Research on the nose landing gear of a military training aircraft

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Abstract: *This paper presents the analysis of the landing gear configurations and the proposal of a solution for a military training aircraft. The paper presents both landing gears: nose and main because they are inextricably linked. The nose landing gear of military aircraft is a complex system composed of structural elements, electric and hydraulic components, energy absorption components, aircraft tire wheels etc., which is dimensioned according to the weight of the aircraft. Additional components attached to the nose landing gear include a landing gear extension and retraction mechanism and a steering system. The landing gear must withstand the weight of the aircraft in all phases of take-off (maximum weight: fuel, armament, ammunition, other equipment, flight crew etc.) and landing (impact from landing and a lower weight after completing the mission due to fuel consumption and ammunition use).*

Key Words: *Nose landing gear, main landing gear, steering system, extension and retraction mechanism*

1. INTRODUCTION

Military aircraft can be of various types (see Figure 1):

- Attack aircraft;
- Bombing aircraft;
- Air combat aircraft;
- Aircraft for electronic warfare;
- Aircraft with early warning and control systems;
- Air transport aircraft for military troops or equipment;
- Multi-role combat aircraft;
- School and training aircraft.

Military aircraft are equipped with a tricycle landing gear (a nose landing gear and two main landing gear positioned left and right under the wings) in a strongly reinforced area. The nose landing gear of military aircraft is a complex system composed of structural elements, electric and hydraulic components, energy absorption components, aircraft tire wheels etc.,

which is dimensioned according to the weight of the aircraft. Additional components attached to the nose landing gear include a landing gear extension and retraction mechanism and a steering system. The landing gear must withstand the weight of the aircraft in all phases of take-off (maximum weight: fuel, armament, ammunition, other equipment, flight crew etc.) and landing (impact from landing and a lower weight after completing the mission due to fuel consumption and ammunition use).

Boeing F-15E Eagle attack aircraft [12]

Northrop Grumman B-2 Spirit - bomber aircraft [13]

Boeing F-22 Raptor - fighter aircraft [14]

E-2D Advanced Hawkeye-3 – aircraft for electronic warfare [15]

AWACS - aircraft with early warning and control systems [16]

Lockheed Martin C5 Galaxy - air transport aircraft for troops or equipment [17]

F-22 Raptor - multi-role fighter aircraft [18]

Boeing Saab T-X - school and training aircraft [19]

Fig. 1 Various types of military aircraft

There are a large number of different landing gear configurations to be used on different types of aircraft, depending on the size, type of aircraft and the environment in which the aircraft operates at take-off and landing: ground, water or snowy areas (see figures 2 and 3).

