**Lighter-Than-Air Systems**
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**Lecture – 110**
**Features of Hybrid Airships**

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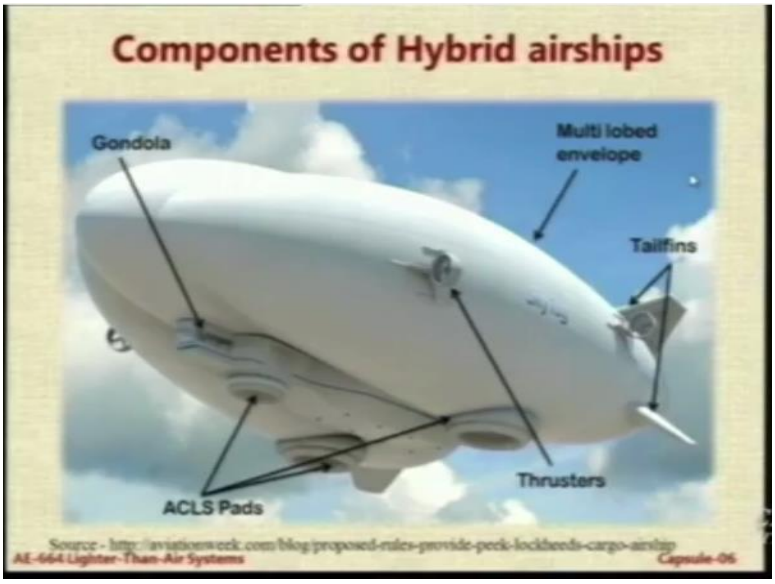


Let us look at the typical components of hybrid airship. You have these multiple lobed envelope. The multiple lobbying is going to give you larger width lower height for a given envelope volume that you need. And this shape also gives you higher L/D lift over drag. So, the L/D which gives you the aerodynamic performance is also improved.

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Applications are many, you can just imagine. Wherever you need heavy lift or wherever you need to use for long distance you also use it for things like disaster relief by dousing the forest fires or for providing medical facilities at disturbed areas.

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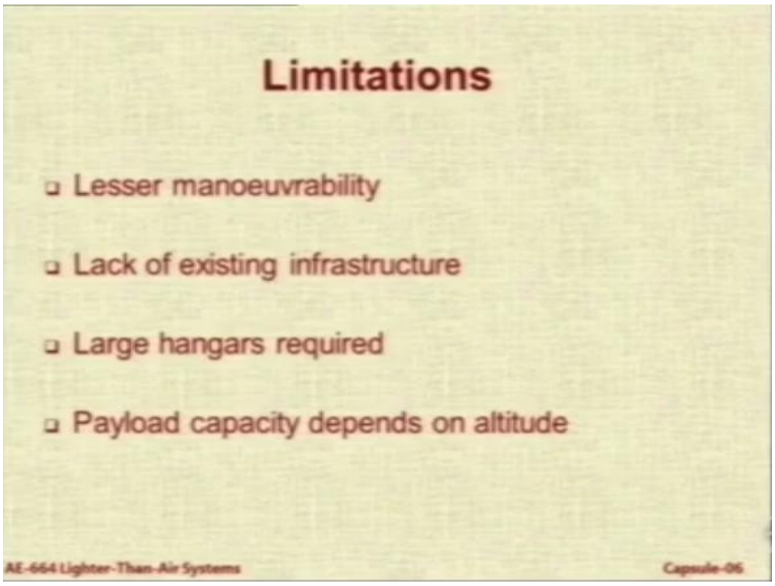


So, these are the four basic limitations of the cargo airships. First of all, they will not be as maneuverable as aircraft because they are bulky in shape and because they are buoyant body. And secondly, their large size will require totally new infrastructure. It is very difficult to expect that you make these airships and you can operate them from existing cargo hangars because existing hangars are not so large in size.

