NOC: Introduction to Airplane Performance
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Lecture - 34
Challenges in Take off and Landing: Single and Twin Engines

Welcome, this is in continuation with take off distance. So, far, we are assuming that the single engine aircraft, but you will very well appreciate, nowadays a bigger aircraft high performance we have got multi engines aircraft. So, we will be discussing something about two engine aircraft, suppose a two engineer aircraft is taking off, the preparation for taking off, is the process of taking off, suddenly one engine fails. What should you do? How to handle this situation? But, naturally if one engine fails in the ground, you should apply the brake and stop there aircraft.

But, then you have to ensure that, once the brakes are applied; that is speed may be very high. So, you need very large runway length to really brake their aircraft to a full stop. So, as a designer, you also have responsibility to see, what is that airstrip length minimum required to ensure that aircraft while taking off even it if fails, if I apply a brake, it should be able to stop. If I could find out some speed as a reference speed, if the aircraft one engine fails before that speed, then I should have sufficient length to brake and put to 0.

If the aircraft engine is failing, one engine is failing after reference speed, then you should have enough excess power to climb and go for a circuit flying. If I do this, I am very clearly optimize this, I can get a balance field length; that is which is safe for to an engine operation, I will explain now this through a diagram.

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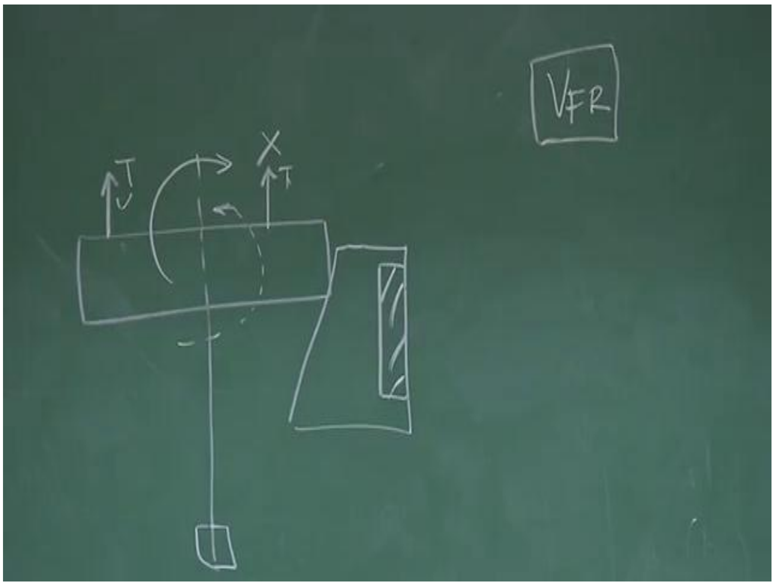

But, before I do that please understand one thing, if I have a two engine airplane, so this is also giving thrust, this is also giving thrust, this is a central line. If suppose this engine fails, so what will happen, this thrust is operative. So, it will having a moment, the airplane will just turn like this. To ensure that, it does not happen I should be able to generate the moment in the opposite direction. Who will give that moment? Obviously, now we have got rudder, you know that rudder.

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There is two engines, one here and one here, let us say right engine has failed. So, what will happen? Because, of these thrust is operative, it will turn the airplane like this on the ground, which will be very dangerous. To ensure that it does not happen, I have to generate a moment in the opposite direction like this. Because of the thrust, it will turn like this, to counter it, I need to generate a moment in this direction, that from top, because of this thrust, it is a clockwise moment it is coming.

So, I have to generate an anticlockwise moments, when I look from the top. So, who would do this? It is only the rudder, only the rudder could do this. Let us say assume that, this is a rudder, assuming the wing is in front, I am going like this. What type of moment I want? I want looking from the top anticlockwise; that means force should be towards you. So, I will deflect the rudder like this, if I deflect the rudder like this and a plane is moving like this, the force will be acting towards you. That is force will be acting like this; that will give your moment anticlockwise and that will balance the disturbed or imbalanced torque or moment.

