Airframes – Instructor Training Manual

Chapter 6 – UNDERCARRIAGE

Learning Objectives

1. The purpose of this chapter is to discuss in more detail the last of the 'Four Major Components' – the Undercarriage (or Landing Gear).

2. So, by the end of the lesson you should have an understanding of the types of undercarriage, it's function and the positioning of them.

The Undercarriage

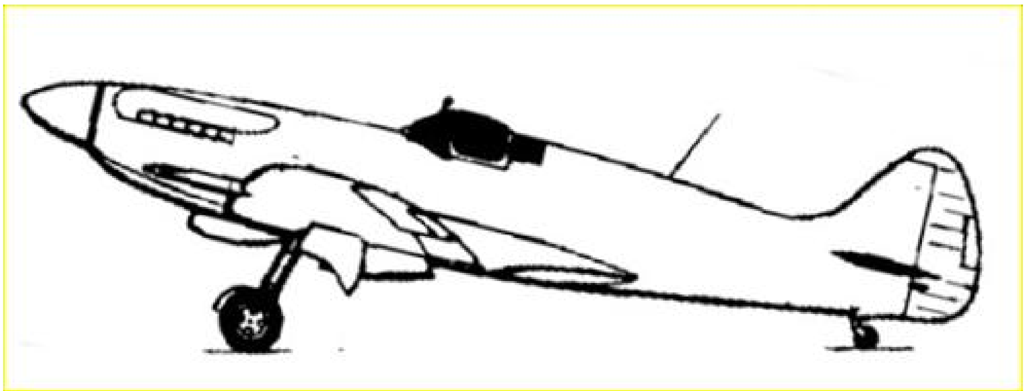
3. An undercarriage (or landing gear) of some sort is needed by all aircraft which operate from land. The types of tasks it is expected to perform include;

- Absorbing the shock of landing
- Supporting the weight of the aircraft whilst on the ground
- Withstanding the side loads experienced during crosswind take-offs and landings
- Withstanding the huge braking loads experienced on landing
- Minimum rolling friction on take-off, minimum drag in the air
- Provides for smooth taxying

'Tail Sitter' Undercarriage

4. Historically, early aircraft had a tail wheel arrangement instead of the nosewheel. These aircraft are referred to as 'Tail Sitters' due to the attitude they took when on the ground.

Although, some light aircraft have a tail wheel instead of a nose wheel, this arrangement is no longer common.



Tri-Cycle Undercarriage

5. Most modern aircraft are usually supported on the ground by three units - two main wheels and a nose wheel. This is what is referred to as a 'Tri-cycle' undercarriage

6. The main advantages of employing a tri-cycle undercarriage layout are;

- Ground manoeuvring is easier with a steerable nose wheel.
- The pilot's view is improved during taxying.
- The aircraft floor is horizontal when it's on the ground.
- Aerodynamic drag on take-off is reduced, giving much better take-off performance.
- Directional stability on the ground is improved, because the C of G is forward of the main wheels.
- Braking is more straightforward, and brake parachutes can be used.
- There is less tendency to float and bounce on landing, making landing easier.

7. Despite all the advantages of utilising the tri-cycle undercarriage layout within an airframe design, there are still some disadvantages;

- Nose wheels need to be stronger and therefore heavier than tail wheels – if not they can be prone to collapsing.
- More damage is done to the aircraft if the nose wheel collapses

Large Aircraft Undercarriage

8. Large aircraft, such as modern passenger aircraft can have complicated landing gear arrangements. The picture shows an Airbus A340 undercarriage just at the point of touchdown

Landing Forces

9. When an aircraft lands, a large force is applied through the undercarriage as it touches the ground.

10. For Transport aircraft, this may be up to 3 times the weight of the aircraft, whilst for an aircraft landing on the deck of a ship, this can be up to 8 times. To prevent damage to the structure, and to stop the aircraft bouncing, this shock must be absorbed and dissipated by the undercarriage.

