Landing Gear System

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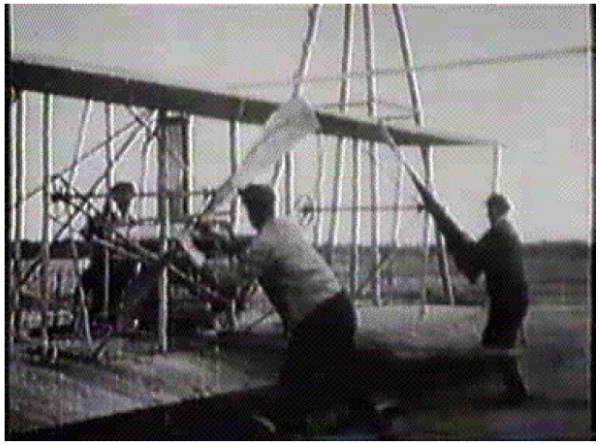
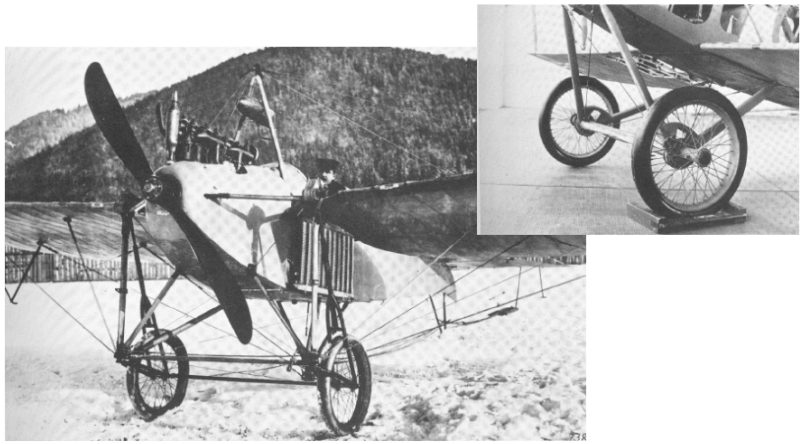
History

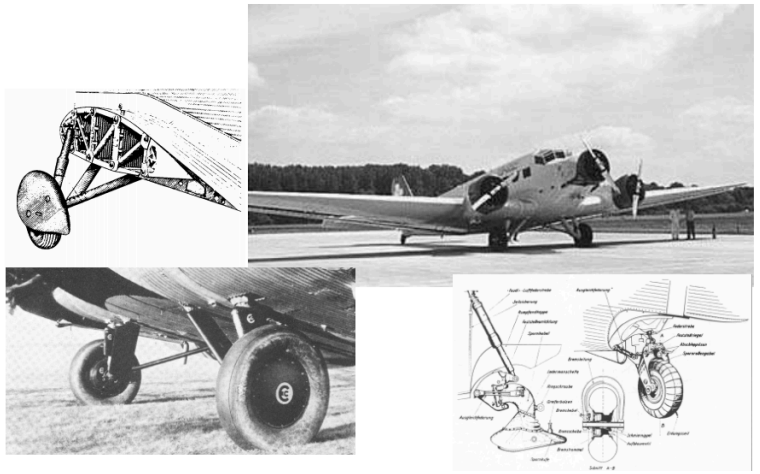


The Beginning - Wright Brothers , 1903



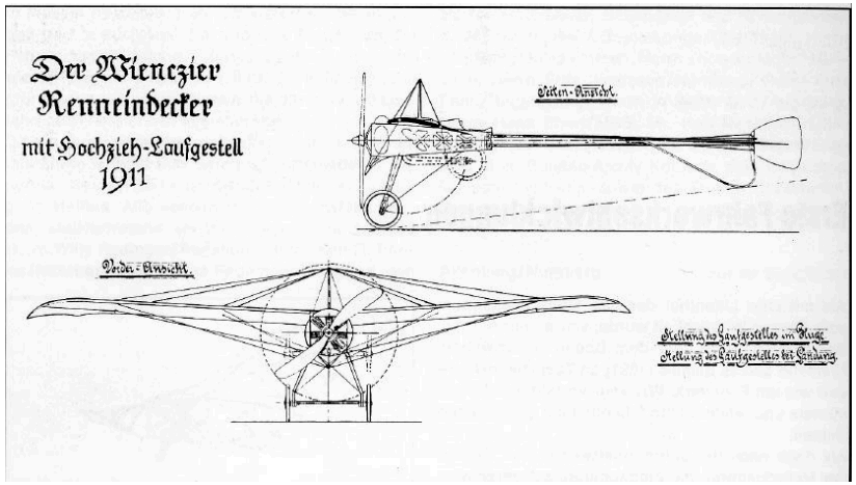
Etrich , 1914 / Albatros , 1918

Messerschmitt Me 20 , 1928

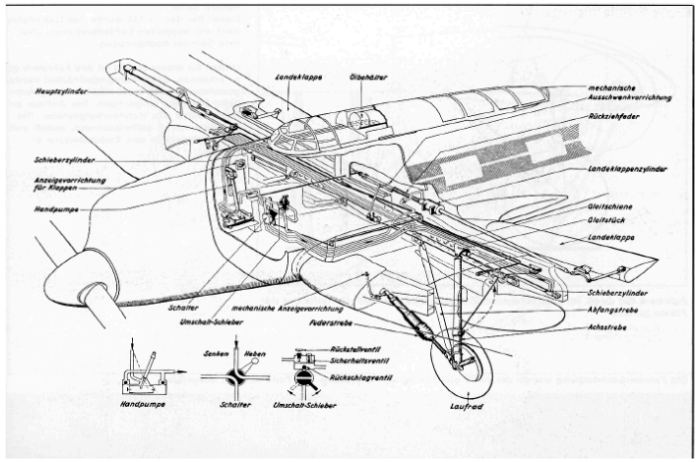


Junkers Ju-52/3m , 1932

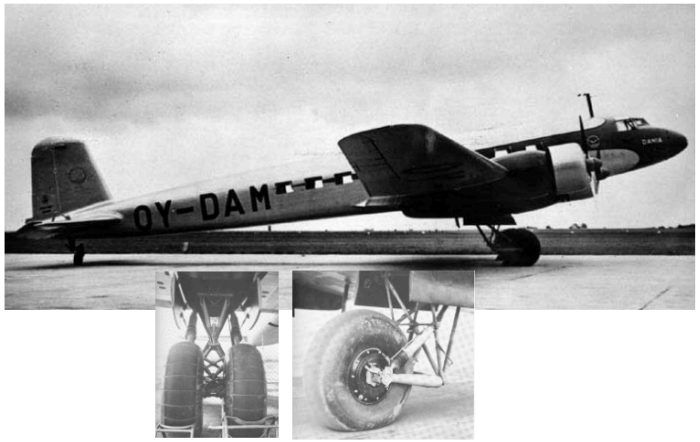
History



Retractable Landing Gear , 1911



Hydraulic powered Landing Gear , He-70 , 1932

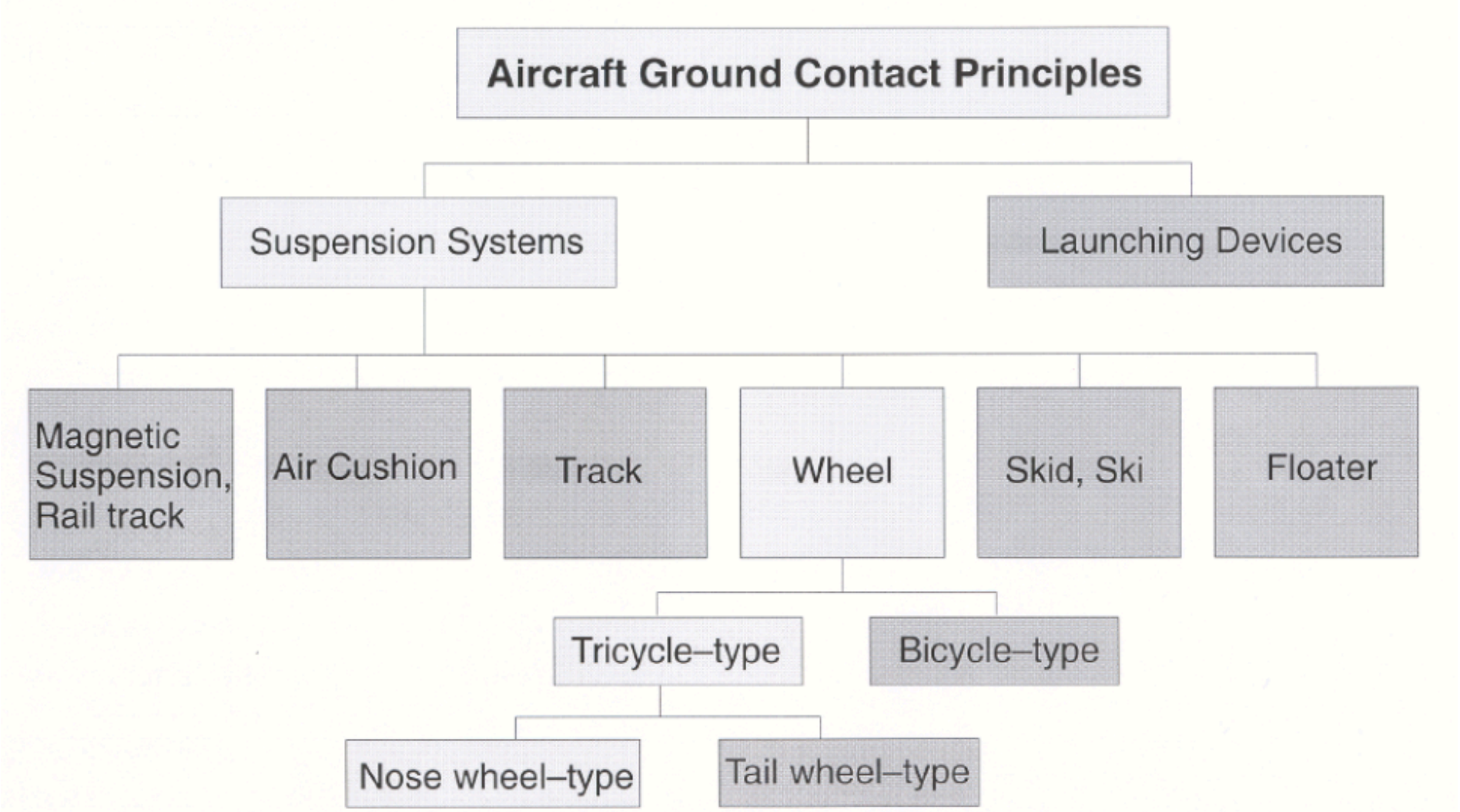


Tail Wheel - Type , Focke Wulf Fw 200 , 1936

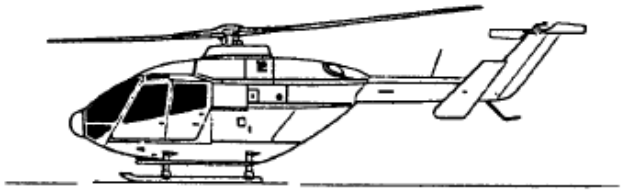
Function Of a Landing Gear

- Support the static load of an aircraft on ground or water during maneuver or in static condition.
- Provide a means of ground maneuver/taxiing.
- Absorb the landing shocks.
- Dampen the vibration.
- Facilitate aircraft for take off and landing.
- Providing the aircraft the braking and steering functions.

