LCA TEJAS DIVISION,

Internship Report.

This Report is based on the Industrial Training engaged in HAL LCA Tejas Division from December 5/2022 to January 4/2023.

By,

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Acknowledgement

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We would like to express my gratitude to Shri. Mohan Raj, Cheif Manager (Equipment and Final Assembly). for taking a genuine interest in our internship and providing invaluable guidance at every stage of this programme.

We would like to take this opportunity to convey our gratitude to Shri Srirama Murthy for their cooperation and guidance throughout the internship.

We are grateful to the HAL TEJAS Division employees for the helpful knowledge they have supplied in their different domains. thankful for their assistance during our internship.

I would like to express my gratitude to Smt. Sumathi of the LCA Tejas Division's Human Resources Department for providing me with the opportunity to complete an internship in the Equipping and Final Assembly Division, where learned about one of the most crucial aspects of Light Combat Aircraft Production.

Declaration

We hereby declare that this report entitled "LCA Tejas,Internship report "in HAL is submitted by us as part of our curriculum during the bachelor's degree in Aeronautical Engineering at Hindustan Institute of Technology & sciences.

Period of the Internship: 05 December 2022 - 04 January 2023

Duration of the Internship: 30 days

Location of the Internship: LCA Tejas Division, HAL Bangalore

Shri Mohan Raj

Chief manager(Equipment & Final Assembly)

PURPOSE OF INTERNSHIP TRAINING

Training and development are the field concerned with organizational activity aimed at improving the performance of individuals and groups in an organization.

From the student perspective, an Internship assists with career development by providing real work experiences that provide students with opportunities to explore their interests and develop professional skills and competencies. During Internships, students are provided with opportunities to apply what they learned in classes to actual practice. expected that students will also be challenged to examine how their attitudes, beliefs, and values influence the helping process. From the agency/facility perspective, an internship provides a unique training experience designed to enhance the professional development and functioning of the student. In accepting students as interns, the agency/facility representative recognizes that the internship is a learning process designed to promote professional growth of the student.

OBJECTIVE

In this training report, technical description has been discussed which have learned during my training at Hindustan Aeronautics Limited (HAL TEJAS Division Bangalore Complex).

The report covers the Major Systems present in LCA TEJAS Fighter Aircraft along with the functional importance and working structure of all Departments, especially METHODS department, under which the internship was done.

The whole Aircraft has systems in a specific order of numerology given below:

- Fuselage, Canopy, Seat and Safety
- Wing
- Tail (Empennage)
- Landing Gear/Undercarriage Power Plant and Fuel System
- Flight Control Systems
- Hydraulics Armament
- Electrical and Avionic Systems
- Environmental Control System

Introduction

Hindustan Aeronautics Limited (HAL) is an Indian government-owned aerospace and defence corporation with headquarters in Bengaluru, India. HAL is one of the world's oldest and largest aerospace and defence industries. HAL began aircraft manufacturing in 1942 with licenced production of the Indian Air Force Harlow PC-5, Curtiss P-36 Hawk, and Vultee A-31 Vengeance.

HAL has eleven dedicated Research and Development (R&D) centres and twenty-one manufacturing

divisions under four production units located throughout India. The HAL HF-24 Marut fighter-bomber was India's first indigenously built fighter aircraft.

South Asia's first military aircraft was manufactured by HAL. Currently, the company designs manufactures and assembles airplanes, jet engines, helicopters, and their spare components. It has numerous facilities around India. HAL operates manufacturing facilities at Nasik, Korwa, Kanpur, Koraput, Lucknow, Bangalore, and Hyderabad, among other locales.

Hindustan Aeronautics has a long history of collaboration with numerous international and domestic aerospace agencies, including Airbus, Boeing, Sukhoi Aviation Corporation, Elbit Systems, Israel Aircraft Industries, RSK MiG, BAE Systems, De Havilland, General Electric (GE), Dassault Aviation, MBDA, EADS, Tupolev, Ilyushin Design Bureau, Dornier Flugzeugwerke, the Indian Aerospace Development Agency, and the Indian Space Research Organisation.

Indigenous Products

HAL has designed and developed numerous platforms throughout the years, including the HF-24 Marut, the Dhruv, the LUH, and the LCH. HAL also manufactures indigenous items using DRDO-transferred technology in partnership with Bharat Electronics for its avionics and Indian Ordnance Factories for its on-board weapons systems and ammunition.

ISRO is supplied by HAL with the integrated L-40 stages for GSLV Mk II, propellant tanks, feed lines of PSLV, GSLV MKII, and GSLV MKIII launch vehicles, and satellite structures

Licensed Production

- Vampire — first combat jet manufactured by HAL, 250+ FB.S2, 60 T.55 models[56]
- Harlow PC-5 — first aircraft assembled by HAL
- Percival Prentice — 66 built by HAL
- Mikoyan-Gurevich MiG-21 — FL, M, Bis and Bison upgrades variants 660 built by HAL
- Ajeet — improved version of the Folland Gnat
- Mikoyan-Gurevich MiG-27 M variant
- SEPECAT Jaguar— IS, IB and IM variants
- BAE Hawk Mk 132 — scheduled production run of 42 aircraft
- Sukhoi Su-30MK1 — a derivative of the Sukhoi Su-30
- HS 748 Avro — modified for military usage, includes Series 2M variant with large freight door
- Dornier 228 — 117 built + fuselage, wings and tail unit for production of the upgraded Dornier 228 NG variant.

- Aerospatiale SA 315B Lama — HAL Cheetah, Lancer, Cheetal Variants
- Aerospatiale SA 316B Alouette III — HAL Chetak, Chetan Variants
- Rolls-Royce Turbomeca Adour Mk 811 — Engine for SEPECAT Jaguar, produced under license
- Rolls-Royce Turbomeca Adour Mk 871 — Engine for BAE Hawk Mk 132, produced under license
- Garrett TPE331-5 — Engine for Dornier 228, produced under license
- Saturn AL-31FP — Engine for Sukhoi Su-30MKI, produced under license
- Klimov RD-33MK — Engine for Mikoyan MiG-29, produced under license
- Turbomeca TM 333 — Engine for HAL Dhruv Helicopter, produced under license

LCA Tejas

Tejas came from the LCA programme which began in 1980s to replace india’s ageing MIG -21 fighters. In 2003, The LCA was officially named as “Tejas” by the former prime minister Atal Bihari Vajpayee. The Tejas is the second fighter developed by HAL after HAL HF-24 Marut. It is designed to meet the tactical requirements roles and a multi-role aircraft capable of comprehensive air superiority and air defence roles.

LCA Tejas is equipped with quadraplex digital fly-by-wire flight control system to ease handling by the pilot. The digital fly-by-wire system of the Tejas employs a powerful digital flight control computer (DFCC) comprising four computing channels, each with its own independent power supply and all housed in asingle LRU. The DFCC receives signals from a variety of sensors and pilot control stick inputs, and processes these through the appropriate channels to excite and control the elevons, rudder and leading-edge slat actuators. The DFCC channels are built around 32-bit microprocessor and use a subset of the ADA programming language for software implementation. The computer interface with pilot display elements like the MFDs through ML-STD-1553B multiplex avionics data buses and RS-422 serial links.

Tejas is intentionally made longitudinally unstable to enhance manoeuvrability. The control laws (CLAW) recover stability and provide good handling qualities to the pilot. They also provide invariant responses with respect to variation in aerodynamics, fuel etc and facilitate robust performance. The CLAW is carefree and ensures that various aircraft parameters are limited automatically. This enables the pilots fly the mission without worrying about exceedance of parameters beyond a safe limit.

Facilities of LCA Tejas Division Bangalore

New structural assembly and final assembly facilities at HAL have been established for the series production for IAF. Hangars have been created exclusively for the LCA programme and structural assembly facilities are fully established to take up production of Tejas aircraft. There are several departments where different stages of aircraft manufacturing take place. These include:

- Fuselage Hangar
- Aircraft Equipping and Final Assembly Hangar
- Machining and Milling Shop
- Electrical Looms Shop
- Wing Hangar
- Drop Tank Assembly Hangdr

- Aircraft Refitting and Maintenance
- Paint Shop
- Flight Shelter
- Seat Assembly
- Quality Testing
- NDT (Non-Destructive Testing) Facility
- Equipping Stores

Looms used in LCA are produced in LCA Tejas to stringent quality requirements for catering EMI-EMC specifications. Automatic cable testers are employed for checking and certification of looms and panels.

LCA Tejas division has an elaborate quality assurance system to handle both in-house production and outsources activities. A metrology department with coordinate measuring machines, ultrasound scanners complement the quality of parts.

The division has the following state of art facilities

- Environmentally controlled hangars for aircraft build
- 5-axis robotic drilling machine for wing skin drilling

Machine shop consisting of both conventional and CNC machines such as

- 5 axis CNC router
- CNC Precision Turn Mill Centre
- CNC Billet Cutting Machines
- CNC Vertical Milling Centre
- Precision Grinding Machine
- CNC Pipe Bending Machine

Specifications

Overall Dimensions

Height	4.40m
Length	13.23m (without nose air data probe)
	13.43m (with nose air data probe)
Span	8.2m

Landing Gear

Wheelbase	4.34m
Main Wheel Track	2.20m
Fuselage Scrape Altitude	14° with oleo collapsed, tyres flat
	17° with oleo fully extended, at lift-off

Performance

Maximum Speed	Mach 1.8 ; Mach 1.6 for IOC version
Range	1850 m
Combat Range	500 km with internal tanks
Ferry Rangen	3200 km with 2x external drop tanks
Service Ceiling	16000m
g limits	+9/-3.5
Wing Loading	255.2 kg/m*2
Thrust / weight	0.94
Dry Thrust	53.9 kN
Thrust with Afterburner	80 kN

Special Features

- Compound delta wing
- Relaxed Static Stability
- Digital quadraplex fly-by-wire system (FBW)
- Full glass cockpit
- Multimode RADAR (MMR)
- Helmet mounted display system (HMDS)
- Advanced RADAR warning system (RWR)
- Power plant has FADEC
- Electronic counter control measure (ECCM)
- Hands-on-throttle-and-stick (HOTAS)
- Composite Structure
- Computer based monitor and control of electro-mechanical systems

