Introduction to Aircraft Design
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Lecture – 36
Landing Gear Layout – Part - 01

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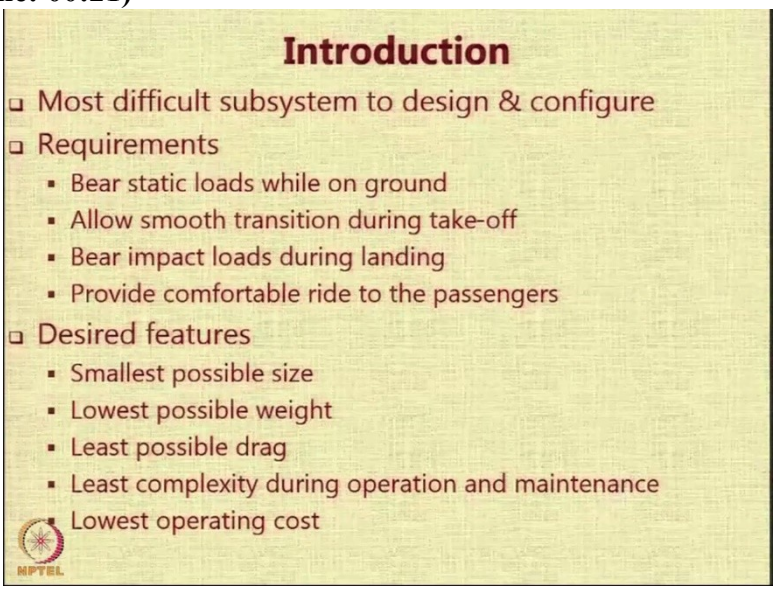

Let us have a look at landing gear layout and how it impacts aircraft conceptual design. The landing gear is typically considered to be the most difficult subsystem of an aircraft to be designed and to be configured and it has to meet a host of very difficult and sometimes conflictive requirements. It has to bear the static loads when it is on the ground. Because that is the item on which the whole aircraft is resting it has to allow smooth transition of the aircraft from the ground to air during take-off.

When it comes into land, it has to withstand the landing loads and at the same time, it has to also provide a comfortable ride to the passengers both during the take-off as well as during the landing. Now, what are the desired features of a good landing gear? This is a wish list of a designer smallest possible size lowest possible weight, least possible drag, least complexity during operation and maintenance and the lowest operating cost.

Now many of these requirements are conflicting with each other so may not be possible to meet all of them together and that is a challenge in landing gear design.

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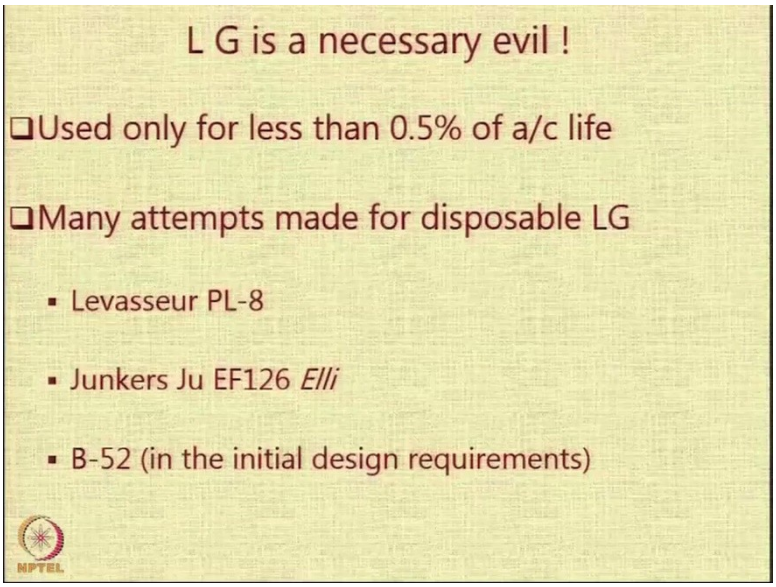

But another problem is that many people view landing gear as a necessary evil. Because, the landing gear is used only for nearly half per cent of its operational life. Of course, when the aircraft is parked and not being used landing gear is essential because the aircraft stands on the landing gear, but if you look at the take-off and the landing phases of the aircraft, they occupy nearly half percent of the total mission.