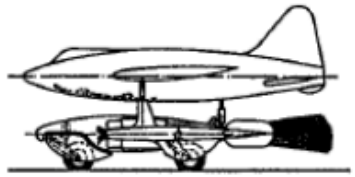
Special Purpose Undercarrige



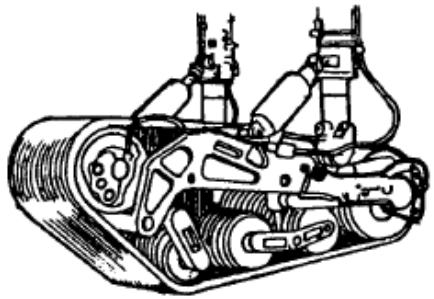
Special Purpose Undercarrige



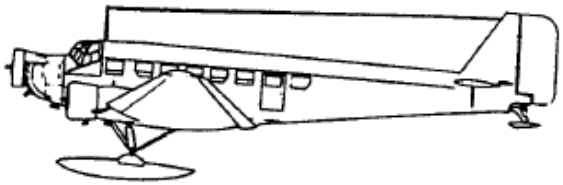
Skid



Take–off Trolley

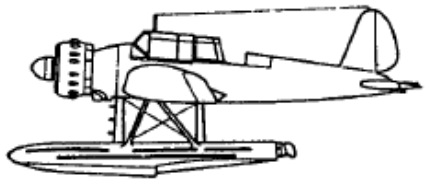


Track



Ski

Air Cushion

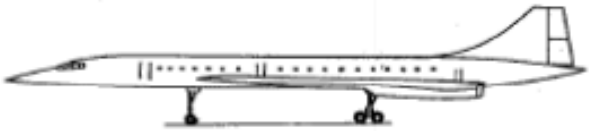


Floater

Aircraft Ground Contact Devices

Types of Landing Gear

Overview of Landing Gear Types



Nose wheel – type (retractable)

Tail wheel – type (retractable)

Tandem – type (retractable)

Nose wheel – type (fixed)

Tail wheel – type (fixed)

Aircraft that are not practical to be retracted are more suitable to used rigid/fixed type of landing gear. ii. It is usually equipped with cowlings or fairings known as: 1) Spats. 2) Speed Fairings. 3) Wheels Pants.

Retractable Landing Gear

- Minimizing the amount of parasite drag by means of retracting the landing gear to its designated compartment known as “Landing Gear compartment” or “Wheel Well” area.
- Also contribute to more better and improved aircraft performance.
- Note: Extreme care is taken for landing gear because it received rough treatment throughout operation such as frequent landing shocks an irregular contact with ice, dirt and abrasive grit. By regularly washing, lubricating and servicing the landing gear, it guards against corrosion, seizure of mechanical parts and failure of electrical components.

Retractable Landing Gear

There are 4 types of retraction direction on a retractable landing gear :

- 1) Rearwards retraction.
- 2) Sideward retraction.
- 3) Forward retraction.
- 4) Upward retraction.

Retractable Landing Gear

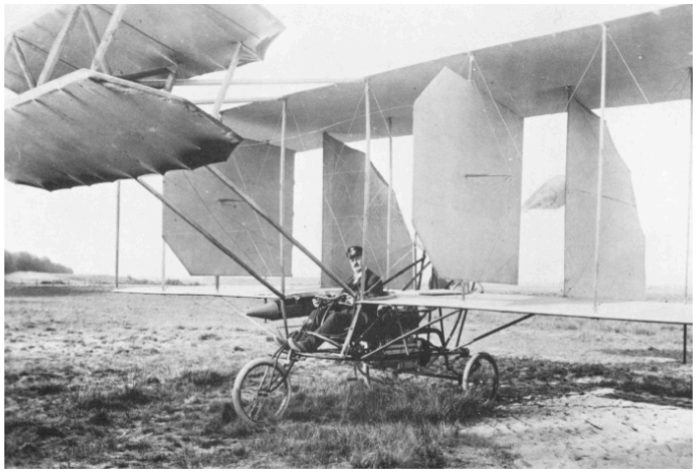
- Rearward retraction:
- 1) Could be used on nose landing gear, tail gear and main alighting gear.
- 2) The disadvantage of this design is that the airflow could not be used as an aid or assisting in emergency extension.
- 3) Require back-up pressure system for emergency extension case.
- Sideward retraction:
- 1) Landing gear retracting inboard or outboard is used only on ‘main landing’ gear application and are not suitable to be used on ‘nose landing’ gear.
- 2) Fuselage does not allow any ‘nose landing’ gear or ‘tail’ wheel to be retracted in this direction (small structure, electrical compartment, radar, etc).

Retractable Landing Gear

- Forward retraction:
- 1) Used generally on both landing gear, which is ‘nose landing’ gear and ‘main landing’ gear.
- 2) Considerable effort required to retract (raise) the landing gear with this methods because it’s against the airflow during flight.
- 3) Airflow acts as an aids or assisting in emergency extension of the landing gear with forward retraction.

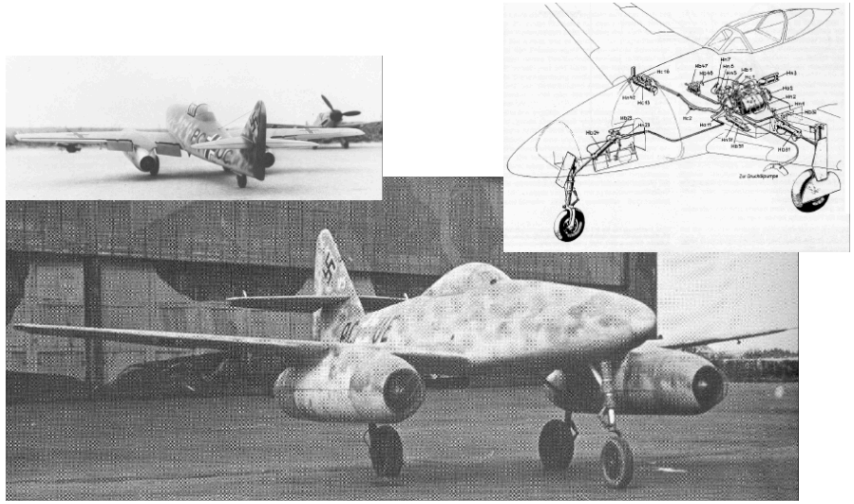
- Upward retraction:
- 1) The alighting is retracted upwards into the fuselage known as ‘pod’ or ‘blister’.
- 2) Retracting the landing gear into the wing is not a viable option due to the size construction of the landing gear.
- 3) Mainly used on high wing plane aircraft such as ‘Lockheed C-130’.

Nose Landing Gear

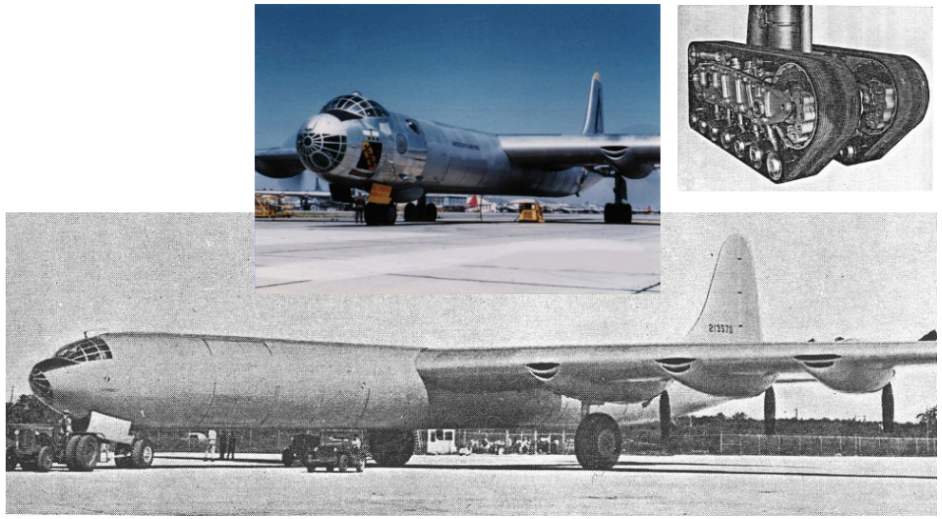


Nose Wheel-Type Landing Gear , Jatho IV , 1908

NLG-Type with Twin Wheels , B-29 , 1939



NLG-Type with Single Wheels, Me 262 , 1942



Single Wheels , Convair XB-36 , 1946

Nose Landing Gear Steering System

- Ground steering of a small nose wheel aircraft is accomplish by either a direct linkage to a rudder pedals or by means of differential braking (castering of a nose wheel).
- Free castering system ;
  - Some light aircraft the nose is free to caster.
  - This type of nose wheel steering system is controlled by the aircraft brake system.
  - When the left brake or right brake is pressed or applied, the aircraft will turn in the direction of the applied brake which is left or right direction.
  - The rate of the turn can be determine or controlled by the amount of pressure applied to the brake.

