Lighter-Than-Air Systems
Prof. Rajkumar S. Pant
Department of Aerospace Engineering
Indian Institute of Technology - Bombay

Lecture - 79
Validation of Airship Design Methodology

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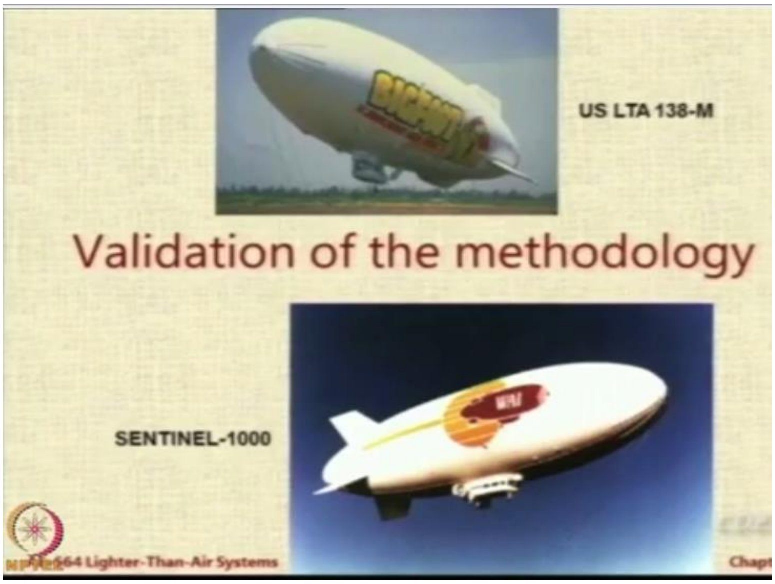

So, we did the validation for 3 airships which are available at that time or I should say that data for which was available at that time. One of them is this, US LTA 138-M and the other one is SENTINEL-1000 which unfortunately did not really, the program was cancelled midway. SENTINEL-1000 was the airship which actually revived the airship technology after its downfall in the late 30s, in the mid 80s, early 90s.

It was this SENTINEL-1000 airship project which brought airship technology back into the focus. But because of budget cuts, this project was cancelled. So a smaller version of this airship called as Skyship 600 was made and then commercialized as 600 B and sold. So, data for these two airships and from one more airship from a company called Ulita, unfortunately the company has gone bust.

So even if you try to search the website, you will get no information. I could not get even a picture of the airship to show today, but I do have the data about that airship from Jane's All the World's Aircraft.

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Validation of mass estimation-1

Sentinel-1000

Component	Estimated	Quoted	% Di
Empty	2098.4	2061	2
Fin	762.7	960	-21
Gondola + LG	748.2 + 82.4	910	-9
Engine + Fuel + Thrust Vectoring +Trans.	635.8	622.7	2
Propeller + Duct	220.8	356	-9
Controls	236.4	249.6	-5
Elec. + Instruments	418.9	438	-4
Miscellaneous	124.6	128.7	-3
Total	5328.2	5726	-7

So, what I want you to do is talke a look at the numbers, they do not matter. Look at the percentage difference, look at the last column. The last column showcases the percentage difference between what we estimated versus what is the actual data but for the fin weight everything is within 10%. And in most cases we are underestimating because it is negative that is not good.

If you underestimate information, it means there are certain factors which you are not being able to consider. However, theoreticians or academicians who do not have any practical experience on working on airships we really cannot be better than this. Because we do not know what is a factor to be put for additional weight of the envelope because of patches. How do I do that? How do I know?

Now I know it because I have made so many airships so I can say okay if you are making a remotely control blimp of this size you must put so much factor. Now people are referring to our papers on remotely controlled airship sizing because we have now data of our own, but again our work is focused on particular type of envelope, particular material. So, within 10% error except for the fin, for the fin we are off by 21%.

That means the actual fin for Sentinel-1000 was far heavier than what we predicted. That means our assumption as I mentioned to you we had to formulae for fin assumption. One was Raymer's formula for aircraft fin, the other one was area density method, but hopelessly both of them were giving us wrong value. So, now we know that our fin estimation is wrong, needs to be corrected.