So, something that is used only for half percent of its actual mission, but it has to be carried is called as a necessary evil. And therefore, there have been many attempts by designers to this landing gear its work is over. So, if you go back in history, you come up with a very interesting plane called the Levasseur PL-8 designed in France and the Germans had designed something called as Junkers Ju EF126 Elli.

The B-52 in the initial design stages was also being considered as an aircraft that would be without the landing gear, but then during the detailed design studies, it was decided that landing gear was unfortunately essential.

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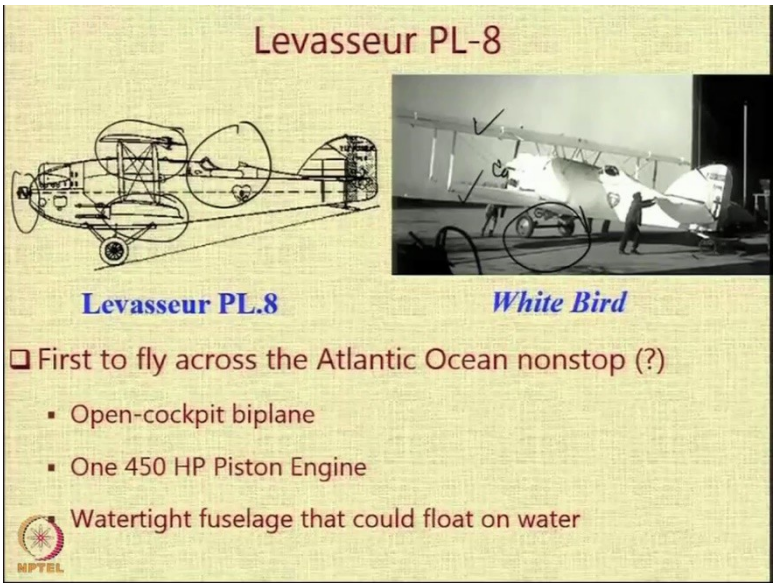

The Levasseur PL-8 is a very interesting aircraft. This aircraft, as you can notice, is a very old aircraft, it is a biplane and you know, the white bird aircraft was designed with a very simple and a single mission in mind. These were the early days of aviation, when we were interested to explore the increase in the range. So, the aim of this particular aircraft was just to cross the sea between France and England that was the only aim.

So, it was the first aircraft, it was the aircraft which was designed to fly across the Atlantic Ocean nonstop and very simple aircraft you can notice there is an open cockpit aircraft. The canopy is open and it is a biplane as you can see there is there are 2 wings 1 on the top, 1 on the bottom. You can see here also there are 2 wings. It had a single piston engine which was mounted right in the nose somewhere here, you can see it here.

And it was supposed to have a watertight fuselage because there was a chance that it would not be able to make up make meet the requirement and hence it had to be dished on the in the ocean. So it should be able to float. So, what was done in that aircraft is that the landing gear was actually droppable? So, the moment the aircraft leaves the ground, they would drop the landing gear. And at the end, it would just be designed to go and land on the ground.

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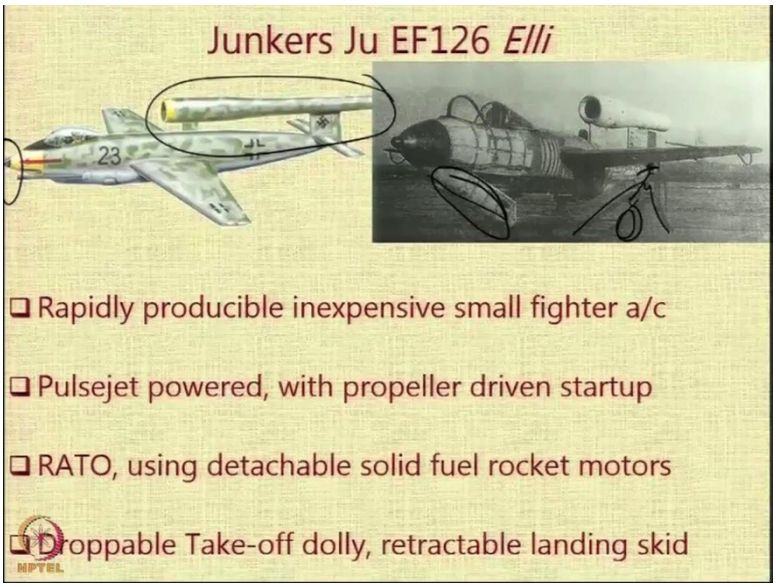