11. On light aircraft, the undercarriage may be just as simple as a piece of spring steel, with perhaps a rubber mounting in the aircraft fuselage. However, on much larger, heavier aircraft a telescopic shock absorber known as an *oleo leg* is almost always used. This allows for the force of landing to be absorbed.

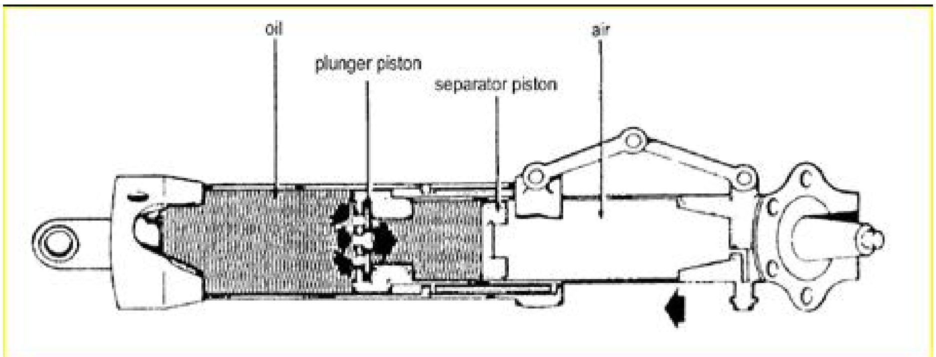
The Oleo Leg

12. Most military service aircraft, as well as civil transports, are fitted with oleo-pneumatic or oil-compression type undercarriages.

13. The operation of both units is very similar. Whilst an oleo-pneumatic unit compresses air or nitrogen gas, an oil-compression unit (often known as liquid spring) works by compressing oil.

14. Compressing the strut reduces the volume inside and compresses the gas or oil in a similar way to the operation of a bicycle pump.

15. Any tendency to bounce is prevented by forcing the damping oil through small holes, so that the strut can only extend quite slowly.



The gas or oil will stay slightly compressed when it has the weight of the aircraft on it, so it provides the aircraft with a cushion against bumps whilst taxying.

Nose Wheel & Steering

16. The operation of Nose Wheel shock absorber units is similar, but their construction differs slightly in that they are usually designed to allow the Nose Wheel to be steered, by rotating the entire unit, or by steering motors on larger aircraft.

17. On large aircraft, some of the main body wheels will pivot (such as those on the B52) to help prevent the tyres from 'scrubbing' in tight turns. Often the Nose Wheel steering must be capable of being disconnected for towing, in order to prevent inadvertent damage.

Undercarriage Design Considerations

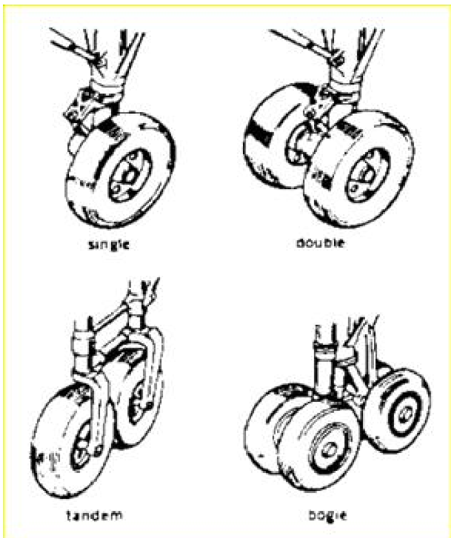
18. To make sure the aircraft tail does not hit the ground on take-off or landing, the main wheels must be behind the *Centre of Gravity*.

If they are too far back, very high loads will be taken on the nose wheel during landings, which may cause it to collapse. For storage during flight, the main units are often retracted into the wings, but in larger aircraft (where body gear is also required to support the increased load) these will be retracted into the body fairing.

Wheel Units

19. All of these design considerations mean that the undercarriage positions must be very carefully calculated and designed.

