on certain activities in an efficient manner. UAVs have lot of different applications. Applications in the industries are particularly useful; in our country and different other countries UAVs are being explored to do number of different things.

UAVs are being explored in the industry to autonomously in an unmanned manner to reach out to places, which are basically difficult to be reached or accessible by humans. Maybe because there are toxic wastes and it is dangerous for the human beings to basically go over there.

So, you UAVs could be designed in such a manner, that these flying objects would fly from a safer location, and land up in a remote location and could collect different data could collect different samples from that remote location, which presumably is hazardous, which presumably cannot be made accessible to humans and so on. UAVs likewise have different different types of applications we will talk about the different other applications in detail..

UAVs have application in health care, UAVs have applications in agriculture, UAVs have applications in manufacturing plants. In steel plants in nuclear power plants where there are hazards of nuclear radiation and you know maybe close to the nuclear reactors, where there is hazard of nuclear radiations and their exposure and it is difficult for humans to go and take samples or collect samples or do certain types of monitoring activities. So, UAVs can come as a

helping hand to do all these different activities remotely, which would be otherwise difficult to be done by human beings. So, UAVs are very helpful.

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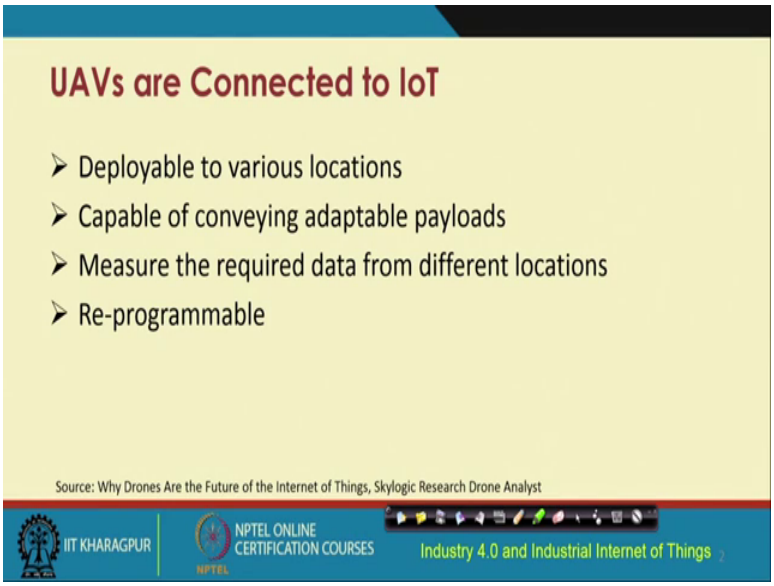

So, UAVs in the industry can help in doing number of different things and in the industry we are not just talking about single UAVs, we are talking about connected UAVs, swarms of UAVs; that means, UAVs which can talk to one another, UAVs which can send messages from one UAV to another UAV and maybe then back to the terrestrial control station and so on.

So, UAVs and the connected UAVs are very attractive. So, UAVs can extend the networks the terrestrial IoT networks to the aerial IoT networks. So, UAVs can extend beyond the terrestrial domain and carry the information from the ground; that means, from the terrestrial domain to the air aerial.

So, you know connecting the terrestrial IoT networks to the aerial IoT networks and then sending back the signals from the aerial once to the ground; so, all of these could be done with the help of UAVs. So, UAVs single UAVs use of single UAVs are quite common use of swarms of UAVs connected UAVs is also becoming quite popular. Because, these connected ones can do activities can do achieve certain tasks in a much more efficient manner than the single UAVs. So, UAVs

could be deployed in various locations in the power plants, in the manufacturing plants, in the different industries and so on.

They would be capable of conveying adaptable payloads depending on the requirements you know different payloads could be adjusted adaptable payloads could be carried by these different UAVs. UAVs could lift the load from one point in the industry and could send and could you know release the load to another point in the industry, and maybe it can do that in a much more efficient manner than the conventional means of transporting load in an industrial plant or a power or a manufacturing plant. So, UAVs can help in measuring different data, from different locations particularly collecting data from remote locations you know hard to reach locations, locations which could be hazardous for human beings and so on.

UAVs can also be made reprogrammable so; that means, these UAVs can help you know cater to certain requirements and then dynamically those requirements if they change, they can be reprogrammed, you know many different things can be done with these UAVs and these connected UAVs or swarms of UAVs.

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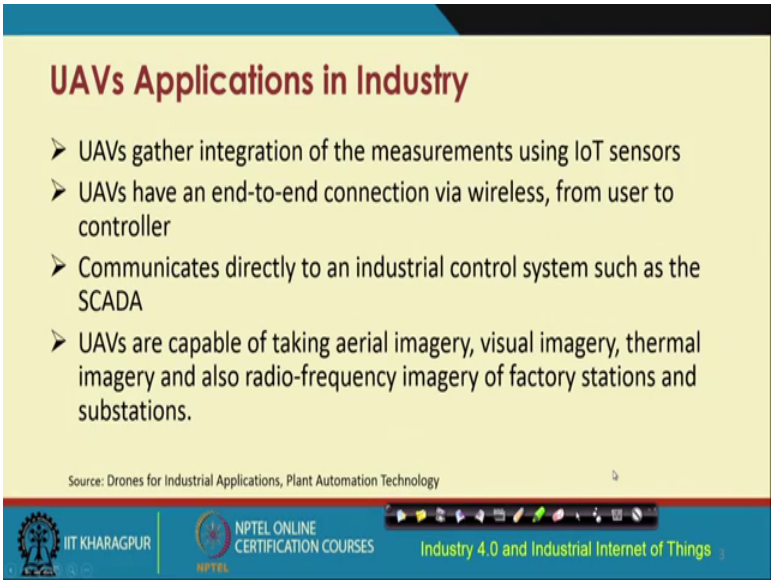

In the industry UAVs can help gather different data, collect different measurements, using different sensors that could be integrated to these UAVs. UAVs can help in achieving end-to-end

connection, as I was telling you not only terrestrial connection, but also terrestrial to aerial, aerial to terrestrial and so on..

So, UAVs have an end to end connection typically via wireless from the user to the controller. UAVs can help communicate directly to an industrial control system such as a SCADA and details of SCADA we have already understood in another lecture.

So, it is basically for supervisory control, supervisory data acquisition and so on. So, scatter devices and their integration with UAVs are also a reality that is happening in the industrial IoT sector. UAVs are also capable of taking aerial imagery, visual imagery, thermal imagery, and also radiofrequency imagery of factory stations and substations. So, before I go any further I would like to show you two different things.So, let me just show you how a UAV looks physically.