So, this opened up one more area for someone to look into in more detail. What went wrong in our fin calculation and maybe we can revisit this and go for better estimation. But everywhere else we are within 10% which is not bad for initial conceptual design.

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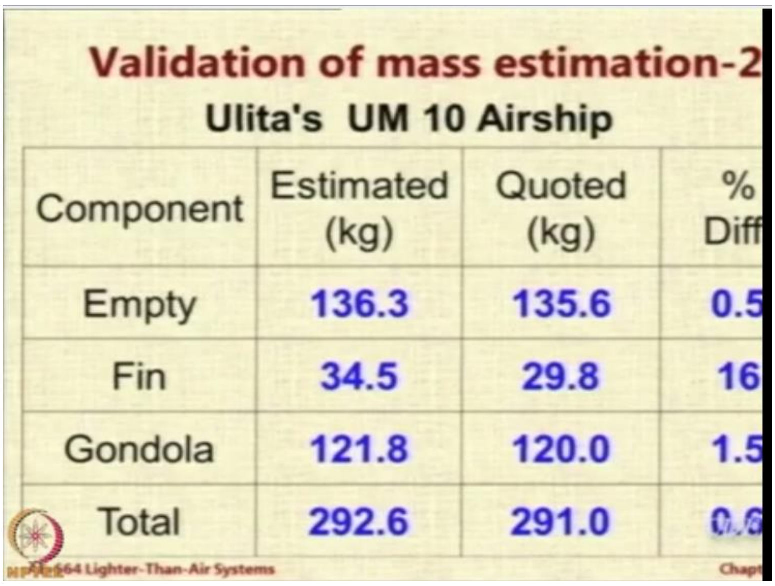

Validation of mass estimation-2

Ulita's UM 10 Airship

Component	Estimated (kg)	Quoted (kg)	% Diff
Empty	136.3	135.6	0.5
Fin	34.5	29.8	16
Gondola	121.8	120.0	1.5
Total	292.6	291.0	0.6

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This is the airship, small airship. Now, one more thing I should tell you. Smaller the airship better we were in the estimates. So now this airship is a small one. Here the errors were only half percent, one and a half percent, 0.6%, but again we are wrong in the fin by 16%. In this case, we are overestimating. So, our formulae are inappropriate for smaller airships because we overestimated by 16%. They are inappropriate for large airships because we underestimated 20%. So we are grossly hopelessly bad in our estimate of the fin weight.

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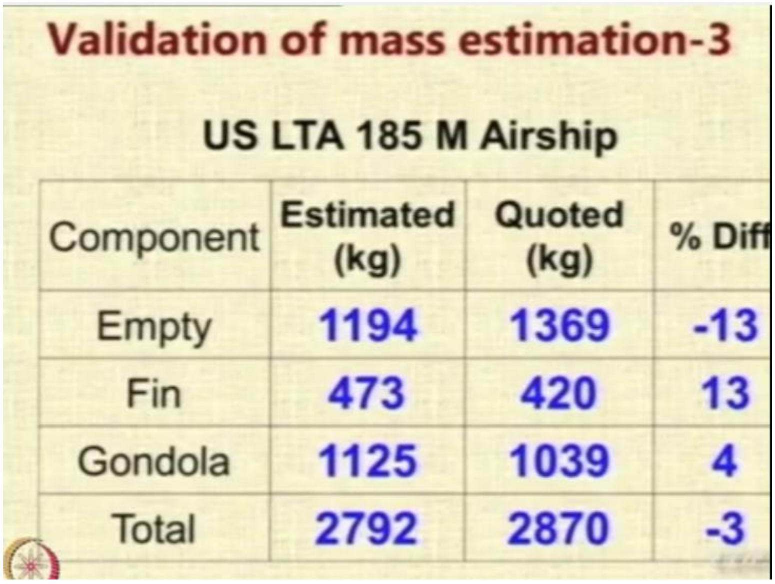