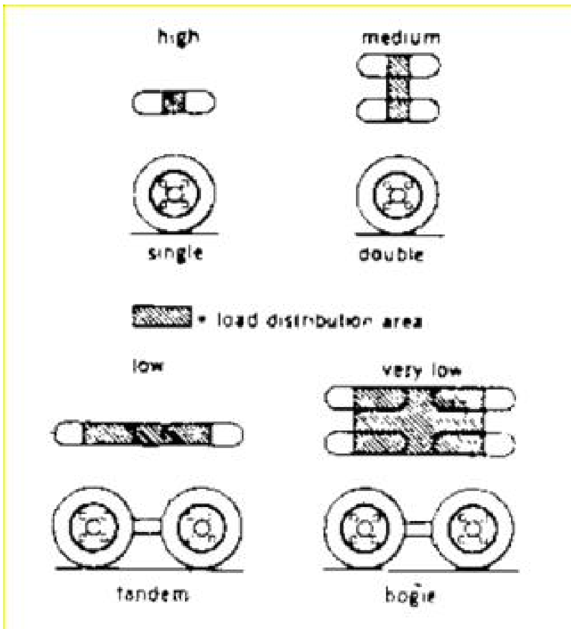
20. Each main-wheel unit consists of a single, double, tandem or bogie unit, of four or more wheels. There are even more variations than this, but they are not common.



As aircraft become heavier, the loading on a single wheel increases, leading to a great increase in the damage done to runways.

Distributing the Load

21. By having the weight spread over a number of wheels, the contact pressure of the undercarriage is reduced. This leads to reduced undercarriage weight and increased safety if a tyre bursts on landing.



22. For example, The new Airbus A380 has 22 wheels. This is broken down as four main units, 2 with four-wheel bogies and 2 with 6 wheel-bogies, and a double nose-wheel unit. The large number of main gear and wheels is necessary in order to ensure the heavy load of the aircraft is distributed.

23. For military aircraft, the landing gear will be designed for the role and loads the airframe will encounter on landing and take-off. For instance, the nose landing gear of the Boeing T45 Goshawk aircraft has a double wheel layout. This is necessary to cope with the landing loads, as this aircraft lands on a Carrier.

Conversely, the nose and main wheel landing gear of the Typhoon consists of a simple single wheel arrangement, as it is designed to operate from airfields.

<u>Jockey Wheels</u>

24. A variation of the tandem arrangement is the Jockey Unit, which comprises two or three levered legs in tandem on each side of the fuselage, sharing a common horizontal shock absorber.

25. Amongst the advantages of this design are excellent rough-field performance and the ability to lower the aircraft down (kneeling) for easier loading. The units also retract into a small space, without penetrating into the load space.

This makes this arrangement ideal for transport aircraft like the Hercules or Antonov AN-225 Mriya (as shown below).

Undercarriage Retraction

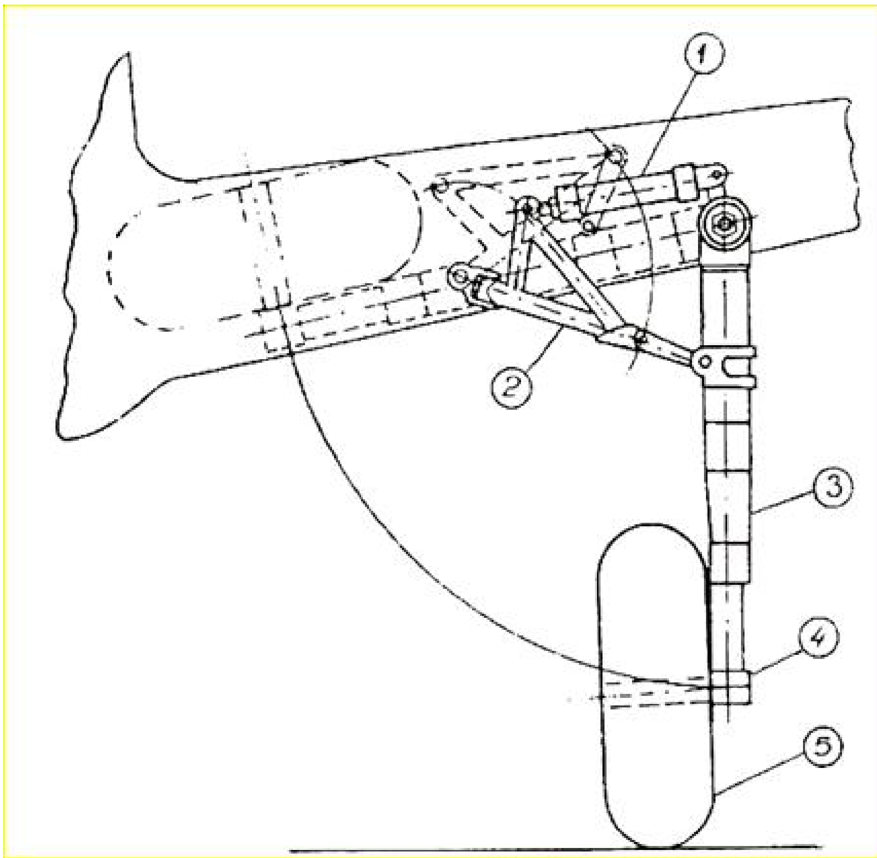
26. A fixed undercarriage causes a lot of drag in flight, so it is desirable for higher speed aircraft for the undercarriage to be retracted into the wings or fuselage, except when needed.