Nose Landing Gear Steering System

- Large aircraft is steered by means of hydraulic pressure (NLG down pressure) in the steering cylinders.
- This large cylinder will acts as a shimmy dampers during take-off and landing but acts as a steering cylinders when aircraft is taxiing.
- Fluid is then directed into and out of these cylinders by the steering control valve that being moved by the application of rudder pedals or a nose wheel steering.
- Nose wheel steering system consists of:
  - A cockpit control such as wheel, handle, levers or a switch to allow starting and stopping and at the same time to control the action system.
  - Mechanical (by means of cables), electrical or hydraulic connection for transmitting cockpit control movements to a steering control unit.
  - A control unit which is usually a metering valve or control valve.
  - A source of power, which is in most instances the aircraft hydraulic system (NLG down pressure).

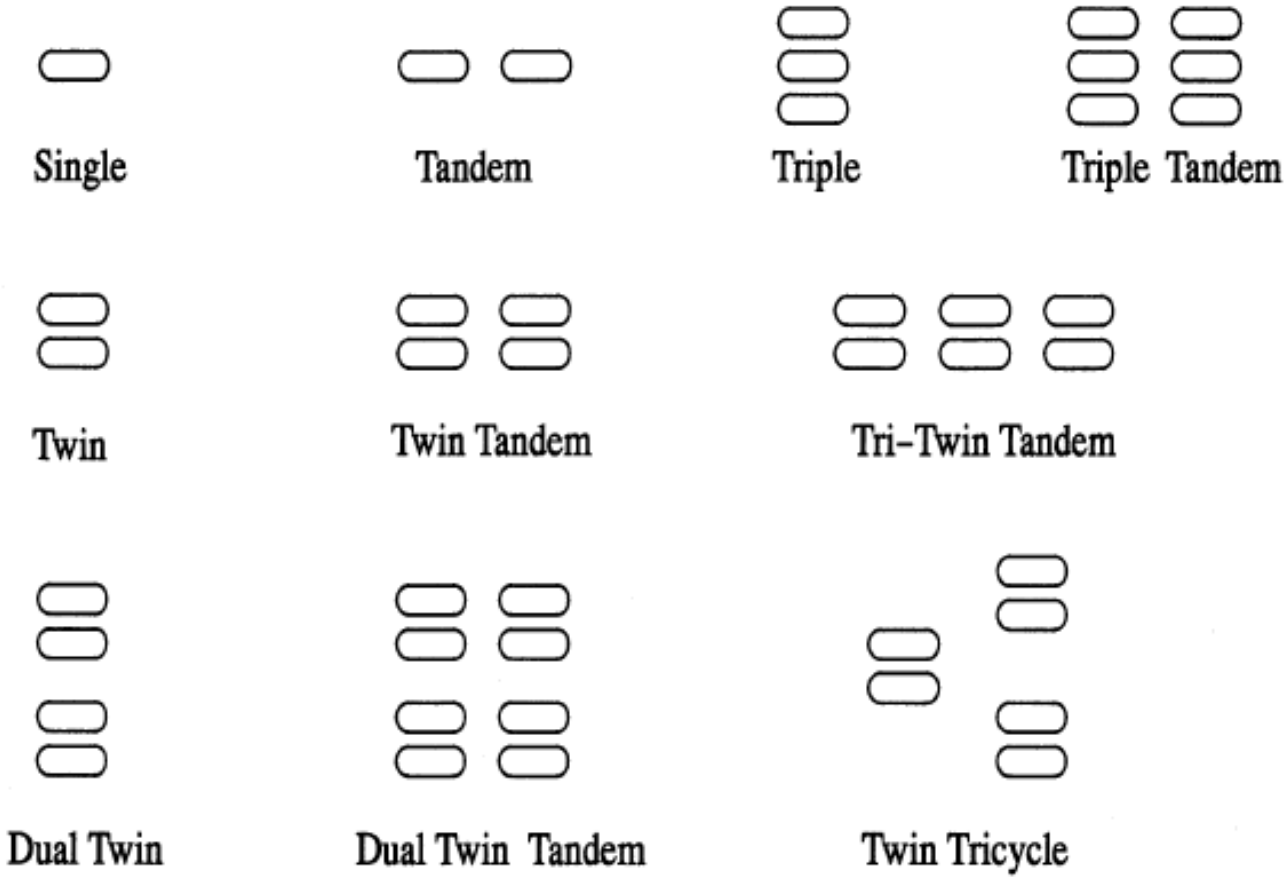
Nose Landing Gear

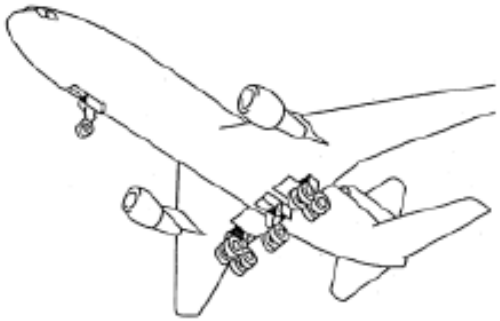
Advantages of the NLG-Type:

- Improved rolling characteristics
- Horizontal floor
- The Pilot has better visibility
- Easier ground handling (e.g. towing)

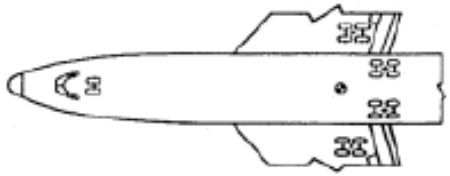
Wheel Arrangements

Overview of Wheel Arrangements





DC-10

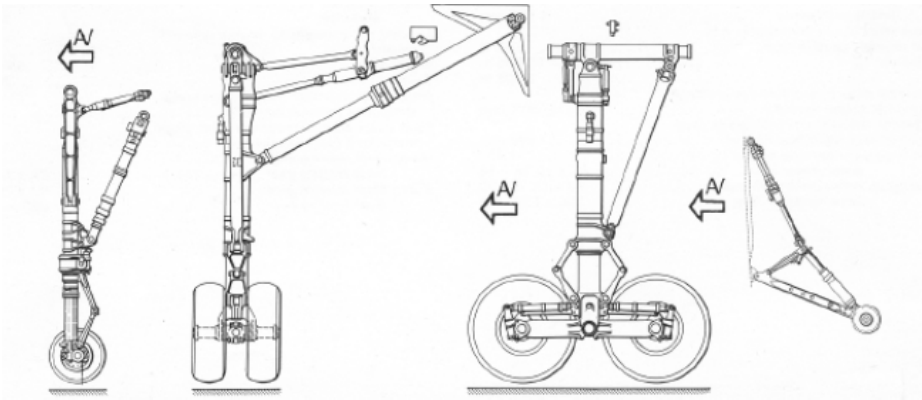


B 747-400

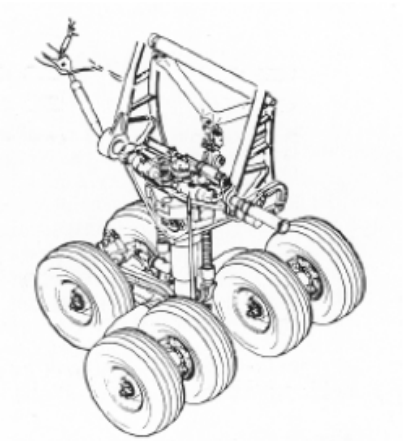
Multiple (Bogie/Truck) Landing Gear

Tandem Gear , Boeing B-52 , 1954

Concorde , 1969



Lockheed C-5 Galaxy , 1968



Antonow An-225 , 1988

Multiple (Bogie/Truck) Landing Gear

The number of wheel determined by the gross design weight of aircraft and the surfaces on which the loaded aircraft may require performing landing.

Advantages:

- Multiple wheels spread the aircraft weight over a larger area of load distribution.
- Providing safety margin in a case of one of the tire burst during take off or landing.
- Extra braking effort or efficiency of braking is accomplish by the number of brake unit attached in each wheel.

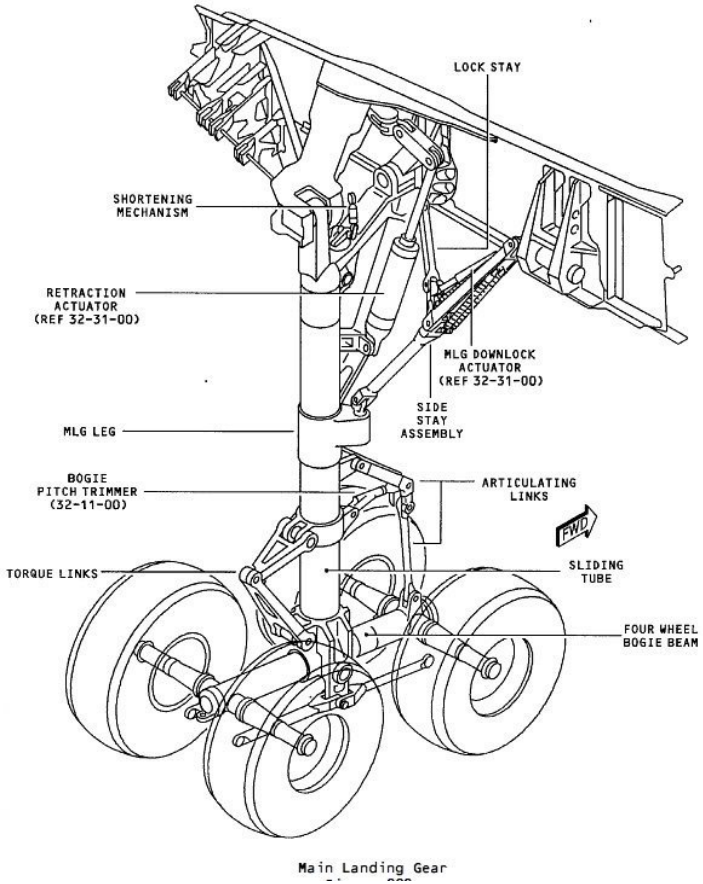
Disadvantages:

- More moving parts and therefore require greater amount of maintenance.
- Tires tends to scrubs during turning maneuver.
- Larger turning radius required to prevent or reduce tire wear and therefore need a larger space for movement.