So, you require very large hangars. And secondly you cannot actually climb to very high altitudes. So, while transporting cargo if in the way there are very high altitudes, you have to skirt it rather than going over it because with heavy cargo if you want to go over an obstacle or a mountain of some such high structure, then the volume and size will become very large.

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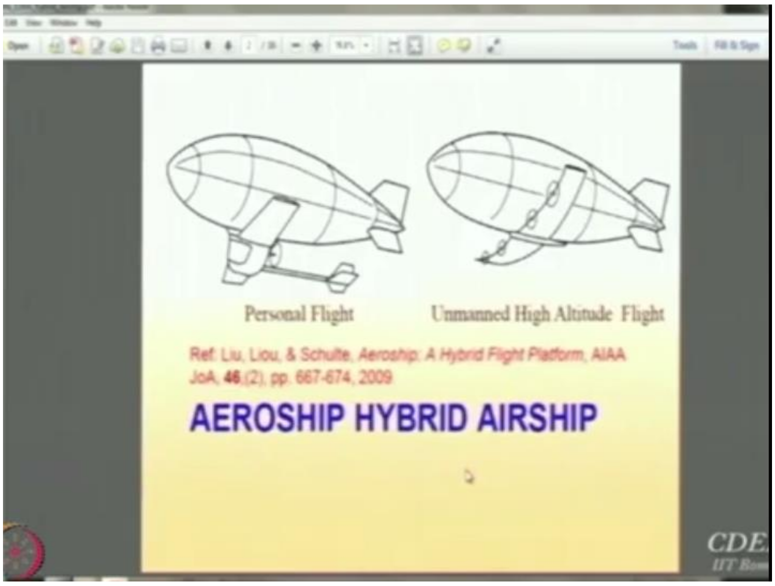


Now, last thing I will do today very briefly is I will try to show you a comparison between how the performance of an aircraft is estimated along with the performance of airship. So, there are a series of 4 very interesting papers on performance estimation of hybrid airships. So, the first such paper appeared in 2009 for what is called an aeroship which is basically a winged airship.

Either you have a wing and a tail mounted below or you have just the wing with engines mounted below. So, a hybrid flight platform was proposed by these researchers and then they carried out performance estimations for that.

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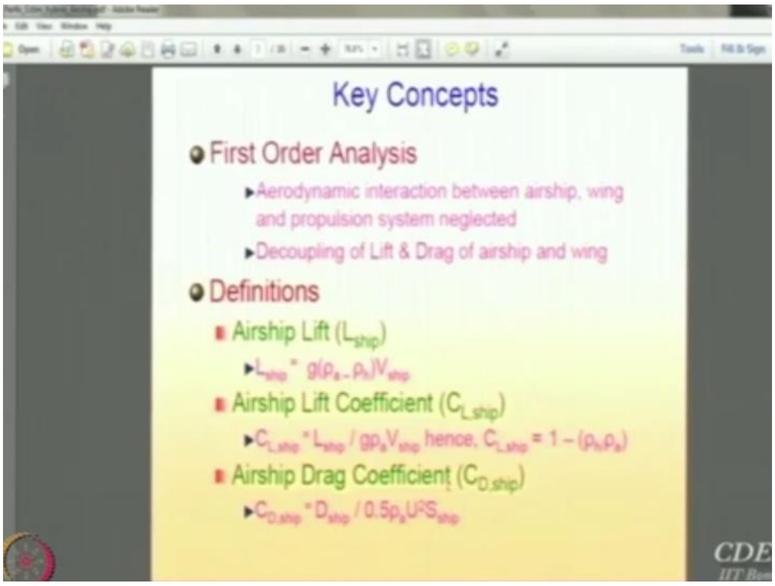


So, what they have done is they have basically done a first order analysis of aerodynamic interaction between airship wing and propulsion system, I mean the interaction is neglected for it is a first order analysis and also the drag on the left is decoupled. So, you have a $C_L$ and a $C_D$

and you are not going to use it for coupling though for an airship you will get the buoyant lift as $L_{ship}$ which will be density difference into volume, correct.

