Introduction to Aircraft Design
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Lecture – 37
Landing Gear Layout – Part - 02

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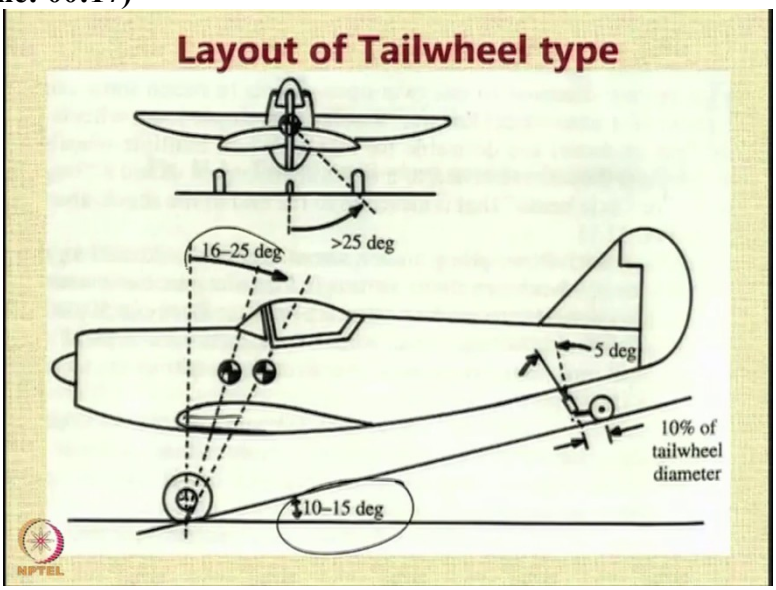

Here is another picture that shows the layout of the tailwheel type which has to be kept in mind while designing a tail dragger or a tail wheel type aircraft. Notice that the 10 to 15 degree angle that might be encountered during take-off has to be considered in locating the landing gear ahead of the centre of gravity with a little bit of margin.

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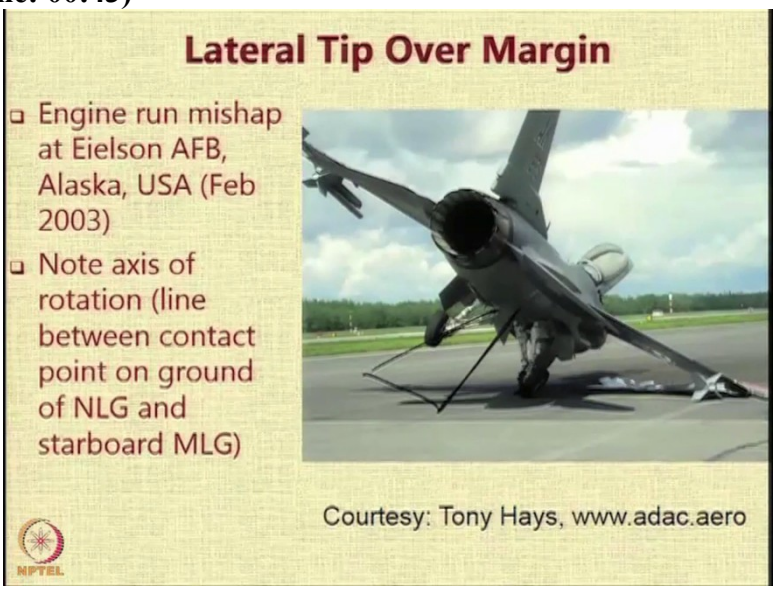

Let us have a look at what happens when there is a problem in the lateral direction with the tip over margin as shown in the previous slides is not considered this incidents took place at

the Eielson Air Force Base in Alaska in 2003, in which the starboard wing of the aircraft tipped and hit the ground because of lateral imbalance. It is worth it is important for us to note the angle between the point of contact of the nose landing gear and the main landing gear. If this particular angle is not sufficient is not appropriately designed, one can have a problem of lateral tip over.