Landing Gear System

General Requirements

- Comfortable shock absorption
- Short stopping distance (braking)
- High rolling stability during ground maneuvering
- Small storage volume
- Low drag (specially for fixed landing gears)
- High reliability and safety
- Low maintenance
- Low weight



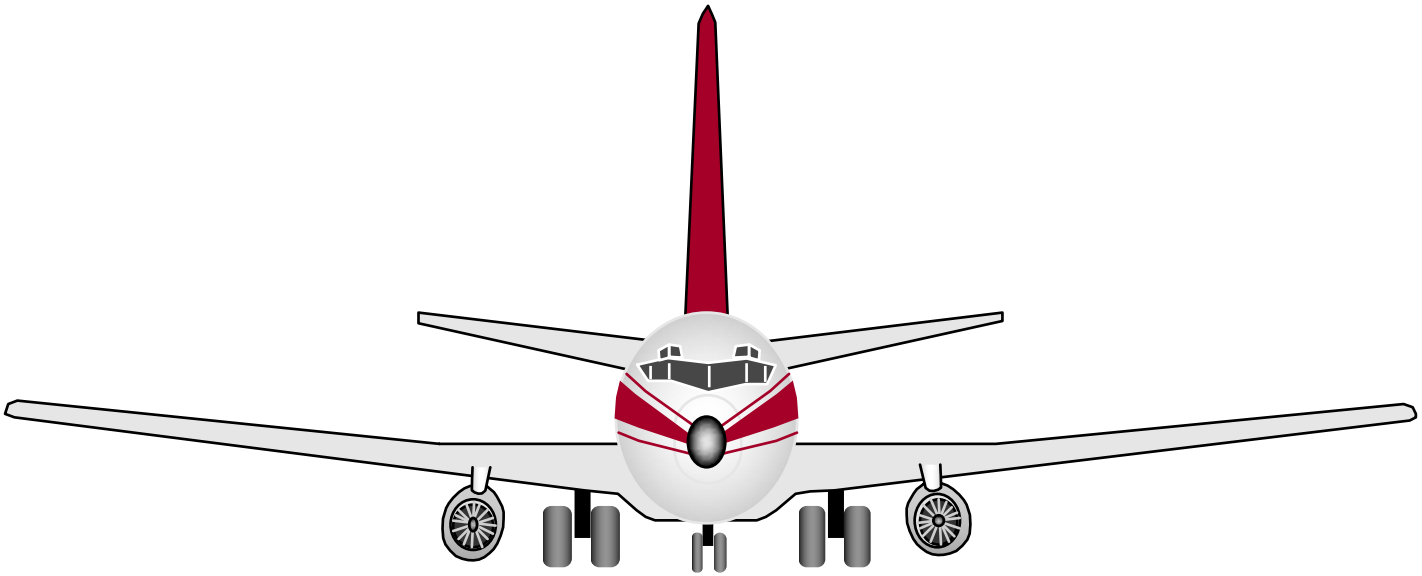
Main Landing Gear

Landing Gear System

Aircraft Landing Gear, consists:

- **Main Landing Gear.**
- **Auxiliary Landing Gear.**

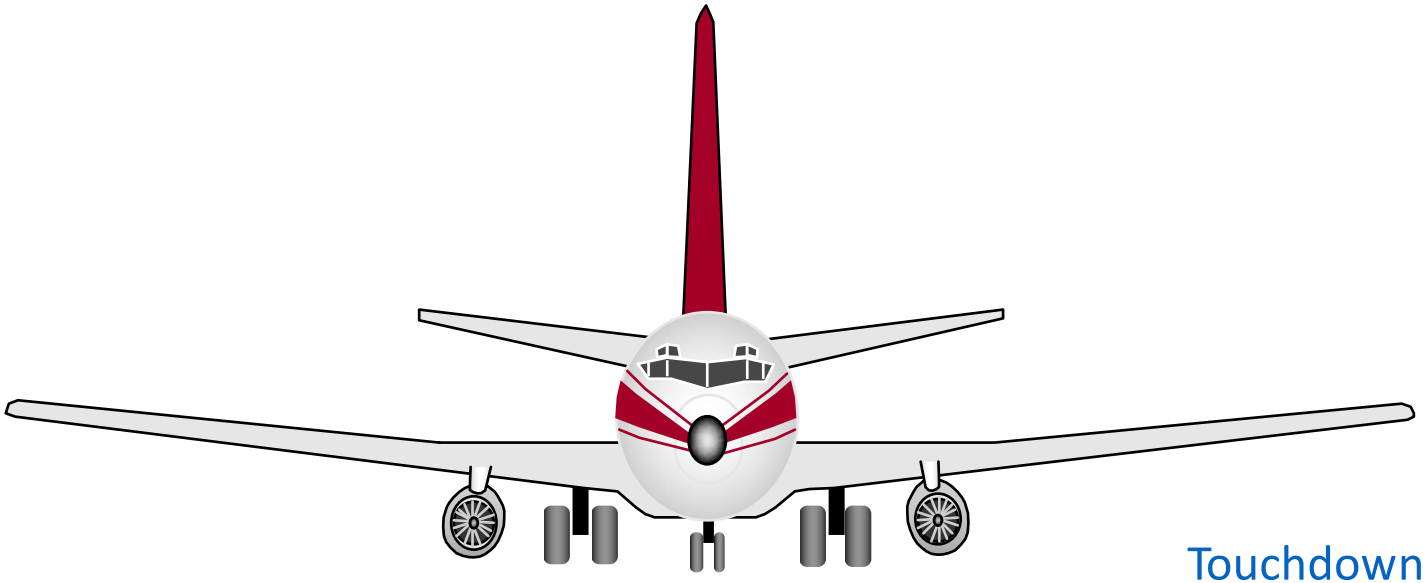
Where may or may not be retractable.



Landing Gear System

Main Landing Gear forms the principle support of the aircraft on land or water (include any combination of wheels, floats, skis, shock-absorbing, brake, retract mechanism, controls and warnings).

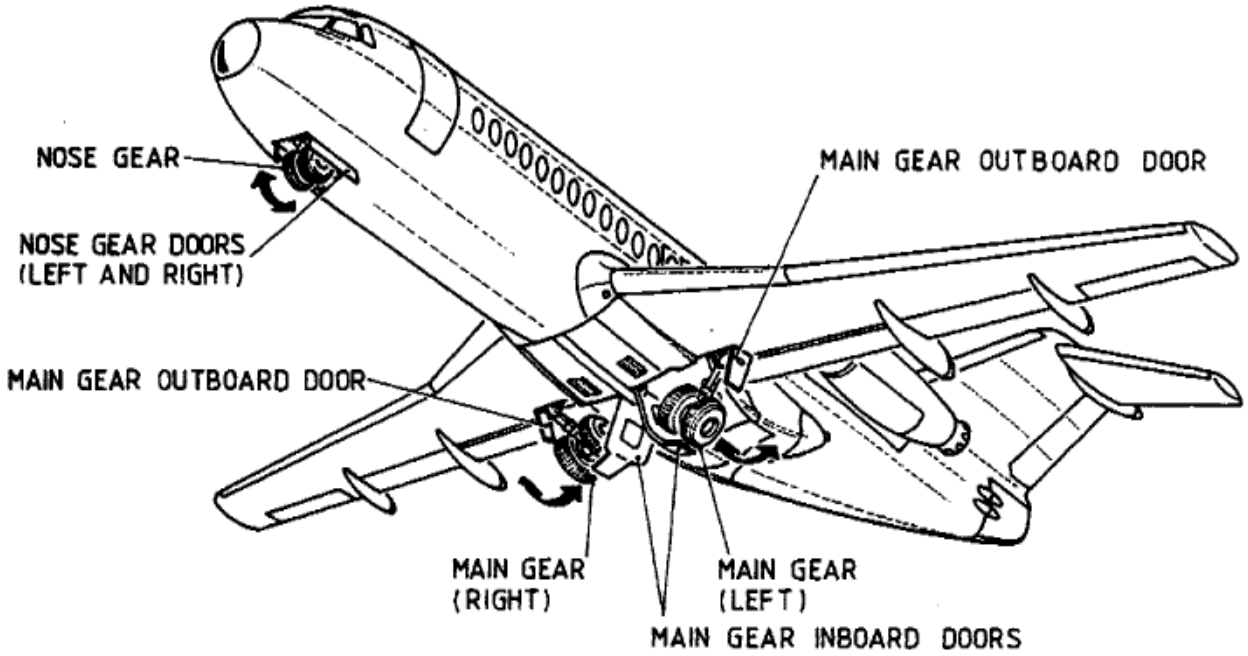
Auxiliary Landing Gear, consists of tail or nose wheel; skids; necessary cowling.



