Lighter than Air Systems
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Module No # 1
Lecture No # 3
The three conventional LTA systems

Main problem is in a transportation system it has to be reliable because people plan their journey in advance. You cannot say we will go if we can go. Now this is excellent when you are adventure or when you have a situation where people say ok no problem we are a tourist we would like to go around these places. If the airship is available and flying we will use it. If it does not, does not matter we have other option to do it.

So for such applications airships are being used and they can be used where the liability is not a major issue. For adventure for pleasure for aerial sight seeing when possible they are being used.
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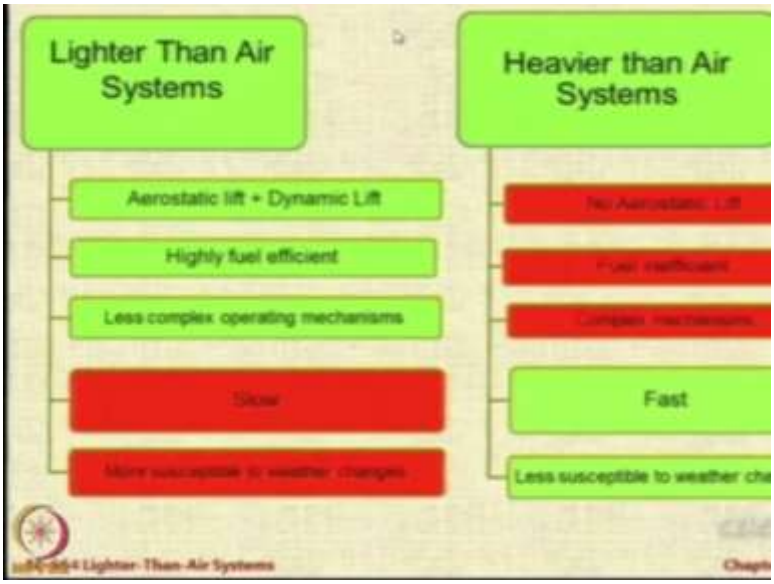

But another reason why they are not being used is that they tend to be very expensive from the total operating cost point of view. Fuel cost is the small component of operating cost. You should have an infrastructure you should have the trained crew for the operating it maintaining it ok. And unless you invest a large amount of money in a this is a very niche business in all niche business is thing go very expensive ok.

But that does not mean that they are useless we will discuss in this course and I hope to convince you that for certain niche application they are the best and hence people are designing them now or looking at bringing in airships or aerostats on those applications ok. So we are looked a lot at the drawbacks but the advantage is of aerostatic lift high fuel efficiency and less complex mechanism these are making it very easy for student to build airships and fly them ok.

When you make a flying vehicle and some of you are experience in making aerial flying vehicle or aerial robots right. It is very common that when we learn aero modeling or when we learn how to make an aircraft. It is very common to spend 8 hours in making an vehicle and 8 minutes in breaking it. Because it is very difficult to control this force called thrust. And unless you properly control this force it can really take you immediately away.

And other variable vehicle you need certain minimum lift generation just to overcome the weight and then you will lose the balance to provide the forward or the other directional motion. So if you look at students who want to make an aerial vehicle flying very soon we have got the feedback from the students that we tried quadrotor, we tried UAV, we tried we found that making balloon is easier.

But balloon is forget full if balloon is blown and hit the wall and it bounces back it does not break ok. But try that way the quad rotor ok. Very soon you will find that unless you get it perfectly balanced you will not able to even start that does not mean you should not make quad rotors. Every aerial vehicle has it is own role quad rotor has fantastic ability which airships do not have.

So we are not saying that this is bad that is bad we are just saying this is one more thing available for you to play with. So this line less complex mechanism is a very important line for an aerospace engineers who want to make a small flying system without its limitation but they want to make something that flies. And they challenge that you have to overcome in making a small airship which can be stand in a small disturbances is really very exciting one ok.

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3 types of systems that are normally consider there are hybrids also so you will have combinations of these. And we will cover that in the last capsule of this course. But for the moment let us assume that there are 3 basic vehicle 3 basic system. Extreme right is hot air balloon which is simply hot air. So you generate buoyancy by using the fact that when air is hot its density becomes less compare to the ambient air. So either you can cool the air around you that is very expensive and very difficult.