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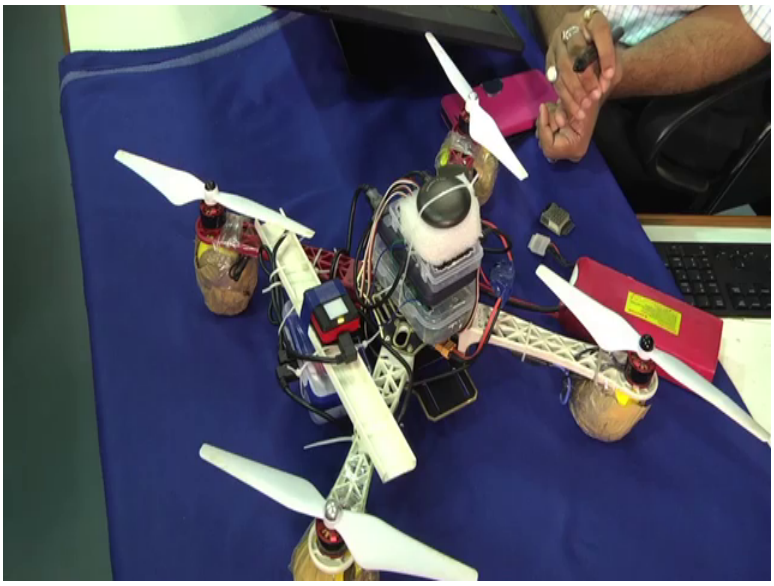

So, this is an example of an UAV and this is an example of a UAV. So, as you can see over here, this UAV has different parts. This UAV has this is a propeller; this is a propeller of an UAV as you can see so, there are this is a quadcopter right; so this is a quadcopter. So, which has four different rotors, four different propellers right so, there are four ones. So, there could be you know hexacopters, quadcopter you know octocopters which means that there could be 6 propellers, 8 propellers and so on.

So, these are these different propellers and these propellers they rotate by virtue of the rotation of the motors. So, these propellers are connected to these motors, this is a motor. So, underneath as you can see this is a motor this is the small one, the red colored one is a motor. So, the propeller is connected to a motor, this is actually UAV we actually in our lab the swarm lab in our Department CSE, Department at IIT Kharagpur we do a lot of work with UAVs. And, this is one such UAV that we work with and this is actually for agro imagery we use it for agro imagery.

And, so, this is a quadcopter UAV and this UAV is a fully autonomous UAV; that means, that you do not need any remote control to operate it. And, we have in our lab we have made it fully autonomous. And so as I was telling you let us continue you know explaining the different parts. So, this is basically one propeller likewise there are 4 different propellers. So, connected to these propellers are these motors the red coloured ones that I showed you.

So, there are 4 different motors; motors can come in different you know specifications you can have higher capacity motors and so on. So, if you have higher capacity motors that will give you know higher you know altitude, the higher thrust, you know bit better payload carrying capacity and so on. So, these motors and then you have you know this one is something known as the APM, this is a controller.

So, this controller basically controls all these different motors. These motors basically rotate in you know there are 4 different motors. And, these motors they rotate in two different directions. And one set of motors one set of motors will rotate like this one and this one, these two motors will rotate in a counterclockwise direction whereas, these two motors rotate in the clockwise direction.

So, consequently the propellers also one set of propellers will rotate in the clockwise direction, the other set will rotate in the counterclockwise direction. And, this basically will help this UAV to take the lift. So, this is very important in the design of a UAV. So, so, as I was telling you that this is this APM controller which basically will control these different motors that we have. And, this is this GPS unit, which will help in getting the GPS position of this device when it is in flight.

There is also this you know there is a raspberry pi you know an intelligent controller, I mean or a an intelligent devices server, which can do lot of computation. And, this computation will be performed locally on certain data that are being received or procured by this UAV.

So, certain computation will be done by this device this raspberry pi and this raspberry pi can also help in sending the other data that it cannot process over here through the communication channel it can be sent. So, like this UAV could be fitted with different sensors, this is one such sensor to which it is fitted. So, it is a basically a solar sensor, which can basically detect the intensity of the solar radiation. So, this is the solar sensors a sun sensor and so on.

And like this there are different other sensors depending on the application specific requirements, these other sensors could also be attached to this UAV. There could be if it is for gas monitoring different gas sensors like you know methane sensor carbon monoxide sensor and so on. All these different gas sensors could be fitted to this UAV..

And these gas sensors when this UAV flies these gas sensors will be collecting the gas concentration data not just in one place, but because it is flying over a you know over a large area over which this UAV is going to fly, this gas concentration and the data about the gas concentration in these different locations of flight could also be retrieved. So, consequently what is going to happen this is going to be like a mobile sensor unit right? It is going to be like a mobile sensor unit, which is going to collect lot of data while it is in flight.

So, this is an advantage of the use of UAVs and fit these UAVs with these different sensors. So, these this UAV could also be fitted with cameras, this is one camera as you can see over here I do not know whether you are able to see it properly.

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This is a camera this is fitted with a camera, you know over here as you can see this is a camera. And, this UAV could be fitted with cameras to collect images while it is on flight. This particular UAV can and this camera can collect images while it is on flight over agricultural fields to understand different crop conditions and so on and so forth.

As I was telling you this is an agro UAV that we have in our lab you know we use this UAV for collecting crop data and so on from agricultural fields. So, like this there are different other components. So, this camera basically sends this data to, this data could be sent to a mobile phone like this.

And so, in our lab the swan lab in the Department of Computer Science and Engineering at IIT Kharagpur, we work a lot with UAVs. We do designs of UAVs, network UAVs, we also cater to the requirements solving different application level challenges in different sectors, agriculture, healthcare, surveillance and so on.

So, we do a lot of research using UAVs. So, I thought that let me take it as an opportunity to show you a UAV how it looks like. So, this is a sample UAV that I have brought for you from my lab, this particular UAV is for catering to certain agricultural monitoring application. This UAV we use for agro imagery taking images of agricultural field.

So, this particular image UAV is a quadcopter. So, as you can see over here there are 4 propellers; 1 2 3 and 4 there are 4 propellers. So, this is a quadcopter UAVs do not necessarily have to be quadcopters, UAVs could be of different different types. There are so many different types of UAVs that are there. UAVs could be hexacopters having 6 different propellers, could be octocopters 8 propellers and so on.

So, irrespective of what type of UAV it is, UAVs could be monitored or could be run UAVs could be run using some remote control device, which is quite common. And, these remotely operated UAVs are quite common in the marketplace; whenever you go and buy a UAV, you will mostly get the remote control ones

So, this particular UAV is not a remote controlled one it is an automated UAV, a fully automated UAV. So, this particular UAV does not need any remote control. So, there is no remote control to operate this UAV. So, going back I was talking about this quadcopter having 4 different propellers. So, two of so, there are two sets of propellers. One set of propellers this, this one and this one, they rotate in a counterclockwise fashion whereas, the other set these two would rotate in the clockwise fashion.

So, because of this combination of counterclockwise and clockwise rotation of these propellers the lift of the UAV takes place. So, UAV lifts up from the ground and goes for a flight, this is one of the reasons like this there are many other reasons why the lift happens. So, a combination of counterclockwise and clockwise motion basically lifts this UAV. Now, these UAVs and their propellers are basically powered through the motors, powered in the sense like you know there are different motors which make these propellers rotate. So, there are 4 propellers so, 4 motors.

These motors can be of different specifications, some of these motors can be of higher specification. So, they can have better capacity for lifting payload for improved thrust and so on. Some motors can be of lower capacity, depending on the requirements different capacity of these motors could be used for these UAVs. So, you know so, there are four different motors let me show you how this motor looks like. So, this is a motor.