27. In most cases, a hydraulic jack is used to pull the undercarriage legs, about a pivot at the top. The doors to the undercarriage well may be attached to the legs, or may use separate jacks to open and close them.

In many cases the undercarriage needs to fit into a very small space, and the units may be turned, twisted or folded to enable this to be done.

28. The components of a simple landing gear and retraction system consist of;

1. Retraction Jack
2. Down-lock
3. Oleo Leg
4. Axle
5. Wheel



Undercarriage Doors

29. It is important that the doors open before the undercarriage units extend or retract, and close afterwards. This is accomplished by using a sequencer valve to control the supply of hydraulic fluid.

The sequencer valve ensures that the correct hydraulic actuator and/or jack is supplied with hydraulic fluid in the correct order.

Undercarriage System Failure

30. So what happens if the hydraulic system fails – how does the undercarriage get lowered?

31. Airframe designers must consider the potential for failure, so that the aircraft can be landed safely.

Therefore, it is common for pressure bottles to be fitted, which store enough pressure to allow the undercarriage to be extended once, if the system fails.

Once activated, the undercarriage must then be able to lower to it's full extension under it's own weight.

Additionally, nose wheels are normally retracted forwards and in an emergency, the aerodynamic drag will assist them to reach full extension.

Locking the Undercarriage

32. To prevent the undercarriage collapsing on the ground, and to hold it firmly in position in flight, *uplocks* and *downlocks* are fitted.

These are unlocked as part of the extension and retraction sequence and it would be catastrophic if the undercarriage were retracted accidentally with the aircraft on the ground, so additional locks are fitted, disabling the retraction mechanism when on the ground.

Brake Systems

33. Modern large aircraft often land at high weights and speeds. This means that the braking system must be capable of absorbing and dissipating very large amounts of heat, as the energy of motion is converted during th act of stopping or slowing down.

34. There are two main types of brake:

- Drum Brakes
- Disc Brakes

The *Drum Brake* is rarely used, because it suffers from poor heat dissipation, causing the brakes to overheat and fade. This is where the brakes lose their braking effectiveness as their temperature increases.

