SILVER

Cover Page:

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Abstract

Aircrafts of the 21st century are fast, and reliable. But the development in the field of tilt rotor aircraft is still in its incipient stages. The Silver is an aircraft designed to overcome some of the difficulties that the present tilt rotor aircraft have to face. The Silver has an external structure based on the famous tilt rotor, the V-22 Osprey. The Silver incorporates 2 modified turbofan engines for propulsion. The engine has a fan followed by a set of axial compressors and turbines. The engine has incorporated a mechanism where a vacuum cylinder is incorporated into the principal shaft of the engine. Due to the heat developed by the combustion of fuel, thermal emission takes place from the cathode. The electrons thus emitted travel towards the positive anode with high velocities. Due to the high velocity of the electron current, a large current is created. Because of this current, a mechanical force is experienced by the shaft by virtue of the electron interaction with the magnetic engine case. Due to this the shaft experiences rotational motion which drives the propeller fan. This technology is used as a starting mechanism for the engine and also for thrust augmentation. It is also used as a power saving mechanism when the aircraft is in hover mode.

The Combustion chamber and the fuel injector have been modified in the Silver. Here the fuel injector is made to eject small quantities of a dil. HCl and powder of magnesium. These two combine to liberate hydrogen which has a very high calorific value. The hydrogen is created at the sight of combustion and is used as primary fuel for jet propulsion. This avoids the hassles and the dangers involved in storing and transporting hydrogen gas. This mechanism is employed as a starting mechanism for the flight.

When the aircraft runs for a certain period of time a high amount of heat is generated. The fuel dissociation chamber consists of water containing a definite a quantity of electrolytes. The heat generated dissociates the water molecules into hydrogen and oxygen. This is recombined again to generate energy. This will comprise about 50% of the energy required for operation. The rest is provided by the acid- metal method mentioned above. This mechanism also serves the purpose of engine cooling.

The Silver also incorporates an air friction resisting mechanism where diamagnets comprising of superconducting electromagnets are placed at crucial points on the external surface of the aircraft. This helps in saving power and also adds to propulsion.

The aircraft also employs an innovative auxiliary power unit which stores the excess power from the turbofan engines and uses them during the tilting of the engines and for sucking water into the internal tank.

Introduction

Since the advent of flight, the technology involved in the design of aircrafts has changed radically. But the principle of flight remains the same. Aircrafts today are very efficient and reliable. But they are faced with the challenge of landing on short runways. Helicopters can achieve vertical landing in almost any area, but are constrained to a large extent by their speed and range. To take an intermediate approach, the tilt rotor crafts are designed. The Silver is an attempt to solve the existing problems and constraints faced by the present tilt rotor crafts. It also aims to expand its capabilities by enabling it to land on both water and land.

Today, the tilt rotor crafts are the most efficient and economically viable method of obtaining vertical takeoff and landing. These aircrafts are of extreme use in areas of rescue operations. They are also helpful in reaching remote areas where conventional aircrafts cannot land. But these rotorcrafts are limited in their capabilities as they cannot land in water. Many rotorcrafts are constrained to low cruise speeds and are short range. Keeping all the above factors in mind, the Silver has been designed to deliver the best performance.

Current Rotorcrafts

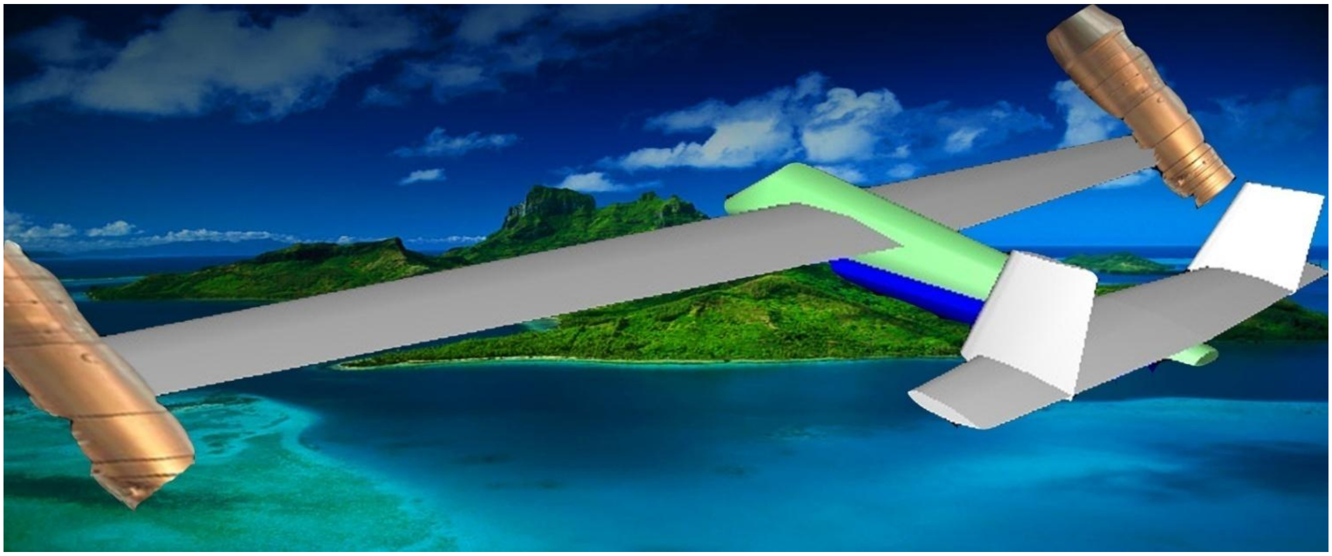
When we speak of rotorcrafts, the earliest attempts of this type would be the helicopters. Then variants such as the auto gyro and the gyro dyne crafts were created. The idea of Vertical lift by the use of tilt able rotors was first suggested by George Lehberger in 1930. The first attempt in this direction was the Baynes heliplane in 1938. This tradition of the tilt rotor propulsion was continued by the Focke-Achgelis Fa 269, Havilland Platt, Bell XV-3, Doak VZ-4 , Curtiss-Wright X-19, EWR VJ 101, Bell X-22 , Aerospatiale N 500 ,Bell XV-15 , V-22 Osprey , Bell Eagle Eye and the Bell/Augusta BA609.

The most popular among these tilt rotor aircrafts are the Bell XV-15 , V-22 Osprey , Bell Eagle Eye and the Bell/Augusta BA609. The basic advantage of a tilt rotor over a helicopter is that it has a higher speed and a greater range. The maximum speed achieved by a helicopter is given by the turn speed of the rotor. IF this speed exceeds a particular limit, then the helicopter would stall .They are also restricted to speeds of about 150 knots. Tilt rotors can achieve speeds of about 300 knots and also achieve altitudes of about 6000m. These types of aircrafts are also less noisy in forward flight when compared to helicopters.

External design

The external fuselage design of any aircraft is done after hours of testing in wind tunnels. The external design cannot be accurately deduced from theoretical calculations. Hence the Silver is designed based on the tilt rotor, the V-22 Osprey. The V-22 is a variant derived from the Bell XV-3 program. It is also the world's first tilt rotor to be mass produced.

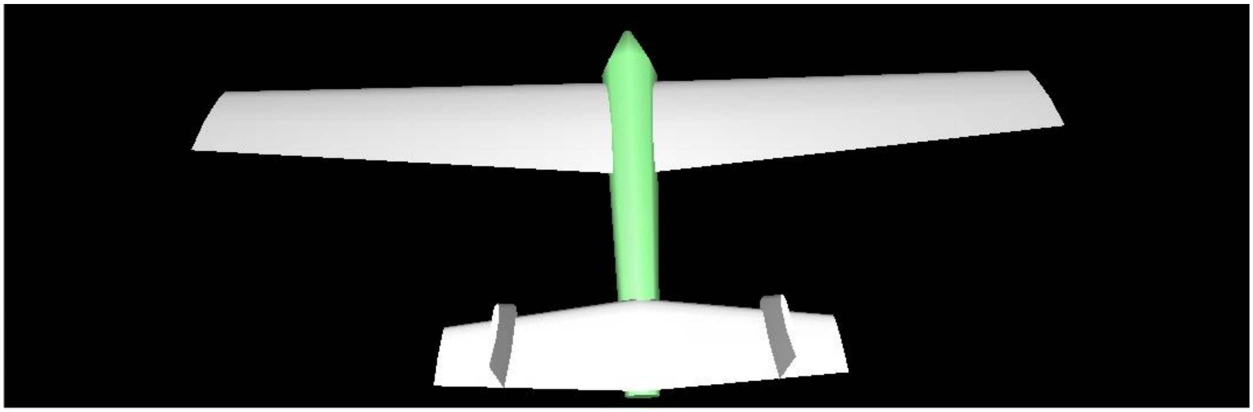
V-22 Osprey (image: Wikipedia)



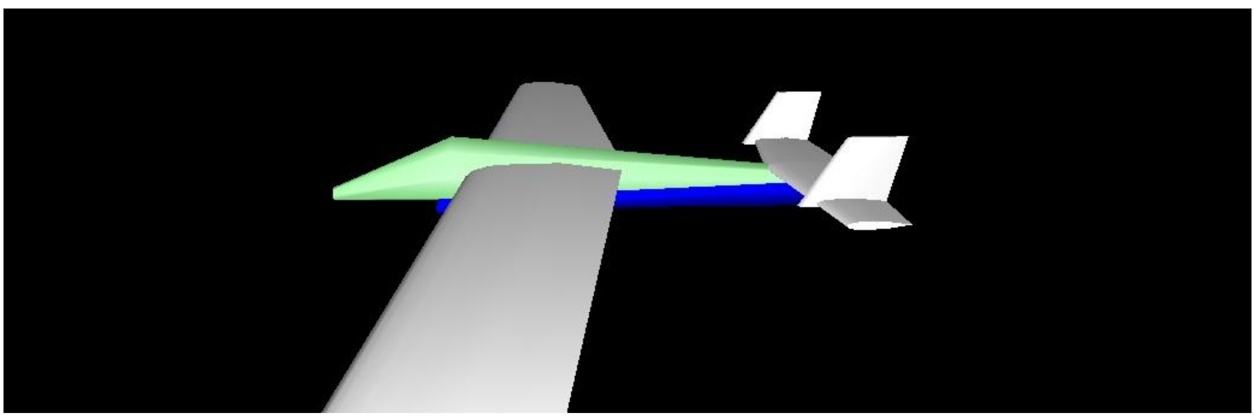
Silver (transition from normal flight to hover mode)

(Background and engine texture source mentioned after References section)

Air Frame Views



Top View



Side view

The Silver uses a modified fuselage based on the V-22 design to meet its requirements. The length of the aircraft is 156ft, 10”, the width of the fuselage is 45ft 2” and the total width of the aircraft including the wingspan is 126ft. The dimensions are based on the conceptual V-22 design dimensions and are proportionately increased to increase load bearing capacity. The two modified turbofan engines are placed at the ends of the two wings similar to the V-22. There is an auxiliary power plant located inside the aircraft which provides the power for tilting the engines.

It also has a water storage facility indicated in blue color as shown in the figure above. The aerodynamically sensitive areas are installed with an air friction reduction mechanism.

The aircraft is made up of aluminum alloys. Some sensitive areas on the external surface of the aircraft are made up of composite materials.

The aerodynamics of an aircraft is based on the following mathematical relations:

The airfoil is designed on the basis of the Bernoulli's equation:

$P + (\rho v^2)/2 + \rho gh = \text{constant}$

The air flow through the external surface of the aircraft is given by the equation of continuity given by:

$\rho_1 u_1 A_1 = \rho_2 u_2 A_2$

Differentiating the above equation;

$$\frac{d}{dx}(\rho u A) = 0$$

$$\frac{d\rho}{\rho} + \frac{du}{u} + \frac{dA}{A} = 0$$

P is the density of the air

U is the internal energy per unit mass of air

A is the cross-sectional Area

The aircraft has the basic shape of the V-22. It has two wings swept at a small angle in the forward direction. It has two tail fins for maneuvering the aircraft. Most of the aircraft fuselage is made up of aluminum alloys as they are inexpensive, light weight and can withstand large amounts of stress.

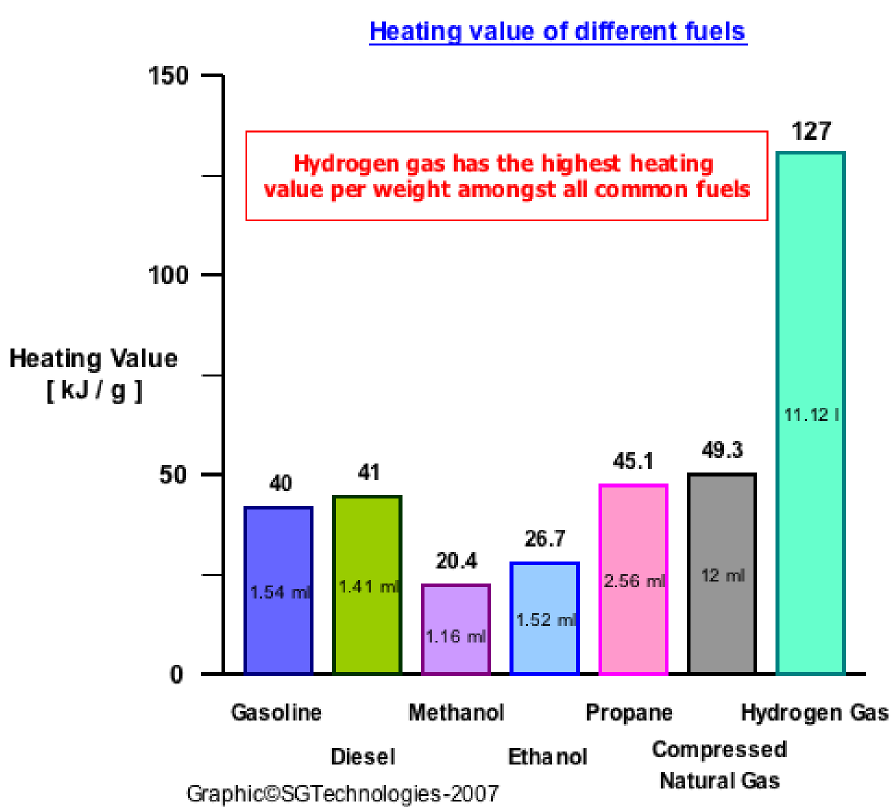
There are air friction resisting apparatus (AFRA) installed at aerodynamically crucial points on the external surface of the aircraft. These are super conducting electromagnets. These behave as perfect diamagnets during their operation and repel the diamagnetic nitrogen molecules. Thus they reduce the collision of air molecules on the surface of the aircraft and subsequently reduce the air friction.