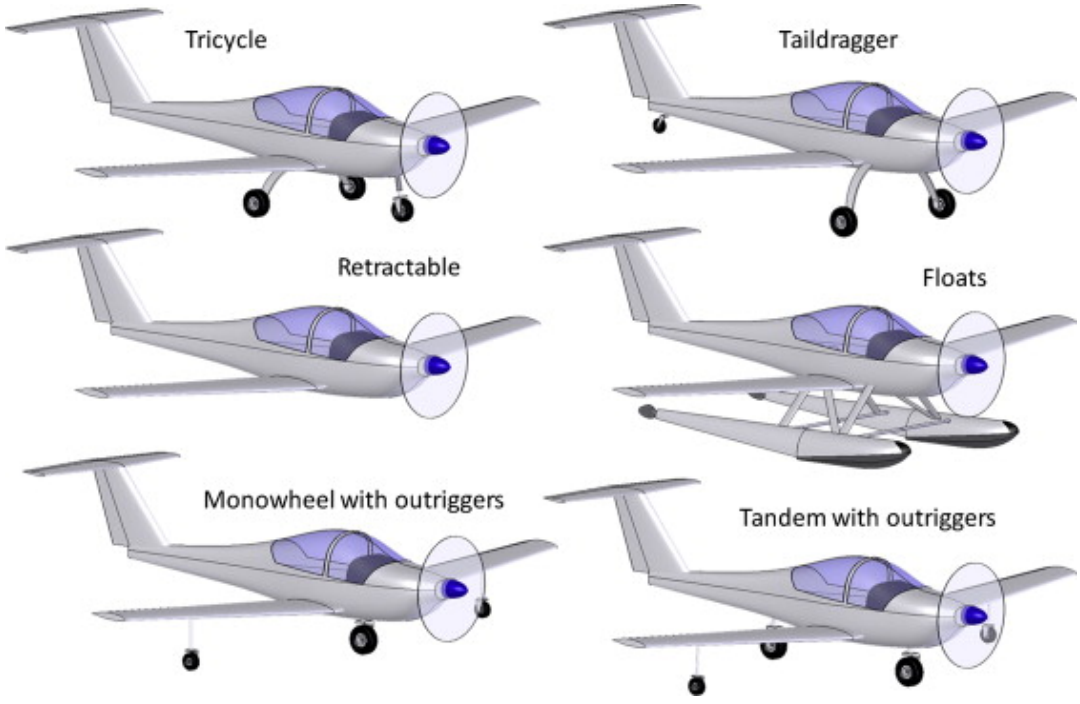

Fig. 2 Types of landing gear used in general aviation [20]

Aircraft operating exclusively on the ground have a fixed or retractable landing gear with wheels and air tires (see Figure 3).

Aircraft operating exclusively on water have a fixed landing gear with airtight, air-filled metal floats, and aircraft operating exclusively on snow have a ski landing gear. There are variants in which the skis are installed under the landing gear wheels (see figure 3).

The most used landing gear configuration is the tricycle, used for commercial and military aircraft; this configuration comprises the nose landing gear which is placed in front of the aircraft and the main landing gear consisting of two symmetrical components, left – right, placed under the aircraft wings in a heavily reinforced area (see Figure 3).

In the aircraft categories mentioned above, the landing gear is retractable, i.e. it is retracted into aircraft structure after take-off.

The retraction action of the landing gear is commanded by the pilots, immediately after the aircraft reaches the safety altitude and speed.

The landing gear of the aircraft structure is closed by doors that fit perfectly into the outer geometry of the aircraft to ensure an optimal aerodynamic profile for the aircraft in order to minimize the drag.

The doors move synchronously with the landing gear both when the landing gear is extended and retracted.

As the aircraft prepares to land, the pilots order the landing gear to be extended. After the pilots command, the doors open and the landing gear is extended.

Tricycle, retractable [21]

Fixed with floats [22]

Tricycle, retracted [23]

With skis mounted under wheels [24]

Fig. 3 Various types of landing gear for military aircraft

Each extreme position of the landing gear, extended or retracted, is mechanically locked to prevent the accidental retraction or extension of the landing gear.

Extreme positions are properly signaled on board the aircraft, but only after the mechanical locking of the landing gear.

2. NOSE LANDING GEAR FOR A MILITARY TRAINING AIRCRAFT

The nose landing gear for military training aircraft consists of the following main parts (see Figure 4):

- hydraulic or pneumatic shock absorber (nose landing gear body) consists of an upper cylinder and a lower rod by forcing fluid through a restriction;
- steering system of the nose landing gear wheel;
- tire;
- rim;
- wheel axle;
- wheel fork;
- torsion arms;
- trunnion of the nose landing gear;
- ear for the hydraulic drive cylinder which allows extension/ retraction of the nose landing gear;
- hydraulic or pneumatic shock absorber vent valve.

The typical pneumatic/ hydraulic shock absorber uses compressed air or nitrogen combined with hydraulic fluid to absorb and dissipate shock loads from landing.