What is easy is you create a bag which is gas proof or air proof. And the air inside can be contained heated and hence you get buoyancy. So you go up that is what you can do. You go up and then the wind will take over. So with the hot air balloon you can have fun you call it adventure. You cannot plan your journey. Your journey will depend on wind condition your destination and speed is a function of wind conditions.

Some people have tried to make control of balloon by using the sector but they become very complicated. So this is the most basic LTA system and we will experiment with this system also but as you can understand it has got limitations in its capability. Go to the middle of the slide you come with you come across a system which is actually a kind of you know it is a very confusing thing. It is an aerospace system which remains stationary. Hence the name is aerostat ok.

This is very much contrary to common perception how can an aircraft remains stationary. But this aircraft is considered to be good and well-designed if it remains stationary. If an aircraft moves we

are unhappy with it. We do not want it to move. We want it to remain stationary. We want it to automatically aligned with the wind and maybe drift slightly but remains stationary. So what we do is we arrest one of the degree of freedom of the balloon.

So you can assume it to be an aerospace system which is divert to the ground. So all of us who are played with the balloon as children we have played with the most basic aerostat. A string attached to a balloon which contains gas is an aerostat. The difference is that the envelope of the aerostat is designed in such a way that it has best possible aerodynamic behavior. So please tell me what kind of aerodynamic behavior you would like to have in a good aerostat envelope.

What aerodynamic feature you would like to have? Do you want to have it or no? So what is dynamics? You are have an pitching dynamics ok and I am coming over aerostatics. Yes that is dynamics. Alignment requires motion talk about only statics. Will you be happy with positive lift. Will you happy with some amount of lift. No I want to maximum lift. I would like to have maximum lift possible from a given shape ok.

So now which shape will give you a maximum lift. Which shape will give you maximum lift or aerostatic lift. Elliptical is one answer ok. But I do not thing optically you are right. It will be spherical because a sphere is a geometrical body which has got the least surface area for a given volume. So if weight of the system is proportional to the square limit area of the envelope which is true then the best envelope shape will spherical from the weight point of view.

But the spherical envelope need not have a best aerodynamic characteristics. It may not be the best to align it may not be the best shape to prevent yaw and role or pitch ok. So therefore you have to give it an aerodynamic shape so that the drag is minimized. So an aerostat envelope is shaped so that the drag is minimized on the back side you can see there are with fins which I have given so that it align with the ambient wind.

Because it is not aligned with the wind it will have more drag, if it aligned with the wind it will be facing with the least possible frontal area and hence it will have less drag ok. Your question is that if it is a stationery system you should have more drag, so that it does not move. So your argument is true for your flying vehicle which is untethered. If in a balloon you have more drag what will happen is it will actually go like this.

So you do not want the balloon to be near the ground. You want the balloon to be up in the air at the height you want. So there is something called blowby which is that lateral motion of the balloon because of drag it has to be the least and for that we need low drag shape ok. And the on the extreme left we have a system called airship which is not which is untethered it have got a dynamic shape to give you low drag but it has got these control surfaces on the back.

It also has some portion of the control surfaces are fixed. For example these figure if you can see the hashed member are fixed. The light thing is moving radar. So you need stability also and control. We will discuss this when we come to stability and the control. But additional feature is there is also power plant or an engine in this which gives forward motion. So this is like a proper three axis control with the propulsion system as against the aerostat which has a tether on the ground.

As against a balloon which has no propulsion no tether and no directional control at all. So mostly we will discuss aerostats and airship because they are the one which can be used for some serious or useful scientific or commercial work. However hot air balloons make a lot of money. So for commercial purposes hot air balloons are also very good right. We are not dispensing them we are saying that their capable is limited because they are at the mercy of the wind ok.

