Lighter-Than-Air Systems
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Lecture – 18
Autonomous Airships

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Let us go ahead now. The current project in which we are engaged is the autonomous outdoor airship okay. This is the airship that has been fabricated recently.

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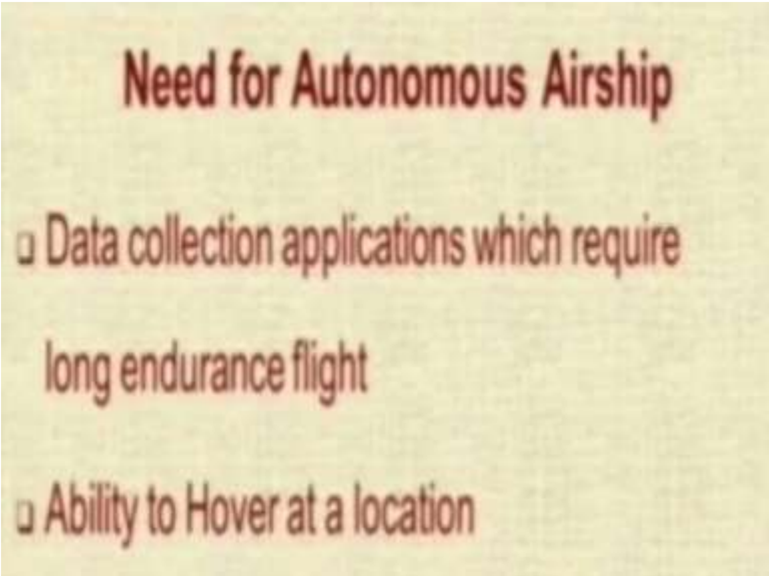

What is the need for autonomous airship? The point is that the selling point of airships is high endurance okay, 8**,** 9**,** 10 hours instead of 15 minutes, 1 hour for an aircraft on a given amount of fuel and if you expect a person to fly it manually for 8 hours it is very difficult. So, first small demonstration of half an hour or 40 minutes, it is fine you can have remotely controlled airship, but for any scientific or commercial work or long durations of time, it will be difficult to expect it to be done manually.

So, it has to be autonomous. Secondly, if you have a system which is autonomous then it can also be configured in many cases, not always, but in many cases. It can be configured to maintain its position by sensing the disturbances and creating forces just enough to overcome the disturbances. This is called as hovering okay. It can be done by aircraft with the thrust vectoring like the Harrier and also by helicopters.

Airships can also do it because airships do not need forward motion to overcome the weight. So, if you have a autonomous system it becomes easier for a human being to make something hover, to make an airship hover will require a lot of work continuously. And the third thing is you are now independent of line of sight or of the ground stations because normally you need to have a line of sight between the remote and the airship. But if it is autonomous, it can do on its own okay.

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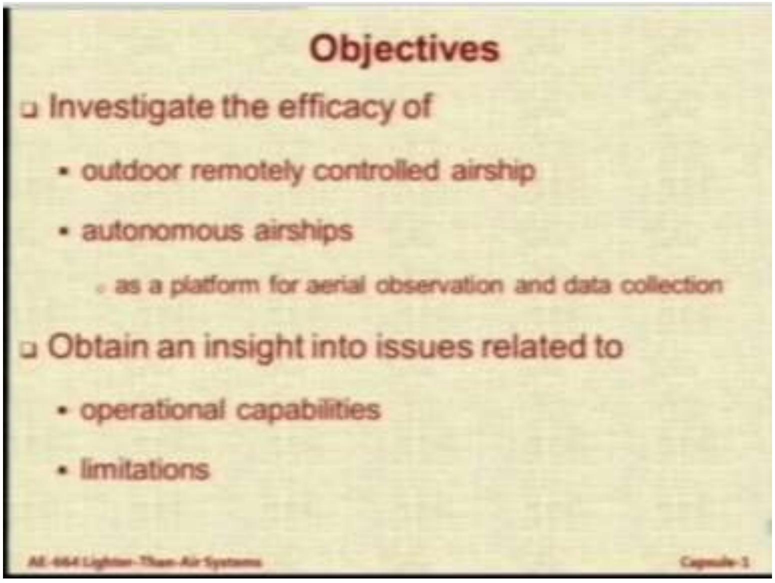

So our task was to look at what is the efficacy of these and also what are the limitations? More importantly, what are the operations and abilities and limitations for autonomous airships?