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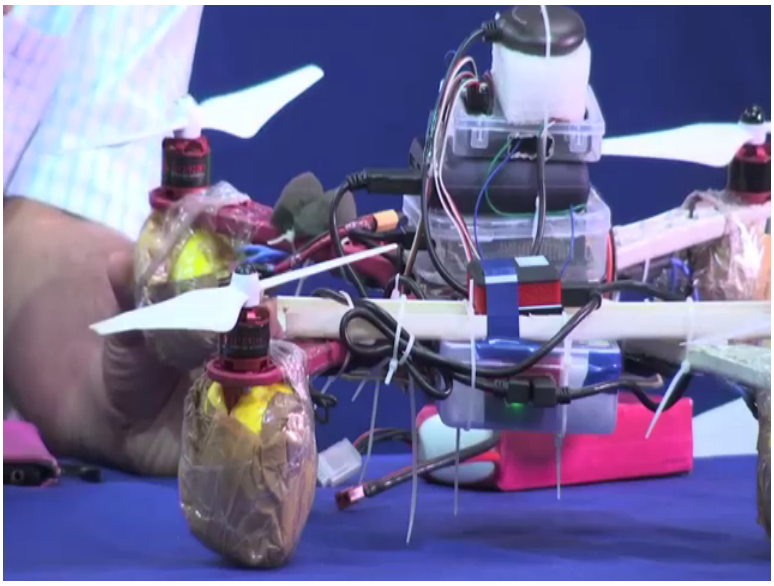

So, as you can see this red colored one is a motor. So, this is this motor right, this is this motor as you can see over here like this all. So, this is this propeller and below it is this motor right. So, like this there are four different motors.

Now, let me show you the other parts of the UAV. This whole UAV, this whole UAV has to be powered right for it to operate. So, there are different batteries that could be used to power these UAVs this is one such battery. So, this is known as the lipo battery, this is a very powerful battery, you know medium powerful I mean it is not extremely powerful, but you know it can make these UAVs fly for several minutes.

So, these lipo batteries are good for flying these UAVs for several minutes like you know 7, 8 10 minutes 14 minutes and so on. So, these batteries so, I can show you that this battery is fully charged. So, that how much is the charge content in these batteries could also be could also be tested with the help of this (Refer Time: 18:34) device as you can see this is giving you how much is the charge content right, how much is the volts right. So, this could be done with the help of, the testing could be done with the help of this particular device.

So, this battery is attached to this UAV. So, it will be attached like this I am not doing it now, but you know it could be attached to this and the UAV along with the battery is going to fly. And, this UAV also has an intelligent device.

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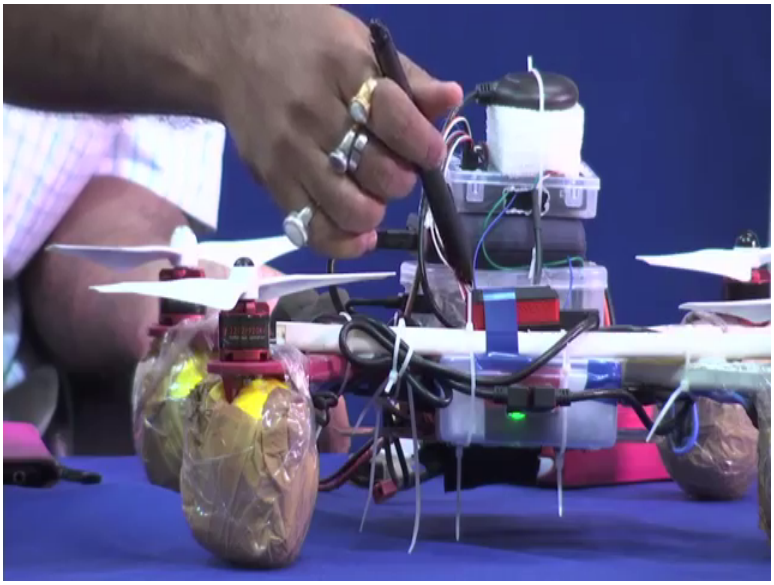

So, it is basically over here it is the raspberry pi. So, this is this raspberry pi that you can see over here this one, this is this raspberry pi. So, raspberry pi is inside this one. So, this particular device this raspberry pi it does some local processing right. So, it is basically a mini computer and which can do certain processing, you know depending on the application specific requirements. Now, this one as I was telling you this particular UAV has been designed for catering to agricultural agro imagery requirements.

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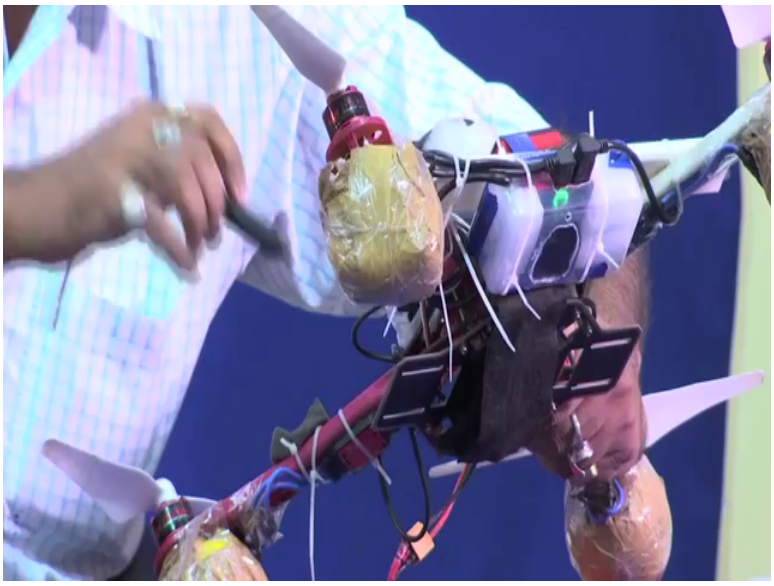

So, agro imagery requirements so, there is this camera as you can see, there is a camera that is fitted to it this is this camera. And, this camera basically takes the images of the field you know from the top and some of this can be processed locally, in this raspberry and the other could be sent to the cloud. And this is this camera and this camera and the images could also be retrieved or what could be received in your mobile phones the smart phones and so on.

So, you know there are certain apps that are already installed here, which can help you to view the ground images that are being taken on this mobile phone or any other remote device can also you know show, the ground images that are retrieved through this camera. So, this particular camera is even again powered using another external power source, which is a power bank and that you know an additional power bank that is required to power powering this camera.

And on the top what you have is the GPS device for getting the GPS position while this UAV is on flight, getting the GPS position dynamically this particular device can help you do that. And, below this GPS is this APM controller and it is this controller which basically makes or controls these different motors to operate.

So, this APM controller not only the motors the flight of these UAVs with the help of the APM controller is performed. So, this is how an UAV looks like and I just wanted to show you this you

know. So, that you can get an idea about how these UAVs are and how they look like and next let me show you an interesting thing we do as I told you that we do a lot of research using UAVs. So, let me now show you know some of our UAV based experiments that we have this is let me start with this one.