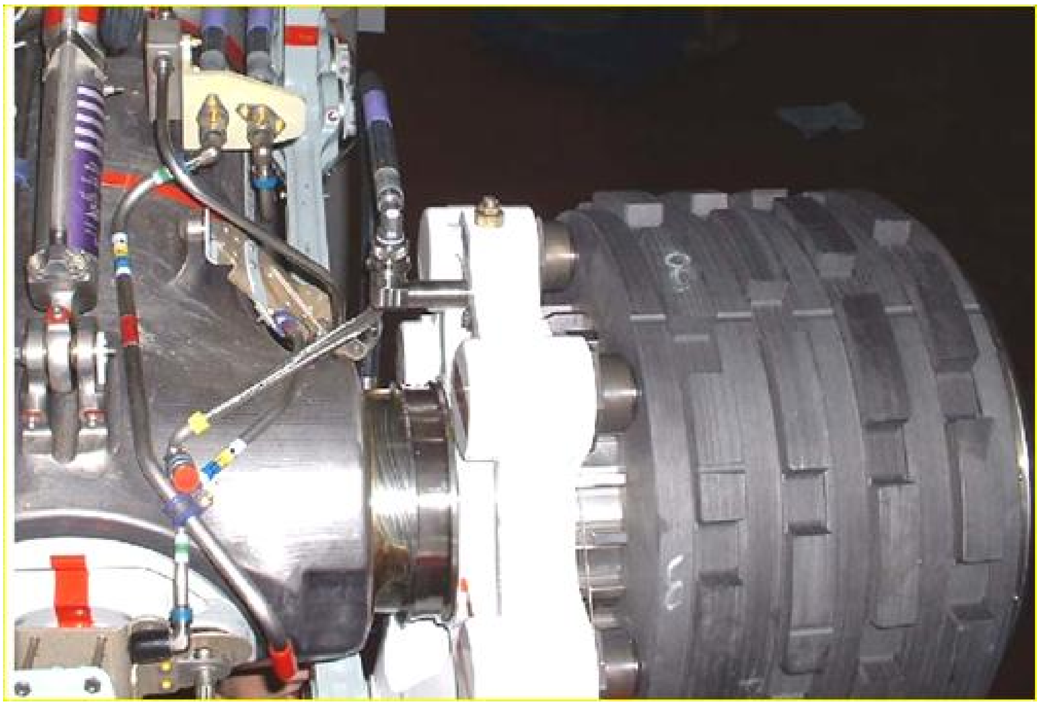
The *Disc Brake* is much more effective at dispersing the heat produced, and maintain their effectiveness during long periods of heavy braking.

35. Disc Brakes consist of a disc or series of discs of aluminium alloy, steel, carbon or other material, gripped between pads of friction material.

These pads are forced against the discs by pistons under hydraulic pressure. Control is usually achieved by placing a toe pedal for the brake on each side on its respective rudder pedal. These can then be operated differentially by the pilot, giving the ability to steer the aircraft by applying different amounts of braking on each main wheel.

Applying the brakes equally on both main units allows the aircraft to be braked smoothly in a straight line.

36. Large aircraft may have quite a number of discs in each wheel, to get the required braking forces and heat dissipation.



Anti-Skid

37. An anti-skid unit, called a *Maxaret* unit, prevents skidding by detecting when the wheel or wheels on any unit stop turning, and momentarily releases brake pressure on that unit only.

This gives the aircraft the ability to stop in the shortest possible distance without loss of control. Similar units, known as *ABS*, are fitted to many cars, and work in the same way.

Alternative Braking Methods

38. Another form of braking is air brakes, used in flight, which consist of large plates fitted to the fuselage (or wings – Viking and Vigilant) which can be lifted into the airflow when required. They cause a large increase in drag to slow the aircraft.

39. In addition, after touch-down, reverse thrust can be deployed. This is achieved by moving doors into the jet exhaust to deflect the flow forwards. For Turbo-prop engines a similar effect can be achieved by changing the pitch of the propeller to reverse the airflow – but the operation of these types of alternative braking systems are the subject of the Propulsion ACP.

Alternative Undercarriage Types

40. Over the years, many different designs have been tried. An experiment was tried in the 1950's, when an aircraft with no undercarriage was tested. It relied on landing on rubber runways, but the idea was quickly abandoned.

41. Another experiment was with tracked undercarriages for soft field landing on the Convair B-36 – again this idea wasn't pursued.

Conclusions

42. You should now have a basic understanding of the types of undercarriage, the forces that they must be able to cope with, how they are used to absorb the forces sustained during landing, as well as the types of braking system employed.

43. Undercarriages are essential components of any airframe. They allow the aircraft to move about on the ground as well as ensure that the high loads are carried effectively.