Subsystems in Aircraft Equipping and Final Assembly Hangar

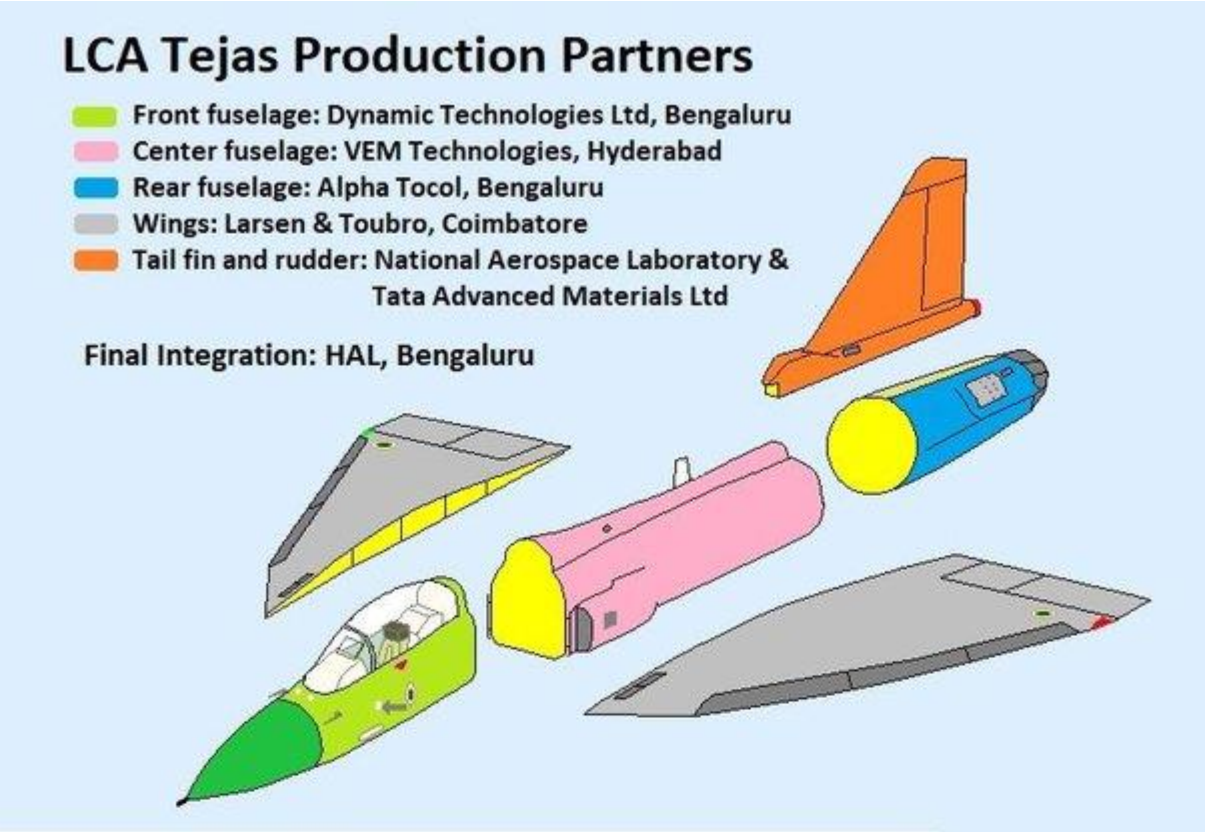
- Powerplant and fuel system (PFS)
- Hydraulics system
- Flight Control System (FCS)
- Electrical and avionics
- Environmental Control System (ECS)
- Seat and safety

Departments in LCA Tejas Division

There are a total of 15 departments in the LCA TEJAS project. Each department has its own roles to fulfil for ensuring smooth functioning of this division. The departments are as follows:

- Methods Department (MDS)
- Design Liaison Department (DLE)
- Machine Shop
- Quality Control
- LRU Management Group (LMG)
- Management Service Department (MSD)
- Scheduling Department
- Tooling Department
- Stores
- Assembly Progress
- Outsourcing (OS)
- Integrated Material Management (IMM)
- IT Department
- Human Resource (HR)

STRUCTURE



Fuselage

The Fuselage is a semi-monocoque structure consisting of frames, floors, Bulkheads, longerons and stringers covered with skins. It houses nose and main under carriage (U/C), all the avionic equipment including radar,general systems components, gacha gun and ammunition, furthermore, also houses the power plant and integral fuel tanks. Each assembly has its separate activity list

The Fuselage Structure of LCA TEJAS consists of three assemblies- Front Fuselage, Centre Fuselage and Rear Fuselage. There are different teams assigned accordingly to work on these three assemblies. The entire fuselage is further deconstructed into different stations. There are a total of 38 stations in the LCA Tejas. The assemblies represented by the total number of stations they contain are as follows:

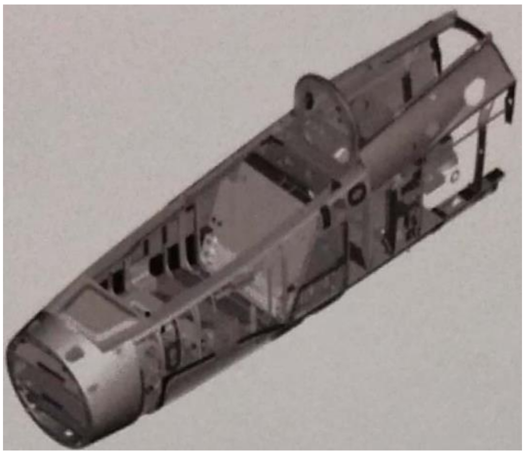
- Station 1— Station 20 4 Front Fuselage
- Station 21— Station 30 4 Centre Fuselage
- Station 31 —Station 38 4 Rear Fuselage

The reason for further breaking down of the fuselage into different stations is to delegate work appropriately amongst the teams formed to ensure organizational hierarchy and high efficiency. The jig's which are present in the structure's hanger along with the number of parts required to complete the assembly on each jig are as follows:

- Front Fuselage - 1931 parts
- Centre Fuselage - 1367 parts
- Rear Fuselage - 458 parts
- Nose Box - 307 parts
- Air Intake - 235 parts
- Nose Landing Gear Doors - 262 parts
- Stub Wing - 156 parts
- The Fabrication Techniques involved in LCA Tejas are:
- Machining — CNC, GMC
- Sheet Metal Forming
- Pipe Bending
- Welding
- Forging
- Casting
- Wire Cutting
- Water Jet cutting machine for rubber part

Front Fuselage

This section of the fuselage comprises of the Canopy, the radar equipment bay, the avionics rack, and the cockpit airframe. Furthermore, it also contains housing for the liquid oxygen sphere to provide the pilot required oxygen even at high altitudes.

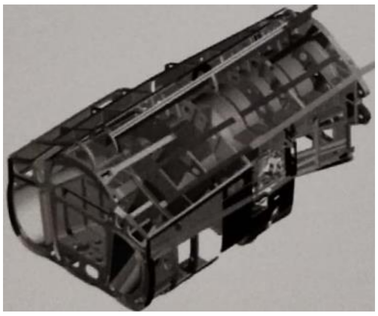


Assembly comprises of:

- Cockpit
- Equipment bay
- Fuel tank
- Nose Landing gear bay
- Mountings for: Radar, Nose cone, Canopy, Wind screen, Air data probes

Centre Fuselage

In this region, the gun, ammo box, hydraulic reservoir, secondary power system and air duct from part of the primary structure. Fuel tanks are formed by the enclosure of skin, air duct and floors. In this section, may NC milled frames take up wing attachments.

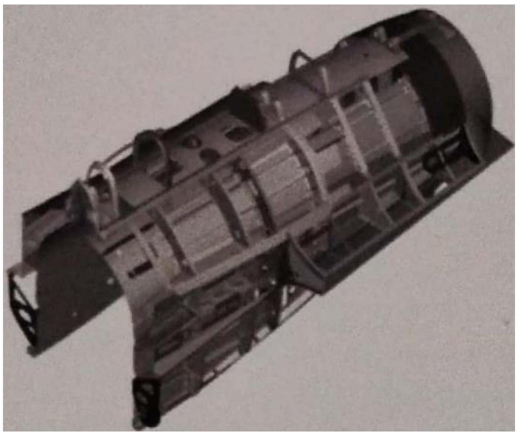


Assembly comprises of:

- Fuel tanks
- Air intakes
- Landing gear bay
- Wing mounting
- Gun

Rear Fuselage

Basic structure is inverted horseshoe shape, conventional stressed skin semi-monocoque and consists offrames, stringers, longerons, inclined floors, shroud and walls. It is designed to accommodate GE engine and has CFC parts.



Assembly comprises of:

- Engine bay
- Mountings for: Fin Rudder, Airbrake, Titanium engine mounts

Coupling and Assembling

It is the procedure in which we couple the main fuselage, centre fuselage and rear fuselage. These assemblies are coupled using various fasteners along with sealants. The different types of sealants used during assembly of the fuselage, their usage and their curing time are as follows:

Name of the sealant	Curing time	Usage
1770C12	8 hours	Used for mating 2 parts, to decrease friction
177082	2 hours	Used to form a gasket-like structure on the removable components of the aircraft
1770A2	2 hours	To avoid leakages in parts like fuel tanks
1770B(1/2)	0.5 hours	It is like 177082, the only difference is the curing time
1770A(1/2)	0.5 hours	It is like 1770A2, the only difference is the curing time

The 1770A2 and the 1770A (1/2) are sealants with very low viscosity, furthermore the layer of sealant which they add is also negligible in thickness. The sealant 1770C12 is generally not used on the fuel tanks since it is not required. On fuel tanks the sealant first used in 1770B2 followed by 1770A2. The sealants like 1770B (1/2) & 1770A (1/2) are used only if there need to be some quick application of sealant right before leaving the hanger for delivery. The sealant to hardener ratio followed by HAL is 10:1.

For the sheet metal components or the aluminium structures on which holes must be drilled for further assembly looking at the drawing every time for every sheet would be extremely inefficient, especially for mass production. Therefore, HAL uses something called panel tools. These tools confirm the same shape as the sheet metal and have the desired holes drilled in them. These act like templates for the original part, thus enhancing production efficiency. The holes are drilled using a pneumatic drill gun. These panel tools are stored in the vertical tool storage, so that their storage doesn't take large production space thereby giving more space to the aircraft assembly. After drilling all the components when it comes to riveting, to ensure that there is no misalignment of the holes of the two components wedge locks fasteners are used. These types of fasteners are used to secure the holes at the two ends of the row using a wedge lock gun. Depending on the diameter of the holes there are three types of wedge lock fasteners used by HAL. Those are as follows:

Types of Fasteners	**Sizes**
Black Wedge Lock Fastener	Diameter — 4mm
Golden Wedge Lock Fastener	Diameter — 3.2mm/ 6mm
Silver Wedge Lock Fastener	Diameter — 2.5mm

The remaining holes in that row are then riveted using a rivet gun. Depending on the diameter of the rivet there are different speeds on the rivet gun from 2x to 5x. These speeds depict the total amount of load to be applied, higher the diameter, higher the load thus higher the speed. This process is followed for all the assemblies of the aircraft. During riveting through CFC (carbon fibre composites) components there is some amount of Carbon Fibre dust generated. Being carcinogenic in nature it is extremely harmful for the workers. Due to this there are industrial vacuum cleaners kept near each assembly jig.

Once the entire assembly is done, using this vacuum cleaner all the CF dust is cleaned up to avoid harmful effects. Parts of the aircraft which are exposed to the atmosphere (Aircraft skin) are given acoat of Primer before assembly. This is done because paint is not adhesive on materials like CFC and Al-alloys. Once applied it is observed that paint can be easily peeled off from these surfaces. Therefore, to ensure

high adhesion of paint, primer coating is used. The aircraft engine GE F404 is attached to the rear fuselage of the aircraft using only 3 brackets. Two brackets from this are made from Ti-alloy and the remaining bracket is made from Al-alloy.