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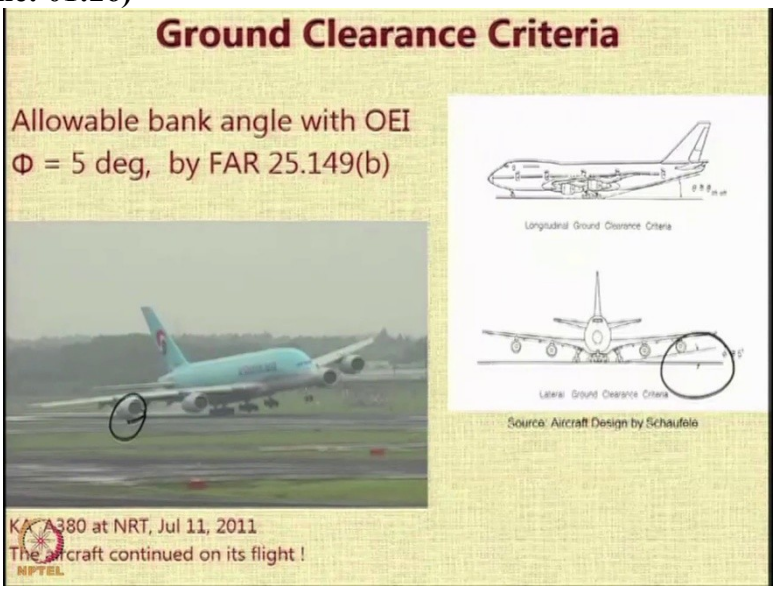

Also it is important to realize that when you design the landing gear, there is a ground clearance criteria. So as per the FAR regulations, if FAR part 25 regulations, when an aircraft comes into land with one engine in operational, we have to allow for a bank angle of 5 degrees. So, the, the landing gear should be located so that even when there is a bank angle of 5 degrees, that wheels do not touch the ground, the engine does not touch the ground.

Now, this happened in one case at the Narita Airport in Tokyo when the A380 actually dangerously brushed. So, this engine actually brushed the ground while coming into land. But interestingly, it was not a very serious problem. So, the aircraft continued in the flight.

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Effect of rear CG location on the landing gear stability is very important as this picture from Buffalo airport shows because of collection of iec on the rear part of the aircraft and loading of the aircraft, you know the tail of the aircraft has hit the ground.

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Similarly, there is something called as tail sitting when you exceed aft c.g. limit, while loading or unloading of cargo, you can have this problem in which you know, the rear of the aircraft hits the ground. The one that you saw earlier was because of weather conditions here it is because of improper procedure followed or not following the SOP during the loading and unloading of the cargo. So, as a result, the rear part of the aircraft became heavy and so, the tail has sit on the ground.

Another example of tail sitting is here you can see the nosewheel is up in the air above the ground and not visible but the tail has actually hit the ground. This is on a DHL aircraft while loading, unloading cargo.

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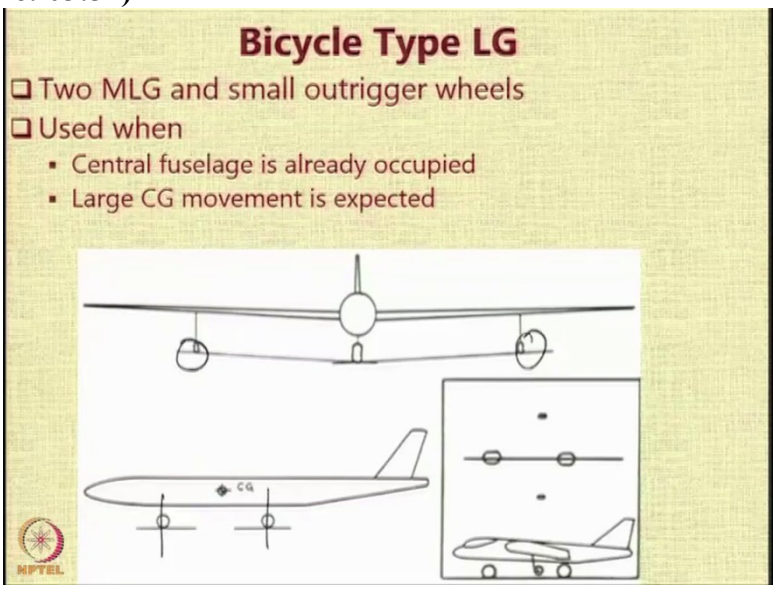

Let us look at the bicycle type landing gear which is a landing gear that has 2 main landing gear wheels and a small outrigger wheel. This is used when the central fuselage is occupied with something else more important or when a very large lateral CG movement is expected. Here is a sketch of the bicycle type landing gear you notice that there are actually 2 main gears one behind the other and there are these outrigger wheels just to provide lateral stability of the aircraft while it is moving on the ground.

