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## A Study on Landing Gear Arrangement of an Aircraft

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**ABSTRACT:** Landing gear is a vital structural unit of an aircraft which enables to take off and land safely on the ground. A variety of landing gear arrangements are used depending on the type and size of an aircraft. The most common type is the tri-cycle arrangement with one nose landing gear unit and two main landing gear units. Even during a normal landing operation heavy loads (equal to the weight of an aircraft) are to be absorbed by the landing gear. In turn joints are to be provided such that heavy concentrated loads are first received by the airframe and subsequently diffused to the surrounding areas. Normally heavy concentrated loads are received through a lug joint. Therefore design of a lug joint against failure under static and fatigue loading conditions assumes importance in the development of an aircraft structure.

**KEYWORDS:** Landing Gear types and Arrangement.

### I. INTRODUCTION

Aircraft is machine that is able to fly from one place to another place. Many researches were made to fly the machine since from mythology, many had lost their life during their experiments, and many failed to fly their machine. But finally in 1910 Wright Brothers build machine which is able to fly for 59seconds, which is very short duration but it is first milestone for development of aviation. Further many researches were made to transport the goods and passengers. Then it is brought into business for transportation. And also used in military for air support, thus many fighter planes are developed. An aircraft is a machine that is able to fly by gaining support from the air, or, in general, the atmosphere of a planet. It counters the force of gravity by using either static lift or by using the dynamic lift of an aerofoil, or in a few cases the downward thrust from jet engines. The human activity that surrounds aircraft is called aviation. Landing gear is one of the critical subsystem of an aircraft and is often configured along with aircraft structure.

### II. LITERATURE SURVEY

#### Types of Landing Gear:

##### Tail wheel-type Landing Gear:-

Tail wheel-type landing gear is also known as conventional gear because many early aircraft use this type of arrangement. The main gear are located forward of the centre of gravity, causing the tail to require support from a third wheel assembly. A few early aircraft designs use a skid rather than a tail wheel. This helps slow the aircraft upon landing and provides directional stability. The resulting angle of the aircraft fuselage, when fitted with conventional gear, allows the use of a long propeller that compensates for older, underpowered engine design. The increased clearance of the forward fuselage offered by tail wheel-type landing gear is also advantageous when operating in and out of non-paved runways. Today, aircraft are manufactured with conventional gear for this reason and for the weight savings accompanying the relatively light tail wheel assembly.

The proliferation of hard surface runways has rendered the tail skid obsolete in favor of the tail wheel. Directional control is maintained through differential braking until the speed of the aircraft enables control with the rudder. A steerable tail wheel, connected by cables to the rudder or rudder pedals, is also a common design. Springs are incorporated for dampening.

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*Tail wheel configuration landing gear on a DC-3 (left) and a STOL Maule MX-7-235 Super Rocket.*

### Tandem Landing Gear:-

Few aircraft are designed with tandem landing gear. As the name implies, this type of landing gear has the main gear and tail gear aligned on the longitudinal axis of the aircraft. Sailplanes commonly use tandem gear, although many only have one actual gear forward on the fuselage with a skid under the tail. A few military bombers, such as the B-47 and the B-52, have tandem gear, as does the U2 spy plane. The VTOL Harrier has tandem gear but uses small outrigger gear under the wings for support. Generally, placing the gear only under the fuselage facilitates the use of very flexible wings. The tailwheel aircraft also sits with its nose higher than tricycle gear airplane, lowering forward visibility for the pilot during ground operations. It's more difficult to taxi without being able to see directly in front of you, which is why you'll often see pilots of tailwheel aircraft do S-turns while taxiing.

And steering a tailwheel aircraft is different than steering a nosewheel aircraft since steering is accomplished from behind the pilot instead of in front. There are certainly benefits to a taildragger, as well. The nose-high attitude on the ground means that the propellers on tailwheel aircraft often have more clearance from the ground, making them better suited for grass or dirt runways. And they're often designed and configured for slow flight, making them easier to land on short runways. Many are high-design and are better suited for backcountry flying than nosewheel aircraft are. Tailwheel airplanes are without a doubt the favorite airplane among bush pilots.



