AIRCRAFT SYSTEMS AND CONTROL

IV B. Tech V semester (Autonomous IARE R-16)

BY

Mr. Anudeep P
Assistant Professor
Mr. Suresh Kumar R
Assistant Professor

DEPARTMENT OF AERONAUTICAL ENGINEERING
INSTITUTE OF AERONAUTICAL ENGINEERING
(Autonomous)
DUNDIGAL, HYDERABAD - 500 043

CO's	Course outcomes
CO1	Define the System concepts, sub-systems, Generic system definition, inputs, outputs, feedback, external influence
CO2	Describe the Electrical loads in aircraft. Explain Electrical power generation and control- DC, AC- types, variable speed constant frequency (VSCS), 270 V DC systems.
CO3	Define Hydraulic systems and pneumatic systems. explain their Working principles, Typical air pressure system, Brake system, landing gear systems.
CO4	Describe the Principle of operation of aircraft gas turbine engines, Engine monitoring sensors, indicators. Describe the Fuel systems- characteristics, components, operating modes
CO5	Define Flight control systems- primary and secondary flight control explain Engine control systems, Push pull rod system,

INTRODUCTION TO AIRCRAFT SYSTEMS

UNIT - I

CLOs	Course Learning Outcome
CLO1	Define the meaning of the system and its Characteristics and identify different types of aircraft systems.
CLO2	Describe the airframe systems, vehicle systems of aircraft systems.
CLO3	Explain the generic system and operating conditions of aircraft systems.

SYSTEM CONCEPTS

- Is a broad field of practice that covers the behavior of systems across a wide range of subjects including
- Organizational
- Operational
- Practical
- Commercial
- Economical
- Human and educational systems.

- For aircraft systems- elemental building blocks are the components, physical components like pipes ,valves ,sensors etc. that determine hardware characteristics of systems.

- Apart from this software systems human is the form of pilot, crew technician ,passengers, or a maintainer is also vital part of the systems

- For aircraft systems- elemental building blocks are the components, physical components like pipes ,valves ,sensors etc. that determine hardware characteristics of systems.

- Apart from this software systems human is the form of pilot, crew technician ,passengers, or a maintainer is also vital part of the systems

SYSTEM DEFINITIONS

- The system of an aircraft must be designated to meet the design targets. Such as low mass, low power consumption ,high performance ,high accuracy ,high integrity and low cost apart from safety targets.

- System applies to various combinations of components and control units that perform a use full function in the operation of aircraft

- A system is an assembly of parts, components, processes or functions connected together in an organized way

- A complete system include all equipments related facilities materials ,software's,services and personals required for its operation and support to the degree

EXAMPLES OF SYSTEMS

The word 'system' is often used loosely in everyday speech by people to describe large amorphous 'things' or corporations. These are complex things that defy a simple description.

- Examples include

• Natural systems such as the eco-system or solar system

• National Health Service

• Building and construction industry

SYSTEM CONCEPTS

Is a broad field of practice that covers the behavior of systems across a wide range of subjects including

- Organizational
- Operational
- Practical
- Commercial
- Economical
- Human and educational systems.

•For aircraft systems- elemental building blocks are the components, physical components like pipes ,valves ,sensors etc. that determine hardware characteristics of systems.

•Apart from this software systems human is the form of pilot, crew technician ,passengers, or a maintainer is also vital part of the systems.

•For aircraft systems- elemental building blocks are the components, physical components like pipes ,valves ,sensors etc. that determine hardware characteristics of systems.

•Apart from this software systems human is the form of pilot, crew technician ,passengers, or a maintainer is also vital part of the systems

SYSTEM DEFINITIONS

- The system of an aircraft must be designated to meet the design targets. Such as low mass, low power consumption ,high performance,high accuracy ,high integrity and low cost apart from safety targets.

- System applies to various combinations of components and control units that perform a use full function in the operation of aircraft.

- The system is an assembly of parts, components, processes or functions connected together in an organized way

- A complete system include all equipments related facilities materials,software's, services and personals required for it operation and support to the degree

EVERYDAY EXAMPLES OF SYSTEMS

The word ‘system’ is often used loosely in everyday speech by people to describe large amorphous ‘things’ or corporations. These are complex things that defy a simple description.

➢Examples include

- Natural systems such as the eco-system or solar system
- National Health Service
- Building and construction industry

AIRFRAME SYSTEMS

Considering the aircraft as overall main system is classified into 4 important co systems.

•The airframe can be viewed as a system since it is a complex and integrated set of structural components that supports the mass of systems and passengers, and carries loads and stresses throughout the structure.

•The airframe is designed and constructed as a set of sub-systems that are integrated to form the whole structure

VEHICLE SYSTEMS

•The aircraft systems are also know as General Systems or Utility Systems. Many of these systems are common to both civil and military aircraft. They are a mixture of systems with very different characteristics.

•Some are high speed, closed loop, high integrity control, such as flight controls, others are real time data gathering and processing with some process control functions, such as the fuel system and yet others are simple logical processing

•Coming to individual systems of vehicle systems:

•Propulsion system to provide the primary source of thrust and motive power via pilot demands, electronic and hydro-mechanical fuel controls.

•A propulsion system has a source of mechanical power (some type of engine or motor), and some means of using this power to generate force.

•Fuel system to provide a source of energy for the propulsion system. the system consists of tanks, a quantity measuring system, pumps, valves, non-return valves and pipes to transfer fuel from tank to tank and to the engines.

•An aircraft fuel system allows the crew to pump, manage, and deliver fuel to the propulsion system of an aircraft.

- **Electrical power generation and distribution**: to generate AC and DC power from the engine connected generators and batteries, and to distribute the power to all connected equipment.

- **Hydraulic power generation and distribution** to generate hydraulic power from engine driven pumps and to distribute hydraulic power to all connected systems.

- Secondary power system to provide a source of electrical, hydraulic and cooling power for aircraft on the ground, and to provide a form of energy to start the engines.

- Auxiliary or secondary systems help the aircraft perform its main function: flying from a to b.

- Emergency power generation to provide energy to allow safe recovery of the aircraft in the event of a major power loss.

- Flight control systems to convert pilot demands or demands from guidance systems into control surface movements to control the aircraft attitude.

- Landing gear to ensure that the aircraft is able to land safely at all loads and on designated runway surfaces.

- Brakes/anti-skid to provide a safe form of braking without loss of adhesion under a wide range of landing speeds and loads.

- Steering to provide a means of steering the aircraft under its own power.

- Environmental control system to provide air of an appropriate temperature and humidity to provide a safe and comfortable environment for crew, passengers and avionic equipment.

- Ice protection to monitor external ambient conditions to detect icing conditions and to prevent the formation of ice or to remove ice.

- External lighting to ensure that the aircraft is visible to other operators and to ensure runway/taxiway visibility during ground movements

Military aircraft also require the following systems:

•Crew escape to provide a means of assisted escape for aircrew.

•Canopy jettison or fragmentation to provide a means of removing the canopy from the aircraft or breaking the canopy material to provide a means of exit for escaping aircrew.

•Biological and chemical protection to protect the crew from the toxic effects of chemical or biological contamination

- **Arrestor mechanism** to provide a means of stopping the aircraft on a carrier deck or at the end of a runway.

- **In-flight refueling** to allow the aircraft to obtain fuel from a tanker aircraft.

- **Helicopter deck** lock to secure helicopters to a carrier deck.

Commercial aircraft and large military aircraft require the following systems specifically for their use:

Galley to allow meals to be prepared and cooked for passengers

Passenger evacuation to allow safe evacuation of passenger

Fig. 1.1 Galley

Entertainment systems to provide audio and visual entertainment for passengers

Telecommunications to allow passengers to make telephone calls and send e-mail in flight

Gaseous oxygen for passenger use in case of de pressurization In case of cabin depressurization the aircraft is equipped with oxygen masks located above each seat . If it is necessary, the mask falls automatically.

Cabin and emergency lighting to provide general lighting for the cabin and galley, reading lights, exit lighting and emergency lights to provide a visual path to the exit

Fig. 1.2 Depressurization

AVIONICS SYSTEMS

•The avionic systems are common to both civil and military aircraft. Not all aircraft types, however, will be fitted with the complete set listed below.

•The majority of the systems collect, process, transfer and respond to data.

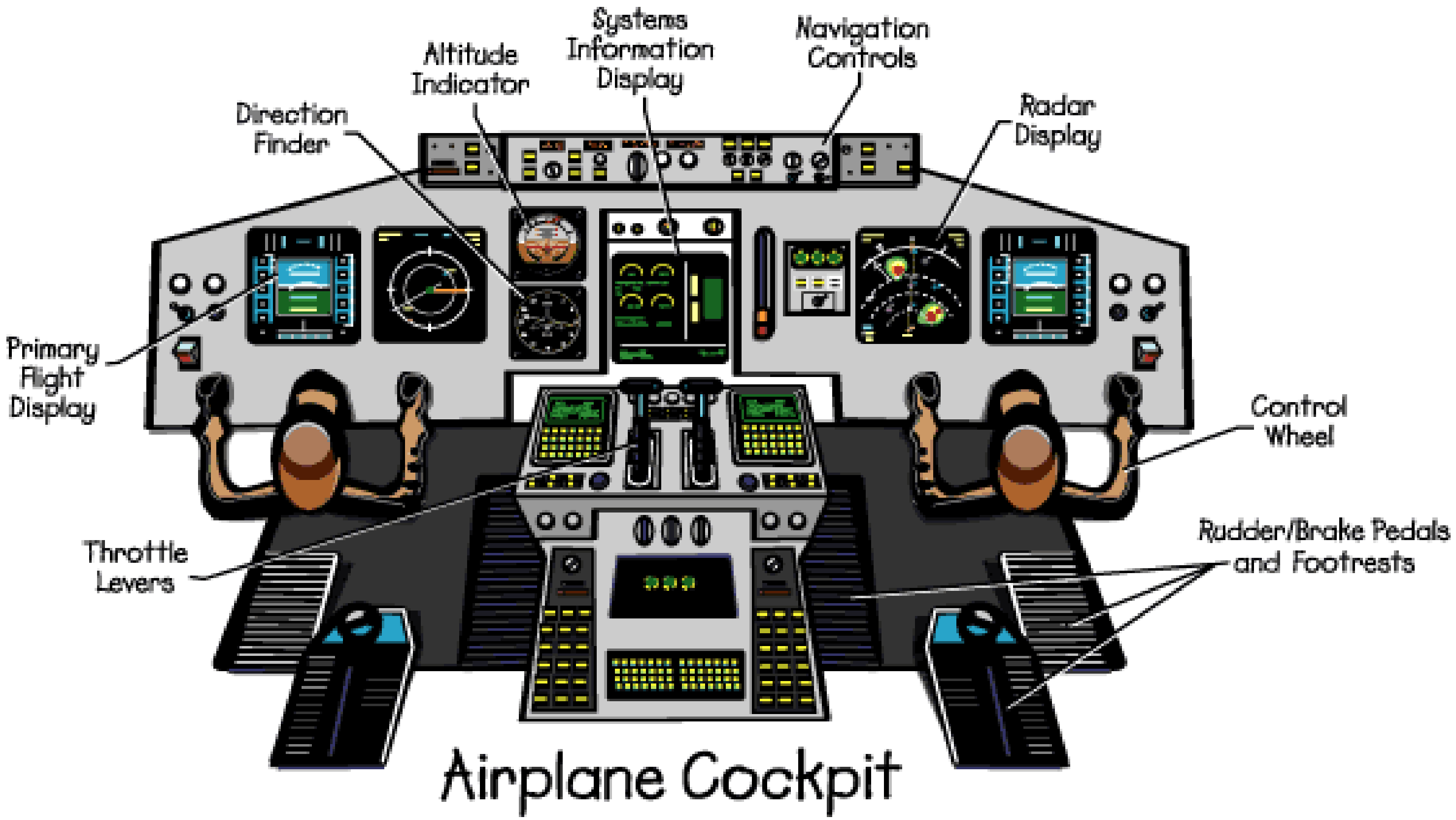
•Any energy transfer is usually performed by a command to a vehicle system.

- The following are the common (module) avionic system s both for civil and military aircrafts:

- Displays and controls to provide the crew with information and warnings with which to operate the aircraft.

- Communications to provide a means of communication between the aircraft and Air Traffic Control and other aircraft. Communications connect the flight deck to the ground and the flight deck to the passengers.

- Navigation to provide a worldwide, high accuracy navigation capability


Systems Information Display
Navigation Controls
Altitude Indicator
Direction Finder
Radar Display
Primary Flight Display
Control Wheel
Throttle Levers
Rudder/Brake Pedals and Footrests
Airplane Cockpit

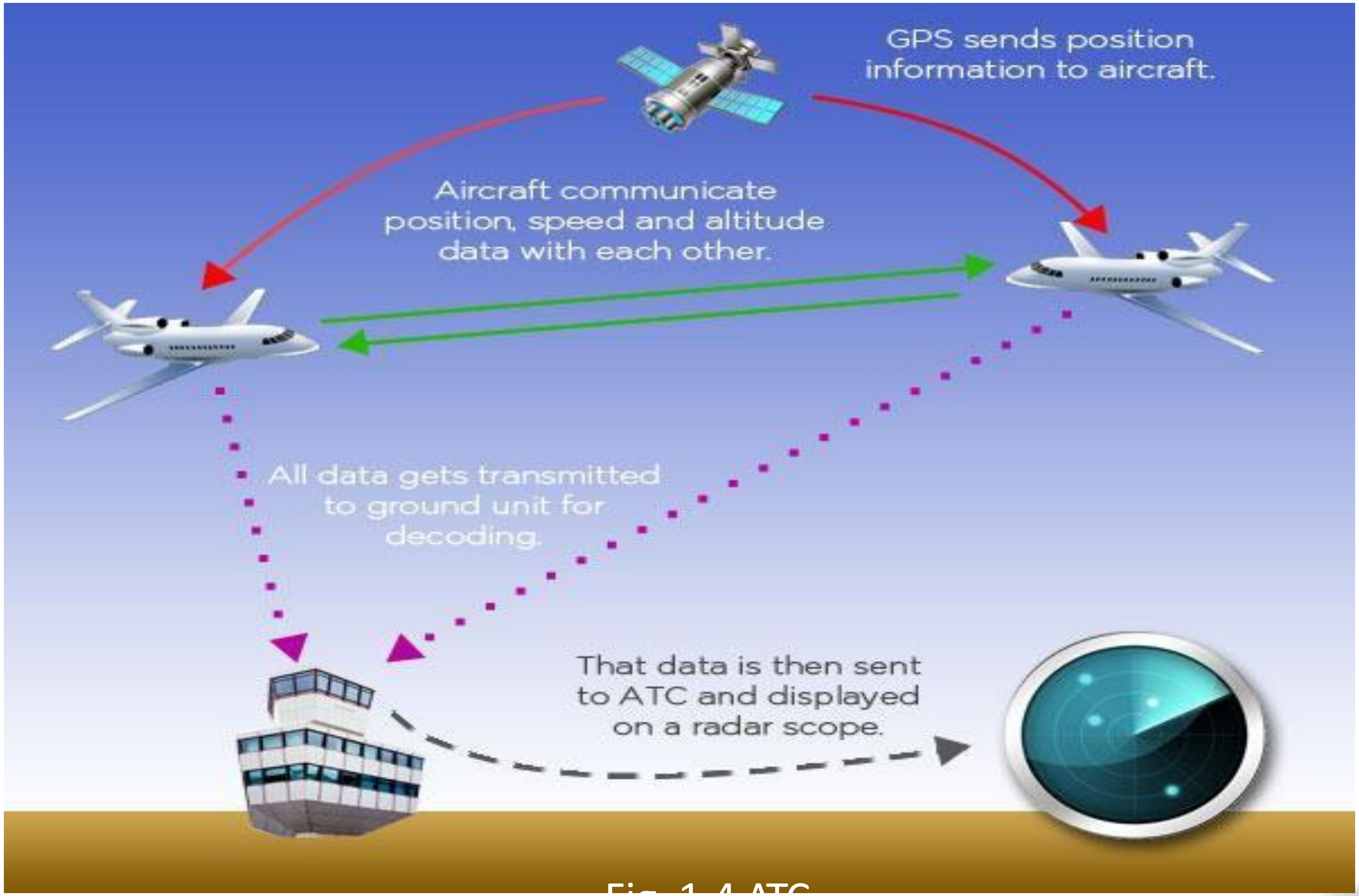

GPS sends position information to aircraft.
Aircraft communicate position, speed and altitude data with each other.
All data gets transmitted to ground unit for decoding.
That data is then sent to ATC and displayed on a radar scope.

Fig. 1.4 ATC

Flight Management System to provide a means of entering flight plans and allowing automatic operation of the aircraft in accordance with the plans

- An FMS is a specialized computer system that automates a wide variety of in-flight tasks, reducing the workload on the flight crew to the point that modern civilian aircraft no longer carry flight engineers or navigators.

Weather radar to provide information on weather conditions ahead of the aircraft.

- Weather systems such as weather radar and lightning detectors are important for aircraft flying at night or in instrument meteorological conditions where it is not possible for pilots to see the weather ahead.

•Weather radar also called weather surveillance radar (WSR) and Doppler weather radar is a type of radar used to

- Locate Precipitation,
- Calculate its motion,
- Estimate its type (rain, snow, etc)

IFF/SSR to provide information on the aircraft identification and height to air traffic is a radar system used in air traffic control (ATC), that not only detects and measures the position of aircraft i.e. range and bearing, but also requests additional information from the aircraft itself such as its identity and altitude.


GROUND PROXIMITY
INOP
FLAP
INHIBIT
SYS TEST
NORMAL

- Ground proximity warning system (GPWS)/Terrain avoidance warning system(TAWS) to reduce the risk of aircraft flying into the ground or into high ground.

- A ground proximity warning system (GPWS) is a system designed to alert pilots if their aircraft is in immediate danger of flying into the ground or an obstacle.

- More advanced systems introduced in 1996 are known as enhanced ground proximity warning systems (EGPWS) although sometimes called terrain awareness warning systems.