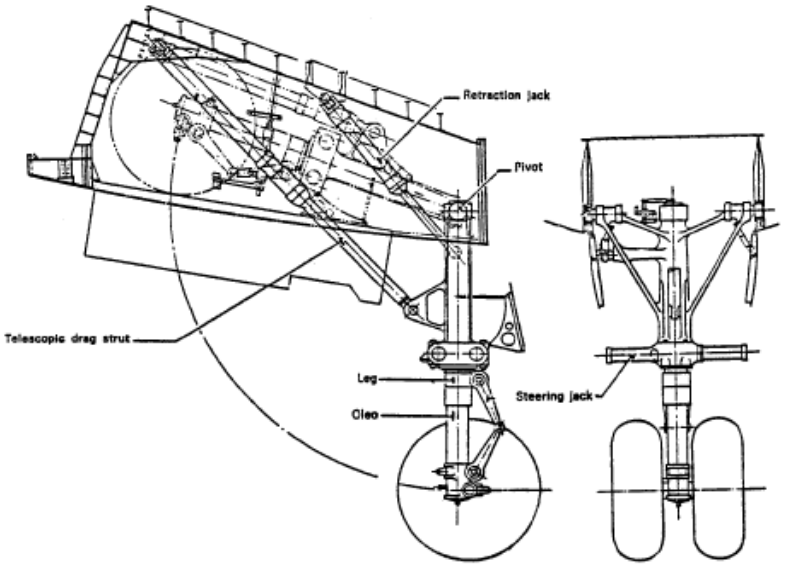
Touchdown Video

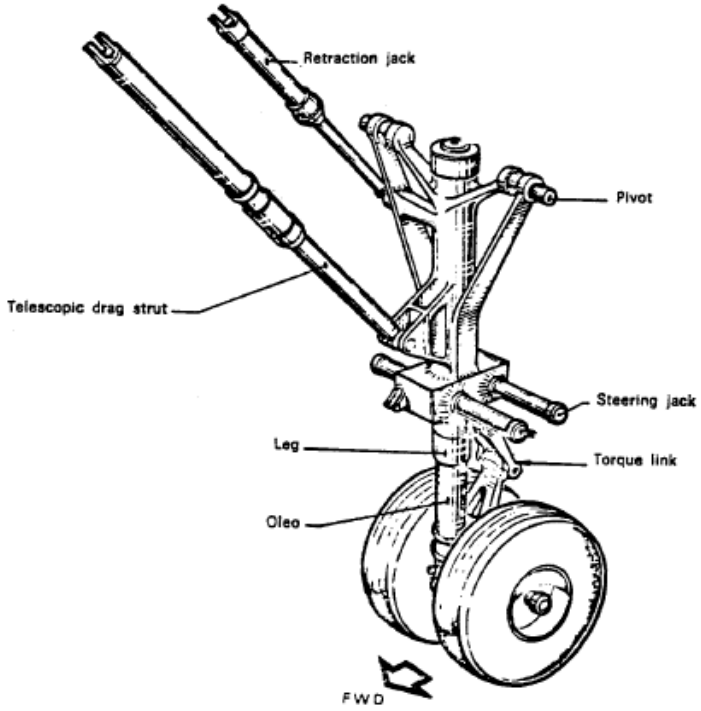
Landing Gear System

Tricycle landing gear retractable are arrangement with the Main Gears and Nose Gear.
Main gear consist of two oleo/pneumatic struts with pair of wheels and brakes.
Nose gear steerable oleo/pneumatic.