*Tandem landing gear along the longitudinal axis of the aircraft permits the use of flexible wings on sailplanes (left) and select military aircraft like the B-52 (center). The VTOL Harrier (right) has tandem gear with outrigger-type gear.*

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## Tri-Cycle Type Landing Gear:-

The most commonly used landing gear arrangement is the tricycle-type landing gear. It is comprised of main gear and nose gear. In this type of Gears the main gears are mounted below the wings. COG is exactly in between the nose wheel nose Gear and main Gear. Tricycle-type landing gear is used on large and small aircraft with the following benefits:

1. Allows more forceful application of the brakes without nosing over when braking, which enables higher landing speeds.
2. Provides better visibility from the flight deck, especially during landing and ground manoeuvring.
3. Prevents ground-looping of the aircraft. Since the aircraft centre of gravity is forward of the main gear, forces acting on the centre of gravity tend to keep the aircraft moving forward rather than looping, such as with a tail wheel-type landing gears.

The nose gear of a few aircraft with tricycle-type landing gear is not controllable. It simply casters as steering is accomplished with differential braking during taxi. However, nearly all aircraft have steerable nose gear. On light aircraft, the nose gear is directed through mechanical linkage to the rudder pedals. Heavy aircraft typically utilize hydraulic power to steer the nose gear. Control is achieved through an independent tiller in the flight deck.

The main gear on a tricycle-type landing gear arrangement is attached to reinforced wing structure or fuselage structure. The number and location of wheels on the main gear vary. Many main gear have two or more wheels. Multiple wheels spread the weight of the aircraft over a larger area. They also provide a safety margin should one tire fail. Heavy aircraft may use four or more wheel assemblies on each main gear. When more than two wheels are attached to a landing gear strut, the attaching mechanism is known as a bogie.



Tricycle-type landing gear with dual main wheels on a Learjet (left) and a Cessna 172, also with tricycle gear (right).

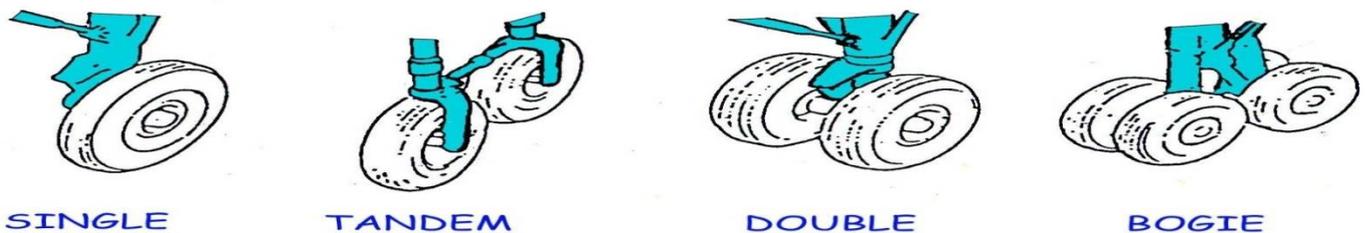


Fig:- Different types of Landing Gear

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**Fixed and Retractable Landing Gear:-** Further classification of aircraft landing gear can be made into two categories: fixed and retractable. Many small, single engine light aircraft have fixed landing gear, as do a few light twins. This means the gear is attached to the airframe and remains exposed to the slipstream as the aircraft is flown. As discussed in Chapter 2 of this handbook, as the speed of an aircraft increases, so does parasite drag. Mechanisms to retract and stow the landing gear to eliminate parasite drag add weight to the aircraft. On slow aircraft, the penalty of this added weight is not overcome by the reduction of drag, so fixed gear is used. As the speed of the aircraft increases, the drag caused by the landing gear becomes greater and a means to retract the gear to eliminate parasite drag is required, despite the weight of the mechanism.

A great deal of the parasite drag caused by light aircraft landing gear can be reduced by building gear as aerodynamically as possible and by adding fairings or wheel pants to streamline the airflow past the protruding assemblies. A small, smooth profile to the oncoming wind greatly reduces landing gear parasite drag. A Cessna aircraft landing gear used on many of the manufacturer's light planes. The thin cross section of the spring steel struts combine with the fairings over the wheel and brake assemblies to raise performance of the fixed landing gear by keeping parasite drag to a minimum.