The floats are required for water landing. But the conventional placement of these floats below the wings adds to the drag of the aircraft and reduces efficiency significantly. Hence the silver has been designed to incorporate the floats with the landing gears and thereby unify both into a single apparatus. According to the design, the landing gears are retractable. The aircraft has a single landing gear located at the nose of the aircraft and 3 pairs of landing gears at a distance of every 10ft. Hence an arrangement where landing gears are provided uniformly in the horizontal part of the base is achieved. These gears serve 2 purposes. One, it serves in uniformly distributing the load of impact during vertical landing among the seven gears and thus reducing the impulse on each gear. Secondly, during water landings, these landing gears are bent at an angle of 90 degrees such that 1 face of the wheel touches the lower surface of the fuselage. The front gear is bent backwards and the left gears are bent towards the right and the gears on the right side are bent towards the left. Each wheel of the landing gear is fitted with a floatable device at its centre. When the aircraft has to perform a water landing, these devices help the aircraft afloat.

Fuels

In conventional aircrafts, the fuel used is manufactured from crude oil. They consist of a great number of hydrocarbons. A pound of typical fuel might be composed of 16% hydrogen atoms, 84%carbon atoms and a small amount of impurities a such as sulfur, nitrogen, water an d sediments and other particulate matter. The most common jet fuels are the JP series (JP 1 –JP 8) and the Jet A, jet A1 and Jet B fuels. Jet A and Jet A1 are the most commonly used jet fuels for commercial aircrafts. Both are kerosene type fuels. Jet A has a freezing point below -40^{0}F and Jet A1 has a freezing point below -58^{0}F. Jet B fuel and JP-4 are basically alike. They are wide boiling range fuels. They have an initial boiling point below that of kerosene. They also have a lower specific gravity.

But the common drawback of all the above mentioned fuels is that they are carbon based and the main exhausts due to these fuels are carbon monoxide and carbon dioxide. Both of these are harmful to the environment. They cause the green house effect which leads to global warming.



Calorific values (image: SGT technologies)

Hence the silver is designed to use hydrogen along with magnesium powder as its primary fuel. Hydrogen has a very high calorific value when compared to traditional fuels. It is also environmentally friendly in a sense that the product of combustion of hydrogen is water vapor which is harmless to the environment.

But the major problem in the use of hydrogen as a fuel is the production of hydrogen gas. Traditionally, hydrogen gas is extracted from hydrocarbon based chemicals. This is a very expensive process. The storage and the transport of hydrogen gas is also a major concern. Hydrogen is a very volatile gas and undergoes combustion very easily.

Hence the silver is designed to produce the hydrogen gas at the site of combustion. This avoids the hassles involved in the manufacture, storage and transportation of hydrogen fuel. It also significantly reduces the costs involved in using hydrogen as a fuel. It also reduces the dangers involved in using hydrogen as hydrogen is evolved at the site of combustion. Hence, this avoids the need of a storage mechanism required to store the volatile hydrogen fuel.

In Silver, the production of hydrogen gas takes place by the reaction of a dilute acid with an alkaline earth metal. Here dil.HCl is made to react with magnesium powder. As a result of this reaction, hydrogen gas and a salt of magnesium sulfate is produced.

This in accordance with the equation:

$$Mg + 2HCl \longrightarrow MgCl_2 + H_2$$

According to this chemical equation 1 mole or 24.3 grams of magnesium reacts with 2 moles or 73 grams of dilute HCl to give 1 mole or 94 grams of magnesium sulfate and 2 grams of hydrogen gas. 2 grams of hydrogen gas occupies 22.4 liters of volume at 273 K at 1atm pressure. Hence a large amount of hydrogen gas is created by relatively small amounts of the raw materials.

The salt, magnesium sulfate would be in vapor form due to the heat produced in the engine. This is let off to the exhaust. The Hydrogen gas is made to flow into the combustion chamber where it is made to react with the oxygen molecules of the incoming air to produce water vapors along with the liberation of an enormous amount of energy.

$$2\ H_2\ (g) + O_2\ (g) \rightarrow 2\ H_2O\ (l) + 572\ kJ\ (286\ kJ/mol)$$

According to this equation 2 moles or 4 grams of hydrogen gas react with 1mole or 32 grams of oxygen gas and liberate 2 moles or 36 grams of water along with the liberation of 572 Kilo joules of energy. This high amount of energy is utilized to so thermal work on the incoming air.

The energy liberated is made to expand the incoming air in accordance with the gas laws. Due to this a large amount of pressure is created. This pressurized jet of gas is made to exit through the exhaust creating forward thrust.

The Silver also incorporates a secondary method of production of hydrogen gas by utilizing the heat generated at the engine turbines. In this process water containing a particular quantity of electrolytes is passed though tubes along the walls of the engine lining the turbines. The water gets heated up and is converted into steam. As the temperature of the turbines is in the order of 2200^0 C, the steam is dissociated into hydrogen and oxygen gases. These gases do not recombine until the temperature is maintained and exist in the form of ions. These gases then flow into the combustion chamber; they gradually cool and form into gas molecules. The hydrogen gas again reacts with oxygen in the combustion chamber and liberates the amount of heat it had absorbed to break up which is then used to propel the aircraft. This process is in accordance with the first law of thermodynamics.

The above process is based on the thermo chemical equation: $\Delta G = \Delta H - T\Delta S$
G= free energy change
H= Enthalpy of the reaction
T= Temperature
S= Entropy
The quantity Δ represents the change in the above quantities. IN other words, it gives the difference of the quantity between the product side and the reactant side.
Consider the equation
$2\ H_2\ (g) + O_2\ (g) \rightarrow 2\ H_2O\ (l)$ + 572 kJ (286 kJ/mol)
When water is subjected to heat the reverse of the above reaction takes place as follows

$2\ H_2O\ (l) \longrightarrow 2\ H_2\ (g) + O_2\ (g)$ -572KJ
Hence energy of 572 KJ is required to split to moles of water into hydrogen and oxygen.

For a reaction to take place the free energy change must be negative. I.e. the free energy of the products must be less than the free energy of the reactants. According to the equation: $\Delta G = \Delta H - T\Delta S$, the value of the free energy change depends on the Enthalpy change of the reaction, the temperature and the net entropy change. For the above chemical reaction the enthalpy change and the entropy change is constant. Hence the direction of reaction depends only on the temperature. As the temperature increases the value of ΔG gradually decreases and finally becomes negative for the dissociation reaction. Hence the dissociation reaction takes place.

The quantity of heat absorbed is given by: Q=mSdT
Q= heat absorbed
m=mass of water
S=specific heat of water =4200J/kg/k
dT= Change in temperature

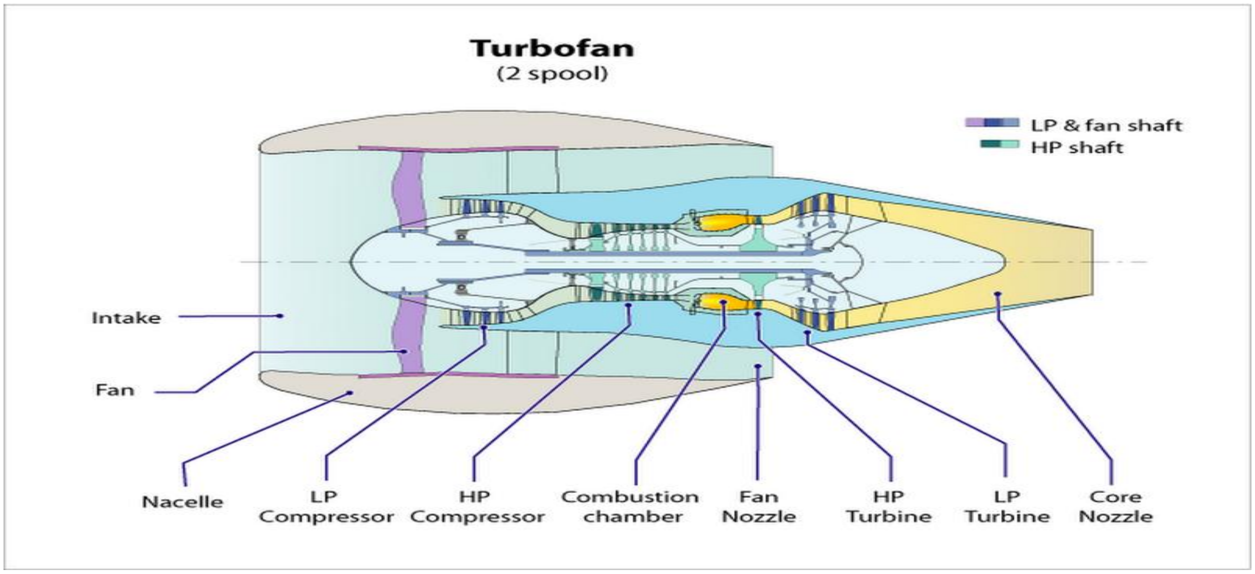
1 mole of water weighs 18 grams=0.018Kg
When the water is made to flow, it absorbs the heat of the turbines and the temperature can rise as high as 1900 degrees considering that the temperature of the turbine would be about 2200 degrees.
Substituting the above values in the above equation,
Q=0.018x4200x1900=143640 Joules =143.64 KJ
It is known that 286 KJ of energy is required for the dissociation reaction to produce 1 mole or 2grams or 22.4 liters of hydrogen gas. Therefore 143.64 KJ of energy will produce =22.4x143.64/286=11.25 liters of hydrogen gas.

The addition of catalysts further enhances the rate of the reaction and makes this process more efficient.

This process serves 2 purposes. It helps in cooling the turbines, thus increasing its efficiency and it also acts as a mechanism to recycle excess heat which would otherwise be left unutilized. This increases the total efficiency of the aircraft enormously and reduces the cost of operation.

Engines

The engines of the Silver are modified 2 spool turbofan engines.



2 Spool Turbofan engine (image: Wikipedia)

The conventional turbofan engine is as shown above. It consists of an intake, a fan, nacelle, Low pressure and high pressure compressor, combustion chamber, fan nozzle, high and low pressure turbine and an outlet nozzle. The main advantage of this type of engine is its high efficiency.

Current Turbofan technology:

The turbofan engine has a fan enclosed in the duct which is mounted at the front of the engine. The fan runs at the same speed as that of the compressor or is geared down to reduce its speed .The air coming from the fan can be made to exit separately from that of the engine air or it can be ducted to mix with the air of the primary engine. The two gas streams may be kept separate for the entire length of the engine.

Working: The inlet duct of the engine contains a fan which sucks air in. The diameter of the intake duct is greater than that of the primary engine. So there are two air flows created in the engine. The primary air flow which passes through the engine core and is compressed by a set of compressors .The secondary airflow directly comes out of the fan. The ratio of the secondary airflow to the primary airflow is known as bypass ratio. The total thrust created by the engine is the sum of the primary and secondary airflow. The primary airflow would be higher because the air flowing through the engine core would be compressed and subjected to a high amount of heat in the combustion chambers and then expanded in the turbines where useful work is done. The gases are then liberated from the exhaust.

The bypass ratio in the first generation of turbofan engines such as the Pratt Whitney JT3D Engine was 1:1. But the second generations of turbofan engines like the general electric CF6, the Pratt & Whitney JT9D have a bypass ratio 5:1 or 6:1.

Reason for selection of the Turbofan engine:

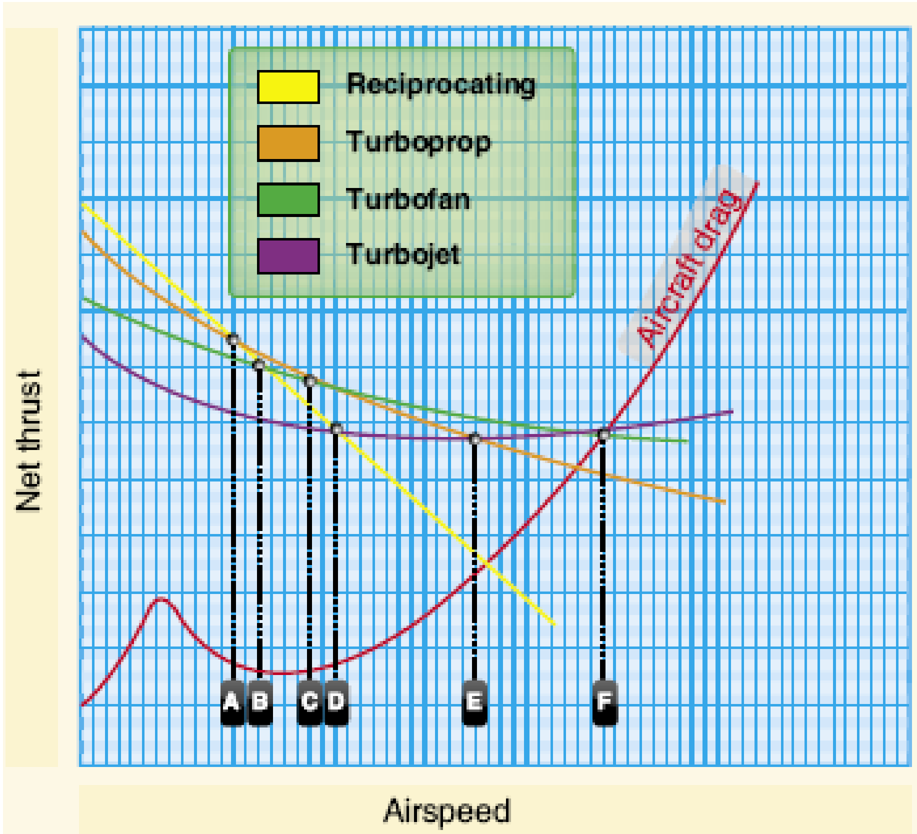
The efficiency of the turbofan engine is higher than those of the turbojet engines. This is due to the fact that the fuel energy obtained is largely converted into pressure energy rather than the kinetic energy of the exhaust gases. The Fan engines have a definite advantage over pure jet engines in speed ranges below mach 1. Due to the development of the trans-sonic blade, the turbo fan engine can be made to reach speeds that are near to Mach 1.

The noise levels of the turbofan engine are about 20% less than other engine of comparable performance. The weight of this engine lies between that of a turbojet and a turboprop engine. Turbo fan engine is capable of two kinds of exhausts. Hence the secondary exhaust can be used during vertical hover situations while the combination of primary and secondary thrust can be used in normal flight conditions. Due to this arrangement the engine is less susceptible to stalling.