Wings

TEJAS has a near mid-wing compound delta wing configuration, which is

attached to the fuselage to transfer the wing loads. into five parts:

- IS (Inter Spar) Box
- Nose Box
- Slats
- Fairings
- Stub Wing

IS Box: This is the section which mostly consists of the wing fuel tank. There are several fuel pipelines which pass through the fuel tank as well. This fuel is constantly supplied to the engine by using a pressure based system. A natural flow supply cannot be used because when the aircraft is manoeuvring it shouldn't happen that the direction in which it is manoeuvred that wing's fuel feed rate becomes less than that ofthe other wing. If this happens the COG (Centre of Gravity) of the aircraft will shift laterally causing instability. Furthermore, the actuator of the elevon also is attached to the IS box section on the bottom skin of the wing. The small remaining part of the IS box consists of perplexes lights. These are the lights which are visible on the tip of the wing. The lights colour is different on different sides of the wing. It is red on the LH wing (left wing) and green on the RH wing (right wing). The left wing and right wing are referred based on the direction of flight of the aircraft.

Slats: This is located on the leading edge of the wing. They are also referred to as high lift devices which provide more lift during take-off and act as producing high drag during landing. There are a total of 3 slats namely inboard, middle, and outboard slats. They can be actuated by both electrically and hydraulically as well. Their maximum angular and translational movement depends on the length of the slat track which is connected to the wing. The material of the track is determined to be Maraging Steel.

Nose Box: This part is located in front of the IS box, near the leading edge of the wing. It consists of all the electrical looms, hydraulic pipelines and electrical pipelines. The electrical conduits are required to supply constant power to the perpex lights and similarly to the actuators and all electrical systems in the wing. It also consists of all hydraulic conduits to actuate the slats. The pipes are made of an Al-alloy and the rings used to connect two pipes are made of a smart material named Ferrule. The reason why it is called as smart material is that if this ring is placed in liquid nitrogen, then we can change the shape of the material as per the requirement. The rings used are of similar diameter as the pipes, so after they are removed from liquid nitrogen they are forced-fitted on the pipe. This method of assembling without usage of sealant is 15 called a dry assembly. On top of the rings there is an insulation material covering it called PEEK (polyetheretherketone) it is used so that in an event of lighting strike the electricity should not conduct throughout the aircraft since it can ignite the fuel and cause a fatal accident.

Fairings: This is present around the attachment point of the wing to the fuselage. The main purpose of the fairings is to reduce the drag and smoothen the intersection.

Stub Wing: The fuselage of the aircraft is not of the same diameter throughout from the nose to the tail. Due to this it is difficult to manufacture a wing which is of the same contour as that of the fuselage. Therefore, we use a stub wing attachment. This is attached to the between the leading edge and the fuselage. This ensures that the wing can be attached in the same plane as that of the fuselage, thus reducing manufacturing difficulty.

Characteristics of the wing

- The wing has been designed to:
- Provide a minimum weight structure by optimizing and use of composite materials like CFC and glass fibre
- Provide a Structural box capable of resisting aerodynamic and structural loads as also accommodate the required fuel
- Achieve Interchangeability
- Facilitate easy manufacturing and maintenance

- There are a total of 3 pipelines passing through the wing, namely hydraulic lines, electrical lines and fuel lines. To differentiate the respective pipelines, they are denoted by part number as per the HAL nomenclature. The pipelines containing 5P are used for fuel transfer, 7P for hydraulics and 9G for electrical cables.
- There are a total of 5 actuators attached to a wing, 2 are Elevon Actuators and other 3 are Slat Actuators.
- The wing is attached to the fuselage through 5 points.

Wing Assembly

The wing consists of ribs, spars and the top wing skin and the bottom wing skin. All the parts of the wing are made from CFC (carbon fibre composite). The ribs and the spars together are called the skeleton of the wing. The skeleton is attached to its respective jig. As per the different components of the wing there are different jig created which facilitate easy and rapid serial production. The different jigs are as follows:

- RH wing assembly (Right Wing Assembly)
- LH wing assembly (Left Wing Assembly)
- Nose Box
- Stub Wing
- Elevon Assembly

The skeleton of each of the components is installed on their respective jigs. Then as per the aircraft drawing the holes for the fasteners are drilled. This drilling of holes is done a step wise procedure to ensure that the final hole drilled lies within the provided tolerance limits. For example, if the hole to be drilled needs to have a diameter of 6 cm, then first a 2 cm hole will be drilled followed by superimposing a 3 cm drill so on and finally a 6cm drilled hole. The holes which have been made in the skeleton have to be projected on the top and bottom wing skin because it will cover the wing. To avoid any errors like misalignment of the to-be drilled rows of holes, the bottom wing skin is kept beneath the wing skeleton and the two extremes of the rows of holes are drilled from the skeleton to the skin. These two holes are then fastened (to arrest movement about all DOF) with a drill frame which has all the holes as per the skeleton. Then following the drilling technique mentioned above all the holes on the skin are accordingly drilled. The skin and the skeleton then are then coated with get name of this to prevent corrosion and damage of the part. This is followed by drilling the existing les as CSK holes to ensure no irregularity on the skin of the wing since it will hamper the aerodynamic characteristics of the aircraft. The wing skeleton is then fastened to the wing skin by using anchor nuts. These nuts are covered by a sealant cap followed by application of sealant. The sealant cap is necessary because if there is any rework to be done then it is possible to remove the sealant cap and do so, but if the sealant is applied directly on the nut, then it cannot be reworked. Sealant is required to close any possible air gaps which might be present but not visible to the naked eyes. This is extremely important in parts where liquid is carried for example fuel tanks, since any leakage mid-air will be extremely dangerous. The sealants used in the manufacturing process are as follows:

Name	Types of sealant
PR1770C2	Interfacing Sealant
PR177082	Beading Sealant
PR1770A2	Overcoat Sealant
PR1770B (1/2)	Bending Repair Sealant
PR1770A (1/2)	Overcoat Sealant
PR1764	Conductive Sealant
PR2001B2	Aerodynamic Smoother
PR1829	Windshield and Canopy Sealant
AV138HV998	Araldite
EA934	Hysol

Types of Fasteners used:

- Anchor Nuts
- Cherry Rivets
- MLGP Rivets
- MAS Rivets
- Wedge Lock

Empennage and Landing Gears

The fin and rudder together comprise the Tail/Empennage of the aircraft. It has been designed with the objective of developing a lightweight flight worthy structure using advanced state of the art technology developed in NAL, using CFC (carbon fibre composites) composites. There is only 1 Rudder Actuator used to control the Rudder Motion.

Under Carriage System

The landing gear system is a hydraulically operated retraction mechanism controlled electrically by the pilot. The following are the characteristics of the undercarriage system:

- To provide a stable support structure for the aircraft on ground.
- To facilitate Take off & Landing.
- To facilitate Directional control during taxiing.
- To facilitate Ground manoeuvring & Parking.
- To facilitate deceleration & stopping of the aircraft by means of braking.
- To provide cushioning effect during landing & taxiing.
- To reduce aerodynamic drag by retraction.

Nose Under Carriage

- Total Mass of Nose U/C assembly is 87.8 kg
- U/C Assembly Locked in Down position by mechanical Down lock provided in the Retraction Jack
- U/C Assembly Locked in up position by Single mechanical Up-lock Mounted on the Structures and a locking pin provided Cylinder Assembly
- Extended and retracted by the Nose U/C retraction Jack

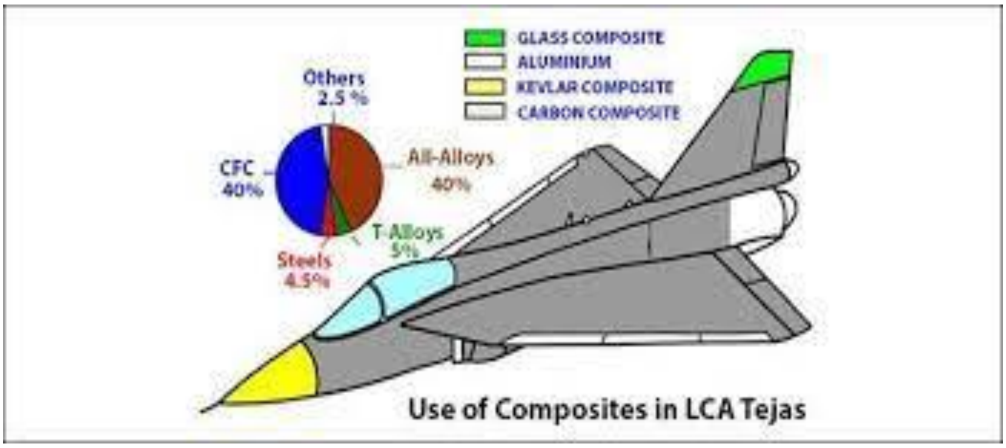
Main Under Carriage

- Total Mass of single main U/C assembly is 182.2 Kg
- U/C Assembly Locked in Down position by mechanical Down lock Provided in the Retraction Jack
- U/C Assembly Locked in up position by Single mechanical Up-lock Mounted on the Structures and a locking pin provided on the Leg
- Extended and retracted by the Main U/C retraction Jack.

Due to such high sink rates experienced by the aircraft accompanied with high-speed landing and intensive breaking, the wearing out of tyres is exponentially greater than commercial aircrafts. Thus. to avoid situations like tyre disintegration, after every 5 flights the tyres are replaced.

Materials

- The Raw materials involved in LCA TEJAS are:
- Composites (CFC, GFRP), it is 45 % by weight and 90% by surface area
- Aluminium-Alloys, it is 40% by weight
- Copper - Alloys
- Steel, 4.5% by weight
- INCONEL (Iron - Cobalt - Nickel)
- Titanium-Alloys, 5.0% by weight
- Perspex
- Acrylic
- Nylon
- Rubber



Tooling

Jigs

A jig may be defined as a device which holds and locates the component or work piece and guides in true One or more cutting tools. The holding of the workpiece and guiding of the tool are such that they are position relative to each other. Its primary purpose is to provide repeatability, accuracy, and interchangeability in the manufacturing of products. It includes machining jigs, woodworking jigs, welders' jigs, etc.

Advantages:

- It eliminates marking out, measuring and other setting methods before machining and the handling time is greatly reduced due to quick setting and locating of work.
- It increases machining accuracy and production capacity by enabling several workpieces to be machined in a single setup and several tools may be made to operate simultaneously.
- It reduces the operator's labour, expenditure on the quantity control of finished products and overall cost as it is partly an automated process

Foreign Object Detection (FOD) Jig

It is used to detect foreign objects which might have fallen inside the aircraftaft during coupling and assembling. This includes metallic scraps, fallen rivets, sealants, etc. These foreign objects need to be removed as soon as possible since they may lead to accidents during high-speed flights. The jig facilitates a 360° rotation of the entire assembled fuselage. If there is any unwanted sound coming from within the structure, then the jig is rotated continuously till the debris fall out. Furthermore, the inaccessible places for riveting during the assembling of the three fuselages and the coupling process can be easily reached in the FOD process. This can be done by simply rotating the jig, thereby properly fastening all the fasteners. The total number of parts and stages in this process are 1158 and 310 respectively.