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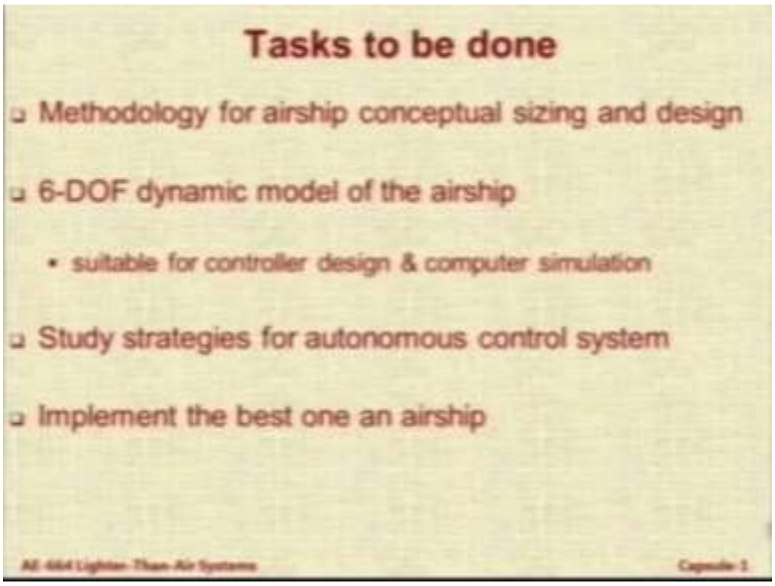

So, the task to be done was first of all, although by this time we have developed several RC airships or remotely controlled airships, we have not got the time to sit down and write a formal methodology just like I did it for the bigger airships in 2003. So recently, a paper has appeared in which this methodology has been properly documented along with the data. I told you it is a part of a dual degree project of Sayyam one of our recent dual degree students.

Another activity that we have attempted is to create the 6-DOF dynamic model of the airship. This model should be suitable for controller design and computer simulation. So this is currently a work in progress. We have not made much progress in this so far, but we are working on it and I am looking for people to join hands with me to take this activity further.

We also studied various strategies that are reported in literature for autonomous control and tried to implement the best one on the airship. This activity is currently work in progress in the laboratory.

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Our students are investigating various strategies for the airship. Without the running model also you can create controllers based on certain logics, so that is what they are attempting. These were the specified requirements for the airship. The most important one here is the wind speeds 10 to 15 meters per second and endurance of 30 minutes.

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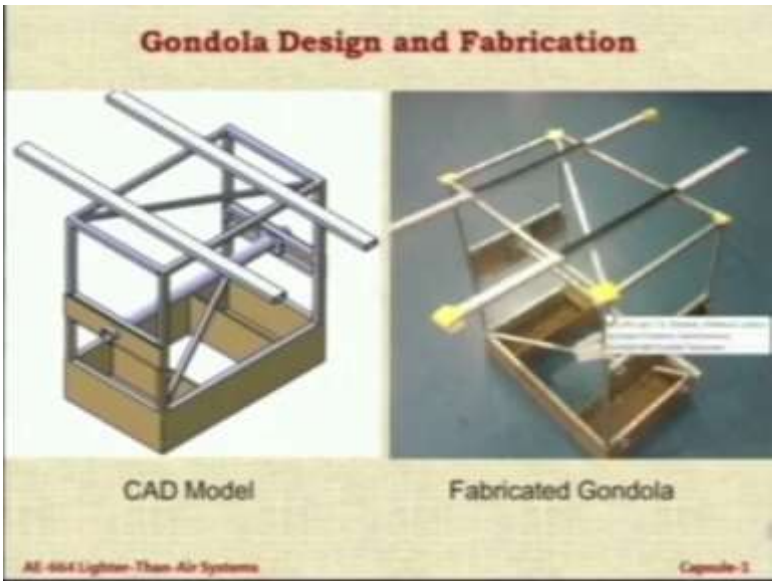

And I will show you some pictures of our progress so far. So the first thing is the Gondola or the item that carries all the equipment, the onboard camera, the engines, the controllers. It has to be fairly robust and sturdy plus easily accessible. So one student who came for internship designed this particular gondola. So you see the design and the actual fabricated system.