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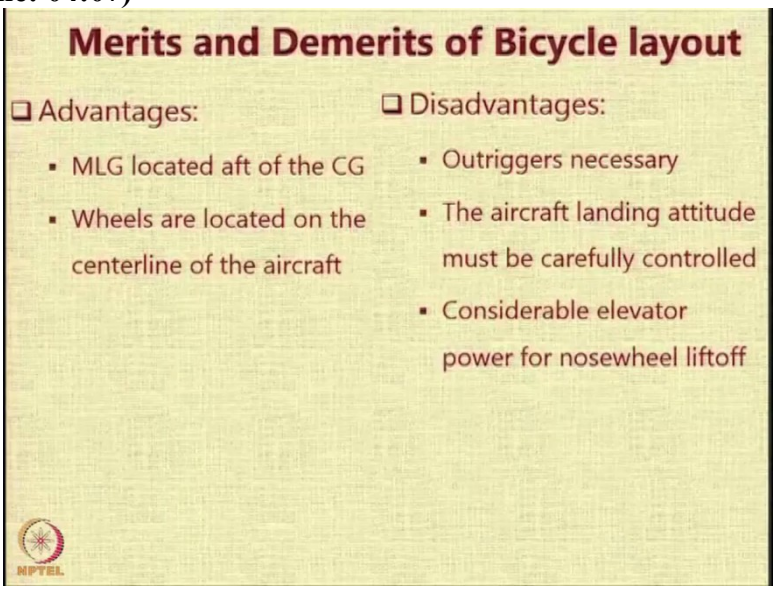

There are many merits and demerits of bicycle type layout. The advantages are that the main landing gear is located after the CG and the wheels are located on the aircraft center line. So

they get the entire load of the aircraft. But the demerits are that you need outrigger wheels. And because the aircraft is on 2 main wheels, you have to be very careful in you know while landing, it is very difficult to bring an aircraft down so that both the main wheels touch the ground at the same time. Secondly, the elevator power that is required for nosewheel liftoff is very large, because effectively both the wheels are actually the main wheels.

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There are some examples of bicycle type. This is one example B 47 aircraft in which the central part of the fuselage where you normally mount the landing gear is occupied in carrying bombs a large amount of bombs and hence the landing gear had to be moved outside. So that is there are 2 main wheels in the front, 2 on the back. And there are outrigger wheels on the sides.

Another example is the Harrier aircraft, in which the central portion of the aircraft is occupied to mount the swivelling nozzle for vertical take-off. So, therefore you end up having 1 wheel in the front and 2 wheels on the back. And you then have these outrigger wheels on the sides. So this is the same aircraft B 47. You can see there are 2 wheels here there are 2 wheels here. And this whole area in the centre is occupied in carrying the bombs.

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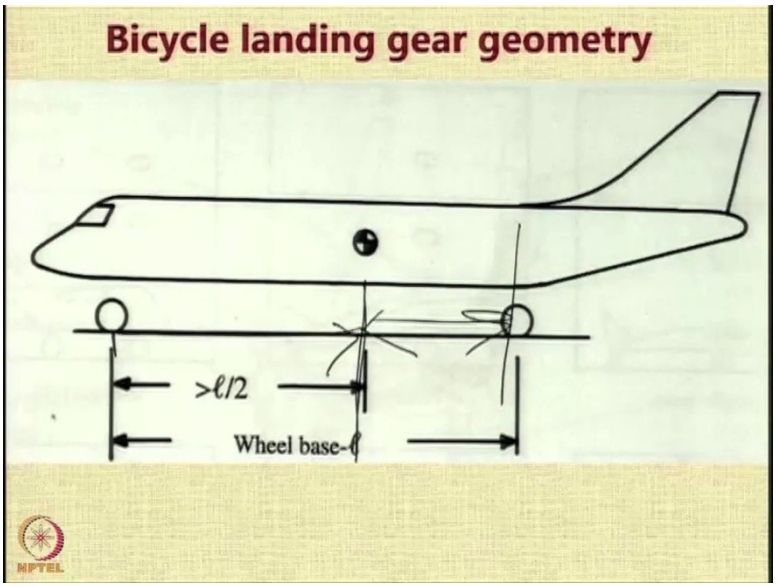