Fixtures

It is a work holding device that holds, supports, and locates the workpiece for a specific operation but does not guide the cutting tool. It provides only a reference surface or a device. What makes a fixture unique is that each one is built to fit a particular part or shape. The main purpose of a fixture is to locate and, in some cases, hold a workpiece during either a machining operation or some other industrial process. Examples: Vices, chucks.

Powerplant and Fuel System

Power plant is the main and only power source of an aircraft. In addition to providing the propelling force for the aircraft, the power plant also provides power for the electrical generator, hydraulic pumps and provides. compressed air for operation of various systems like environment control and fuel tank pressurization etc. Electrical generator provides the electrical power for operation of avionic and electrical LRUs. Hydraulic pumps provide power for actuation of flying control actuators and other services and compressed air is used for ECS, radar pressurization, anti-icing system & fuel tank pressurization.

Model	F404 GE-IN20
Type	Low bypass turbofan with afterburner
Fan (LP) compressor	3 stage axial flow
HP compressor	7 stage axial flow
Turbine	LP & HP both single stage
Rotor speed	N1 13270 rpm (100%) N2 16810 rpm (100%)
Direction of rotation	Clockwise from tail looking forward
Length of engine	404cm
Diameter of engine	89cm
Weight	1035kg
Max Thrust	18000lbs class at max power given standard day setting 59° F, 0% humidity, sea level static conditions
Thrust to weight ratio	8:1
Compression ratio	27:1
Airflow at IRP & above	Approx. 140lbs
Fuel used	Jet A1
Bypass ratio	0.34
Specific Fuel consumption at dry	0.5lbm/hr
Specific Fuel consumption at reheat	1.76lbm/hr

Engine

F404GE- IN20 is divided into 6 modules and an accessory gearbox:

- Fan module
- Compressor module
- Combustor module
- HP turbine module
- LP turbine module
- Afterburner module

This engine has an engine accessory gearbox which has six pads for running accessories.

Fan Module: It is the forward module of the engine which draws ram air through the air intake and compresses it to be delivered to the compressor and bypass duct. The compressed air at the outlet of the fan is divided as the primary airflow and secondary airflow. The primary airflow passes through the engine core where it is compressed by the HP compressor and burnt in the combustion chamber. The primary air is added with energy of fuel, driving the HP and LP turbine. The secondary air flow bypasses the core engine and flows through the bypass section. This bypass air also adds to the total thrust due to the ram compression of the air.

Compressor Module: It is located aft of the fan module at the central portion of the engine. Dry weight of the compressor module is approximately 600 lbs (272 kgs). The purpose of the high-pressure compressor is to increase the pressure of air further from the fan and it passes this air to the combustor. it also supplies bleed air for anti-icing, The compressor rear case provides a bleed air manifold at stage four for low pressure turbine cooling and for front frame anti icing. The manifolds provide free bleed air ducts.

Combustor Module: It is circumferentially bolted to the compressor stator aft casing bolt flange. Dry weight of the combustion chamber is approximately 47 lbs (21 kg). It is of annular type construction. It is the place where the fuel and air are mixed and burned. The combustion process produces hot gases that are used to rotate the turbine and further it rotates the HP compressor. The combustion chamber has two igniter plugs primary and redundant and has 18 spray nozzles to supply atomized fuel inside the combustion chamber. Out of these 18 spray nozzles, one spray nozzle provides marginally increased fuel

spray to operate as a flame retainer during flame out conditions.

HP Turbine Module: It is located behind the combustor module. It derives thermal energy released from the combustor module and converts it to mechanical energy for driving the compressor and other accessories connected with the engine accessory gearbox. Dry weight is approximately 215 lbs (98 kg). The HP turbine extracts the kinetic energy from the expanding gases and converts this energy to shaft horsepower. It uses this mechanical energy to rotate the HP compressor and AGB drive.

LP Turbine Module: It is located aft of the engine HP turbine module. Dry weight of the LP turbine module is approximately 294 lbs (133 kg). LP turbine is a single stage turbine which extracts the kinetic energy from the gases coming out of the HP turbine. The LP turbine converts this energy to shaft horsepower to rotate the LP compressor.

Afterburner Module: It is located on the rear most part of the engine. The dry weight of the module is 352 lbs (160 kg). The afterburner provides a means of injecting and burning fuel downstream of the turbine to augment the engine thrust. Both primary and secondary air are mixed before the afterburner and exhausted through the variable area fit nozzle to produce the forward thrust. This improves the take-off thrust, climb, and combat performance of the aircraft and provides a source of power for emergency purposes.

Power Take-off Drive Assembly: It is mounted on two pads in the centre of the mid-frame. A bevel gear on the compressor rotor front shaft engages a bevel pinion on the power take off. Power to drive 69 the accessory gearbox assembly is extracted from the engine by the power take off drive assembly. The transferred power is utilised to drive all accessories mounted on the engine accessory gearbox.

Variable Exhaust Nozzle: The VEN provides a passage for the flow of hot gases from the afterburner section and provides the contour for external airflow around the engine the turbine and the maximum thrust efficiency while controlling low pressure turbine discharge d gene. The VEN provides for operation.

Accessory Gearbox Assembly: It provides power to drive the engine accessories such as after burner pumps, lubricating oil pumps, VEN power unit and fuel metering unit is extracted from the compressor rotor of the engine by the AGB. The AGB also provides a means to transmit the torque for starting the engine. It is driven by an engine compressor rotor through a bevel gear system and provides a drive for all the engine requirements of fuel, electrical power, hydraulic power and lubrication system.

Energy Flow

- Starting: JFS AMAGB—* PTO Shaft-0. EGB ► Engine
- Accessory: Engine---0EGB ---■PTO Shaft ----■AMAGB ► Accessories

Major Components which control and assist the core engine in its operation

- Jet Fuel Starter (JFS)
- Alternator
- Variable exhaust nozzle (VEN) power unit
- Fuel metering unit (FMU)
- Main fuel pump (MFP)
- Afterburner fuel pump
- Afterburner fuel control
- **Lube** and scavenge pump
- N2 core speed transmitter

The engine in provided with 10 boroscopic inspection ports to enable easy inspection of engine modules.

Engine Working

- The F404-GE-IN 20 is a twin spool engine having a fan (LP compressor) run by LP turbine and compressor (HP) run by HP turbine. The LP compressor is also called fan assembly. The three stage fan motors are driven by a single stage LP, turbine rotor. The seven stage HP compressor rotor is driven by a single stage HP turbine. Both the fan and the compressor incorporate a variable geometry system to control the mass of air flow across them to increase store margin during flame out and to eliminate surge provoking condition during operation.
- The fan assembly compresses the air and the compressed air at the outlet of the fan is divided as the primary airflow and secondary airflow. The primary airflow passes through the engine core where it is compressed by the HP compressor and burnt in the combustion chamber. The primary air added with energy of fuel drives the HP and LP turbine. The secondary airflow bypasses the core engine and flows through the bypass section. This bypass air also adds to the total thrust due to the ram compression of the air. Both primary and secondary air are mixed before the afterburner and exhausted through the variable area jet nozzle to produce the forward thrust.
- An annular combustion chamber is bolted to the compressor stator after casing bolt flange. The combustion chamber has two igniter plugs primary and redundant and has 18 spray nozzles to supply atomized fuel inside the combustion chamber. Out of these 18 spray nozzles, one spray nozzle provides marginally increased fuel spray to operate as a flame retainer during flameout conditions.
- The afterburner provides a means of injecting and burning fuel times downstream of the turbines to augment the engine thrust to improve the take-off thrust, climb and combat performance of the aircraft and provides an additional source of power for emergency purposes. The weight of the afterburner module is 352 lbs (160 kg).

- The Accessory Gearbox (AGB) is driven by engine compressor rotor through a bevel gear system and provides a drive for all the engine requirements for fuel, electrical power, hydraulic power and lubrication system. The AGB also provides a means to transmit torque to the engine for starting the engine through the power take off shaft. When the engine is running, the same shaft is used for transmitting power from engine to aircraft mounted accessory. Gearbox (AMAGB) for driving other accessories of the aircraft.

Engine Starting System

The purpose of engine starting system is to provide a reliable starting means for starting on ground and in air. The starting designed for Tejas in addition to the basic purposes of starting the engine fulfils the following additional requirements:

- To carry out dry rollover of the engine in which the engine is run cranked between 19-21% rpm for 60s.
- To dry and wet crank the jet fuel starter (JFS)
- To crank and start the engine on air after a flame out if wind milling rpm could not achieve re flight .

The starting system consists of:

- JFS
- Alternator
- Primary Ignition Exciter
- Secondary/Redundant Ignition Exciter
- Starter Control Unit (SECU)
- Full Authority Digital Electronics Control (FADEC)

A microcontroller based electronic fuel control system known as starter electronic control unit (SECU) controls the operations of JFS by scheduling the fuel during starting, acceleration, speed governing and shut off. SECU provides full authority control of fuel flow to starter unit.

Engine Air Intake

- Air intake duct supplies streamlined air to the compressor which enters the engine through the front frame and passes through the fan where it is compressed at a ratio of 4.1:1 at maximum power setting. The front frame assembly of the engine is meshed with air intake to provide an airtight joint with the airframe and engine.
- TEJAS has a bifurcated duct fixed geometry air intake system designed to feed the F-404 GE-IN20 engine mounted in the rear fuselage. The intake is shielded by the wing to provide good pressure recovery characteristics at high angles of attack.
- Auxiliary Air Intake Door (AAID) in the outward wall of each inlet duct hinged along the forward edge. These AAIDs facilitate extra air to enter the engine when required

Engine Cooling System

Ram air is directed to the engine so as to control the temperature of the engine bay to acceptable limits. The F 404 GE-IN20 engine is cooled by ram air. There are two flush air inlet scoops located on the bottom of the rear fuselage and two scoops one each on the port and starboard side of the rear fuselage. The ram air cools the engine & exits to the atmosphere through the gap between the rear fuselage structure and the engine.

Engine Oil System

The purpose of an engine oil lubrication system is to provide lubricating oil to all moving parts of the engine for lubrication, dissipating heat of moving parts and providing a media for carrying debris resulting from normal wear and mechanical failure. This system is also used as a means for transferring heat to the fuel for better atomization of fuel for burning. The engine oil system is a self-contained recirculatory, dry sump system and requires no external aircraft connections or inputs. Type of oil used is MIL-PRF-23699 Class C/I or MIL-PRF-7808.This system has a capacity of 12.3 litres and a tank capacity of 8.5 litres.