Retractable landing gear stow in fuselage or wing compartments while in flight. Once in these wheel wells, gear are out of the slipstream and do not cause parasite drag. Most retractable gear have a close fitting panel attached to them that fairs with the aircraft skin when the gear is fully retracted. Other aircraft have separate doors that open, allowing the gear to enter or leave, and then close again.

In addition to supporting the aircraft for taxi, the forces of impact on an aircraft during landing must be controlled by the landing gear. This is done in two ways: 1) the shock energy is altered and transferred throughout the airframe at a different rate and time than the single strong pulse of impact, and 2) the shock is absorbed by converting the energy into heat energy. Many aircraft utilize flexible spring steel, aluminium, or composite struts that receive the impact of landing and return it to the airframe to dissipate at a rate that is not harmful. The gear flexes initially and forces are transferred as it returns to its original position. The most common example of this type of non-shock absorbing landing gear are the thousands of single-engine Cessna aircraft that use it. Landing gear struts of this type made from composite materials are lighter in weight with greater flexibility and do not corrode.



Fig:- Retractable Landing Gear

### Alignment system of Landing Gear:-

As previously mentioned, a torque arm or torque links assembly keeps the lower strut cylinder from rotating out of alignment with the longitudinal axis of the aircraft. In some strut assemblies, it is the sole means of retaining the piston in the upper strut cylinder. The link ends are attached to the fixed upper cylinder and the moving lower cylinder with a hinge pin in the center to allow the strut to extend and compress.

Alignment of the wheels of an aircraft is also a consideration. Normally, this is set by the manufacturer and only requires occasional attention such as after a hard landing. The aircraft's main wheels must be inspected and adjusted, if necessary, to maintain the proper tow-in or tow-out and the correct camber. Tow-in and tow-out refer to the path a main

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wheel would take in relation to the airframe longitudinal axis or centerline if the wheel was free to roll forward. Three possibilities exist. The wheel would roll either: 1) parallel to the longitudinal axis (aligned); 2) converge on the longitudinal axis (tow-in); or 3) veer away from the longitudinal axis (tow-out).

The manufacturer's maintenance instructions give the procedure for checking and adjusting tow-in or tow-out. A general procedure for checking alignment on a light aircraft follows. To ensure that the landing gear settle properly for a tow-in/tow-out test, especially on spring steel strut aircraft, two aluminum plates separated with grease are put under each wheel. Gently rock the aircraft on the plates to cause the gear to find the at rest position preferred for alignment checks.



Wheel alignment on an aircraft.

A straight edge is held across the front of the main wheel tires just below axle height. A carpenter's square placed against the straight edge creates a perpendicular that is parallel to the longitudinal axis of the aircraft. Slide the square against the wheel assembly to see if the forward and aft sections of the tire touch the square. A gap in front indicates the wheel is towed-in. A gap in the rear indicates the wheel is towed-out.

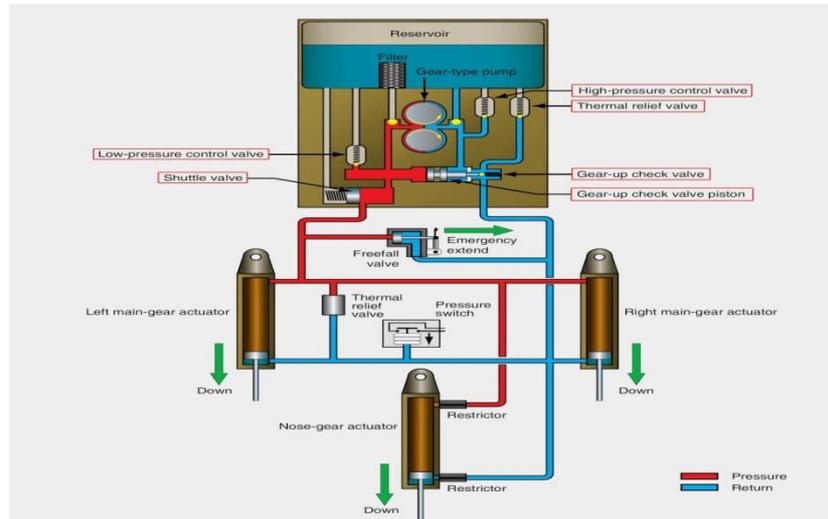
Camber is the alignment of a main wheel in the vertical plain. It can be checked with a bubble protractor held against the wheel assembly. The wheel camber is said to be positive if the top of the wheel tilts outward from vertical. Camber is negative if the top of the wheel tilts inward.

