AIRCRAFT SYSTEMS AND AVIONICS

15BTAR503

15BTAR503 AIRCRAFT SYSTEMS AND AVIONICS 3 0 0 3 100

INTENDED OUT COMES
To describe the principle and working of aircraft systems and instruments.

UNIT - I AIRCRAFT SYSTEMS

Hydraulic systems - Study of typical workable system - components - Hydraulic system controllers - Modes of operation - Pneumatic systems - Advantages - Working principles - Typical Air pressure system – Brake system - Typical Pneumatic power system - Components, Landing Gear systems - Classification – Shock absorbers - Retractive mechanism.

UNIT - II AIRPLANE CONTROL SYSTEMS

Conventional Systems – Power assisted and fully powered flight controls – Power actuated systems – Push pull rod system – operating principles – Modern control systems – Digital fly by wire systems – Auto pilot system, Active Control Technology, Engine control systems.

UNIT - III ENGINE SYSTEMS AND AUXILLIARY SYSTEMS

Fuel systems – Components - Multi-engine fuel systems, lubricating systems - Starting and Ignition systems –Basic Air cycle systems -Oxygen systems - Fire protection systems, Deicing and anti-icing systems.

UNIT - IV INTRODUCTION TO AVIONICS

Need for avionics in civil and military aircraft and space systems – integrated avionics and weapon systems – typical avionics subsystems, design, technologies – Introduction to digital computer and memories. Avionics system architecture–8085 Architecture– data buses – MIL-STD-1553B – ARINC – 420 – ARINC – 629.

UNIT – VAVIONICS SYSTEMS

Control and display technologies -CRT, LED, LCD, EL and plasma panel- Civil cockpit and military cockpit: MFDS, HUD, MFK, HOTAS- Communication Systems - Navigation systemsADF, DME, VOR, LORAN, OMEGA, ILS, MLS - Air Data Systems.

TEXT BOOKS:

S.NO.	AUTHOR(S)	TITLE OF THE BOOK	PUBLISHER	YEAR OF PUBLICATION
1.	Ian Moir, Allan Seabridge	Aircraft Systems: Mechanical, Electrical and Avionics Subsystems Integration	John Wiley and Sons, New York.	2012
2.	David Lombardo	Aircraft Systems	McGraw Hill Professional New York.	2009
3.	R. P. G. Collinson	Introduction to Avionics Systems	Springer-Verlag, New York.	2013

REFERENCES BOOKS:

S.NO.	AUTHOR(S)	TITLE OF THE BOOK	PUBLISHER	YEAR OF PUBLICATION
1.	S. Nagabhushana	Aircraft Instrumentation and Systems	I. K. International Pvt Ltd, New Delhi	2010
2	Thomas Wild, Michael Kroes	Aircraft Power Plants	McGraw-Hill, New York.	2013
3	Treager, S.	Gas Turbine Technology	McGraw-Hill New York.	2002
4	Middleton, D.H., Ed.	Avionics Systems	Longman Group UK Ltd., England.	1989
5	Cary R. Spitzer and Cary Spitzer	Digital Avionic Systems	Prentice Hall, Englewood Cliffs, New Jersey, USA.	2000

WEB REFERENCE:

www.aircraftinstruments.com/
dcb.larc.nasa.gov/Introduction/Controls
www.mtu-online.com/mtuonsiteenergy/products/gas-engine-systems
academicearth.org/courses/aircraft-systems-engineering
www.efunda.com

KARPAGAM ACADEMY OF HIGHER EDUCATION

(Deemed to be University Established Under Section 3 of UGC Act 1956)

Faculty of Engineering

DEPARTMENT OF MECHANICAL ENGINEERING (AEROSPACE)

COURSE PLAN

Subject Name : **AIRCRAFT SYSTEMS AND AVIONICS**
Subject Code : **15BTAR503** (Credits - 3)
Name of the Faculty : **ARUN PRAKASH .J**
Designation : **ASSISTANT PROFESSOR**
Year/Semester/Section : **III/V Sem**
Branch : **B.Tech Aerospace Engineering**

Sl. No.	No. of Periods	Topics to be Covered	Support Materials
UNIT - I AIRCRAFT SYSTEMS			
1.	1	Hydraulic systems, Study of typical workable system, components	T [1] ,T [2]
2.	1	Hydraulic system controllers , Modes of operation	T [1] ,T [2]
3.	1	Pneumatic systems , Advantages , Working principles	T [1] ,T [2]
4.	1	Typical Air pressure system	T [1] ,T [2]
5.	1	Brake system	T [1] ,T [2]
6.	1	Typical Pneumatic power system ,Components	T [1] ,T [2]
7.	1	Landing Gear systems	T [1] ,T [2]
8.	1	Classification of Landing Gear systems	T [1] ,T [2]
9.	1	Shock absorbers, Retractive mechanism	T [1] ,T [2]
Total No. of Hours Planned for Unit - I			**9**

Sl. No.	No. of Periods	Topics to be Covered	Support Materials
UNIT - II AIRPLANE CONTROL SYSTEMS			
10.	1	Conventional Systems	T [1] ,T [2]
11.	1	Power assisted and fully powered flight controls , Power actuated systems	T [1] ,T [2]
12.	1	Push pull rod system – operating principles	T [1] ,T [2]
13.	1	Modern control systems	T [1] ,T [2]
14.	1	Digital fly by wire systems	T [1] ,T [2]
15.	1	Auto pilot system,	T [1] ,T [2]
16.	1	Active Control Technology	T [1] ,T [2]

17.	1	Engine control systems - Boeing	T [1] ,T [2]
18.	1	Engine control systems - Airbus	T [1] ,T [2]
Total No. of Hours Planned for Unit - II			**9**

Sl. No.	No. of Periods	Topics to be Covered	Support Materials
UNIT - III ENGINE SYSTEMS AND AUXILLIARY SYSTEMS			
19.	1	Fuel systems – Components	T [1] ,T [2] ,R [1]
20.	1	Multi-engine fuel systems,	T [1] ,T [2] , R [1]
21.	1	lubricating systems	T [1] ,T [2] , R [1]
22.	1	Starting and Ignition systems	T [1] ,T [2] , R [1]
23.	1	Basic Air cycle systems	T [1] ,T [2]
24.	1	Oxygen systems	T [1] ,T [2]
25.	1	Fire protection systems	T [1] ,T [2]
26.	1	Deicing systems.	T [1] ,T [2]
27.	1	Anti-icing systems.	T [1] ,T [2]
Total No. of Hours Planned for Unit - III			**9**

Sl. No.	No. of Periods	Topics to be Covered	Support Materials
UNIT - IV INTRODUCTION TO AVIONICS			
28.	1	Need for avionics in civil and military aircraft and space systems	T [3],R [2]
29.	1	Integrated avionics and weapon systems	T [3],R [2]
30.	1	Typical avionics subsystems, design, technologies	T [3],R [2]
31.	1	Introduction to digital computer and memories.	T [3],R [2]
32.	1	Avionics system architecture–	T [3],R [2]
33.	1	8085 Architecture– data buses —	T [3],R [2]
34.	1	ARINC – 420	T [3],R [2]
35.	1	ARINC – 629.	T [3],R [2]
36.	1	MIL-STD-1553B	T [3],R [2]
Total No. of Hours Planned for Unit - IV			**9**

Sl. No.	No. of Periods	Topics to be Covered	Support Materials
UNIT – V AVIONICS SYSTEMS			
37.	1	Control and display technologies	T [3],R [2]
38.	1	CRT, LED, LCD	T [3],R [2]
39.	1	EL and plasma panel-	T [3],R [2]
40.	1	Civil cockpit and military cockpit:	T [3],R [2]
41.	1	MFDS, HUD, MFK, HOTAS-	T [3],R [2]
42.	1	Communication Systems -	T [3],R [2]
43.	1	Navigation systems ADF, DME, VOR.	T [3],R [2]

44.	1	LORAN, OMEGA, ILS, MLS	T [3],R [2]
45.	1	Air Data Systems	T [3],R [2]
46.	1	Previous Year Question paper Discussion	
Total No. of Hours Planned for Unit - V			**9+1**

TOTAL PERIODS : 46

TEXT BOOKS

T [1] – Aircraft Systems: Mechanical, Electrical and Avionics Subsystems Integration by Ian Moir

T [2] – Aircraft Systems - David Lombardo

T [3] - Introduction to Avionics Systems – R. P. G. Collinson.

REFERENCES

R [1] - Aircraft Power Plants by Mekinley, J.L. and Bent, R.D.

R [2] - Digital Avionic Systems – Spitzer, C.R.

WEBSITES

W [1] - dcb.larc.nasa.gov/Introduction/Controls

W [2] - Avionics - YouTube

W [3] – academicearth.org/courses/aircraft-systems-engineering

JOURNALS

J [1] - Aerospace Science and Technology - Journal - Elsevier

J [2] –Journal of Aerospace Engineering - ASCE Library

J [3] – Journal of Aircraft - AIAA

UNIT	Total No. of Periods Planned	Lecture Periods	Tutorial Periods
I	9	9	-
II	9	9	-
III	9	9	-
IV	9	9	-
V	9+1	9	-
TOTAL	46	45	-

I. CONTINUOUS INTERNAL ASSESSMENT : 40 Marks

(Internal Assessment Tests: 30, Attendance: 5, Assignment/Seminar: 5)

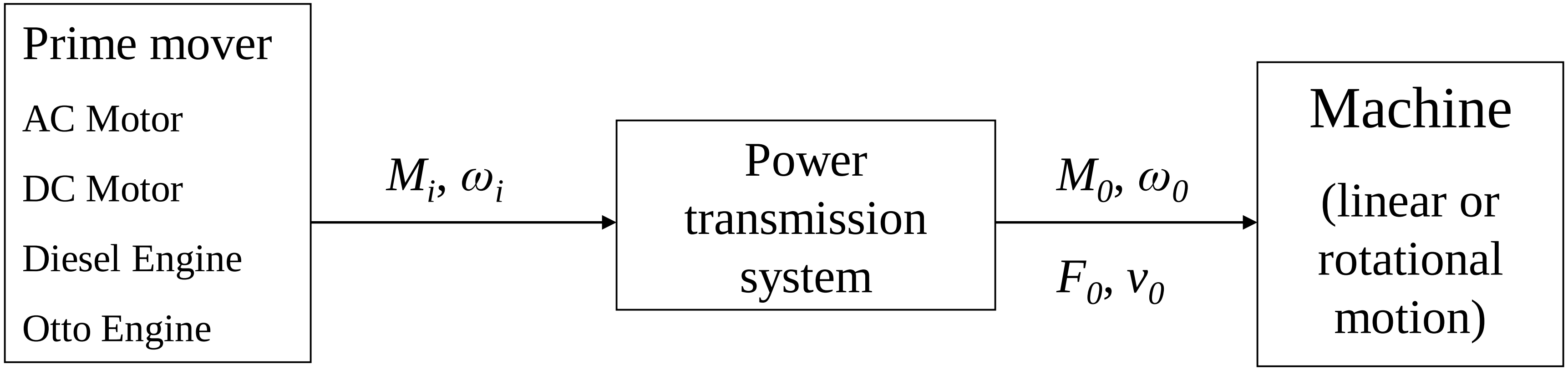
II. END SEMESTER EXAMINATION : 60 Marks

TOTAL : 100 Marks

FACULTY **COORDINATOR/ AERO** **HOD / MECH** **DEAN / FOE**

Aircraft Hydraulic and Pneumatic Systems

Power train



power transmission:

- Gears
- Belt drive
- Friction drive
- Rigid couplings
- Clutches

Properties:

- Continuously variable drive is difficult
- The relative spatial position of prime mover is fixed
- If the motor is electrical (DC motor or AC motor with variable frequency), then the rotational speed can be continuously changed but they are expensive

Hydraulic power transmission

power transmission:

Hydro = water, aulos = pipe

The means of power transmission is a liquid (pneumatic → gas)

Hydrodynamic power transmission:

- Turbo pump and turbine
- Power transmission by kinetic energy of the fluid
- Still the relative spatial position is fixed
- Compact units

Hydrostatic power transmission:

- Positive displacement pump
- Creates high pressure and through a transmission line and control elements this pressure drives an actuator (linear or rotational)
- The relative spatial position is arbitrary but should not be very large because of losses (< 50 m)

✓ A continuously variable transmission is possible

Most of this lecture will be about hydrostatic systems (in common language it is also called simply hydraulics)

Hydrostatic vs hydrodynamic systems

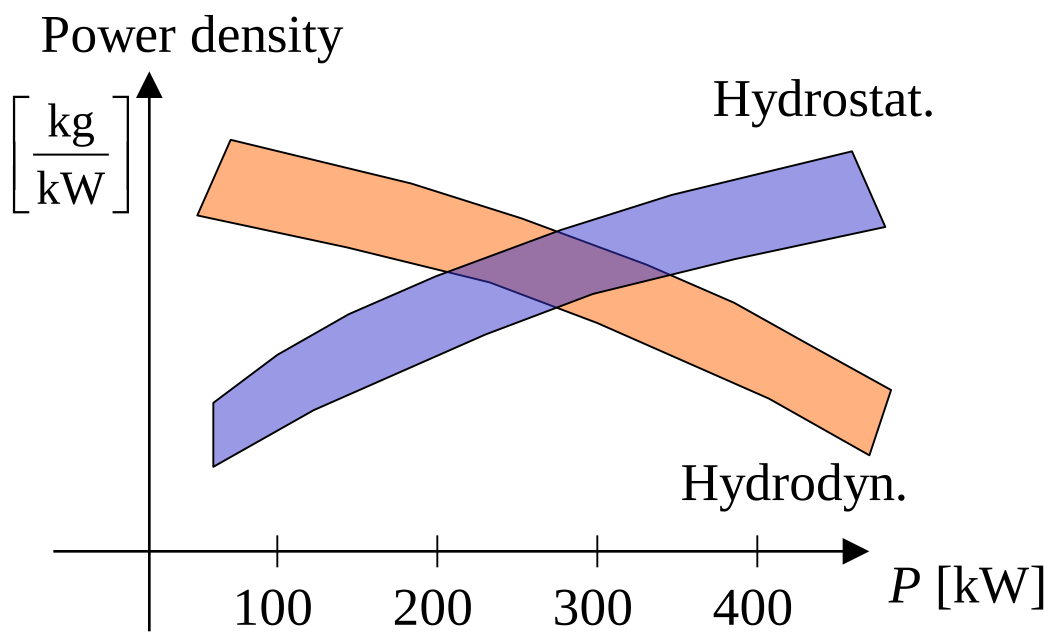
Roughly speaking:

$P = \Delta p \cdot Q$

Large Q, small Δp →
hydrodynamic transmission

Large Δp, small Q →
hydrostatic transmission.

