Unit - 1

An aircraft is a vehicle designed to travel through the air by generating lift or thrust, typically using wings, rotors or jet propulsion. Aircraft are used for transporting people and goods, military operations, scientific research and recreation.

Key characteristics of an aircraft

* Operates within Earth's atmosphere
* Capable of controlled flight
* Uses aerodynamic forces (lift, thrust, drag & weight)

Common types of aircraft:

* Airplanes (fixed-wing)
* Helicopters (rotary-wing)
* Gliders
* Drones (UAVs)
* Airships and ballons

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Aircraft Instrumentation:

A coordinating group of instruments that provide the flight crew with information about the aircraft & its subsystems.

Crew: A group of 6 to 8 people working in an aircraft

These instruments provide:

* flight situation of the aircraft
* Direction
* Attitude
* Altitude
* Airspeed.

5 main components of an aircraft.

* Fuselage: The main hallow tube that holds passengers & cargo, also known as the body of the airplane.

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* Wings: Also known as foils, the wings generate the lifting force needed for flight. The wings are in the middle & back of the airplane

* Empennage: The tail end of the aircraft, which helps with stability using assistance from the rudder and elevator.

* powerplant: The Engine and propeller make up the power plant

Flight Control Surfaces

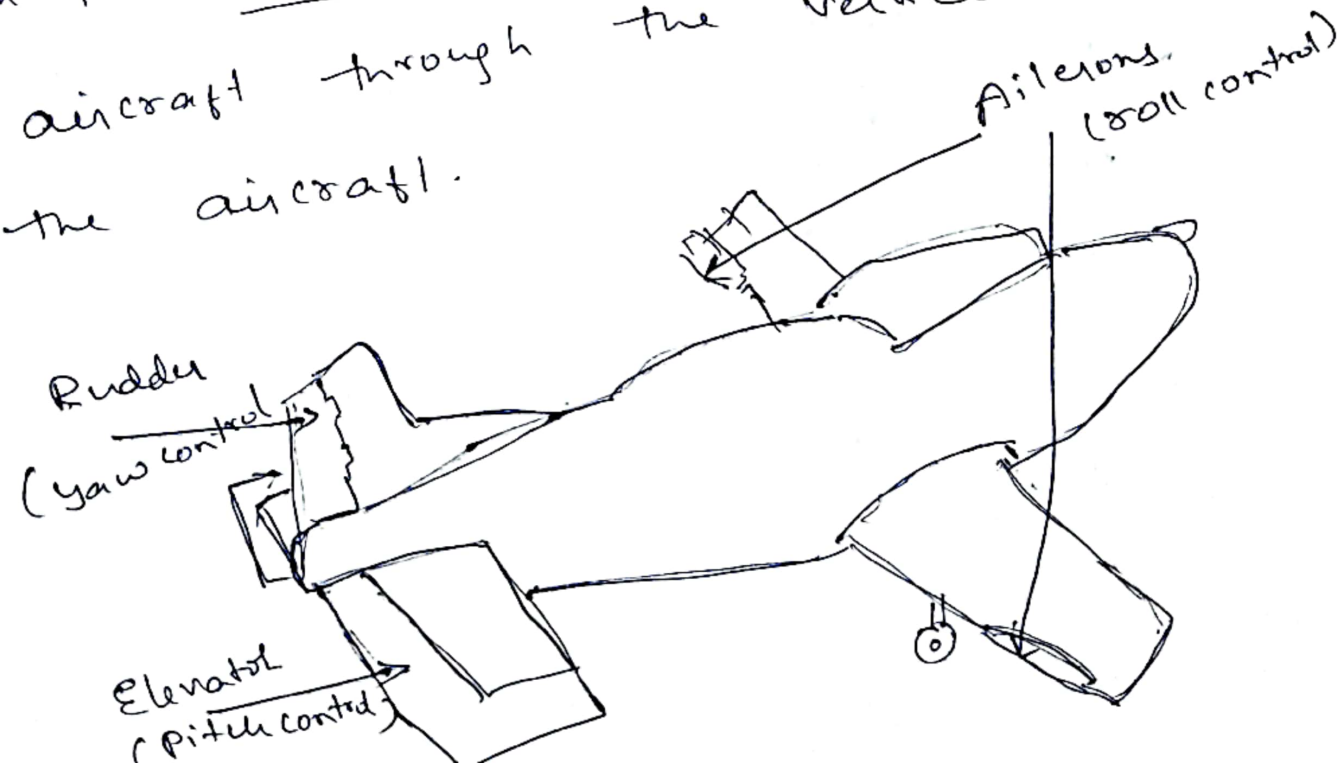
* primary control Surfaces:

The true primary aircraft control surfaces are the ailerons, elevators & rudder, which control the aircraft roll (around the longitudinal axis),

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pitch (around the lateral axis) and yaw (around the vertical axis), respectively, enabling the pilot to move the aircraft safely.