Oil System Indications: It is used to indicate the oil quantity, temperature and pressure of the oil and it includes items such as transmitter, indicator, wiring and warning systems.

Engine Drain System

The engine drain system reduces the risk of fire by collecting fuel, oil, and hydraulic fluid, which leaks from the various systems and accessories and discharges it to the atmosphere. This system also disposes off the unburned fuel from the combustion chamber, bypass duct and afterburner. The engine drain system collection discharges fluid leakage overboard to the check and drain valve located at the bottom centre of the engine. The check and drain valve are a small, spring-loaded valve that is connected between the oil cooler and the combustor manifold to provide for draining when the engine is shut down. Fuel collected in the lower outer duct is also drained through the check and drain valve.

Engine Health Monitoring System

It is designed to provide a high level of engine fault detection and isolation, which is integrated into the engines. While the engine health monitoring system is primarily a flightline level maintenance tool providing mechanics with identification of failed line replaceable assemblies and guidance in troubleshooting false symptoms, information available from the system can also be used at both the intermediate and depot levels of maintenance. There are two major components to the EHMS on the aircraft. These are: FADEC and BHEEM- EU. Diagnostics and engine support functions provided by the system include:

- Detection and isolation of failed control system LRUs
- Identification of invalid sensor signals
- Acquisition and storage of fault data
- Event based procedures for troubleshooting using acquired fault data
- Trend monitoring

- Measuring life usage indices which provide input to the engine parts life tracking system
- Techniques employed in FADEC include memory check sums, wrap-around checks of output signals,parallel processing of input signals, timer checks and signal range checks.
- The first mission of FADEC BIT is to identify failure of itself or an interfacing component. It has the capability to isolate many of the failures to the system replaceable assembly's level. It communicates fault detection /isolation information to the BHEEM- EU.
- An engine fault indicator on the central maintenance panel will indicate that an engine fault has occurred.

The algorithms hosted in BHEEM- EU and FADEC are intended to detect the following:

- Flame out
- Stall
- High/low oil pressure
- Afterburner blowout and no light
- 1\11 and N2 over speeds
- Over temperature
- Oil debris detection
- Signal validity

Fuel System

Aircraft fuel system is designed to meet the customers operational requirements such as range and endurance. It also ensures uninterrupted fuel supply to the engine maximum internal fuel capacity is 2546 kgs.Due to such high mass flow rate, this amount of fuel proves insufficient while traversing long distances. Therefore, additionally beneath the fuselage and the wings of the aircraft there are a total of 7 hard points (attachment points) provided to carry drop tanks Extemal Tank f Drops tanks (external fuel tanks). These are distributed as 3 per wing and 1 under the fuselage respectively. The capacity of each of these tanks along with the naming standards are as follows:

Fuel tanks	**Tank capacity**	**Pressure Refuelling**	**Gravity Refuelling**
Wing tanks	1224 kg	1180 kg	1140 kg
Fuselage tanks	1262 kg	1210 kg	1180 kg
F1/F2 tanks	826kg	790 kg	760 kg
F1A Tank	436kg	420 kg	420 kg
Total internal fuel	2486kg	2390 kg	2320 kg
Wing IB stations (LH & RH)	960kg	960 kg	960 kg
Centre drop tank	580 kg	580 kg	

The three hard points on the wing can be categorized as inboard, midboard and outboard. The attachment can be used for any of the three(large wing drop tank/small wing drop tank / bombs or missiles). The midboard can only be used for the small wing drop tank or the bombs and finally the outboard point can only be used for bombs or missiles .

Working

Fuel is introduced through a single inlet Main Fuel Pump (MFP) and passes through the filter to the Fuel Metering Unit (FMU). The other output from the filter goes to the Afterburner Fuel Controller (ABC) where is sent to the afterburner spray bars, distributor valves and main spray bars. Output from the FMU goes to Fan Variable Geometry (FVG) actuator to operate the inlet guide vanes on the fan module. The balance of the fuel from the MFP goes to the FMU and is distributed to the combustor manifold, CVG's and the ABC.

The FMU operates the CVG actuators of the HPC module. From the FMU, fuel passes through the air cooler to the combustor manifolds and nozzles. The check and drain valve prior to the manifolds shut off fuel flow when the pressure falls below a set value. The ABC divides the flow into pilot and main spray bar flow.

During non-AB operation, fuel is circulated through the AB manifold and flows back to the ABC. This action minimises AB initiation time by eliminating manifold time. The fuel system comprises of:

- Main Fuel Pump (MFP)
- Check and Drain Valve (C&D)
- Main Fuel Nozzles
- Afterburner Fuel Pump (ABFP)
- 10 Micron Fuel Filter
- Combustor Fuel Manifold
- Lean Blowout (LBO) Main Fuel Nozzle
- Afterburner Fuel Control

The Fan Variable Geometry actuator (FVG) and compressor variable geometry (CVG) along with main and pilot spray bars are included in this system. The Fuel system can operate satisfactorily on JP-4 or JP-5 fuel (MIL- DTL-5624) or on JP-8 (MIL-DTL-83133). In addition to being used for combustion, fuel is also used as the working fluid hydraulically switching on afterburner and cooling tasks. The GE F404-IN20 engine has two interconnected fuel systems, one supplying metered fuel to the engine and the other supplying fuel to the afterburner. The engine fuel control system calculates and controls the quantity of fuel supplied to the engine as per throttle setting by the pilot. All the fuel and control components are mounted on the engine. The aircraft fuel system supplies fuel to the engine fuel system. The engine fuel control system meters the fuel and injects it into the combustion chamber. It also sends and receives digital and analog signals from other aircraft systems for display and control. The following aircraft systems are cooled by fuel:

- Hydraulic System 1
- Hydraulic System 2
- Aircraft Mounted Accessory Gearbox Oil System
- Integrated Drive Generator Oil System

The fuel system is provided with redundancy to enhance the system reliability. Two booster pumps (BP 1 and BP 2) are installed in the supply tank for engine fuel supply system redundancy. The BP 2 comes into operation when BP 1 fails or is switched off. When BP 1 and BP 2 are failed, the engine can suck the fuel through failed BP 1 and operate below 9.2 km altitudes with certain degradation in performance. The gravity refuelling is a redundancy for single point pressure refuelling

Fuel Refuelling and Transfer System

- The aircraft has two ways through which it can be refuelled on the ground and one way through which it can be refuelled in air. On ground, fuel can be either filled in all the tanks (internal & external) using their respective filler caps or, all the tanks can be filled using a single point refuelling cap.
- The ECFMU (Environment Control Fuel Monitoring Unit) is the brain of the fuel system. In the single point refuelling method, all the tanks are being filled simultaneously. Each tank has an ERV (electrical refuelling valve) attached within the refuelling pipe to detect the amount of fuel filled in the respective tank. Internal Tanks Capacity F1F2 Tank 892 kg F1A Tank 430 kg Wing Tank (Combined) 1224 kg Total 2546 kg Maximum Fuel Capacity 6232 kg 20
- Once the tank is filled the ERV shuts down further fuel inlet in that tank and sends voltage signals to the ECFMU which is further relayed to the pilot in the cockpit and to the GRP (Ground Refuelling Panel) which is present beneath the wing in the fuselage.
- Depending on the weather conditions where refuelling is taking place the total amount of time taken to refuel the aircraft from the single point refuelling system will range from 9-12 minutes.
- The fuel transfer to the engine takes place from the F1F2 tank by using an electrically operated Booster Pump. Therefore, all the drop tanks are connected to the F1F2 tank by using a pressure based system to ensure there is uninterrupted fuel supply to the main tank, thereby avoid engine starvation. The sequence of emptying tanks when fuel transfer takes place is as follows:

- Wing Drop Tanks Centre Drop Tank ---> Wing --> F1A F1F2
- All fuel tanks have fuel gauging probes installed within them. Each wing tank has a total of 4 fuel asure the fuel gauging probes. Whenever the fuel quantity drops below a certain me probe electrical signals to the ECFMU which will intimidate the pilot about the fuel condition of that respective tank.

Hydraulics System

The TEJAS aircraft is provided with a reliable hydraulic power system for maximum combat survivability and for operational readiness. The purpose of hydraulic system in this aircraft is to provide hydraulic power to Flight Control System (FCS), Landing Gear (LG), Wheel Brake System, Nose Wheel Steering System and Utility Systems.

The hydraulic power system consists of two independent systems namely System 1 (RH) and System 2 (LH). In addition to this, an emergency system provides hydraulic power in the event of System 1 and System 2 failure. The aircraft primary flight controls remain operational after two successive failures to permit at least 10 minutes of flight at cruise speed. The hydraulic fluid pipelines are routed sufficiently apart to enhance operational reliability.

The hydraulic power system consists of Main Hydraulic Pump (RH & LH), Engine Driven Pump (EDP), Electric Motor Driven Pump (EMDP), Boot Strap Reservoir (RH & LH), Accumulators (RH & LH), Accumulator (Wheel Brake), Hydraulic Motor Driven Generators (HMDG 1, HMDG 2, & HMDG 3) and Hydraulic Motor Driven Fuel Pump (HMDFP).

- Engine Driven Pump: It is a standby pump which is present on the L.H.S. of the engine and provides hydraulic pressure if the primary pump fails.
- Electric Motor Driven Pump: The EMDP provides emergency power when both hydraulic systems 1 & 2 fail.
- Hydraulic Motor Driven Generator: The HMDG is driven by hydraulic pumps that provide 280 bar pressure. These generators run continuously and supply electrical power to two channels of the DFCC. There are no separate controls for the HMDG, and it starts running as the engine starts. It is a 0.35 kVA generator, generating alternating current and powering the AC run equipment and the TRU. The TRU is used to convert AC to DC.
- Hydraulic Motor Driven Fuel Pump: It is the primary fuel pump to transfer fuel from the wing tanks to the central tank then to the engine. It supplies fuel to the engine feed line during failure of the main booster pump.
- High Pressure Relief Valve: It protects the circuit from over pressurisation of the circuit in the event of failure of the pressure compensating mechanism of the respective pumps. It cracks open between 3 320 bar and resets above 284 bar.