The turbofan engine, unlike the turboprop engine does not experience fall in thrust due to increasing airspeeds. Hence this is a better engine over the turboprop engine.

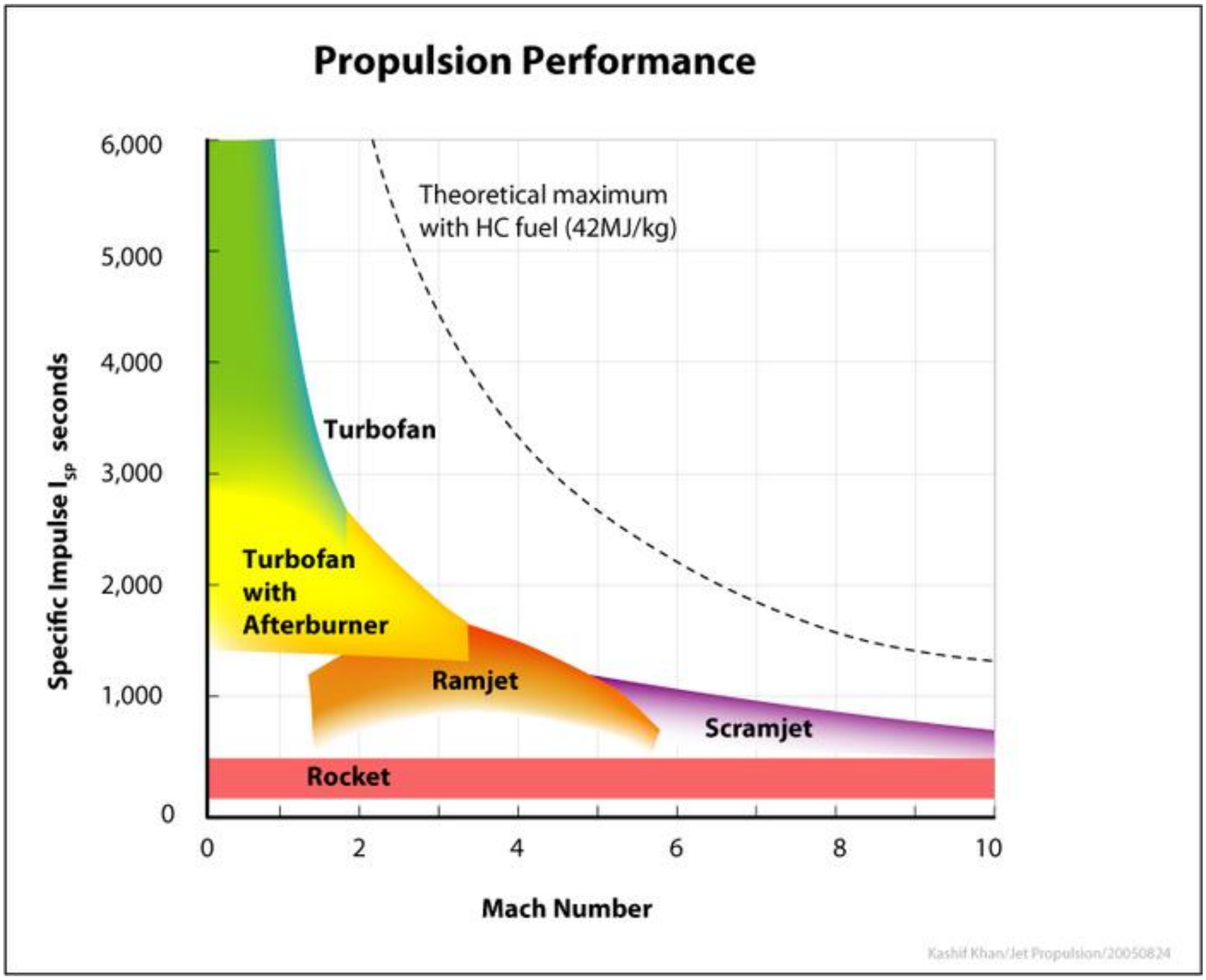
The turbofan engine can operate in a wide range of climatic conditions and under a wide range of temperatures. The TSFC and the specific weight are lesser than that of the turbojet engine. This results in operating economy and aircraft range. The ground clearances lie between the turbojet and the turboprop engines.

These features show that the turbofan engine is suitable for long range and high speed flights. The Turbofan engine is a fine optimized blend of efficiency and performance. But there are several drawbacks that hinder high performance. Hence a modified turbofan engine is used.



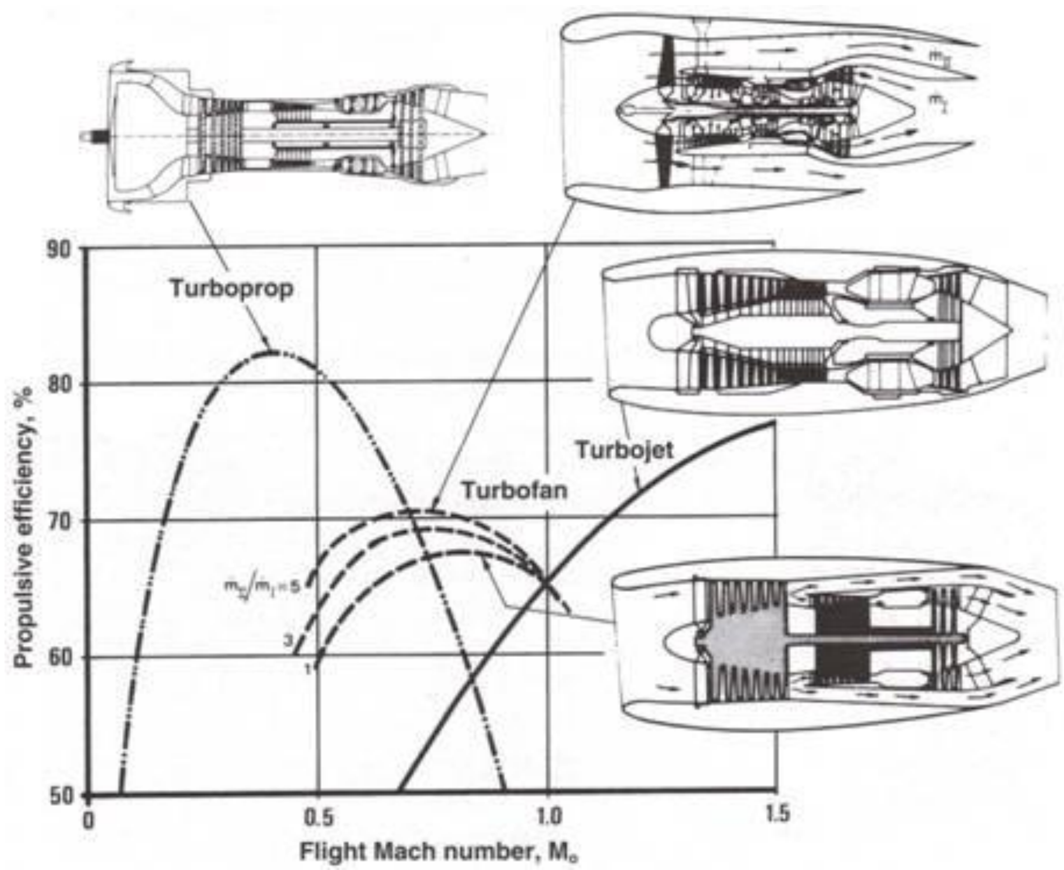
Net thrust v/s Airspeed (image: www.flightlearnings.com)

The above image shows that the turbofan engine has the best net thrust versus airspeed ratio.



Specific impulse (image: Wikimedia)

The specific Impulse is high in Turbofan Engines. Hence the fuel efficiency is high and the operating costs are low.



Propulsive efficiencies (image: www.ligoeleos.com)

Components of the Modified Turbofan Engine:

Inlet duct:

The inlet duct is the entrance point to the primary engine core. It plays a vital role in deciding the capabilities of the aircraft. The thrust generated can be high only if the inlet duct provides enough airflow at the highest possible pressure. The Silver is designed to operate at subsonic speeds nearing mach 1. Hence the inlet duct is designed so that it does not produce shock vibrations and is of the minimum possible weight. The inlet duct is given a bell mouth shape so that it meets the requirements of subsonic flight. Such a design has a high potential of converting the kinetic or dynamic pressure of the incoming air into static pressure and feed it to the compressor. The bell mouth design eliminates contraction and allows the maximum possible quantity of air into the engine. It practically offers zero air resistance. The inlet duct is also incorporated with a filter that screens undesired materials from entering into the engine.

The mass flow of air per unit area is given by

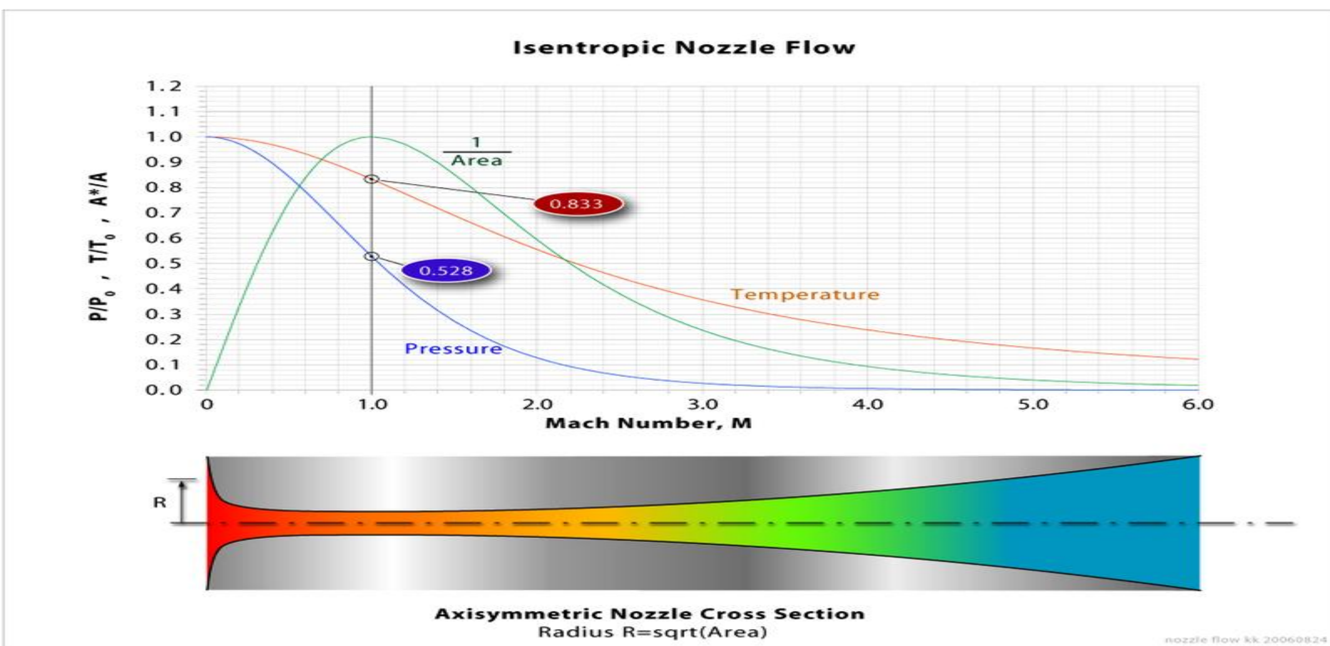
$$\dot{m} = A\rho_0 \left[\frac{2}{\gamma+1}\left(1+\frac{\gamma-1}{2}M^2\right)\right]^{-\frac{1}{\gamma-1}} V$$

Fans:

The fan blades are made out of titanium. The main function of the fan blades is to compress the air and send it into the primary and secondary gas paths. Each of these fan blades has a mid span support. The blades are replaceable in pairs and are held by slots and split ring blade lock.

The fan is enclosed by a fan case. It consists of the front fan case and the fan exit. They constitute the engine structure that the supports the nacelle inlet. The front fan case consists of the fan blade rub strips and also prevents the fan blades from flying off racially in case they break.

The fan exit contains 84 guide vanes. These are made of composite material with the leading edges made of metal. The fan exit also straightens the discharge air before it moves into the thrust reverser. The bleed valve connects the fan exit to the low pressure compressor and assists in the flow of primary air into the compressor.



Nozzle flow relation (Image: Wiki books)

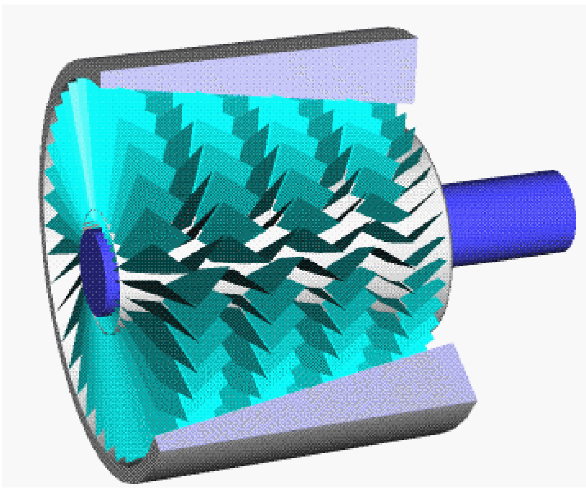
Compressor:

The compressor stages are placed in the front portion of the engine after the inlet duct. The function of the compressors is to compress the incoming airflow to high pressures. They convert the kinetic energy of the incoming air into static pressure. The compressors are of two types- The low pressure compressors (LPC) and the high pressure compressors (HPC). Based on their design they are also classified as axial and centrifugal compressors. The engine of the Silver incorporates a two spool axial flow compressors. The engine has 16 compressor stages. The low pressure system has 5 low pressure compressor stages and the high pressure system has 11 high pressure compressor stages. Here the first stage of the LPC is the fan. The fan is larger in diameter when compared to the other compressor stages. The HPC and LPC are designed to work independent of each other.

The total compression ratio is 30:1. The bypass ratio, which is the ratio of the secondary airflow to the primary airflow, is kept at 5:1. Hence secondary airflow contributes 78% of the total thrust while the primary airflow contributes 22%. The above features are designed in line with the Pratt & Whitney 4000 series engines which are considered to be the representative of the standard turbofan engine.

Each stage of the compressor consists of an inlet guide vane, a stator and rotor. The inlet guide vane guides the incoming air towards the stator. There is no change in velocity during this process. The stator refers to the stationary component of the compressor stage. The stator compresses the incoming air so that it incurs a loss in velocity that in turn translates into a gain in static pressure of the air. This air at high pressure is guided towards the rotor. The rotor is the rotatable component of the compressor stage. The air flowing into the rotor rotates it.