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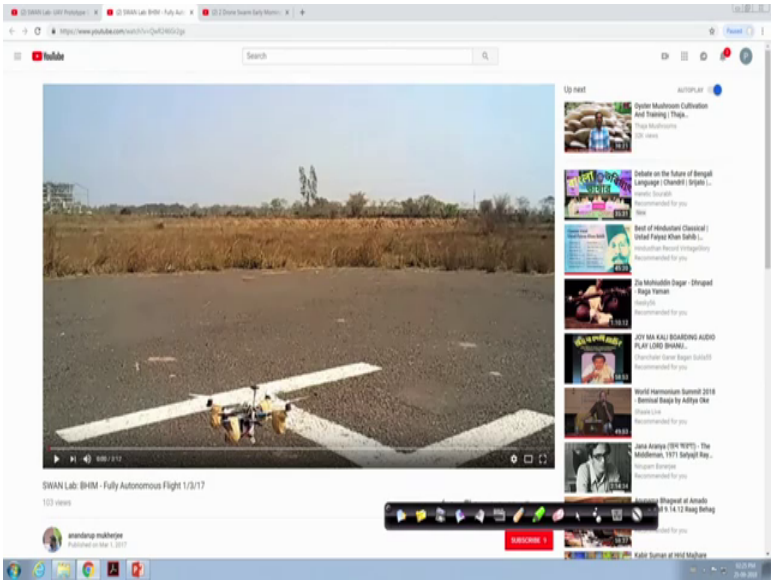

This is this agricultural field where we conduct not the agricultural field sorry this is a this is the field which is little outskirts of our campus, it is basically for helipad; it is a helipad for helicopter landing. And we do some of our experiments over here small scale low flight experiments we perform, and this is this UAV it is in flight, it is flying in the air.

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And, as you can also notice carefully that the one set of propellers is rotating counterclockwise the other set is rotating clockwise. And this is how these UAVs fly, this is you know an example of the UAV that I had shown you, how it is going to be when it is flying.

And depending on what you are doing with this UAV you can capture images, you can capture different sensor data. So, it might so happen that you need certain you know in an industry environment, industrial environment you need to capture different data about the gas concentration. May be gases such as toxic gases such as methane, carbon monoxide etcetera, their concentration etcetera, in an industrial plant, you know you could use these UAVs.

But, those UAVs are going to be different those are going to be the indoor UAVs; indoor UAVs and outdoor UAVs are little different. So, you know this is an outdoor UAV, but for industrial you know indoor monitoring of industrial plants etcetera, indoor UAVs could be used. And, these UAVs could be fitted with different sensors and these sensors could be of different types depending on what you want to monitor well the UAV is on flight. So, it could be different gas sensors, temperature sensor, you know different other types of sensors could be fitted to these UAVs.

So, this is one such flight that, I showed you let me show you that UAV you know. So, I told you that we use these UAVs for agricultural purposes.

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So, this is our agricultural field over here. And this UAV basically helps in taking the different images and can also act like a mobile relay node, which can help connect different base stations to each other through this UAV. So, this is our agricultural field and it is being you know this UAV is flying and capturing the different images from this agricultural field.

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So, the last one is basically a small network of UAVs. Let me now show you two UAVs, which are networked with each other flying. This is also from our lab you know some experiments that we have performed, these are all there in YouTube if you want to search further you know you can search with our lab name swan lab UAVs. So, you would be able to see different videos of testing that we often do. So, these two UAVs, it is a small network these two UAVs are able to talk to each other and are able to pass information from one point to the other.

So, let me now go back and continue with our discussions so I was telling you that UAVs are very attractive in the industry; UAVs could help in you know monitoring the conditions, different types of conditions in the industrial power plants, in the different industrial settings. UAVs could help in reaching out to areas in the industries, which could be hazardous for human beings to go UAVs could help in collecting different data for acquiring different images of different units in a manufacturing plant. For example, chimneys; chimneys accessing the chimneys as you know, chimneys which throw a lot of exhaust gases accessing those chimneys is very difficult.

So, UAVs could help in collecting images for maintenance of these chimneys in a much more efficient manner and much more easily the maintenance the images could be collected of these chimneys to understand how much maintenance what would be required, when the maintenance has to be carried on and so on. So, likewise these UAVs could be fitted with different sensors to

understand the ambient conditions around these chimneys. So, like it is there are different applications of UAVs for sensing for acquiring images for control and many others.

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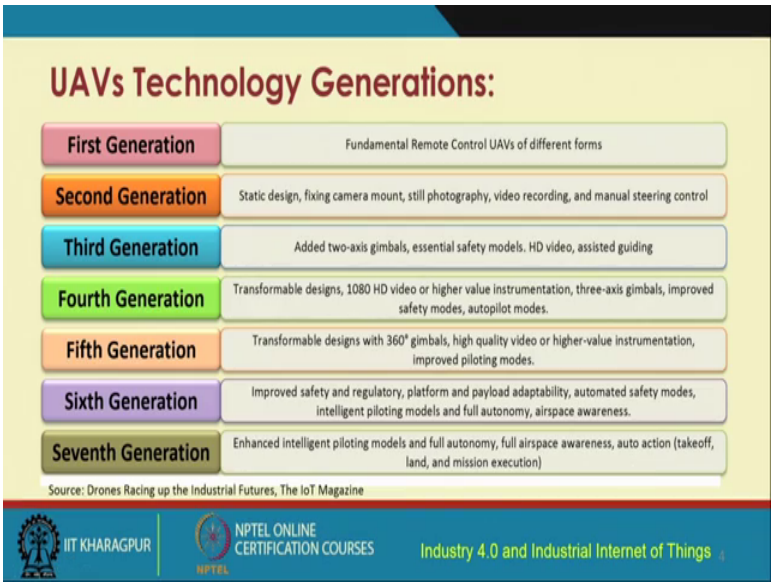

So, let me now go quickly and you know run you through some of the different other concepts. These are the 7 generations of the transformation of UAVs; that means, the UAVs have gone through 7 generations. So, first generation UAVs had fundamental remote control of different forms, then came the second generation UAVs which had a static design, a fixing device for camera mounting for taking still photography, video recording, manual steering control and so on.

That was the second generation like this these UAVs have evolved over the years third generation, fourth generation, fifth generation, sixth generation and at present we have the seventh generation UAV which have intelligent, which have different intelligent systems fully autonomous systems in place for doing different things. So, currently we are in the seventh generation of UAV technology transformation.