The Junkers Ju EF126 Elli was another aircraft which was taken up by the Germans during the war. This was the first aircraft to have a very unique engine called as a pulse jet engine, which you can see is mounted above the fuselage. So, the idea of this aircraft was to come up with a rapidly producible inexpensive small fighter aircraft during the war. It was a pulsed jet powered, but it had a very small propeller in the front to give start up.

It had rocket assisted take-off using detachable solid rocket fuel motors and the landing gear was droppable. So droppable take-off dolly, and a retractable landing skid. So this particular skid, the landing skid was retractable type and not very clear here. But there is a dolly kind of a structure here, which is supposed to be detached from this point after the take-off is achieved. So once you take off from this from the ground, you drop the landing gear. And when you come into land, you bring out the skid and then try to land with that skid.

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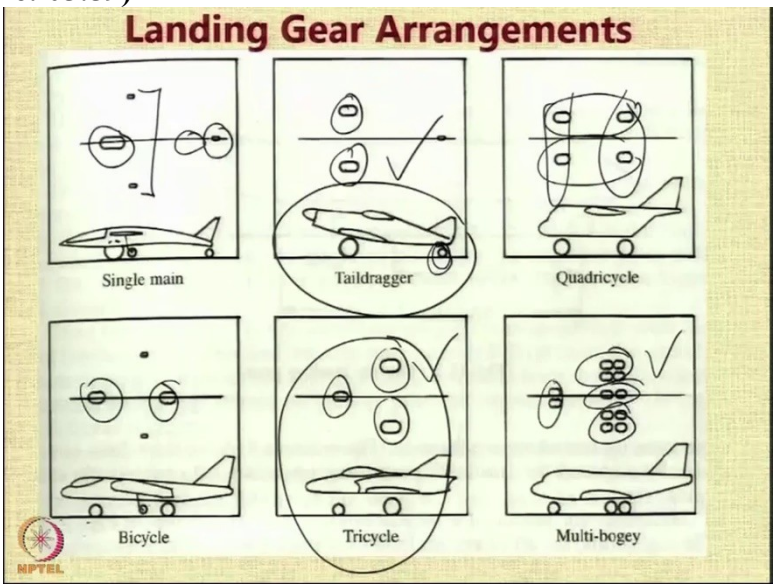

These were very unique designs, because the focus of the designers was to somehow get rid of the landing gear. Let us look at the various layouts for landing gear. And the sketches for this particular section have been borrowed from the book by Daniel Raymer. There are many possible landing gear arrangements, 6 of them which are quite popular are shown here. You can have a single main landing gear where there is 1 main wheel and then there is 1 auxiliary wheel and then there are 2 wheels on the sides to support and to give the lateral stability.

You can have the most common ones are the tail dragger or the tail wheel type in which auxiliary wheel is in the front. There are 2 of them and on the back you have these are the 2 main wheels and then you have an auxiliary wheel on the back, then you have a tricycle type, which is the most common type today we call it as a conventional type. At one time this was conventional today this is conventional.

In which you have the main legs are behind the center of gravity and you have one in the nose. And then there are some variation there is a bicycle type which is the single mean when type with 2 wheels. In other words, you can say that the auxiliary wheel is made strong and mode in the front you have the quadricycle type, which is like a car 4 wheels. And you have a multi bogey which is very common in very large transport aircraft. Where you have not to but may be a third main leg in the center and a pair of wheels in the nosewheel.