Adjustments can be made to correct small amounts of wheel misalignment. On aircraft with spring steel gear, tapered shims can be added or removed between the bolt-on wheel axle and the axle mounting flange on the strut. Aircraft equipped with air/oil struts typically use shims between the two arms of the torque links as a means of aligning tow-in and tow-out. Follow all manufacturer's instructions.

### Small Aircraft Retraction System:-

As the speed of a light aircraft increases, there reaches a point where the parasite drag created by the landing gear in the wind is greater than the induced drag caused by the added weight of a retractable landing gear system. Thus, many light aircraft have retractable landing gear. There are many unique designs. The simplest contains a lever in the flight deck mechanically linked to the gear. Through mechanical advantage, the pilot extends and retracts the landing gear by operating the lever. Use of a roller chain, sprockets, and a hand crank to decrease the required force is common.

Electrically operated landing gear systems are also found on light aircraft. An all-electric system uses an electric motor and gear reduction to move the gear. The rotary motion of the motor is converted to linear motion to actuate the gear. This is possible only with the relatively lightweight gear found on smaller aircraft.



**Fig:-Gear down condition of light aircraft using hydraulic power pack**

**Large Aircraft Retraction System:-**

Large aircraft retraction systems are nearly always powered by hydraulics. Typically, the hydraulic pump is driven off of the engine accessory drive. Auxiliary electric hydraulic pumps are also common. Other devices used in a hydraulically-operated retraction system include actuating cylinders, selector valves, uplocks, downlocks, sequence valves, priority valves, tubing, and other conventional hydraulic system components. These units are interconnected so that they permit properly sequenced retraction and extension of the landing gear and the landing gear doors.

The correct operation of any aircraft landing gear retraction system is extremely important. An example of a simple large aircraft hydraulic landing gear system. The system is on an aircraft that has doors that open before the gear is extended and close after the gear is retracted. The nose gear doors operate via mechanical linkage and do not require hydraulic power. There are many gear and gear door arrangements on various aircraft. Some aircraft have gear doors that close to fair the wheel well after the gear is extended. Others have doors mechanically attached to the outside of the gear so that when it stows inward, the door stows with the gear and fairs with the fuselage skin.

In the system, when the flight deck gear selector is moved to the gear-up position, it positions a selector valve to allow pump pressure from the hydraulic system manifold to access eight different components. The three downlocks are pressurized and unlocked so the gear can be retracted. At the same time, the actuator cylinder on each gear also receives pressurized fluid to the gear-up side

of the piston through an unrestricted orifice check valve. This drives the gear into the wheel well. Two sequence valves (C and D) also receive fluid pressure. Gear door operation must be controlled so that it occurs after the gear is stowed. The sequence valves are closed and delay flow to the door actuators. When the gear cylinders are fully retracted, they mechanically contact the sequence valve plungers that open the valves and allow fluid to flow into the close side of the door actuator cylinders. This closes the doors. Sequence valves A and B act as check valves during retraction. They allow fluid to flow one way from the gear-down side of the main gear cylinders back into the hydraulic system return manifold through the selector valve.

To lower the gear, the selector is put in the gear-down position. Pressurized hydraulic fluid flows from the hydraulic manifold to the nose gear uplock, which unlocks the nose gear. Fluid flows to the gear-down side of the nose gear actuator and extends it. Fluid also flows to the open side of the main gear door actuators. As the doors open, sequence valves A and B block fluid from unlocking the main gear uplocks and prevent fluid from reaching the down side of the main gear actuators. When the doors are fully open, the door actuator engages the plungers of both sequence valves to