The g is only meant for the units. For airship there will be an airship lift coefficient which will be $\frac{L_{ship}}{g\rho_a V_{ship}}$ because for an airship volume, $V_{ship}$ is the volume of the airship envelope. So, lift available per unit, so you just divide this and therefore that will be $(1 - \frac{\rho_h}{\rho_a})$, it is a relative density RD, $\rho_h$ means density of helium and $\rho_a$ means density of air.

You could have helium or hydrogen. Similarly you have airship drag coefficient which is the drag obtained divide by $\frac{1}{2}\rho U^2 S$. So, U basically is velocity.

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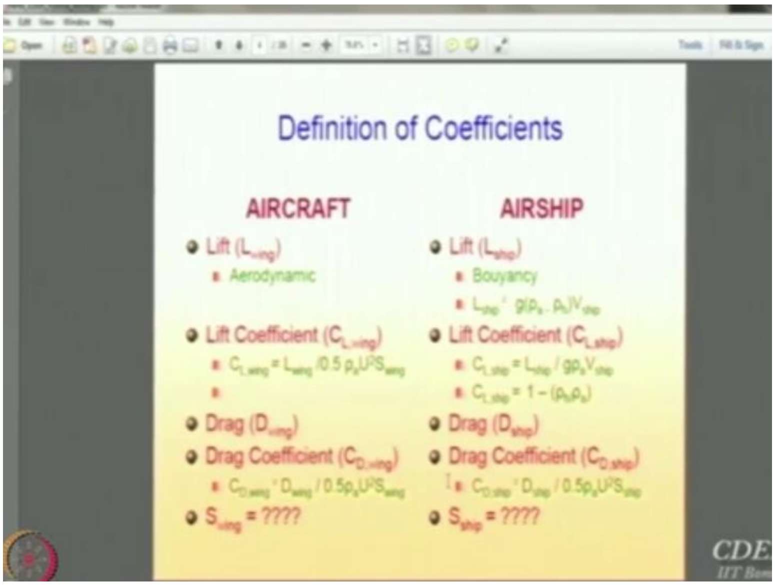


So, now you can see on the aircraft and the airship there are two sides. On the aircraft side we have only the aerodynamic lift, so we have just $C_L = \frac{L}{\frac{1}{2}\rho V^2 S_{wing}}$. We have drag which is $C_D = \frac{D}{\frac{1}{2}\rho V^2 S_{wing}}$. But what is wing area? So, what do we take as $S_{wing}$ in the analysis? **"Professor – student conversation starts."** So can someone tell me what is the answer to this question? On the aircraft side what is the $S_{wing}$ in this formula?

Planform area of the wing. So how do you define the platform area of the wing? Correct. **"Professor – student conversation ends." Correct**. So, this is basically is called as wing reference area, not planform area, but wing reference area which includes the area inside the fuselage projected from the wing root to the centerline. Is this point clear to everybody? Yes or no?

In the airship you have buoyancy and also you have which is basically the density difference into volume. And as I have already showed you there is a definition of lift coefficient, but now where we will you use the area for the airship. **“Professor – student conversation starts.”** For the drag estimation of the airship what would you give as the area? Okay. What are justifications for that? it is a parameter for volume, so and designing airship in the upper area like that, It do not make sense exactly. **“Professor – student conversation ends.”**

It does not give you a proper scaling parameter, it does not make sense. What makes sense is to use volume of the scaling parameter and therefore to get the units of area from volume you just do $Volume^{2/3}$. So, the reference area in the case of airships will be $Volume^{2/3}$ and therefore the drag coefficient will be also called a $C_{D_V}$ volumetric drag coefficient.