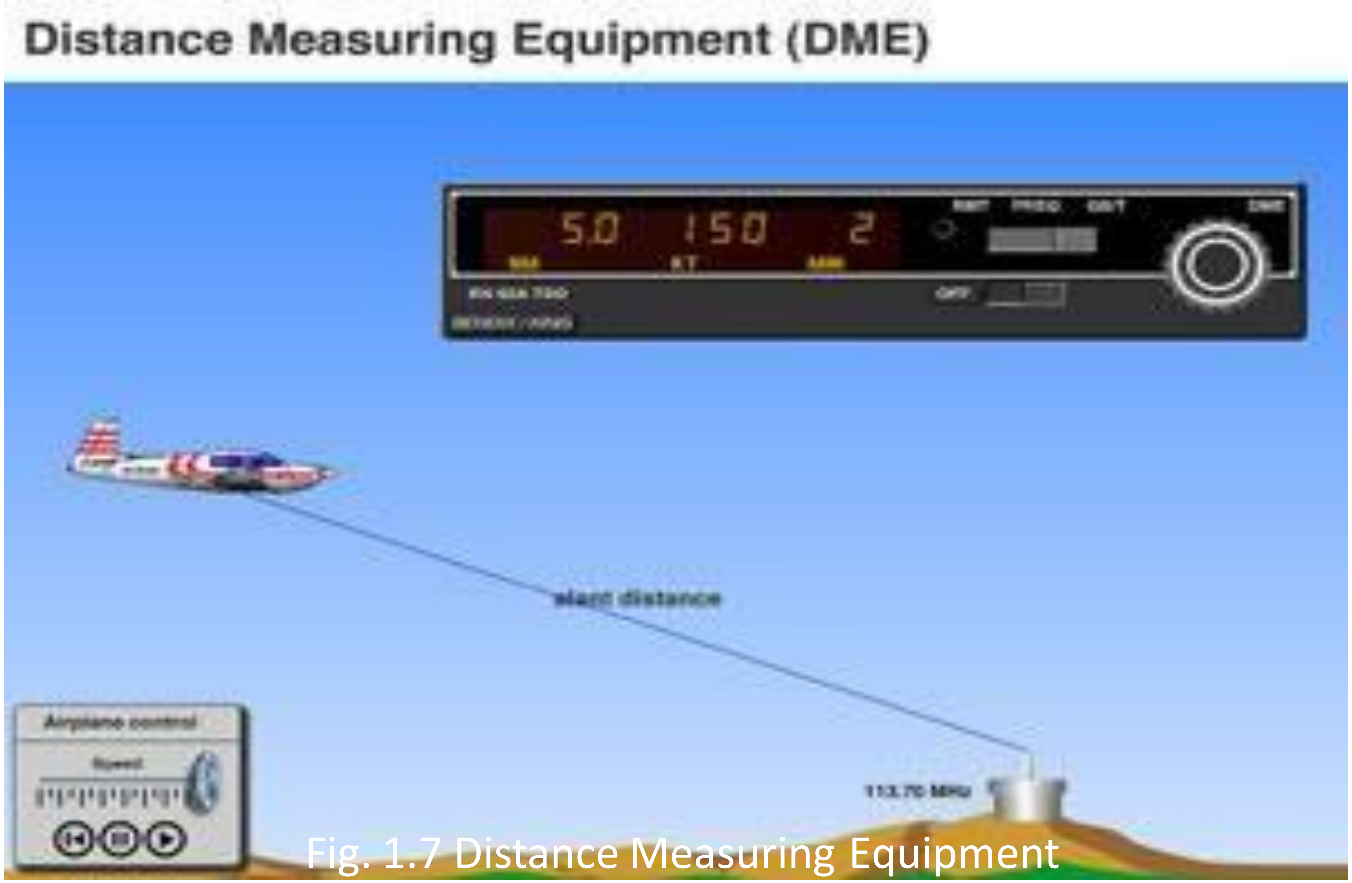


Fig. 1.7 Distance Measuring Equipment

Distance measuring equipment (DME) is a transponder-based radio navigation technology that measures slant range distance by timing the propagation delay of VHF or UHF radio signals.

- As the name implies DME provides information on the distance from the aircraft to the ground station.

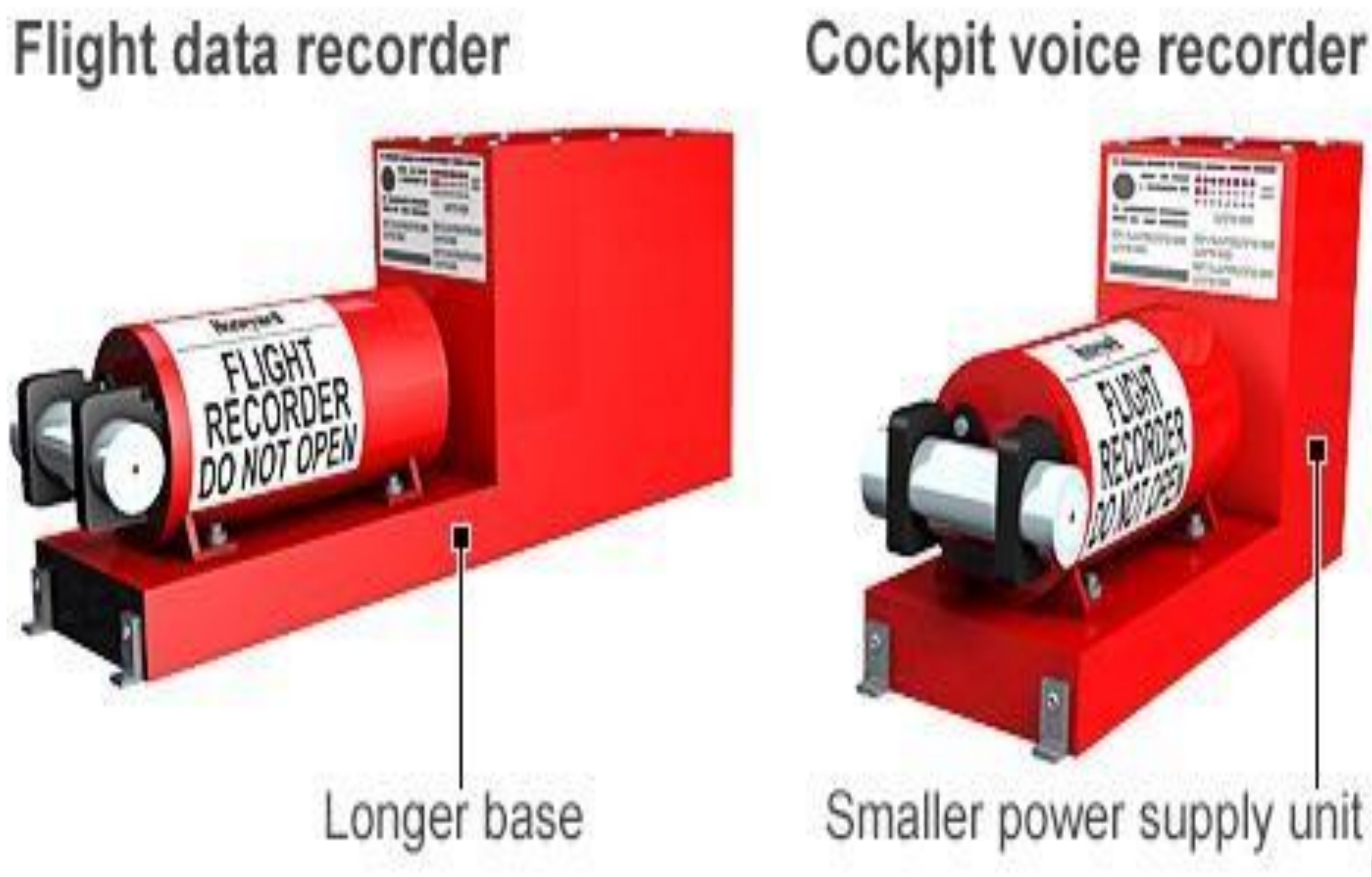
- Used to establish position along an airway and also to establish hold points

- Air data measurement to provide information to other systems on altitude, air speed, outside air temperature and Mach number.

- Accident data recorder to continuously record specified aircraft parameters for use in analysis of serious incidents.

- Cockpit voice recorder to continuously record specified aircrew speech for use in analysis of serious incidents.

- Internal lighting to provide a balanced lighting solution on the flight deck for all panels and displays.


Flight data recorder
Cockpit voice recorder
FLIGHT RECORDER DO NOT OPEN
FLIGHT RECORDER DO NOT OPEN
Longer base
Smaller power supply unit

•flight recorder (or aircraft's black box) is an electronic recording device placed in an aircraft for the purpose of facilitating the investigation of aviation accidents and incidents.

•Any type of aircraft in any condition of flight can be viewed in terms of its input parameters (e.g. control instructions) and output parameters (e.g. flight sensors) without any knowledge of its internal workings as a black box model.

MISSION SYSTEMS

Used for military aircrafts.

The military aircraft requires a range of sensors and computing to enable the crew to prosecute designated missions.

•The mission systems gain information about the outside world from active and passive sensors and process this information to form intelligence.

Attack or surveillance radar to provide information on hostile and friendly targets.

Electro-optical sensors to provide a passive surveillance of targets.

Electronic support measures (ESM) to provide emitter information, range and bearing of hostile transmitters

•Military telecommunications, the terms Electronic Support (ES) or Electronic Support Measures (ESM) describe the division of electronic warfare involving actions taken under direct control of an operational commander to detect, intercept, identify, locate, record and/or analyze sources of radiated electromagnetic energy for the purposes of immediate threat recognition (such as warning that fire control RADAR has locked on a combat vehicle, ship, or aircraft) or longer-term operational planning

•Magnetic anomaly detector (MAD) to confirm the presence of large metallic objects under the sea surface (submarines) prior to attack is an instrument used to detect minute variations in the Earth's magnetic field.

•The term refers specifically to magnetometers used by military forces to detect submarines.

•Military MAD equipment is a descendent of geomagnetic survey instruments used to search for minerals by detecting their disturbance of the normal earth-field.

•Acoustic sensors to provide a means of detecting and tracking the passage of under water objects.

•Mission computing to collate the sensor information and to provide a fused data picture to the cockpit or mission crewstations.

•Defensive aids to provide a means of detecting missile attack and deploying countermeasures

•A defensive aids system (DAS) is a military aircraft system which defends it from attack by surface-to-air missiles, air-to-air missiles and guided anti-aircraft artillery.

•A DAS typically comprises chaff, flares, and electronic countermeasures combined with radar warning receivers to detect threats.

•On some modern aircraft, the entire system is integrated and computer-controlled, allowing an aircraft to autonomously detect, classify and act in an optimal manner against a potential threat to its safety

- Helmet-mounted displays to provide primary flight information and weapon information to the crew, whilst allowing freedom of movement of the head.

- Data link to provide transmission and receipt of messages under secure communications using data rather than voice

•Data link is the means of connecting one location to another for the purpose of transmitting and receiving digital information.

•It can also refer to a set of electronics assemblies, consisting of a transmitter and a receiver (two pieces of data terminal equipment) and the interconnecting data telecommunication circuit.

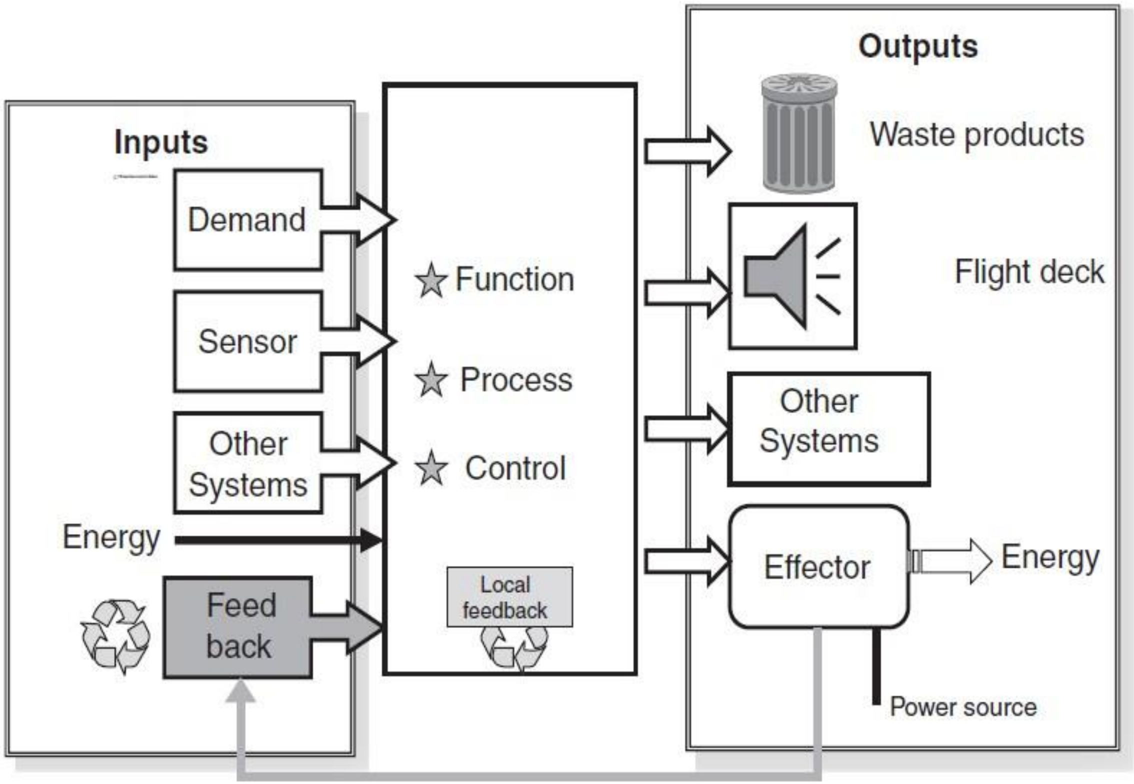
•These are governed by a link protocol enabling digital data to be transferred from a data source to a data sink.

GENERIC SYSTEM DEFINITION

- An aircraft will be equipped with various combinations of these systems according to its particular role.

- Some of the systems will be integral to the aircraft, others will be carried as role equipment in pallets or wing mounted pods.

- The majority of these engineering systems are similar in their format.


Inputs
Demand
Sensor
Other Systems
Energy
Feed back
Function
Process
Control
Local feedback
Outputs
Waste products
Flight deck
Other Systems
Effector
Energy
Power source

FEEDBACK

•Feed Back is obtained from measuring devices or sensors in the output devices to allow control to be exercised for reasons of stability of the output.

•Energy is provided to enable the system to operate.

•This usually needs to be conditioned by the system to ensure that it is the correct voltage and free from transients or noise to ensure correct operation

Operational Environments

- In military parlance, the operational environment is the combination of the conditions, circumstances, and influences which will determine the use of military forces and help a unit commander make decisions.
- There are many different examples of an operational environment, and in most cases, they describe U.S. troops when they're deployed in another country.
- The best known, but perhaps the most unsettling one for soldiers and other troops is a hostile environment.

Unit 2

ELECTRICAL SYSTEMS AND AIR CONDITIONING, PRESSURIZING SYSTEMS

UNIT - 2

CLOs	Course Learning Outcome
CLO4	Describe the various electrical power generations in the aircraft and discover more Electric aircraft.
CLO5	Estimate the electrical power requirements and can optimize the load distribution.
CLO6	Explain the basic air cycle systems and vapour cycle systems of aircraft systems.

ELECTRICAL POWER SYSTEM

•Electrical systems have made significant advances over the years as aircraft have become more dependent upon electrically powered services.

•A typical electrical power system of the 1940s and 1950s was the twin 28 VDC system.

•This system was used a great deal on twin engined aircraft; each engine powered a 28 VDC generator which could employ load sharing with its contemporary if required.

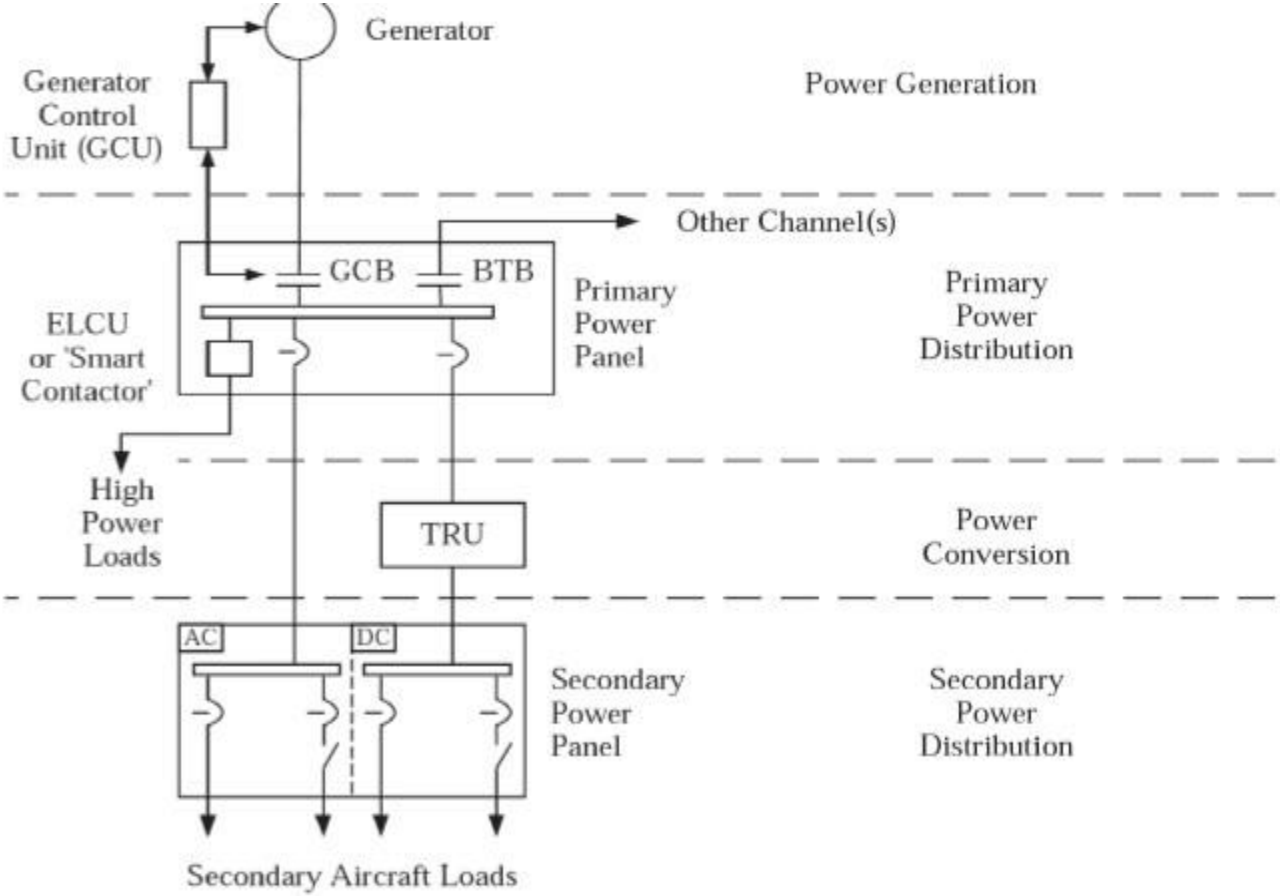
- Later aircraft were fitted with four 115 VAC generators, one being driven by each engine.

- To provide the advantages of no-break power these generators were paralleled which increased the amount of control and protection circuitry.
-
- The generators work with the specification of 115 VAC 400 Hz.

- Recently the variable frequency generators are fitted in modern aircraft.

- The advances in high power solid state switching technology together with enhancements in the necessary control electronics have made variable speed / constant frequency (VSCF) systems a viable proposition in the last decade.

- The VSCF system removed the unreliable CSD portion; the variable frequency or frequency wild power from the AC generator being converted to 400 Hz constant frequency 115 VAC power by means of a solid state VSCF converter.