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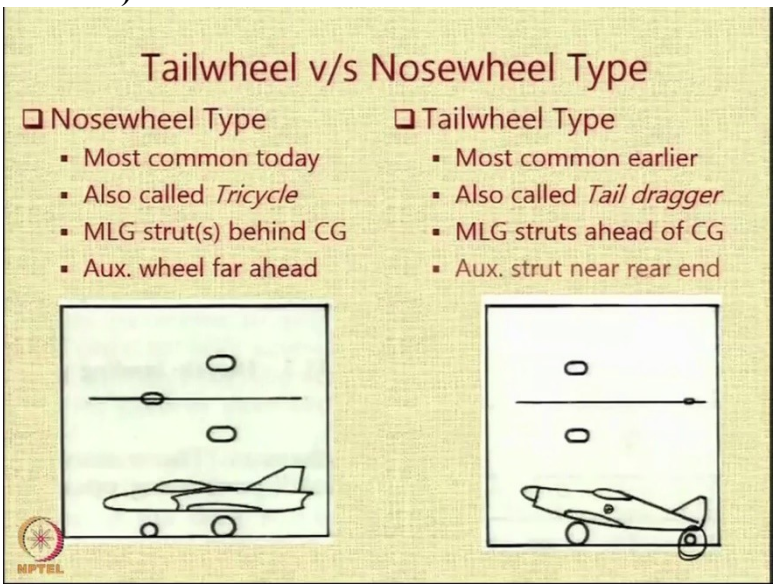

So, the most common ones are the tail wheel in the nose wheel types. And you know the most common one today, but also we also got another tricycle type in which the main landing gear struts or struts are behind the center of gravity and the auxiliary wheel is far ahead in the

nose. Earlier the tail wheel type was the most common configuration. This is also called the tail dragger type, because the tail is being dragged literally the tail is being dragged behind the aircraft.

In this case, the main landing gear struts are actually ahead of the center of gravity and the auxiliary struts are mounted on the rear near the rear end.

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Let us have a look at some examples of nosewheel and table type aircraft. So, this is one you know you can see this is the tail wheel type and this is the nosewheel type. This is again the nosewheel type and we have the tailwheel type. So, these as you can see are the old generation aircraft, most of the aircraft that you see today are the nosewheel type and the nosewheel can have single wheel or multiple wheels, the main wheel can have single wheel or multiple wheels as seen here.

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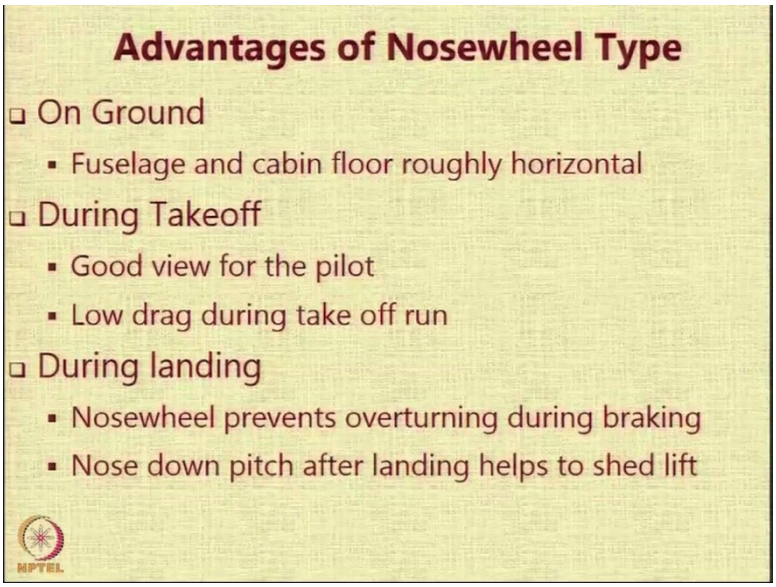

There are many advantages of nosewheel type because of which has become very popular on ground. The main advantage of a nosewheel type is that when the aircraft is on ground, the fuselage and the cabin floor are roughly horizontal. So therefore, it is very convenient for the pilots and for the passengers because the seating position is natural and horizontal. During take-off, the nosewheel type gives a good view for the pilot again because it is horizontal and during the take-off, you do not have very high angle.