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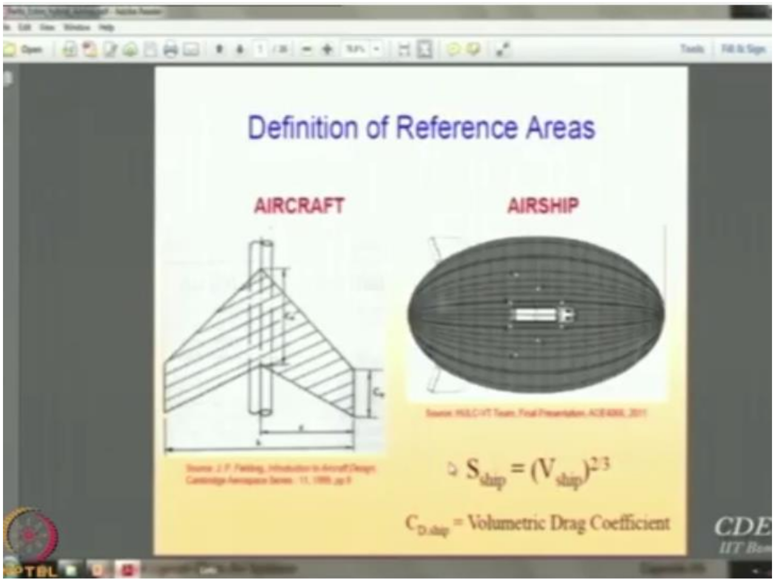


So, this is what we have already seen in the last couple of minutes. For aircraft, we have this cross sectional area including the, not cross sectional area reference area including the area inside the fuselage. And for the airship we have $Volume^{2/3}$.

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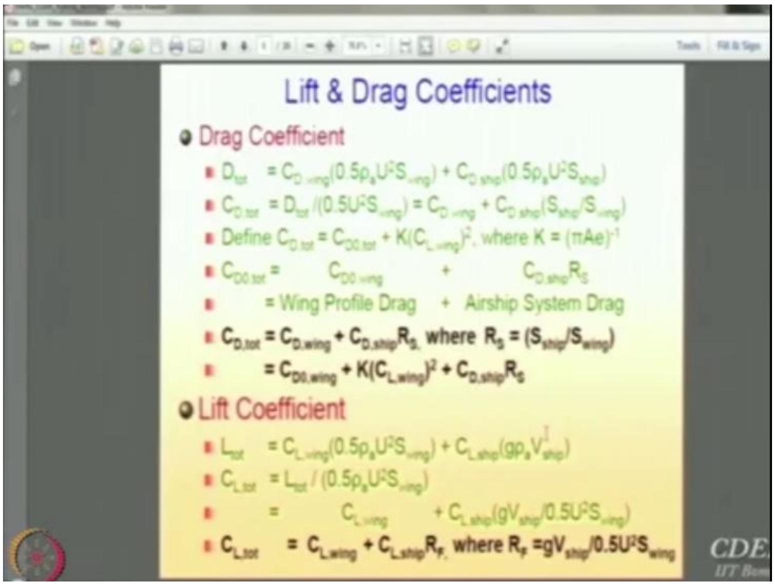


Now, no need to really get psyched. I do not have animation in this unfortunately. But my suggestion to you will be that this is essentially taken from 3 or 4 papers which I am going to upload. So, it is nothing but bringing in an aircraft like coefficient into the airship formulae. So, you basically say that there is something called as $C_{D,total} = C_{D,wing} + C_{D,Airship}$. Similarly, for lift you have the dynamic lift plus the lift acting because of the airship size.