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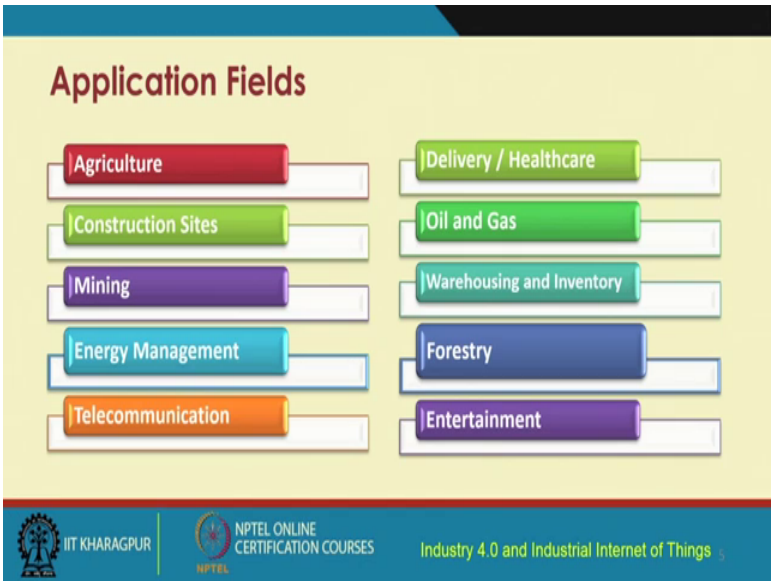

UAVs as I was telling you would be used in different industries; in agricultural industry construction sites mining industry, energy management for telecommunication industry, for offering connectivity between different remote places UAVs could be used.

So, where existing communication infrastructure is not already there UAVs could be used to offer connectivity between two different points. UAVs have also lot of applications not only in the civilian sector, but also in the military sector as well. The UAVs could be used to carry out different missions military missions in a much more efficient manner. UAVs could be used in the military for carrying out different reconnaissance surveys and reconnaissance activities.

So, in the other industries also UAVs could be used healthcare industry oil and gas, warehousing and inventory, forestry and entertainment industry. These are some of the names of different industries where UAVs find applications.

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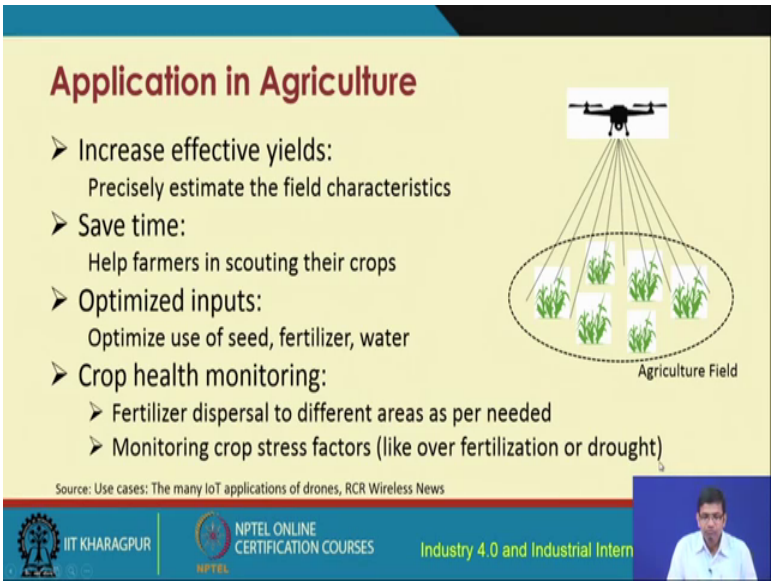

So, UAVs in agriculture there are diverse applications and particularly in our country, use of UAVs in agriculture is very much required is very much there are a lot of different efforts from different research labs, in the academic research labs and so on.

And also there are a lot of startup companies on UAVs which are focusing on agricultural application. UAVs in agriculture would help you to get agricultural images, monitor the condition of the crops, monitor whether a particular crop is stressed in different ways water stress nutrient stressed. So, lot of analytics will have to be superimposed on top of these images that are collected through these UAVs. Like this the UAVs can also help in sending payloads from one point to another. UAVs in agriculture could help you in spraying of pesticides in the agricultural field. So, UAVs could also help in spraying fertilizers like this UAVs can do number of different things in agriculture. So, this is the use of UAVs in the agricultural industries.

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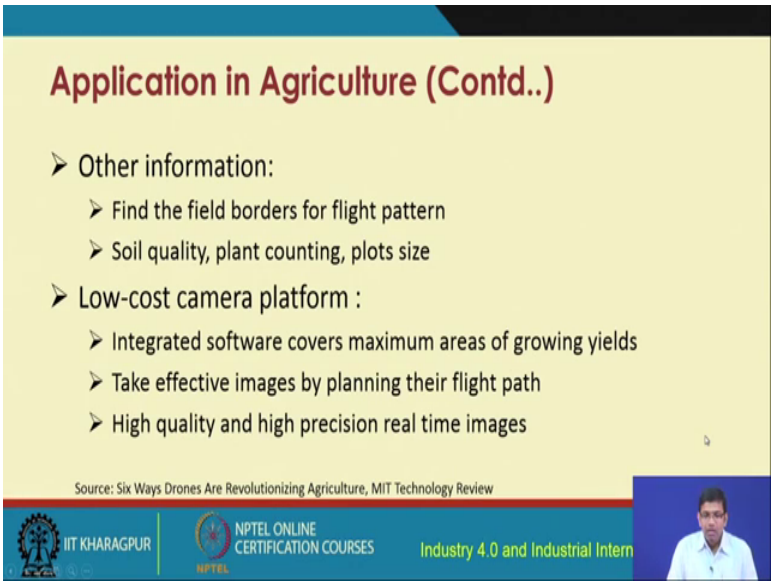

There are lot of different other uses of use of UAVs in agriculture, particularly if you mount these UAVs with a camera. These cameras and the images that are captured either the static images or the real time video images, all of these could be analyzed and you know effective decision making about their the crop condition and that the requisite action that has to be taken based on these collected images the collected data could be made.

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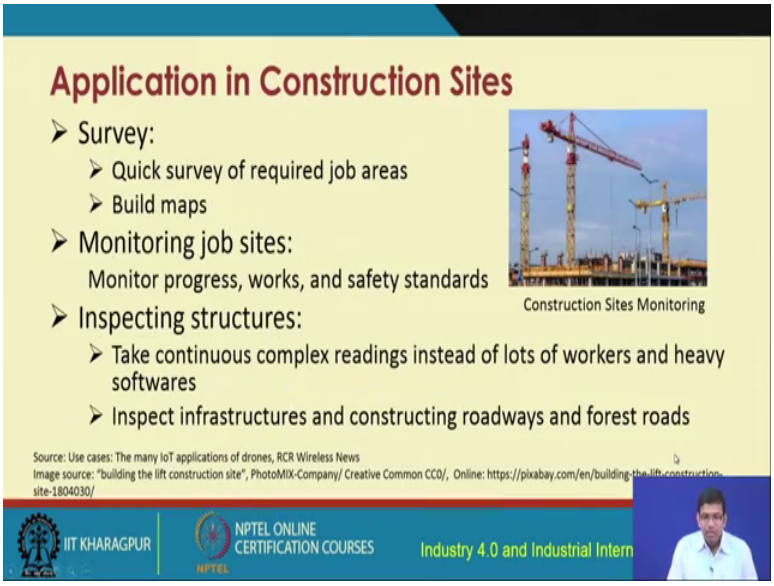

In construction sites UAVs could be used like this; this is a construction site where the UAVs could be used to monitor the construction sites and you know whether there is any hazard, whether there is how much is the progress in terms of construction, monitoring the progress of the work. The safety standards the safety, measures that are being taken by these different, workers in these construction sites all of these could be done, inspection of the construction structures could be done continuously, remotely this monitoring could be done in a real time continuous manner.