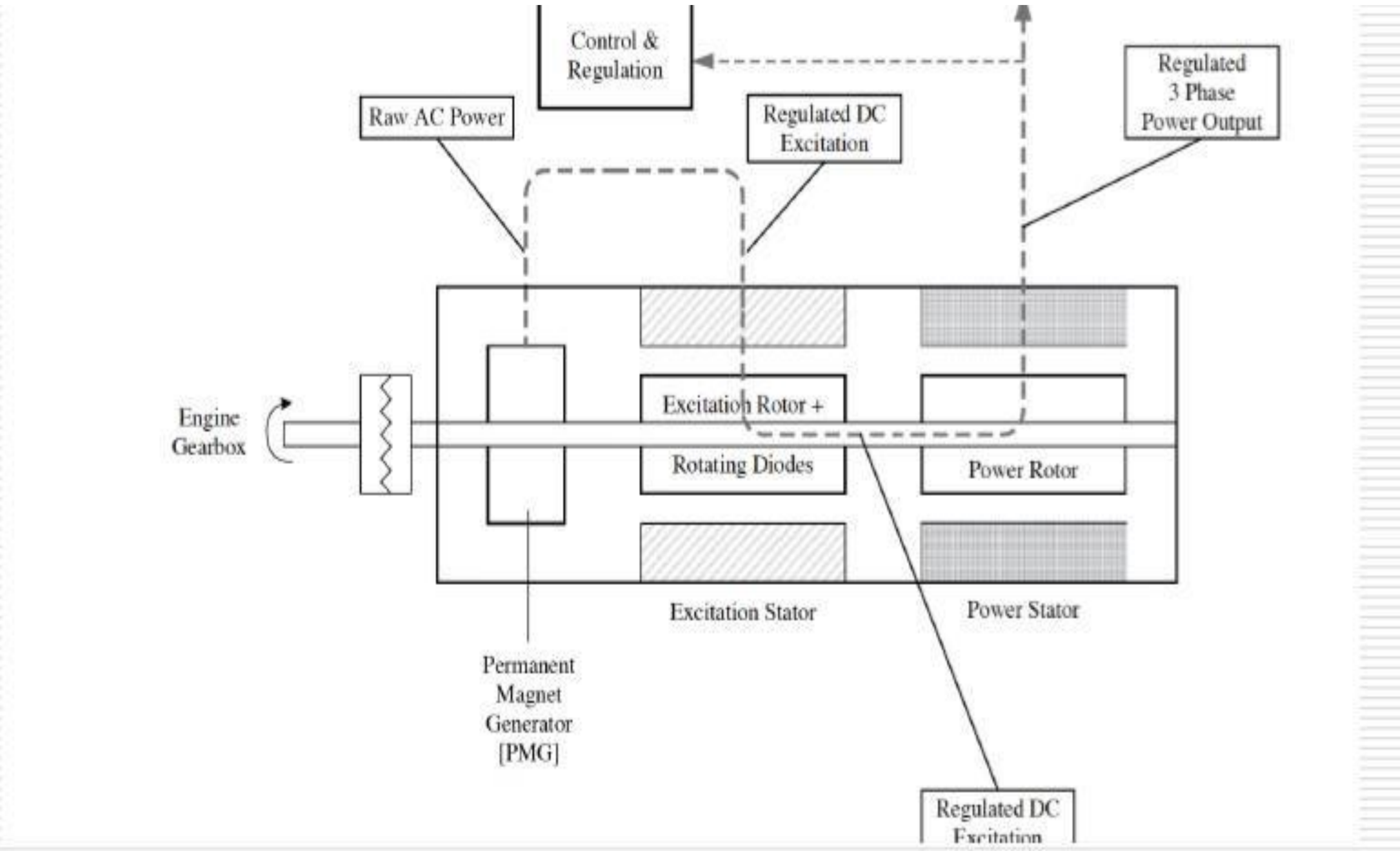
Generator
Generator Control Unit (GCU)
Power Generation
Other Channel(s)
GCB
BTB
Primary Power Panel
Primary Power Distribution
ELCU or 'Smart Contactor'
High Power Loads
TRU
Power Conversion
AC
DC
Secondary Power Panel
Secondary Power Distribution
Secondary Aircraft Loads

- The primary elements of power system control are:
- DC systems
- Voltage regulation
- Parallel operation
- Protection functions

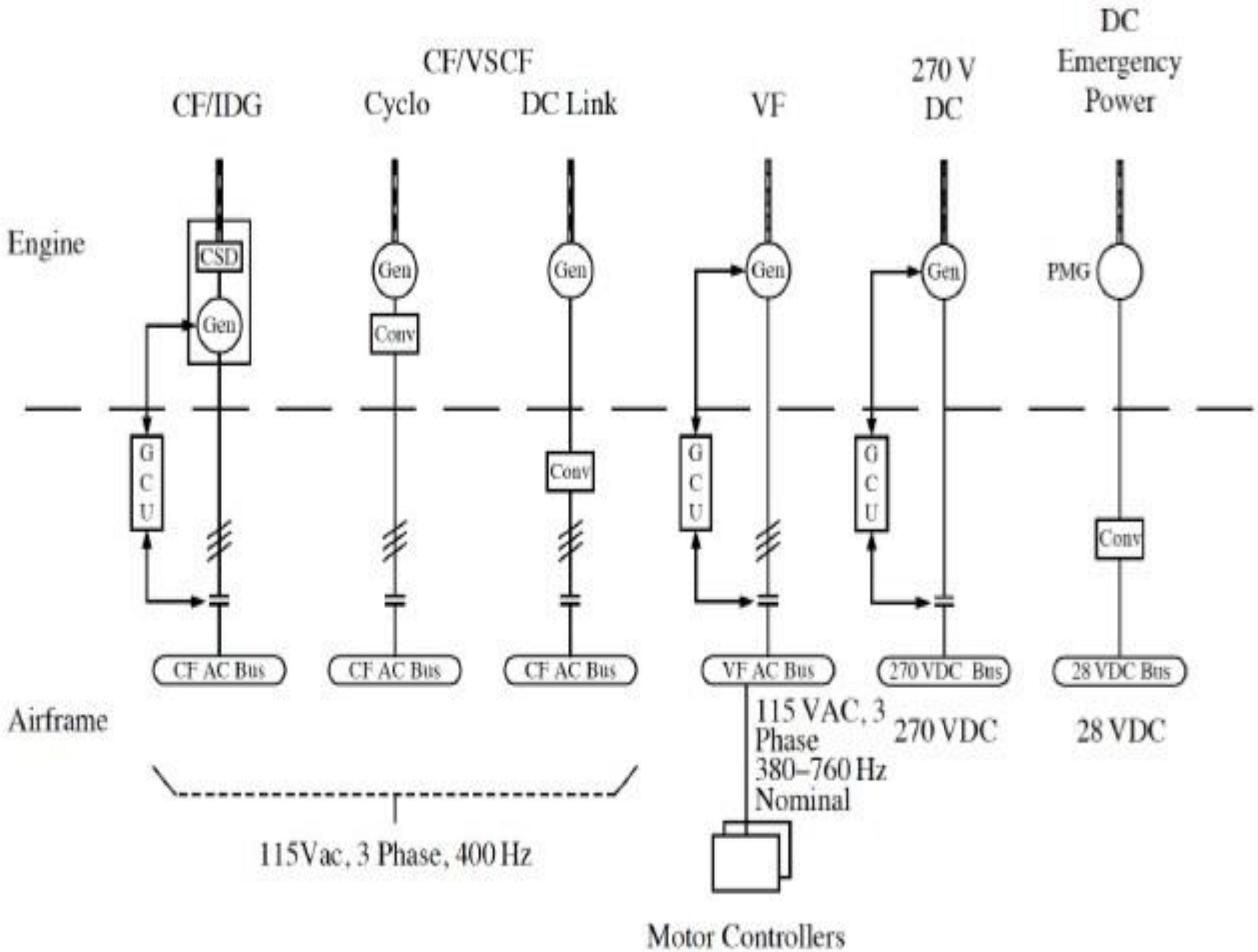
- AC systems
- Voltage regulation
- Parallel operation
- Supervisory functions

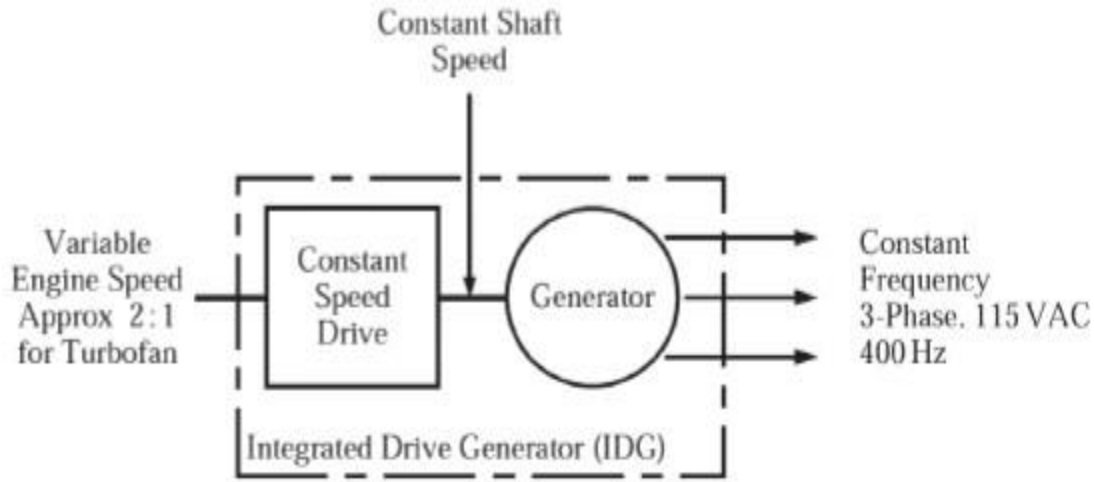
AIRCRAFT ELECTRICAL SYSTEM

- Power generation
- Primary power distribution and protection
- Power conversion and energy storage
- Secondary power distribution and protection



Control &
Regulation
Raw AC Power
Regulated DC
Excitation
Regulated
3 Phase
Power Output
Engine
Gearbox
Excitation Rotor +
Rotating Diodes
Power Rotor
Excitation Stator
Power Stator
Permanent
Magnet
Generator
[PMG]
Regulated DC
Excitation


CF/IDG
CF/VSCF
Cyclo
DC Link
VF
270 V
DC
DC
Emergency
Power
Engine
CSD
Gen
Gen
Gen
Gen
Gen
Conv
PMG
G
C
U
G
C
U
G
C
U
Conv
Conv
CF AC Bus
CF AC Bus
CF AC Bus
VF AC Bus
270 VDC Bus
28 VDC Bus
Airframe
115 VAC, 3
Phase
380–760 Hz
Nominal
270 VDC
28 VDC
115Vac, 3 Phase, 400 Hz
Motor Controllers



Features:

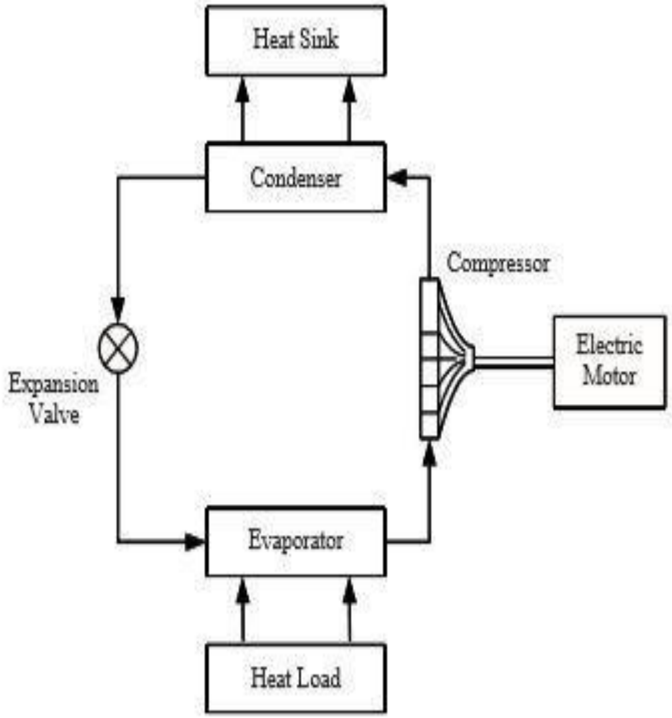
Constant frequency AC power is most commonly used on turbofan aircraft today

System is expensive to purchase & maintain; primarily due to complexity of Constant Speed Drive (CSD)

Single company monopoly on supply of CSD/IDG

Alternate methods of power generation are under consideration

BASIC AIR CONTROL SYSTEMS



DEICING AND ANTI ICING SYSTEMS

- The precise mix of electrical and hot air (using bleed air from the engines) anti/deicing methods varies from aircraft to aircraft.
- Electrical anti/de-icing systems are high current consumers and require controllers to time, cycle and switch the heating current between heater elements to ensure optimum use of the heating capability and to avoid local overheating.
- Windscreen heating is another important electrical heating service.
- A dedicated controller maintains the temperature of the element at a predetermined value which ensures that the windscreen is demisted at all times.

OXYGEN SYSTEM

- The environmental air supply from the engines stops then so does the supply of oxygen. Therefore, small backup oxygen systems are required for emergency situations to enable the pilot to descend to altitudes where oxygen levels are high enough for breathing.

- Inmilitaryaircraftwhicharetypicallydesignedtoflytoaltitudesinexcesso f 50 000ft, both cabin pressurization and oxygen systems are employed to help alleviate the effects of hypoxia.

NEED FOR CABIN CONDITIONING

- The cockpit is affected by the sources of heat described above, but a high performance fighter is particularly affected by high skin temperatures and the effects of solar radiation through the large transparency.

- However, in designing a cabin conditioning system for the fighter, consideration must also be taken of what the pilot is wearing.
- If, for example, he is flying on a mission over the sea, he could be wearing a thick rubber immersion suit which grips firmly at the throat and wrists.

ENVIRONMENTAL CONTROL SYSTEMDESIGN

- The cooling problem brought about by the heat sources described above must be solved to successfully cool the aircraft systems and passengers in flight.

- For ground operations some form of ground cooling system is also required. Heat must be transferred from these sources to a heat sink and rejected from the aircraft.

- The outside air is used either directly as ram air, or indirectly as air bled from the engines.

VAPOUR CYCLE SYSTEM

- The vapour cycle system is a closed loop system where the heat load is absorbed by the evaporation of a liquid refrigerant such as Freon® in an evaporator (NB the trade name Freon® is a registered trademark belonging to E.I. du Pont de Nemours & Company (DuPont)).

- The refrigerant then passes through a compressor with a corresponding increase in pressure and temperature, before being cooled in a condenser where the heat is rejected to a heat sink.

BOOTS-TRAPSYSTEM

- Conventional bootstrap refrigeration is generally used to provide adequate cooling for high ram temperature conditions, for example a high performance fighter aircraft.
- The basic system consists of a cold air unit and a heat exchanger .
- The turbine of the cold air unit drives a compressor.
- Both are mounted on a common shaft. This rotating assembly tends to be supported on ball bearings, but the latest technology uses air bearings.

EVAPORATIVE VAPOR CYCLE SYSTEMS

- •The vapor cycle system is a closed loop system where the heat load is absorbed by the evaporation of a liquid refrigerant such as Freon® in an evaporator (NB the trade name Freon® is a registered trademark belonging to E.I. du Pont de Nemours & Company(DuPont)).
- •The refrigerant then passes through a compressor with a corresponding increase in pressure and temperature, before being cooled in a condenser where the heat is rejected to a heat sink.

OXYGEN SYSTEM

- The environmental air supply from the engines stops then so does the supply of oxygen.
- Therefore, small backup oxygen systems are required for emergency situations to enable the pilot to descend to altitudes where oxygen levels are high enough for breathing. In military aircraft which are typically designed to fly to altitudes in excess of 50 000ft, both cabin pressurization and oxygen systems are employed to help alleviate the effects of hypoxia.
- In cases where aircrew are exposed to altitudes greater than 40 000ft, either due to cabin depressurization or following escape from their aircraft, then additional protection is required.
- In the event of cabin depressurization the pilot would normally initiate an emergency descent to a 'safe' altitude.

- However, short-term protection against the effects of high altitude is still required.
- At altitudes up to 33 000ft, the alveolar oxygen pressure can be increased up to its value at ground level by increasing the concentration of oxygen in the breathing gas.

DE-ICING AND ANTI -ICING SYSTEMS

- The precise mix of electrical and hot air (using bleed air from the engines) anti/deicing methods varies from aircraft to aircraft.
- Electrical anti/de-icing systems are high current consumers and require controllers to time, cycle and switch the heating current between heater elements to ensure optimum use of the heating capability and to avoid local overheating.
- Windscreen heating is another important electrical heating service. In this system the heating element and the controlling thermostat are embedded in the windscreen itself.
- A dedicated controller maintains the temperature of the element at a predetermined value which ensures that the windscreen is demisted at all times.

FIRE DETECTION SYSTEMS

The aircraft systems that have fire detection are:

- Engines (Turbines).
- APU (Auxiliary Power Unit) – this is a small engine installed generally in the aircraft tail. It is used to start the big engines (Turbines) and provides electrical power and air conditioning mainly on the ground.
- Cargo Compartment.
- Avionic Compartment.
- IFE (In-flight Entertainment).
- Lavatories.

UNIT - 3

HYDRAULIC SYSTEMS AND PNEUMATIC SYSTEMS

UNIT - 3

CLOs	Course Learning Outcome
CLO 7	Describe the importance of hydraulic Systems and its components and develop hydraulic systems.
CLO 8	Describe the pneumatics systems and its components. Illustrate the importance and criticality of landing gears.
CLO 9	Recognize the applications of pneumatic systems and the application of the bleed air.

HYDRAULICS INTRODUCTION

- Hydraulics is a method of transmitting power through pipes and control devices, using liquid as the operating medium.

- For certain applications hydraulic systems are used in preference to mechanical or electrical systems

- Hydraulic systems made their appearance on aircraft in the early 1930s when the retractable undercarriage was introduced.

- Since that time, an increasing number of tasks have been performed by the application of hydraulic power and the power demand has consequently increased greatly.

- Hydraulic power was seen as an efficient means of transferring power from small low energy movements in the cockpit to high energy demands in the aircraft.

- Hydraulic systems now have an important role to play in all modern aircraft, both military and civil.

- The introduction of powered flying controls was an obvious application for hydraulic power by which the pilot was able to move the control surfaces with every increasing speeds and demands for maneuverability.

- This application brought hydraulics in the area of safety critical systems in which single failures could not be allowed to hazard the aircraft.

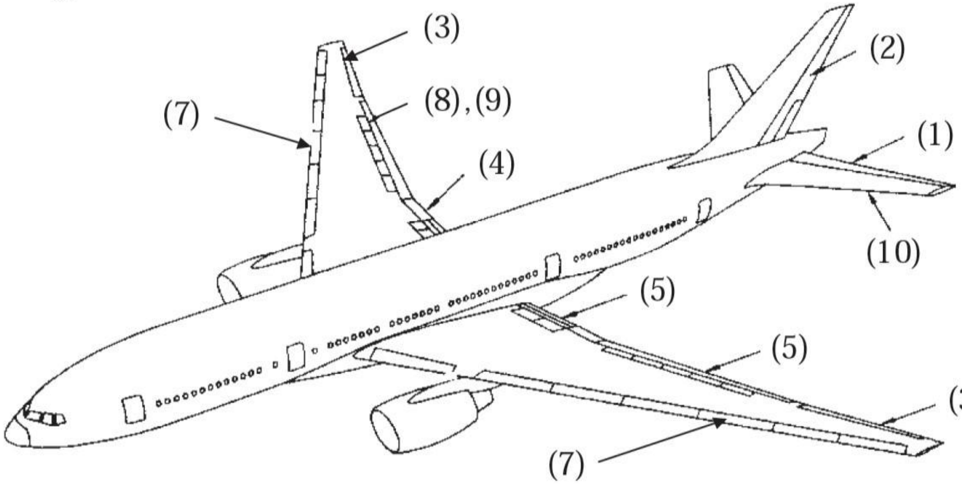
- The system developed to take account of this using multiple pumps, accumulators to store energy and methods of isolating leaks.

- The hydraulic system today remains a most effective source of power for both primary and secondary flying controls, and for undercarriage, braking and anti-skid systems.

- However, now a days, more-electric systems are being considered to replace hydraulically powered systems in some areas.