Hydraulic fluid used	MIL-H-5606E
Nominal system pressure	280 bar
Normal Acceptable fluid as per cleanliness level	Class 7 of NAS1638 or better
Operating temperature range	-54 degrees C to 135 degrees C

Working

- When the engine of the aircraft is ON, a power takes off (PTO) shaft drives an aircraft mounted accessory gearbox (AMAGB), which in turn drives two independent hydraulic pumps. During normal operation, these pumps deliver hydraulic power to hydraulic system 1 and system 2 . The EDP supplies hydraulic power to system 2 when system pressure drops below 260 bar. The electric motor driven pump is provided for emergency hydraulic power at a rated pressure of 210 bars. These pumps are named as pump 1, pump 2, pump 3 and EMDP.
- Pump 1 of system 1 supplies power to PISTON END of tandem actuators of elevons, rudder and to hydraulic motor driven generator (HMDG-1). The pump 1 also supplies fluid through an isolation valve to undercarriage (normal operation), wheel brakes (normal operation), leading edge slats, nose wheel steering, hydraulic motor driven generator (HMDG 5K VA) and to hydraulic motor driven fuel pump (HMDFP).
- Pump 2 of system 2 supplies power to the actuators of elevons, rudder and mounting end' of tandem ac to the hydraulic motor driven generator (HMDG 2). This pump also supplies fluid through an isolation valve to undercarriage (emergency operation), wheel brakes (standby), airbrake and parking brake.
- Pump 3 (EDP) supplements pump 2 output flow if the pressure in system 2 drops below 260 bars. The EDP is a backup for system 2. This is mounted on the engine gearbox LH side.
- Electric motor driven pump (EMDP) supplies fluid only top rimary flight control actuators in the event of failure of pump 1 , pump 2 and pump 3 or engine failure. The EMDP is located between stations 30 and 31 LH side.

System Specifications

The hydraulic power system of Tejas uses a hydraulic fluid (MIL- PRF - 5606) or equivalent

with system cleaniness level of class 7 or NAS 1638 . The operating fluid temperature is - 54 deg celcius to 135 deg celcius .

Flight Control System (FCS)

Tejas is a single engine, tailless delta wing aircraft which is longitudinally unstable. It is designed with relaxed ki static stability to enhance manoeuvrability performance. An aircraft with negative static stability i.e., RSS, quickly departs from level and controlled flight unless the pilot constantly works to keep it in trim. This enhances manoeuvrability, but it is very difficult for a pilot to control with a conventional mechanical flight control oslys tem. Thus, RSS is made practical on the Tejas by a new technology i.e., a digital quadruplex Fly-By-Wire control System. This system uses DFCC to electronically stabilise the aircraft.

The wing leading edge incorporates 3 section slats that will generate vertex lift over the inner wing and high energy air flow along the tailfin. This improves high angle of attack stability, improves lift to drag ratio and prevents departure from controlled flight. The wing trailing edge is occupied by two segment elevons to provide pitch and roll control. The only tail fin mounted control surfaces are the single piece rudder, and two air brakes are located in the upper rear part of the fuselage, one each on either side of the fin.

Tejas employs a powerful Digital Flight Control Computer (DFCC) comprising four computing channels, each with its own independent power supply and all housed in a single LRU. The DFCC receives signals from a variety of sensors and pilot control stick inputs, and processes these through the appropriate channels to excite and control the elevons, rudder and leading-edge slat hydraulic actuators. The FCS converts the pilot's manoeuvre specific commands into electrical signals that activate the control surfaces on the aircraft and enable it to achieve the desired motion or trajectory. RSA, ASA and ADCs sense the angular rates, velocities and accelerations of the aircraft. The sensed values are converted into electrical signals and depending upon the differences between the sensed and the commanded values, proportionate electrical signals are given to the primary and secondary actuators of the aircraft. These laws are incorporated in the DFCC.

The Flight Control Systems (FCS) consists of 3 sub-systems:

- Air Data System
- Flight Control Surfaces
- Feedback Assemblies and Autopilot

Fly by Wire System

Fly-by-wire (FBW) is a system that replaces the conventional manual flight controls of an aircraft with an electronic interface. The movements of flight controls are converted to electronic signals, transmitted by wires, and flight control computers determine how to move the actuators at each control surface to provide the ordered response. It can use mechanical flight control backup systems or use improved fully Fly-by-Wire controls.

Improved fully Fly-by-Wire systems interpret the pilots' control inputs as a desired outcome and calculate the control surface positions required to achieve that outcome; this results in various combinations of rudder, elevator, aileron, flaps and engine controls in different situations using a closed feedback loop . The pilot may not be fully aware of all the control outputs acting to affect the outcome, only that the aircraft is reacting as expected. The Fly-by-Wire computers act to stabilise the aircraft and adjust the flying characteristics without the pilot's involvement and to prevent the pilot operating outside of the aircraft's safe performance envelope.

Air data system

lt provides the air data anti flow angle parameters after suitable collection, voting provide necessary outputs, The FCS requires critical air data parameters, which are electrical and pneumatic Interface to process ambient pressures, temperatures, end flow angles to provide necessary outputs.

The FCS requires critical air data parameters , which are provided by the ADS to compute like angle of attack, baro altitude, Mach number, calibrated airspeed, and vertical speed etc . Air Data Computers implement these data for computation, The resultant output is given to DFCC parameters and are executed to achieve longitudinal and lateral stability of the aircraft.

Nose Air Data Probe (NADP)

The nose air data probe is commonly known as the pitot static tube. It consists of:

- Pt- Total Pressure: It measures the critical Indicated air speed,
- Ps- Static Pressure: It measures the altitude of the aircraft,
- α1- it measures the pitch up angle of the aircraft.
- α2- It measures the pitch down angle of the aircraft.
- β1- It measures the right-side banking of aircraft.
- β2- It measures the left-side banking of aircraft.

Side Air Data Probe (SADP)

Present on either side of the nose cone, it measures all parameters like NADP except the banking of the aircraft.

Angle of Attack Vane (AOAV)

It is also called alpha sensor or a vane. These probes are used to measure the pitch up and pitch down angle of the aircraft with an angle range of ± 45°. It is mounted with a Rotary Variable Differential Transducer (RVDT). There are two AOAVs:

- Left hand angle of attack (LHAOA)
- Right hand angle of attack (RHAOA)

The AOAV contains a damping fluid which damps the vibrations caused by the movement of AOAVs. The LHAOA & RHAOA are located on the nose, ahead of the cockpit on the left and right side respectively.

Angle of Sideslip Vane (AOSSV)

Angle of Side Slip is also known as 13 vane. It will give a differential f3 value. There is a single AOSS sensor located on the nose, below the cockpit. It is pre-fitted with a heater inside to keep it from icing.

Total Air Temperature Probe (TATP)

It is used to sense the air temperature value. It is located on the front fuselage behind the canopy end on the top side. The total air temperature of a flow is the sum of the Static Air Temperature (SAT) and a kinetic component (air compression and friction) depending on the speed and type of medium. Air compression and friction lead to a relative temperature increase compared to the Static Air Temperature (SAT) at an altitude. The measurement is carried out with specially shaped temperature probes, which stop the flow of air relative to the aircraft inside it. The kinetic energy of the decelerated and compressed air is internally converted into energy. The compression of the air causes an adiabatic increase in temperature.

Flight Control Surfaces

The Control Surfaces on LCA Tejas are classified into 2 categories: Primary and Secondary control surfaces. The Primary control surfaces consist of the eievons and rudder. The secondary control surfaces are the slats and air brakes.

- **Elevons**

- The LCA is a tailless aircraft which means that the elevators for pitch up and pitch down of aircraft are absent. Instead, they are combined with the ailerons; that are responsible for the rolling motion of the aircraft; and form the elevons (elevators + ailerons).
- There are 4 elevons present on the aircraft (2 on each wing) controlled by separate hydraulic actuators for each. The aircraft rolls and pitches by differential or by combined movement of these elevons. The elevons are present on the trailing edge of the wings.

- The maximum deflection is ±25°
  - Rudder
- The rudder is present on the fin (vertical stabiliser) of the aircraft and is moved by using a hydraulic actuator. The rudder controls the yawing motion of the aircraft.
- The maximum deflection is ±30°.
  - Slats
- The slats are present on the leading edge of the aircraft's wings. They are used for lift augmentation. There are 3 slats on each wing (Inboard, Midboard and Out board). The slats are controlled by the. FCS; in case the aircraft is flying close to stalling speed, they are deployed. They are essential during low-speed landings and low speed manoeuvring of aircraft.
  - Maximum deflection of inboard slats is 17.5°.
  - Maximum deflection of midboard slats is 27.5°.
  - Maximum deflection of outboard slats is 30°.

Air Brakes

- Aerodynamic braking of the aircraft is achieved by simultaneous deployment of two drag creating surfaces i.e., two air brakes namely left and right air brakes located on the rear fuselage below the vertical fin. These air brakes bleed the airspeed of the aircraft when deployed by increasing the drag.
- The air brake surfaces are expected to work synchronously and are fully deployed or fully retracted. They are controlled manually and have separate hydraulic actuators.
- Maximum deflection angle is 60°.

Feedback Assemblies & Autopilot

ASA — Accelerometer Sensor Assembly

It is an LRU used in LCA Tejas to measure lateral and vertical 'g'. The quadruplex sensor assembly provides a high degree of redundancy and is used for deriving control signals for feedback.

RSA — Rate/Gyro Sensor Assembly

A Rate/Gyro is a type of gyroscope, which rather than indicating direction, indicates the rate of change of angle with time. This unit measures & indicates the bank angle of aircraft with respect to the horizon in all the 3 axes.

APP — Autopilot

The role of the autopilot is to hold the aircraft on a given flight path, slope and track. This system determines the difference between the actual flight path or attitude with the flight path or attitude selected by the pilot. The optimum control coincides with zero difference. The computer for autopilot exists in DFCC. The DFCC converts the flight path or altitude difference into a steering command. This conversion is required as the response of the autopilot to 'detected deviations' is different according to the aircraft altitude, speed and configuration.

Electrical and Avionics

Tejas aircraft is provided with the basic hybrid power generating system and two batteries for emergency backup . It consist of components that provide power to the control components , ignition capability to allow both automatic and external activation

Electrical Power Generating System

The Electrical Power Generating System (EPGS) consists of both AC and DC generating systems. it consists of the following sources:

Main power sources:

- 30/40 KVA, 115/200 V, 400 Hz, 3 phase AC IDG (Alternator-1)
- Two 250 Amps TRUs giving 28V DC outputs
- Two 0.350 KVA HMDG systems giving 28V DC outputs through voltage regulator units (also called Rectifier Converter Units)

Standby sources:

- 5 KVA, 115/200 V, 400Hz, 3 phase HMDG system (Alternator-2)
- 5 KW, 28V DC generator

Emergency sources:

- 44 Ah, 24 V(Nickel-Cadmium) batteries (1 & 2)

AC Generation System

Basic power is generated by one 30/40 KVA (main power source) with standby sources of KVA hydraulic driven generator and 5kW DC generator mounted on the engine gear box.

Main features are:

- Generator control units (GCU) provided for control, regulation, and protection of respective generators.
- GCU controls generator line contactors which in turn controls all generators to respective bus bars.
- Power transfer and load shedding are carried out by connecting or disconnecting bus tie contactors.
- Emergency ac power is provided by a static inverted of 250 VA Capacity.

DC Generation System

DC is derived through two TRU of 250A in parallel (for normal condition) and standby 5kW Dc generator (for failure condition) with battery connected across a buffer.