In the bicycle type landing gear, the geometry is such that to allow a little bit easy in the rotation, you keep the centre of gravity more than half the length. So this distance is generally around 35 to 40% compared to these distance. This allows ease in rotation.

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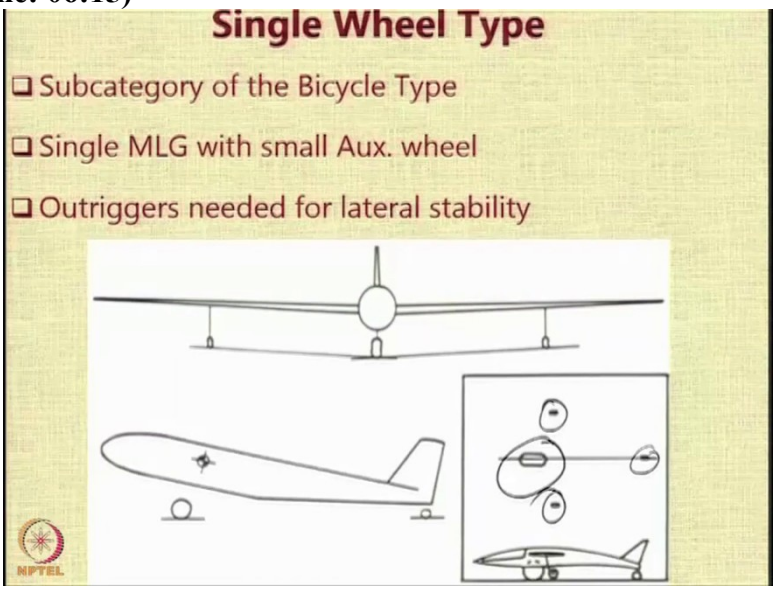

We also have a single wheel type which is basically a subcategory of the bicycle type in which you have just a single auxiliary single main landing gear wheel and a small auxiliary wheel on the back. Again you need outriggers for stability as shown in this particular figure. So, 1 main wheel, 2 outrigger wheels and a small auxiliary wheel for longitudinal stability of the aircraft during operation. Such consideration is very common in gliders.

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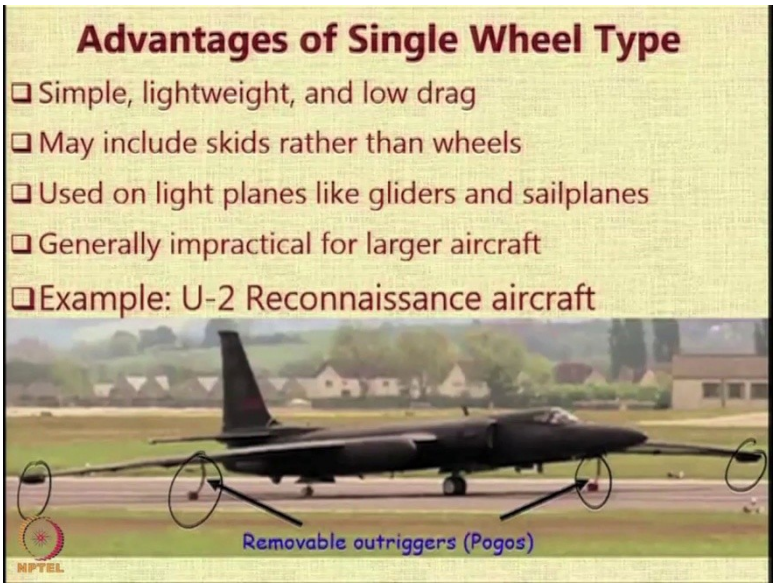

And in many cases, the single wheel type allows the gliders. So these are simple lightweight and low drag aircraft because there is only one main leg, but instead of introducing the wheels you may also have skids and very commonly seen on light planes like gliders and sailplanes. But generally such configurations are impractical for larger aircraft. One example of this particular type on a large aircraft was the U-2 reconnaissance aircraft.