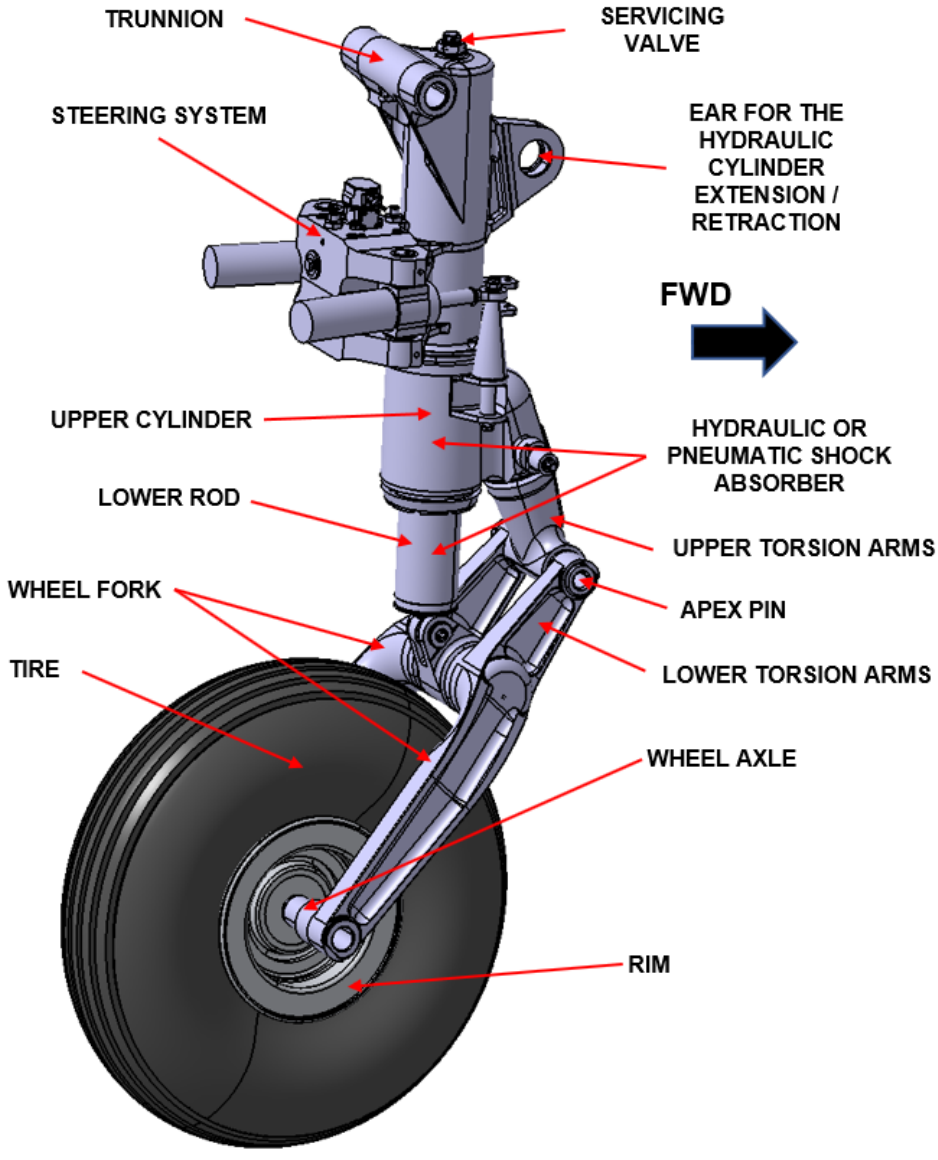

Fig. 4 Nose landing gear

The shock absorber of the nose landing gear is fitted with a pair of positioning cams to keep the nose landing gear wheel aligned.

A cam with protrusions is attached to the lower cylinder and a cam with mating recesses is attached to the upper cylinder.

These cams align the wheel assembly and the shock absorber shaft in an upright position when the shock absorber is fully extended.

This allows the nose landing gear wheel to fit snugly into the fuselage place when the nose landing gear is retracted and prevents structural damage to the aircraft.

This cam also aligns the wheels with the longitudinal axis of the aircraft before landing when the nose landing gear is fully extended (see Figure 5).