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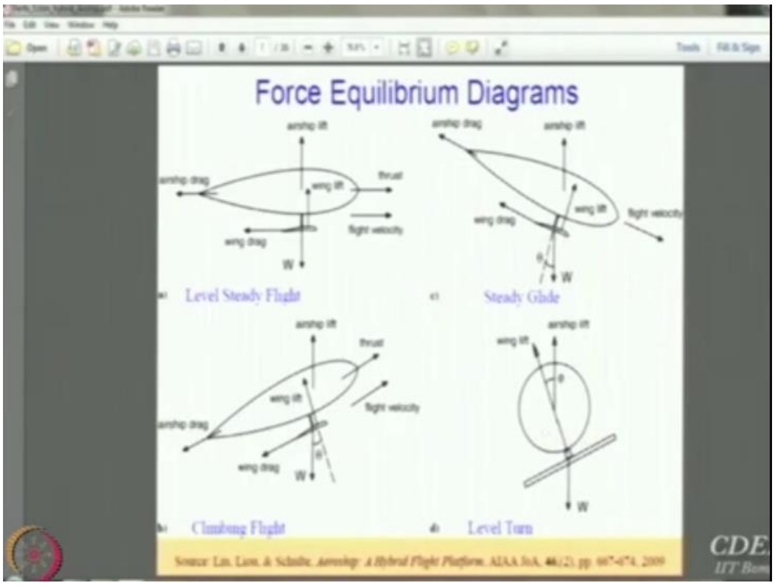


And then there are force, this is of not much relevance.

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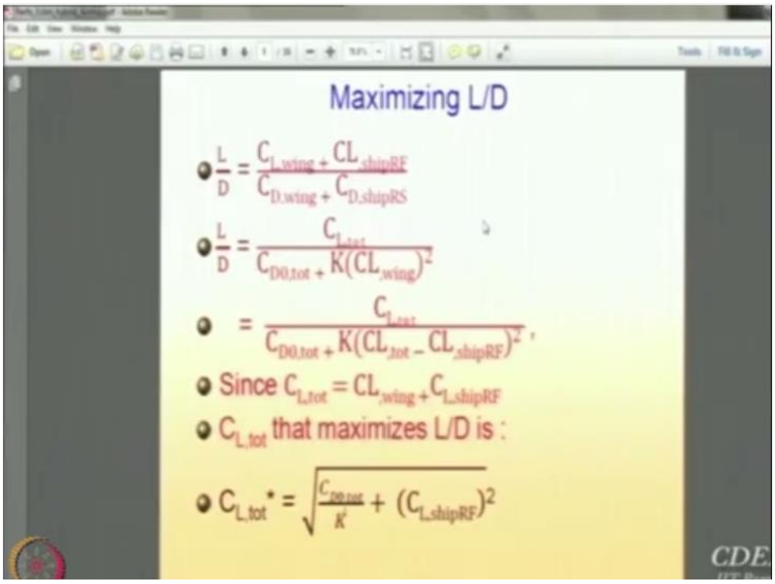


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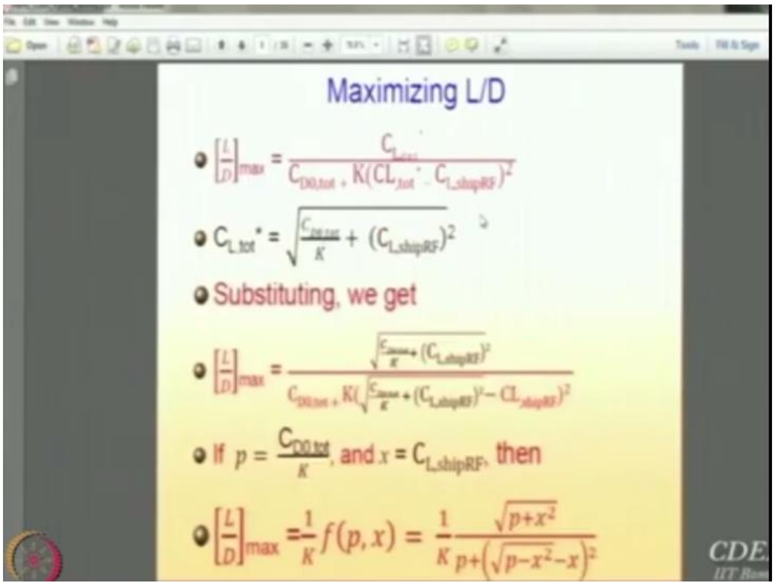


And then you can get expression for $\left(L/_D\right)_{max}$.