So, therefore, the drag acting on the aircraft is lower. During landing you land on the main wheel and then actually you bring the nosewheel down and when you land on the main with the nosewheel down, the tendency of the aircraft to overturn is minimized because the nose will act like a prop. Secondly, after landing on the main wheels, since the nose wheel is being brought down the angle of attack is being reduced.

Hence the lift is going to be reduced and that is what is beneficial when you are coming in for landing. Because of these reasons, the nosewheel type is considered to be the most common and hence the conventional landing gear you will find it in most of the aircraft.

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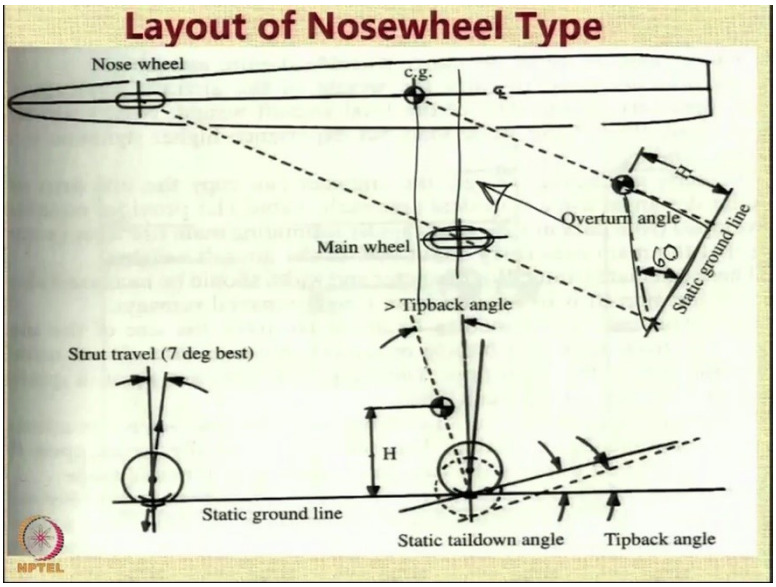

And this diagram tells you how the layout of the nosewheel type is carried out. So, generally, the main wheel is located some distance behind the center of gravity. And if you look at this view, you have this overturn angle this angle is normally to be kept around 60 degrees if you keep it you know if the back of this angle is less than more than 60 degrees, then there is a tendency for the aircraft to have a problem during lateral stability during landing.

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So, there are many advantages of a tailwheel type which are listed in this particular slide. The most common one is simplicity; you have a small and the light tailwheel. So the net weight of the landing gear is lesser. You can easily streamline the main landing gear because it is the one that is facing the flow so you can put nice nacelles or coverings on that. So during the take-off, it gives a very high angle of attack.

So, naturally you have shorter take-off and during the take-off and landing, because the nose wheel has got a main wheel in the front there is a large height between the propeller and the ground. So, this gives good propeller clearance. It is said that the ground handling when you move the aircraft is easier if you have a tail wheel type and when you apply brakes on the main landing gear, when you apply brakes the aircraft tends to pitch nose down.

And it gives you a general tendency for the skidding to be reduced and location of the main landing gear is such that it is easy to mount on the structure. So, these are the advantages of the tail wheel type.