Validation of mass estimation-3

US LTA 185 M Airship

Component	Estimated (kg)	Quoted (kg)	% Diff
Empty	1194	1369	-13
Fin	473	420	13
Gondola	1125	1039	4
Total	2792	2870	-3

But this is a medium airship. US LTA 185 M is a medium airship. Again we are overestimating by around 13%. Emtpy weight we were wrong. Now empty weight under prediction is acceptable because actual airship may become heavier than what it needs to be because of certain structural modifications, some damages, repair work or they may say we want to make it statically heavy for some application. Still we are only over by 13%.

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Validation of empty weight estimatio

Airship	Estimated (kg)	Quoted (kg)	% Diff
PD 300	1664	1500	11
MD 900	5193	4680	11
Skyship 600	3601	3331	8
A 150/S 42	2524	2866	-12

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Now we looked at some bigger airshps which were either on paper like PD 300 and MD 900 are Russian airships which were on paper at that time. And I think they are also on paper today. They have not been built. Similarly skyship 600 was theoretical airship, it was built. And A 150 also was an airship. So, again we are off by around 10 to 12% in most cases, fine.

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Key Input Parameters

Parameter	Demo	PaxCarg
Payload Weight	Not known	1500 kg
Envelope volume	1000 m^3	Not Kno
Temperature = ISA +?	+15^{o} C	+15^{o} C
Minimum altitude	2000 m	2000 m
Cruising altitude	3500 m	3500 m
Pressure altitude	4000 m	4000 m
Cruising speed	78 kmph	92 kmph
Range	100 km	500 km
Envelope l/d ratio	3.05	4.0
Engine Type	Petrol	Diesel
Engine Charging	Normally Aspirated	Superchar

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So, what we basically concluded is that our methodology is very simple. It can be easily put into a spreadsheet and you get errors within around 10%. So, if you really want to be very particular you can say okay whatever number you get I will add 10% and that will be a realistic number. Let us look at some results that we got. So, firstly to get the record straight you should know what are the input parameters that were given so that you get a mental idea about the requirements.

So, the demo airship payload is not known, we are going to say how much can we get with 1000 meter cube envelope. Temperature will be ISA+15. The minimum altitudes, maximum altitudes, and cruising altitudes are the same for both the airships. Cruising speed was chosen based on the engines available that is why these odd numbers of 78 and 92, not 80 and 90 but 78 because with back calculated.

We had this engine available. With this engine what is the kind of speed I am getting that is the number. Nobody told us fly at this speed. We said we will use this engine, it is available, it is low cost, we will get so much speed. Range 100 kilometers and 500 kilometers. Envelope l/d ratio length to diameter ratio of 3.05 in one case and 4 in the other case. Engine charge was petrol and diesel and here we used normal and supercharging.

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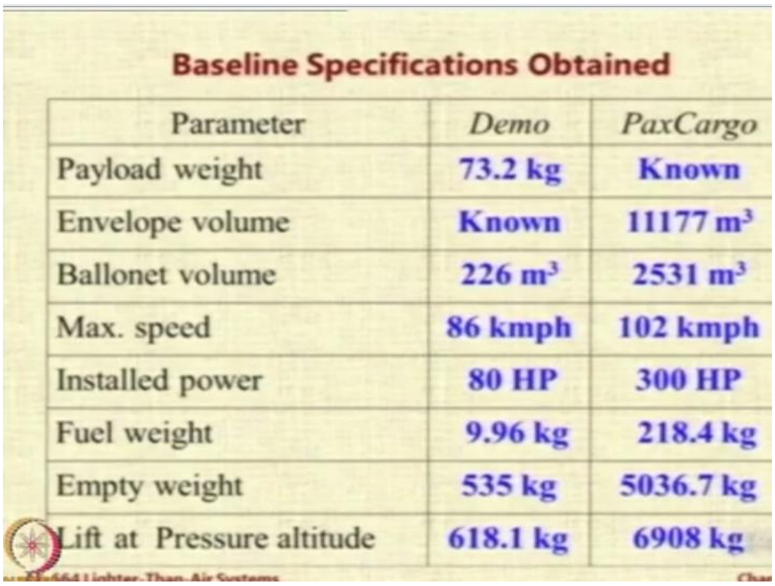