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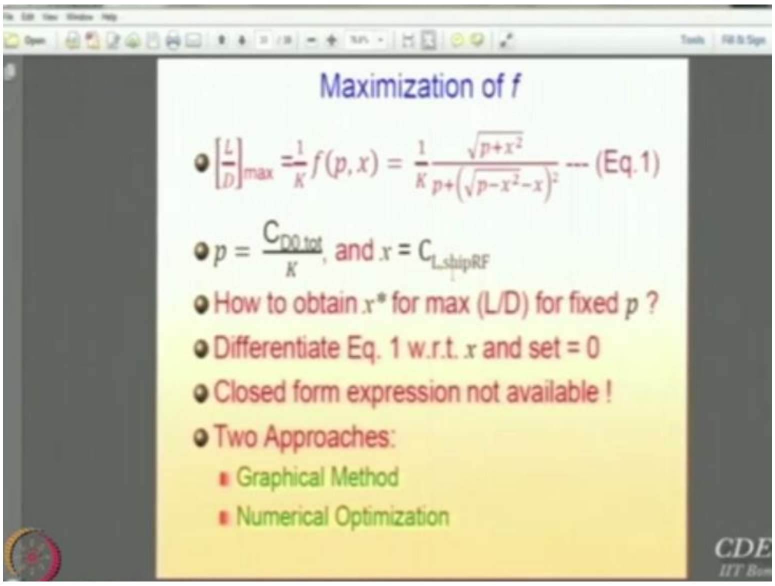


Now, finally just to conclude we will get an expression like this, which will say $\left(L/_D\right)_{max} = \frac{1}{k}\,f(p,x)$. Now, my question to you is how do you find the optimal value of x which maximizes L/D for a fixed p? For now, this is a simple optimization problem.

So, you can use any optimization method to obtain the optimum x or I used a simple graphical method.

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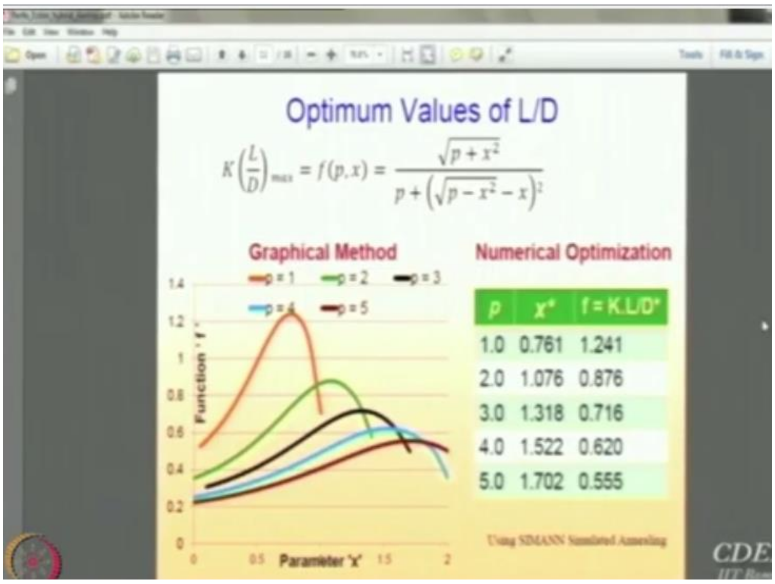


| p | x* | f = K.L/D* |
|---|---|---|
| 1.0 | 0.761 | 1.241 |
| 2.0 | 1.076 | 0.876 |
| 3.0 | 1.318 | 0.716 |
| 4.0 | 1.522 | 0.620 |
| 5.0 | 1.702 | 0.555 |

So, what I have done is for various values of p, I just plotted this curve. So, we notice that as p increases the peak is coming down, it is flattening as if somebody is pulling this on this side. So, for various values, one can get the values of the peak.