As you can see, you have just 1 main wheel inside there are a couple of wheels here and there are small auxiliary wheels. But in this case, since it was meant for very long endurance flying and you know you cannot have these outrigger wheels during the flight of the aircraft. So what they have done is in this airport are designed in such a way that during take-off, these outrigger wheels, they fall off once the aircraft attains a little bit of climbing attitude, the 2 outrigger wheels are thrown out, and when the aircraft comes into land.

And you need very good piloting skill to bring the aircraft down very smoothly. So, therefore this particular aircraft is a very unique aircraft in which a car always travels by its side to guide the aircraft during landing. There is a communication between the pilot in the cockpit and the driver in the car and the driver of the car continuously drives along the aircraft and communicates with the pilot and at the end of the landing run.

To avoid these outriggers hitting the ground you know 2 people actually on each side they run and they attach this dolly. So, these outrigger the removal outriggers are called as Pogos. So, it is a very unique it is a very unique aircraft and hence there is a very unique solution for its requirements.

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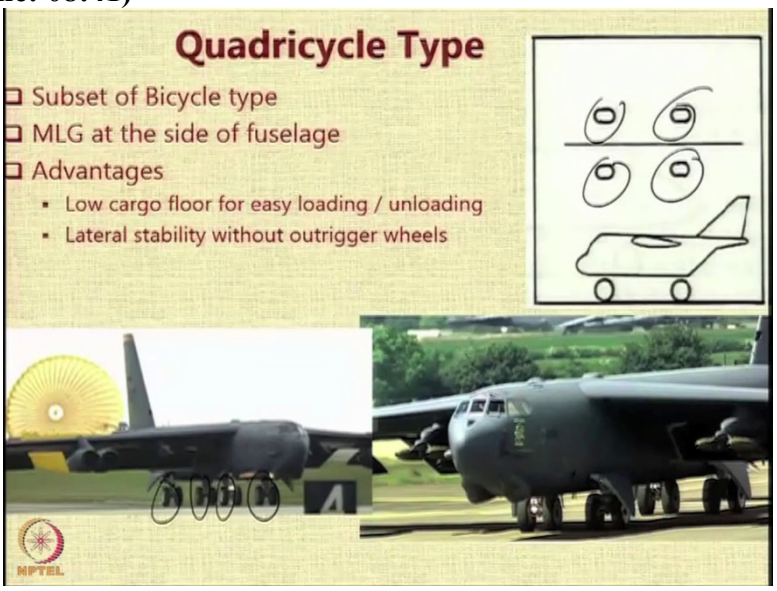

We also see in many military aircraft, the quadricycle type, which is also a subset of the bicycle type where you have main landing gear at the side of the fuselage. So, it is like a car there are essentially 4 points on which you load the aircraft. So, you can see the main legs there are now 4 of them, there could be pairs as you can see in this case, there are pairs of 2 tyres each such configuration allows you lateral stability without any outrigger wheels, and also it gives you a low cargo floor for easy loading and unloading. So, you see this mostly in some cargo type aircraft.