Baseline Specifications Obtained

Parameter	*Demo*	*PaxCargo*
Payload weight	73.2 kg	Known
Envelope volume	Known	11177 m^3
Ballonet volume	226 m^3	2531 m^3
Max. speed	86 kmph	102 kmph
Installed power	80 HP	300 HP
Fuel weight	9.96 kg	218.4 kg
Empty weight	535 kg	5036.7 kg
Lift at Pressure altitude	618.1 kg	6908 kg

So, let us see. The payload weight for 1000 meter cube envelope volume came to 73.2 kg, So, this airship can barely take the pilot, it cannot take anything extra, but it is okay if you find not someone like me, but a lightweight person who can manage within 73 kg. So, you can have airship flown by a pilot demonstrated, does not carry anything additional to as a payload. But maximum speed was more than what we anticipated in our initial calculation.

Look at the fuel weight, you are traveling 100 kilometers with only 10 kilograms of fuel that is a very big selling point. And it is a large structure, it is almost a half a ton weight, empty weight, but it travels within 10 kg it goes 100 kilometers. For the bigger airship with one and a half tonnes payload capacity, it goes with around 220 kgs and it is 5 tons is the empty weight.

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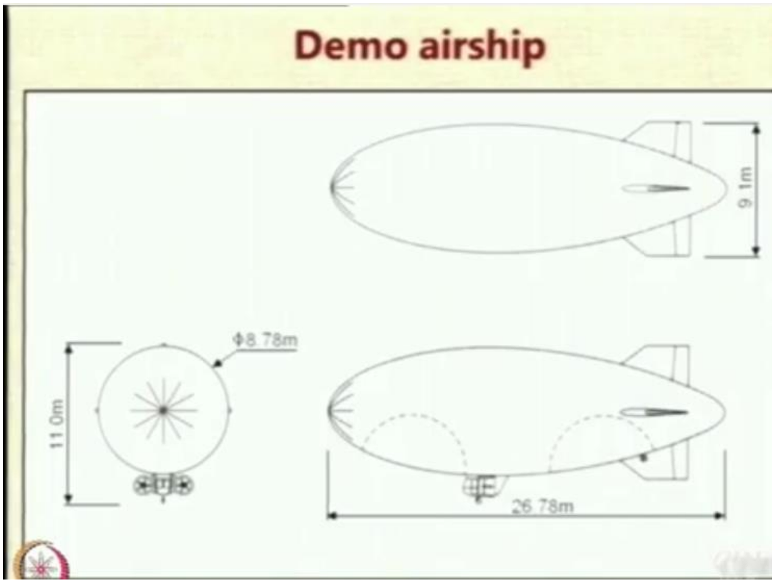

Now, let us look at some more details. So, here is the 3-view diagram of the demo airship that we got. You will notice that the maximum height is 11 meters. Diameter of the envelope itself is around 9 meters, 8.78 meters and the length is 26.78 meters. What does it carry? Only one passenger and that is a pilot. So what had gone wrong? Why do we have to have 27 meter length and you know 11 meter height just to carry pilot itself and the pilot.

So which requirement do you think has been the most stringent? Let me flash to you the requirements. Altitude that is right. Altitude is the killer because airships are basically meant to fly at lower altitudes. As you make them fly at higher altitudes, they suffer a huge loss in the payload carrying capacity. Interestingly, the same airship if I operate at sea level, I can carry 4 passengers plus the pilot, same airship.

The airship PaxCargo which carries only one and a half tons payload if I bring it to sea level, it becomes a 30 seater aircraft. So that is the problem. The problem is that the operating requirements are actually not suitable for airships because the altitude of operation is very high.