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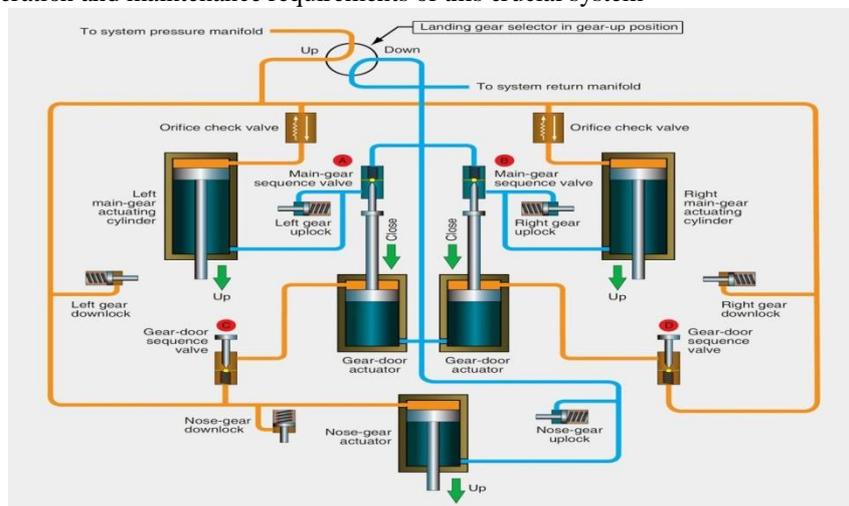
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open the valves. The main gear unlocks, then receives fluid pressure and unlock. The main gear cylinder actuators receive fluid on the down side through the open sequence valves to extend the gear. Fluid from each main gear cylinder up-side flows to the hydraulic system return manifold through restrictors in the orifice check valves. The restrictors slow the extension of the gear to prevent impact damage.

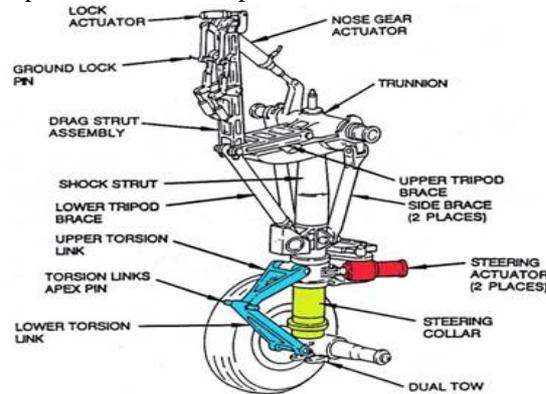
There are numerous hydraulic landing gear retraction system designs. Priority valves are sometimes used instead of mechanically operated sequence valves. This controls some gear component activation timing via hydraulic pressure. Particulars of any gear system are found in the aircraft maintenance manual. The aircraft technician must be thoroughly familiar with the operation and maintenance requirements of this crucial system



**Fig:-Retraction system of large Aircraft using Hydraulic power pack**

### Nose wheel steering system:-

The nose wheel on most aircraft is steerable from the flight deck via a nose wheel steering system. This allows the aircraft to be directed during ground operation. A few simple aircraft have nose wheel assemblies that caster.



**Fig:- Steering system of nose wheel**

Such aircraft are steered during taxi by differential braking. Most small aircraft have steering capabilities through the use of a simple system of mechanical linkages connected to the rudder pedals. Push-pull tubes are connected to pedal horns on the lower strut cylinder. As the pedals are depressed, the movement is transferred to the strut piston axle and

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wheel assembly which rotates to the left or right. Due to their mass and the need for positive control, large aircraft utilize a power source for nose wheel steering.

## III. CONCLUSION

The need to design landing gear with minimum weight, minimum volume, high performance, improved life and reduced life cycle cost have posed many challenges to landing gear designers and practitioners. Further it is essential to reduce the landing gear design and development cycle time while meeting all the safety and regulatory requirements. Many technologies have been developed over the years to meet the challenges of landing gear design and development. These technologies have matured over the years and widely used in the current landing gear system and new technologies will continue to evolve in future. The future landing gear design for aircraft poses many new challenges in configuration design, use of materials, design and analysis methods. These challenges can be met, while adhering to all regulatory requirements of safety, by employing advanced technologies, materials, analysis methods, processes and production methods. By applying functional simulation and developing design tools, the development time and cost are reduced considerably. Use of higher strength materials, composites, and technologies like active damping control, electric systems, along with CAX, KBE and health monitoring technologies will steer the landing gear design in the days to come