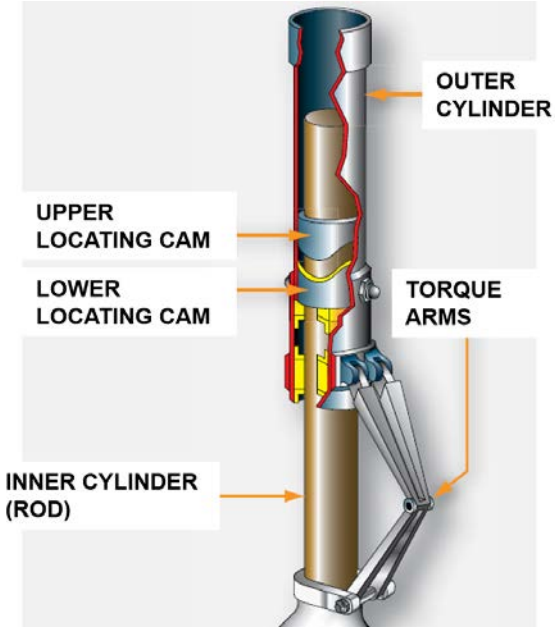

Fig. 5 Positioning cams of nose landing gear [14]

The shock absorber consists of two telescopic cylinders that are closed at the outer ends. The upper cylinder is attached to the structure of the aircraft, and the lower cylinder, which is called the rod, is free to slide into the upper cylinder. Two chambers are formed: the lower chamber is always filled with hydraulic fluid, and the upper chamber is filled with compressed air or nitrogen.

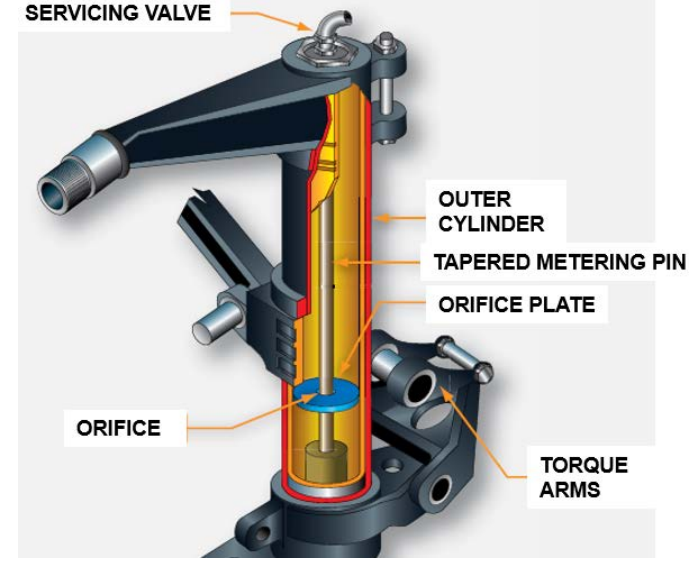

Fig. 6 The shock absorber for a nose landing gear [14]

A hole in the plate separating the space between the two cylinders provides a passageway for fluid from the lower chamber to enter the upper cylinder when compressed and vice versa when the shock absorber relaxes (see Figures 6 and 7) [1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11].

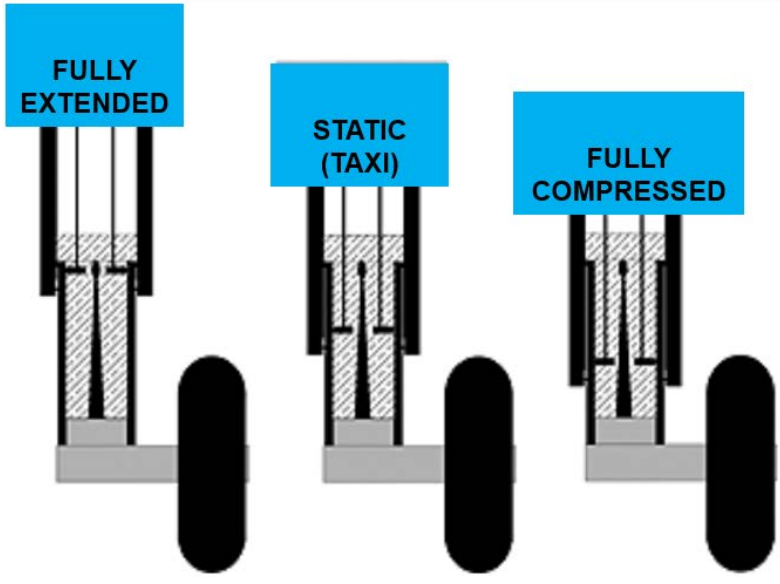

Fig. 7 Diagram of the hydraulic shock absorber [5]

In older shock absorbers, the separator plate with hole and conical rod which together constitute a throttle are missing, and the variable volume chamber is partly filled with hydraulic fluid and partly with compressed air or nitrogen, as in figure 8 [1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11].