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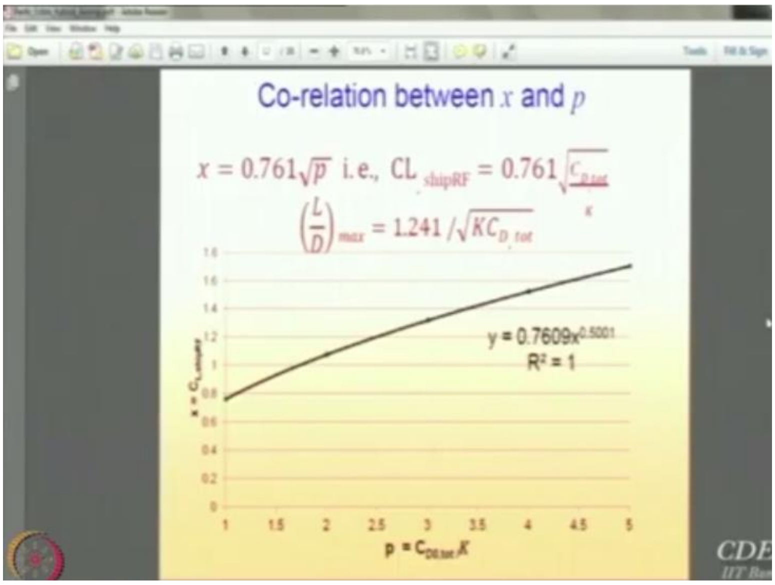


And then one can easily create a correlation between x and p which is just almost like a line, of course it is a power series curve.

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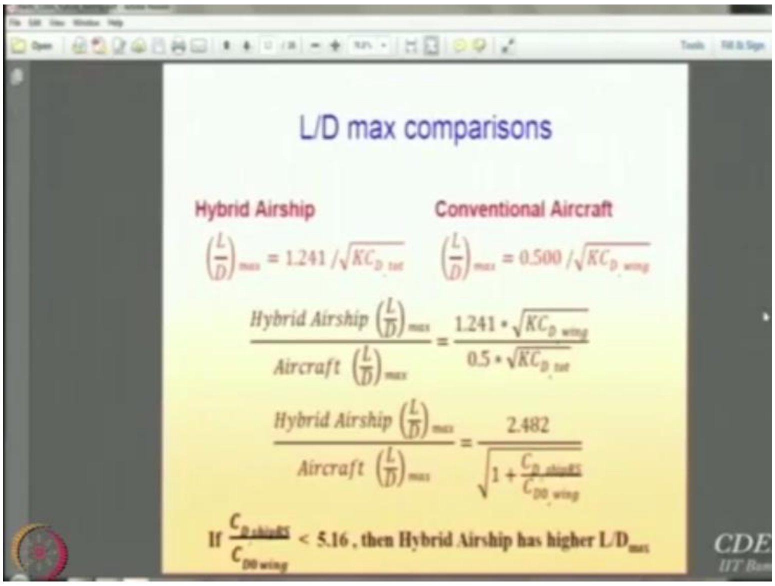


And then you can do L/D comparison for both aircraft and airship.

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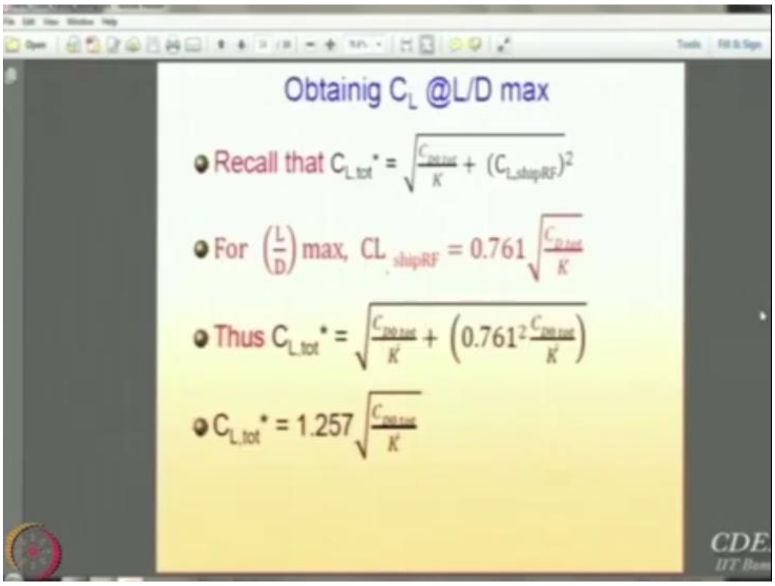


