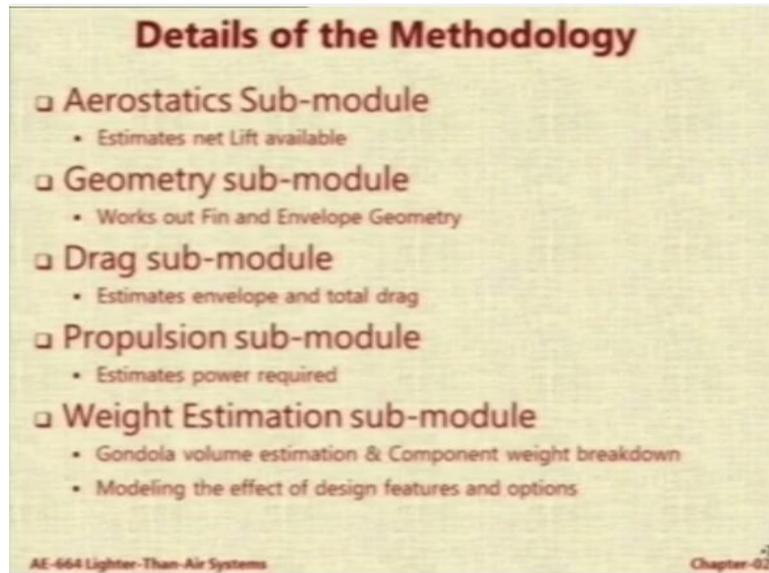


**Lighter-Than-Air Systems**  
**Prof. Rajkumar S. Pant**  
**Department of Aerospace Engineering**  
**Indian Institute of Technology - Bombay**

**Lecture - 73**  
**Details of Airship Design Methodology (ADM)**

(Refer Slide Time: 00:16)



Let us look at the details. So, there are various sub-modules in this particular methodology. Once we get an overview of the modules, then we will understand what it can do, what it cannot do. The first sub-module is very specific to LTA systems that is why we have spent so many lectures deriving those very ugly looking mathematical expressions because we need to link the net lift available versus the aerostatic parameters such as humidity, temperature, pressure, superpressure, you know all those parameters.

All the 9 or 11 parameters we need to establish a link between them and the net lift because our whole sole net lift is coming mainly from aerostatics. So, we need to understand that. Then the geometry sub-module. This works out the sizing of the fin and the envelope. So, I must say that this methodology is only for conventional airships. The airships which will have a single envelope, axisymmetric body-of-revolution and they will have a fin.

They will have in fact 2 vertical and 2 horizontal members which will be the fins. So, we have to figure out some way of sizing the fin. Given an envelope what would be the appropriate fin. Then there is a drag sub-module which estimates the total drag of the airship under some

operating condition and also the main part of the drag of the airship nearly half is going to be the envelope.

So envelope drag estimation and then scaling up by some semiempirical methods to get the drag of the entire airship. Then there is a propulsion sub-module. So given the drag expected at an operating condition, it works out the power required and given the power required for a particular engine type, it works out the horsepower or weight of the engine and the fuel consumption also. And then we have the weight estimation sub-module.

So it estimates the weight of gondola, components and it also does some effect of design features and options on to the weight breakdown. So, for each of these, separate sub-modules were created and these sub-modules as I mentioned are explained in detail all the formulae which go inside are explained in detail in the papers which I will be uploading, which I will repeat you are supposed to read and understand and use the Moodle page for asking any queries that you have about it.

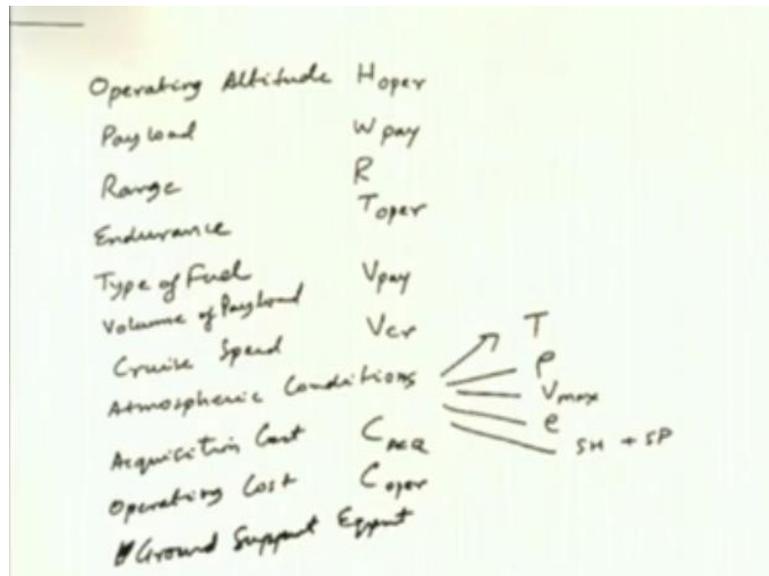
Now, this methodology works in two modes. So, let me ask you already we have one suggestion that why do not we start with the volume first. What is the basis of your suggestion? It is a right suggestion, but what is the basis?