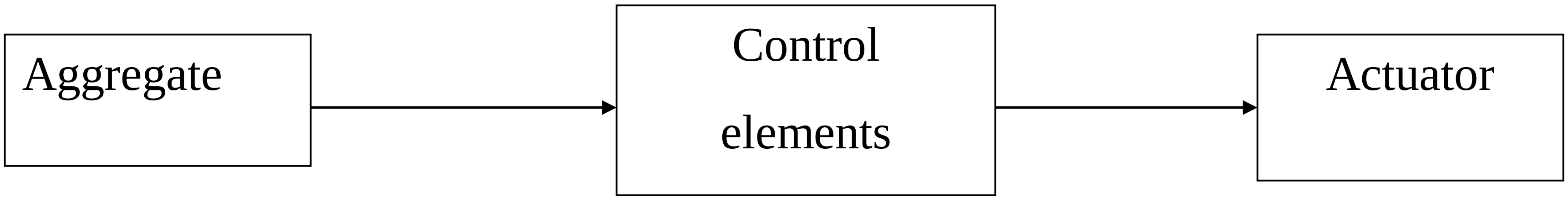
But there is no general rule,
depends on the task.



- Generally larger than 300 kW power hydrodynamic is more favourable.
- But for soft operation (starting of large masses) hydrodynamic is used for smaller powers either.

- ❑ Linear movement against large forces: hydrostatic
- ❑ Linear movement and stopping in exact position: also hydrostatic

Structure of a hydrostatic drive



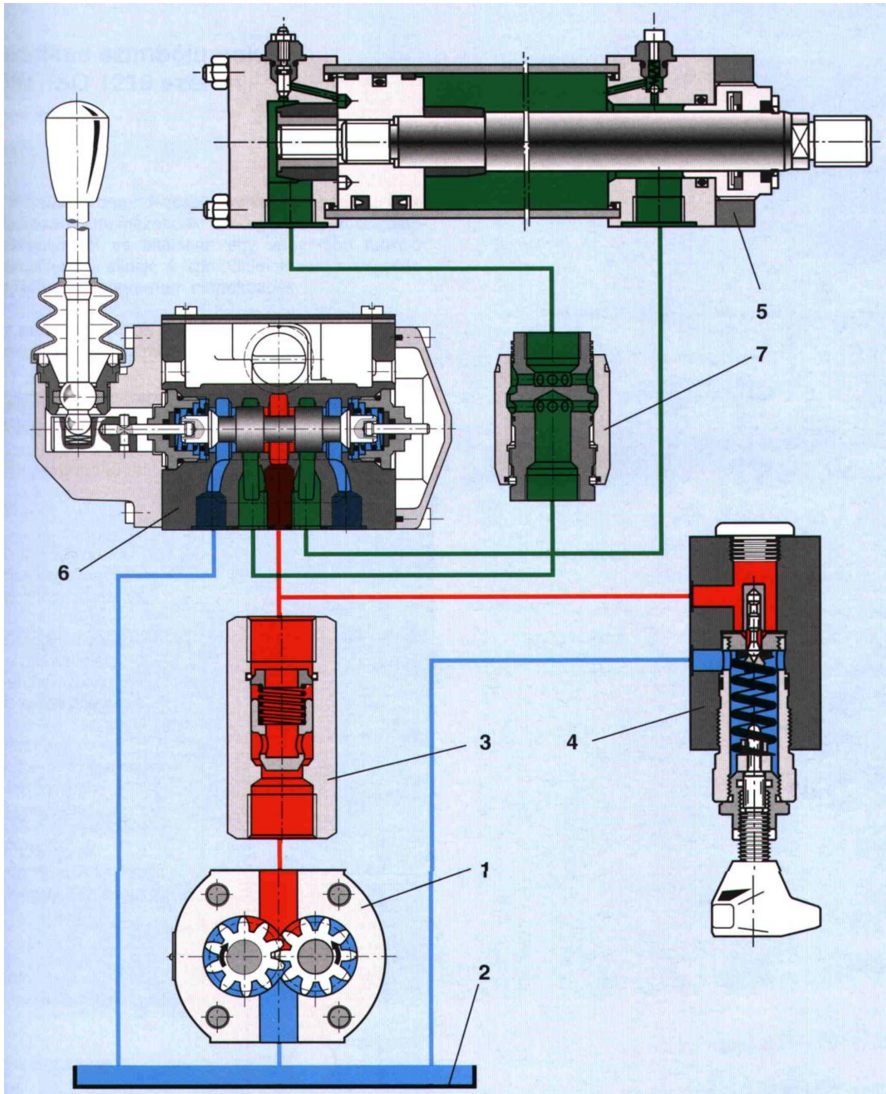
Pump, motor
Fluid reservoir
Pressure relief valve
Filter
Piping

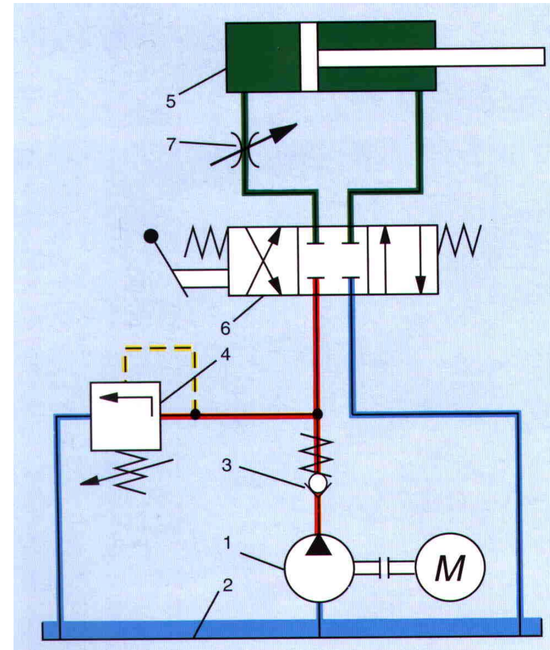
Valves, determining the path, pressure, flow rate of the working fluid

Elements doing work
- Linear
- Rotational
- Swinging

These components and their interaction is the subject of this semester

A typical hydraulic system





1 – pump
2 – oil tank
3 – flow control valve
4 – pressure relief valve
5 – hydraulic cylinder
6 – directional control valve
7 – throttle valve

Advantages of hydrostatic drives

- Simple method to create linear movements
- Creation of large forces and torques, high energy density
- Continuously variable movement of the actuator
- Simple turnaround of the direction of the movement, starting possible under full load from rest
- Low delay, small time constant because of low inertia
- Simple overload protection (no damage in case of overload)
- Simple monitoring of load by measuring pressure
- Arbitrary positioning of prime mover and actuator
- Large power density (relatively small mass for a given power compared to electrical and mechanical drives)
- Robust (insensitive against environmental influences)

Disadvantages of hydrostatic drives

- Working fluid is necessary (leakage problems, filtering, etc.)
- It is not economic for large distances

Hydraulic fluids - tasks

They have the following primary tasks:

- Power transmission (pressure and motion transmission)
- Signal transmission for control

Secondary tasks:

- Lubrication of rotating and translating components to avoid friction and wear
- Heat transport, away from the location of heat generation, usually into the reservoir
- Transport of particles to the filter
- Protection of surfaces from chemical attack, especially corrosion

Hydraulic fluids - requirements

- Functional
  - Good lubrication characteristics
  - Viscosity should not depend strongly on temperature and pressure
  - Good heat conductivity
  - Low heat expansion coefficient
  - Large elasticity modulus

- Economic
  - Low price
  - Slow aging and thermal and chemical stability $\Rightarrow$ long life cycle

Hydraulic fluids - requirements (contd.)

- Safety
  - High flash point or in certain cases not inflammable at all
  - Chemically neutral (not aggressive at all against all materials it touches)
  - Low air dissolving capability, not inclined to foam formation

- Environmental friendliness
  - No environmental harm
  - No toxic effect

Hydraulic fluid types

1. Water (3%) ↑
2. Mineral oils (75%) ↓
3. Not inflammable fluids (9%)
4. Biologically degradable fluids (13%) ↑
5. Electrorheological fluids (in development)

Hydraulic fluid types (contd.)

1. Water:

- Clear water
- Water with additives

- Oldest fluid but nowadays there is a renaissance
- Used where there is an explosion or fire danger or hygienic problem: Food and pharmaceutical industry, textile industry, mining

Advantages:

- No environmental pollution
- No disposal effort
- Cheap
- No fire or explosion danger
- Available everywhere
- 4 times larger heat conduction coefficient than mineral oils
- 2 times higher compression module than mineral oils
- Viscosity does not depend strongly on temperature

Hydraulic fluid types (contd.)

1. Water:

Disadvantages:

- Bad lubrication characteristics
- Low viscosity (problem of sealing, but has good sides: low energy losses)
- Corrosion danger
- Cavitation danger (relatively high vapour pressure)
- Limited temperature interval of applicability (freezing, evaporating)

Consequences: needs low tolerances and very good materials (plastics, ceramics, stainless steel) $\Rightarrow$ components are expensive

Hydraulic fluid types (contd.)

2. Mineral oil:

- Without additives
- With additives

o „Conventional” use, stationary hydraulics

o Always mixtures of different oils, often with additives

Additives:

- decrease corrosion
- increase life duration
- improve temperature dependence of viscosity
- improve particle transport

Advantages:

- Good lubrication
- High viscosity (good for sealing, bad for losses)
- Cheap

Disadvantages:

- Inflammable
- Environmental pollution

Hydraulic fluid types (contd.)

3. Not inflammable fluids:

- Contains water
- Does not contain water

- o mines, airplane production, casting, rolling, where there is explosion and fire danger
- o Water-oil emulsions (oil synthetic) or water-free synthetic liquids

Disadvantages:

- Higher density, higher losses, more inclination to cavitation
- Limited operational temperature < 55 °C
- Worse lubrication characteristics, reduction of maximum load
- Worse de-aeration characteristics
- Sometimes chemically aggressive against sealing materials

Hydraulic fluid types (contd.)

4. Biologically degradable fluids:

- Natural
- Synthetic

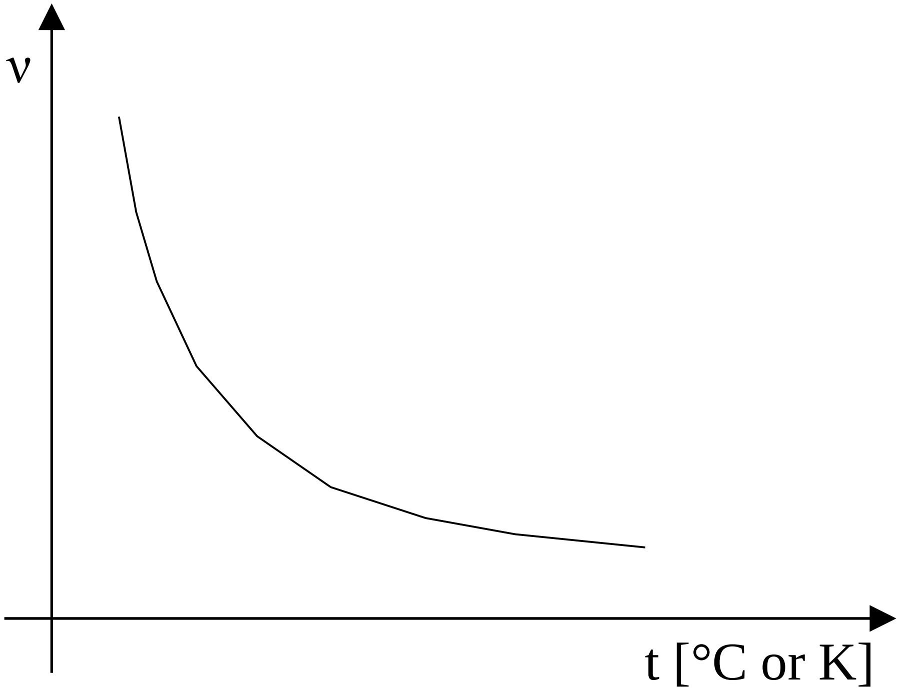
- Environmental protection, water protection
- Agricultural machines
- Mobile hydraulics

Characteristics similar to mineral oils but much more expensive.

If the trend continues its usage expands, price will drop.

Properties of hydraulic fluids

Viscosity: well-known



Temperature dependence

⇒ log-log scale

Ubbelohde-Walther:

$$\lg(\lg(\nu + c)) = K_v - m \cdot \lg T$$

c, m, K_v are constants,

T is in K

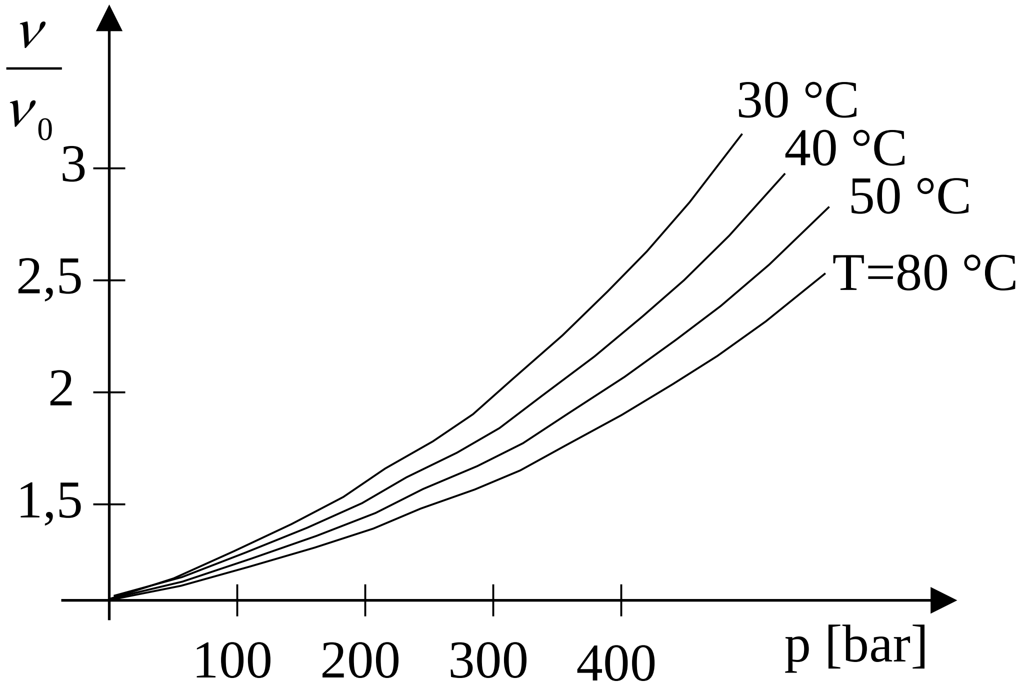
Vogel-Cameron:

$$\mu_t = A \cdot e^{\frac{B}{t+c}}$$

A, B, C are constants,

t is in °C

Properties of hydraulic fluids (contd.)



Pressure dependence of viscosity

$$\mu_p = \mu_0 \cdot e^{\alpha p}$$

μ_0, ν_0 viscosity at atmospheric pressure

Temperature dependence of density is small

Density dependence on pressure:

$$\frac{\Delta V}{V} = -\frac{\Delta p}{K}$$

like Hooke's law, K is the compressibility

K is not a constant but depends on pressure itself

effective K is also influenced by:

- ☞ Air content
- ☞ Flexibility of the pipe

Hydraulic Fluids

Air content in oil is harmful.