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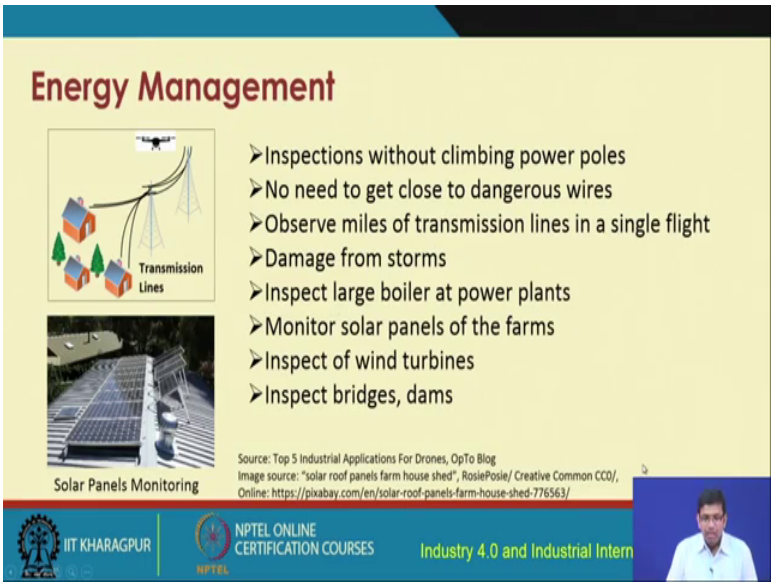

For energy management also UAVs could be used; UAVs could be used to monitor the power transmission lines. So, you know the monitor that the periodic monitoring of the power transmission lines is something that is done typically and that is done manually. So, UAVs could be used to do real time continuous monitoring of these transmission lines.

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In the mining sector as well there are lots of use of UAVs particularly in opencast mines use of outdoor UAVs is very common. For indoor mines UAVs could also be used; that means, you know, but those the specifications of those UAVs are going to be different.

So, indoor mining use of UAVs will require specially designed indoor UAVs for catering to the requirements of the mining sector, but in the mining sector whether it is open cast or indoor mines, the UAVs could be used to monitor you know to monitor different things for surveillance.

So, for monitoring the safety of the operations that are being conducted to surveil a particular area, to explore the site how much of extraction and extraction of the minerals extraction of the metals or the minerals are being taken how much is left. So, you know autonomous automated efficient monitoring of these you know extractions of these minerals like coal etcetera could be done. Like this there are different other applications of use of UAVs in the mining sector.

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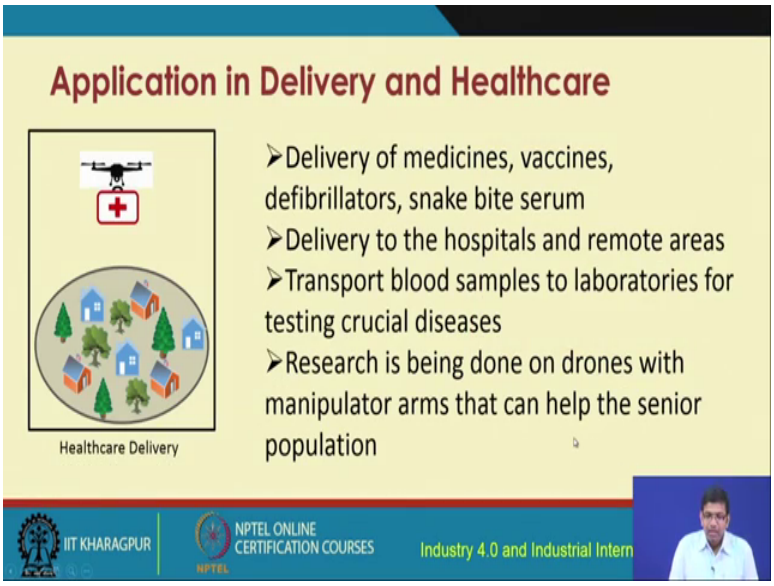

For the healthcare sector and drug delivery etcetera also UAVs could be used particularly in our country drug delivery from a tertiary care hospital, which is already equipped with lot of amenities, lot of you know, lot of different drugs lot of facilities. UAVs as per requirement can be flown from a tertiary care hospital, to a remote primary care hospital, a village hospital, where maybe there is no drug. So, like this there are different vaccines medicines etcetera depending on the requirement, specific requirement could be transported from one location to another.

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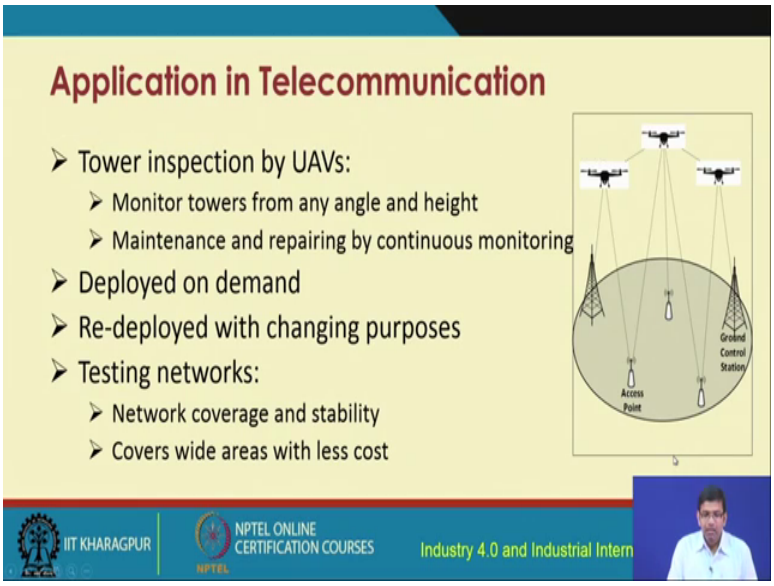

In telecommunication industry also UAVs could help in connectivity, UAVs could be like you know aerial gateways, they could act like aerial gateways or aerial access points, which can help in connecting two different points which otherwise may not be within their range. So, you know offering that kind of connectivity is possible with the help of flying UAVs.

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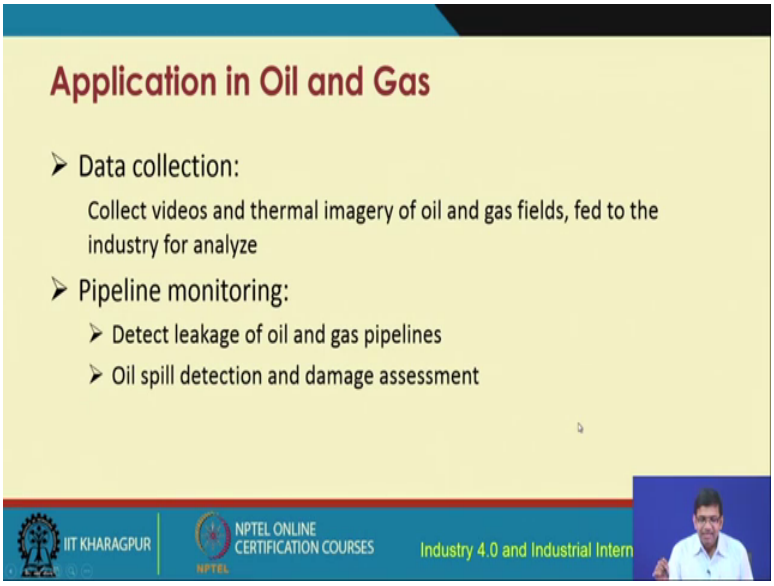

In the oil and gas sector as well for pipeline monitoring for detecting leakages, for collecting images about the distribution network all of these could be done with the help of UAVs.