So, what is important that your rudder, rudder of the airplane should be powerful enough to generate enough restoring moment to nullify the moment imbalanced, because of one engine failure, so that is first criteria.

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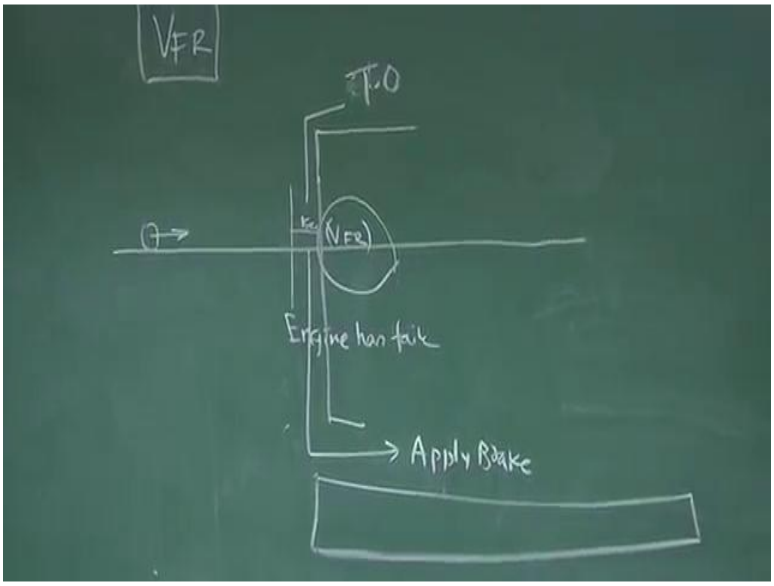

Second thing, we were looking for some critical speed which generally, you see some old literature is called VFR or failure recognition speed. What is the meaning of that? Let us say the airplane has started from here, at some point it has failed, engine, one engine has failed. Now, for one second, I will give him time to recognise that speed, he has to check. I told you, if he is given a speed as a guideline that dear friend, you check whatever speed at which one engine has failed, please check that if it is less than VFR, then simply apply brake.

If it is more than VFR, then go for climb or take off, when he goes for takeoff, you have to also ensure that. The design should be such that even after one engine has failed, the aircraft should have enough excess power to climb at a particular attitude, easily at least and these are as per the regulation, there are numbers for that. You can, you should climb and then take a circuit flying and he may land same airport or land in nearby airport depending upon the emergency.

So, how do I select that VFR? What is that speed reference with which pilot will compare and the speed at which one engine has failed? And he will compare and see, if that speed at which engine has failed is less than VFR, then we apply brake or more than VFR will go for takeoff. Meaning thereby, if the failure speed is less than VFR, he should enough field length for making the aircraft to a standstill.

If it is not if it is more than that, then you should go for takeoff, this is the understanding. How do I get this VFR? That is very important speed reference, which is a guideline for the pilot to ensure, whether he goes for takeoff with the single engine or apply brake and stop.

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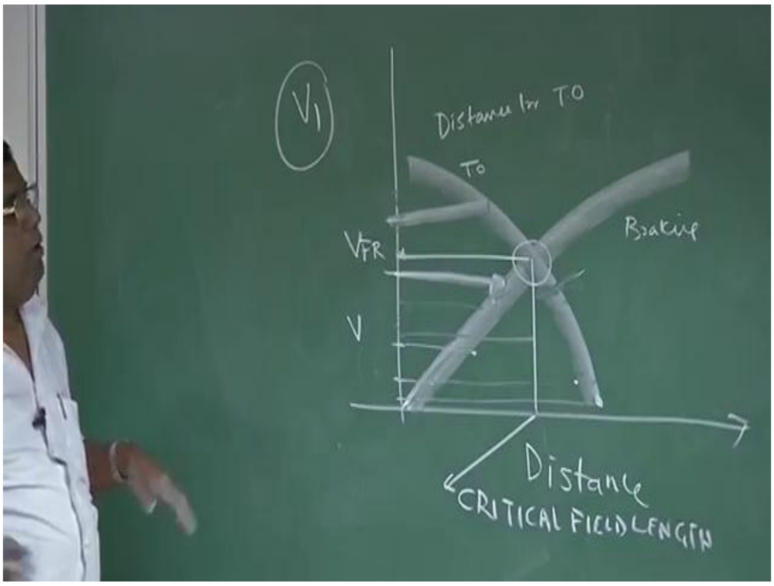