## REFERENCES

- 1) Anil Kumar, G.Vijay Kumar, "Design optimisation of Landing Gears Legs for unmanned aerial Vehicle". 4 August, 2012.
- 2) Amit Ghoyal, Dr.H.V.Lakshminarayan "Design, Analysis and simulation of a composite main Landing Gear for light Aircraft". Coventry university postgraduate study centre MSRSAS, Bangalore.
- 3) Clark, S.K.Dodge, R.N.Nybakken "Dynamic properties of Aircraft tires", journal of Aircraft, Vol.11, No.3,1974.
- 4) Sengfelder, Günther (1993). German Aircraft Landing Gear. Atglen, PA USA: Schiffer Publishing. pp. 40–42. ISBN 0-88740-470-7. A significant advantage of this [Ar 232] aircraft was its rough-field landing gear. With the landing gear in the compressed position, the eleven pairs of wheels mounted on independently-sprung legs beneath the fuselage, together with the wide-track main landing gear (8.4 meter, 27 ft 6 in wheel track) and the levered-suspension nose wheel, endowed the aircraft with outstanding rough field capabilities.
- 5) <http://gizmodo.com/the-worlds-largest-cargo-plane-can-swallow-a-737-whole-511093454>
- 6) Canada Aviation and Space Museum (n.d.). "Messerschmitt Me 163B-1a Komet". Retrieved 13 May 2012.
- 7) "Aerostories: Arado 234, July - August 1944: no ordinary missions." Aerostories. Retrieved: 16 March 2016.
- 8) Brewczyński D. and Tora G. (2013): Analysis of the wheel orientation angles in Lockheed F-104S starfighter aircraft. – Journal of Kones, vol.20, No.3, pp.79-87. Cervantes-Sanchez J.J., Moreno-Baez M.A., Aguilera-Cortes L.A. and Gonzalez-Galvan E.J. (2005): Kinematic design of the RSSR-SC spatial linkage based on rotability conditions. – Mechanism and Machine Theory, vol.40, pp.1126– 1144. Chace M.A. (1965): Solutions to the vector tetrahedron equation. – Transactions of the ASME, Journal of Engineering for Industry, vol.87, Series B, pp.228–234.
- 9) Manuale tecnico catalogo nomenclatore illustrato delle parti di ricambio VELIVOLO F-104S. Psang Dain Lin and Jung-Fa Hsieh (2007): A new method to analyze spatial binary mechanisms with spherical pairs. – Journal of Mechanical Design, vol.129, pp.455–458. Reimpell J. and Betzler J. (2004): Car chassis. Basics of structures. – Warsaw: WKiŁ. Shigley J.E. and Uicker J.J. (1995): Theory of Machines and Mechanisms. – McGraw-Hill Book.
- 10) Rkaina, Sam (6 August 2014). "Rosetta probe: Recap updates after spacecraft successfully reached deep space comet orbit". Daily Mirror. Retrieved 24 August 2014.
- 11) S. Ulaeac; S. Espinasse; B. Feuerbacher; M. Hilchenbach; D. Moura; H. Rosenbauer; H. Scheuerle; R. Willnecker (2006). "Rosetta Lander—Philae: Implications of an alternative mission". Acta Astronautica. **58** (8): 435–441. Bibcode:2006AcAau...58..435U. doi:10.1016/j.actaastro.2005.12.009.
- 12) J. Biele (2002). "The Experiments Onboard the ROSETTA Lander". Journal Earth, Moon, and Planets. **90** (1–4): 445–458. Bibcode:2002EM&P...90..445B. doi:10.1023/A:1021523227314.
- 13) Benton, Dale (2016-08-09). "Deep Space Industries' mining ambitions move one step closer with Prospector-1". Mining Global. Retrieved 2016-08-09.
- 14) Bergin, Chris (2016-09-27). "SpaceX reveals ITS Mars game changer via colonization plan". NASASpaceFlight.com. Retrieved 2016-09-27.
- 15) "Making Humans a Multiplanetary Species" (PDF). SpaceX. 2016-09-27. Archived from the original (PDF) on 2016-09-28. Retrieved 2016-10-16.

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