There is a gradual decrease in the diameter of the compressor stages. Hence there is an increase in the static pressure of the air flowing through it. In effect, the air undergoes a high degree of compression which is given by the compression ratio.



Compressors (image: Wikipedia)

Combustion chamber:

The combustion chamber is located in between the compressor and the turbines. The combustion chamber in the Silver is an improvised annular type design based on the Pratt & Whitney J9TD combustion chamber. Here, the fuel is injected at the upstream of the primary combustion zone. This allows efficient mixing of the fuel air mixture. This design also incorporates a low surface area to volume ratio which leads to a faster rate of cooling.

The fuel injector: It consists of two concentric sets of emitters embedded in a hemisphere. The two concentric sets of emitters are closely spaced. The emitters in a circle of smaller radius emit droplets of concentrated HCl. These droplets are of a specific size and are emitted at a specified divergent angle. The outer ring of emitters emits powdered magnesium in a direction perpendicular to the axis of the hemisphere. Due to the angular arrangement, the liberated conc. HCl and the powdered magnesium react to form magnesium chloride and hydrogen gas. The Magnesium chloride is a liquid and collects at the bottom of the combustion chamber and is immediately removed through openings so that they don't reduce the efficiency of the engine. The hydrogen gas moves forward, where it is ignited by the spark plug.

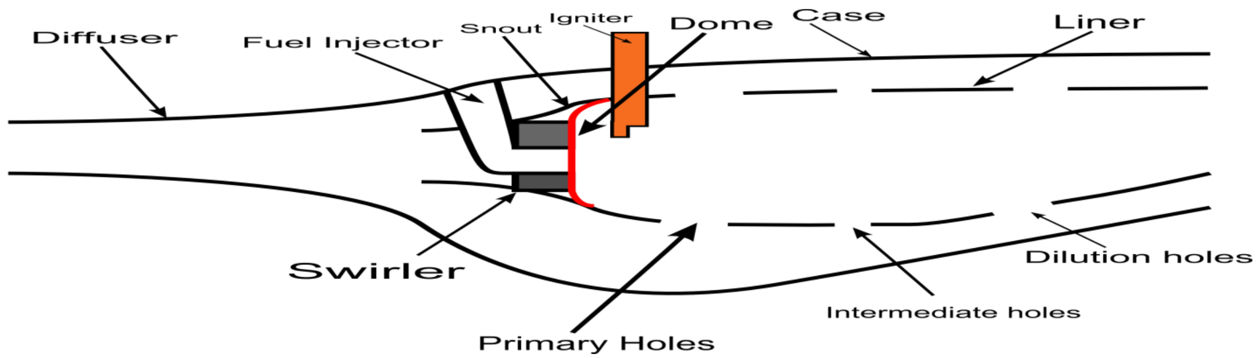
Spark Plug: The spark plug is a high voltage device which derives its power from the auxiliary power plant. It gives a single spark only while starting the combustion of fuel. Once the fuel is ignited, it is a self sustaining process and the high temperature maintains continuous combustion of the fuel.

Construction: The combustion chamber consists of fuel injector at the upstream of the primary combustion zone. There is a spark plug located at the lower region of the chamber. The can of the chamber is surrounded by an air duct. This has several openings throughout the length of chamber. This provides the air necessary for the combustion of the fuel.

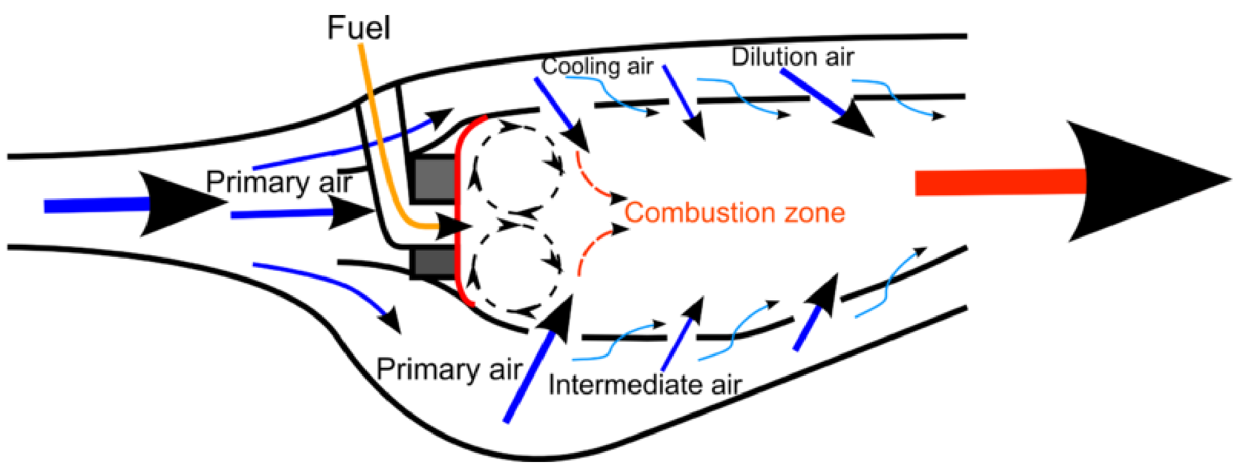
Working: The fuel ingredients are emitted by the fuel injector combines to form the fuel. This fuel is ignited by the sparks form the igniter. Due to this the fuel burns and produces heat. The incoming air is heated by the direct application of this heat. The air is thus set to a high temperature and pressure. This air is then expanded at the turbines.

But the fuel may not be completely burnt in the primary combustion zone. The incomplete combustion of the fuel leads to excess fuel consumption. This leads to the decrease in the efficiency of the aircraft. Moreover the fuel used is hydrogen gas. Hence the incomplete combustion of hydrogen gas leads to the passage of this gas along with the air. Due to the prevalent temperatures in the engine core, the highly inflammable hydrogen gas may undergo combustion elsewhere in the engine where oxygen is present. This is highly dangerous to the engine.

Hence to prevent such a phenomenon, secondary and tertiary inlets are provided along the length of the combustion chamber.



Combustion chamber Construction (image: Wikipedia)



Combustion Chamber Working (image: Wikipedia)

Cooling mechanism and fuel recycling:

Hydrogen has a very high calorific value. Hence the combustion of small quantities of hydrogen gas produces very large amounts of heat energy. This leads to very high temperatures of about 3000 degrees. But the blades of the turbines can withstand temperatures only up to 1200 degrees. But the excessive temperature that the turbine generates due to its functioning adds\ to the already existing temperature created by hydrogen combustion and exceeds the limit. Hence a cooling mechanism is provided to reduce the temperature of the turbines.

But, in order to increase the efficiency of the aircraft and to reduce fuel consumption, the heat must be re-utilized to do work. This can be achieved by the following mechanism:

The entire turbine section is surrounded by tubes. Water mixed with a catalyst fed into these tubes. The catalyst used for this process is $Mg_6\ Al_2O_8\ (OH)_2$

Since it is a catalyst, small quantities would suffice. This water is made to flow into the tubes. It then absorbs the excess heat from the turbines and acts as a coolant. Due to the extreme temperature of the turbine section, the water undergoes thermolytic dissociation to form hydrogen and oxygen gases. The addition of the catalyst further increases the rate at which these gases are formed. The catalyst is not consumed by the reaction. The catalyst re-generates itself at the end of the reaction. Hence this can be again reused.

The hydrogen and oxygen formed exist as separate gases as long as the temperature corresponding to the free energy change is maintained .once these gases are let out into the combustion chamber through separate fuel injection inlets known as the secondary fuel injection inlet, they are expanded. Due to the expansion, the pressure decreases, volume increases and the temperature of the gas mixture decreases in accordance with the Charles Law of gases. Due to this, the hydrogen and oxygen gases again combine to form water.

Hence the heat of the turbine is effectively utilized by this process. The overall efficiency of working o f the engine is also increases. The consumption of the primary fuel also decreases.

Turbines:

The combustion chamber is followed by a set of 6 stages of turbines. The primary function of the turbines is to expand the incoming air and to extract useful work out of it. There are two basic types of turbines- the impulse turbine and the reaction turbine. The turbines used in aircrafts are reaction turbines. It uses the reaction force generated by the air to rotate the turbine.

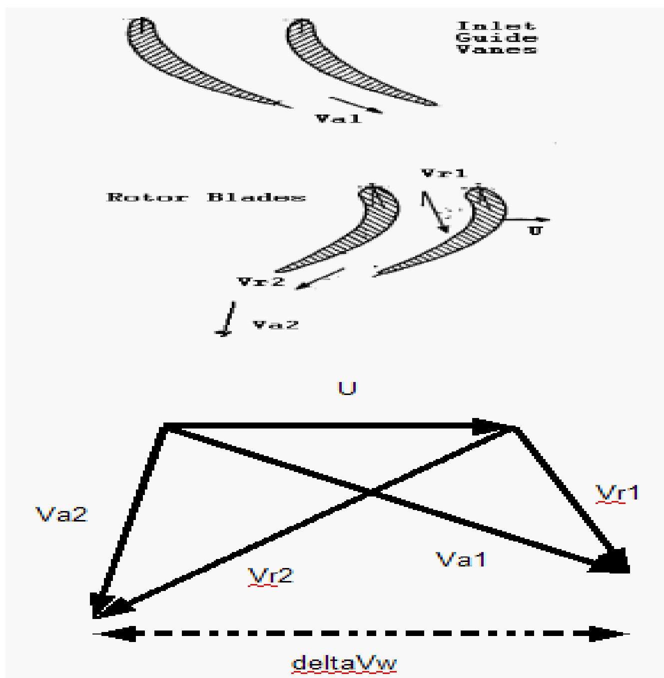
The engine consists of a four stage low pressure turbine and a 2 stage high pressure turbine system.

High pressure turbine (HPT): The force required to rotate the high pressure compressors is provided by the 2 stage high pressure turbine. It consists of 60 blades made using a single crystal material and 82 blades using directionally solidified material. The HPT includes the case and the vane assembly, two rotor disks and blade assembly, rotating inner air seal.

The cooling system cools the first and second stage disk and blade assembly, 21 second stage clusters and the inner air seal.

Low pressure turbine (LPT): The LPT provides the necessary force for the rotation of the LPC including the fan by means of the drive shaft. The stage3 consists of 39 nozzle guide vanes and 128 turbine blades. Stage 4, 5 and 6 consists of 44, 38 and 36 vane clusters and 130,118 and 128 turbine blades respectively.

Turbine (source: nature.com)



Air Flow through the inlet guide vanes (Image: Wikipedia)

Engine Starter:

A conventional engine may use starters such as an electric motor, starter generator, air turbine starter, cartridge starter, hydraulic starter etc. All these methods require additional mechanisms for its functioning and hence are not very efficient.

Hence the silver incorporates an electromagnetic starter to increase the efficiency of the process. The starter is built inside the central shaft of the engine. Hence it is integrated with the engine itself.

Here the shaft is made up of a material of high magnetic permittivity. Hence the shaft also serves as the engine starter. The end of the shaft toward the exhaust is fitted with a thermal electron emitter material. This material is negatively charged due to the presence of electrons. The material used can be Cs-Rydberg matter which has a very low work function and hence can emit electrons very easily. The side of the shaft near the inlet valve is fitted with a positively charged material. The positive charge can also be attained be connecting a conducting material to the positive terminal of a battery.

Here the electron emitter emits the electron and acts as the cathode and the positively charged material attracts the electrons and acts as the anode. A vacuum is created inside the shaft tube to aid the flow of electrons. The electron emitter starts to emit electrons when the temperature increases. This phenomenon is known is thermionic emission. When the combustion of the fuels takes place the temperature of the engine core rises and thus the emitter starts to emit electrons. The ejected electrons are attracts towards the anode. The electrons also have an ejection velocity which aids in the amount of current produced.

The Thermal ejection of electrons is governed by the Richardson-Dushman equation

$$J = A_{\mathrm{G}} T^2 \mathrm{e}^{\frac{-W}{kT}}$$

J=Current density
T=Temperature
W=Work function of the emitter material. For the Cs-Rydberg material it is about 0.7eV.
K=Boltzmann constant

$$A_{\mathrm{G}} = \lambda_{\mathrm{R}} A_0$$

$$A_0 = \frac{4\pi m k^2 e}{h^3} = 1.20173 \times 10^6 \,\mathrm{A\,m^{-2}\,K^{-2}}$$

h=Planck’s constant
m= mass of the electron
e=charge of the electron
The current density J is also given by the relation

J=nev_d
n= the number of electrons
e=charge of each electron
v_d=drift velocity of the electrons

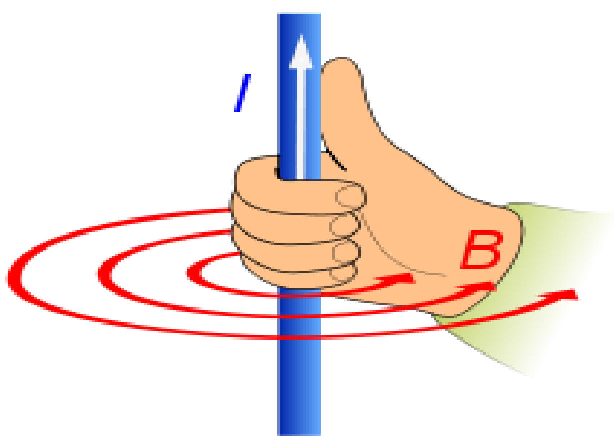
The drift velocity of the electrons is the velocity with which the electrons travel from the cathode to the anode. This depends on the medium between the 2 electrodes. Hence the vacuum between the electrodes helps increasing the current flow by maintaining high drift velocity.

The emission of electrons is also given by the equation

E = W+ (mv^2)/2
E=applied energy
W=work function
V= velocity of ejection of electrons.
This velocity is further increased by the potential created by the anode

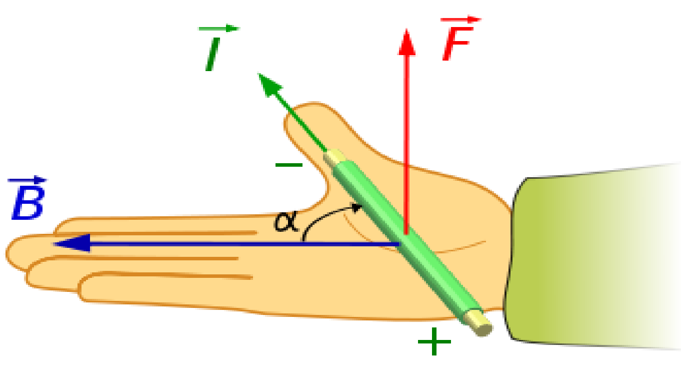
A small amount of emitter material can emit about 10^{20} electrons at velocities of about 10^6 m/s by the above process. This produces a very high current of about 10^6 amperes. This is also due to the fact that the vacuum helps in avoiding the current losses due to resistance.