* The ailerons control the rolling motion of the aircraft through the longitudinal axis
* The Elevator, which controls the pitch of the aircraft through the lateral axis.
* The rudder controls the yaw of the aircraft through the vertical axis of the aircraft.



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Secondary control Surfaces:

on aircraft, like flaps, slats, spoilers and trim tabs aren't essential for basic flight but improve performance, Efficiency, & safety by modifying lift and drag for takeoff, landing & descent.

* The flaps & slats help to slow down the aircraft for landing & help to reduce the ground roll on take-off.
* The trim control surfaces reduce the effort the pilot has to apply to fly the aircraft.
* Spoilers & Speed brakes assist the pilot in roll & Speed and lift reduction.

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Forces of flight:

* **Lift**: upward force generated by wings, creating lower pressure above the wing & higher pressure below.
* **Weight**: Downward force due to gravity
* **Thrust**: Forward force from Engines
* **Drag**: Backward force opposing thrust, caused by air resistance

Working of an aircraft

1. **Lift**: while in flight, the airplane is supported by Lift. Lift is the force acting opposite of gravity & is generated whenever air flows smoothly over a wing. As air flows over & under the wing, an area of low pressure is created above the wing, acting to pull the airplane up. when lift exceeds

gravity, the aircraft will leave the ground & climb.

2. Weight : weight is caused by gravity & acts to pull the airplane toward the ground.

3. Thrust : The airplane's propeller acts like a wing turned on its side. Lift is known as thrust, & the low pressure in front of the propeller pulls the airplane forward, much as the Engine & propeller of a ship provide thrust in the water.

4. Drag : is the force that opposes thrust. It's the same force you feel if you extend your arm out of the window of a fast-moving car. drag ↑ as speed ↑.

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Flight controls & movement

Pilots control the aircraft attitude across three axes using primary control surfaces:

* **Pitch** (Lateral axis): controlled by Elevators on the tail. moving the nose up or down allows the plane to climb or descend

* **Roll** (Longitudinal axis): controlled by ailerons on the outer rear Edges of the wings. They allow the plane to bank left or right for turns

* **Yaw** (vertical axis): controlled by the rudder on the vertical stabilizer. It moves the nose left or right, often used in coordination with ailerons for smooth turns.

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Angle of Attack (AoA) for an aircraft

is the angle between the wing's chord line (an imaginary straight line from the leading Edge to the trailing Edge of the wing) & the relative airflow (oncoming air)

* AoA determines how much lift a wing produces
* Increasing AoA → more lift, up to a certain limit.
* If AoA Exceeds the critical angle of attack, the wing stalls (loss of lift) & lift decreases sharply
* AoA is independent of airspeed - a stall can occur at any speed if the critical AoA is Exceeded.

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History of aircraft

* Early Ideas of flight
* Ballon & Glider Era
* first powered flight (1903)
* Wright brothers
* Modern Aviation

Aircraft instruments and their layout

1. Airspeed Indicator : is like the speedometer in the car (Reads: 122 knots)
2. Attitude Indicator / artificial horizon shows the airplane's pitch & bank in relation to the horizon (shows level flight)
3. Altimeter : Shows the aircraft's height above mean sea level (msl) (Reads: 3,000 feet msl)
4. Heading Indicator : shows the direction the aircraft is flying (Reads: 150 degrees)