I am going to skip this in detail.

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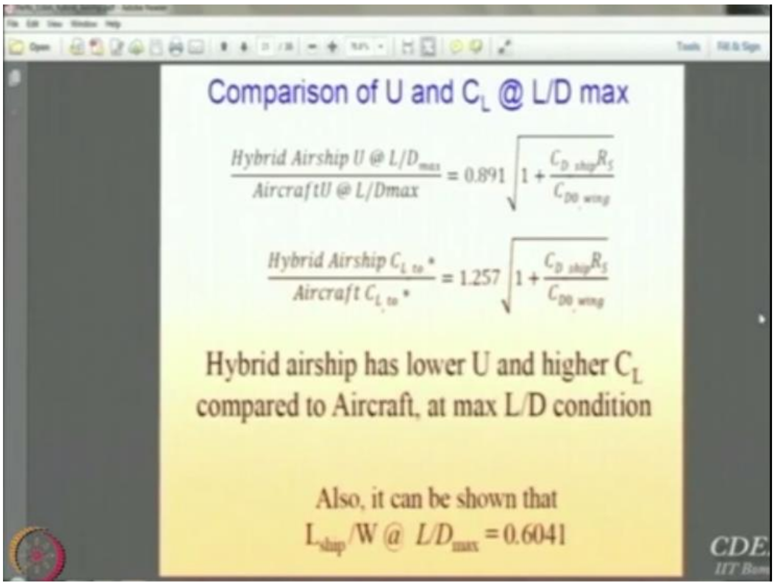


Because I think you will be able to appreciate this only and only if you go through these papers.

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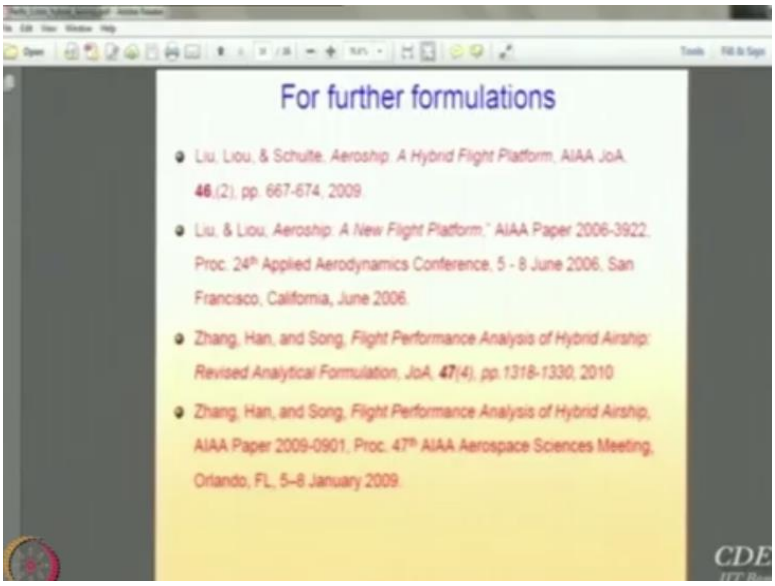


Now, what you see are basically two journal papers and two conference papers. The conference papers have been updated as journal papers. So, once you read these two papers, the first one is in 2009 where this concept is introduced, aeroship or a typical winged aerostat. And the second paper the flight perfromance formulae have been given. So that is all. I think with this we will end today.