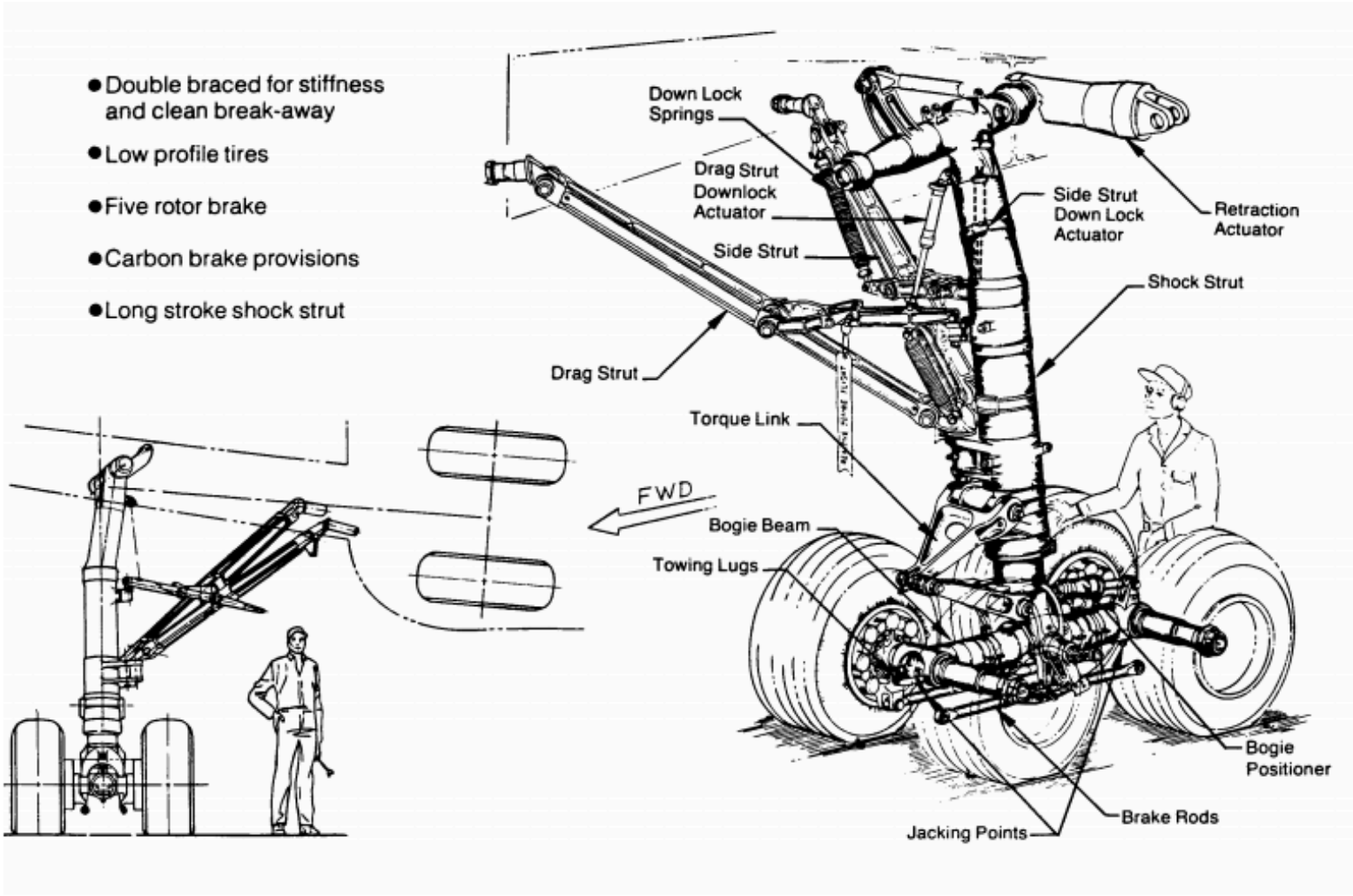
Struts and Shock Absorbers





NLG (Nose Landing Gear) , Airbus A300

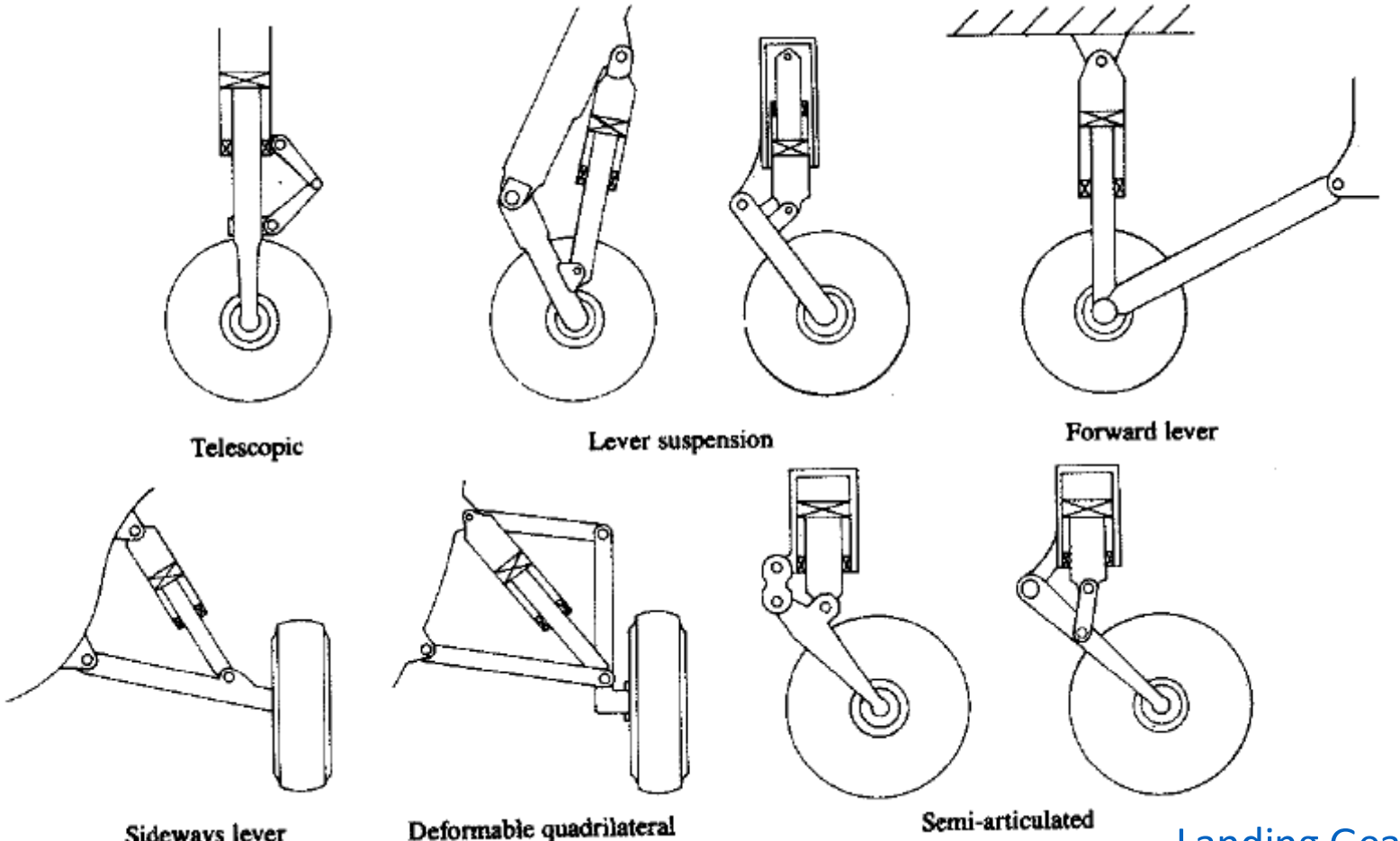
Struts and Shock Absorbers



MLG (Main Landing Gear) , Boeing B767

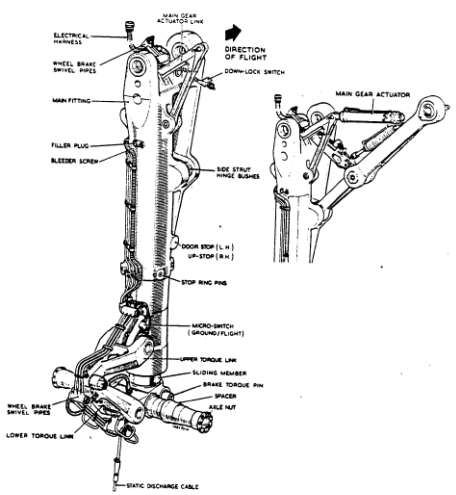
Struts and Shock Absorbers

Overview Strut-Types

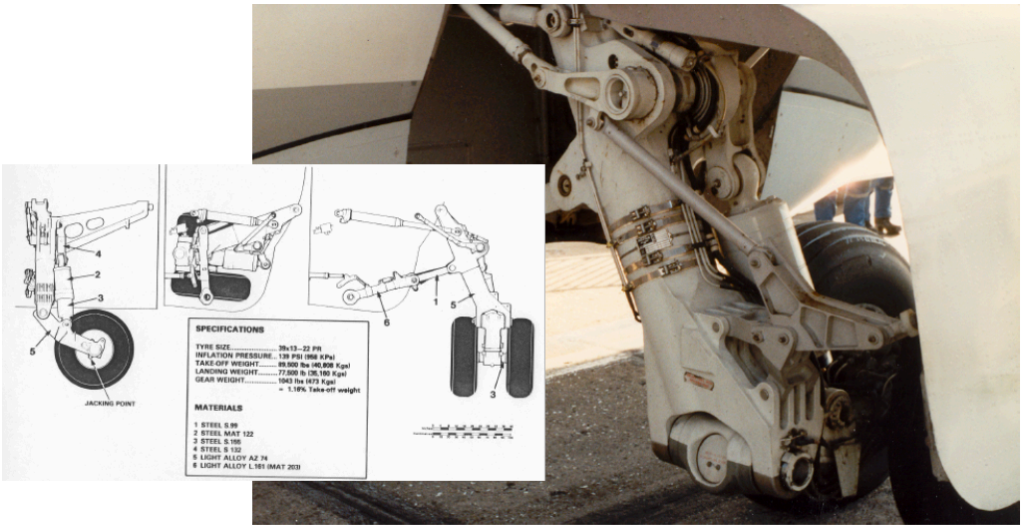


Landing Gear Animation

Struts and Shock Absorbers



Telescopic-type MLG , Fokker F-28



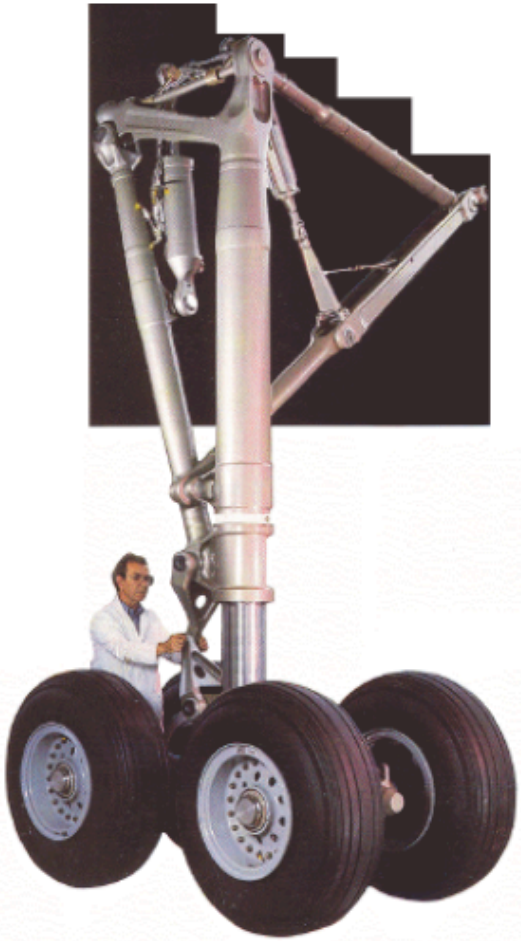
Lever-type MLG , BAe 146

Semi-lever-type MLG , TU 154

4 Wheel MLG , Caravelle

Struts and Shock Absorbers

MLG , A300

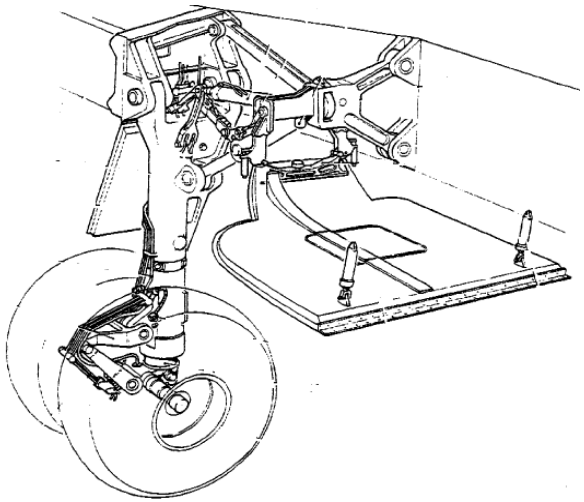


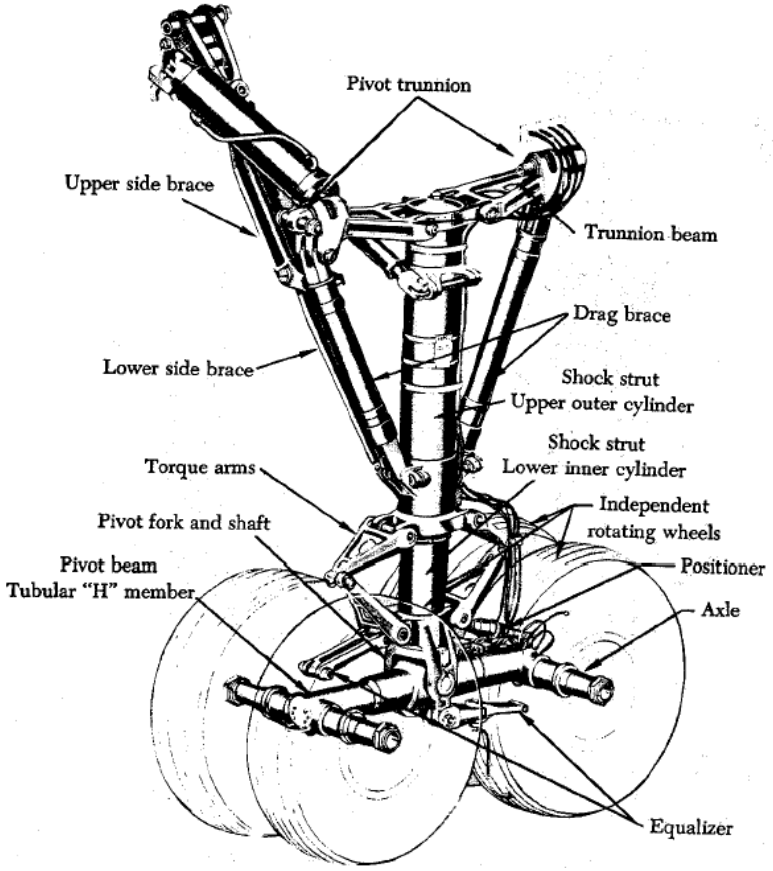
MLG , A310

MLG , A340

Struts and Shock Absorbers

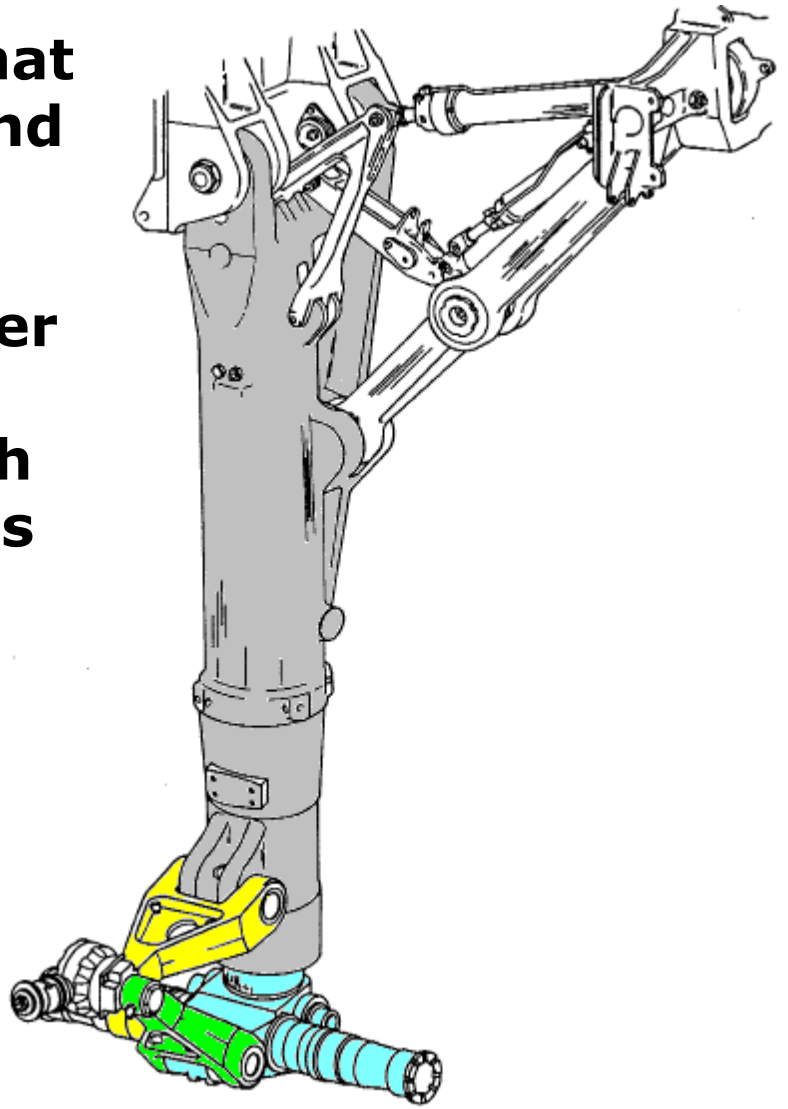
- **Some of aircraft have dual wheels on strut and more than two wheels referred to as "bogie".**
- **Retraction and extension by hydraulic with selector lever in the flight compartment.**
- **Alternate extension can be mechanically, pneumatic compressor air.**