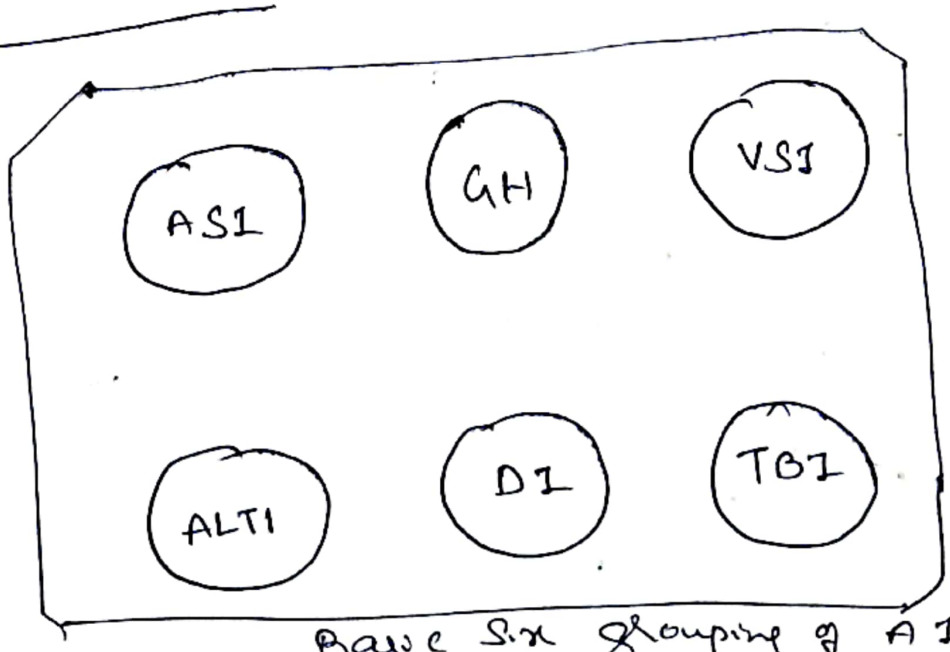
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5. Vertical Speed Indicator: Shows the rate in feet per minute that the aircraft is going up or down.

6. Tachometer: indicates how much power the Engine is producing

7. Fuel gauges: most general aviation aircraft have one fuel tank in each wing, but airplane may have more. This gauge shows how much fuel is in each tank.

The Basic Six (Instrument Flying Panel)



Basic Six grouping of AI

These Six instruments form the core of flight information, typically arranged in 'T' shape on the instrument panel.

* Airspeed Indicator (ASI) Displays speed in knots relative to the air
* Attitude Indicator (Gyro horizon): Shows the aircraft's orientation (pitch & roll) relative to the horizon
* Vertical Speed Indicator (VSI): Shows the rate of climb or descent in feet per minute.
* Altimeter: Shows altitude above sea level.
* Heading Indicator: Shows the aircraft's direction (heading)

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a Turn coordinator / Turn & Bank Indicator:

Shows the rate of turn & the quality of the turn (coordination)

Basic T arrangement:

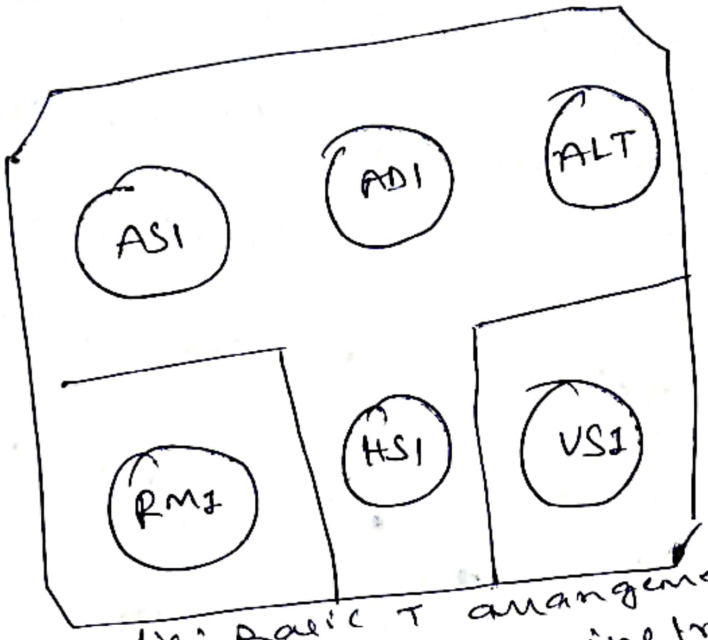


fig: Basic T arrangements

After reviewing modern instruments, requirements of newer generation of aircraft, & pilot feedbacks, designers arrived at 'Basic T" grouping of most important flight instruments required for safety flying the aircraft, without much Effort & Eye Scan by the pilots.