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And I will show you a video of testing of the thrust vectoring system of this gondola.

So we wanted to have thrust vectoring capability. So we have run main motor which can be swirled. The white thing on top of the airship envelope and kept near. So during the ground testing, the system behaved perfectly well and therefore we did the testing of this particular systems. But during flight testing after the first flight we realized that the torque load coming on the servers is much higher than what we expected.

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And one of the servos actually the teeth inside have broken because of the excessive torque. So, then overnight we came up with another version of the gondola which had a fixed motor for vertical, fixed motor for forward and one more motor as I will show you.

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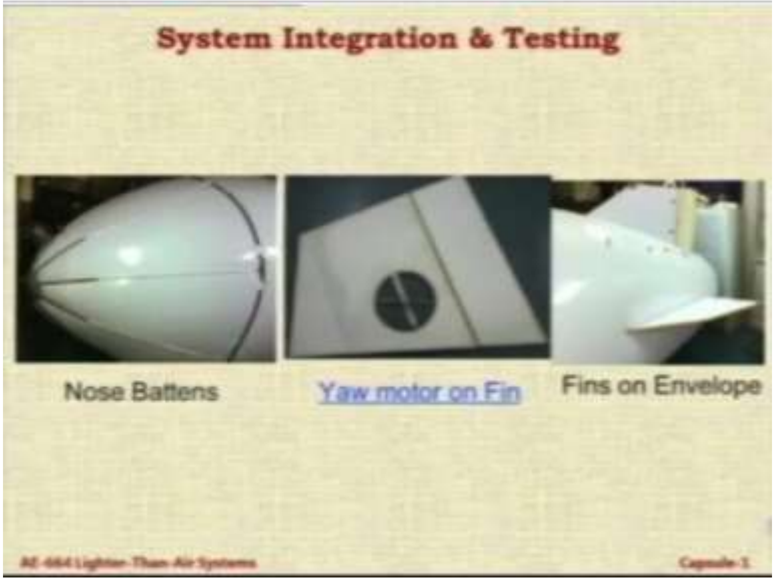

So, now the envelop of the airship has to be protected against the dynamic pressure acting on it as well as the other loades acting on it in the nose plus we need to attach it to the mast. So, you cannot attach a solid metallic mast to the soft envelope, there has to be some interfacing between them. This is done through what is called as a nose battens. About this, we will have a special lecture on the design of nose battens.

Right now, just to inform you that there is some kind of a structure to be put in the front of the airship. Then although the spaceship is outdoor, it might be required to operate in some conditions where the ambient winds are very less and especially when you want to make it fly autonomous you cannot depend on wind loads for giving you the required yaw or turning performance. So, what we decided is to put a dedicated yaw motor.

That means we will fit one motor on the side in the fin and when commanded it will give direct side force which will augment the running load because of the fin.

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So, let me show you the testing of this motor in the laboratory. So you can see that the vertical fin member has been attached to the envelope. So we go for a double attachment. We go for a velcro between the envelope and the fin gear and the bottom.

And then we have these cable of good system to hold it in place. With this it becomes fairly steady and it is able to take the loads. So this airship has flown with this kind of system working very well.

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"Professor – student conversation starts."

Yes. Sir is the area of the entire body is near the gondola right. Yes. Sir at least the fins of the yaw motor is at a very high level, so does not it create problems actually when you are flying?

It does. See the side force is acting with kind of a moment arm. So it does give, but the airships have extremely good roll capability because it is a heavy mass which is slung under almost zero weight body.

"Professor – student conversation ends."

So, they have what is called as pendulum stability. So, any motion which takes it this way will automatically be brought down because of gravity because of the pendulum effect.

So, the coupling between the modes can be considered to be weak and hence this problem that can come in a flying aircraft with so much of moment imbalance does not manifest itself so much in the case of airships. However, we do have to be careful about mounting the propulsion system with the thrust line correctly inclined so that when you give power either the nose should go down or go up as per the desired value okay.