If you do a theoretical exercise, let us say this is distance and this is speed, if I try to plot trend of braking distance versus different initial speed. For example, suppose the airplane has just failed as far as one engine is concerned too early and let us say the braking distance is this much. As the speed at which the airplane engine has failed increases, the braking distance will go on increasing.

So, let us say that variation is something like this, I can calculate assuming different, different speed at which the engine has failed and calculate the distance, braking distance by using our formula is V. Now, we are coming back to a takeoff distance, let us say, if the airplane is taking off, which has started from here, then it will take a longer distance for takeoff, little higher speed, little less distance as the speed increases.

So, this will follow a train something like this, but this is distance for takeoff and this is braking, we call it accelerated braking, this is clear know. If I want to apply brake and stop the vehicle and the speed is very low, but distance will be low. As I started applying the brake with a higher speed, the distance required to make it to 0 will be more like that, this graph will be changing and reverse in takeoff, it will be like this.

For a smaller speed, I need larger takeoff distance, if I start at higher speed; I will take smaller takeoff distance, because I already I got high speed. But, this is the point, where both these distance are same, you see and that distance is called critical field length and this corresponding speed is called VFR. Let us try to understand this graph, this is VFR failure required at a speed at which your braking distance and distance to take off are same; that is why this is called critical field length or balanced field length.

What is the interpretation? Suppose, aircraft is failed at speed V 1, the pilots will check, if V 1 is less than VFR, then he will go for braking. If V 1 is more than VFR, it will go for takeoff as simple as that and this way, you can avoid lot many accident. That is where for two engines or multi engines, the critical field length or balanced field length is so important. You know by the concept of rudder power; that is, if one engine fails, it will give some light moments and rudder should be enough powerful at that speed.

To ensure that the airplane does not do like this or like that, while takeoff and same time the designer must given a bandwidth that even if one engine has failed, if the speed of the airplane is less than the particular speed, which is called VFR. Then, the pilot will apply a brake and go for braking and if that failure speed is more than VFR, then you should takeoff.

So, the designer must ensure that, the airplane has enough rate of climb even with single engine, this thing you have discussed. The another important aspects for flying is, which is very important for designers to have a perception is, how an airplane to be landed during cross wing. Cross wing means, suppose I am coming like this ((Refer Time: 10:56)) and the wing is coming from right to left or left to right. So, natural thing will be the moment, there is a wing from right to left, the airplane will be lifted like this, but you want to land in a particular air stream, a particular mass.

So, how a designer should give that bandwidth where the pilot can easily manage, it should be manageable. If a designer gives the bandwidth that it can manage, then pilot can manage. If that is not in the design, the pilot cannot manage. So, designer should understand, what are the ways to land in a cross wing. So, let us see what is the aim, aim is suppose this is a air strip, I am taking the top view and pilot is to land here somewhere, central line, let us say.

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Suppose, pilot is trying to land like this and there is a cross wing, whether this side from this side or from that side. So, there will be tendency of the airplane to be lifted, this way or that way, but pilot has to be land here. So, what is the way to handle it; that is a question.