HYDRAULICS APPLICATIONS

- **Primary Flight Controls:**
  - -Elevators – (1)
  - -All-moving tail surfaces (military)
  - -Rudders – (2)
  - -Ailerons – (3)
  - -Flaperons – (4)
  - -Canards
- **Secondary Flight Controls**
  - -Flaps – (5)
  - -Slats – (7)
  - -Spoilers – (8)
  - -Airbrakes – (9)
  - -Stabilizer trim – (10)
- **Utilities**
  - -Landing gear
  - -Brakes
  - -Gear steering
  - -Aerial refueling probes (military)
  - -Cargo doors
  - -Loading ramp (military)
  - -Passenger stairs



Primary flight controls:

- Elevators
- Rudders
- Ailerons

Secondary flight controls:

- Flaps
- Slats
- Spoilers
- Airbrakes

Utility systems:

- Undercarriage – gear and doors
- Wheel brakes and anti-skid
- Parking brake
- Nose wheel steering
- In-flight refueling probe
- Cargo doors
- Loading ramp
- Passenger stairs
- Gun purging scoop
- Canopy Actuation

NUMBER AND TYPE OF HYDRAULIC SYSTEMS

- A source of energy – engine, auxiliary power unit or ram air turbine
- A reservoir
- A filter to maintain clean hydraulic fluid
- A multiple redundant distribution system – pipes, valves
- Pressure and temperature sensors
- A mechanism for hydraulic oil cooling
- A means of exercising demand – actuators, motors, pumps
- A means of storing energy such as an accumulator
- A means of exercising demand – actuators, motors pumps
- A means of storing energy such as an accumulator

ADVANTAGES OF HYDRAULICS

- Ease of application of force
- Ability to increase the applied force as necessary
- Ease of routing of pipelines and
- Elimination of backlash between components.
- Incompressibility, enables movement to be transmitted through pipelines, over great distances, without loss of time or motion.

HYDRAULICS

- Friction increases with any increases in viscosity or velocity of the liquid, results in power into heat, and in a reduction in pressure throughout the pipelines.

- Any restriction in a pipeline will increase liquid velocity and reduced pressure.

- A restrictor is used to limit the rate of liquid flow, and thus the rate of movement of components such as the landing gear or flaps.

HYDRAULIC FLUIDS

•Almost any sort of liquid could be used in a hydraulic system, but the special requirements of aircraft systems have resulted in the use of

•Vegetable oil,

•mineral oil and

•synthetic-based oil

HYDRAULIC FLUID PROPERTIES

- Good lubrication of components.

- Viscosity is low enough to minimize friction , but high enough to prevent leakage from components.

- Prevents internal corrosion in the system.

- Wide operating-temperature range.

PUMPS

- Fixed volume or variable volume, multi-piston type hydraulic pumps, driven from the engines.

- Gear or vane positive displacement pumps, are generally used for powering emergency systems.

- Hand pumps, where fitted, are often of the double-acting type.

FIXED VOLUME PUMPS

- Deliver a fixed quantity of fluid into the system at a particular speed of rotation, regardless of system requirements,

- Diverting pump output when it is not required in the system.

HAND PUMPS

- Used for emergency use & ground servicing operations.

- DOUBLE-ACTING HAND PUMP Delivers fluid on each stroke.

PRESSURE CONTROL

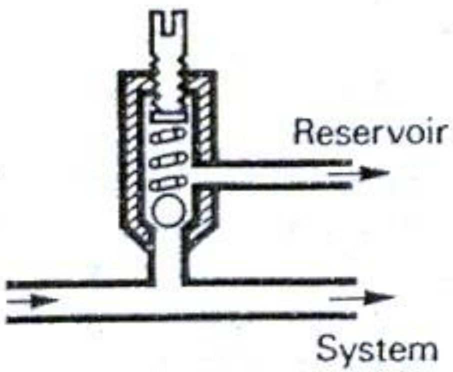
•Maximum system pressure is often controlled by adjustment of the main engine-driven pump, but a number of other components are used to maintain or limit fluid pressures in various parts of a hydraulic system, and these sometimes have additional functions.

RELIEF VALVES

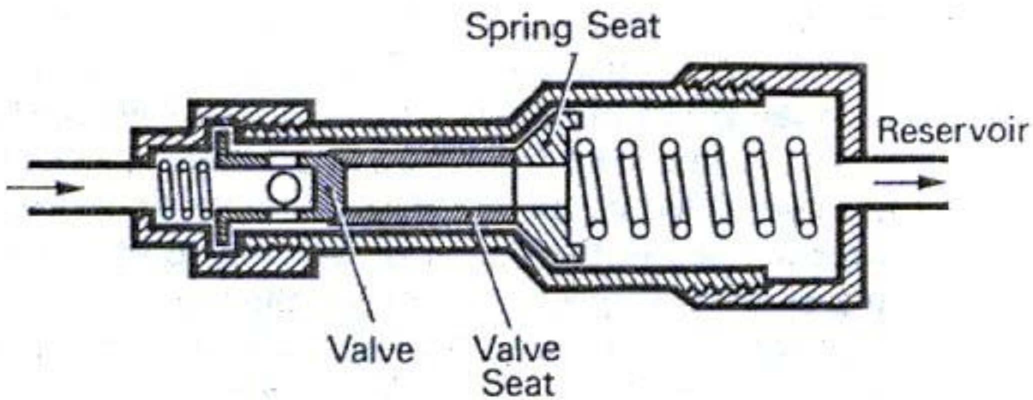
- Simplest form of pressure limiting device.

- Used as a safety device, e.g. a thermal relief valve, in which case it is adjusted to blow-off at a pressure slightly higher than normal system pressure, relieves a small quantity of fluid.

- In a full-flow relief valve to by-pass full pump output to the reservoir in the event of failure of the cut-out valve, or of blockage elsewhere in the system.



BALL-TYPE RELIEF VALVE



FULL-FLOW RELIEF VALVE

RELIEF VALVES

ACCUMULATORS

Emergency supply of fluid to the system in the event of pump failure.

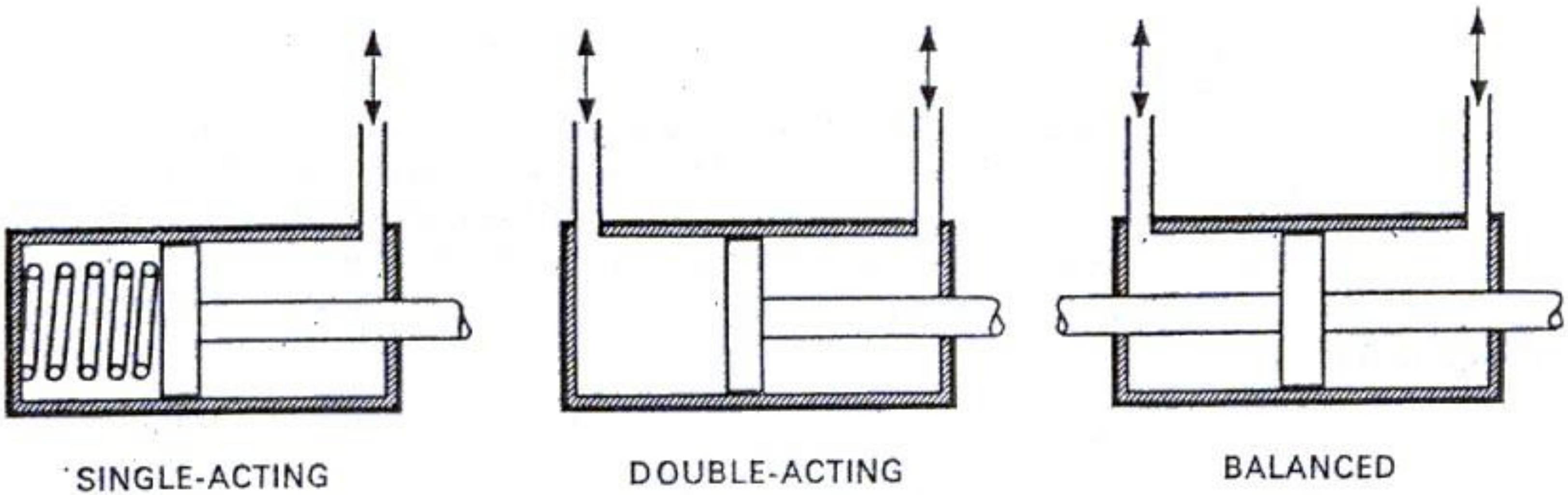
•A non-return valve fitted upstream of an accumulator, prevents fluid form being discharged back to the reservoir.

RESERVOIRS

•Provides both storage space for the system fluid, and sufficient air space to allow for any variations in the volume of fluid.

•Most reservoirs are pressurized, to provide a positive fluid pressure at the pump inlet, and to prevent air bubbles from forming in the fluid at high altitude.

•On modern jet aircraft, air pressure is normally supplied from the compressor section of an engine, but it may be supplied from the cabin pressurization system.



ACTUATORS

HYDRAULICS

•The primary source of power on an aircraft is the engine, and the hydraulic pump is connected to the engine gearbox.

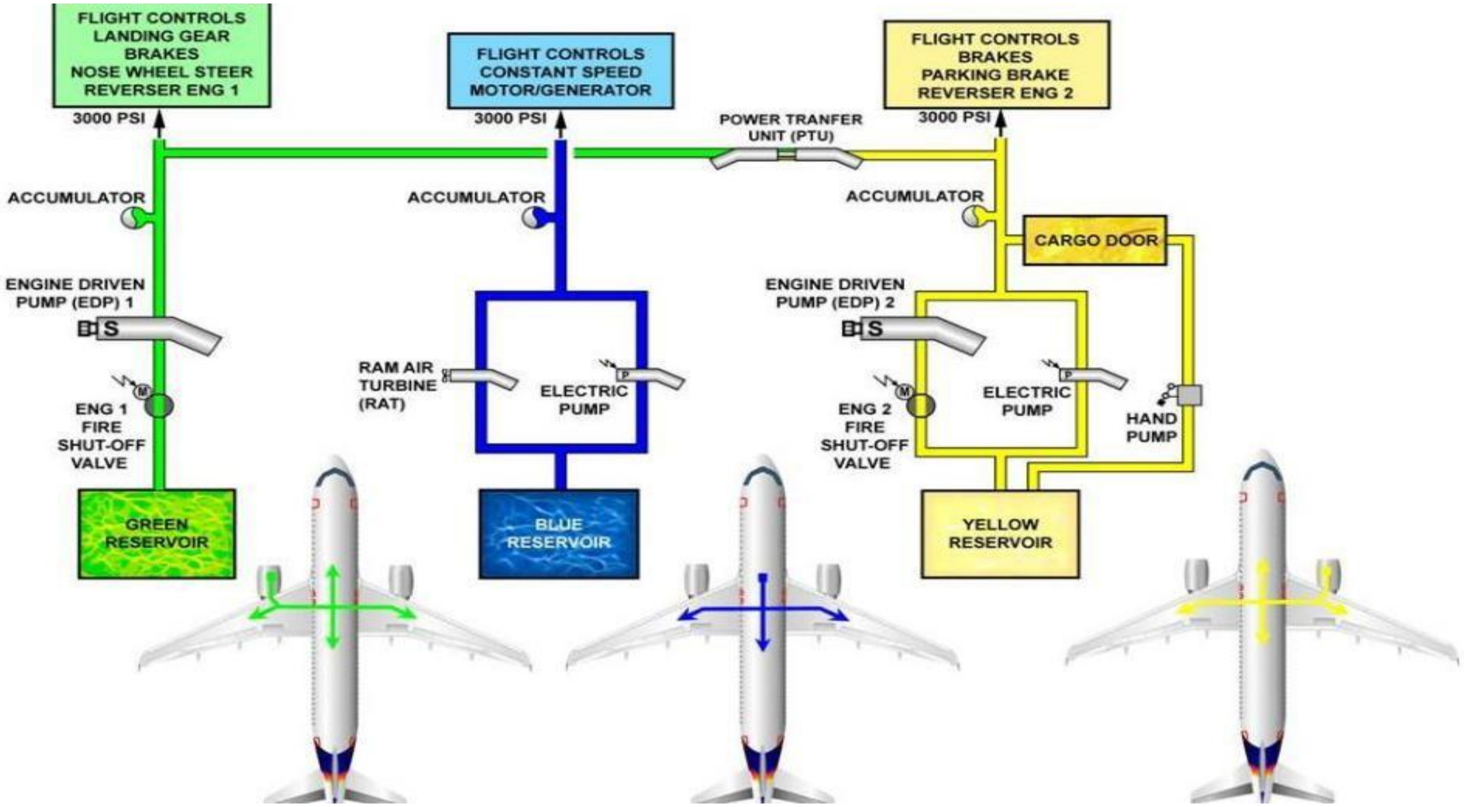
•The pump causes a flow of fluid at a certain pressure, through stainless steel pipes to various actuating devices.

•A reservoir ensures that sufficient fluid is available under all conditions of demand.

•This simple system is unlikely to satisfy the condition stated above, and in practice most aircraft contain multiple pumps and connections of pipes to ensure that single failures and leaks do not deplete the whole system of power.

- The working fluid will be considered as a physical medium for transmitting power, and the conditions under which it is expected to work, for example maximum temperature and maximum flow rate are described.

- Safety regulations bring about some differences between military and civil aircraft fluids.


FLIGHT CONTROLS
LANDING GEAR
BRAKES
NOSE WHEEL STEER
REVERSER ENG 1
3000 PSI
FLIGHT CONTROLS
CONSTANT SPEED
MOTOR/GENERATOR
3000 PSI
POWER TRANFER
UNIT (PTU)
FLIGHT CONTROLS
BRAKES
PARKING BRAKE
REVERSER ENG 2
3000 PSI
ACCUMULATOR
ACCUMULATOR
ACCUMULATOR
CARGO DOOR
ENGINE DRIVEN
PUMP (EDP) 1
ENGINE DRIVEN
PUMP (EDP) 2
RAM AIR
TURBINE
(RAT)
ELECTRIC
PUMP
ELECTRIC
PUMP
HAND
PUMP
ENG 1
FIRE
SHUT-OFF
VALVE
ENG 2
FIRE
SHUT-OFF
VALVE
GREEN
RESERVOIR
BLUE
RESERVOIR
YELLOW
RESERVOIR

LANDING GEAR

- The landing gear is the structure that supports an aircraft on the ground and allows it to taxi, take-off, and land .

- The landing gear usually includes wheels but some aircraft are equipped with skids for snow or float for water .

- In the case of a vertical take-off and landing aircraft such as a helicopter, wheels may be replaced with skids

•The primary functions of a landing gear are as follows:

•1. To keep the aircraft stable on the ground and during loading, unloading, and taxi .

•2. To allow the aircraft to freely move and maneuver during taxing .

•3. To provide a safe distance between other aircraft components such as wing and fuselage while the aircraft is on the ground position to prevent any damage by the ground contact .

LANDING GEAR CONFIGURATION

In general, there are ten configurations for a landing gear as follows:

- Bicycle
- Tail-gear
- Tricycle or nose-gear
- Quadricycle
- Multi-bogey
- Releasable rail
- Skid
- Seaplane landing device
- Single main
- Human leg

Single Main

•The simplest configuration of landing gear is the single main .

•It includes one large main gear that carries a large portion of the aircraft weight and load; plus a very small gear under the nose. In terms of size, the main gear is much larger (both strut and wheel)

Bicycle

- Bicycle landing gear, as the name implies, has two main gears one aft and one forward of aircraft cg; and both wheels have a similar size .
- The main advantages of this configuration are the design simplicity and the low weight.

Tail-gear

•Tail-gear landing gear has two main wheels forward of the aircraft cg and a small wheel under the tail.

•The wheels in front of the aircraft cg is very close to it (compared with aft wheel) and carries much of the aircraft weight and load

Tricycle

•Tricycle is the most widely used landing gear configuration. The wheels aft of the aircraft cg is very close to it (compared with forward gear) and carries much of the aircraft weight and load; thus is referred to as the main wheel.

•Two main gears are in the same distance from the thus both are carrying the same load.

•The forward gear is far from cg (compared with main gear); hence it carries much smaller load

Quadricycle

•As the name implies a quadricycle landing gear utilizes four gears; similar to a car conventional wheel system. Two wheels at each side where two wheels are in front of aircraft cg and other two aft of cg.

•The load on each gear depends on its distance to cg. If aft and forward wheels have the same distance to cg, they will have to carry the same load.

•In this case, it is very hard to rotate the aircraft during take-off and landing; so the aircraft will perform a flat take-off and landing.

Multi-bogey

- As the aircraft gets heavier, number of gears needs to be increased.

- A landing gear configuration with multiple gears of more than four wheels also improves take-off and landing safety. When multiple wheels are employed in tandem, they are attached to a structural component referred to as “bogey” that is connected to the end of the strut.

LANDING GEAR ATTACHMENT

•Main gear is attached to the wing, but the nose gear is attached to the fuselage

•Main gears are attached to the wing, but the tail gear is attached to the fuselage

•All struts/wheels are attached to the fuselage

•Main gears are attached to the nacelle, but nose gear is attached to the fuselage (in a nose-wheel configuration).

FIXED AND RETRACTABLE LANDING GEAR

- Many small, single engine light aircraft have fixed landing gear, as do a few light twins.

- This means the gear is attached to the airframe and remains exposed to the slipstream as the aircraft is flown.

- Classification of aircraft landing gear can be made into two categories: fixed and retractable.

•Retractable landing gear stow in fuselage or wing compartments while in flight.

•Once in these wheel wells, gear are out of the slipstream and do not cause parasite drag.

•Most retractable gear have a close fitting panel attached to them that fairs with the aircraft skin when the gear is fully retracted. Other aircraft have separate doors that open, allowing the gear to enter or leave and then close again.