Sucking air with the pump happens but is by proper installation avoidable.

The oil is quickly into solution during the increasing pressure.

Air bubbles come to oil mostly so that with decreasing pressure the air „goes out of solution”.

$$V_a = V_f \cdot \alpha \cdot \frac{p_2}{p_1}$$

α - dissolving coefficient at normal pressure

At normal pressure $V_a = V_f$.

At high pressure, the volume of the dissolved air is much more than the volume of the liquid.

When the pressure drops the air leaves the solution suddenly but the dissolution happens gradually.

Problems with air content:

- Sudden, jerky movements, oscillation, noise
- Late switching
- Reduced heat conduction
- Accelerated aging of the liquid, disintegration of oil molecules
- Cavitation erosion

$$K_{mixture} = K_l \frac{\frac{V_f}{V_{a0}} + 1}{\frac{V_f}{V_{a0}} + K_l \frac{p_0}{p^2}}$$

K_l	:	liquid compressibility
V_f	:	volume of liquid
V_{a0}	:	volume of gas in normal state
p_0	:	normal pressure
p	:	p under investigation

Hydraulic Fluids

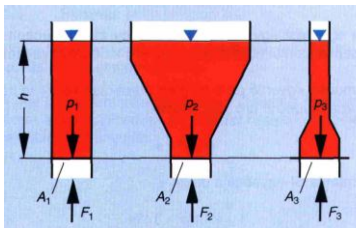
The manufacturer specifies the characteristics of the required liquid and the duration of usage.

Before filling in the new oil, the rig has to be washed with oil.

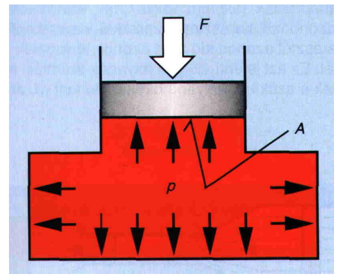
Never mix old and new oil!

Calculation basics

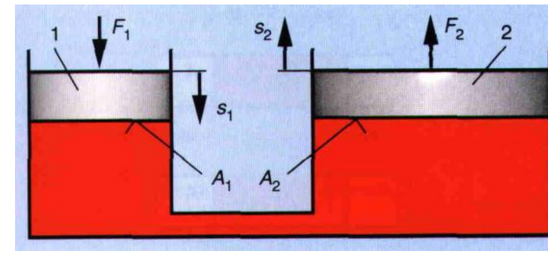
a) Hydrostatic pressure



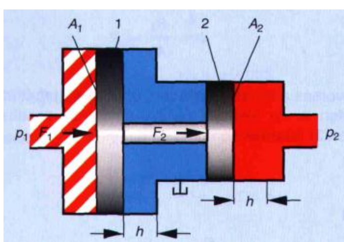
b) Pascals's law



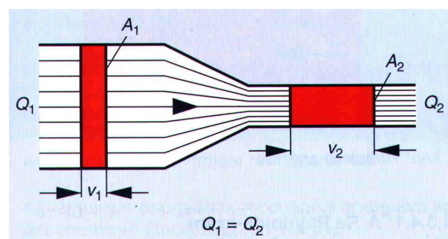
c) Transmission of power



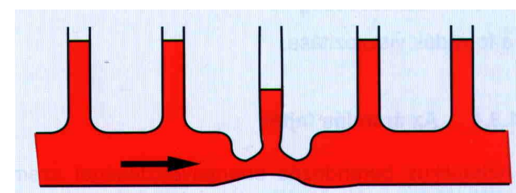
d) Transmission of pressure



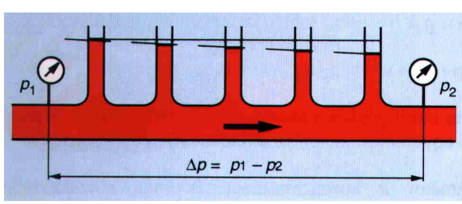
e) Continuity



g) Bernoulli equation



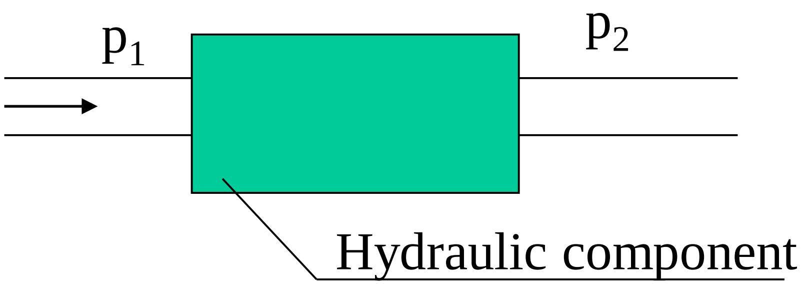
f) Flow resistance



Flow resistance:

$$p_1 - p_2 = \Delta p_{loss} = f\left(Q\right)$$

$$\Delta p_{loss} = \zeta \frac{\rho}{2} \bar{v}^2 \text{ or } \Delta p_{loss} = \zeta \frac{\rho}{2} \frac{Q^2}{A^2}$$



Calculation basics:

If the two cross sections are not the same then:

$$p_1 - p_2 = \frac{\rho}{2}\left(\bar{v}_2^2 - \bar{v}_1^2\right) + \Delta p_{loss}$$

$$\Delta p_{loss} = \zeta_{1,2}\frac{\rho}{2}\bar{v}_{1,2}^2 \text{ or } \Delta p_{loss} = \zeta_{1,2}\frac{\rho}{2}\frac{Q^2}{A_{1,2}^2}$$

$$\frac{\zeta_1}{\zeta_2} = \frac{A_1^2}{A_2^2}$$

$$\zeta = \zeta(\text{Re}) \qquad \text{Re} = \frac{d_h \cdot \bar{v}}{\nu} \qquad d_h = \frac{4A}{U}$$

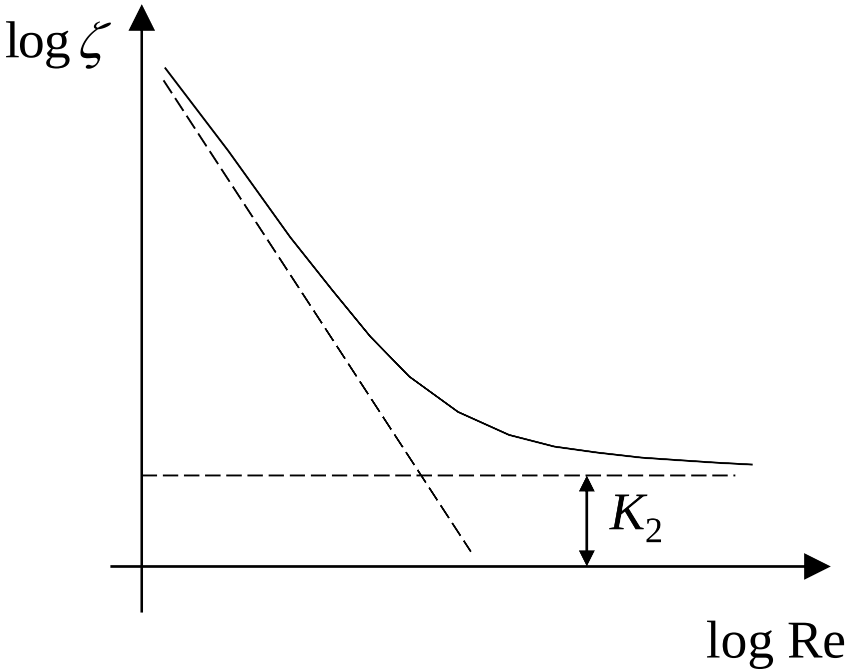
For a straight, stiff pipe:

$$\zeta = \lambda \cdot \frac{l}{d_h}, \lambda = \begin{cases} \dfrac{64}{\text{Re}} & \text{laminar} \\ \dfrac{0{,}3164}{\sqrt[4]{\text{Re}}} & \text{turbulent} \end{cases}$$

<u>Calculation basics:</u>

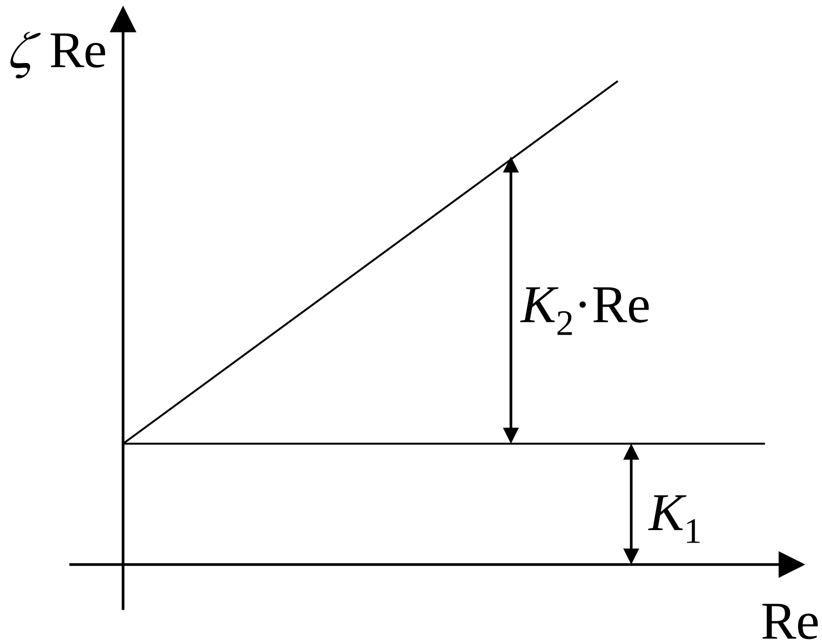
Usually the function $\zeta = \zeta(\text{Re})$ looks like the following:

$$\zeta = \frac{K_1}{\text{Re}} + K_2$$



Practically:

$$\zeta\,\text{Re} = K_1 + K_2 \cdot \text{Re}$$



Calculation basics

Calculation basics:

On this basis we can define two hydraulic resistances:

$$\Delta p_{l1} = R_h \cdot Q$$

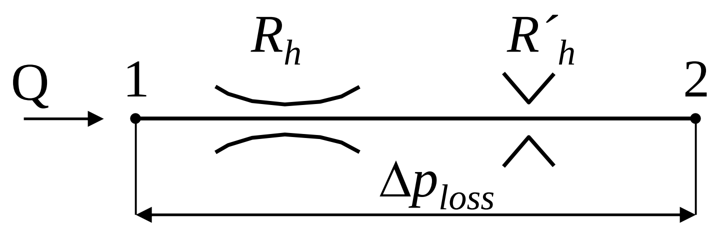
$$R_h = \frac{\rho \cdot \nu \cdot K_1}{2 d_h \cdot A}$$

Depends on viscosity

$$\Delta p_{l2} = R_h' Q^2$$

$$R_h' = \frac{\rho \cdot K_2}{2 A^2}$$

Does not depend on viscosity



Calculation basics

Three different coefficients are used to express pressure loss:

$$Q = A \cdot \alpha \cdot \sqrt{\frac{2}{\rho} \Delta p} \qquad Q = G_h \cdot \Delta p_1 \qquad Q = G_h' \cdot \sqrt{\Delta p_2}$$

$$\alpha = \sqrt{\frac{1}{\zeta}} \qquad G_h = \frac{2 d_h \cdot A}{\rho \cdot \nu \cdot K_1} \qquad G_h' = \sqrt{\frac{2}{\rho \cdot K_2}} \cdot A$$

G_h: Hydraulic admittance

For elbows, sudden expansions, T-pieces, etc. values are given as a function of Re, roughness and geometric parameters

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For a series circuit:

$$\Delta p_{total} = \sum_{i=1}^{n} \Delta p_i \text{ and } Q = Q_i$$

For a parallel circuit:

$$Q_{total} = \sum_{i=1}^{n} Q_i \text{ and } \Delta p = \Delta p_i$$

Leakage losses

Leakage losses:

- External losses
- Internal losses

Occur always when components move relative to each other

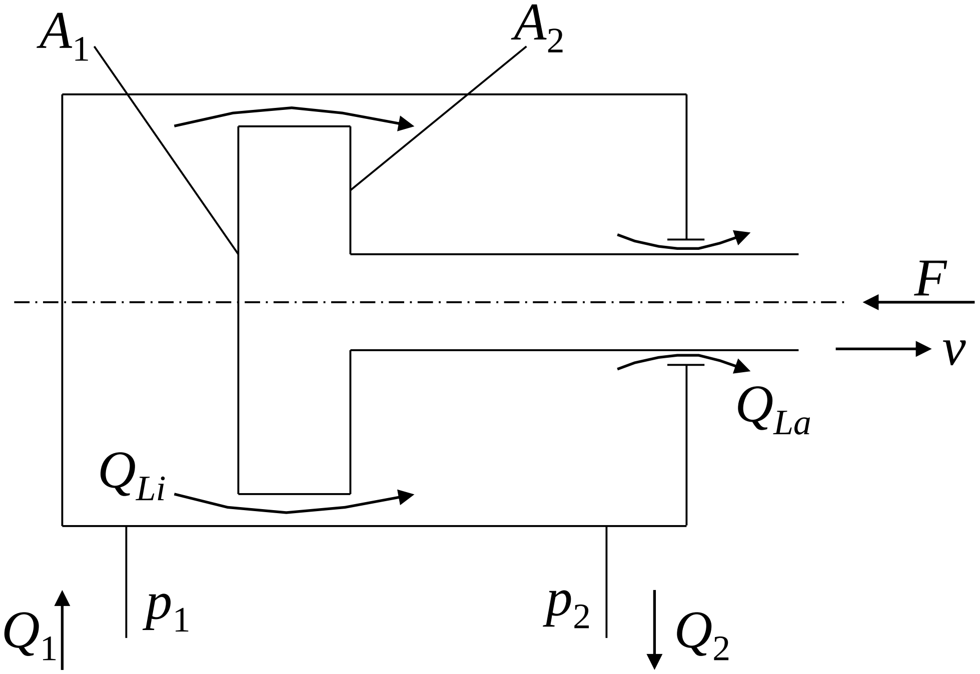
They reduce efficiency

In case of external leakages there is environmental damage and the lost fluid has to be refilled. External losses can be avoided by careful design and maintenance.

Internal losses cannot be avoided.