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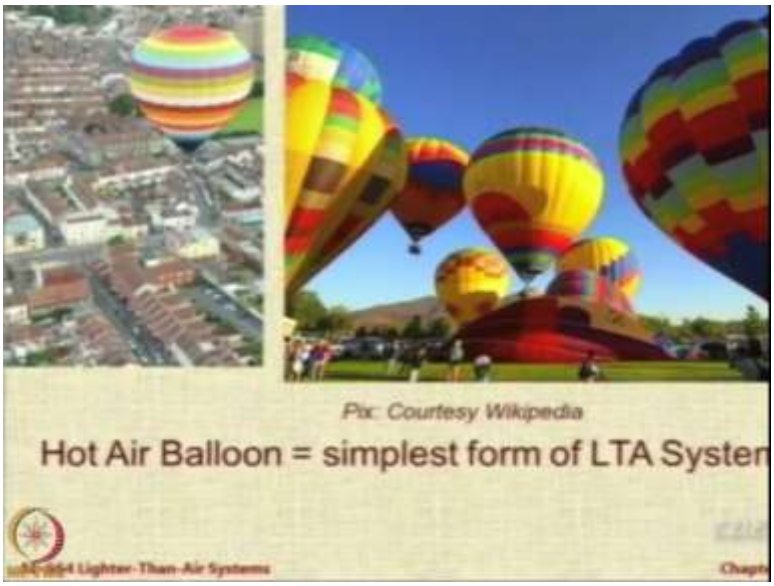

So hot air balloon is a very exciting system and the amount of LTA technology that you need to know to make a good hot air balloon and to make it fly well is phenomenal. So all the LTA experts actually are hot air balloon enthusiast normally because they can implement their knowledge and the expertise live on a system.

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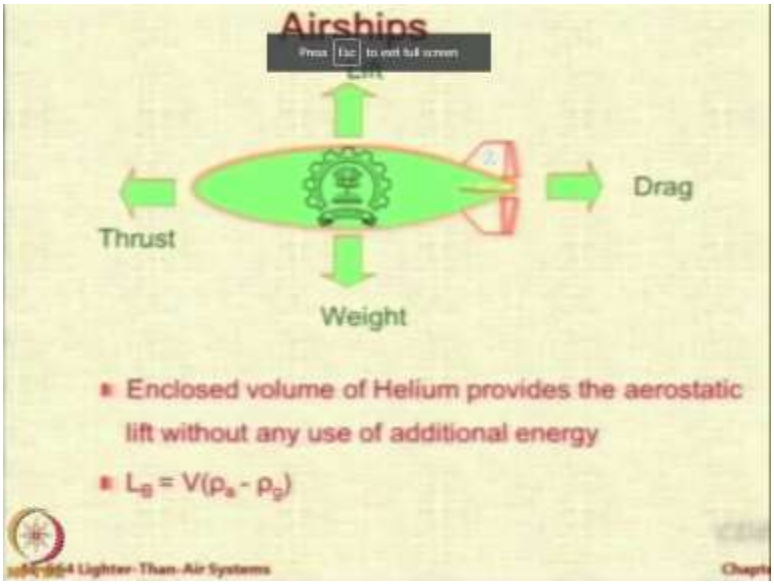

Ok in an airship like any flying aircraft whereas same four forces. Now first think I want to ask all the aerospace engineering here is there something fundamentally wrong in this picture. We are showing an airship ok IIT Bombay it is not a wrong thing good. shapes also seems to be alright and yes there are 4 surfaces 2 vertical and 2 horizontal. But there is something wrong fundamentally wrong in the way this figure has been drawn.

What is wrong with the drag right that is one point that the direction of the drag will be always along the ambient wind. So this may not be at 0 angle of attack that is acceptable. What else? So if we assume that there is an airship in equilibrium with 0 angle of attack suppose I assume that. Then lift will be equal to weight and thrust will be equal to drag. So the 4 forces will be in balanced as we have shown but still there is something fundamentally wrong.

What is it? Ok what is the real scenario they may not be aligned. What about thrust and drag? Correct so may not be. So there is no need for lift to be exactly opposite to weight and drag to be exactly opposite to thrust. That is what is wrong it this picture that the point of action of these forces needs not to be exactly at the same. It is representative picture which just show that there

are 4 forces 2 of them are cancelling each other in the vertical direction and 2 in the horizontal direction. Now out of this 4 forces 2 of them are natural and 2 of them are manmade.