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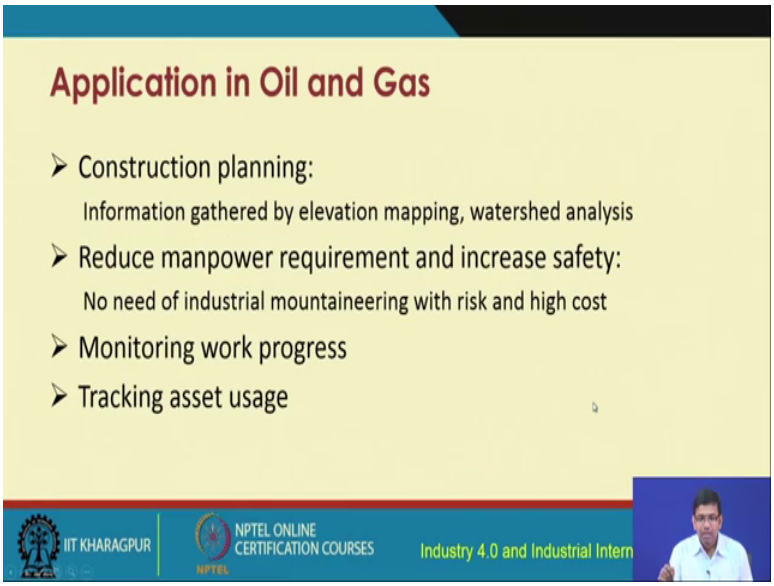

Similarly, construction planning reduced manpower requirement, monitoring these chemical plants or the oil and gas plants their machinery etcetera, while they are in; while they are in running condition. So, monitoring those equipments you know in a remote fashion can be done with the help of these different UAVs.

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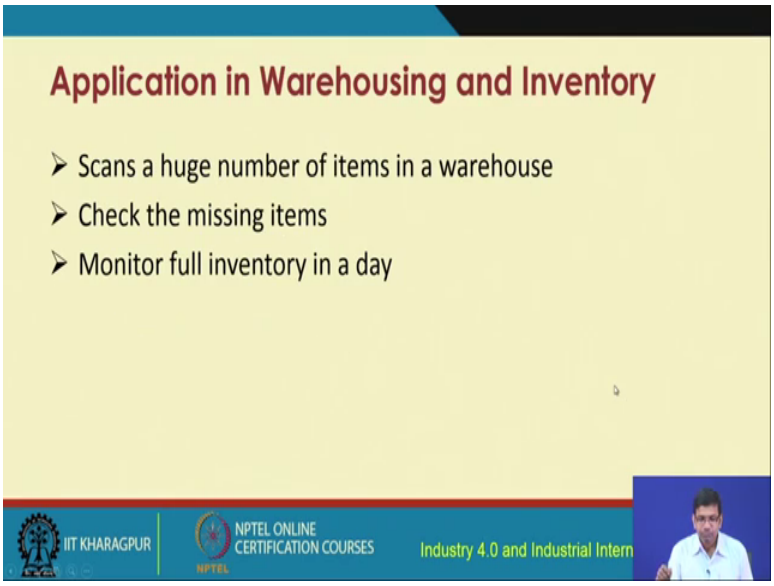

For warehousing and inventory control as well UAVs could be used. UAVs are used in different warehouses, the indoor UAVs particularly are used in the different warehouses to monitor the different shelves, in those warehouses. So, the inventories that are existing in those warehouses. So, all of these things can be done in with the help of indoor UAVs.

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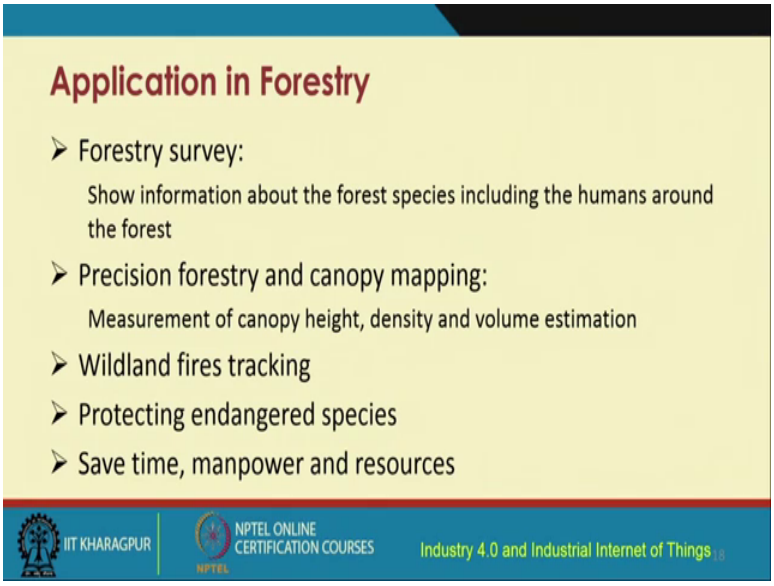

For forestry applications also forestry survey, precision forestry, canopy mapping, wildfire detection tracking, monitoring of speed of wildfire; if a wildfire has already taken place, protecting endangered species saving the time manpower and resources, forest resources, you know forest rangers for example, you know with the help of UAVs they can monitor the condition of these forests, the species the wildlife that is there. And also the different plants that their growth of these plants all of these things can be monitored with the help of UAVs in a much more efficient manner.

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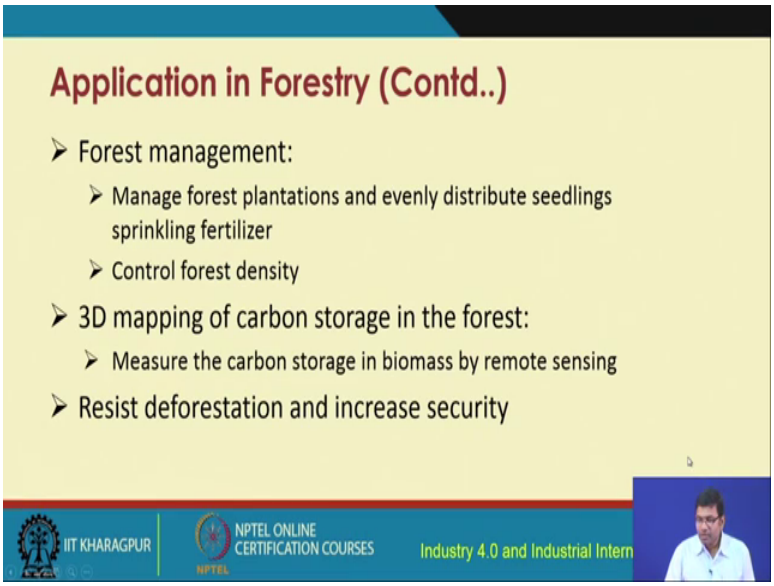