The outer case of the engine is coated with a magnetic material. When there is an electron flow inside the shaft, due to the interaction of the magnetic field of the moving electrons with the magnetic field of the external magnets the shaft experiences a rotating force due to which it rotates. The direction of the different components is shown below:



Right hand Grip rule (Image: Wikipedia)

The right hand grip rule which is the principle behind the working of the engine starter is shown in the above image. The current through the conductor I produces a magnetic field B around itself.



The Right hand Rule (Image: Wikipedia)

This is in accordance with the Biot Savart's Law given by:

$$\mathbf{B} = \int \frac{\mu_0}{4\pi} \frac{I d\mathbf{l} \times \hat{\mathbf{r}}}{r^2},$$

B=magnetic field.
I= Current through the conductor
r= distance
μ_0 =Magnetic permittivity of free space

This mechanism is only used when the engine is required to start and when the aircraft is in vertical takeoff/landing/ hover mode. This mechanism must be shut down during normal flight. But the high temperatures produced in the engine core even during normal flight. This triggers the emission of electrons. To prevent this emitter material is kept below another similar material with a small gap between the 2 materials. The electromagnetic repulsion between the similar materials prevents the emission of the electrons when not required.

Exhaust Valve:

The exhaust nozzle is the final component of the engine. It helps in the removal of exhaust gases form the engine and provides thrust for the forward movement of the aircraft. A convergent type of nozzle is provided for the silver. This helps to maintain a constant internal pressure.

Noise pollution has also become a major concern and it appropriate to take measures to reduce the effects o f the same while designing the aircraft.

The source of sound in any aircraft is the turbulence created when the air from the engine of the aircraft at high pressure and temperature exits into the surrounding ambient atmosphere. The turbulence increases as the speed of the aircraft increases. But the noise is also created due to the compressor. The noise from the compressor is of high frequency and hence highly directional and it tends to deteriorate due to contact with obstructions. Hence it is not bound to cause any noticeable noise pollution. But the sound from the jet exhaust stream is of low frequency and is non directional. Hence this is the major cause of the noise produced due to the functioning of the aircraft.

The noise produced by ordinary jet engines is as high as 140 decibels. The suppression of this sound is achieved by selecting the turbofan engine. A turbofan engine produces much less noise than a turbojet of comparable performance. Having a high bypass ratio for the turbofan engine also reduces the amount of noise created from the exhaust. The passage of the engine is also lined by acoustical dampeners which absorb the sound created. Portable noise suppressors are also installed in the exhaust which reduce the noise levels to as low as 25 decibels.

Auxiliary Power Unit (APU)

The auxiliary power unit is used for various purposes during the operation of the aircraft. It is used to supply power for internal lighting, air conditioning, for running the onboard computer systems, flight control systems, engaging the landing gears etc. But the most important use of the auxiliary power unit is the tilting of the two turbofan engines during vertical flight.

The auxiliary power unit is located at the center of the aircraft fuselage in alignment with the two turbofan engines. It is connected to the two engines by means of a rotatable connecting rod.

The APU is a type of an electric generator cum motor. It acts as a generator to store power and uses the same when required. The APU is connected to the engines by means of a connecting rod. This rod is geared to the central engine shaft. When the APU is required to charge, the gears are brought into contact and the rotation of the central shaft of the turbofan engines results in the rotation of the connecting rod.

The connecting rod is inserted inside the APU. The rod is connected to the generator which converts its rotary motion into electricity. This electricity is then stored inside the APU. This electricity is then supplied to the various parts of the aircraft.

Tilting Mechanism through APU:

During vertical lift off and landing the two turbofan engines must be tilted by an angle of 90 degrees and then must be brought back to its original position for normal flight. The APU is used for this purpose. The electric energy stored in the APU is used here. During the tilting of the engines, the connecting rod is removed from its geared position with the central shaft. It is then made to fix rigidly with the body of the engine. Once it is rigidly connected, the connecting rod rotates in a clockwise direction with the help of the electric motor in the APU. This rotation stops once the engines have been placed at the desired angle. In this way, the tilting of the engines is achieved.

When the engines are required to be brought back to the original position, the connecting rod is made to rotate in the anti clockwise direction by the same angle by means of the electric motor.

The connecting rod is again geared back to the central shafts of the turbofan engines on either side and the APU again functions a generator. The connecting rod rotates and produces electricity.

Air Friction Reduction Mechanism

According to Newton's second law of motion a force applied on an object must create acceleration. But in many of today's aircrafts we have to burn fuel just to maintain its speed. This is due to air resistance. It is a type of frictional force which is formed by high speed air particles impacting the aircraft. But the same air creates the much necessary lift required to keep the aircraft in air. Hence, it is necessary to design a system which would strike a balance between lift and unnecessary air friction. In this direction, we have designed a Friction shield which would repel air molecules and avoid energy loss due to air resistance. Air is comprised of 78% of Nitrogen and21% of oxygen. Nitrogen is a predominantly diamagnetic molecule and Oxygen is a predominantly paramagnetic molecule. Therefore, the external surface of the aircraft has been fabricated into a superconductor electromagnet at aerodynamically critical regions. Theoretically, electricity flowing through a conductor is associated with a magnetic field around it. In case of a super conductor a perpetual magnetic field can be created with a small quantity of electricity. Many metals behave as super conductors at low temperatures, but 2^{nd} type of superconductors comprising of metal alloys can behave as superconductors at temperatures as high as 181K or -92°C. Therefore, it is necessary to use $Sn_{1.0}Pb_{0.4}In_{0.6}Ba_4Tm_5Cu_7O_{20+}$ (Patent Pending) alloy which is claimed to behave as a superconductor at 181K or $SnInBa_4Tm_4Cu_6O_{18+}$ alloy which is claimed to behave as a superconductor at 150K as the electromagnets. By this procedure, very efficient electromagnets can be created by using very less amounts of electricity. The above mentioned alloys are brought to their operational temperature by using liquid Nitrogen. When functioning, these electromagnets can repel the diamagnetic Nitrogen and attract the paramagnetic oxygen and thereby reduces up to 78% air friction.

A delicate balance can be struck between the lift required and the reduction of air resistance by controlling the amount of electricity flowing to the electromagnets. Moreover, the paramagnetic oxygen attracted by the electromagnets, ensures the continuity of the required lift to keep the aircraft at the desired altitude.

This is an optional feature that can be incorporated to increase the aerodynamic efficiency of the aircraft. This feature can also be modified to use the conventional diamagnets if the superconductor electromagnet is considered to be unfeasible. This feature is installed only at small regions of high aerodynamic importance in order to increase the overall speed, cost effectiveness and efficiency of the aircraft.

Water intake mechanism:

The silver can be used to fight forest fires and other similar situations as it incorporates a water collection and storage mechanism. The mechanism is brought into effect by means of 4 pairs of retractable water tubes which can be released from the rear of the aircraft.

The aircraft is brought over a source of water where it goes into vertical flight mode. The water tubes are then released into the water source. As soon as the tubes come into contact with the water source, it sucks water into the storage facility located at the base of the aircraft fuselage.

The water collection mechanism is also operated by the power supplied from the APU. The electric power stored in the APU is used to run the electric motor. The motor creates the suction power necessary for the suction of water from the water source into the storage facility.

When the water is collected, the tubes are retracted from by the electric motors. When the aircraft has to release the water from the storage facility, the hatches at the lower surface of the storage facility are opened and the water is released.

The water storage facility has a total of 4 chambers with each chamber having a pair of openings at the lower surface. This helps in the partial release of the water stored. This also enables the aircraft to release the water at several different places at different points of time.

Mode of Operation

The silver is a multi functional and a versatile aircraft. It is capable of carrying about 100 passengers on board. It can also simultaneously hold up to 10000 liters of water in the storage facility. The aircraft can also be modified to hold about 25000 liters of water without the passengers.

Take Off: The aircraft can take off both from land and water. It can take off from land either conventionally by means of a runway or it can also perform a vertical takeoff. It can take off from water only by means of a vertical takeoff.

The Silver can take off from a runway of just 300 meters through the conventional takeoff mechanism. The vertical takeoff is achieved by tilting the two turbofan engines to a vertical position. The shaft of the engines is then disconnected from the compressors and turbines by means of a spool and the vertical lift is achieved only with the help of the fan. This is done as the compressors and the turbines cannot run at such low velocities of the incoming air. The fan is then temporarily run by the engine starter which is an electron emitter system surrounded by a magnetic engine case. This mechanism also starts the engine.

Cruise flight: After the vertical takeoff, the engines are brought back to its original position by means of the electric motor in the APU. The shaft is reconnected to the sets of compressors and turbines and the engine starter is switched off by concealing the electron emitter and thus preventing it from emitting the electrons. Now the forward thrust of the aircraft is the sum of the thrusts due to the primary and secondary sir flows through the fan and the engine core.

During this normal flight, the hydrogen fuel created at the site of combustion ignites and produces the required energy needed to run the engine. The turbofan engines of the silver incorporate the same basic structure of the compressors and turbines of the united technologies' Pratt & Whitney 4000 series turbofan engine. Hence the engine is almost of the same dimensions as that of the above mentioned engine. Hence the engine is approximately 133 inches long and 97 in across the largest diameter. It weighs about 4713 kgs and provides a thrust of about 100000 lbs by virtue of increased efficiency due to the modified engine design.

Net Thrust:

$$F_n = m \cdot (V_{jfe} - V_a)$$

The aircraft can reach up to speeds of mach 0.8 with the help of trans-sonic blades.

V= 0.8x330 (mach 1= 330 m/s)
V= 264 m/s
V= 264/0.5144

V=513.22 knots

Vertical Hovering: When the aircraft is required to hover over land or water, the two turbofan engines are again brought back into a right angled position. The shaft is again disconnected from the compressors and the turbines and the aircraft is made to hover only with the help of the fan run by the engine starting mechanism. The thrust crated is equal to the gravitational pull. Hence the aircraft maintains a constant and stable altitude. The aircraft can also be made to move vertically upwards or downwards by correspondingly increasing or decreasing the thrust.

The aircraft is again brought back into normal flight by the same mechanism as mentioned above for the takeoff.

Landing: The aircraft can be made to land in water or on land. It can be made to land on a land either conventionally by means of a runway. A runway of about 300 meters would suffice. It can also be made to land vertically by again bringing the engines into the right angled position and disconnecting the shaft form the compressors and turbines. The engine would be run by the starter mechanism. The aircraft is slowly brought down by gradually reducing the thrust.

The aircraft can also be made to land on water by bending the landing gears at an angle of 180 degrees and positioning them such that they are arranged in rows below the lower surface of the fuselage. The core of each tyre of the landing gear is fitted with a float which helps in maintaining the aircraft afloat once it has landed on water. The landing mechanism is same as mentioned above.

The aircraft can also be made to float on water by using the water storage facility as a float when it is empty.

Cost Estimates

The cost of the aircraft can be divided into three categories-The cost of construction, operation and maintenance.

Cost Of construction:

The cost of construction depends on several factors. Although the cost of the raw materials used to construct an aircraft is more or less same in all parts of the world, the total cost of the final aircraft depends on the place at which it is built and the techniques used for its construction.
The construction costs is also largely dependent on the labor costs which depends on the country in which it is built, the quality of materials used and the techniques used. Hence taking all these factors into account, the cost estimate for the construction of silver is the done taking the basic minimum requirements required for the operation of the aircraft.

The basic fuselage is estimated to cost about USD 5 million when using the basic minimum materials at the lowest available methods of construction.
The auxiliary units like the APU, water intake devices, seating, landing gears and the internal lightings and other accessories is estimated to cost about USD 10mn.
The flight control systems, the cockpit installations, radar installations, external lightening etc. is estimated to cost about USD 5mn
The two modified hydrogen powered turbofan engines is estimated to cost about USD 10mn.
The cost of the air friction reducing devices depends on the choice of usage of the diamagnets. The installation of the most efficient diamagnets at only the most crucial parts of the engine and other miscellaneous expenses like the computer and communication systems is estimated to cost about USD 1mn.

Hence the total estimated cost of the construction of the Silver is about USD 31mn

Cost of operation:

The cost of operation of the Silver is much less than other aircrafts of similar performance. The cost of operation depends upon the type of mission that the Silver is expected to accomplish. Hence the cost of operation can only be compared with standard aircrafts.

The cost of operation of the engine is just about 5% of a standard conventional turbofan engine of similar performance. This is due to the fact that several improvisations are done to the engine to improve efficiency.

The air friction reducing devices saves fuel consumption by about 20% and reduces cost of operation.

The fuel used is obtained from magnesium powder and conc. HCl; hence the cost of the fuel is also very low and is only about 10% of the conventional jet fuel. Moreover 50% of the fuel required in cruise flight is obtained by hydrogen dissociated from water by reutilizing the excess heat of the engine. This reduces the cost of operation.

The Hydrogen gas which is used as a fuel has a very high calorific value. Hence the amount to fuel required for the production of particular amount of heat energy is very less. This saves operation costs enormously.

In total, the cost of operation of the Silver is only about 10% of the cost required for the operation of a conventional aircraft with similar capabilities.

Cost Of maintenance:

The cost of maintenance of the Silver is about 20% less than the cost of maintenance of any other conventional aircraft of comparable performance. This is due to the fact that the air friction reduced helps in preventing the wear and tear caused to the various parts of the aircraft due to continuous usage.

Coupling of Two Aircraft

The design of the silver has been described in the previous sections. Now, this section tries to explain the mechanism by which two such aircrafts can used to carry loads which is about twice the load that each individual aircraft can carry.

Advantages involved in coupling:

The coupling of two aircraft increases the efficiency with which a certain task can be performed. Heavy loads which cannot be lifted by a single aircraft can be lifted by two aircrafts working in coordination with each other. Some loads cannot be dismantled to be carried on different aircrafts separately. Hence the coupling of aircrafts would help resolve such a situation.

Problems involved in coupling of aircrafts:

There are several technical difficulties involved in the coupling of aircrafts. Some of them are listed below:

1. The load to be carried must be place in such a way that they apply equal load on both aircraft and thus must be balanced.
2. The aircrafts used must have enough lifting capabilities to meet the requirements.
3. The aircrafts carrying the load must be well coordinated during their flight.
4. The aircrafts must land with utmost care.

