**Lighter-Than-Air Systems**

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**Lecture – 93**
**Introduction to Aerostat Design Methodology**

So, today we will look at a methodology which has been developed by a series of students for design of a tethered aerostat system. We have seen one methodology for airships. This is for a similar purpose, but there is a slight difference in the way we go about doing the calculations. So, essentially let us have a very brief look just to refresh our memory because we have been talking mostly about airships in the last few lectures. Now, we come back to aerostats.

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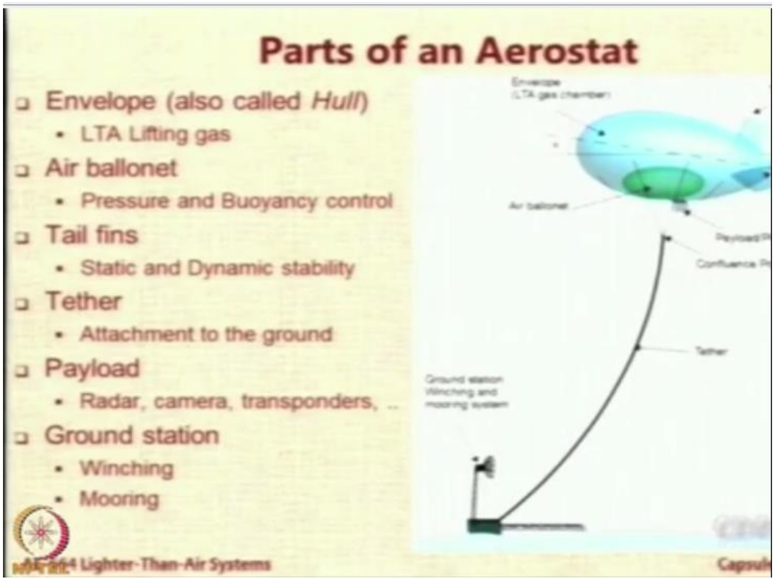


So, to refresh your memory this is a picture of a tethered aerostats system. The main component is the envelope which is also called as a Hull that is filled with the LTA gas and inside that envelope we have this green colored airbag or air ballonet which is essentially for pressure and buoyancy control. There are tail fins which have been given for static and dynamic stability. So the sizing of these fins have to be done keeping in mind the requirement from stability.

Recall about the difference between static and dynamic stability. Can someone again elaborate and tell me what is meant by static stability and what is meant by dynamic stability? Recall your memory we have discussed this. So, when you write a proposal to do a project, you write something like this is what we will do, we promise this, we promise that. And then in the end what you actually do?

So, what do you propose is static stability, what you actually do is dynamic stability. So, with this can you try to recall the difference and tell me quickly? **“Professor- student conversation starts.”** Yes Chetan. Actually the zero position of the envelope that goes from one position to the another it remains there. I think dynamic stability is from where. No that is not correct. What you are telling is about neutral stability and unstable or stable it is not that.

Anybody else? Yes Amir. Stability means that goes if probably displacement is given from its original position it will return to that position. Static stability is that overall situation of overall situation in time it should return. And dynamic stability is the power or tendency to return as soon as it is hit. It is actually the opposite. So, static stability is from an equilibrium condition if there is a disturbance, the tendency is to come back, not to divert or stay where you are. **“Professor- student conversation ends.”**

So, for example if I have a system in equilibrium and if I push it and it just goes to some other position in equilibrium, then it is neutrally stable. But if it tends to go away further, then it is unstable. If it tends to come back to the original position it is statically stable. Now if it actually after some oscillations maybe comes to the original position or very near to it, then you say it is dynamically stable.

Then tether is the cable which is attached to the ground, the link between the balloon or the envelope and the ground. Then we have payload which is the choice of the user. And we have a ground station which has winching and mooring. So, now in all these components let us look at which are the components which we as aerospace engineers can hope to design? So going from the bottom can we look at the ground station?

Not really, it is basically a mechanical and electrical problem. Because there is hardly any aerospace engineering in designing a winching and mooring system. So we will not talk about it. Payload something that you are given by somebody. You do not design the payload, right. In the lantern that you design, you do not design the payload. You picked up some piece of stone or piece of metal that is a payload.

Tether; tether is it something that you will design? No, it is a item which is brought out. But the question I want to ask is how much tether is needed? Suppose the aerostat is expected to deploy from a height of sea level to 1 kilometer. Under the action of ambient wind, it will occupy some kind of a position such as shown in the figure. How much is the length of this tether? **"Professor- student conversation starts"** It will depend on the wind only. Exactly.

So, let us say we are told that the maximum continuous wind is so much. So, using that information we need to determine if the height is 800 meters or 1000 meters that tether will not be 800, it will be more than that. How much more? 10%, 15%, 20%. So, that is something. Now what will determine the profile of the tether? One is the wind condition. Then what else? Self weight. Self weight, right. If it is very heavy, it will be more taut.

What else?  Yeah, so how it reacts to the forces acting? Elastic modulus of the tether. Yes aerodynamic loads, diameter, windspeed, Reynolds number, Mach number plus also the shape of the envelope will determine the drag acting on the envelope which will affect the tension on the tether which will affect the profile. **"Professor- student conversation ends."**

So, we as aerospace engineers what we can do is we can determine the profile of this tether under some given operating conditions. So, that is what we will study. Although you can always say okay if the height is 1 kilometer 20% extra, 30% extra that is also a safe assumption, but it is better to get a better estimate. Going up tailfins, yes this is our job because we are concerned with sizing the aerostat for static and dynamic stability.

The actual process of designing the fins and sizing the fins is very cumbersome. But in conceptual design, we always take some empirical, semiempirical assumptions or formulae and get some shape. Going up air ballonet. How do you decide how much is the volume of the air ballonet needed? How do you do that? By determining the inflation fraction.

The density ratio at the maximum altitude of deployment upon density ratio at the bottom altitude and it could be under ISA plus some other temperature not ISA standard temperature. So, we have spent I think couple of lectures in finding out inflation fraction, etc. So with that, the ballonet volume can be estimated. Once the volume is known you have a choice of having an integral ballonet or hemispherical ballonet.

You can work out the size of the ballonet that means the material needed to do it. Envelope of course is our job. We have to decide the shape of the envelope. We must decide the dimensions of the envelope. This envelope dimension will depend on many things. First of all on what user requirements will the volume of the envelope determine or depend? **“Professor – student conversation starts.”** We have carry to carry the payload.

Payload to be carried. What else will affect the envelope volume? Altitude. Altitude of operation or deployment yes. **“Professor – student conversation ends.”** Ambient conditions at that altitude, right. Pressure may be different from standard pressures, temperature may be different from standard temperatures. Then you may also need to know for how long we are supposed to deploy it continuously because then you will estimate the gas leakage.

And then you will say I should have so much extra volume to ensure that it does not come down. Suppose I want to deploy for 15 days. It should not happen after 4 days the aerostat is half down. It will not be correct. If the user says I want it to be deployed for 14 days at a stretch, at the natural you can ask the user in 14 days how much height loss will you accept 1%, 5%, 10 meters, 20 meters that you can ask and then we can plan for that.