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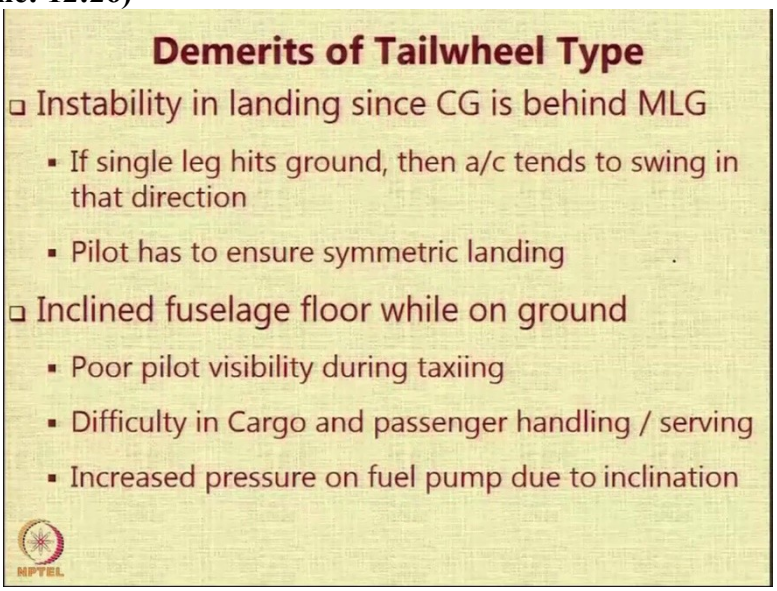

But there are also severe demerits of the tailwheel type because of which it is not very popular now, especially in larger aircraft, because the center of gravity is behind the main landing gear, there is instability in landing. So, for example, if it comes into land and by chance, let us says the port or the left leg hits the ground first, then the aircraft tends to swing in that direction.

Because the weight of the aircraft is on the CG mounted behind and if there is instability in landing and if the left or the port wheel touches the start the aircraft tends to go forward on the center of gravity. So it will tend to swing in that direction. So, in the case of a tail wheel type, you need good piloting skill to ensure that you have a symmetric landing, if you have a bad unsymmetric landing there can be serious problems.

The second problem is that a tail wheel type aircraft sits with a fuselage inclined at an angle to the ground. So during taxiing it gives a very poor visibility to the pilot because the pilot is looking up whereas the ground is below loading and unloading of cargo and passengers is a problem because due to gravity, the cargo tends to roll down towards the ground and because there is an inclination, the fuel pumps are going to be under larger workload because not only they have to pump the fuel at a pressure, they have to also overcome some amount of gravity in pumping the fuel.

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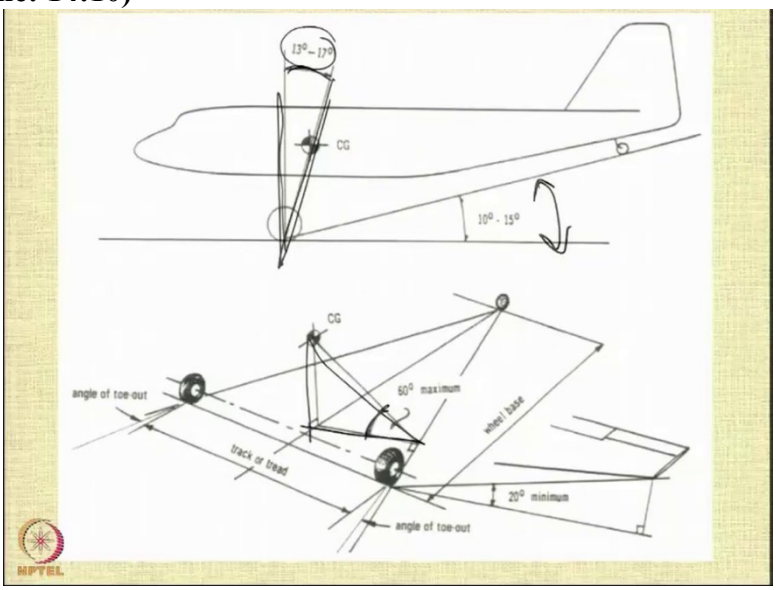

Let us look at the tail will type layout. So, when you do the layout of the tailwheel type, you can notice here that it is mounted slightly ahead of centre of gravity. And this particular angle between 13 to 17 degrees is to ensure that the angle at which you come and land during landing does not lead to hitting of the tail on the ground. Similarly, you have this particular figure here, where this angle is to be maintained around 60 degree maximum. If you increase it to beyond 60 degrees, you can have tipping. Thanks for your attention. We will now move to the next section.