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most important indicators are:

ASI, ADI & Altitude Indicator - ALTI, which form the horizontal bar of T. HSI is at the centre & makes up the vertical bar of T, as shown in fig.

Classification of aircraft Instruments

i) Quantitative display:

Variable Quantity which is measured is presented in terms of a numerical value by moving the points or index over a graduated scale.

Eg: airspeed.

ii) Qualitative display:

Data (changes in parameters measured is presented in symbolic or pictorial format. Eg: flight situation

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The factors that govern the choice of scale length for a particular range are:

* Size of the instrument
* Accuracy with which is needs to be read
* conditions under which it is to be observed

Quantitative displays:

There are three principal methods by which data may be displayed:

i) Circular scale - clock type of scale
ii) Straight scale
iii) Digital or counter

i) Circular scale:

A simple indicator showing the change of value of the parameter to be measured over a range of 0 to 30

In circular displays, again there are two types:

* Linear displays
* Non-linear displays

Square-law: Airspeed

Logarithmic: Rate of altitude change

High Range Long-scale displays

a) Concentric scales Eg: Engine Speed Indicator

b) fixed & rotating scales - pneumatic airspeed indicator

c) common scale & Triple pointers - altimeter

ii) Straight scale: ECT

iii) digital display:

* type of display is one that is generally found operating in conjunction with the circular type of display.

Dual-indicator displays (to conserve space)

These displays are designed for conserving panel space, particularly when the measurement of various quantities related to Engines is concerned.

Operational range markings (Coloured Displays)

* RED radial line: maximum & minimum limits
* YELLOW arc: Take-off & precautionary ranges
* GREEN arc: Normal operating range
* RED arc: Range in which operation is prohibited.

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Qualitative displays:

* These are special type of displays in which information is presented in a symbolic pictorial form to show the condition of a system.
* It shows whether the value of any Dip is increasing or decreasing or it shows the movement of flight control surfaces.

Basics of Director displays:

* These displays are associated with the monitoring of flight attitude & navigational data & present it to the flight crew such that they will be able to control movements & correct

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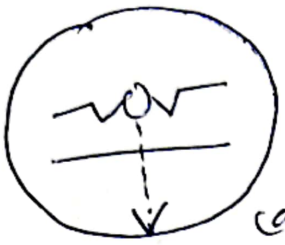
any departure from a desired flight path. The different director displays are:

* Gyro Horizon (GH)
* Attitude Director Indicator (ADI) - New Indicator
* Electronic Attitude Director Indicator (EADI) - Latest

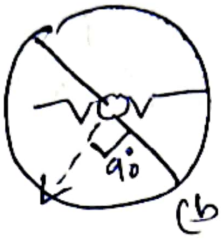
* Gyro horizon or Attitude Indicator is a gyroscopic flight instrument that shows the aircraft's attitude with respect to the Earth's horizon.

Horizon: is a horizontal reference line used to judge the pitch & roll of an aircraft.

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(a) Aircraft flying, nose up & wings level, pilot must make the nose down to fly straight & level.



(b) left banked



(c) Aircraft flying straight & level

fig: Attitude Indicator (gyro horizon) with different aircraft attitudes.