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Now, let me go ahead and show you this is a picture of the assembled airship. As you can see it completely occupies the aero foyer space, there is hardly any space left. So, that gives you an idea about the dimensions This was 8 meters envelope length and the mast occupies another 3 or 4 meters because of the long legs on the other side. You can see one leg and also one more leg on that side.

So to take this picture we have to juggle a lot so that we can show the fins also, we can show the envelope also and we can show the mast also okay.

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And then the nose battens which I spoke about they have to be attached to the mast. This is a picture showing Vishal one of our project engineers attaching the mast of the airship to the nose okay. And you will see that we are gone for cane structure for the mast. Now, this is also very interesting work in progress. The structural design of the mast is very important. You need strength, but you also need low weight.

And you need some mechanism by which we can attach it rigidly to the mast. So, in this case what we have done is, we hired a specialist mechanic from IDC who has expertise in making things out of cane. As you might know there is something called as a bamboo studio in IDC where a lot of research going on bamboo and cane as a material. Now, they are not propagating that as a material for structural applications like this.

But we found that this cane is a very good candidate for the nose battens. Only problem is it has to be pains takingly made by hand. As you can see each of these gondola each of these nose battens to give legibility, they have been hand woven with cane strips on cane rods. So it takes some time to make, but structurally it is very rigid and very lightweight. So the message is that you have to keep your eyes and ears open to find solutions to your problems, wherever you can get them.

Then, the time when many of you are giving your end sem examinations in 2013 that is a time when Gymkhana ground is relatively free and available for testing, etc. Because many students do not come to the Gymkhana ground during the end sem and mid sem timings.

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So we occupy Gymkhana ground usually during mid sems and end sems. So during this end sem period, the last two days actually available to us we were in the Gymkhana ground attempting to test this airship.

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So here is a small video that shows the outdoor remotely controlled airship flight of this airship. So these are some of our team members on the ground.

They are there because near the ground we have to tether the airship and we have to hold it. Now this particular rope that you see is eventually taken off. They do not fly with this long rope, they normally fly free. So what you are seeing is essentially a 6 or 8 foot long piece, which is used to handle the airship on the ground. So it is only a handling rope, you know the one that is hanging here you can see that is the one you are seeing.

The other rope is not going to be left very soon. You can see there are winds coming from one side in a very rapid fashion. There is a onboard cameras mounted on this and I will show you a much better video from the onboard camera. This is just a small clip. I will show you better clip. This shows the airship which is at the height of approximately I think about 80 meters above the ground from where we were.

We actually covered almost half the Powai lake. Remember, we cannot go outside the campus because there is traffic. And if you are very ambitious and go more, there is Mumbai airport. And then we will have a very sorry spectacle of a 747 coming and hitting a small baloon from IIT, Bombay. So, therefore we have to be very careful about the winds and about controlling. So we just went up to half the Powai lake and we were circling over it and then we were bound to land.

So this particular airship was a platform to mount our autonomous control system which is still being developed. So we have not yet. Now let us see what the onboard camera saw. Now this is the video. You can see the gandola hits the ground. Now you can see your campus down. This video is available on YouTube. So if you want to tell your parents or friends whoever is there you can just say please look at this.

Now whole of the campus is visible on this video. During flying of an airship you will always have this issue that what happened if we lose control. Lifting balloon with gas is a very dangerous thing to leave alone. Now you will hear nearly 3 different sounds. There are 2 vertical motors here one is giving you vertical thrust the other gives you forward thrust and the there is a yaw motor which gives you side force okay.

So all three are different sounds and actually we can make out which one is being operating at what particular time. Surprisingly it is coming slow. Okay you can now see we are approaching hostel 12 and 13 and then we also see the Vihar lake which is not accessible to us now okay. We actually wanted to fly over Vihar lake, but we were not sure if we have the permission to go beyond the pipeline. Now we have our campus across the pipeline.

So, therefore subsequent flight of this airship we might like to explore the Vihar lake area also. Although staying one constant worry that you have is what if we lose control. So, one of our project engineer has designed a system using two zigbees which talk to each other and when I want to command any emergency deflation in the envelope to bring it down, I can actually press a lever and it will communicate to zigbee on both which will add a circuit.