Leakage losses

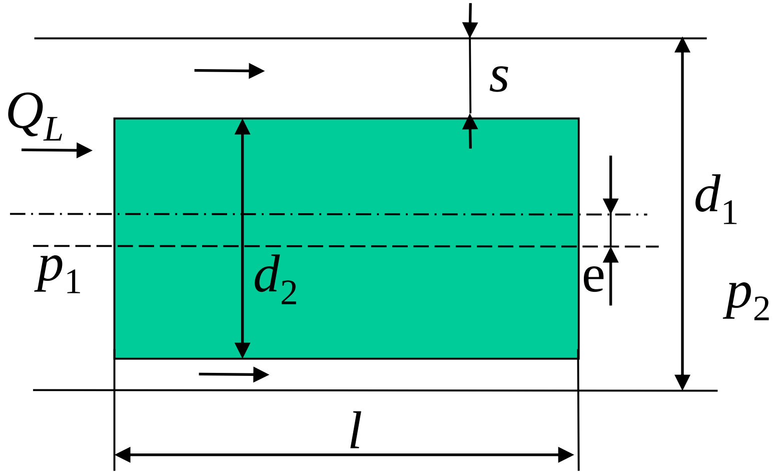
$$p_1 = \frac{F}{A_1} + p_2 \frac{A_2}{A_1}$$

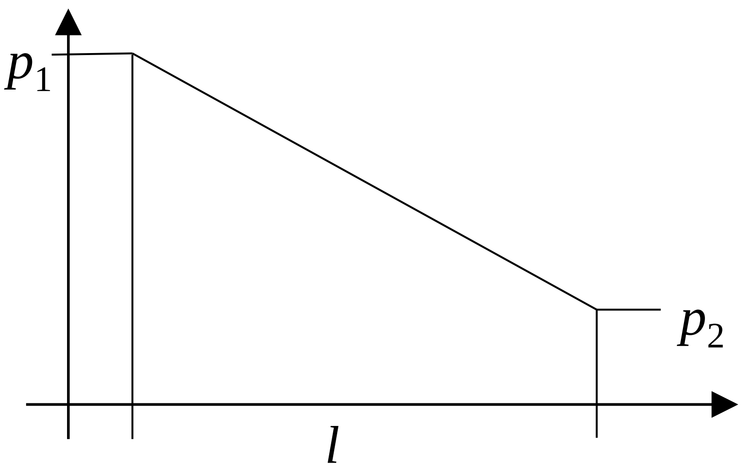


$$v = \frac{Q_1}{A_1} - \frac{G_{Li}}{A_1}\left[\frac{F}{A_1} - p_2\left(1 - \frac{A_2}{A_1}\right)\right]$$

$$Q_2 = Q_1 \frac{A_2}{A_1} + G_{Li}\left(1 - \frac{A_2}{A_1}\right)\left[\frac{F}{A_1} - p_2\left(1 - \frac{A_2}{A_1}\right)\right] - p_2 G_{La}$$

Leakage losses





$$s << d_1$$

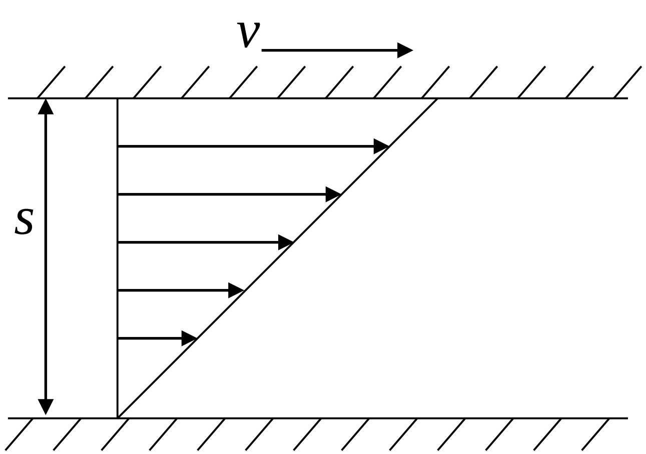
$$Q_L \approx \frac{d_m \cdot \pi \cdot s_m^3}{12 \cdot \nu \cdot l \cdot \rho} \Delta p \left(1 + \frac{3}{2} \frac{e^2}{s_m^2}\right)$$

$$G_L \approx \frac{d_m \cdot \pi \cdot s_m^3}{12 \cdot \nu \cdot l \cdot \rho} \left(1 + \frac{3}{2} \frac{e^2}{s_m^2}\right)$$

$$d_m = \frac{d_1 + d_2}{2} \qquad s_m = \frac{d_1 - d_2}{2}$$

Leakage losses

- the eccentricity increases the leakage flow by a factor of 2,5 if *e* increases to the limit
- $Q_L \sim s^3_m$!
- Because of the large Δp, there are large temperature differences along *l*. Medium viscosity has to be substituted.
- In addition there is a Couette flow – dragged flow, which increases or decreases the leakage



$$Q_d = \frac{v \cdot s \cdot b}{2}$$

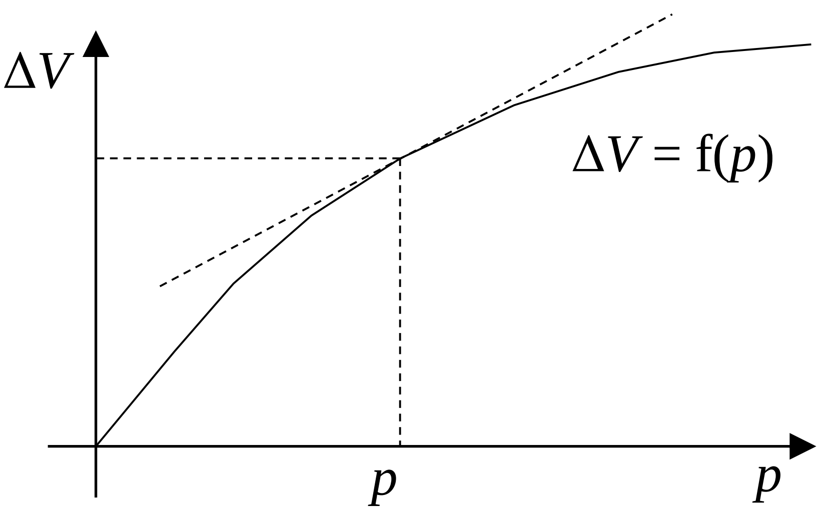
$$Q_L = G_L \cdot \Delta p \pm \frac{v \cdot s_m \cdot d_m \cdot \pi}{2}$$

Hydraulic capacity and inductivity

Hydraulic capacity:

All the things discussed so far referred to steady processes. In practice, however, very often unsteady processes are encountered: starting, stopping, change of load, change of direction of motion, etc.

In these cases the compressibility of the fluid and the pipes, and the inertia of the fluid have to be taken into consideration.



Nonlinear function.

It can be locally linearized and:

$$\frac{d\Delta V}{dp} = C_h, \text{ hydraulic capacity.}$$

Hydraulic capacity:

The capacity has three parts:

$$C_h = C_{fl} + C_{pipe} + C_{accumulator}$$

The capacitive flow rate:

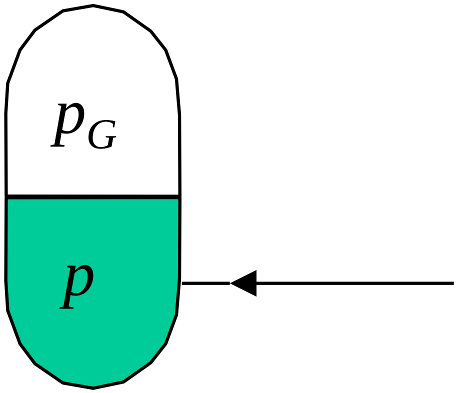
$$Q_c = \Delta \dot{V}_c = C_h \cdot \dot{p} \Rightarrow p = \frac{1}{C_h} \cdot \int Q_c \mathrm{d}t$$

$$C_{fl} = \frac{V_0}{K}$$ K compression module

C_{pipe} is negligible if the pipe is made of metal

C_{pipe} is not negligible if the pipe is flexible.

$$C_{accumulator} = \frac{V_1}{n \cdot p} \cdot \left(\frac{p_G}{p}\right)^{\frac{1}{n}}$$, n is the polytropic exponent.



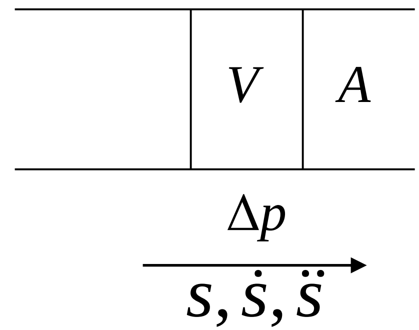
Hydraulic capacity and inductivity

Hydraulic inductivity:

$$\Delta p \cdot A = \rho \cdot V \cdot \ddot{s},\ \ \ddot{s} = \frac{\dot{Q}}{A}$$

$$\Delta p = \frac{V \cdot \rho}{A^2}\dot{Q}$$

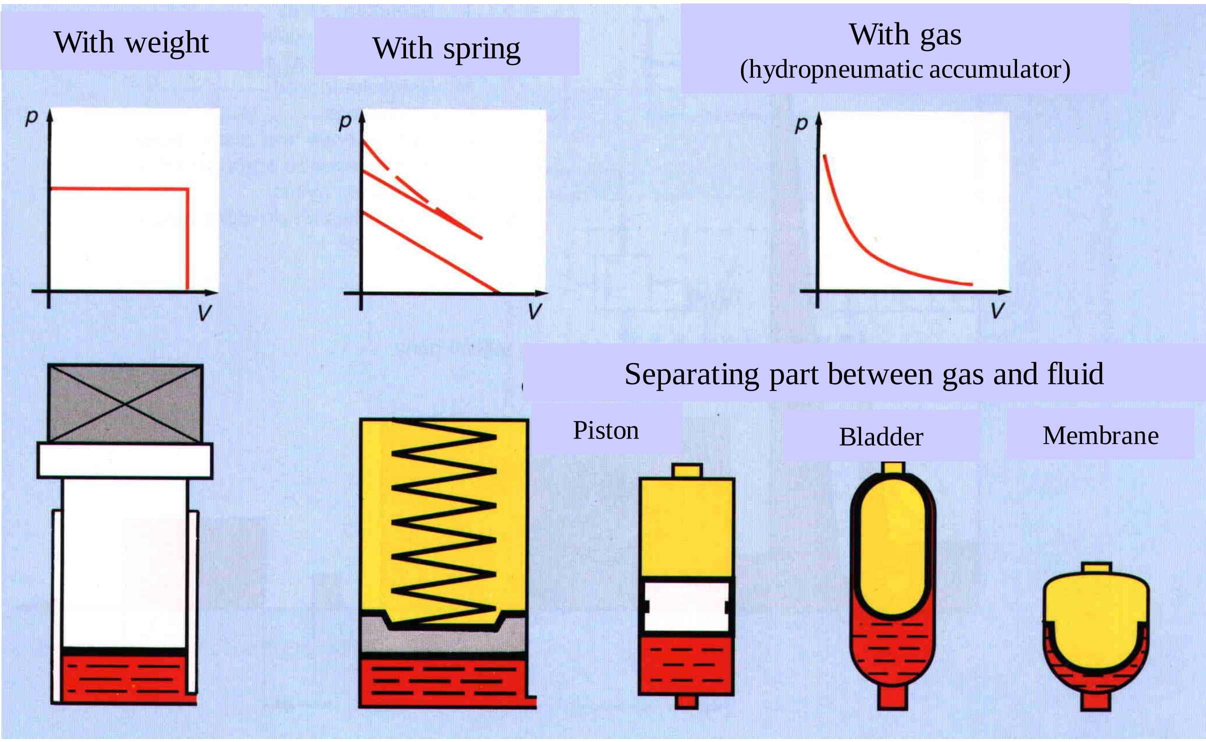
$$\Delta p = L_h \cdot \dot{Q}_{in} \ \Rightarrow \ Q_{in} = \frac{1}{L_h}\int \Delta p \mathrm{d}t$$



$L_{total} = L_h + L_{sol}$, where L_{sol} is the inertia of solid parts.

Hydraulic Accumulators

Constructions and tasks in the hydraulic system



Constructions

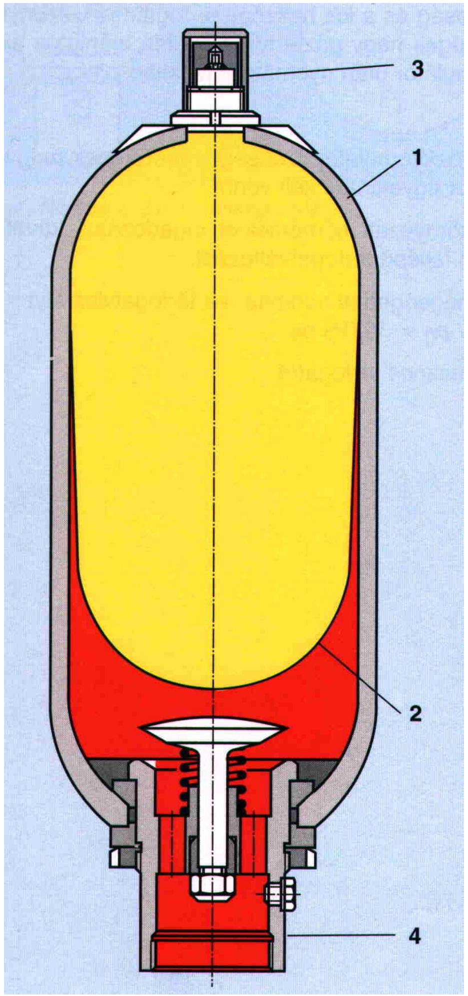
Tasks:

The hydropneumatic accumulators perform different tasks in the hydraulic systems, e.g.:

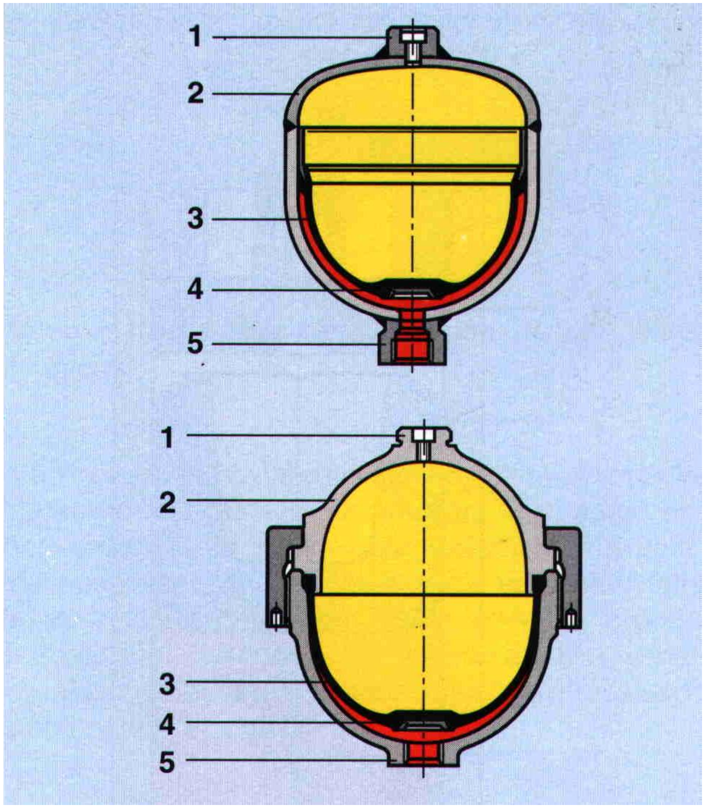
- reserve energy
- store fluid
- emergency operate
- force compensating
- damp mechanical shocks
- absorb pressure oscillations
- compensate leakage losses
- springs in vehicles
- recover of braking energy
- stabilize pressure
- compensate volumetric flow rate (expansion reservoir)