Main features are:

- GCU is provided for control, regulation, and protection of 5kW DC generator.
- Emergency DC power is provided by two 45AH batteries in parallel and kept on float charge. DC distribution system consists of
- DC main bus bar
- DC essential bus bar
- DC alert bus bar

Electrical Modules

- The electrical system consists of:
- Integrated Drive Generator (IDG) 30-40kVA
- 5kVA Hydraulic Motor Driven Generator (HMDG)
- 5kW DC Generator
- Battery Junction Box
- Two Nickel Cadmium batteries
- Two Transformer Rectifier Units (TRU) Two 0.35kVA Hydraulic Motor Driven Generator (HMDG).

Working

- The F404-GE-IN20 aero engine is the primary source of power in the aircraft. Mechanical power from the engine is tapped through a PTO shaft, which drives the AMAGB. Two other pads are available directly on the engine gearbox. One of the drives on the AMAGB drives the 30/40 kVA IDG, which serves as the main power source. Power required for IDG is about 71 HP for a nominal continuous rating of 40 kVA. One of the drives on the EGB drives the 5 kW DC generator. The 5 kVA HMDG provides standby AC power, in case of failure of Alternator 1.

- The AC master box receives AC power generated from AC power sources. AC master box supplies power to AC distribution boxes and the TRUs through CBs. ACDB distributes AC power to various loads through CBs.
- The DC master box receives DC power from both the TRUs and the 5 kW DC generator. It supplies power to distribution boxes through CBs and relays. DCDB distributes DC power to various loads through CBs.
- The battery box houses the battery bus and distribution line CBs. The input power for the battery bus bar is provided by main/emergency sources (TRUs/5 kW DC generator) and in their absence by the Battery 1.
- The DC master box receives DC power from both the TRUs and 5 kW DC generator. It supplies power to distribution boxes through CBs and relays. DCDB distributes DC power to various loads through CBs.
- The battery box houses the battery bus and distribution line CBs. The input power for the battery bus bar is provided by main/emergency sources (TRUs/5 kW DC generator) and in their absence by the Battery 1.
- After starting the engine and when it reaches approximately 58% to 60% of maximum RPM (which is well below idle RPM 70%), then the onboard generator takes over the buses from external power automatically.

<u>Emergency System</u>

- One 44 Ah, 24 V Nickel Cadmium (Ni-Cd) battery (Battery 1) provides power to all emergency DC loads in case of electrical emergency / engine flame out battery is kept on float charge, when any TRU 5kW DC generator is online .
- The other 44 Ah, 24V Nickel Cadmium(Ni-Cd) battery (battery 2) is exclusively for driving EMDP(Electric Motor Driven Pump), in case of hydraulic emergency. Battery is kept on float charge when any TR 5kVV DC generator is online.

<u>Avionics System</u>

The Tejas has a night vision goggles (NVG)-compatible "glass cockpit", head-up display (HUD), three 5 in x 5 in multi- function displays, two Smart Standby Display Units (SSDU), and a "get-you-home" panel providing the pilot with essential flight information in case of an emergency. It includes an Open Architecture Computer (OAC) designed and developed by ADA, combining the functions of earlier mission computers, display processor, video switching unit and mission preparation and retrieval unit. Aircraft communication functions include both voice and data communication. In LCA, several Utility System Management Systems (USMS) are integrated with AWS. These systems are for fuel/oxygen management, engine health monitoring, environmental control system management etc. The above-mentioned functions are achieved through integrated functioning of the mission computer, sensors, controls, displays and the weapon systems - all software driven and in real time mode. The electronic warfare suite is designed to enhance combat survivability. It includes a Radar Warning Receiver (RWR), Laser Warning Receiver (LWR) system, Infrared & Ultraviolet Missile Warning sensors, Self-Protection Jammer, Chaff and Flares Dispenser, an Electronic Counter Measure (ECM) suite and a Towed Radar Decoy (TRD). The major functions performed by the LCA Avionics System include:

- Operational functions including fire control functions
- Mission preparation and data
- System-crew dialogue functions
- Aircraft communication functions
- Integrated maintenance functions

LRUs and Sensors

OAC(Open Architecture Computer): Open Architecture is a type of computer architecture or software architecture that allows adding, upgrading and swapping of components. Tejas Open Architecture Computer is the centralised computer for the Avionics and Weapons system. It performs the system and mission related tasks. There are two identical units namely OAC 1 and OAC 2. OAC lis active by default, and in the event of failure of OAC 1, OAC 2 will take over. This Open Architecture System is defined as equipment that has the following features:

- It can be designed, built, and tooled easily for quick deployment
- It can be easily interfaced with other equipment
- It is simple to modify/reconfigure for assembling new products or changing the existing products
- It is more flexible, easily upgradable, enables technology insertion and provides compatible reusable component-based software

- ECFM-EU (Environmental Control and Fuel Monitoring Electronic Unit): The ECFM-EU is an intelligent microprocessor based dual redundant electronic control and monitoring unit. The electronic unit has two major independent functions, one relating to fuel management and other related to conditioning the cockpit i.e., environmental control system.

- BHEEM (Brake, Hydraulic, Engine and Electrical Monitoring System): The BHEEM-EU is a dual redundant microprocessor based electronic unit with one channel actively controlling the outputs while the other channel is in hot standby. It receives both digital and analog information and processes that data to detect exceedances and abnormal engine behaviour, and to calculate and store engine Life Usage Indices. When an engine fault is detected, the BHEEM-EU generates a fault code, latches the engine fold indicator at the Central Maintenance Panel and stores the event data in an aircraft computer.

- Radio Altimeter: RAM system in Tejas provides the accurate altitude of the aircraft above water or above terrain. The RAM is a Frequency Modulated Continuous Wave (FMCW) radar that operates at 4.2¬4.4 GHz in the C-band. It operates based on continuous transmission of the frequency modulated radio waves and the use of differential beat frequency obtained by combining the echo signal reflected back from the ground. The altitude above the ground is proportional to the time required for the radiated signal to make a round trip to the ground and return to the aircraft. Thus, it gives the accurate height of the aircraft above the ground.
- MMR (Multimode Radar): It is a pulse Doppler radar which operates at X-band frequency. It is the primary sensor known as Fire Control Radar. Its primary role is to detect and locate targets, process the information, lock on the target, and pass this input to OAC. From the active OAC, this information is utilised for weapon release activity. The radar searches, detects and tracks ground and air targets that are within its field of view. The MMR also creates ground and contour maps and supports air to air, air to sea and air to ground missions when selected.
- IFF (Identification Friend or Foe): IFF system is a Secondary Surveillance Radar System consisting of ground interrogator, airborne transponder, processing equipment and related antenna system. Tejas makes use of IFF transponder 1420AL. The ground interrogator transmits the interrogation pulse pair, which triggers the airborne transponder. This causes a reply to be transmitted automatically by the transponder. The interrogator receives the reply and after processing, the result indication is displayed to the ground operator. Based on this reply to information, the interrogator distinguishes between a friend or foe aircraft. The airborne IFF system consists of an IFF transponder and antenna system. The IFF transponder when set to transmit special codes can inform the ground controller about the emergency on board if his radio contact with ground is lost.
- Inertial Navigation System/Global Positioning System: INS/GPS of Tejas provides a wide range of navigation functions with high grade performance. This primary navigation sensor and computing unit with embedded GPS receiver is a highly accurate navigation solution. It provides variou alignment and simultaneous computation of several navigation solutions.

- TACAN (Tactical Air Navigation System): TACAN is a Secondary survellance radar system consisting of ground transponder , air borne interrogator , processing equipment and related antena system.

- TACAN is a Radio Navigation System incorporated in Tejas to provide bearing and range information of the aircraft with respect to the ground TACAN beacon. The TACAN system also provides range of the aircraft with respect to other aircraft equipped with a similar system and TACAN beacon identification signals in morse code. The bearing and range information is used to navigate the aircraft to a particular destination. The range indicates the slant range of the aircraft from the round beacon and the bearing indicates the direction in degrees with respect to magnetic north.

- Very High Frequency Omni-Range/Instrument Landing System (VOR/ILS): VOR is a type of short-range radio navigation system for aircraft, enabling aircraft with a receiving unit to determine its position and stay on course by receiving the radio signals transmitted by a network of fixed ground radio beacons ILS is defined as a precision runway approach aid based on two radio beams which together provide the pilot with both vertical and horizontal guidance during an approach to land in bad weather conditions.

- Solid-State Crash Data Recorder Mk-II: It is a fire and crash resistant data recorder capable of recording and protecting the aircraft data from heat and water. It also records the pilot's voice. The recording duration of voice and aircraft parameters is for two hours and eight hours respectively. The aircraft parameters and audio received and transmitted from aircraft are recorded on a solid-state memory module with a capacity of 384 Mbs in SSCDR Mk-II. The recorded data in the SSCDR Mk-II is retrieved through portable ground replay equipment. The retrieved data and audio are processed for analysis of flight parameters and the performance of different systems of aircraft.

Electronic Warfare System

- Weapon System: Tejas aircraft is a frontline fighter-interceptor for aerial and ground targets at short and medium ranges. It has an armament control system to prepare, and release/fire weapons mounted on various suspension ports. The aircraft is capable of deploying weapons both in daytime and at night in
- any weather condition. The weapon system consists of:
- Suspension System
- Bombing System (air to ground mode)
- Missile System (air to air mode)
- Gunnery System (air to ground/air to air mode)
- Laser Designator System

- Radar Warning Receiver System: The RWR system is designed for threat acquisition, target tracking, interception and identification of airborne and ground-based missile guidance radars. It operates in the frequency band of 2 -18 GHz with azimuth coverage of 360°. The RWR system also provides clearly identifiable audio warnings that alert the pilot to imminent threat.

- Counter Measure Dispensing System: CMDS is an airborne defensive system, which provides self-protection of the aircraft by passive Electronic Control Measure. This helps to protect the aircraft from radar-guided and infrared seeking, air and ground launched missiles, data guided anti-aircraft missiles by misguiding the missiles through the dispersal of chaff and/or flare payloads.

- Smart Standby Display Unit-Get U Home (SSDU-GIU): The SSDU-GUH is a standalone, AMLCD based colour display unit. It operates as a standby unit and displays the essential flight parameters to the pilot in the event of failure of the normal display system. It is capable to perform computations, display page generation and to drive external interfaces based on the input data or derived parameters.

Aircraft parameters displayed on this include:

- Baro Altitude and Baro Setting
- Vertical Speed
- Calibrated Airspeed
- Mach Number
- Magnetic Heading Display
- Aircraft roll and pitch
- Angle of Attack
- Forward Acceleration
- Flight Path Angle
- Laser Designation Pod: LDP is used for ranging and to illuminate ground targets during delivery of conventional and practice bombs. Navigation and Attack system of Tejas facilitates selection, aiming and releasing of Laser Guided Bombs. Laser Guided Armament fire control necessitates carriage of LDP for target tracking, illumination and ranging. The pylon attached to the LH air intake is dedicated for the LD system. The LDP is directly mounted on the pylon.

- Smart Standby Display Unit-Engine Fuel Indicator (SSDU-EFI): It is a standby colour display unit. It displays the essential parameters related to the engine and fuel to the pilot in the event of failure of all the three MFDs inside the cockpit.