That circuit will burn a hole in the airship and the gas will come out okay. So, this is called as the emergency rapid deflation device or ERDD. So, on this airship we have installed an ERDD and I will show you when it operates. Of course, we did not have any video of it operating because we did not have a video camera which you could put on the ERDD. But I have been testing on the ground to see how the hole is created.

But I will show you the working of ERDD with a version of the airship. So, let me just save some time. Now listen very carefully to the sounds. So the motor is off, you hear beeping sound of a device. This beep that you hear they are the beeps indicating that the system is working. Now look at the shadow of the airship on the lake okay. It could give you the indication. So we have now already done the device activation okay.

So she is slowly sinking now if you have to observe. She is approaching near the trees and she is slowly sinking. The shadow is getting slightly bigger and bigger. Right now it is clear and simple drifting balloon. I have no control on the descent. As you can see now the descent is increasing faster and faster. You can see she is coming down very fast now. Unfortunately, at this point of time the onboard memory ran out.

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This video is being recorded by the SD card onboard. The SD card was of 8 GB and 8 GB of data got recorded by this time. So when it was required the most when I wanted to see the airship hitting the floor, the SD card did not work. Now the problem is we have no idea where the airship is, we were in Gymkhana ground, the airship has fallen somewhere that side, no.

So then we were very frantically searching for it because suppose it had not actually deflected properly, she will now drift towards Hiranandani. So we are really concerned and you know the lake has crocodiles. So you know you cannot say jump in the lake and swim and get it down. So we were really concerned and then one of the students got a brainwave that said the best place in the campus to look around from a height is the terrace of one of the hostels, hostel 15 I think.

So he took a bike and he ran to hostel 15, climbed to the top and he could see a white color blobs somewhere. And he said, Sir good news, it is down. It is somewhere near the lake, but I do not know where its in that direction. So who knows that direction. He said I have seen it is at the 4 o'clock position or something like that. So then we searched frantically and we finally found this balloon was entangled on the tree, the last tree before the lake.

But the device was still working, inside there was a hole created and the gas was slowly coming out. So then with the help of some of the labourers who could climb the tree, they went up and they created a bigger hole, brought it down. So that is how we saved this particular.

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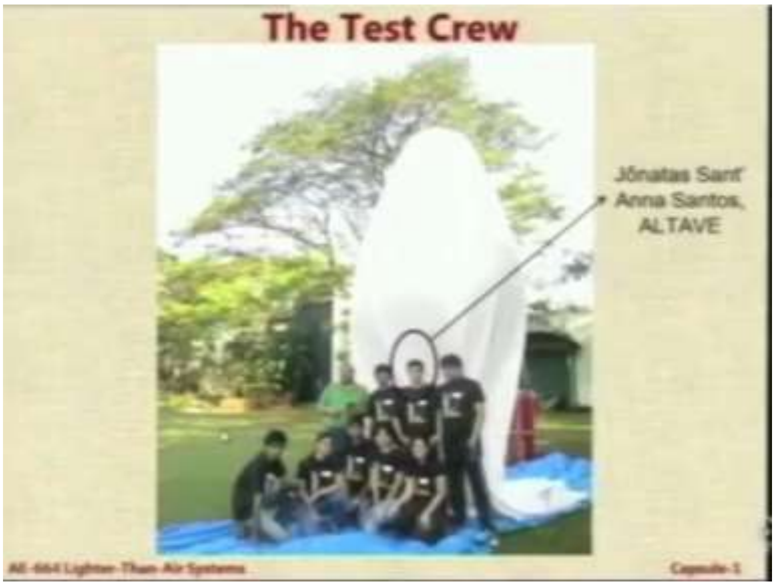

This is our team and these are the people who were helping us in the field that day. Now, a special person in this is a guy from Brazil who came for 2 months internship okay. He was denoted who was our pilot because he has flown in the past. And he is sent by the company with whom I work in Brazil during summers. So they have deputed him to try and implement an autonomous controller on our airship.

So he was there with us for 2 months and actually close to 3 months because he left on 8 th January. So he was there for close to two and a half months or three months.