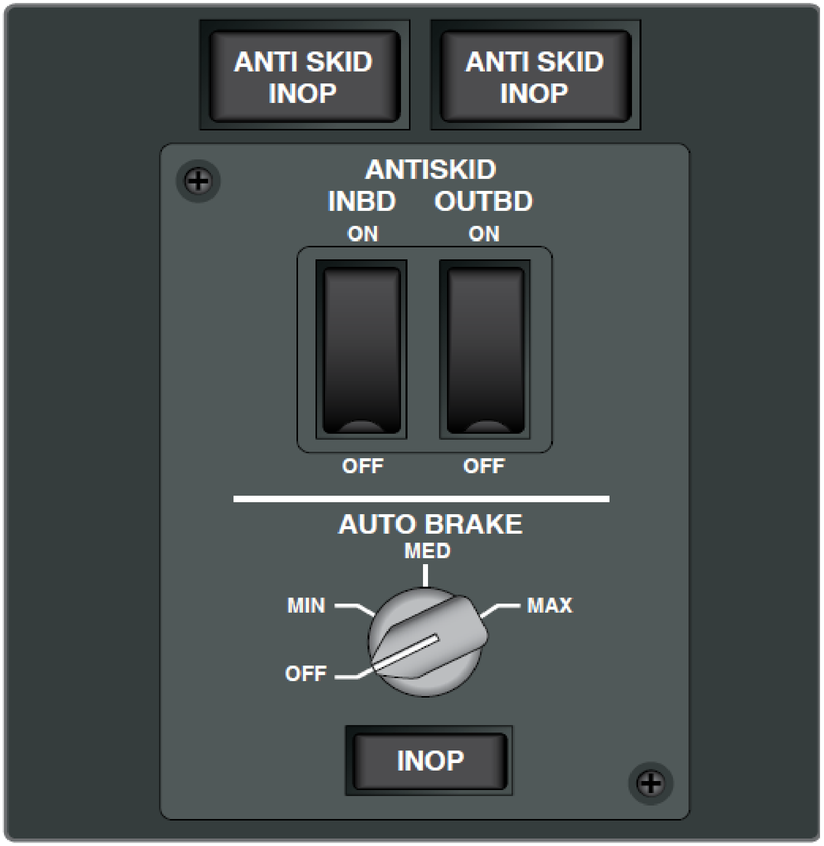


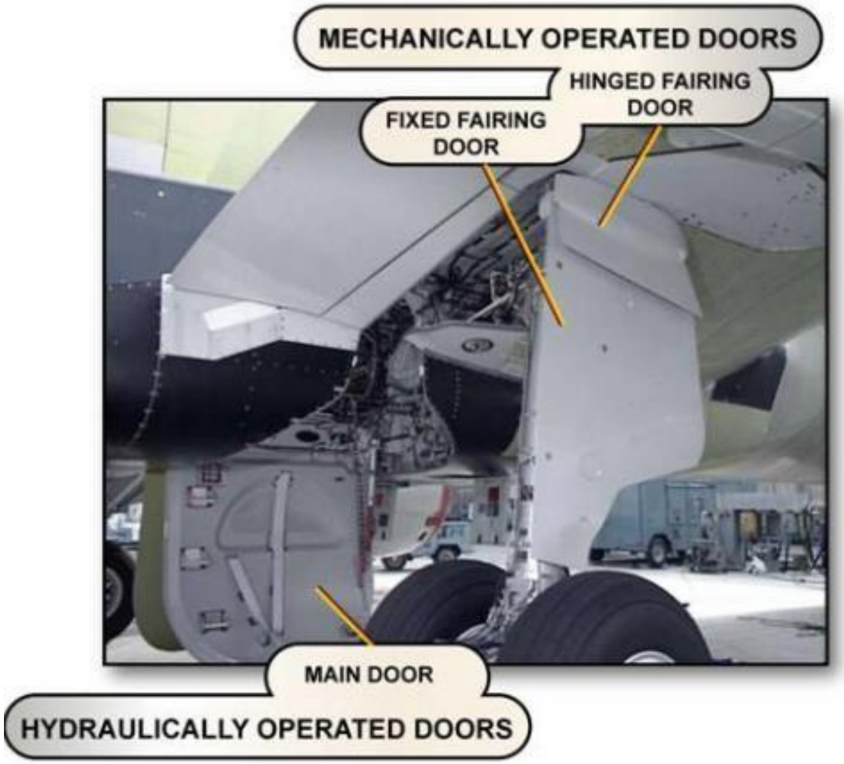
Figure 13-105. *Antiskid switches in the cockpit.*

LANDING GEAR

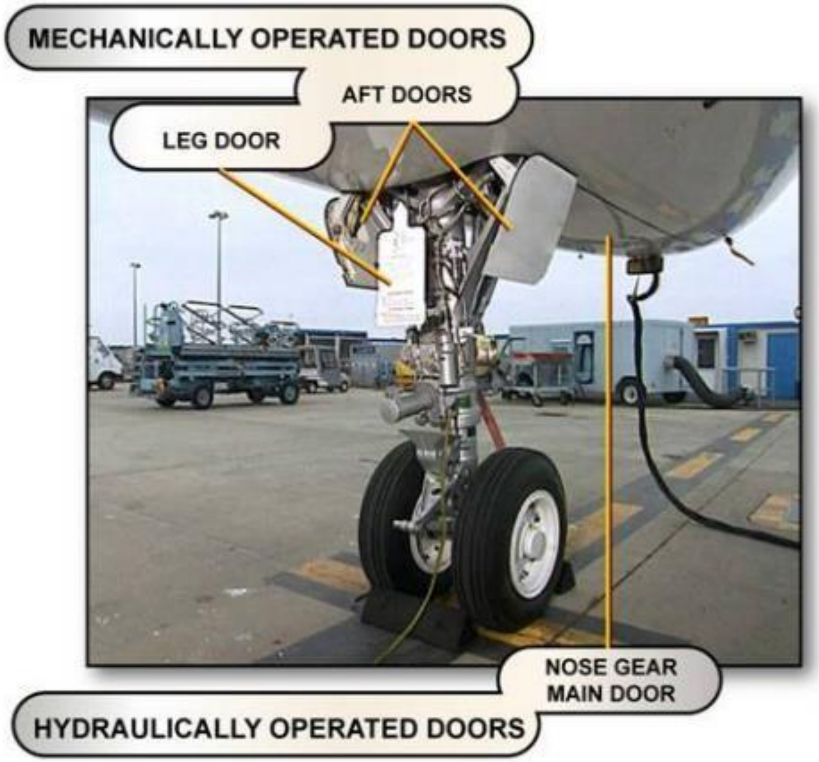
- Each main landing gear has bogie beam (L and R) with four wheels or without bogie beam with two wheels.

- Landing gear supports the aircraft on ground and absorbs landing, T.O. and taxing loads.

- Each main wheel has a tubeless tyre and a brake unit.



Main Landing Gear (MLG)



Nose Landing Gear (NLG)

PNEUMATICS

- The modern turbofan engine is effectively a very effective gas generator and this has led to the use of engine bleed air for a number of aircraft systems, either for reasons of heating, provision of motive power or as a source of air for cabin conditioning and pressurization systems.

- Bleed air is extracted from the engine compressor and after cooling and pressure reduction / regulation it is used for a variety of functions.

•A proportion of bleed air is fed into air conditioning packs which cools the air dumping excess heat overboard; this cool air is mixed with the remaining warm air by the cabin temperature control system such that the passengers are kept in a comfortable environment.

•On the aircraft, bleed air tapped from the engine is used to provide air to pressurize the cabin and provide the source of air to the cabin conditioning environmental control system.

•Bleed air is also used to provide main wing anti-ice protection.

- The pneumatic system is controlled and monitored by 2 Bleed Monitoring Computers (BMC).

- There is one BMC for each engine bleed system.

- Both BMC are interconnected and if one fails, the other takes over most of its functions.

ENVIRONMENTAL PROTECTION SYSTEM

The environment protection system is divided into:

•Ventilation of the wing leading edge

•Protection of the wing leading edge

•Protection of the pylon

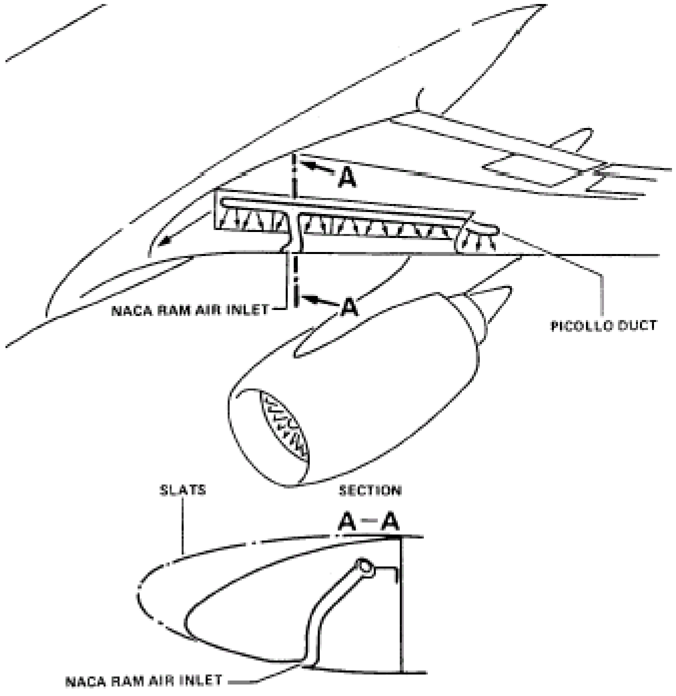
•Protection of the nacelles

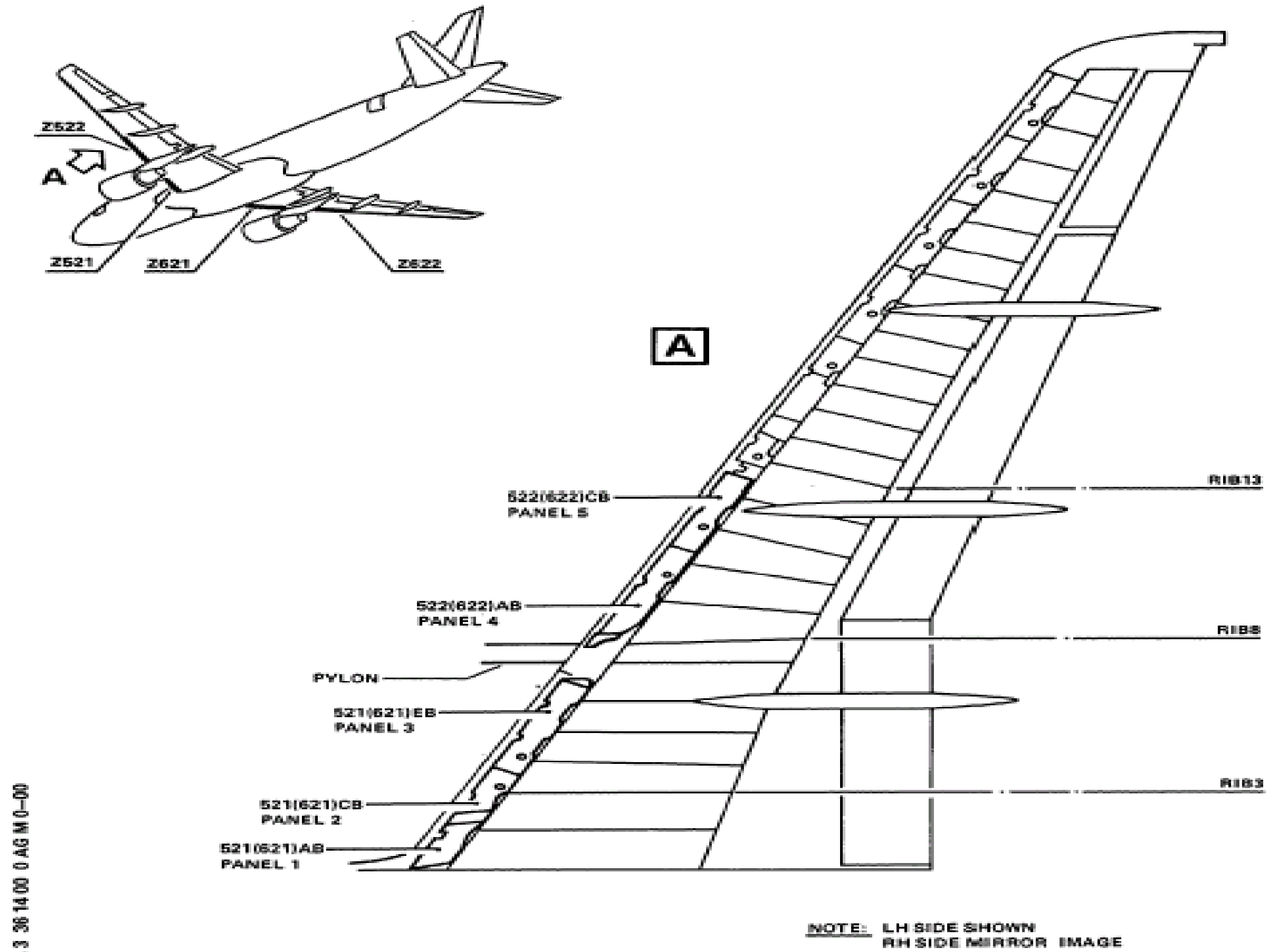
WING LEADING EDGE VENTILATION

•Ensures that the flammable fuel vapor is removed and the hot components are cooled.

•Air enters the wing leading edge through gaps around the slat tracks and goes out through drainage/ escape holes in the lower surface of the wing leading edge.

WING LEADING EDGE VENTILATION




Z522
A
Z521
Z621
Z622
A
522(622)CB
PANEL 5
522(622)AB
PANEL 4
PYLON
521(621)EB
PANEL 3
521(621)CB
PANEL 2
521(621)AB
PANEL 1
RIB13
RIB8
RIB3
NOTE: LH SIDE SHOWN
RH SIDE MIRROR IMAGE
M 3 36 14 00 0 AG M 0–00

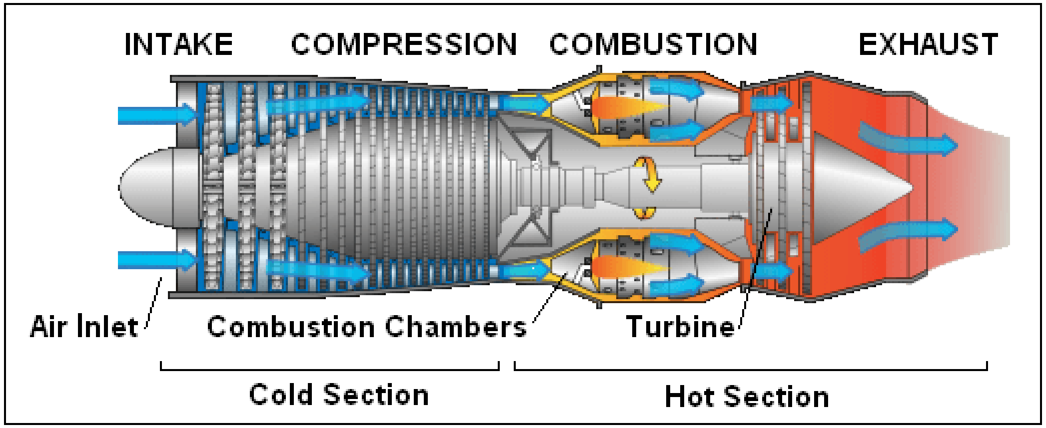
UNIT – 4

ENGINE CONTROL AND FUEL SYSTEMS

UNIT - 4

CLOs	Course Learning Outcome
CLO 10	Explain the components of engine and fuel aircraft systems.
CLO 11	Classify the types of aircraft engine systems and advancement in it.
CLO 12	Estimate the various fuel inerting systems and indications for aircraft systems.

OPERATION OF GAS TURBINE ENGINE



ENGINE/AIRFRAME INTERFACES

- The engine is a major, high value item in any aircraft procurement programme. Often an engine is especially designed for a new aircraft this is particularly true of military projects where a demanding set of requirements forces technology forward in propulsion and airframe areas.
- There is, however, a trend to make use of existing power plant types or variant of types in an effort to reduce the development costs of a new project.

THE CONTROL PROBLEM

- The basic control action is to control a flow of fuel and air to the engine to allow it to operate at its optimum efficiency over a wide range of forward speeds, altitudes and temperatures while allowing the pilot to handle the engine without fear of malfunction.

- The degree of control required depends to a large extent upon the type of engine and the type of aircraft in which it is installed.

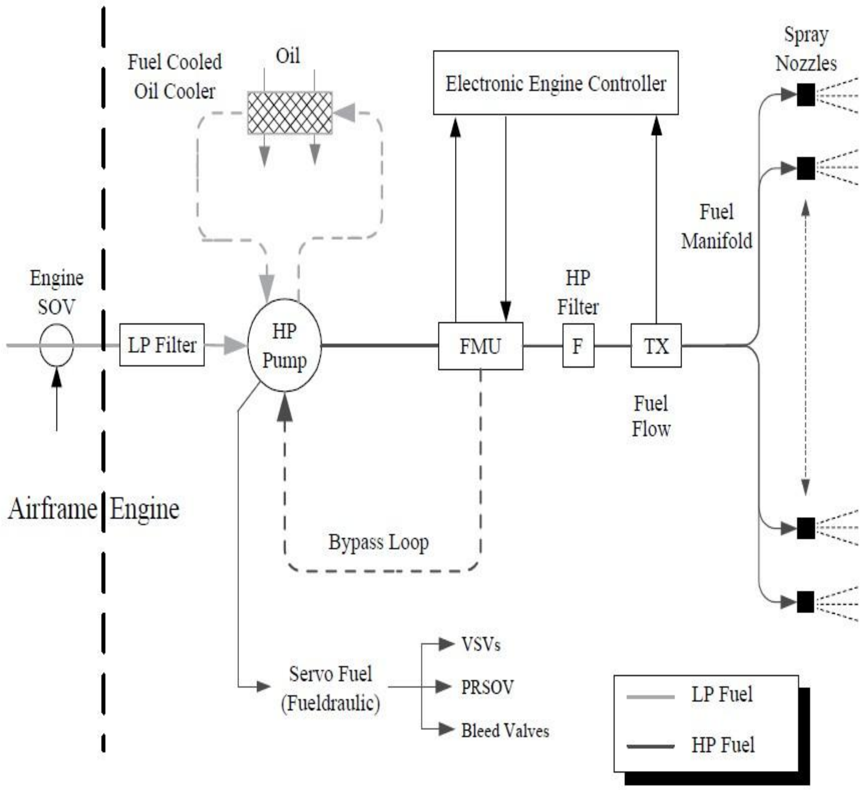
To obtain these objectives, control can be exercised over the following aspects of engine control:

- Fuel flow – to allow varying engine speeds to be demanded and to allow the engine to be handled without damage by limiting rotating assembly speeds, rates of acceleration and temperatures
- Air flow – to allow the engine to be operated efficiently throughout the aircraft flight envelope and with adequate safety margins
- Exhaust gas flow – by burning the exhaust gases and varying the nozzle area to provide additional thrust Electronic control.

FUEL FLOW CONTROL

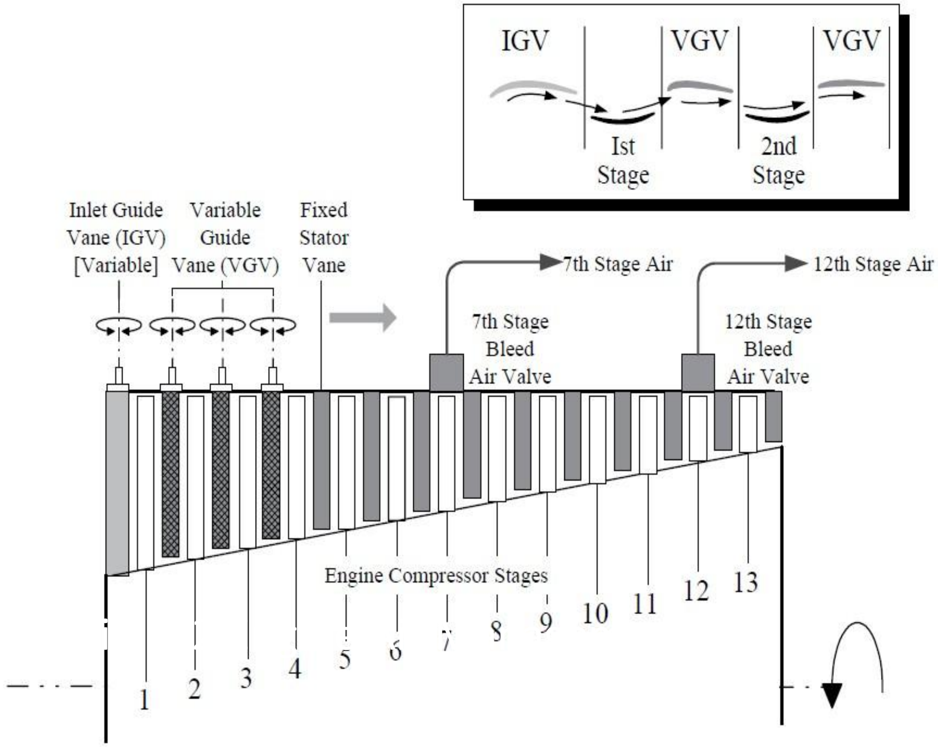
•Control of power or thrust is achieved by regulating the fuel flow into the combustor.

•On turbo jet or turbo fan engines thrust can be controlled by setting an engine pressure ratio or, in the case of the larger commercial fan engines, by controlling fan speed, while on shaft power engines the speed of the gas generator is a measure of the power delivered to the propeller or to the rotor.


Fuel Cooled
Oil Cooler
Oil
Electronic Engine Controller
Spray
Nozzles
Fuel
Manifold
Engine
SOV
LP Filter
HP
Pump
FMU
HP
Filter
F
TX
Fuel
Flow
Airframe
Engine
Bypass Loop
Servo Fuel
(Fueldraulic)
VSVs
PRSOV
Bleed Valves
LP Fuel
HP Fuel

AIR FLOW CONTROL

- It is sometimes necessary to control the flow of air through to the engine to ensure efficient operation over a wide range of environmental and usage conditions to maintain a safe margin from the engine surge line.
- Most modern commercial engines have variable compressor vanes and/or bleed valves to provide optimum acceleration without surge though it is not a feature usually associated with military applications.