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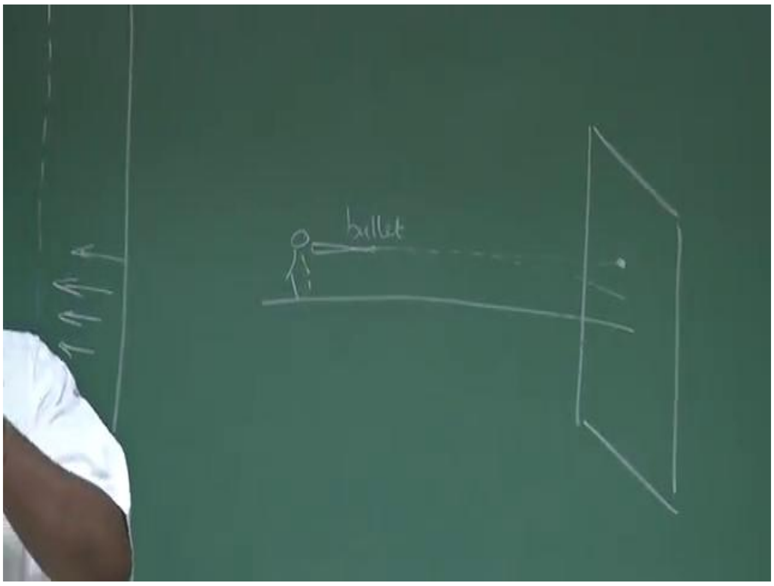

Now, I will take you back to your classes 9, 10th around that, you remember, if this is a screen and this is centre line and you are here, standing here, you want to shoot a bullet. And you are asked to hit this point, what will happen, if your aim your bullet exactly at this point, you know that, it will never hit because of gravity, this will fall like this, gravity is constantly putting it down. So, what is a clever way of doing it, although you want to hit it, if you know how much gravity will put it at this point, so aim some point higher.

So, if aim there, then the projectile will go like this and bullet will go like this and hit, this is one way to handle, I will try to utilise this for this case also, I have to land somewhere here. So, I was going like this, now because of wing, I will be drifted like this, what I will do, I select a separate line, maybe I want to actually land here. So, I will create imaginary line here, I will make my approach aiming at this line.

So, what will happen, because I know because of the wing, coming from right side, I will be naturally towards lift. So, finally, what will happen, I will be flying something like this ((Refer Time: 13:33)), I will be actually flying like this, I will try to go into the wing and ensure that through the trust, this whatever force I am getting, I get neutralize. But, things I am just aiming at from other point here, which is not this point, because of this wing, I will be constantly lifted towards this direction.

So, at some point, when I came here to turn the airplane nose left, flare up and land, this is one way. So, what is that way, if I want to land here, if I know wing is current from right hand side. So, I will be aiming at some other point here, other line here, knowing very well, I will be drifted any way back to this, by the example I have given it here. Similarly, if wind is coming from this side, so I will create imaginary line here by approach, I will try to approach this at the centre line, where I going to land, because of this, we automatically get drifted; I come near the centre line.

So, the pilot which is visualized, if there not flying through the instrumental landing system, there will be applying corrections. ((Refer Time: 14:51)) Now, this is one way, second way is I am flying like this and the wind is coming from my right. So, I will be drifted like this, what I do, I bank my airplane and once I bang it, the lift vector is like this, one component lift I will try to resist this drift and I go like this, near the air stream, I role back, flare up and touchdown. In this landing, there is a problem, if there are error, it may happened that the aircraft accidentally gets landed on a single wheel first. For lighter aircraft, of course, is not a serious problem, for bigger aircraft, it may created very serious problem. So, pilot has very, very perfectly in doing this.

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And third one is we say through sites lift; that is, if this is a line, where I am going to land, I will be, if we draw it, I will be actually flying with a side slip condition, we call it slid slip condition; that is I am flying like this. By velocity vector is around the approach and I am flying like this, what will happened, if you flying like this, you could see that, it will relative air will hit this surface and it will generate a force in this direction and the wind was also trying to push it in his direction. That way, it will nullify.

Again, as it comes near the run way, it has to turn like this, the moment you turn, there is a induced role also. So, just to apply both ((Refer Time: 17:36)) redder. Please understand, whenever you apply a aileron, suppose if I apply a aileron like this and putting it down and putting it up, it will try to go like this, but what will happened as it goes like this, there will be a induced drag more here. So, it will try to turn also. So, always when you apply rudder or aileron, we call it cross check; that is both the stick to apply together.

Thank you.