Struts and Shock Absorbers

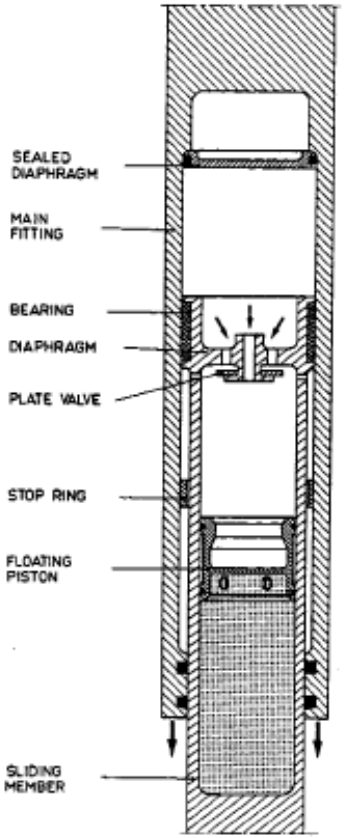
- **Shock strut contains hydraulic that support aircraft on the ground and protect structure by absorbing shock load.**
- **Consists of two telescopic cylinder (inner and outer).**
- **Lower chamber always filled with fluid, the upper chamber contains compressed air.**



Struts and Shock Absorbers

Orifice/metering pin between two chamber provides a passage of fluid during extension retraction.

Controlling the rate of fluid flow during compression. Damping or snubbing on some shock strut equipped to reduce the rebound during extension prevent rapidly extension of shock strut.



Landing Gear Failure

Picture from www.foxnew.com

Airbus A320's Landing Gear failure in 2005

Landing Gear Failure

Picture from www.foxnew.com

Landing Gear Failure

Picture from www.allstar.fiu.edu/aero/flight14.htm

Improperly loaded Boeing 747

Three common types of landing gear

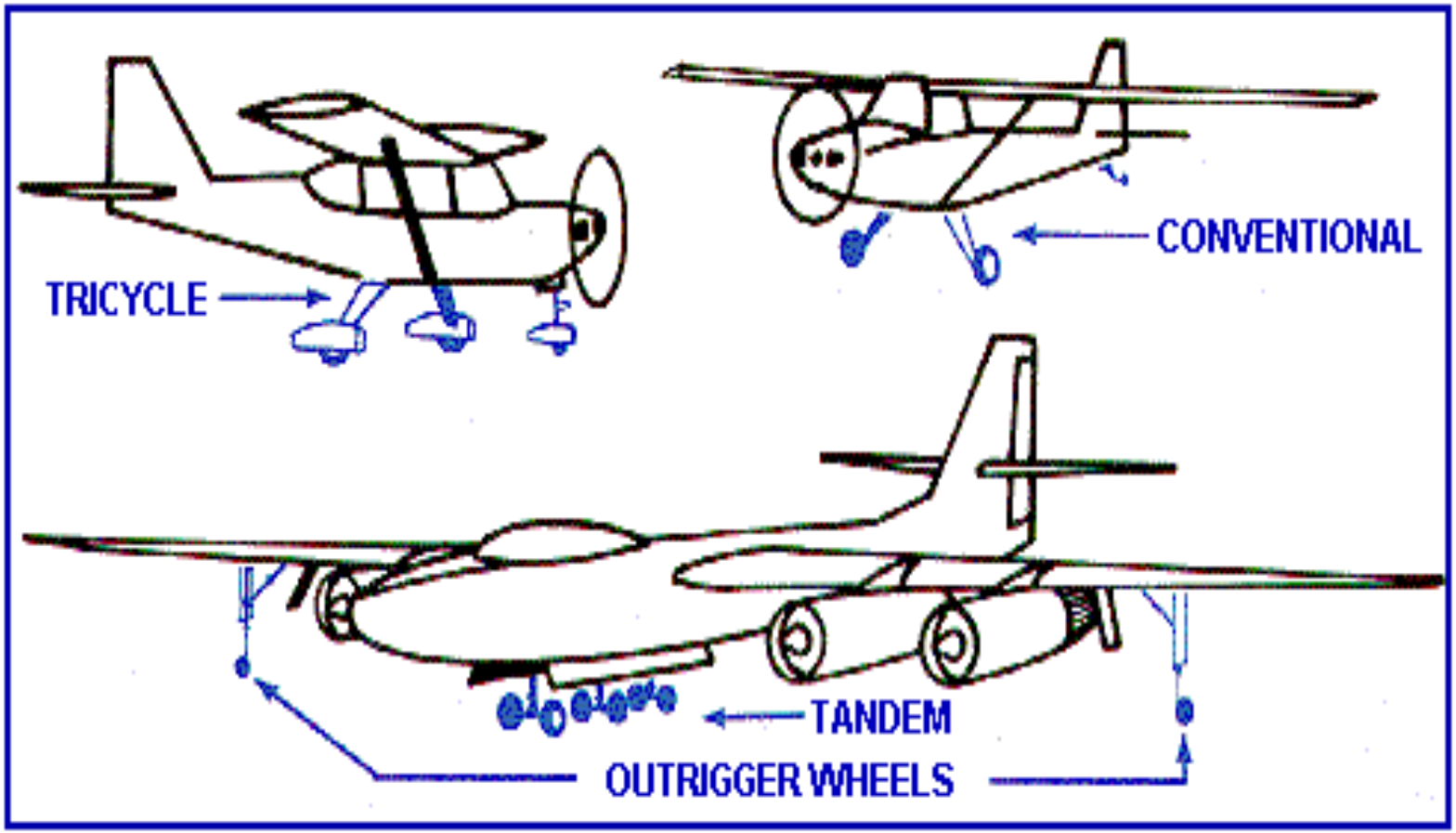
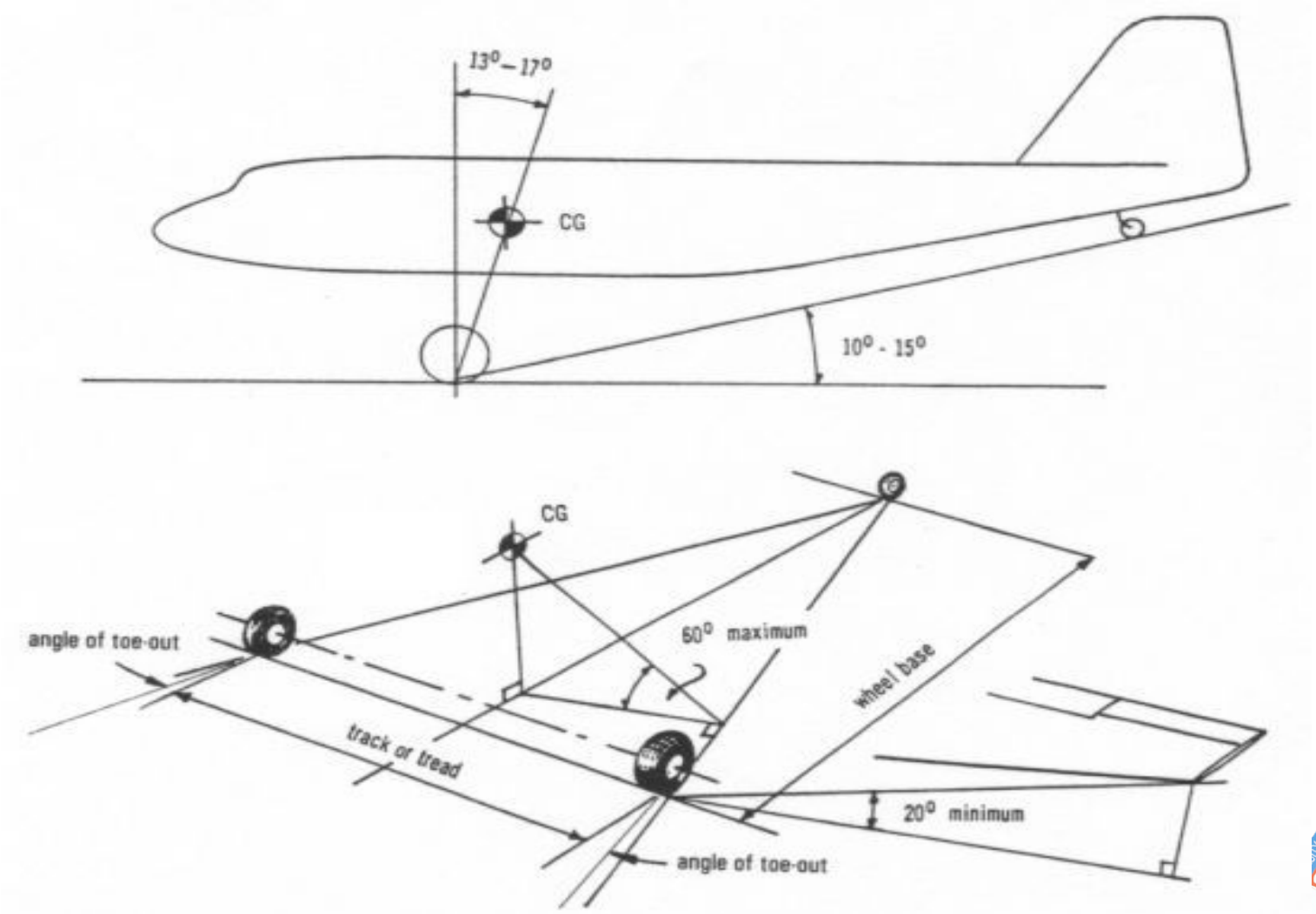