Hydraulic Accumulators

Constructions



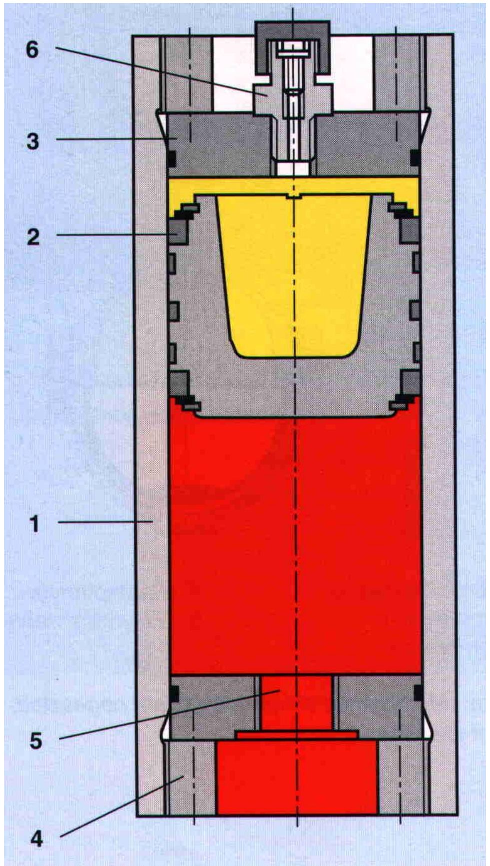
With bladder



With membrane

above welded

below screwed



With piston

Hydraulic Accumulators

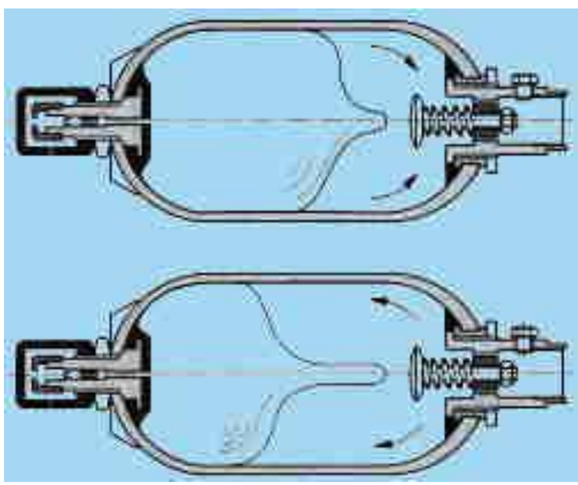
Working states of hydroaccumulators with bladder:

This installation is practically a bladder filled with gas and placed in a tank made out of steal. The bladder is filled with carbon dioxide (gas pressure). At the starting of the pump the fluid flows in the tank and compresses the gas. When required (if there is a high enough pressure difference) the fluid flows very quickly back in the system.

Requirements on the system side:

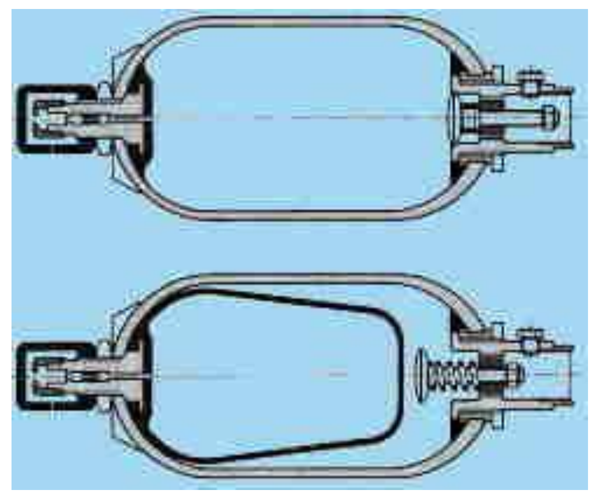
- locks both in the T and P lines,
- controlled release valves,
- juncture for pressure manometer (mostly built with the hydroaccumulator together),
- throw back valve in the P line.

Fluid flows out



Fluid flows in

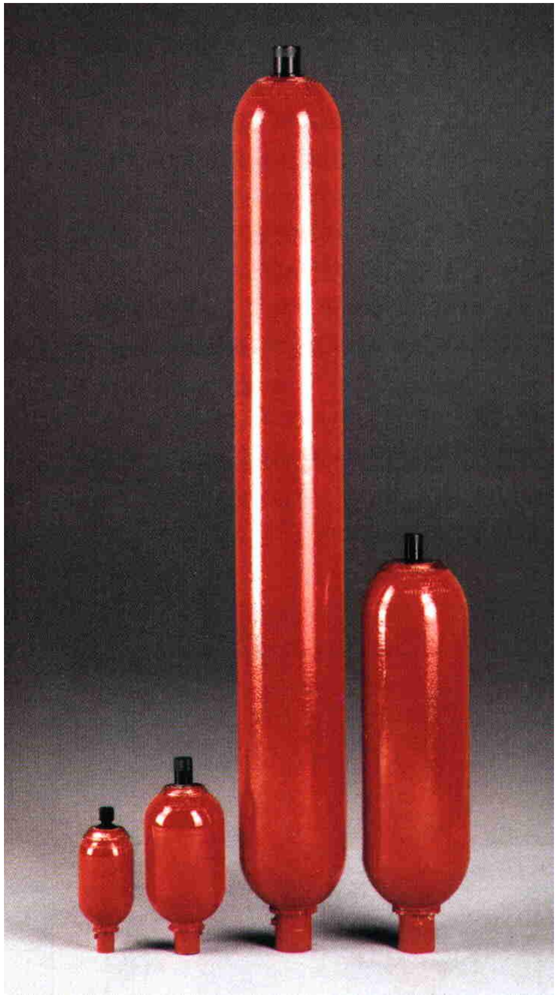
Hydroaccumulator with pre-stressed bladder