Why a Tilt Rotor craft is better suited for this operation than a conventional helicopter:

A tilt rotor craft like the silver can operate in two modes: the aircraft mode and the helicopter mode. In the aircraft mode, the engines of the silver are placed in a horizontal position and hence, the twin turbofan engines propel the aircraft to speeds has high as mach 0.8. At cruise speed, the fuel consumption of the silver would be less than a conventional helicopter of comparable load bearing capacity. In the helicopter mode, the silver can perform vertical takeoff and landing. Hence it is capable of landing and taking off from almost any type of terrain.

The load bearing capacity of the silver is far greater than most of the conventional helicopters. This is due to the high power modified turbo fan engines used in the aircraft. Thus two such aircraft working in tandem can carry a far greater load than two conventional helicopters working together.

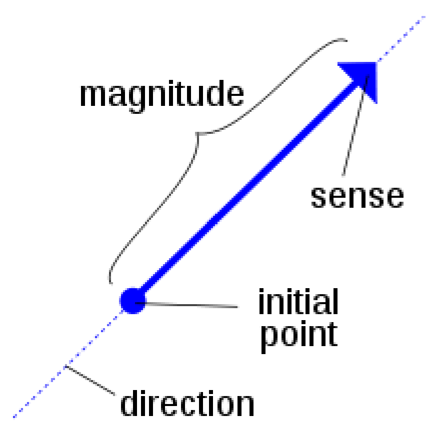
A conventional helicopter can perform vertical takeoff and landing, but it comes at the cost of speed and efficiency. The helicopters consume greater fuels and travel at lower speeds and can be stalled easily. Hence it is far less efficient than a tilt rotor for this kind of a job.

Mechanism of attachment of the load:

The Tilt rotor crafts are separated by a distance which is in proportion to the size of the load. A metallic platform which exceeds the size of the load by a small margin is placed. The platform is attached to the lower surface of the fuselage of the two aircrafts by means of 8 cables, 4 connected to each aircraft. The load is then placed on the platform and then air lifted.

Principles:

The load carrying process is majorly dependent on the scientific principles of vector resolution:

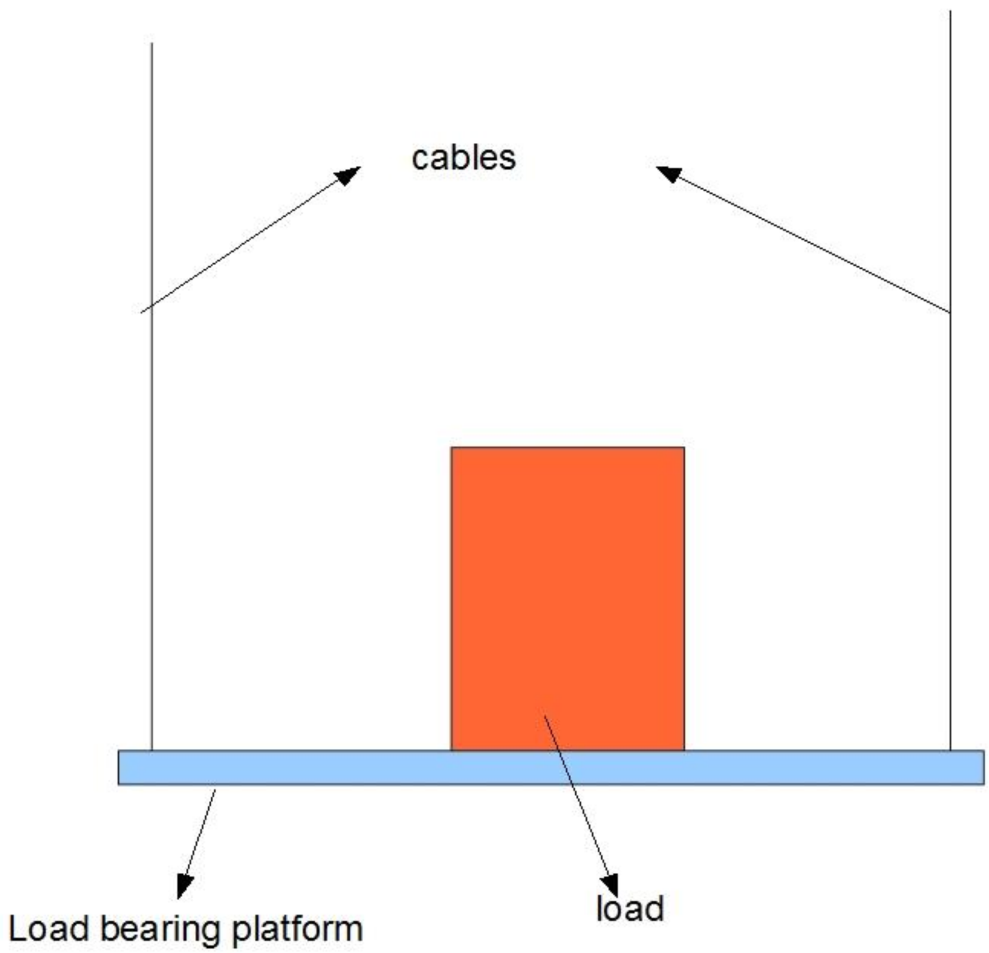


Vector (image: Wikipedia)

A vector is used to describe a physical quantity which has both magnitude and direction. The magnitude of the physical quantity is given by the length of the vector and the sense gives the direction along which the given physical quantity is acting. The Initial point is the point at which the physical quantity originates.

Vector (image: Wikipedia)

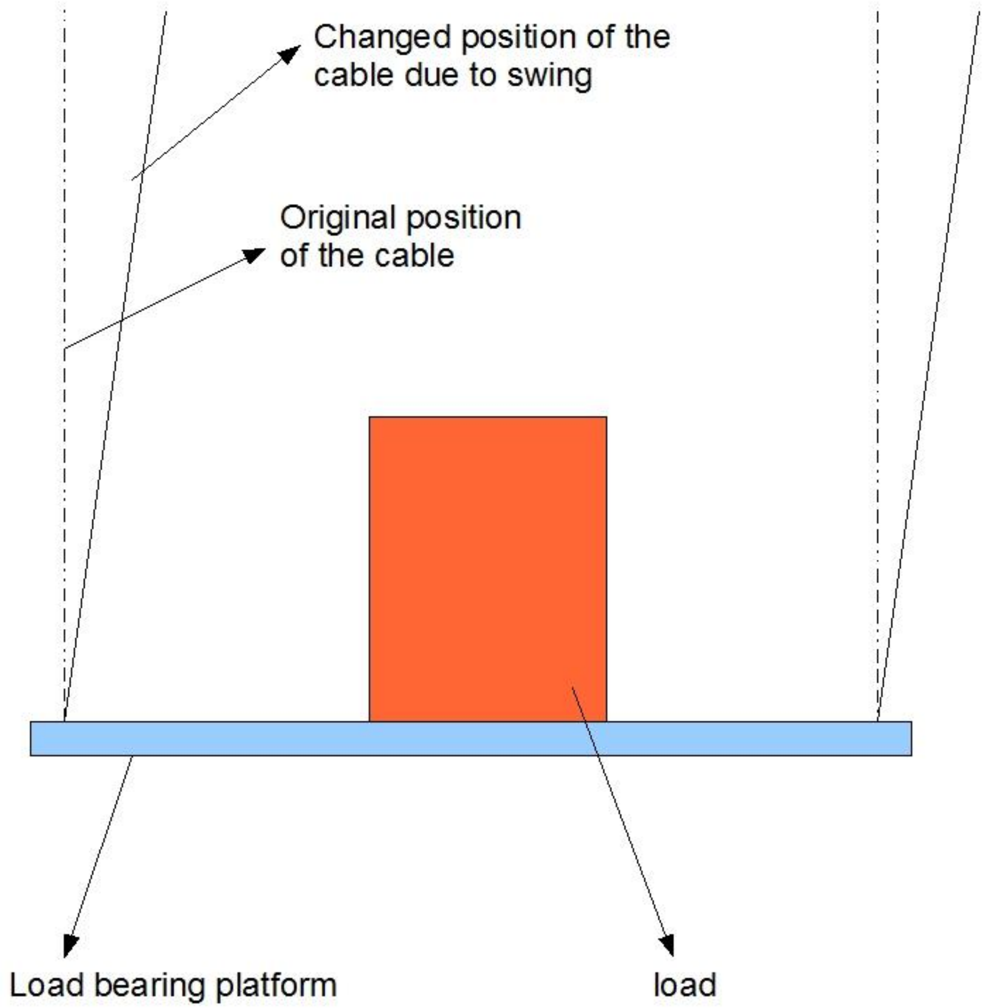
The physical quantity considered here is force. There are only two forces involved during takeoff and landing. This is considering the fact that the takeoff and landing is done vertically. Hence there are only vertical components involved. The two forces involved are the upward lift provided by the engines and the downward pull caused by the force of gravity acting on the load.



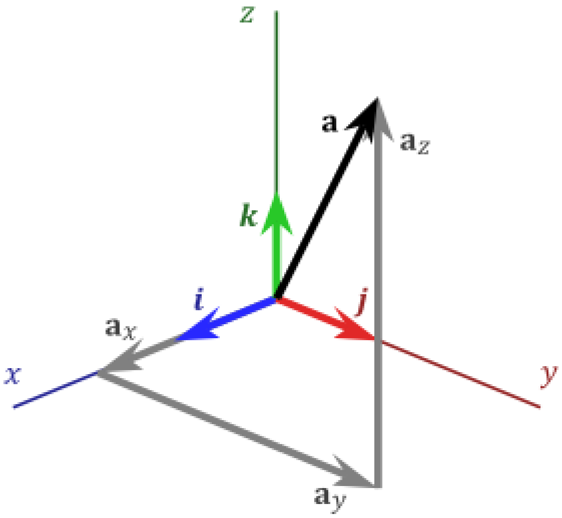
Position of load during takeoff and landing

The upward lift must be gradually increased to a level greater than the downward pull during takeoff and the upward lift must be made equal to the downward pull when travelling at normal velocity. The upward lift must be gradually decreased to levels below the downward pull when landing.

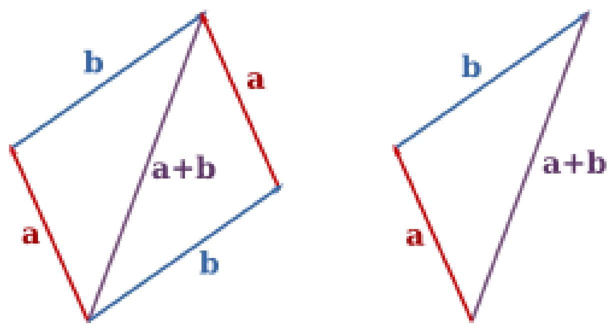
When the aircraft is accelerated or when there is the flow of wind, there is swinging of the platform holding the load. At this point of time there are two components to the force acting on the load. They are the horizontal component and the vertical components. These components are obtained by the vector resolution of the single force.



Position of load during accelaration



Component of force along each of the axes (image: Wikipedia)



Vector sum of the coplanar forces (image: Wikipedia)

The total force acting on the load is the vector sum of their components as shown above. These forces must be adequately compensated to maintain the system in equilibrium.

Flight Stabilization:

Mechanism To detect the amount of swing and compensate it with the appropriate change in thrust:

The external carried by the aircraft can swing by a certain angle when subjected to acceleration or due to the flow of wind. This swinging can cause instabilities in the aircraft and may also lead to the snapping of the connecting cables. Hence the thrust of the engines must be appropriately adjusted to accommodate such factors.

The angle of the swing must first be determined continuously in order to make effective and immediate adjustments to maintain the system in equilibrium. The silver incorporates an adjustment device which meets the requirements of such a job.

The device consists of a chamber filled with water with a certain amount of electrolytes dissolved in it. The walls of the chamber consist of a number of very thin strips made of a hydrophobic material placed close to each other. The opposite ends of these strips are connected to an external electric circuit which comprises of a battery and a current measurement device like an ammeter. The hydrophobic material is non-conducting and does not allow the flow of electricity. But when it is wetted by the electrolytic water, the ions in the water allow for the passage of electricity through the external circuit. As soon as The water is out of contact with the hydrophobic material, there would be no water present in the material due to its hydrophobic nature and there is no flow off electricity through it.

When there is a change in the angle of the load bearing platform with respect to the normal, there is an equal change in the angle of the surface of water in the chamber with respect to the normal. Due to this there is an increase in the level of water on 1 side of the chamber and a decrease in the level in the opposite side of the chamber. Due to the rise in water level, a definite number of hydrophobic strips which is in proportion to the angle of swing gets wetted and conducts electricity which is measured by the current measuring device. Hence the number of strips wetted is directly proportional to the angle of swing. This device then sends signals to the central processor which adjusts the thrust of the engines with a magnitude in proportion with the angle of swing.

Control of the Aircrafts:

The two aircrafts have a pilot each who would maneuver the flight during takeoff and landing. The two aircraft are maintained in proper position with respect to each other by the flight stabilization mechanism mentioned above. When any one of the aircrafts accelerates with respect to the other, there is the swing in the angle of the platform with respect to the normal. Due to this, the flight stabilization takes place as mentioned above and the velocity of the two aircrafts is made equal to each other by thrust compensation.

Mode of Operation:

Take off: When the load is attached to the two air craft by the means mentioned above, they are ready to be lifted. The 2 aircraft are placed with the load in between them. The vertical takeoff is achieved by tilting the two turbofan engines to a vertical position. The shaft of the engines is then disconnected from the compressors and turbines by means of a spool and the vertical lift is achieved only with the help of the fan. This is done as the compressors and the turbines cannot run at such low velocities of the incoming air. The fan is then temporarily run by the engine starter which is an electron emitter system surrounded by a magnetic engine case. This mechanism also starts the engine.

During takeoff there are only two forces acting on the aircrafts and the load. The upward force generated by the engines and the downward force on the load due to gravity. These forces have an angle of 180 degrees between them. The upward lift must be gradually increased to a level greater than the downward pull during takeoff.

Normal flight: After the vertical takeoff, the engines are brought back to its original position by means of the electric motor in the APU. The shaft is reconnected to the sets of compressors and turbines and the engine starter is switched off by concealing the electron emitter and thus preventing it from emitting the electrons. Now the forward thrust of the aircraft is the sum of the thrusts due to the primary and secondary sir flows through the fan and the engine core.