- Cockpit Interface Unit (CIU): It provides input-output interface between the cockpit and OAC. It also generates a voice warning in case of system failure. A Centralised Warning System provides the critical warning display on CMFD and the instructions on LMFD.

Environment Control System (ECS)

The Environmental Control System (ECS) of TEJAS is a simple and efficient system to provide automatic temperature and cabin pressurization along with avionics temperature regulation. As the altitude changes temperature and cabin gas, the pressurization parameters vary accordingly. This is controlled by the ECFMU.

Functions and Subsystems

Functions

- Cockpit Pressurization
- Cockpit Air - Conditioning
- Cockpit Ventilation
- Avionics Cooling
- Windscreen Demisting
- Cabin Sealing
- Fuel Tank Pressurization
- Radar Pressurization

Subsystems

- Bleed Air Control System (BACS)
- Hot Air Leak Detection System (HLDS)
- Air Distribution System (ADS)
- Fuel Tank Pressurization System (FTPS)
- Cabin Ventilation System (CVS)
- Cabin Pressure Control System (CPCS)
- Wind Screen Demisting System (WSDS)
- Cold Air Generating System (CAGS)
- Cabin Sealing System (CSS)
- Radar Pressurization System (RPS)

LRUs

- Venturi with gimble assembly
- PHE Bypass Valve
- Control Unit
- Pre-Cooler (Heat Exchanger -1)
- Primary Heat Exchanger (PHE) (Heat Exchanger -2)
- Secondary Heat Exchanger (SHE) (Heat Exchanger-3)
- Pressure Release Shut Off Valve (PRSOV)
- Re-Heater

- Ejector Shut Off Valve (ESOV)
- Cold Air Unit (CAU)
- Condenser
- High Speed Water Separator
- Diverter Assembly

Flow Sequence

400 — 600 degrees of hot air is tapped from the 7th stage compressor of the engine 4 Pressure Relief ShutOff Valve (PRSOV) Pre-Cooler 4 Primary Heat Exchanger -4 Cold Air Unit (CAU) 4 Secondary Heat Exchanger (SHE) 4 Re-Heater 4 Condenser 4 High Speed Water Separator (HSWS) 4 Re-Heater 4 Cold Air Unit (CAU) 4 Condenser 4 Diverter Assembly.

- PRSOV — The 15-20 bar pressure which is coming from the engine is restricted to 6 bar.
- Pre-Cooler — It is the first heat exchanger with fins in this system. The tapped hot air is cooled by the atmospheres ambient RAM air. It cools up to 30% of the incoming hot air.
- Primary Heat Exchanger (PHE) — This is the second heat exchanger and is present in the ECS bay (Station 16 — Station 24). It is located on the portside (LH) of the aircraft. The medium of cooling again in this case is the RAM air, whose intake is from the duct beside the air intakes of the engine.
- Cold Air Unit (CAU) It consists of two stages, the compressor chamber and a turbine chamber.
- Secondary Heat Exchanger (SHE) — Its function is same as the PHE, just that it is positioned on the starboard (RH) of the aircraft.
- Re-Heater — As the name suggests, it reheats the air to some threshold of temperature to segregate the water particles which might damage the avionics system.
- Condenser — It is used to condense the water which is formed in the Re-Heater.
- High Speed Water Separator (HSWS) — The condensed water is collected in this stage to ensure that dry air will be supplied to all the ECS systems.
- Diverter Assembly — The place where the dry air is divided into the avionics rack, cockpit, etc.In the system, depending on the hot zone regions the ECS pipelines are made of Inconel (Iron — Cobalt —Nickel) Steel while the lower temperature lines are made of Al — alloy. The former regions furthermore have a Hard Lagging insulation whose main purpose is not to allow the heat transfer of the hot air to the sensitive sensors or pipelines. There is another type of lagging, namely called Soft Lagging.is used to ensure that the cold air flowing to the respective sections is not heated by the aircraft components.

Seat and Safety

The escape system saves the pilot when the aircraft is in danger. An ejection seat MK IN 16G is installed to eject the pilot from aircraft and to provide comfortable survival after the separation of seat. The seat has a capability to eject through the canopy in case the canopy removal system fails to function. The escape system is the primary means for pilots to escape from the aircraft when it is in danger. Canopy severance system and the ejection seat together form an emergency escape system. The canopy severance system has a dual Inflight Egress System (IES) and a Ground Egress System (GES)

The escape system consists of the following systems:

- Ejection seat
- Canopy Severance System (CSS)

Ejection Seat

The ejection seat installed in the aircraft is Martin Baker IN 16G. This is a fully automatic, cartridge operated, and rocket assisted seat. It is installed on the bracket assembly of the forward seat bulkhead in the cockpit. It ejects safely at zero altitude in a substantially level attitude to ceiling height of 15 km irrespective of speed and flight path. Safe ejection is possible up to 600 knots. Ejection is initiated by pulling off the seat ejection handle situated on the front of the seat pan. The seat is ejected by the action of gas pressure developed within an ejection gun due to the firing of cartridges. A rocket mounted under the seat pan fired as an ejection gun approaches the end of its stroke by a catapult operated rocket firing unit. The combined thrust will take the seat/pilot mass to a sufficient height to enable the main parachute to develop properly before the pilot impacts the ground even if the ejection initiation has been done at zero altitude and zero speed condition. A drogue parachute, which is smaller than the main parachute, will open immediately after ejection to stabilise the seat initially.

Canopy Severance System

The CSS has a dual inflight egress system and ground egress system. The canopy bubbles are embedded with dual MDC. MDC of IES fractures the Canopy bubbles at U-looped MDC line and MDC of GES fractures the canopy bubbles around its periphery.

Dual Inflight Egress System

The dual IES is integrated with the ejection seat. The system consists of a U-looped MDC cord stuck on the interior surface of the canopy bubble. The MDC shall be initiated by the ejection seat hot gas or movement of the seat, through explosive transfer lines.

Ground Egress System

When the aircraft is in danger on ground, in the event of the canopy locking system failure, the pilot operates the initiator to save himself. It is installed below the RH canopy longeron. GES starts functioning on operation of this handle. GES starts functioning on operation of this handle. This in turn operates the MDC and fractures the canopy bubbles around its periphery. The ground crew can also rescue the pilot by operating the external initiator handle installed on the port and starboard sides of the fuselage. These initiator handles are covered with glass panes and need to be broken before operation.

Brake Parachute System

The aircraft system equipped with brake parachute system at the tail end, to retard the aircraft during the landing roll . deployment of break parachute increases the drag and aborted/rejected take-off and during the landing roll. Deployment of brake parachute increases the decelerates the aircraft in addition to that achieved by the wheel brake, A 'CHUTE' switch provided on LH main instrument panel in the cockpit facilitates the streaming jettisoning operations of the brake parachute.

The system comprises of the following main components

- Brake Parachute
- Container
- End caps
- Release mechanism
- Shear pin (Fuel safe automatic jettison device)

A packed parachute is stowed inside the container which is kept closed with the help of endcaps (clamshell doors). The release mechanism is used to engage the parachute with the aircraft prior to deployment and it disengages the parachute from the aircraft, during jettison operation. It also assists to keep the parachute compartment doors in locked position once the parachute is stowed and it unlocks the compartment doors during parachute deployment process.

The parachute remains disengaged from the aircraft until the 'CHUTE' switch is operated for deployment. The parachute link hook of release mechanism retains the parachute link in proper position which ensures positive locking of parachute with the aircraft deployment. This feature also enables instantaneous automatic jettisoning of parachute is released from its container due to inadvertent opening of compartment doors during flight.

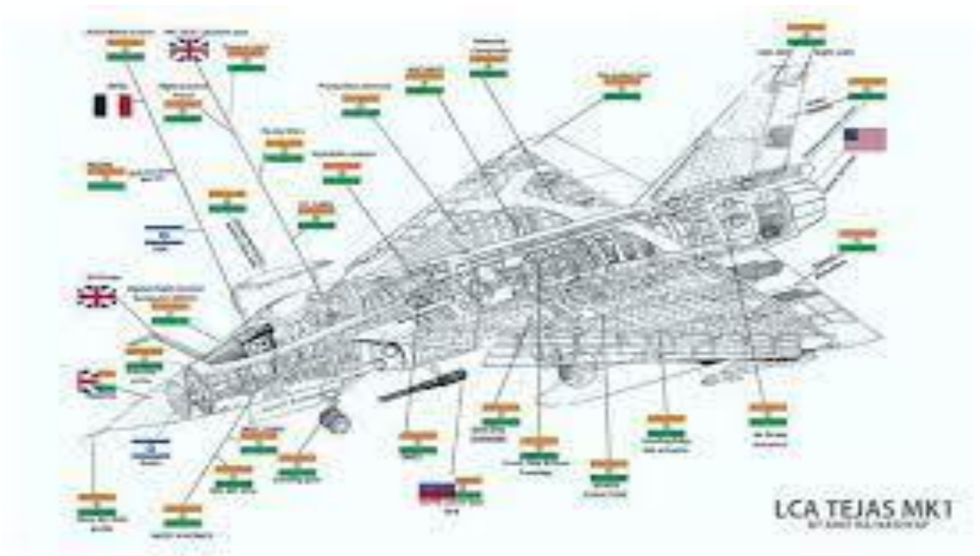
A shear pin is incorporated in the parachute link so that the parachute will detach from the aircraft in case of inadvertent in-flight deployment at high speeds (more than 210 to 220 knot CAS). In case, the inadvertent in-flight deployment happens, at speeds lower than the shear pin operational speed and chute tail to jettison on operation from cockpit, the parachute can be detached by the aircraft above 200 knot CAS.

The brake parachute is deployed in following sequences:

- The electro - mechanical actuator retracts and locks the parachute link with the release mechanism, subsequently unlocks the end cape which are attached with spring jacks
- The spring jacks opens the and caps sideways & retains it in open position

- Preloaded pilot chute (coil spring) ejects the auxiliary parachutes into the airstream
- Inflated auxiliary parachute extracts the main parachute for deployment.
- At any desired time after deployment, selection of chute switch to "OFF/JET' position jettisons the parachute in following
- sequence
- The electro-mechanical actuator extends and unlocks the parachute link from the release mechanism
- Incident air flow and/or jet efflux of aircraft blows away. the chute resting in jettisoning of the chute
- The normal deployment speed for tail chute is 155 knot and is designed for safe deployment up to a max speed of 184 knot

LCA Tejas Indigenious



CONCLUSION

LCA TEJAS is a prestigious project for our country which will boost out defence capabilities. TEIAS has replaced the phased out MIG-21 fighters to strengthen the Indian Air Force. It has become one of the primary combat aircrafts of the IAF. This was possible only with the hard work and dedication of highly trained engineers and staffs of HAL LCA division .

After the completion of industrial training, we enhanced competencies and competitiveness in our respective area of specialization.

We tried to relate the experience in the workplace with knowledge on the job under supervision. We gained the experience and knowledge for my future which will make me better prepared to face the working world.