**“Professor – student conversation starts.”** Lift with volume will give us the amount of density. Correct. So once you fix the volume, the net the buoyant lift or the gross lift will be available as a function of that volume and difference in density. And therefore we can assume or we correct it as it can pick the whole weight of the we can we can know the amount of weight it can lift. So, the amount of weight it can lift will be equal to the buoyant lift maybe with some margin. So, that means if you have to carry X kg of payload, then the total buoyant lift minus X is available to you for everything else, correct that is one way of starting. Is there any other way of starting this whole procedure?

One way is assume volume, then payload is known to you, do the sizing. Can you do it in some other way? So to answer this question, I think you need to ask yourself if you are let us say a user of an airship or a prospective user of the airship. Let us assume that somebody, I am a designer of airships and I am offering you an airship or I am offering to make an airship for you for your requirement.

What kind of requirements will an airline or an operator have when you want to operate an airship? Just list out the requirements. We will note them down here let us see one by one. So I am going to note down one by one whatever you tell me as the operating requirements, one by one please, yes.

**(Refer Slide Time: 05:15)**



Geographical conditions. Geographical conditions, so give me some parameter, 2000. So that means operating altitude. So one parameter is operating altitude. I will call it as  $H_{oper}$  okay. At what height the airship is expected to fly? Then payload fraction. Payload fraction or payload? No, the user cannot give fraction, user does not know what they are actually, I have to tell you so much. So, the next item will be payload to be carried.

Then range. Range okay. Then operating hours. Operation hours like what do you mean operating hours? Endurance. Fuel Yes what else? Fuel. Like what will you say? Which type of fuel use. Type of fuel, very good. Goldola volume, why will the customer give goldola volume as a requirement? It depends if he wants to use it as a cargo airship or passenger airship or his will be general requirement.

So, shall we say volume of payload to be carried? Let us not assume that it is going to go in the gondola only. So, we will say volume of payload. Speed; so now there are many speeds. There is a cruise speed, there is a max speed, there is a minimum speed. Which speed are you talking about? So cruise speed. Then atmospheric conditions. Yes atmospheric conditions. So, now you tell me which are the conditions that user is going to be concerned about?

So, tell me what are the conditions, pressure. Are you really concerned about the pressure? So does any customer say that I want to fly an aircraft at this ambient pressure. So that he must be the location right through for example like where he has been opting... Right. So, this is the task of the designer to decide the pressure inside. Sir is not this factor already considered already in operating altitude? Just altitude, yes. So, you see the altitude can be 1000 meters in US, in India, in Burma there is a difference.

So, yes atmospheric conditions are important, but what conditions? So one is temperature right. Then density, it can vary from place to place. The third thing is winds, maximum expected winds. Then what else? Humidity. I am very happy that somebody talked about relative humidity because we spend so much time in deriving humidity. Then superpressure, superheat. So, superpressure and superheat will come on the basis of how much time will you deploy it in the open.

We will put it because we know there are methods, superheat plus superpressure. Anything else? Cost of construction is initial cost. So, you are saying that as a prospective customer the airship for me you will say give me this, this, this conditions and within so many rupees. So I will call it as acquisition cost. Acquisition cost  $C_{acq}$ . Then operating cost, operating cost. Operating cost, you will ask me in terms of some passenger per kilometer.

Operating cost per kg payload per kilometer something like that. Then somebody else? Size, the dimension. So is the customer going to give dimensions? Yes sir because he have hanger of distance that I would like to follow. But the problem is you cannot expect to give me all these things and the size and say now make it fit in that because you might say 100,000 pounds but hanger of 2 square inches but it cannot be done. But there could be constraints.

So, this is not a requirement, this is the constraint or you can say I have a hanger of this size, tell me how much payload can the airship carry? The answer maybe minus 10 kg that is because that is not sufficient. So, there could be some constraints on size. Anything else that the operator will like to specify? Sir what about the mooring mast? I mean he could give you the requirement of having an empirical mooring mast, Correct. So, I will just call it as ground support equipment.

The user might say I want to operate this airship with only 4 people on the ground or you might say do not worry I have lots of young people jobless I will hire hundred of them and do not worry. Save money on complexity of mooring, give me a very low cost, low operating cost airship, manpower is easily available, this could also be an operating way. So that is why ground support equipment. Now anything else you would like to specify? **“Professor – student conversation ends.”**

So, from the point of view of the design in this methodology, we have only two possible modes. The first mode is called as a formal analysis where we say the envelope volume is fixed for the given operating environment, etc., how much payload can be carried? So, this particular analysis loop this is not designed by the way, this is analysis. So what can it be used for?

This can be used for checking the data given by any operator, any airship manufacturer because they will give us the numbers of volume and payload. We can say okay this airship if it comes to India and if it is flown in this operating condition beyond this speed, this height, blah, blah, blah, we can get a payload of only so much. So that is why I call it as the analysis mode, not the design mode or you can have one more scope.

And that is a design mode which means the customer say I do not know which airship, I do not know how much size. This is the payload I definitely want to carry. Now you tell me whether it is 80 meters or 8 meters. It will depend a lot on the materials also, self-weight also, that is where we use the data about the existing technology. So remember we can run this methodology in either of the two modes.

Therefore, when you make the methodology for me I am expecting from you an updated methodology for airship design as part of the assignment.