Figure 1-8 Three basic types of landing gear arrangements

Purpose of Landing Gear

- To provides structural support to the aircraft for ground operation
- To provides maneuverability for ground operation
- To provides a mean to absorb unusually loads incurred during landing and ground operation

Design considerations

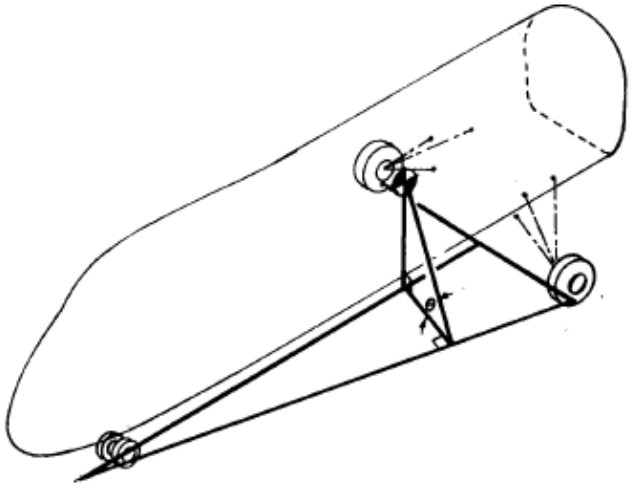


Picture from www.allstar.fiu.edu

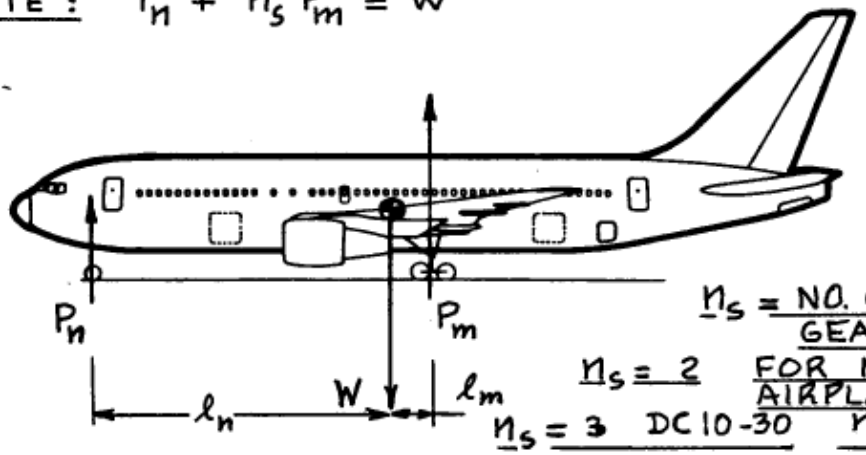
Design considerations

- Maximum strength
- Minimum weight
- High reliability
- Overall aircraft integration
- Low cost
- Airfield compatibility

Landing Gear Design



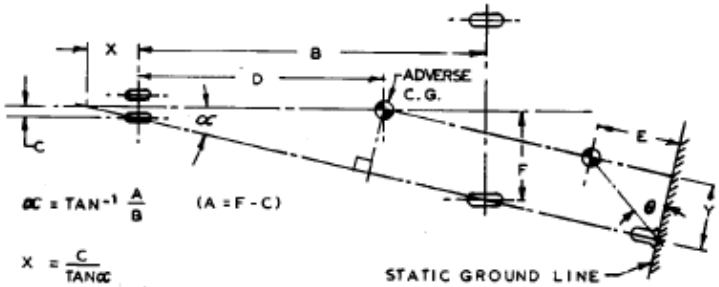
NOTE : $P_n + n_s P_m = W$



n_s = NO. OF MAIN GEAR STRUTS

$n_s = 2$ FOR MOST AIRPLANES

$n_s = 3$ DC 10-30 $n_s = 4$ B747



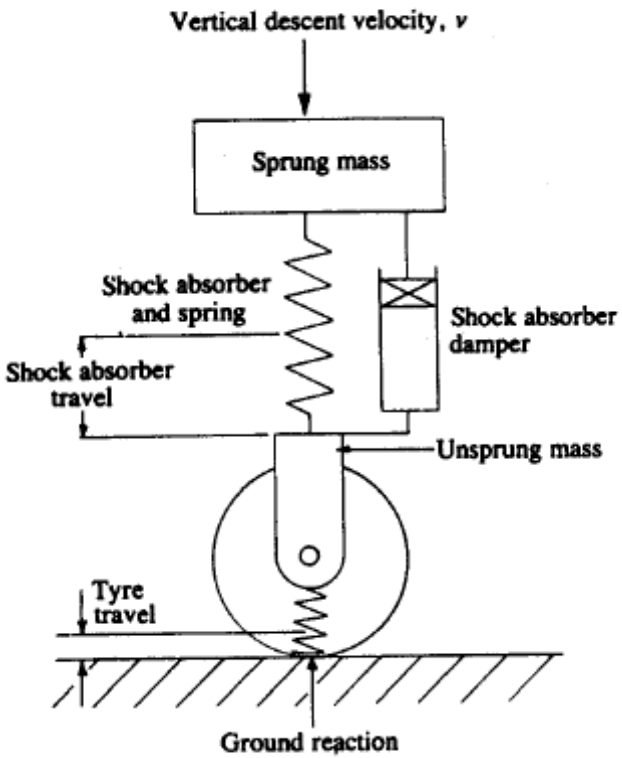
$\alpha = \tan^{-1}\frac{A}{B}$ $(A = F - C)$

$X = \frac{C}{\tan\alpha}$

$Y = (D + X)\sin\alpha$

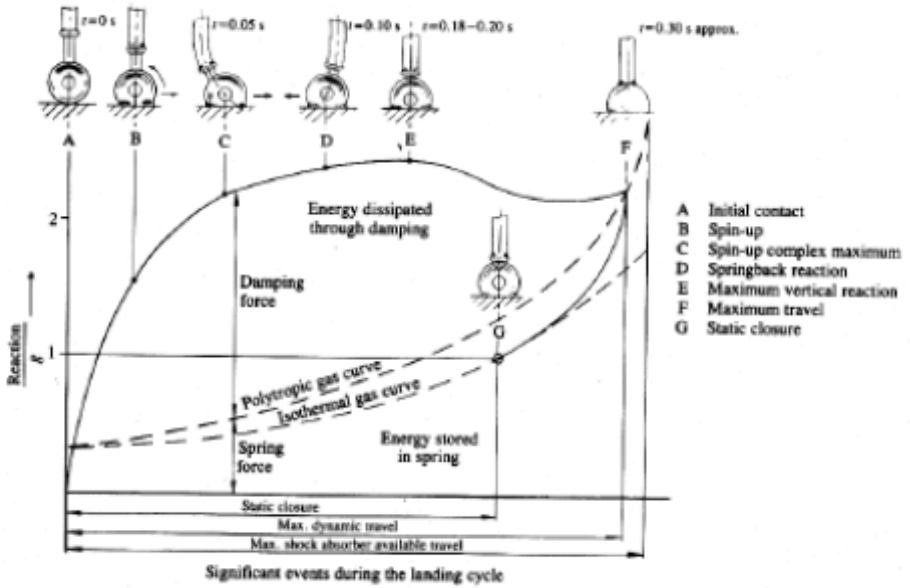
$\theta = \tan^{-1}\frac{E}{Y}$

Landing Gear Design



$$\text{Reaction factor, } \lambda = \frac{\text{Ground reaction}}{\text{Associated mass} \times g}$$

$$\text{Energy} = \tfrac{1}{2} mv^2$$
$$= \lambda . m . g \text{ [shock absorber travel} \times \text{shock absorber efficiency} + \text{tyre travel} \times \text{tyre efficiency]}$$



Significant events during the landing cycle

$$\underset{\text{tire energy}}{(S_t \times n_t \times NW)} + \underset{\text{strut energy}}{(S \times n_s \times NW)} = \underset{\text{kinetic energy}}{WV^2/2g} + \underset{\text{potential energy}}{(W - L)(S + S_t)}$$

where

S_t = tire deflection under N times static load, ft
S = vertical wheel travel, ft (unknown)
n_t = tire efficiency, generally assumed to be 0.47
n_s = shock strut efficiency (assumed initially as 0.80 on an oleo-pneumatic strut)
N = reaction factor
W = aircraft weight, lb
L = lift, lb
V = sink speed, ft/sec

Design consideration

- Landing Gear should locate near the center gravity (CG) of the plane
- CG location are depended on aircraft configuration, loading, fuel state.

Landing Gear Data

Weight:	**2,5 … 5 % of the MTOW**
Cost:	**1.5 to 1.75 % of the Aircraft**
Maintenance:	**20 % of the Airframe DMC**
Loads:	**up to 30,000 kg/wheel**
Speeds:	**over 300 km/h**
Rolling distance:	**up to 500.000 km**
Life time of:	**60.000 hours / 20 years**
In-Service cycle:	**20.000 hours (overhaul)**

Landing Gear Developments

Noise Reduction

- As engines become quieter, landing gear is now making a dominating component of noise in large commercial aircraft
- European co-financed research project Silencer is trying to create low noise landing gear design
- Desires 10db reduction in landing gear noise by 2020, has only dropped 3db so far

Landing Gear Developments

Gear up landing prevention system

- NTSB reports that the majority of gear up landings are due to equipment malfunctions.
- Gear up landing prevention systems will disengage autopilot and alarm at a preset safety altitude if every piece of landing gear is not extended and locked.
- It can be disengaged if a belly landing is the only option.

Materials

- Composites will be integrated into gear because they are stronger and cheaper than the current used high strength steels and titanium

Landing Gear Developments

Materials

- Ultra-High Tensile Steels are already being integrated into the A400M and the B-787 landing gear, replacing the low-alloy steels.
- Research into organic matrix composites and metal matrix composites using titanium are promising, though still very expensive.

Corrosion

- Many modern aircraft have cadmium in the landing gear to prevent corrosion and chrome plating to reduce friction wear.
- Advancements in stainless steels and titanium will replace the cadmium in landing gear.

Test and Certification

- Landing Gear Certification is part of the Aircraft Certification
- Test are performed at the suppliers facilities
- Normally 4 prototypes are simultaneously used for:
- Performance Test
- Fatigue Test
- Strength Test
- Drop Test