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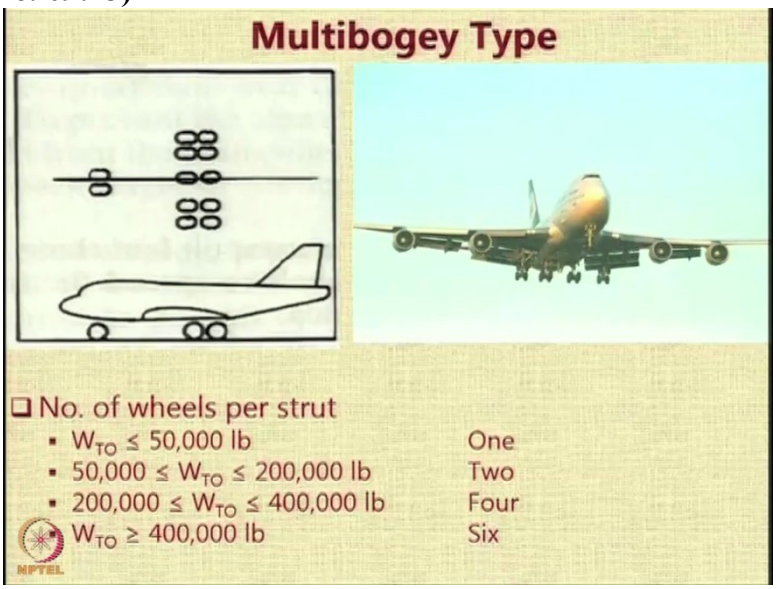

And then you can go for multibogey type aircraft which is seen normally in very large aircraft and the numbers of wheels per strut are a function of the take-off weight of the aircraft. So, all large transport aircraft, you know, that we use for travel Boeing 747, Airbus A 380 etc. They all have a multi bogey type.

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Then when we are want to operate at very unprepared and remote locations, where you have very rough field, you know, we have to provide very special features in the aircraft. This is one example of tundra tyres for rough landing. And these are basically oversized tires with very low pressure and they allow you to operate.

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So, I have a very interesting video clip of the Alaskan bush pilots, how they land their aircraft in very adverse conditions. You see this aircraft is now coming into land almost over a mountain river.

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So, using such kind of landing gears, you can actually land the aircraft on very rough ground. They do not require a properly paved runway because there is not one available where they operate. So, when you have rough field running requirements you go for these oversized low pressure, tundra tyres.

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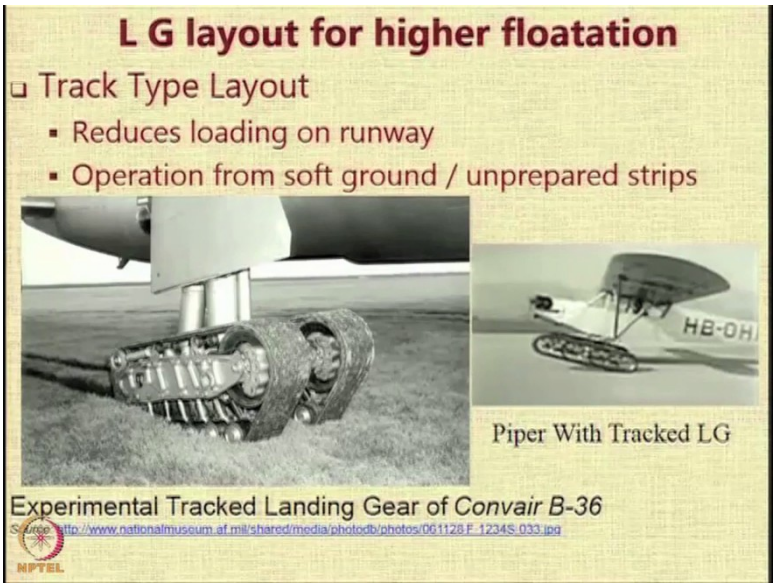

Then taking this particular thing to the extreme, we have track type layout, which reduces loading on the runway and allows the aircraft to operate from soft ground and unprepared strips, just like we have tanks, which have these tracks, you can actually you know load you can actually create a landing gear where you can have track tank like tracks on the ground.

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Here is an example of a testing of a Piper Aircraft mounted with a track type landing gear.

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So, as you saw, by providing a track landing gear, you are able to operate the aircraft from almost any type of ground that you come across. But there are of course, several limitations. The landing gear of this type cannot be retractable type, they will be fixed type and they will create tremendous amount of drag. But when there is a requirement to operate at extremely remote locations, unprepared grounds, you have no other option. Thanks for your attention; We will now move to the next section.