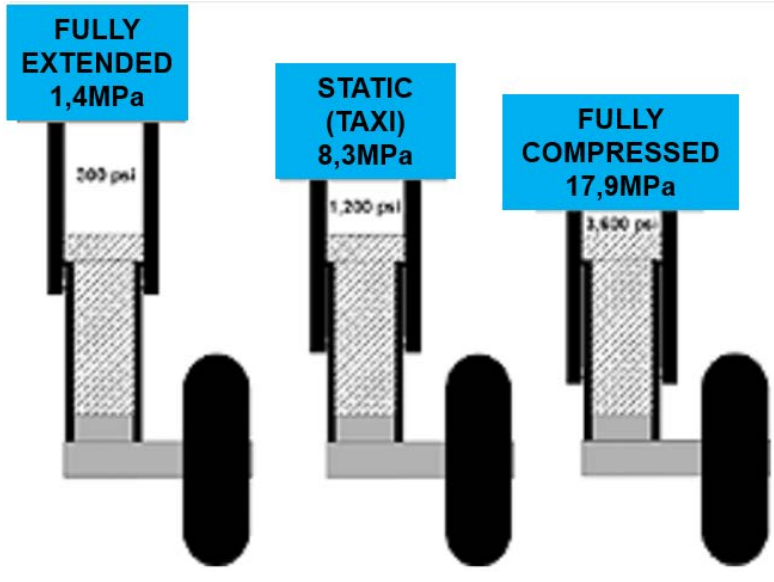

Fig. 8 Diagram of the pneumatic / hydraulic shock absorber [5]

It is observed that as the shock absorber approaches its fully compressed state, the pressure in the two fluids increases, as shown in Figure 8. The upper cylinder of a shock absorber contains a servicing valve located at the top of the upper cylinder (see figures 4 and 6). The

servicing valve allows filling or emptying with hydraulic fluid and air or nitrogen according to the manufacturer's specifications. At the lower end of the upper cylinder there are sealing rings and a scraper ring between the two cylinders that form a translation coupling (see figure 5). To keep the rod and wheel aligned, most shock absorbers are equipped with torsion arms. One end of the arms is attached to the fixed upper cylinder. The other end is attached to the lower cylinder (rod) so that it cannot rotate. Thus, the wheel is aligned. The torsion arms also hold the rod in the lower end of the upper cylinder when the shock absorber is extended, i.e. after take-off or before landing [1, 7, 8, 11, 14, 15, 20, 23, 25, 26] (see Figures 4 and 5).

The nose landing gear is provided, in most cases, with shimmy damping devices (see figure 9) or which are included in the steering system (see figure 4).

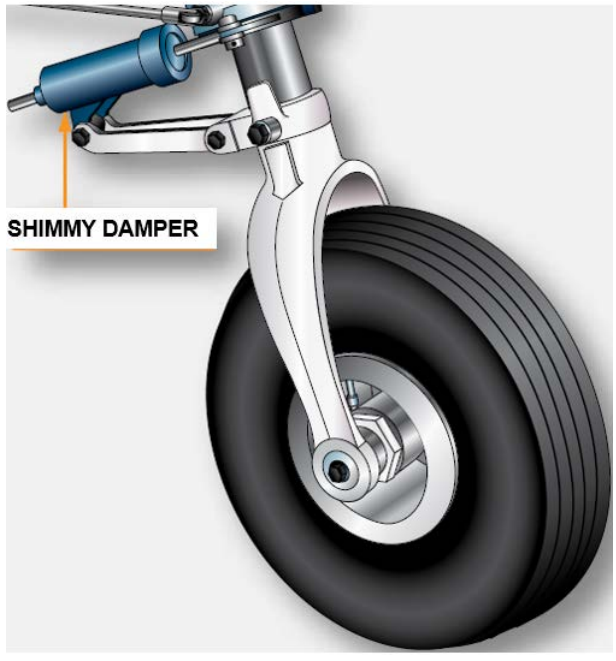

Fig. 9 Shimmy damper [5]

3. THE ROLE OF THE LANDING GEAR

The position of the nose landing gear, of the main landing gear (left and right) and of the doors that close/ open the places in the fuselage after the extension of the trains, and after their retraction, respectively, is shown in figure 10.