IGV
VGV
VGV
Ist Stage
2nd Stage
Inlet Guide Vane (IGV) [Variable]
Variable Guide Vane (VGV)
Fixed Stator Vane
7th Stage Air
12th Stage Air
7th Stage Bleed Air Valve
12th Stage Bleed Air Valve
Engine Compressor Stages
1
2
3
4
5
6
7
8
9
10
11
12
13

CONTROL SYSTEMS

•The number of variables that affect engine performance is high and the nature of the variables is dynamic, so that the pilot cannot be expected constantly to adjust the throttle lever to compensate for changes, particularly in multiengine aircraft.

•In the first gas turbine engined aircraft, however, the pilot was expected to do just that.

INPUT SIGNALS

Throttle position – A transducer connected to the pilot's throttle lever allows thrust demand to be determined. The transducer may be connected directly to the throttle lever with electrical signalling to the control unit.

Air Data – Airspeed and altitude can be obtained as electrical signals representing the pressure signals derived from airframe mounted capsule units.

•**Total temperature** – A total temperature probe mounted at the engine face provides the ideal signal. Temperature probes mounted on the airframe are usually provided, either in the intakes or on the aircraft structure

•**Engine speed** – The speed of rotation of the shafts of the engine is usually sensed by pulse probes located in such a way as to have their magnetic field interrupted by moving metallic parts of the engine or gearbox.

- Air flow control – The control of air flow at different stages of the engine can be applied by the use of guide vanes at the engine inlet, or by the use of bleed valves between engine stages.

- Fuel flow control – The fuel supply to the engine can be varied in a number of ways depending on the type of fuel control unit used. Each device has its own particular failure modes and its own adherents

•The environmental control system must cope with widely differing temperature conditions, must extract moisture and provide air with optimum humidity, and must ensure that the air in the aircraft always contains a sufficient concentration of oxygen and that it is safe to breathe.

•Modern systems do this and more, for the term ‘environmental control’ also includes the provision of suitable conditions for the avionic, fuel and hydraulic systems.

PRESSURISATION CONTROL

- Controls the pressure in the fuselage.
- Operates fully automatically and has a manual backup.
- Pressure change rate is controlled to give satisfactory pressure values of safety and comfort for the passengers and crew.

AIR COOLING SYSTEM

•Decreases the temperature of the hot bleed air from the pneumatic system.

•Also reduces the quantity of water in the hot bleed air.

•Emergency ram air is supplied if there is a failure in the two air conditioning packs.

ICE AND RAIN PROTECTION SYSTEM

- Ice protection is given by the use of hot air, or electrical power, to make the necessary areas of the aircraft hot. The areas that hot air supplies are:
- the leading edge of the slats 3, 4 and 5 on each wing
- Wing anti icing
- the engine air intakes.
- Nacelle anti icing
- The engine bleed air system supplies the hot air to the anti-ice.

ICE AND RAIN PROTECTION

The items with electrical heaters are:

•Cockpit windshield and side windows

•Total Air Temperature (TAT) probes

•Angle of Attack (alpha) probes

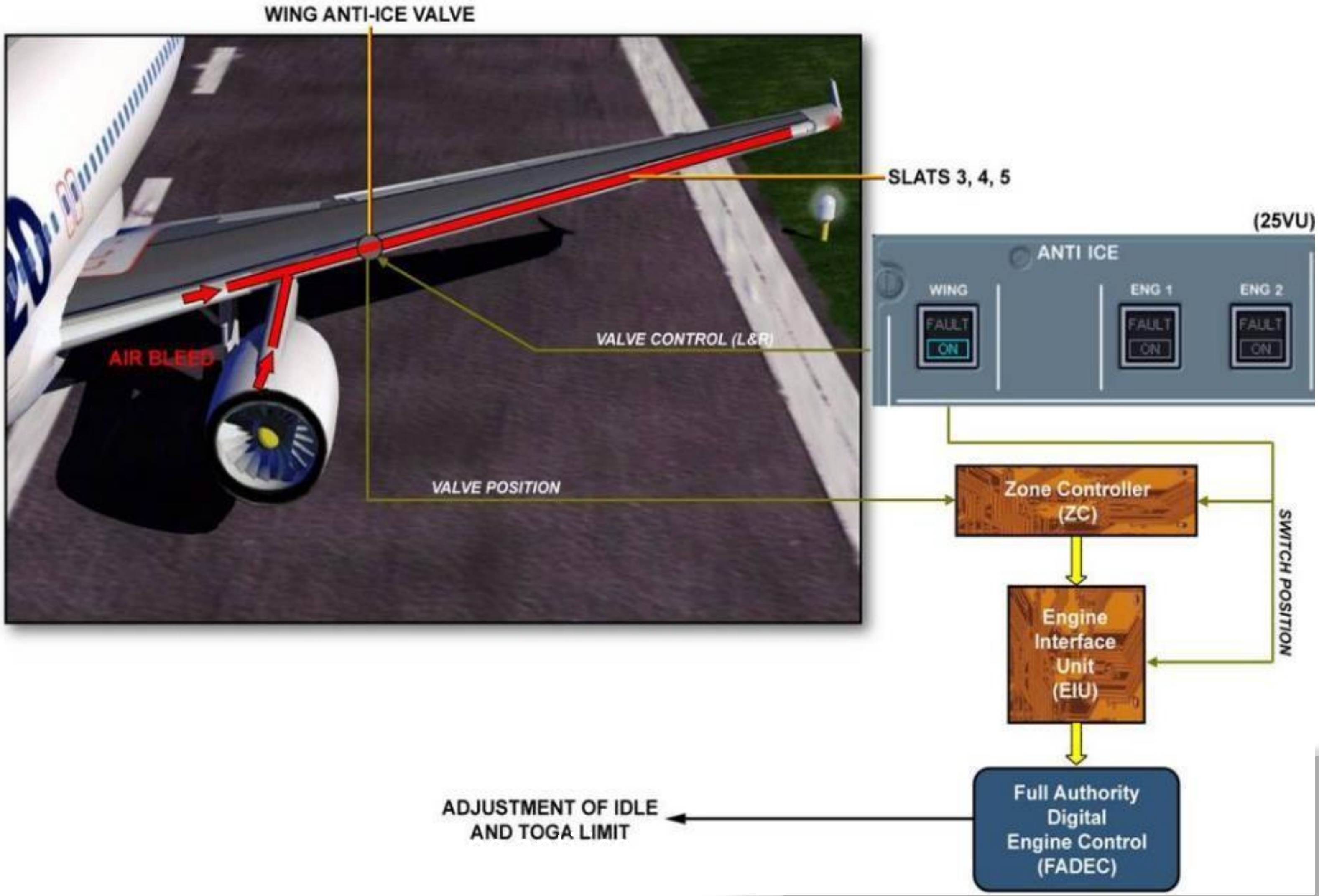
•Pitot and Static probes of the Air Data System (ADS)

•waste-water drain-masts.

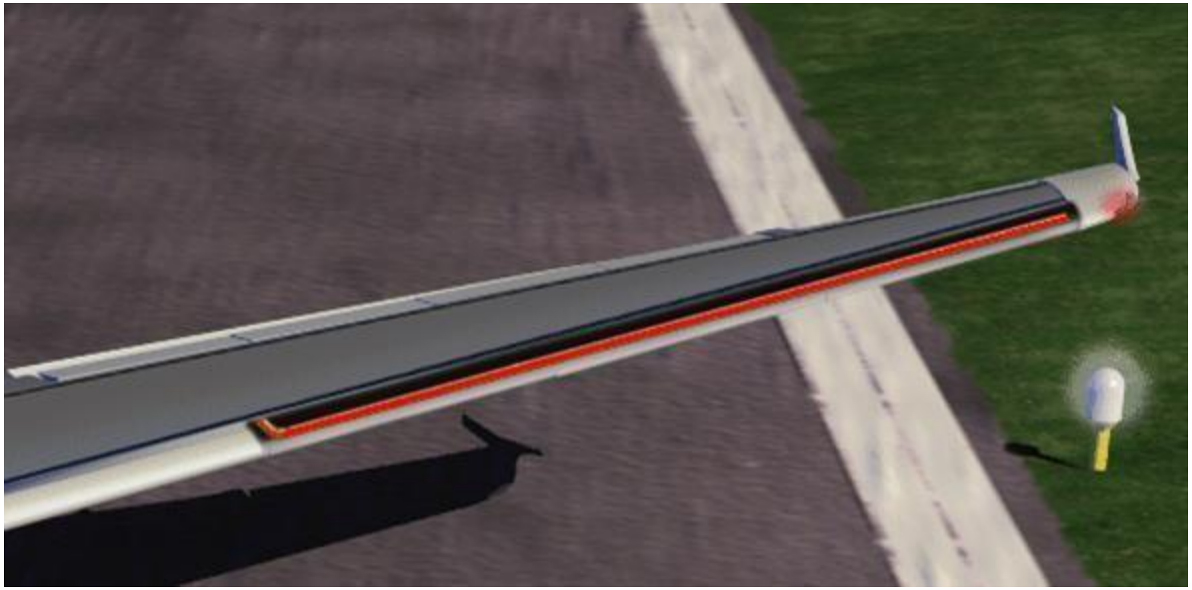
•Rain is removed from the windshield with windshield wipers.

WING ICE PROTECTION SYSTEM

- Prevents ice on leading edge of slats 3,4 and 5
- Same in LH and RH wing
- Uses hot air from pneumatic system
- Available in all flight conditions
- Both engines supply bleed
- If one engine fails cross bleed valve should be open
- Operated continuously


WING ANTI-ICE VALVE
SLATS 3, 4, 5
(25VU)
ANTI ICE
WING
ENG 1
ENG 2
FAULT
ON
FAULT
ON
FAULT
ON
VALVE CONTROL (L&R)
AIR BLEED
VALVE POSITION
Zone Controller
(ZC)
SWITCH POSITION
Engine
Interface
Unit
(EIU)
Full Authority
Digital
Engine Control
(FADEC)
ADJUSTMENT OF IDLE
AND TOGA LIMIT

WING ICE PROTECTION SYSTEM



CONTROL AND INDICATIONS

- ANTI ICE indication
- In white when p/b is pressed arrow
- Not displayed when valve is closed
- Green – normal open
- Amber
- Valve open and press is low or high
- Valve open on gnd for more than 10 sec

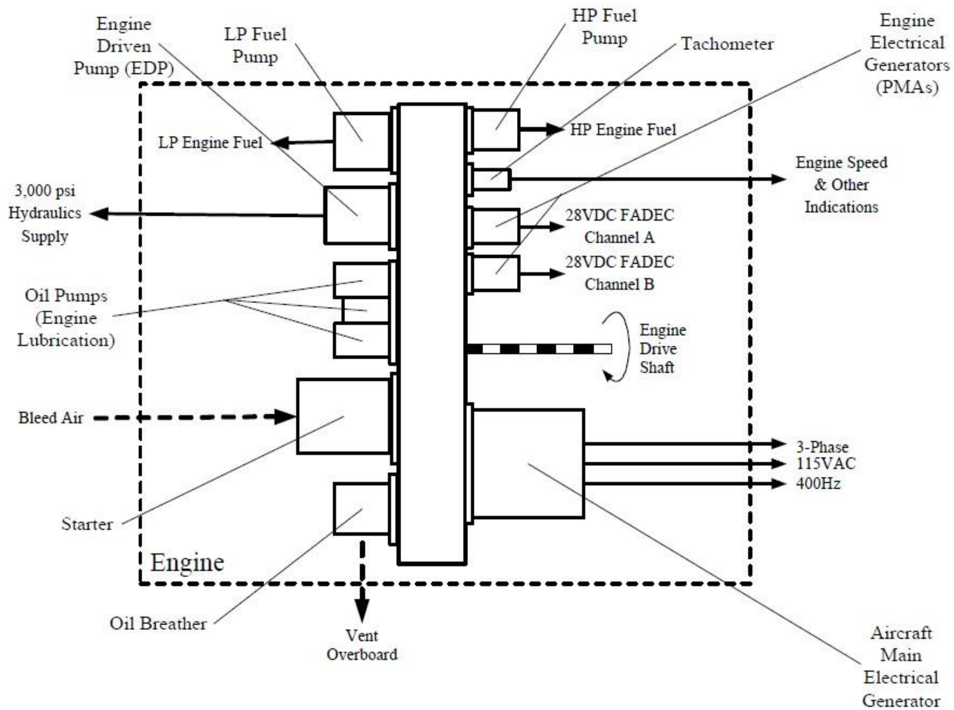
ENGINE AIR INTAKE ICE PROTECTION

- Protects leading edge of air intake cowls
- Normally selected only in icing conditions
- Air bleed is from fifth stage of HP compressor

ENGINE OFFTAKES

•The engine is the prime mover for the majority of sources of power on the aircraft.

•An accessory gearbox enables accessories to be connected to the engine HP shaft and allows a starter connection so that the engine can be started from an external supply or from the Auxiliary Power Unit (APU).


Engine
Driven
Pump (EDP)
LP Fuel
Pump
HP Fuel
Pump
Tachometer
Engine
Electrical
Generators
(PMAs)
LP Engine Fuel
HP Engine Fuel
Engine Speed
& Other
Indications
3,000 psi
Hydraulics
Supply
28VDC FADEC
Channel A
28VDC FADEC
Channel B
Oil Pumps
(Engine
Lubrication)
Engine
Drive
Shaft
Bleed Air
3-Phase
115VAC
400Hz
Starter
Engine
Oil Breather
Vent
Overboard
Aircraft
Main
Electrical
Generator

REVERSE THRUST

Input of bleed air from a suitable air source to start the engine. This can be a ground power cart, the APU or air from the other engine if that has already been started

- Aircraft
- Main
- Electrical
- Generator
- Engine

CHARACTERISTICS OF FUEL SYSTEMS

The essential characteristics of a modern aircraft fuel management system may embrace some or all of the following modes of operation:

- Fuel pressurization
- Engine feed
- Fuel transfer
- Refuel/defuel
- Fuel storage

FUEL SYSTEM COMPONENTS

Fuel Transfer Pumps:

- Fuel transfer pumps perform the task of transferring fuel between the aircraft fuel tanks to ensure that the engine fuel feed requirement is satisfied.
- On most aircraft this will require the supply of fuel to collector tanks which carry out the obvious task of collecting or consolidating fuel before engine feed; thereby assuring a guaranteed (short-term) supply to each engine.
- Transfer pumps may also be required to transfer fuel around the aircraft to maintain pitch or lateral trim.

Fuel Booster Pumps:

- Fuel booster pumps, sometimes called engine feed pumps, are used to boost the fuel flow from the aircraft fuel system to the engine. One of the reasons for this is top reventaeration (i.e. Air in the fuel lines that could cause an engine ‘flameout’ with consequent loss of power).
- Another reason in the case of military aircraft is to prevent ‘cavitation’ at high altitudes. Cavitation is a process in which the combination of high altitude, relatively high fuel temperature and high engine demand produce a set of circumstances where the fuel is inclined to vaporize.
- Vaporization is a result of the combination of low fuel vapour pressure and high temperature.

FUEL TANK SAFTY

- Fuel tank safety embraces a number of issues relating to the electrical components and installation as well as providing oxygen depleted environment in the ullage volume. These electrical and component issues include:
- In-tank wiring. The possibility of electrical energy entering the fuel tank due to normal operation, short circuits, and induced current/voltage on to fuel systems wiring that may potentially lead to ignition of flammable vapors. An earlier energy limit of 200 joules has been superseded by a lower limit of 20 µJoules for in-tank electrical design.∗ Allowable current limits are now 30 mAmps whereas previously no limits were specified. Advisory circular (AC)
- Pump wiring. Spark erosion and hot spots due to short circuits in the pump wiring

- Pump dry-running. Mechanical sparks generated due to component wear or Foreign Object Damage (FOD) inside the pumps.
- Bonding. Electrical discharges occurring with I the fuel tank duet lightning. High Intensity Radiation Fields (HIRF), static and/or fault currents
- Adjacent systems. Ignition sources adjacent to the fuel tanks – ignition of the fuel in the tank due to electrical arcing external to the fuel tank penetrating the tank wall and causing auto- ignition of the fuel due to heating of the tank wall – explosions within the adjacent area
- Arc gaps. Inadequate separation between components and structure that could allow electrical arcing due to lightning.

FUEL INSERTING

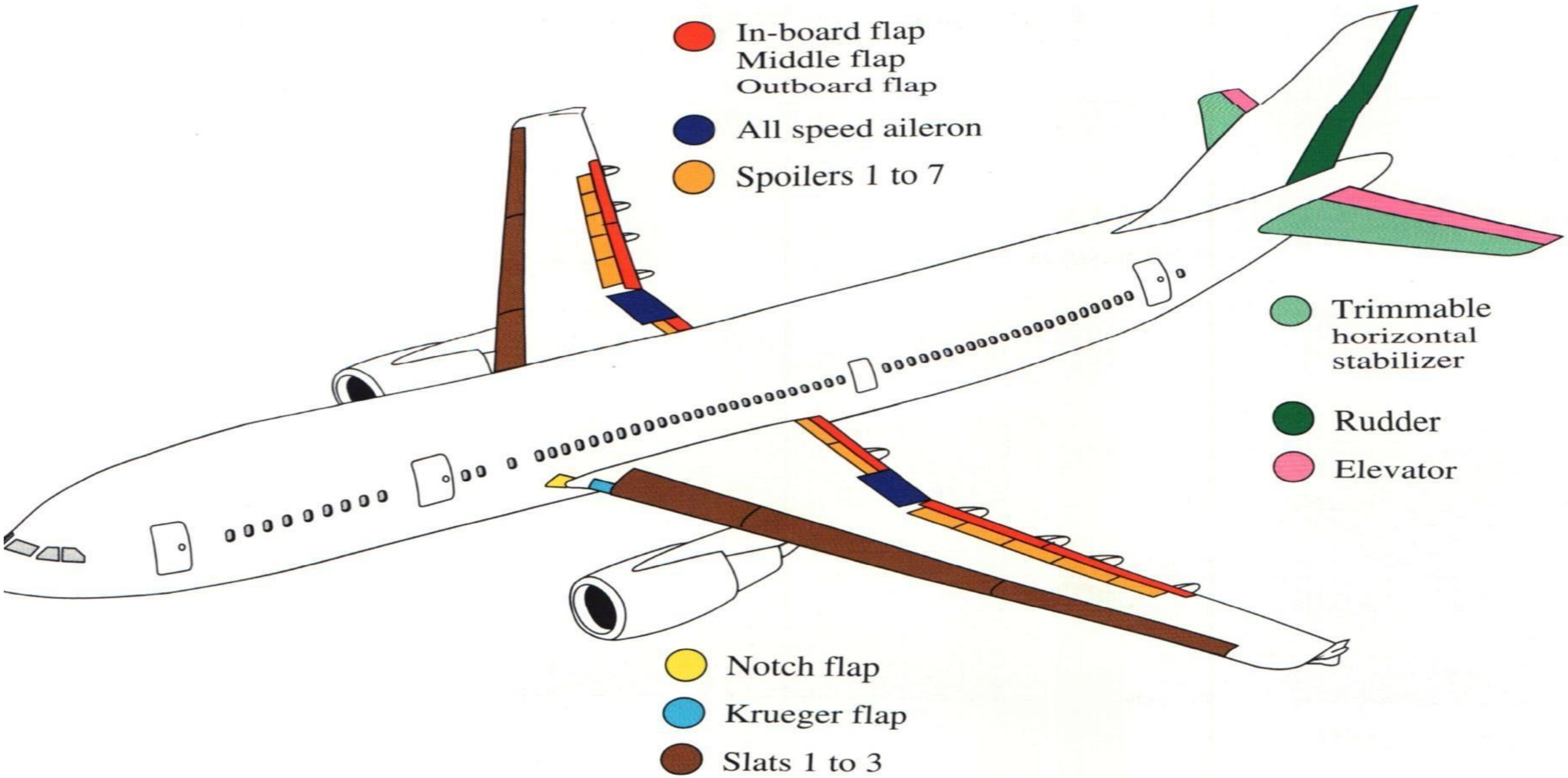
- The JAA produced a similar document – JAA INT/POL 25/12 which was mandatory for all airbus aircraft These documents provided a methodology to categorize the hazards in fuel tanks.
- On a civil aircraft the main fuel tanks usually comprise left, center and right wing tanks.
- The center wing fuel tank is categorized as hazardous; requiring fuel tank inserting due to the temperatures encountered and the proximity to external heat sources of which the air conditioning units represent a significant heat source.
- Left and right wing tanks are usually considered to be nonhazardous, primarily as the fuel contained within is much cooler and the fuel does not suffer from the proximity of hot aircraft components.