During this normal flight, the hydrogen fuel created at the site of combustion ignites and produces the required energy needed to run the engine. The turbofan engines of the silver incorporate the same basic structure of the compressors and turbines of the united technologies' Pratt & Whitney 4000 series turbofan engine. Hence the engine is almost of the same dimensions as that of the above mentioned engine. Hence the engine is approximately 133 inches long and 97 in across the largest diameter. It weighs about 4713 kgs and provides a thrust of about 100000 lbs by virtue of increased efficiency due to the modified engine design.

During normal flight, the aircrafts travel at constant velocity and there are only two opposite forces acting on the load as mentioned. The upward lift must be made equal to the downward pull when travelling at constant velocity.

Accelerated Flight: When the aircraft is accelerated or when there is the flow of wind, there is swinging of the platform holding the load. At this point of time there are two components to the force acting on the load. They are the horizontal component and the vertical components. These components are obtained by the vector resolution of the single force. The computer systems in each of the aircrafts sense this and adjust their engines so that these forces are compensated and the flight is in equilibrium.

Vertical Hovering: When the aircraft is required to hover over land, the two turbofan engines are again brought back into a right angled position. The shaft is again disconnected from the compressors and the turbines and the aircraft is made to hover only with the help of the fan run by the engine starting mechanism. The thrust crated is equal to the gravitational pull. Hence the aircraft maintains a constant and stable altitude. The aircraft can also be made to move vertically upwards or downwards by correspondingly increasing or decreasing the thrust.

The aircraft is again brought back into normal flight by the same mechanism as mentioned above for the takeoff.

Even during hovering and there are only two opposite forces acting on the load and upward lift must be made equal to the downward pull

Landing: The aircrafts can be made to land vertically by again bringing the engines into the right angled position and disconnecting the shaft form the compressors and turbines. The engine would be run by the starter mechanism. The aircraft is slowly brought down by gradually reducing the thrust.

The aircrafts are separated by a distance which is slightly greater than the size of the load carrying platform when landing. The load touches the ground first and then followed by the 2 aircrafts. . The upward lift must be gradually decreased to levels below the downward pull when landing.

The platform is then detached from the two aircrafts and the load is removed.

Amount of load carried:

Each aircraft, by virtue of the powerful engines used is capable of easily carrying 10000 lbs as an externally attached load. Hence 2 of them working together can carry at least 18000lbs. Hence the minimum load of about 7000lbs of ISO containers can easily be carried by the aircrafts.

Executive Summary Briefing:

Introduction:

The Silver is an aircraft designed to overcome some of the difficulties that the present tilt rotor aircraft have to face. The Silver has an external structure based on the famous tilt rotor, the V-22 Osprey. The Silver incorporates 2 modified turbofan engines for propulsion. The engine has a fan followed by a set of axial compressors and turbines. The engine has incorporated a mechanism where a vacuum cylinder is incorporated into the principal shaft of the engine. Due to the heat developed by the combustion of fuel, thermal emission takes place from the cathode. The electrons thus emitted travel towards the positive anode with high velocities. Due to the high velocity of the electron current, a large current is created. Because of this current, a mechanical force is experienced by the shaft by virtue of the electron interaction with the magnetic engine case. Due to this the shaft experiences rotational motion which drives the propeller fan. This technology is used as a starting mechanism for the engine and also for thrust augmentation. It is also used as a power saving mechanism when the aircraft is in hover mode.

The Combustion chamber and the fuel injector have been modified in the Silver. Here the fuel injector is made to eject small quantities of a dil. HCl and powder of magnesium. These two combine to liberate hydrogen which has a very high calorific value. The hydrogen is created at the sight of combustion and is used as primary fuel for jet propulsion. This avoids the hassles and the dangers involved in storing and transporting hydrogen gas. This mechanism is employed as a starting mechanism for the flight.

When the aircraft runs for a certain period of time a high amount of heat is generated. The fuel dissociation chamber consists of water containing a definite a quantity of electrolytes. The heat generated dissociates the water molecules into hydrogen and oxygen. This is recombined again to generate energy. This will comprise about 50% of the energy required for operation. The rest is provided by the acid- metal method mentioned above. This mechanism also serves the purpose of engine cooling.

The Silver also incorporates an air friction resisting mechanism where diamagnets comprising of superconducting electromagnets are placed at crucial points on the external surface of the aircraft. This helps in saving power and also adds to propulsion.

The aircraft also employs an innovative auxiliary power unit which stores the excess power from the turbofan engines and uses them during the tilting of the engines and for sucking water into the internal tank.

Tilt Rotor:

The silver has been designed as a versatile tilt rotor aircraft. The tilt rotor aircrafts are more advantageous than a conventional rotor craft helicopter in many aspects.

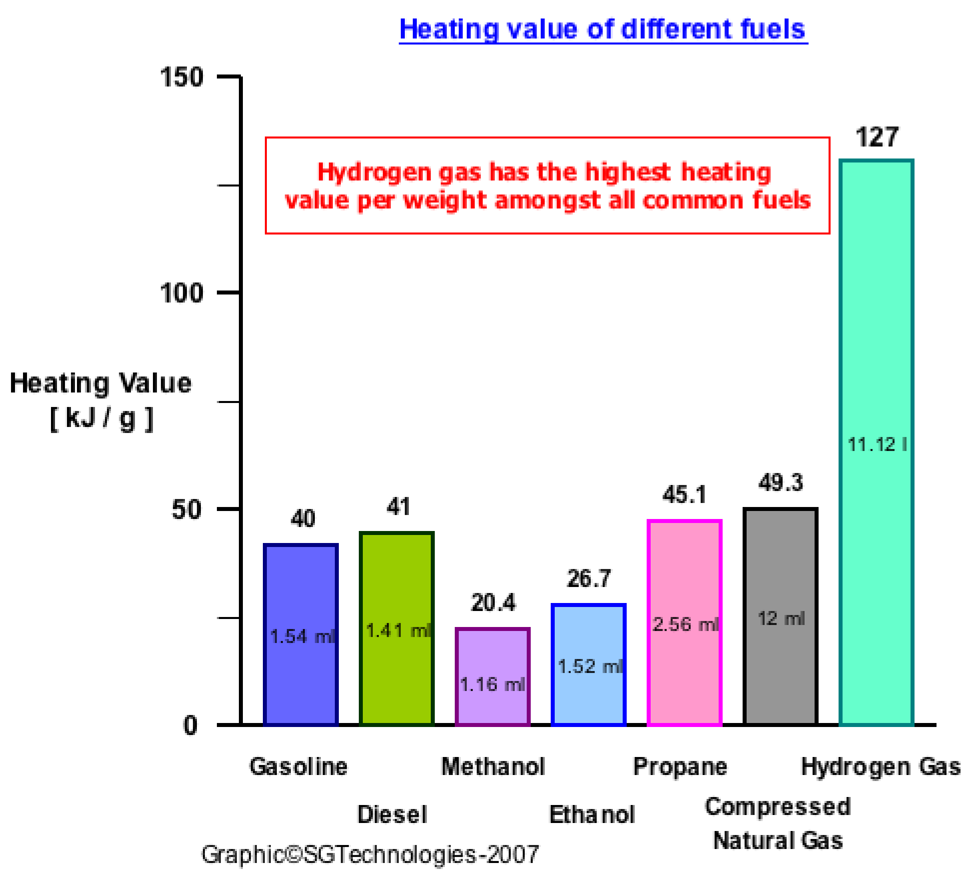
The basic advantage of a tilt rotor over a helicopter is that it has a higher speed and a greater range. The maximum speed achieved by a helicopter is given by the turn speed of the rotor. If this speed exceeds a particular limit, then the helicopter would stall .They are also restricted to speeds of about 150 knots. Tilt rotors can easily achieve speeds of about 300 knots and also achieve altitudes of about 6000m. These types of aircrafts are also less noisy in forward flight when compared to helicopters.

The best of heavy load carrying helicopters can lift only about 20000 to 30000 lbs. But tilt rotor aircrafts can carry much more load; hence it is more economically viable. The silver with its modified design can easily carry about 100000lbs of load.

The silver has a water storage facility with an appropriate water collection mechanism. Hence it can collect liquid loads also. Therefore it can also be used for fighting forest fires.

Fuel Used:

Hydrogen gas is used as the primary fuel for the functioning of Silver. Using hydrogen as a fuel has many advantages when compared to other conventional fuels.



Calorific values (image: SGT technologies)

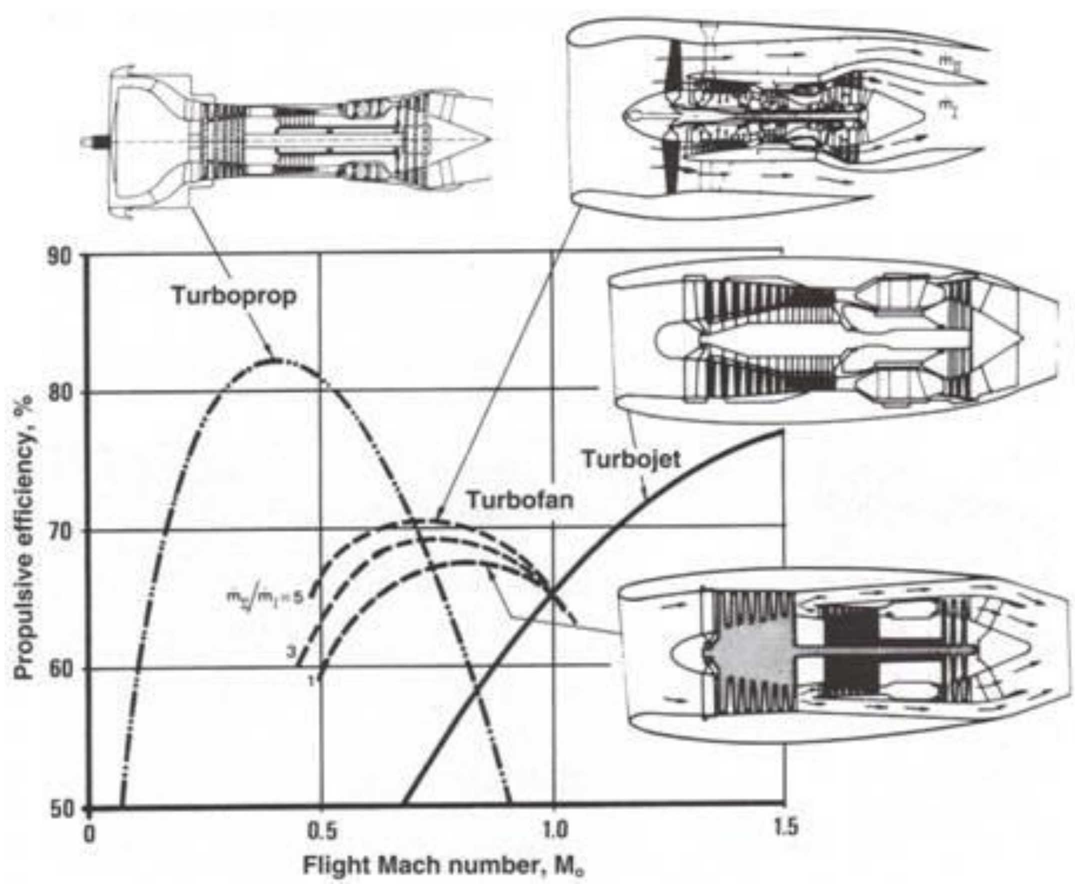
As displayed by the graph, the calorific value of hydrogen gas is very high when compared to the other conventional fuels commonly used. Hence burning 1 gram of hydrogen gives 127 KJ of heat when compared to just 40KJ given by conventional gasoline. Hence using hydrogen gas as a fuel in the Silver has exponentially increased its fuel efficiency and thereby significantly decreased its operating costs.

The storage of hydrogen gas is very difficult. Hence the use of industrially manufactured hydrogen gas as a fuel is dangerous since hydrogen can easily undergo ignition and can even explode. This problem is solved by creating the hydrogen gas at the site of combustion by the metal displacement method. Hence there is no problem with regard to the safety of using hydrogen gas as a fuel in silver.

Turbofan

The Silver has been incorporated with 2 modified turbofan engines based on the Pratt & Whitney 4000 series turbofan engines.

There are many advantages in using turbofan engines as opposed to other jet engines:



Propulsive efficiency (image: www.ligoeleos.com)

As seen from the above figure the turbofan engine is an optimum combination of speed and efficiency when compared to other jet engines.

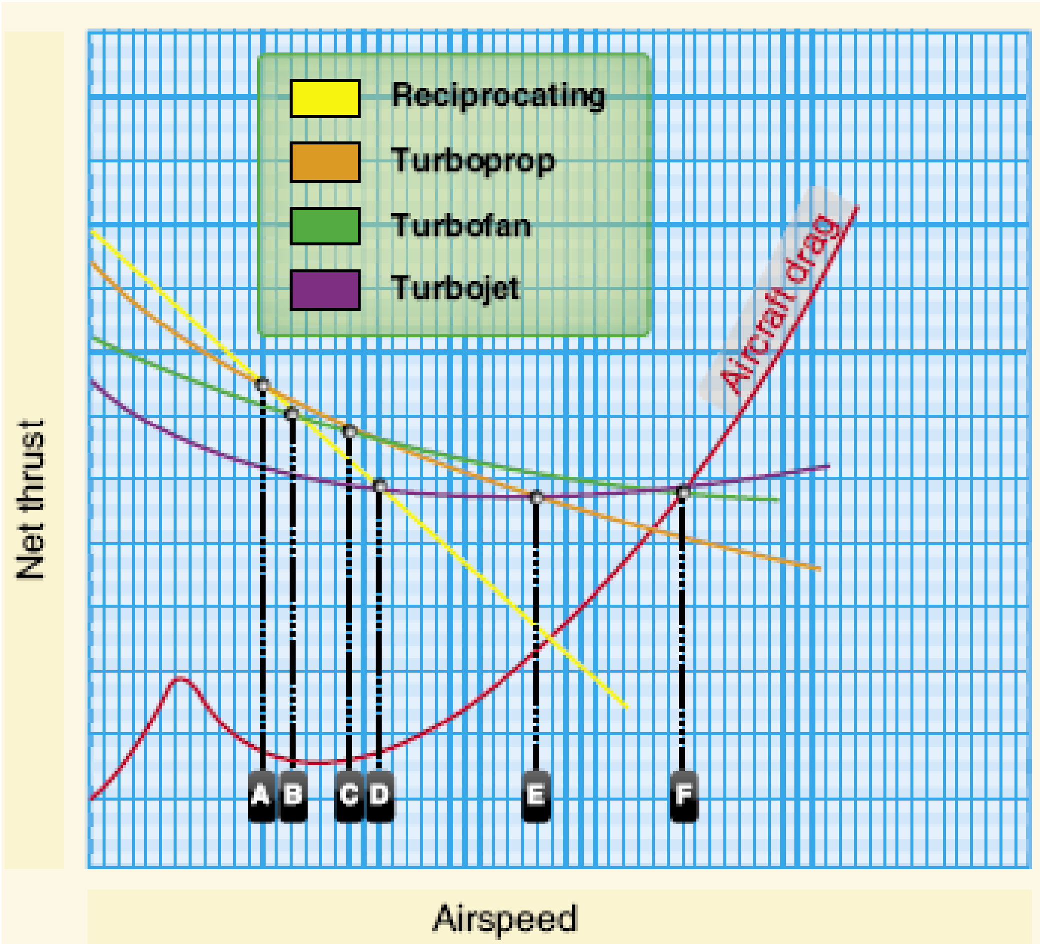
The efficiency of the turbofan engine is higher than those of the turbojet engines. This is due to the fact that the fuel energy obtained is largely converted into pressure energy rather than the kinetic energy of the exhaust gases. The Fan engines have a definite advantage over pure jet engines in speed ranges below mach 1. Due to the development of the trans-sonic blade, the turbo fan engine can be made to reach speeds that are near to Mach 1.