The landing gear system provides the following functions [1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11]:

• allows the extension and blocking of landing gear in normal operation and emergency mode (free fall of landing gear);

• allows the retraction and blocking of landing gear in normal working mode;

• manages the sequence of opening / closing the doors during the extension and retraction of the landing gear;

• signals the position of the landing gear and their locking in the extended or retracted positions, on board of the aircraft, as in figure 11;

• provides signals weight on the wheel on board of the aircraft when the wheels are in contact with the runway. Landing gear also offers the following "mechanical functions" [1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11]:

Fig. 10 Landing gear for a military school and training aircraft

• absorbs landing and taxi loads (with shock absorber, wheels and tires);

• ensures that the wheels of the front train are aligned when the front landing gear is fully extended;

• provides shimmy damping for the nose landing gear wheel.

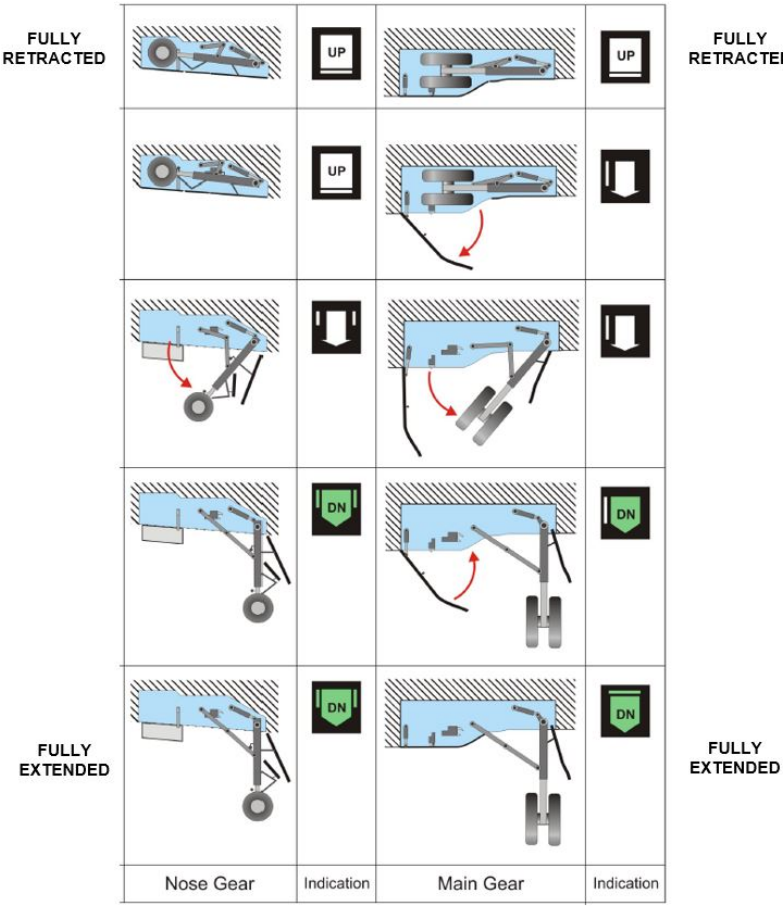

Fig. 11 Extending of a landing gear and indications on board the aircraft [26]

4. CONCLUSIONS

This paper presents the analysis of the landing gear configurations and the proposal of a solution for a military training aircraft. The paper presents both landing gears: nose and main because they are inextricably linked.

The purpose of the landing gear on an aircraft is to provide a support and running system during taxi, take-off and landing operations. The landing gear is designed to absorb and dissipate the kinetic energy of the landing impact, thus reducing the impact loads transmitted to the aircraft structure. The landing gear also facilitates the braking of the aircraft using a main landing gear wheel braking system and ensures directional control of the aircraft on the ground by means of a steering system of the wheels of the nose landing gear.

In all military aircraft the landing gear is designed to be retractable to minimize the aerodynamic drag of the aircraft during flight.

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