pressureless, without pre-stress

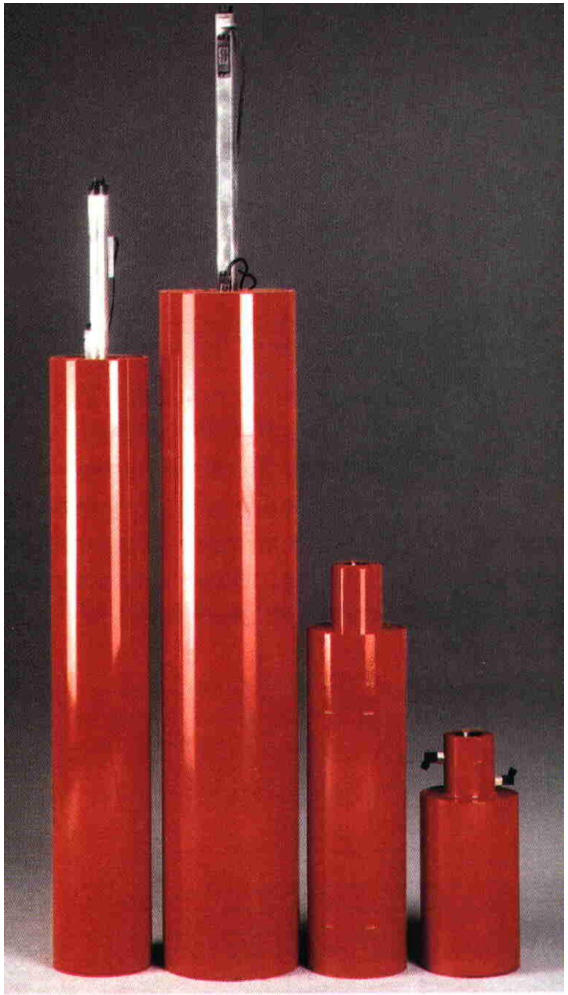
Hydraulic Accumulators

Construction



Bladder

Membrane



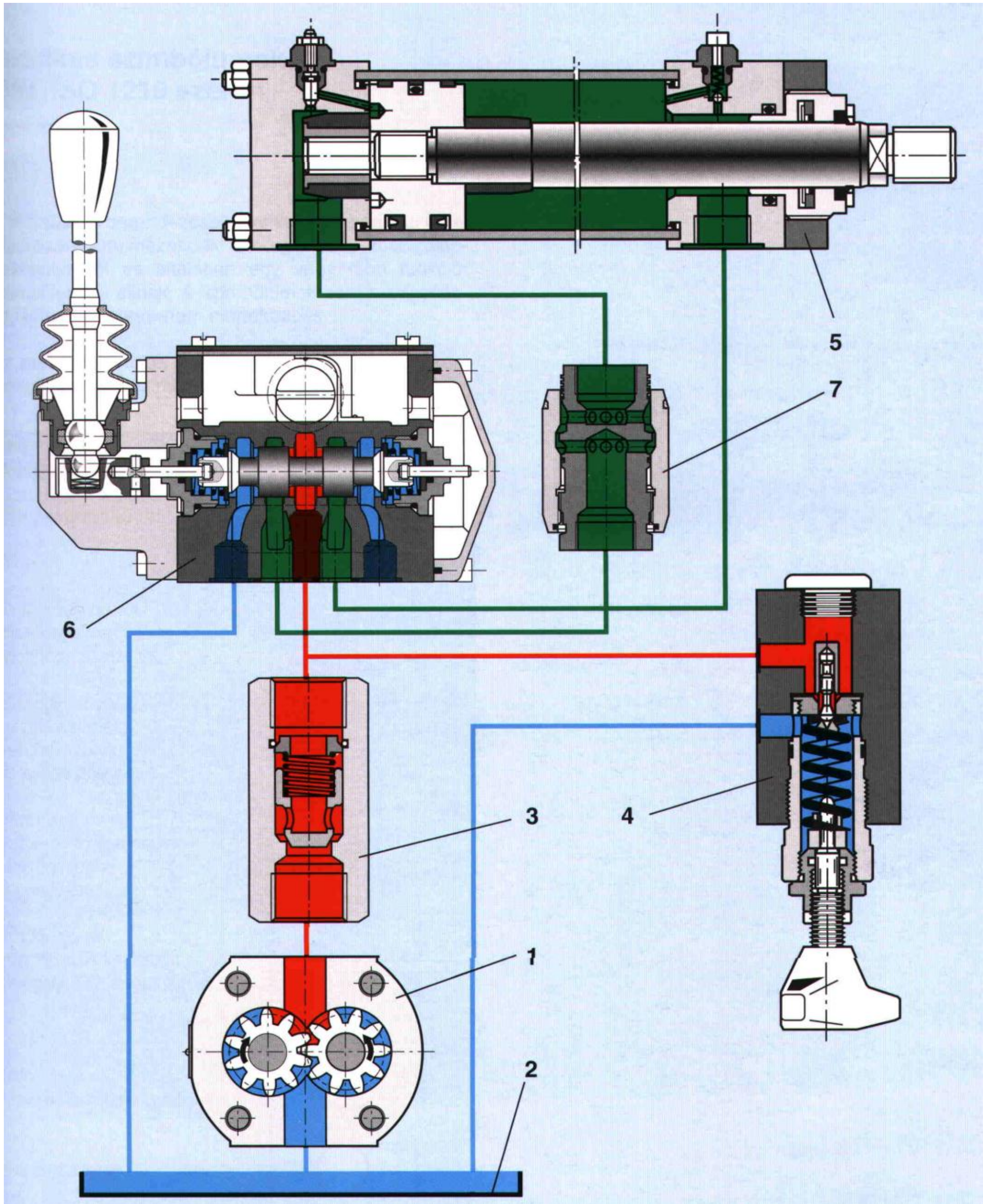
Piston

Big pictures

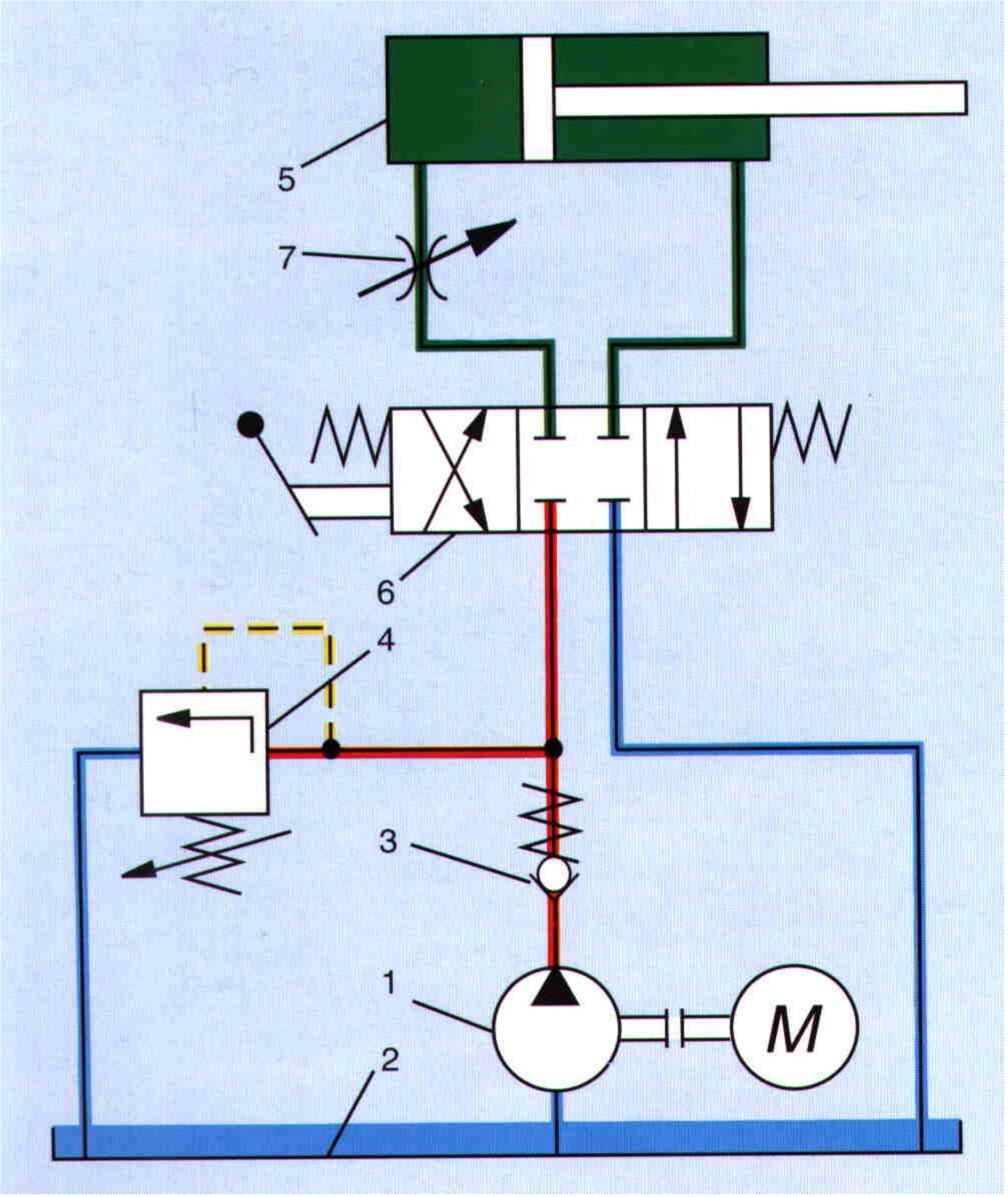
End of normal presentation

Beginning of big pictures

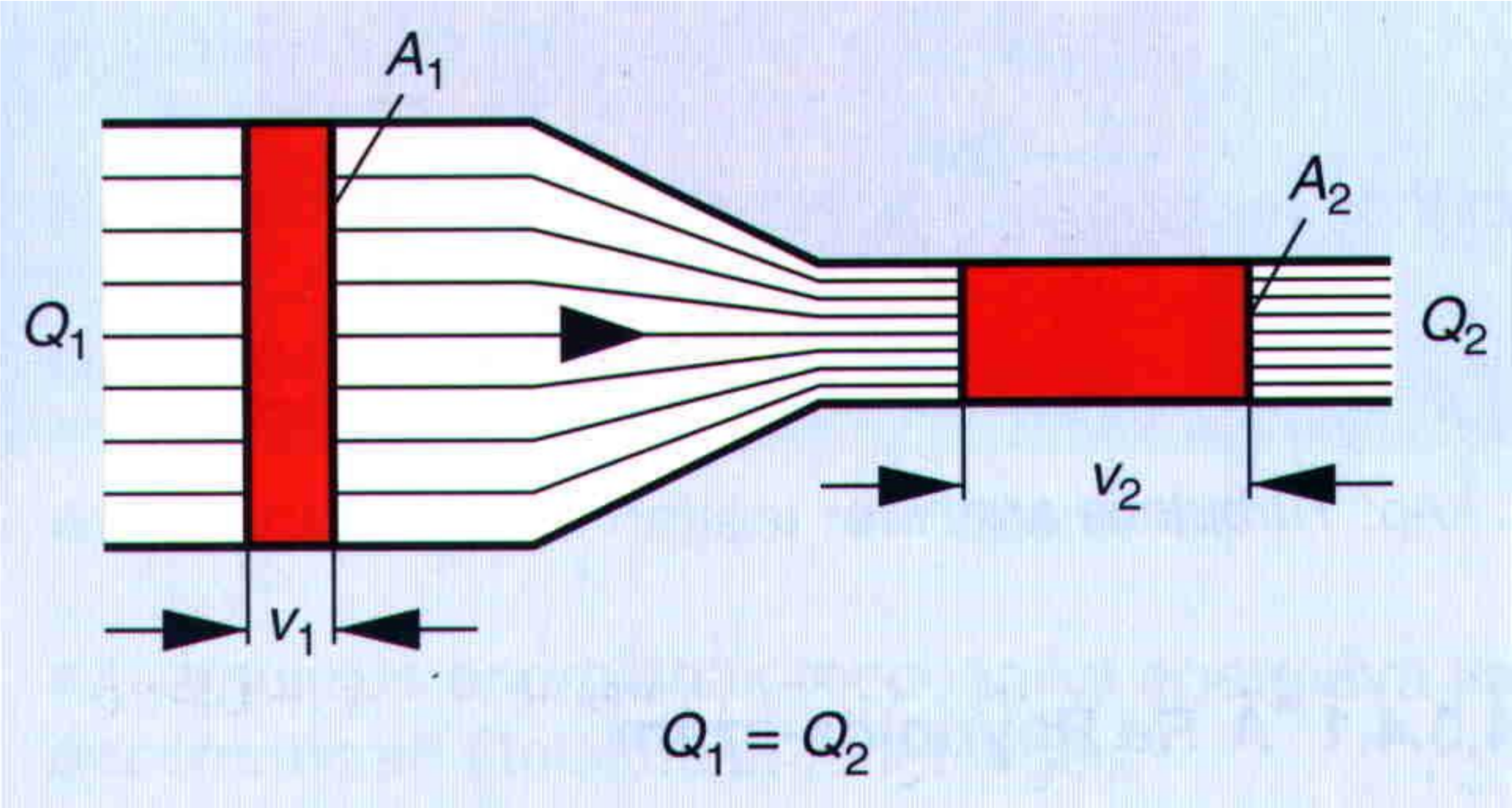
Hydraulic Systems



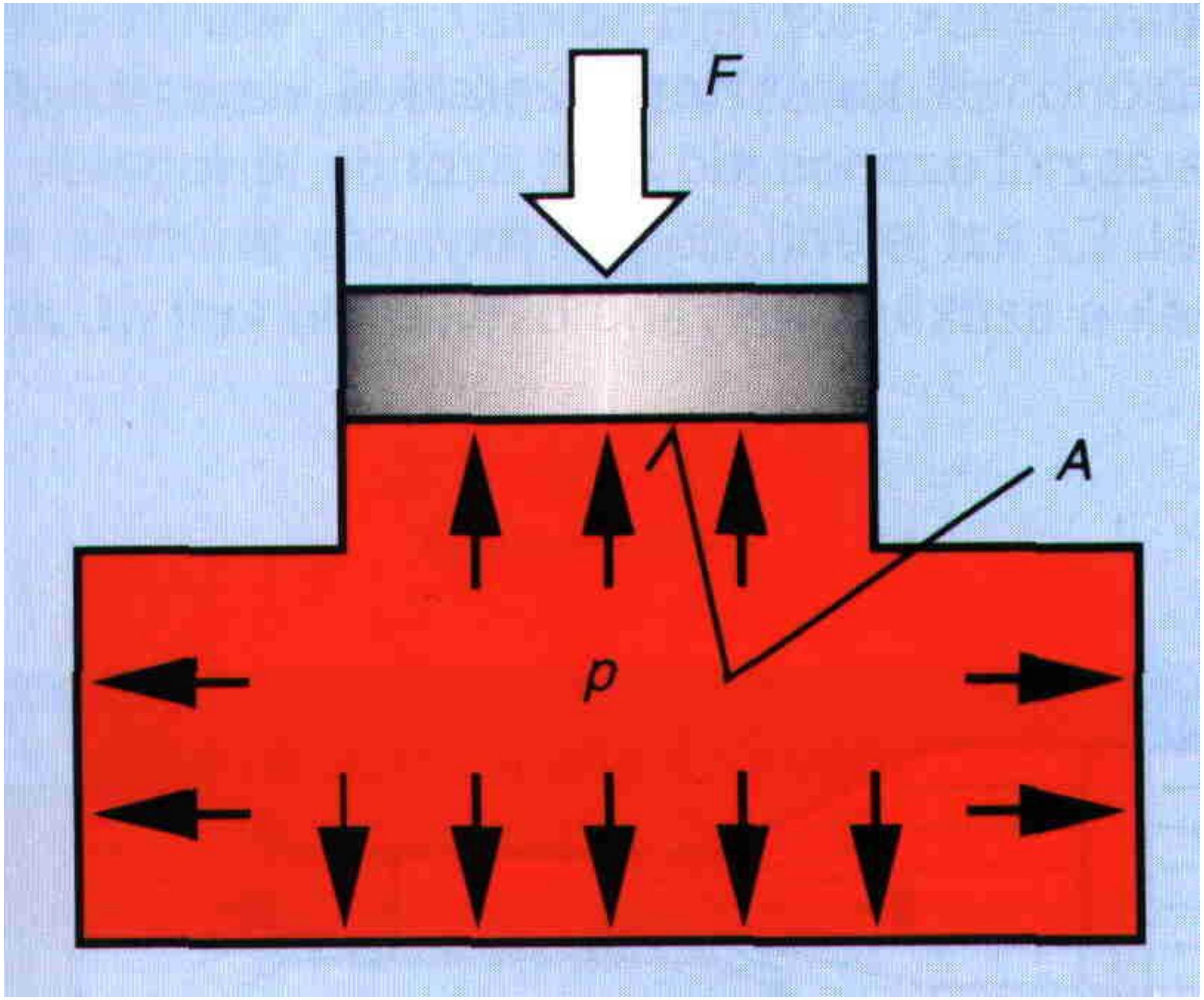
Hydraulic Systems