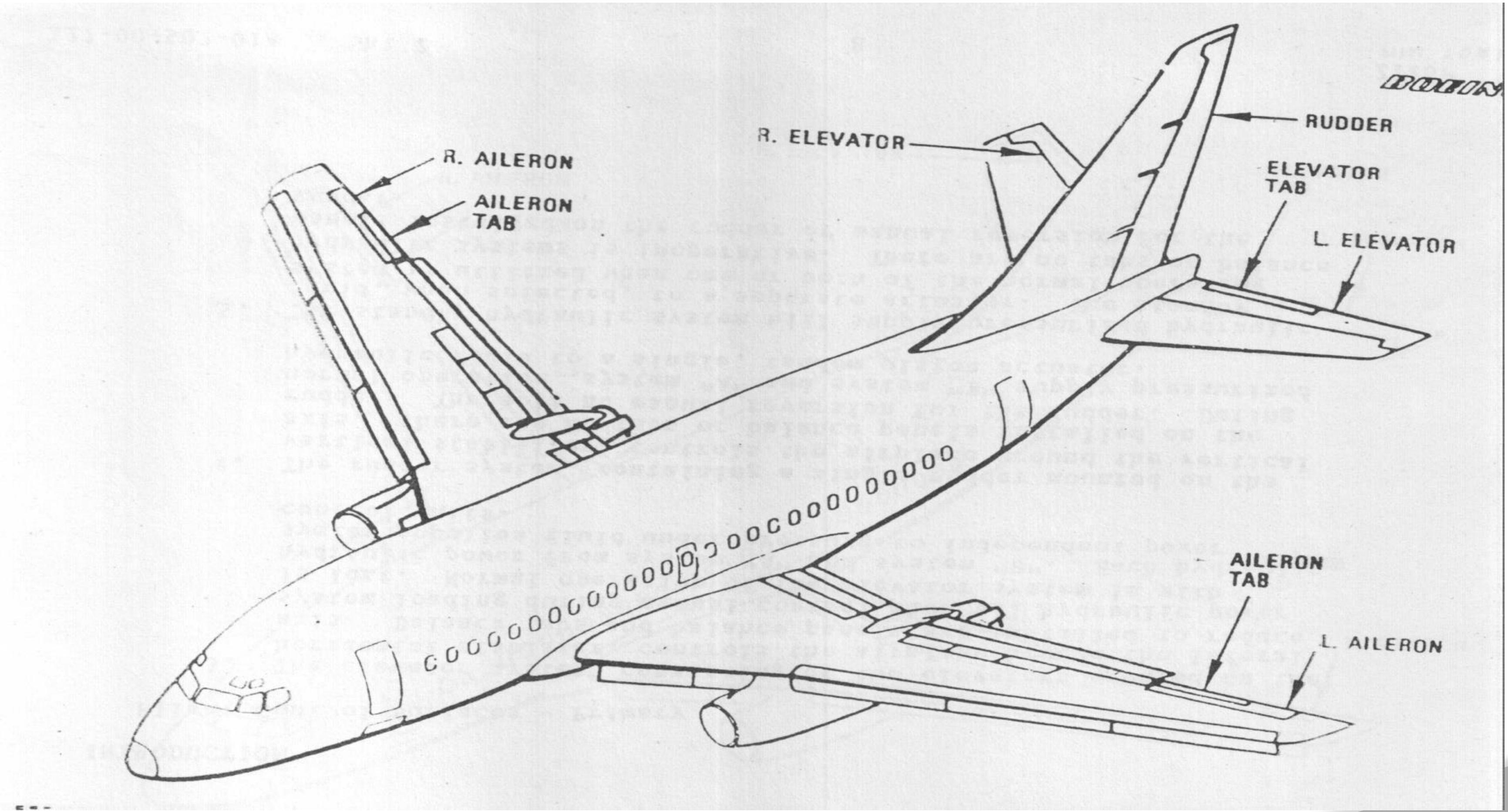
AIRPLANE CONTROL SYSTEMS

UNIT - 5

CLOs	Course Learning Outcome
CLO 13	Illustrate the importance of fly-by-wire technology in aircraft systems.
CLO 14	Identify important flight control operations and selects suitable flight control actuations.
CLO 15	Estimate the various engine performances and their application in aircraft systems.

Flight control systems

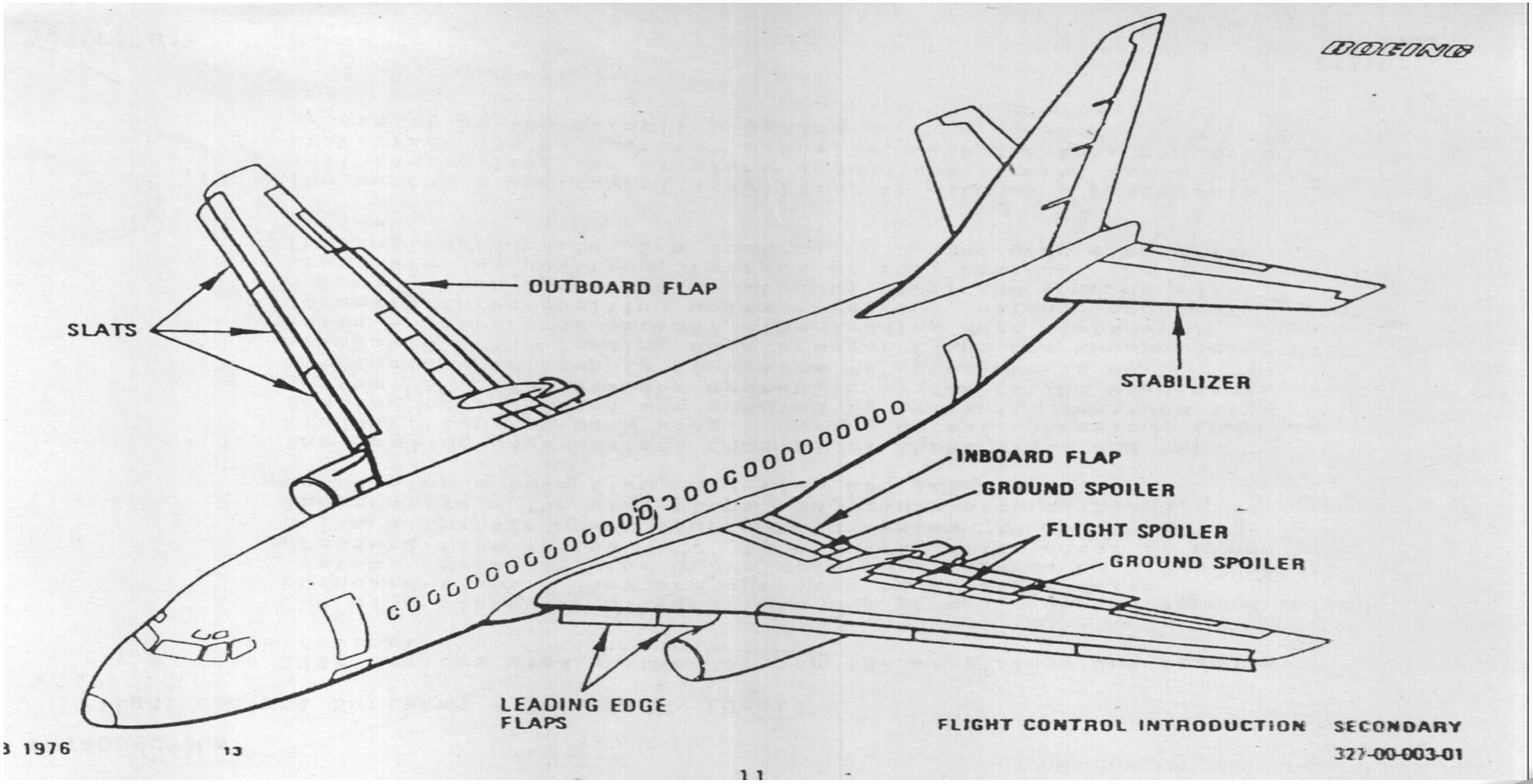

In-board flap
Middle flap
Outboard flap
All speed aileron
Spoilers 1 to 7
Trimmable
horizontal
stabilizer
Rudder
Elevator
Notch flap
Krueger flap
Slats 1 to 3


R. AILERON
AILERON TAB
R. ELEVATOR
RUDDER
ELEVATOR TAB
L. ELEVATOR
AILERON TAB
L. AILERON

- **Pitch control** is exercised by four elevators located on the trailing edge of the tail plane (or horizontal stabilizer in US parlance).

- Each elevator section is independently powered by a dedicated flight control actuator, powered in turn by one of several aircraft hydraulic power systems.

- **Roll control** is provided by two aileron sections located on the outboard third of the trailing edge of each wing.


BOEING
OUTBOARD FLAP
SLATS
STABILIZER
INBOARD FLAP
GROUND SPOILER
FLIGHT SPOILER
GROUND SPOILER
LEADING EDGE
FLAPS
FLIGHT CONTROL INTRODUCTION SECONDARY
3 1976
13
327-00-003-01

•Flap control is effected by several flap sections located on the inboard two thirds of the wing trailing edges.

•Deployment of the flaps during take-off or landing extends the flap sections rearwards and downwards to increase wing area and camber, thereby greatly increasing lift for a given speed.

•The number of flap sections may vary from type to type; typically for this size of aircraft there would be about five per wing.

- **Slat control** is provided by several leading edge slats which extend forwards and outwards from the wing leading edge.

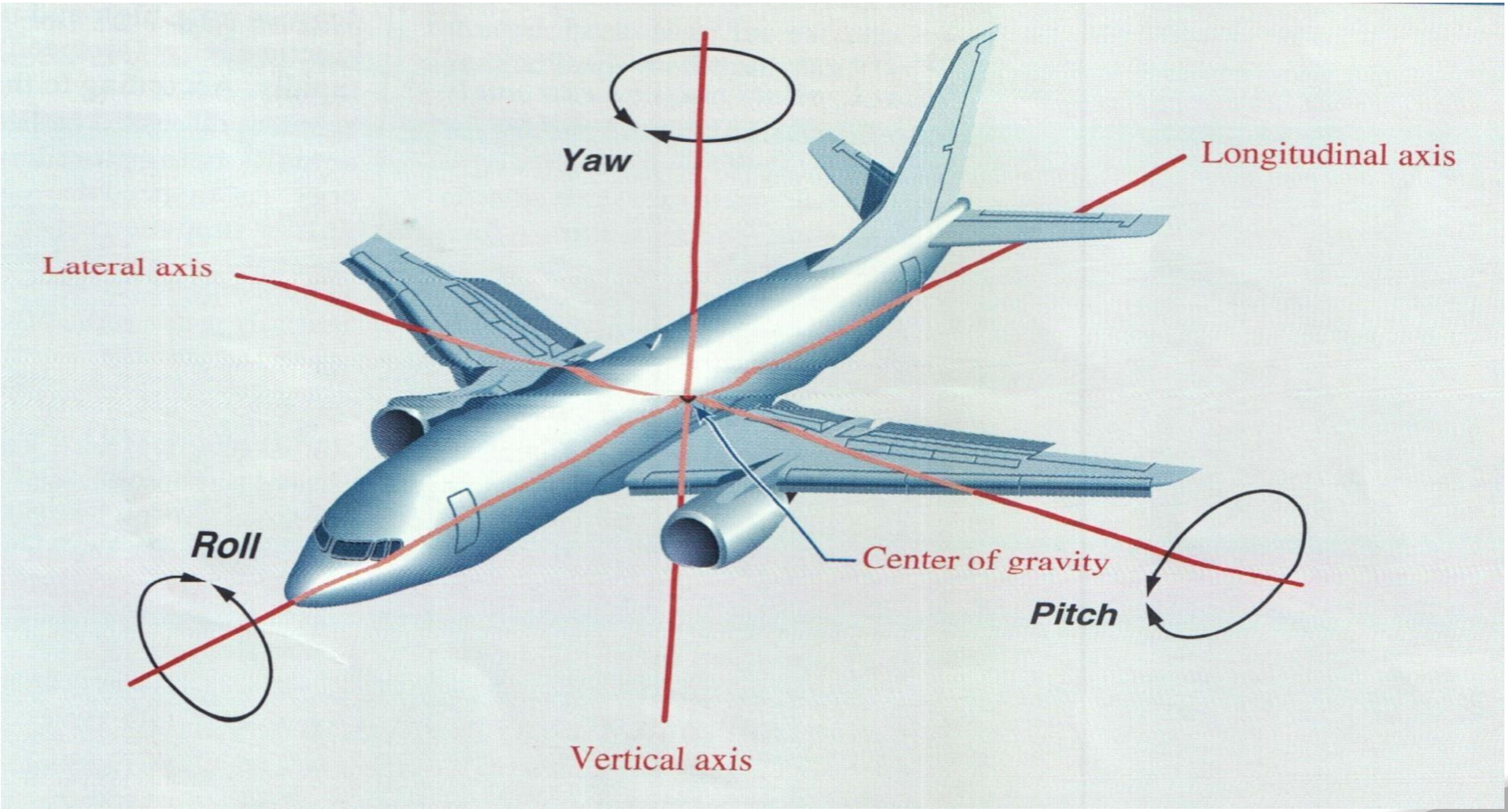
- In a similar fashion to the flaps described above, this has the effect of increasing wing area and camber and therefore overall lift.

- A typical aircraft may have five slat sections per wing, giving a total of ten in all.

- The effect is similar to the use of air-brakes in the fighter, increasing drag so that the pilot may adjust his airspeed rapidly; most airbrakes are located on rear fuselage upper or lower sections and may have a pitch moment associated with their deployment.

In most cases compensation for this pitch moment would be automatically applied within the flight control system

- Speed-brakes are deployed when all of the over-wing spoilers are extended together which has the effect of reducing lift as well as increasing drag.


Yaw
Longitudinal axis
Lateral axis
Roll
Center of gravity
Pitch
Vertical axis

PRINCIPLES OF FLIGHT CONTROL

•All aircraft are governed by the same basic principles of flight control, whether the vehicle is the most sophisticated high-performance fighter or the simplest model aircraft.

•The motion of an aircraft is defined in relation to translational motion and rotational motion around a fixed set of defined axes. Translational motion is that by which a vehicle travels from one point to another in space.

•For an orthodox aircraft the direction in which translational motion occurs is in the direction in which the aircraft is flying, which is also the direction in which it is pointing.

•The rotational motion relates to the motion of the aircraft around three defined axes: pitch, roll and yaw.

•In most fixed wing aircraft, if the pilot wishes to alter the aircraft heading then he will need to execute a turn to align the aircraft with the new heading.

•During a turn the aircraft wings are rotated around the roll axis (Oy) until a certain bank is attained. In a properly balanced turn the angle of roll when maintained will result in an accompanying change of heading while the roll angle (often called the bank angle) is maintained. This change in heading is actually a rotation around the yaw axis (Oz).

FLIGHT CONTROL LINKAGE SYSTEM

The pilot's manual inputs to the flight controls are made by moving the cockpit control column or rudder pedals in accordance with the universal convention:

- Pitch control is exercised by moving the control column fore and aft
- Roll control is achieved by moving the control column from side to side

•Yaw is controlled by the rudder pedals; pushing the left pedal will yaw the aircraft to the left while pushing the right pedal will have the reverse effect

•There are presently two main methods of connecting the pilot's controls to the rest of the flight control system.

These are:

- Push-pull control rod systems
- Cable and pulley systems

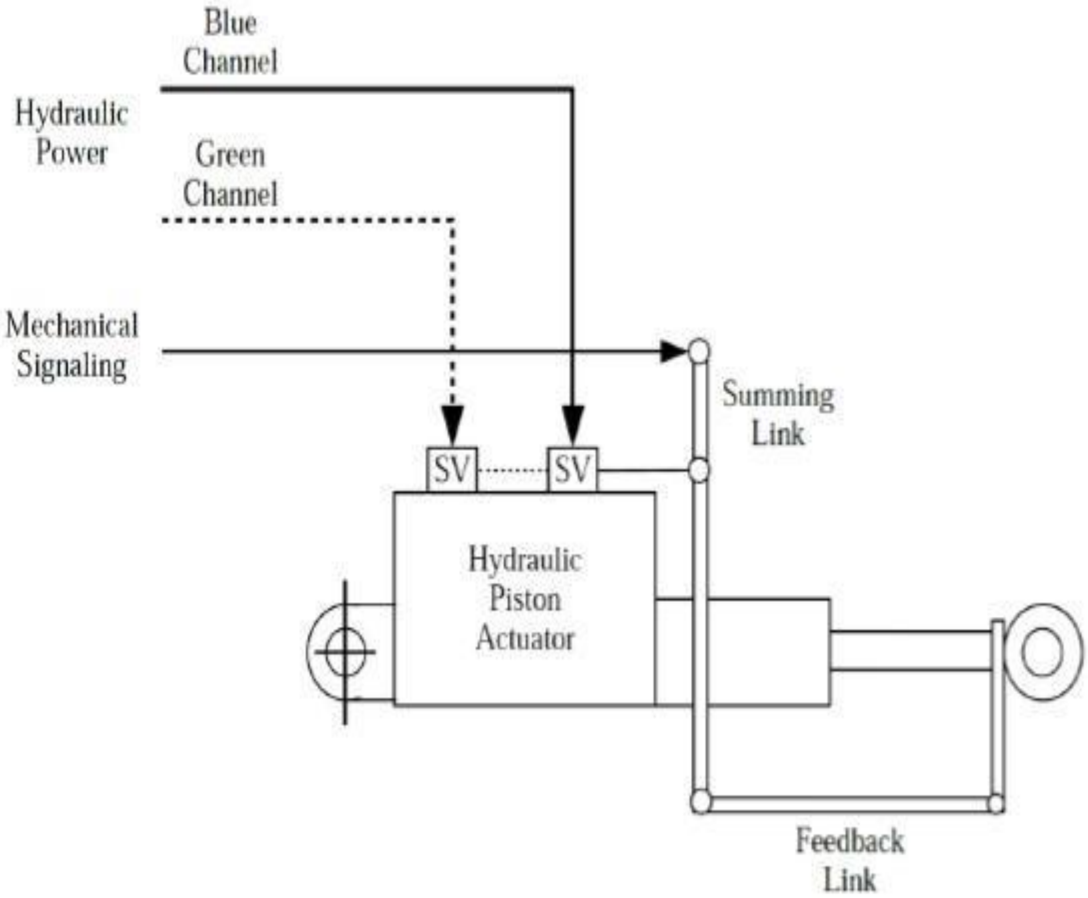
ACTUATORS

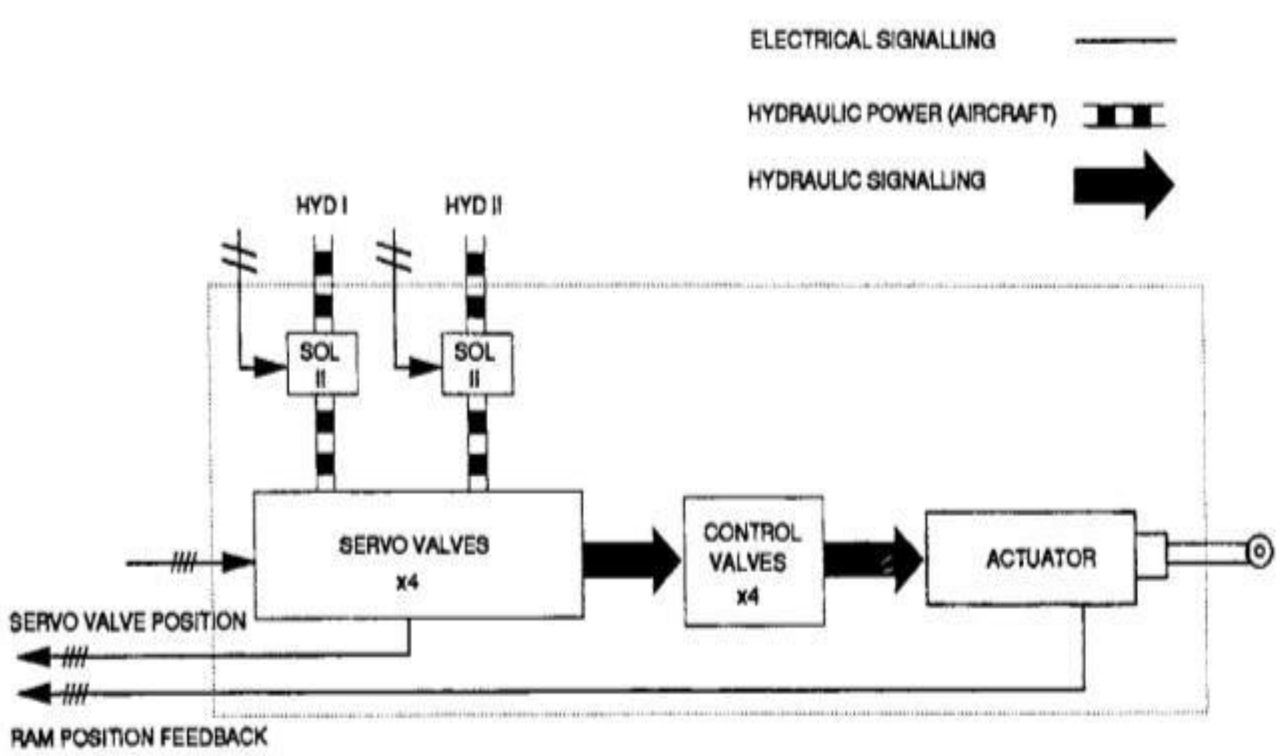
•Addressing actuation in ascending order of complexity leads to the following categories:

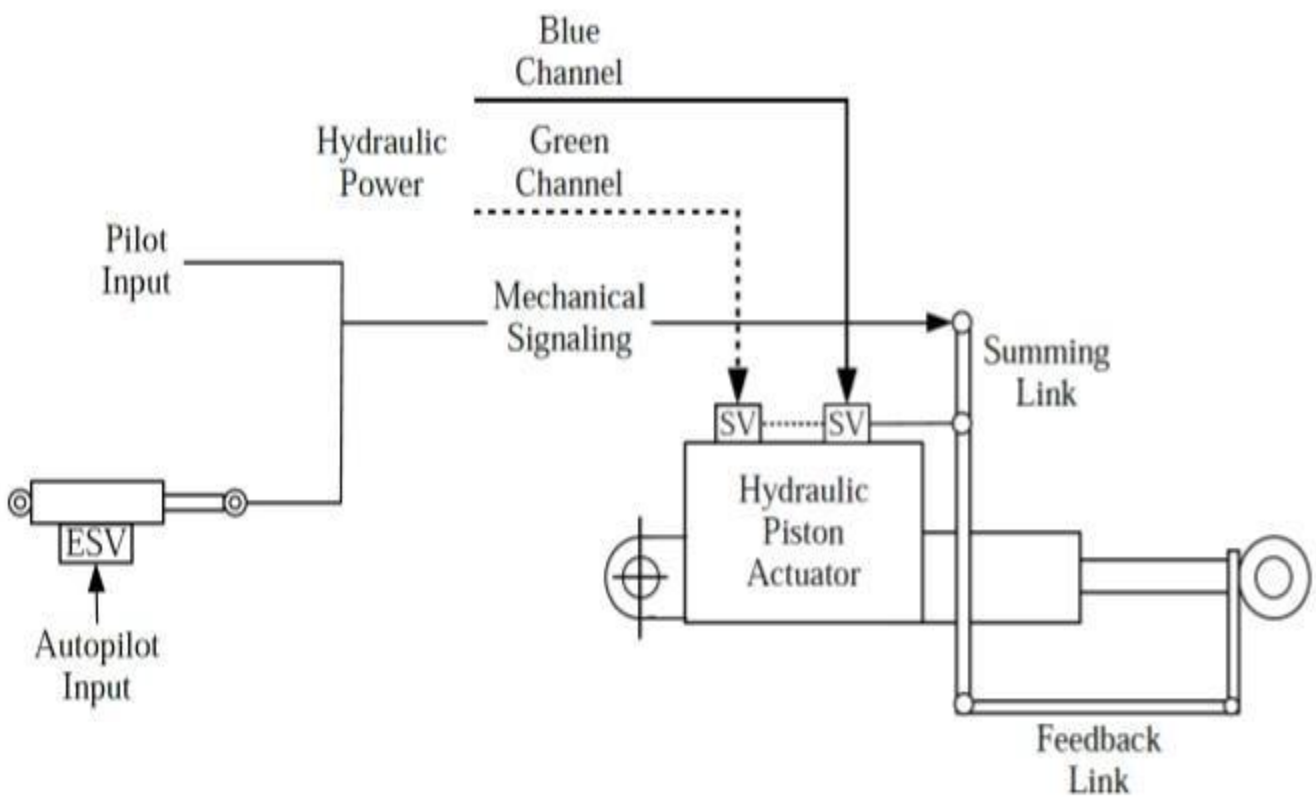
•Simple mechanical actuation, hydraulically powered

•Mechanical actuation with simple electromechanical features

•Multiple redundant electromechanical actuation with analogue control inputs and feedback .


Blue
Channel
Hydraulic
Power
Green
Channel
Mechanical
Signaling
Summing
Link
SV
SV
Hydraulic
Piston
Actuator
Feedback
Link

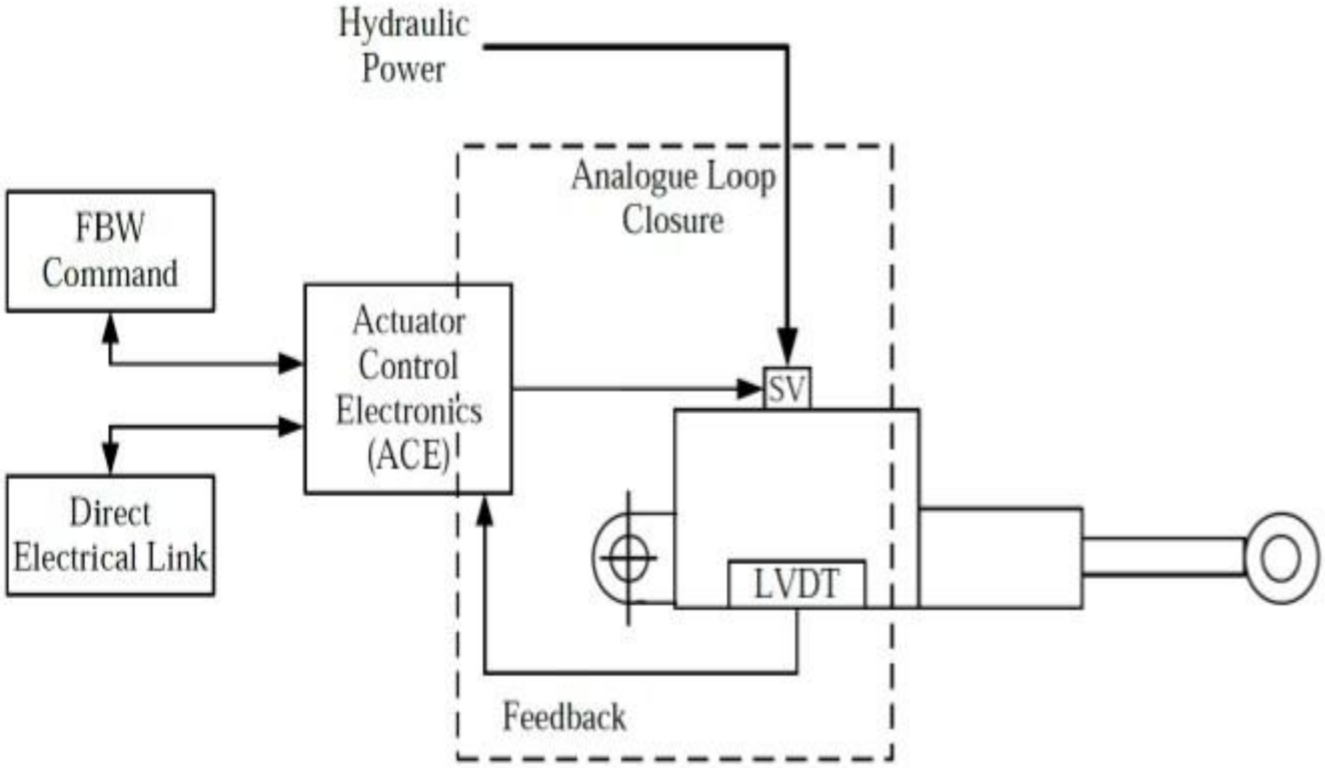

ELECTRICAL SIGNALLING
HYDRAULIC POWER (AIRCRAFT)
HYDRAULIC SIGNALLING
HYD I
HYD II
SOL II
SOL II
SERVO VALVES x4
CONTROL VALVES x4
ACTUATOR
SERVO VALVE POSITION
RAM POSITION FEEDBACK

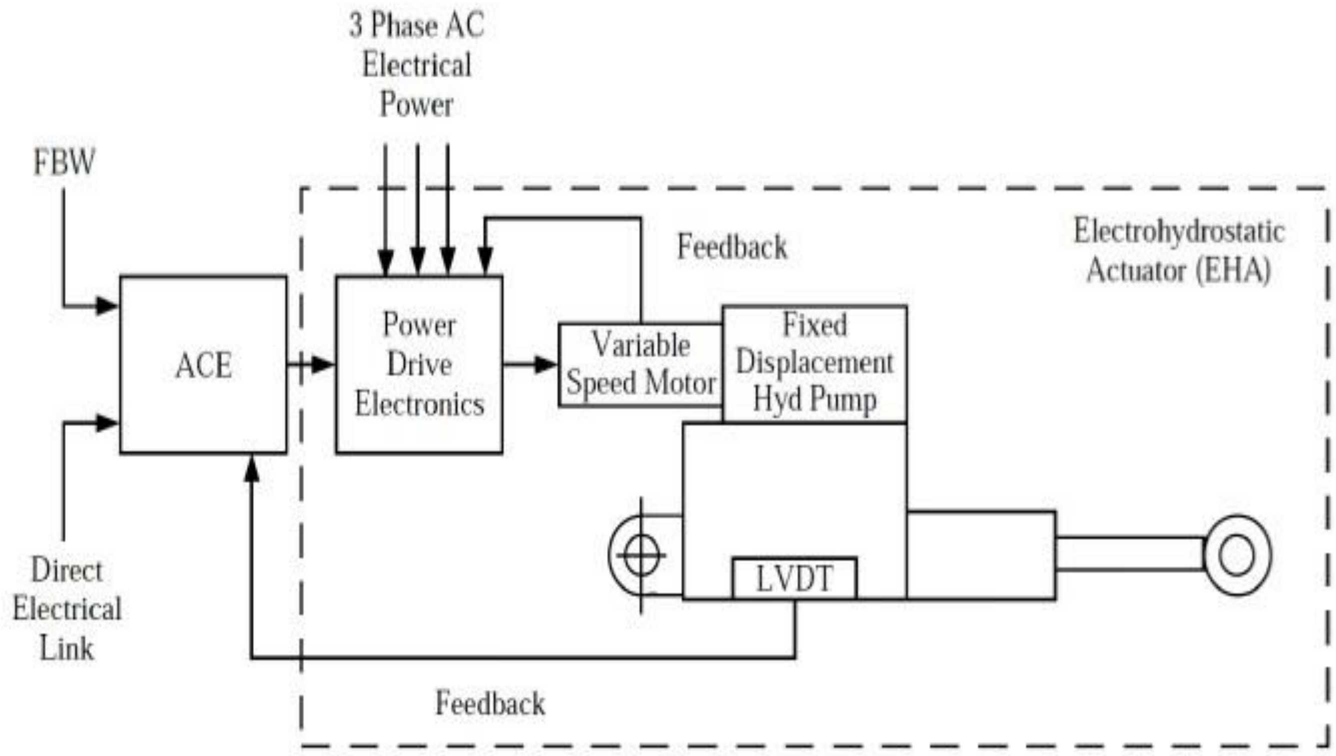

Blue
Channel
Hydraulic
Power
Green
Channel
Pilot
Input
Mechanical
Signaling
Summing
Link
SV
SV
ESV
Hydraulic
Piston
Actuator
Autopilot
Input
Feedback
Link

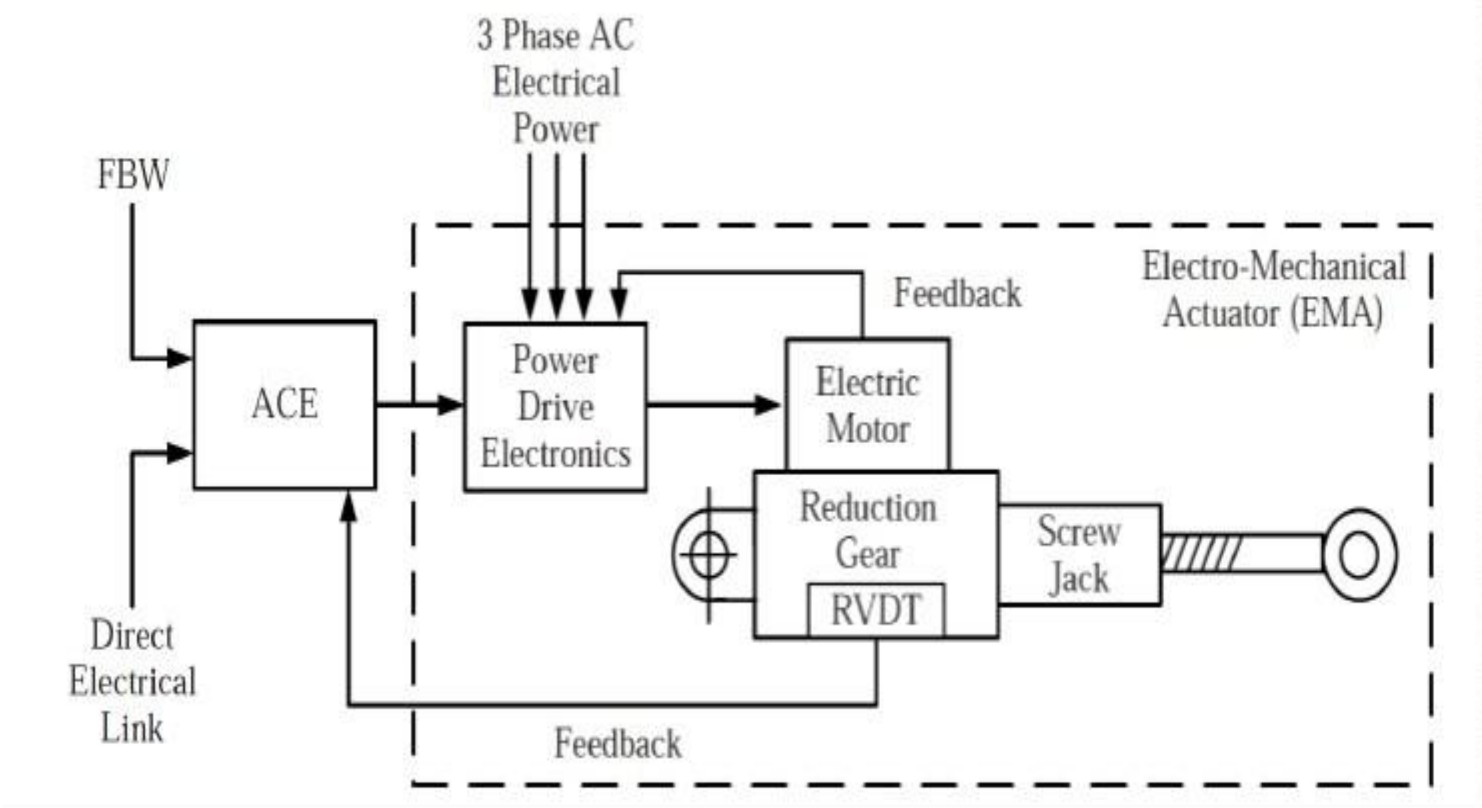
gnaling

ACTUATOR IMPLEMENTATIONS

- Direct drive actuation
- Fly-by-Wire (FBW) actuation
- Electro-Hydrostatic Actuator (EHA)
- Electro-Mechanical Actuator (EMA)


Hydraulic Power
Analogue Loop Closure
FBW Command
Actuator Control Electronics (ACE)
SV
Direct Electrical Link
LVDT
Feedback


3 Phase AC
Electrical
Power
FBW
Feedback
Electrohydrostatic
Actuator (EHA)
ACE
Power
Drive
Electronics
Variable
Speed Motor
Fixed
Displacement
Hyd Pump
LVDT
Direct
Electrical
Link
Feedback


3 Phase AC
Electrical
Power
FBW
Feedback
Electro-Mechanical
Actuator (EMA)
ACE
Power
Drive
Electronics
Electric
Motor
Reduction
Gear
RVDT
Screw
Jack
Direct
Electrical
Link
Feedback

COMMUNICATIONS AND NAVIGATION SYSTEMS

- In aviation, communications between the aircraft and the ground (air traffic/local approach/ground handling) have historically been by means of voice communication.
- More recently, data-link communications have been introduced owing to their higher data rates and in some cases superior operating characteristics. As will be seen, data links are becoming widely used in the HF and VHF bands for basic communications, but also to provide some of the advanced reporting features required by FANS. After selecting the appropriate communications channel on the channel selector, the pilot transmits a message by pressing the transmit button which connects the microphone to the appropriate radio.
- The voice message is used to modulate the carrier frequency, and it is this composite signal that is transmitted.

INSTRUMENT LANDING SYSTEM

- The ILS is an approach and landing aid that has been in widespread use since the 1960s and 1970s. The main elements of ILS include: ï A localizer antenna centred on the runway to provide lateral guidance.
- A total of 40 operating channels are available within the band 108ñ112 MHz. The localizer provides left and right lobe signals that are modulated by different frequencies (90 and 150 Hz) so that one signal or other will dominate when the aircraft is off the runway centre- line.
- The beams are arranged such that the 90 Hz modulated signal will predominate when the aircraft is to the left, while the 150 Hz signal will be strongest to the right.
- The difference in signal is used to drive a cross-pointer deviation needle so that the pilot is instructed to ëflyrightí when the 90 Hz signal is strongest, and ëflyleftí when the 150 Hz signal dominates.

THANK YOU