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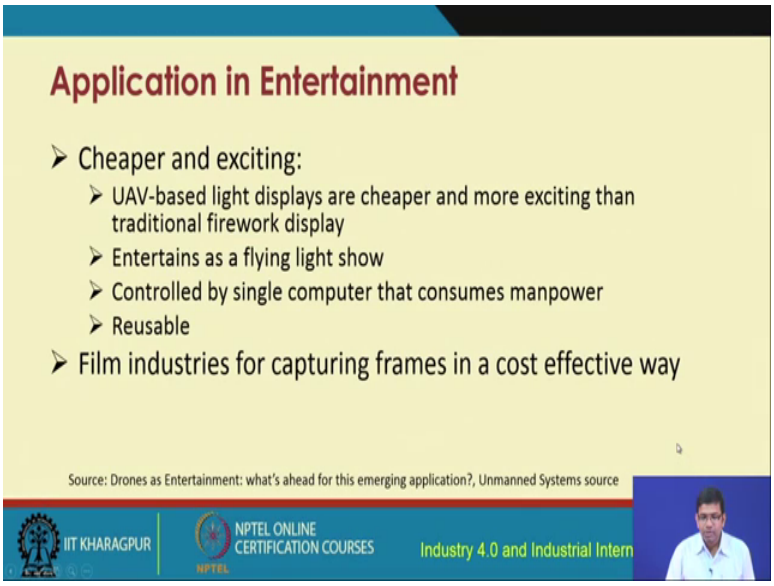

So, likewise there are different other applications in the forestry environment, forestry and environment as well, environmental monitoring by equipping these different these UAVs with different types of sensors temperature sensor or pressure sensor or different other you know air quality monitoring sensors could also be equipped with these different UAVs. And also capturing different images image frames etcetera so, together understanding the environment and the pollution etcetera all these things can also be done with the help of these UAVs.

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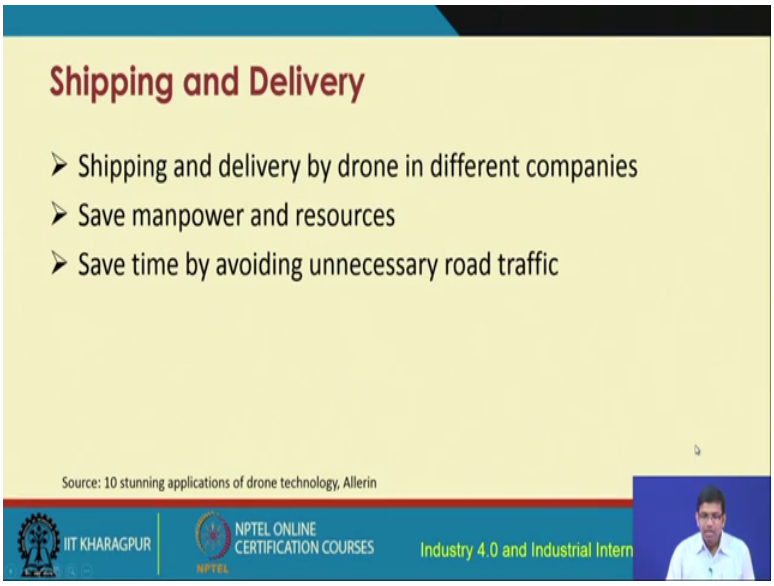

Shipping and delivery this is quite common lot of different applications, you know courier companies in certain parts of the world, they are using the UAVs to basically deliver different packages from one point to another.

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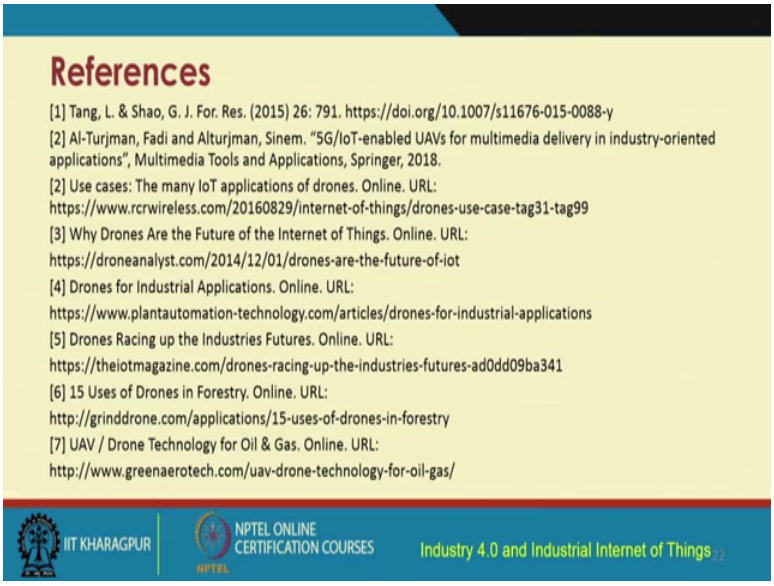

So, courier companies are also using UAVs. So, shipping and delivering UAVs are of you know attraction and they could be used for you know doing all of these different activities. These are

these different types of applications that I have shown you, like this there are a lot of different applications of UAVs. These differences will help you to gain better understanding more information about these UAVs, use of UAVs flights of UAVs you can find lot of different videos in YouTube to excite you more beyond what I have shown you. But if you are interested to know more there are lots of online tutorials that you would be able to find in order to get you started on UAV projects.

So, what is important is in the context of this particular course, think about good industrial use cases where UAVs can be of benefit. And then try to execute projects and try to see whether you can address any of the industrial problems. Maybe if you are coming from an industry, you might yourself be involved in certain processes, maybe if you are coming from a manufacturing plant, there might be certain requirements that might be already there in your particular industry in which you are serving. And try to identify one such challenge one such problem and see whether you can have you can come up with a UAV solution to basically address that particular problem that you are experiencing.

So, single UAVs as I told you is an issue, having multiple UAVs which basically collaborate cooperate with each other in order to accomplish a particular task a mission that is a farther challenge. And also I what I told you is indoor and outdoor UAVs. I have mostly talked about outdoor UAVs the UAVs that I have shown you are basically outdoor UAVs, indoor UAVs and their design operations etcetera that is a completely different ballgame. And you know so depending on your requirements you might want to focus on indoor UAVs or outdoor UAVs, working with outdoor UAVs is bit easier than working with indoor UAVs..

So, with this we come to an end. So, this last lecture on UAVs is something that I wanted to have in order to excite you more beyond the terrestrial IoT. Extend you from terrestrial to the aerial IoT domain and see how UAVs can help accomplish different activities, different tasks, execute different tasks, in a much more efficient manner. Monitor control different tasks different machines etcetera, in a much more efficient manner with this we come to an end these are all these other different references.

Thank you.