The noise levels of the turbofan engine are about 20% less than other engine of comparable performance. The weight of this engine lies between that of a turbojet and a turboprop engine. Turbo fan engine is capable of two kinds of exhausts. Hence the secondary exhaust can be used during vertical hover situations while the combination of primary and secondary thrust can be used in normal flight conditions. Due to this arrangement the engine is less susceptible to stalling.

The turbofan engine, unlike the turboprop engine does not experience fall in thrust due to increasing airspeeds. Hence this is a better engine over the turboprop engine.

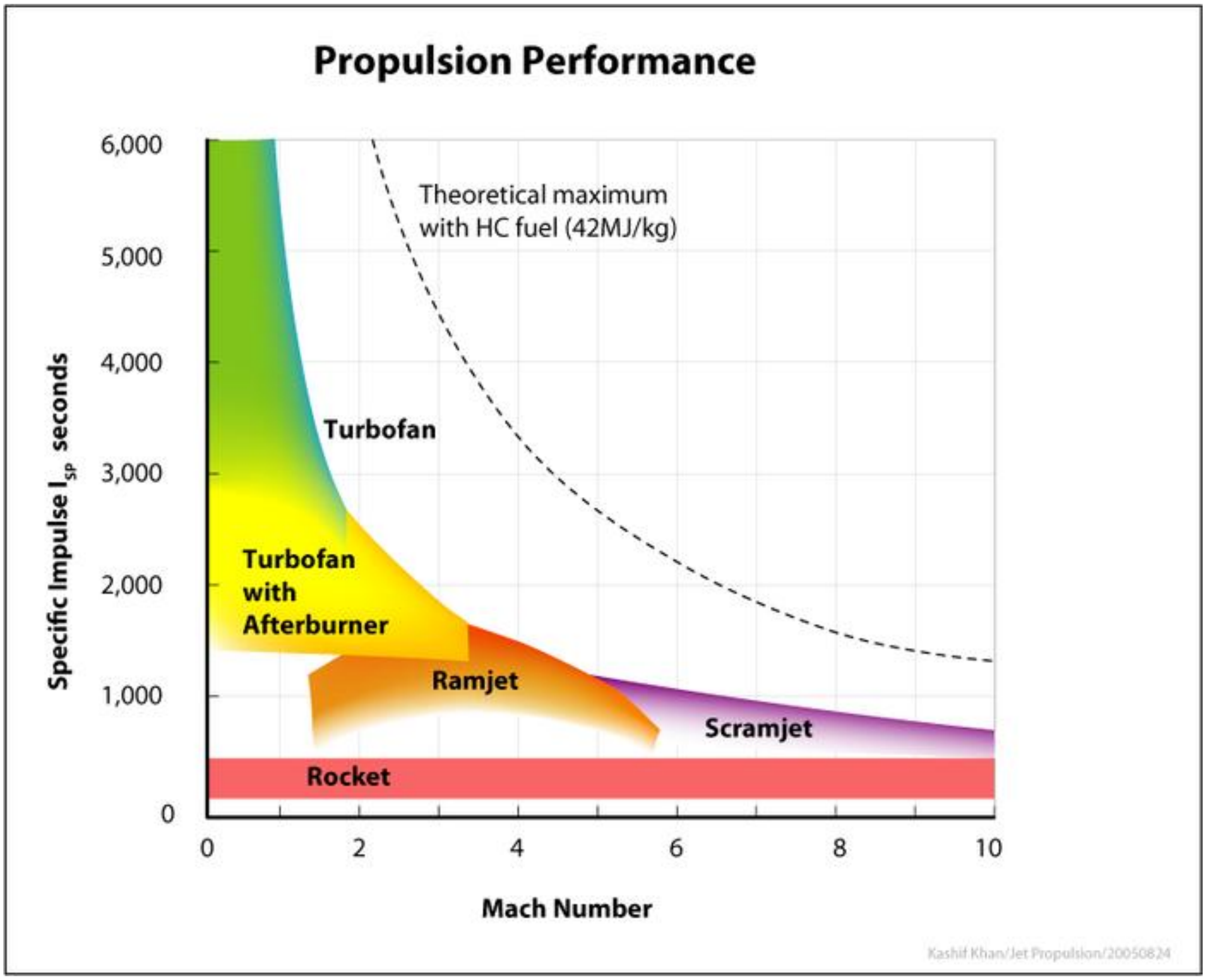
The turbofan engine can operate in a wide range of climatic conditions and under a wide range of temperatures. The TSFC and the specific weight are lesser than that of the turbojet engine. This results in operating economy and aircraft range. The ground clearances lie between the turbojet and the turboprop engines.

These features show that the turbofan engine is suitable for long range and high speed flights. The Turbofan engine is a fine optimized blend of efficiency and performance. But there are several drawbacks that hinder high performance. Hence a modified turbofan engine is used.



Net thrust v/s Airspeed (image: www.flightlearnings.com)

The above image shows that the turbofan engine has the best net thrust versus airspeed ratio.



Specific impulse (image: Wikimedia)

The specific Impulse is high in Turbofan Engines. Hence the fuel efficiency is high and the operating costs are low.

Engine Starter:

A conventional engine may use starters such as an electric motor, starter generator, air turbine starter, cartridge starter, hydraulic starter etc. All these methods require additional mechanisms for its functioning and hence are not very efficient.

Hence the silver incorporates an electromagnetic starter to increase the efficiency of the process. The starter is built inside the central shaft of the engine. Hence it is integrated with the engine itself.

Here the shaft is made up of a material of high magnetic permittivity. Hence the shaft also serves as the engine starter. This helps in providing an effective and economic means of starting the engines as well as sustaining vertical flight.

Energy recycling:

The excess energy in the form of heat in the engine is recycled and reused in the Silver. Hence the fuel efficiency of the silver is very high and the performance is also high when compared to other rotor crafts. This mechanism also serves the purpose of cooling the engine.

Air Friction Protection:

The silver also provides an option of implementation of ordinary or superconductor diamagnets at aerodynamically crucial points on the aircraft to reduce to a large effect, air friction might have on the performance of the aircraft. This feature increases the overall efficiency of the aircraft.

Speed Range and Performance:

Due to its powerful modified turbofan engines and the use of hydrogen gas as fuel, the silver can easily travel at velocities of mach 0.8. It has a large range of about 2500 nm and it can carry a load of about 100000lbs by virtue of its engines each of which can produce a thrust of 100000lbs. The Silver is also capable of taking off, landing and hovering over water, which indeed is a huge advantage over other aircrafts.

Auxiliary Power Unit:

The Silver also incorporates an innovative auxiliary power unit which stores the excess power supplied from the engine and uses it for running the in flight systems. It also provides the energy required to tilt the engines during vertical flight.

Flight Stabilization:

The Silver incorporates the flight stabilization mechanism which provides for the maintenance of flight equilibrium when two aircrafts are coupled to carry load.

Additional Features:

It is recognized that the rotorcrafts of today might not be required just for carrying solid container loads but they might also be required to carry people during rescue operations where conventional aircrafts might not be able to reach. It may also be required to carry water for fighting forest fires.

Keeping these requirements in mind, the Silver has been designed to carry passengers and also collect, transport and dispose water wherever required.

Efficiency: Due the energy recycling and power saving mechanisms mentioned above, the aircraft has very high fuel efficiency. Due to this the overall operating efficiency is very high.

Cost: The cost of construction is estimated to be about USD 32mn which is much less than other aircrafts that delivers similar performance.

The cost of operation of the engine is just about 5% of a standard conventional turbofan engine of similar performance. This is due to the fact that several improvisations are done to the engine to improve efficiency.

The air friction reducing devices saves fuel consumption by about 20% and reduces cost of operation.

The fuel used is obtained from magnesium powder and conc. HCl; hence the cost of the fuel is also very low and is only about 10% of the conventional jet fuel. Moreover 50% of the fuel required in cruise flight is obtained by hydrogen dissociated from water by reutilizing the excess heat of the engine. This reduces the cost of operation.

The Hydrogen gas which is used as a fuel has a very high calorific value. Hence the amount to fuel required for the production of particular amount of heat energy is very less. This saves operation costs enormously.

In total, the cost of operation of the Silver is only about 10% of the cost required for the operation of a conventional aircraft with similar capabilities.

The cost of maintenance of the Silver is about 20% less than the cost of maintenance of any other conventional aircraft of comparable performance. This is due to the fact that the air friction reduced helps in preventing the wear and tear caused to the various parts of the aircraft due to continuous usage.

Environmental Effects:

The primary exhaust from the engines of the Silver during normal flight is in the form of water vapor which is totally harmless to the environment. The Vertical flight mechanism uses the efficient engine starter which utilizes the velocity of electrons to sustain vertical flight. This mechanism has no exhausts and is environmentally harmless.

The noise levels from the engine are reduced by the noise suppressors installed in the exhaust outlet. Hence noise pollution is also reduced.

Results and conclusions:

1. The Silver can reach cruise speeds of up to mach 0.8 and a maximum speed of up to mach 0.9 due to its fuel efficiency, air friction reduction and the usage of transonic blades.
2. The Silver is capable of landing and taking off from both water and land.
3. It is able vertically take off and land on both land and water. It can also be used to land and takeoff conventionally from runways as short as 300 meters. This is due to the fact that the Silver employs a very efficient starter which is used for aircraft takeoff. The power generated by this mechanism is enormous due to the high amounts of current produced.
4. The Silver is capable of hovering over both land and water for comparatively long periods of time.
5. It is also capable of generating about 200000 lbs of thrust and hence can carry about 150000 lbs of load. This implies that it easily carry about 100 to 150 passengers and also about 10000 liters of water.
6. The water intake mechanism enables the silver to collect water from any water source and release it in the region required. Hence it may be used to fight forest fires. The storage mechanism also enables the aircraft to release the water partially at different regions if required.
7. The hydrogen fuel based engines of the silver helps in reducing the cost of operation and increasing the efficiency of the aircraft enormously.
8. The water dissociation process used in the engine helps in reducing the heat of the engine and increasing efficiency by reutilizing the excess heat of the engine.
9. Since the exhaust from the engine is water in the form of water vapors, it is absolutely environmental friendly and does not cause air pollution.
10. The noise levels from the engine are reduced by the noise suppressors installed in the exhaust outlet. Hence noise pollution is also reduced.
11. The effective engine starter employs new mechanisms for the starting of the engine. It also provides an efficient take off and landing mechanism along with the hover mechanism.

12. The auxiliary power unit utilizes the excess power from the shaft of the engines to generate electricity and supplies the same for different operations of the aircraft. Hence it increases the efficiency of operation.
13. The hover mechanism enables the aircraft to carry out rescue operations in case of floods where other aircraft cannot be utilized.

The silver utilizes many ground breaking technologies and mechanisms mentioned above. It is a VTOL aircraft designed for the future aimed at meeting not just the needs of transporting the materials to inaccessible places but also at meeting the larger needs of being to land and take off from almost anywhere on earth.

Silver is a highly efficient, versatile and technologically innovative aircraft that is capable of performing several tasks as mentioned above. NO other aircraft is capable of performing such a wide range of tasks at the present. As many of these are optional features and are not necessary for the functioning of the aircraft, they can be removed when not in use and the aircraft can be built for the need of the mission to be performed...This in effect reduces the cost of construction, operation and maintenance even further.

Proposal for future research:

With the increasing prices of petroleum the prices of jet fuel which is created from a petroleum base is also bound to increase. Hence it is important to develop alternative sources of energy. This proposal tries to outline the conceptually the technical specifications for the viable usage of hydrogen as a fuel in vehicles. It is suggested that research must be done into this topic and economically feasible methods of production of hydrogen gas must be studied. Hydrogen is quite literally the future energy source since it has the capabilities to meet all our existing energy requirements.

Air friction is a major dissipater of energy. Theoretically, all moving objects continue to move at the same speed according to Newton’s first law of motion. But in practical applications, energy is needed just to maintain constant velocity. The reason for this is friction. In case of airborne vehicles, it is air friction. Hence methods of overcoming this problem must be looked into. This proposal tries to conceptually solve this problem by using diamagnetic substances or super conducting diamagnets. This prospect of reducing air friction must be studied.

Feasibility

A first glance at the design of the Silver may bring about a notion of non feasibility due to its non conventional approach. But taking into account the theoretical feasibility, it is possible to build such an aircraft. The current technologies are sufficient to accomplish this task.

The doubt about the feasibility of a certain undertaking is just a frame of mind. As the proverb goes "where there is a will, there is a way". Hence if a strong will to accomplish the construction of such an undertaking will bear fruit.

Historically speaking, the amount of scientific and technological advancement that has taken place in the past 150 years is beyond imagination. Within 50 years of the flight of the first aircraft, the "kitty hawk", it was possible to build aircrafts that travel beyond the speed of sound. And, subsequently, within a few years man was able to land on the moon. Hence there exist no limits to the things that can be achieved in the field of science and technology.

As it is said, the passion for flight is driven by dreams and inspired by freedom. This proposal for Silver dares to break the conventional methods of aircraft functioning and introduces many non-conventional approaches to realizing flight. These proposals may seem impractical, but are quite within the realm of the capabilities of current technologies.

Therefore, it is absolutely imperative that all efforts must be made to undertake research about the above mentioned topics for it is action that defines the future and not just thought.

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