(a) pitch up b) left roll c) straight & level flight

ADI

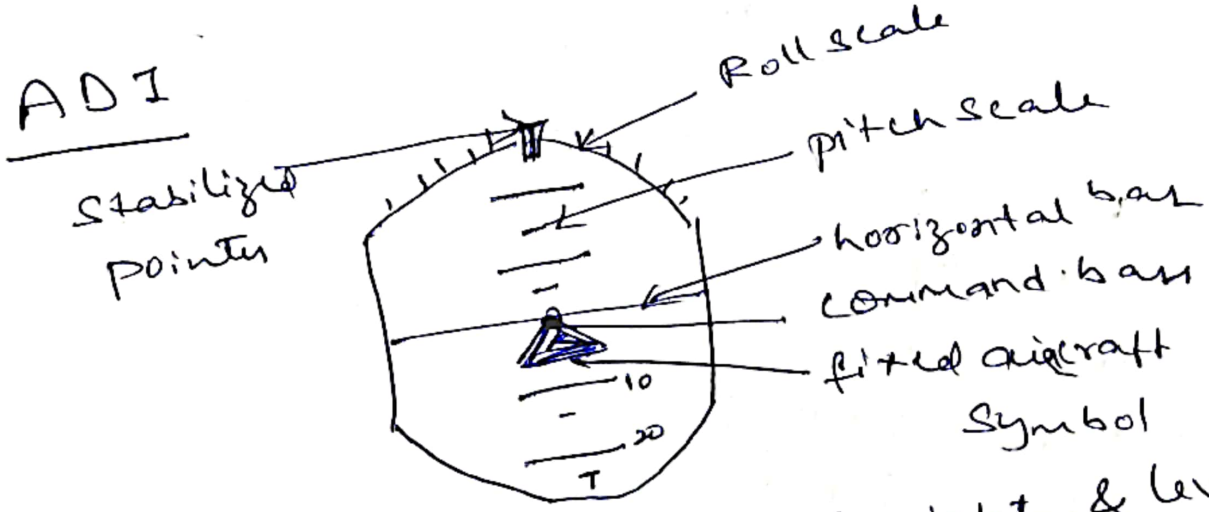


fig: Alc flying straight & level.

* ADI is a primary flight display which displays all information critical to flight
* It indicates pitch (nose up/down) & roll (wings not level) of the aircraft.
* The commands has to be satisfied by pilot.



A/c flying nose up



nose up command



fly left command



fly right command



Commands have been satisfied.

Electronic Attitude Director (EADI)

* It is a digital flight instrument in modern glass cockpit aircraft, displaying the aircraft's pitch & roll (attitude) against a simulated horizon, but also integrates crucial data like flight director command bars, ILS deviation and autopilot status, providing pilot with a comprehensive view of the aircraft's orientation & guidance cues, especially vital for low-visibility flight & complex approache

Key functions:

* Attitude representation
* flight guidance
* Navigation Integration

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* Situational Data

Horizontal Situation Indicator (HSI)

* is primarily a navigation display.
* provides a base horizontal view of the aircraft's navigation around the Earth.
* provides a base horizontal plan view (map view) of the aircraft navigation ~~motion which~~ around the Earth.
* It provides a base horizontal plan view (map view) of aircraft motion which is important to navigate to the desired airport.

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Electronic horizontal situation Indicator (EHSI)

* is a digital display, part of the glass cockpit, shows the aircraft's position, direction & navigation in a plan-view (map-like) format, combining traditional heading info with dynamic navigation aids like VOR/ILS, route waypoints, weather radar & TCAS symbols, providing pilots a comprehensive view of flight progress on the primary flight display.

Key functions & Information Displayed are:

* Glideslope
* course deviation indicator
* heading & track

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* Navigation Aids
* plan view
* weather & Traffic
* performance Data
* heading select memory bug
    * heading
    * course reference
    * course deviation
    * Glideslope information

Flight deck of modern aircraft (glass cockpit)

* modern aircraft cockpit has electronic instrument displays similar to glass monitor displays.
* They utilize few computer controlled displays that can be configured & adjusted to display flight information as required by pilots

* Such avionic systems increase flight safety, improve efficiency of the aircraft & greatly assist flight crew by reducing their workload.

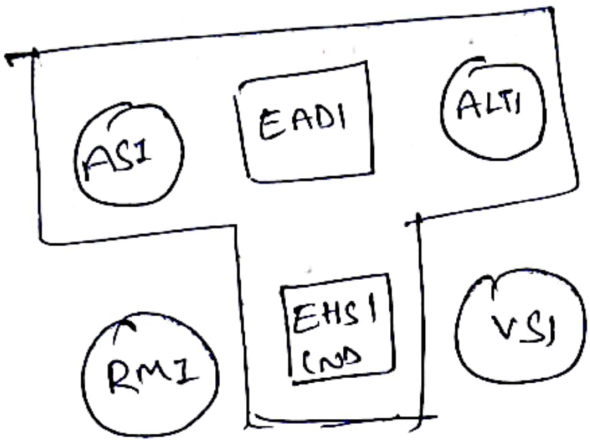


fig: Modern glass cockpit configuration with EADI & EHSI

Key features

* Electronic flight displays
* primary flight display
* Multi-function display
* Integrated systems
* Automation
* Enhanced Situational awareness

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