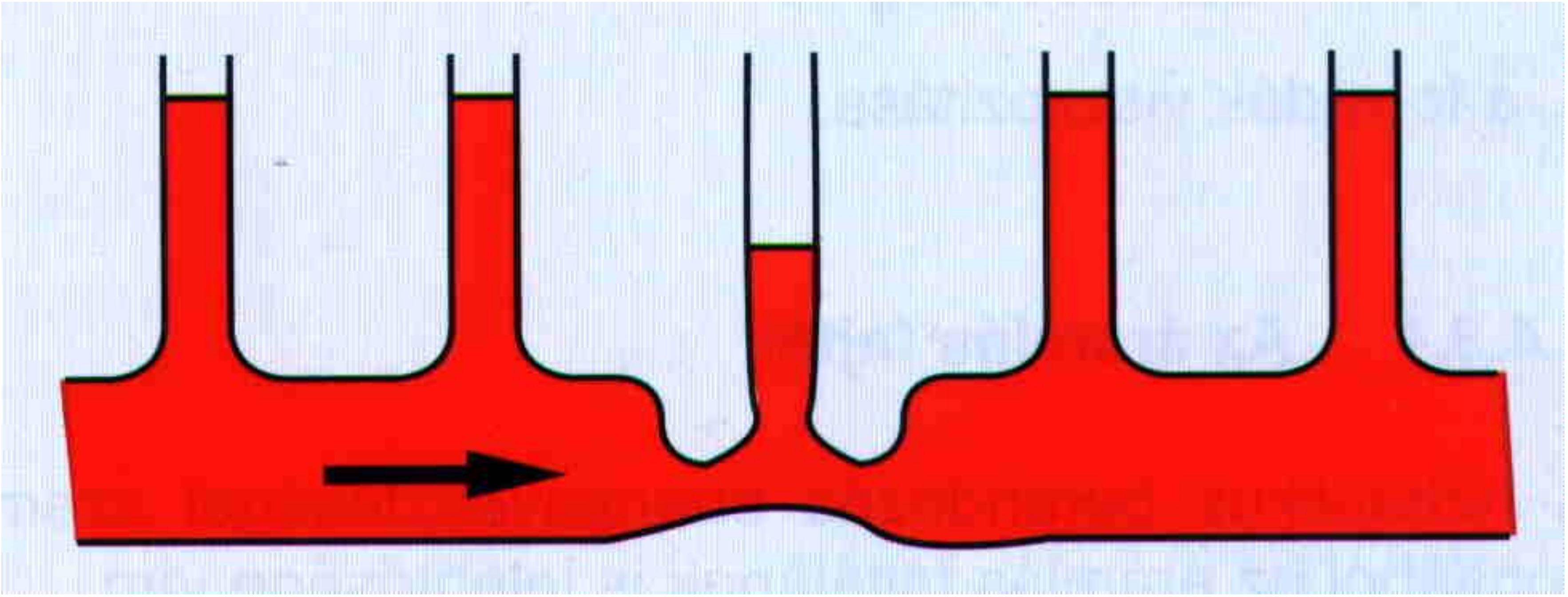
Continuity



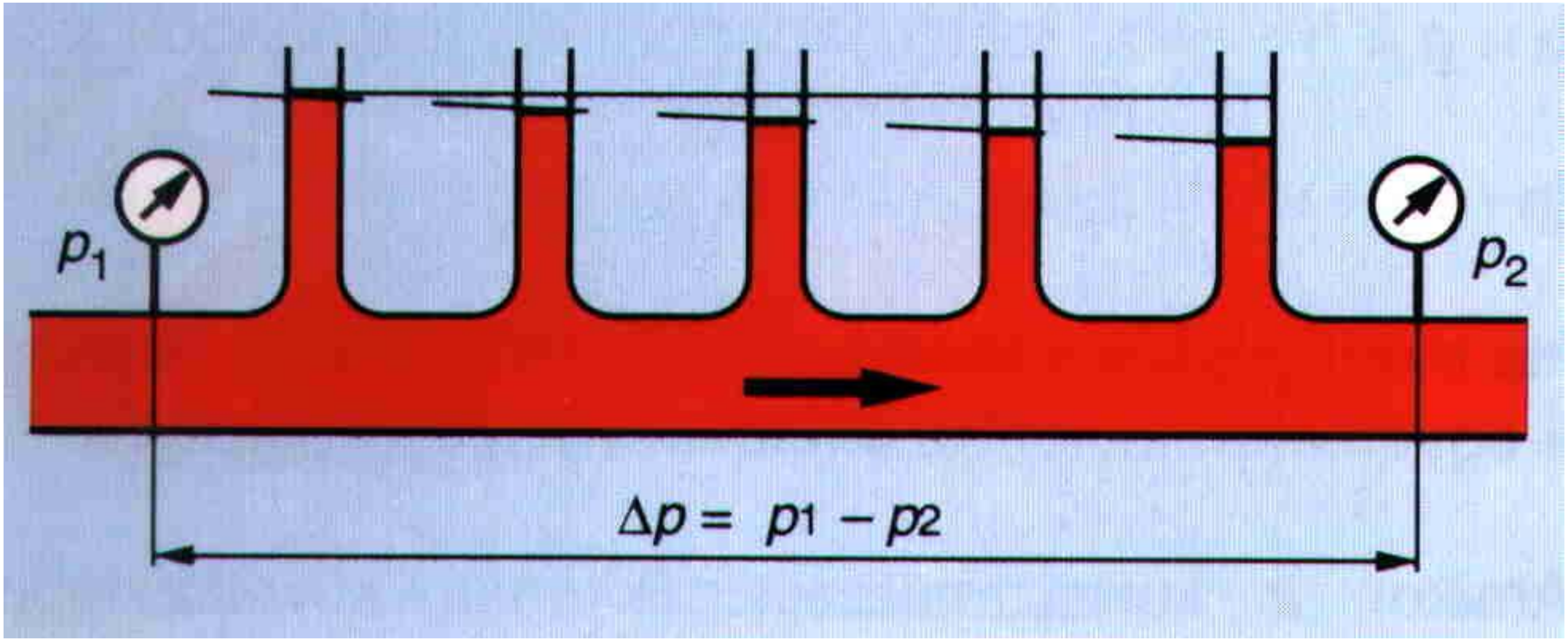
Pascal's law



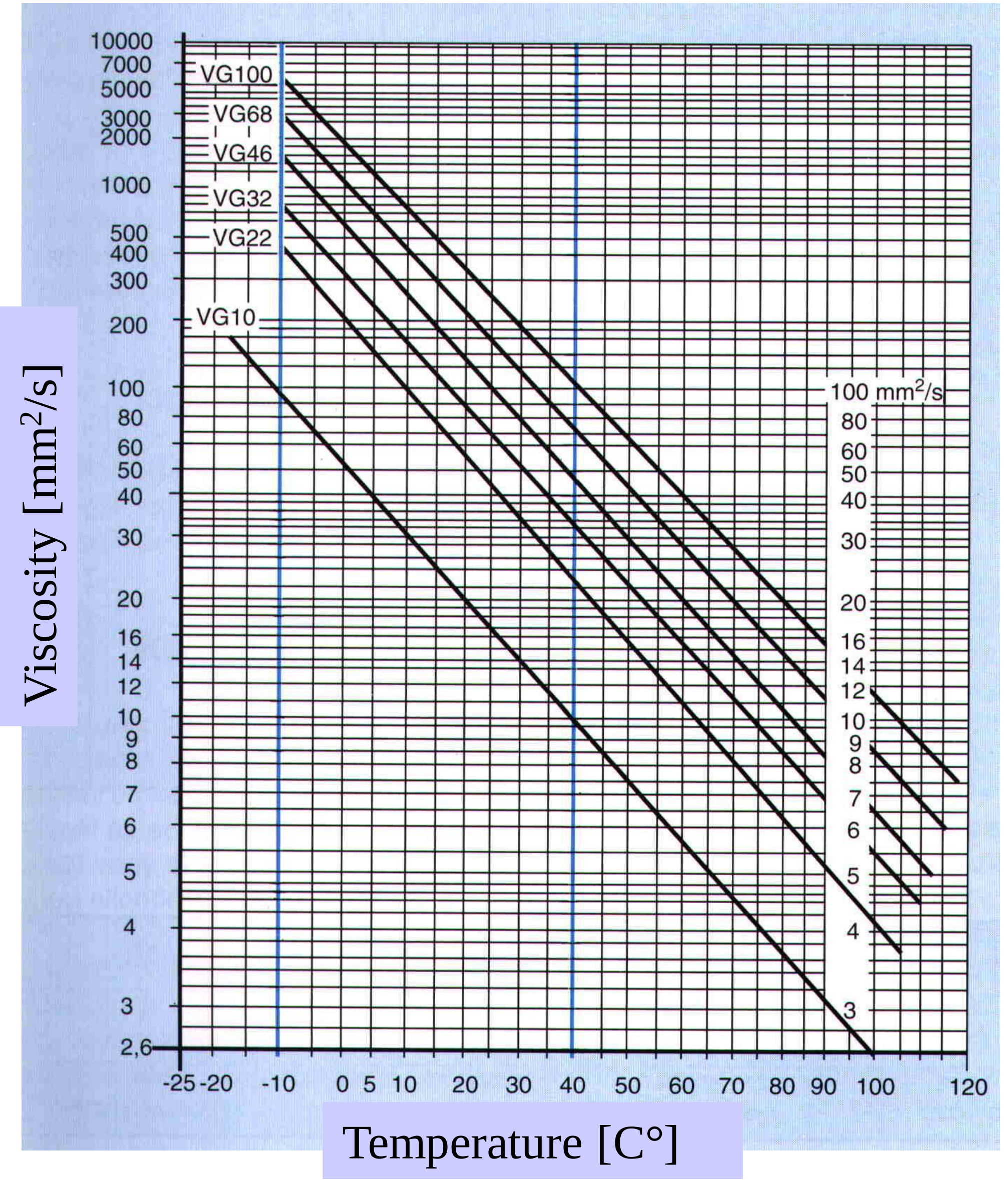
Bernoulli equation



Flow resistance

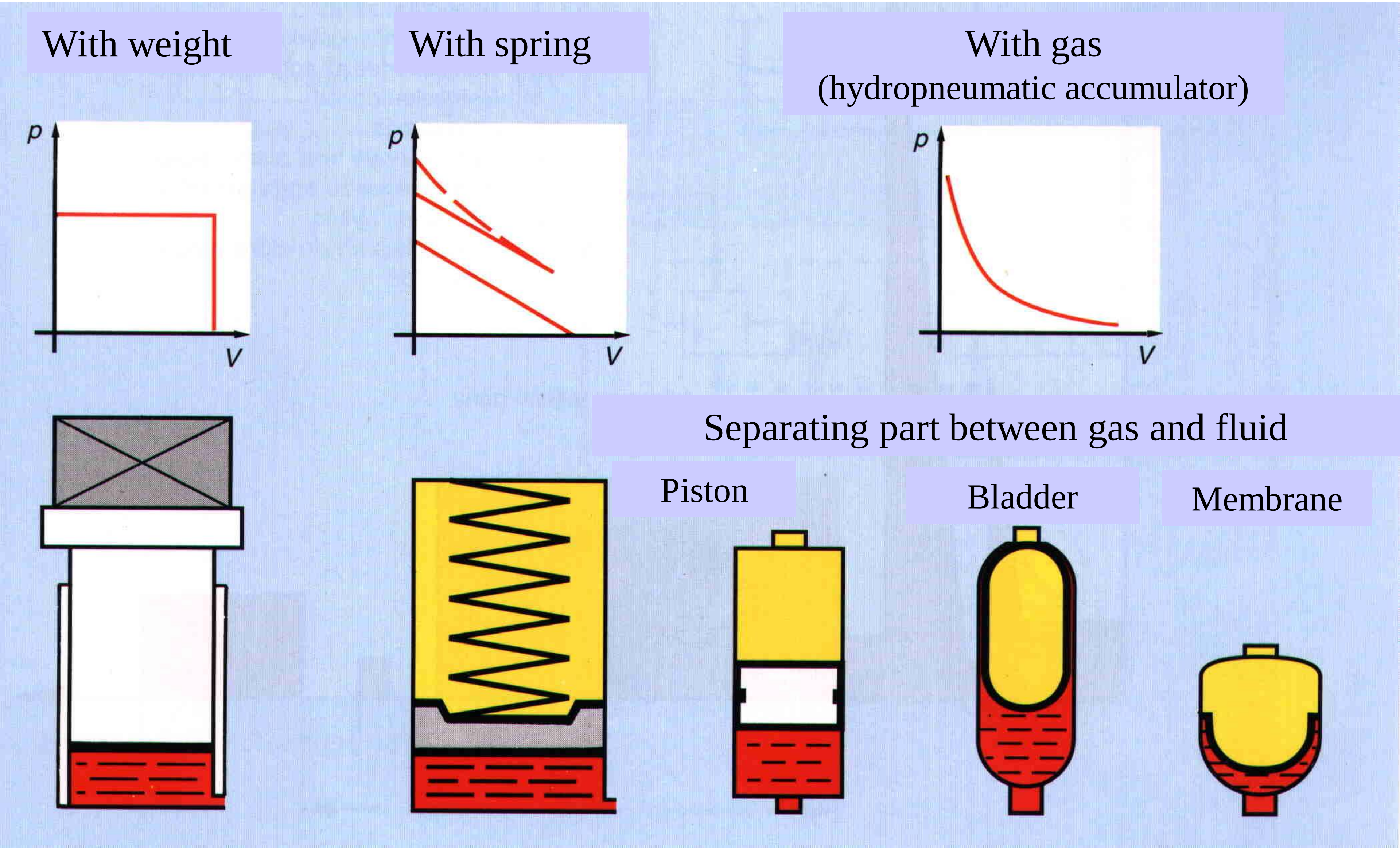


Viscosity over temperature

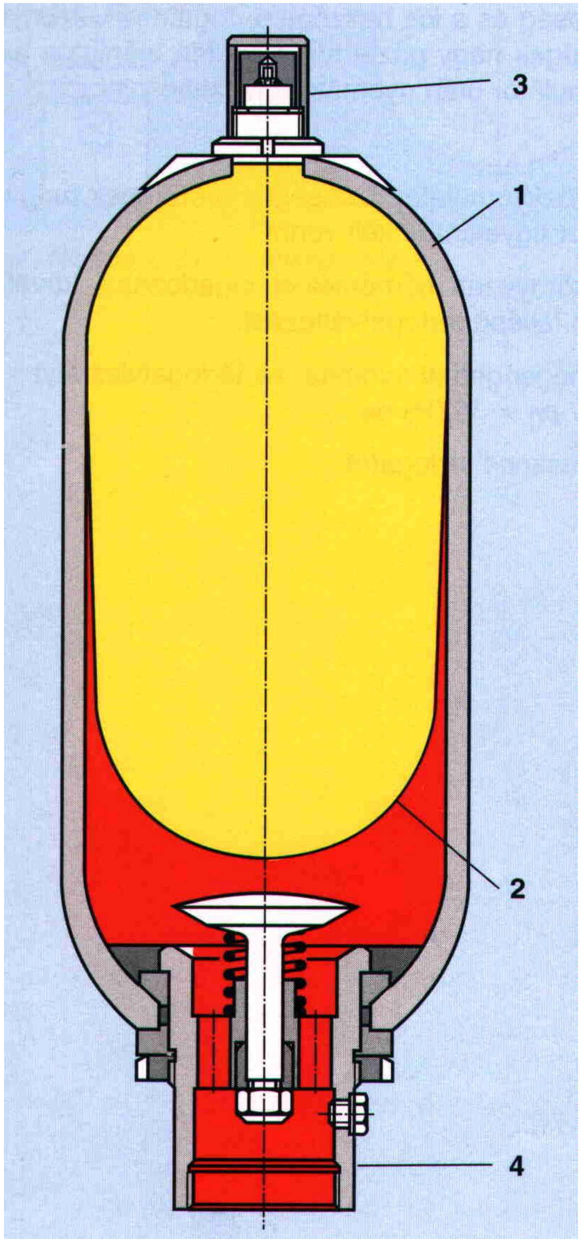


Hydraulic Systems

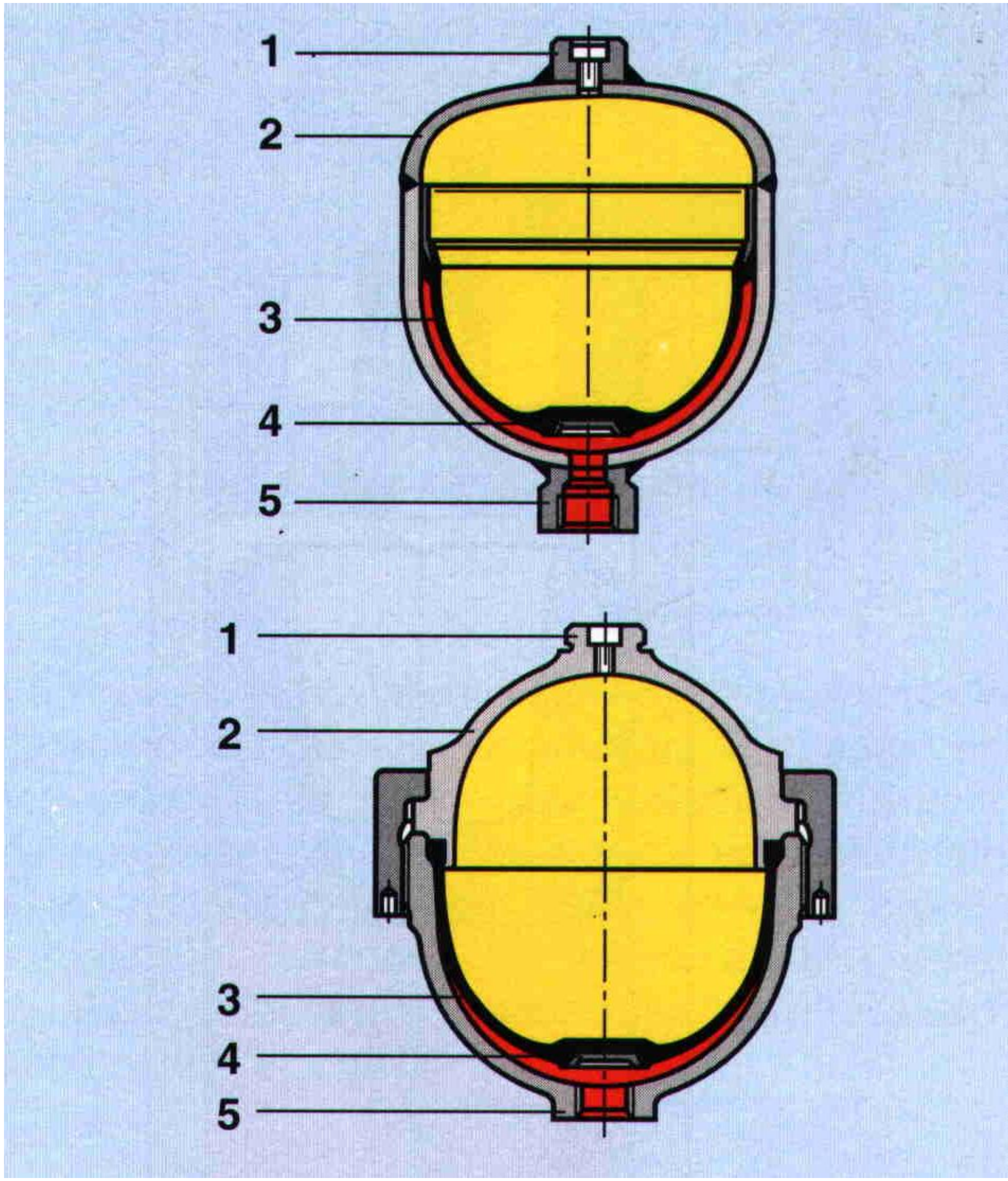
Accumulators:



Accumulators:

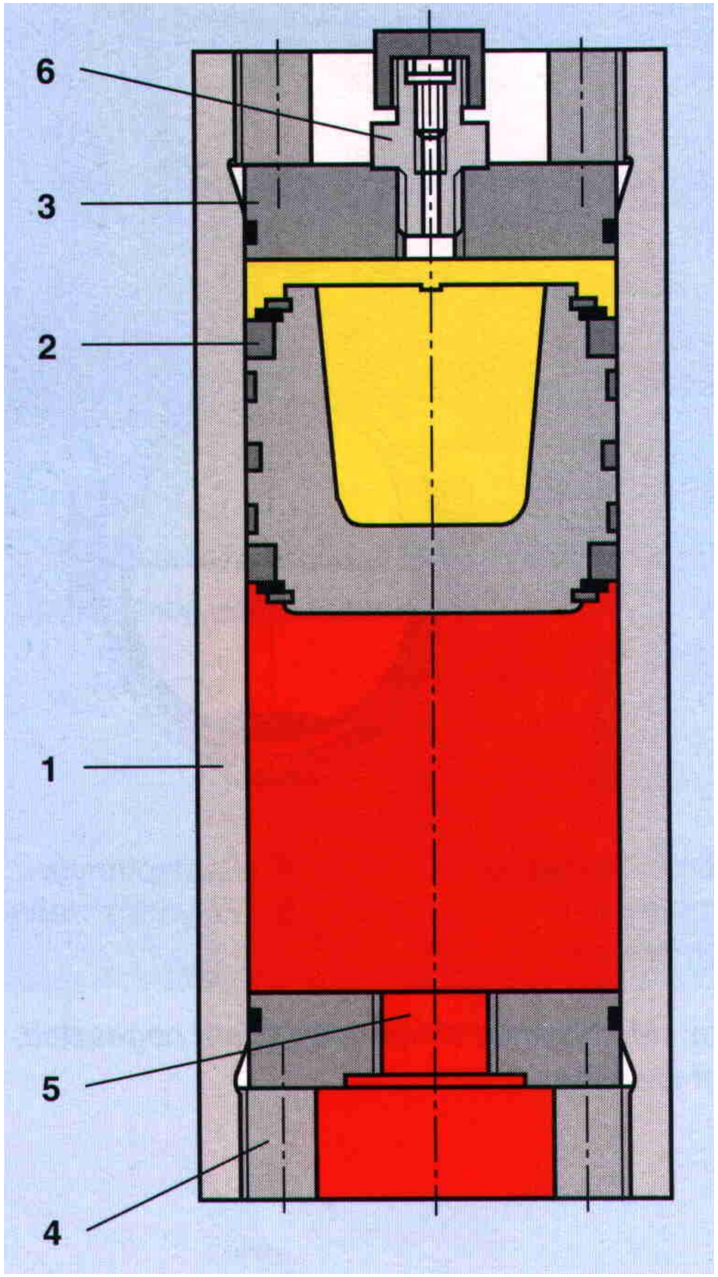


Accumulators:

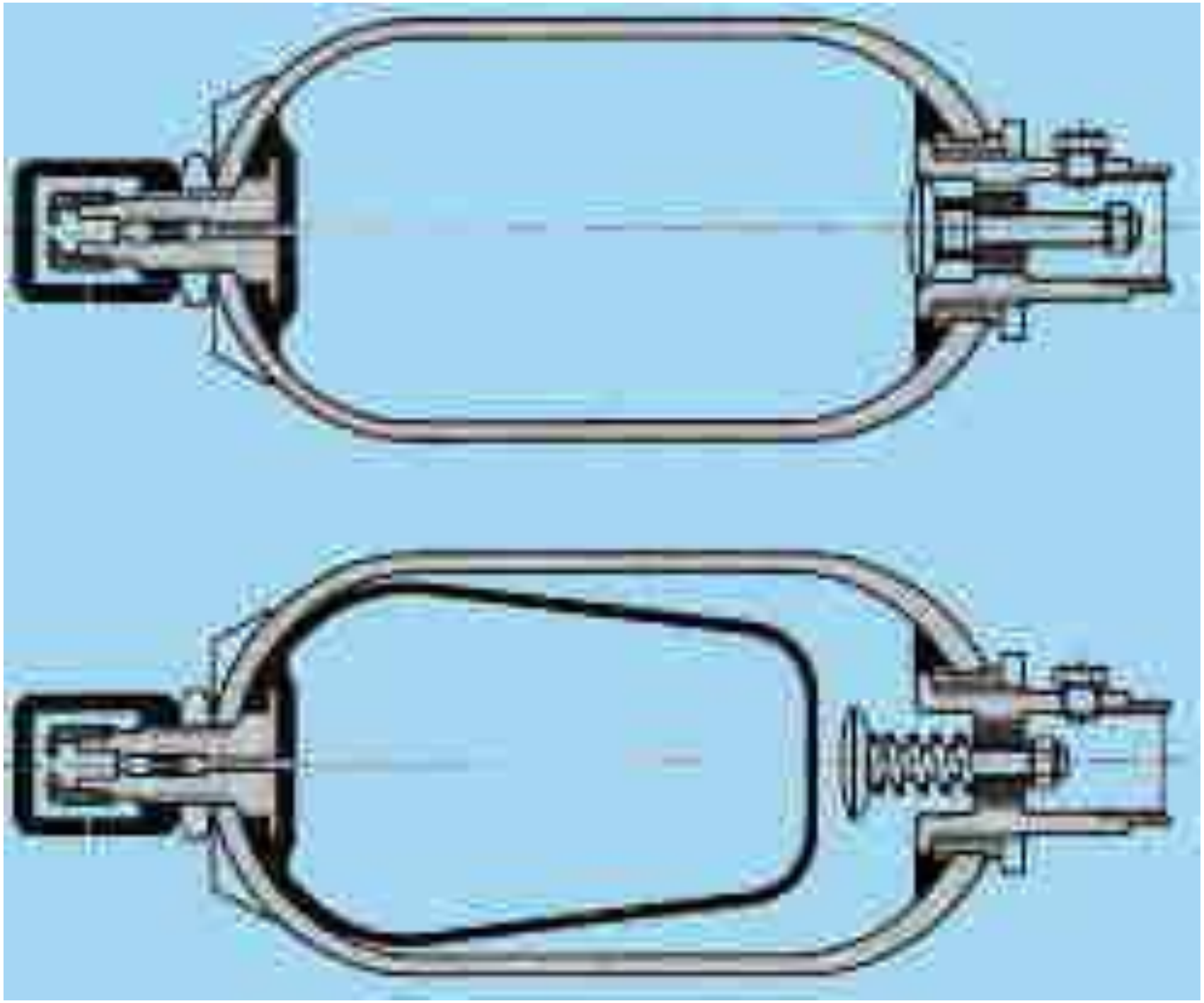


1. Gas filling screw
2. Tank
3. Membrane
4. Valve-disc
5. Juncture for hydraulic system

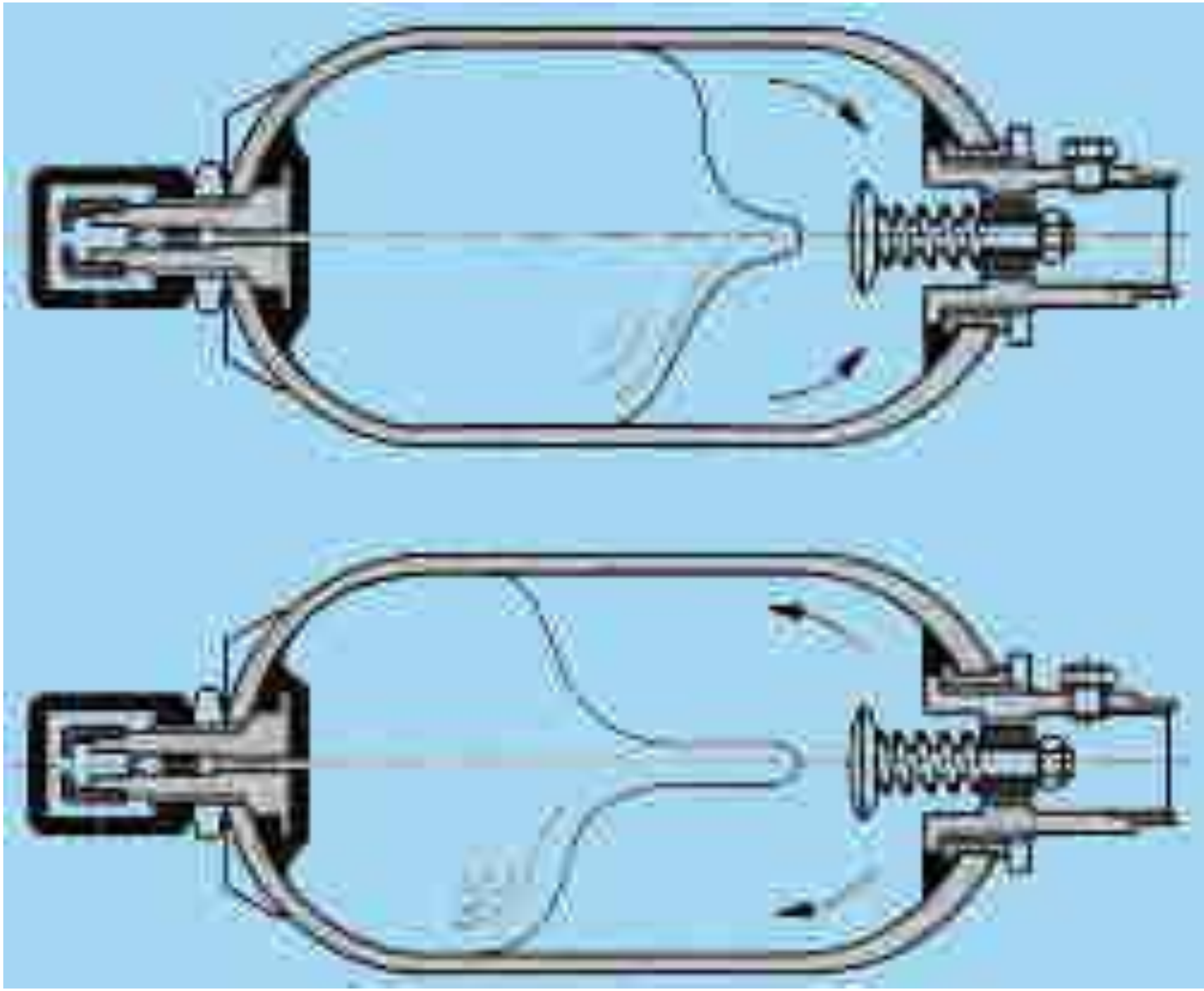
Accumulators:



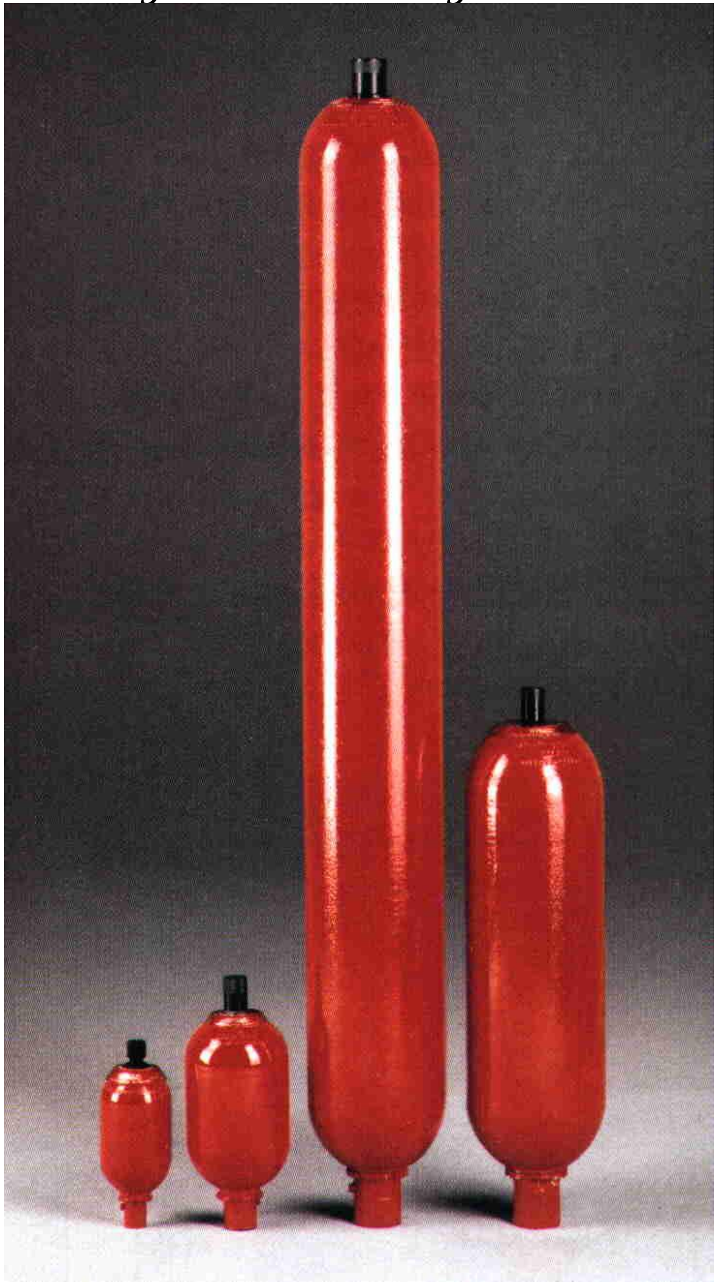
Accumulators:



Accumulators:

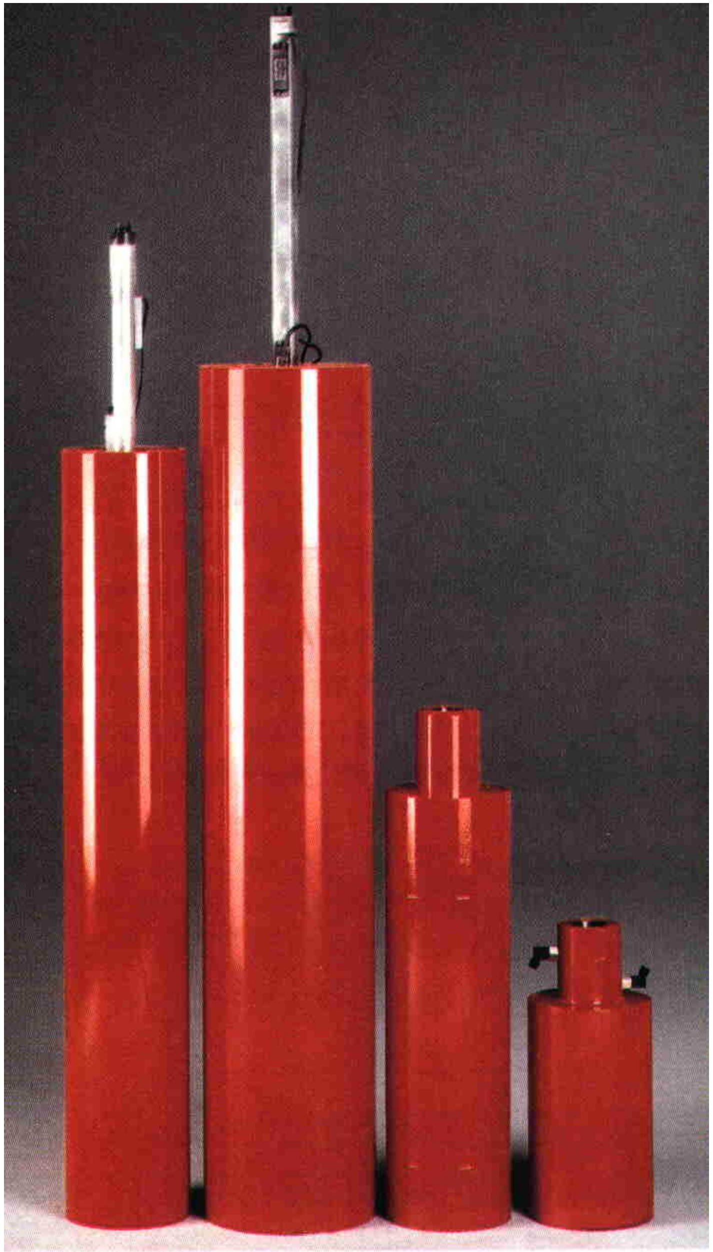


Accumulators with bladder:

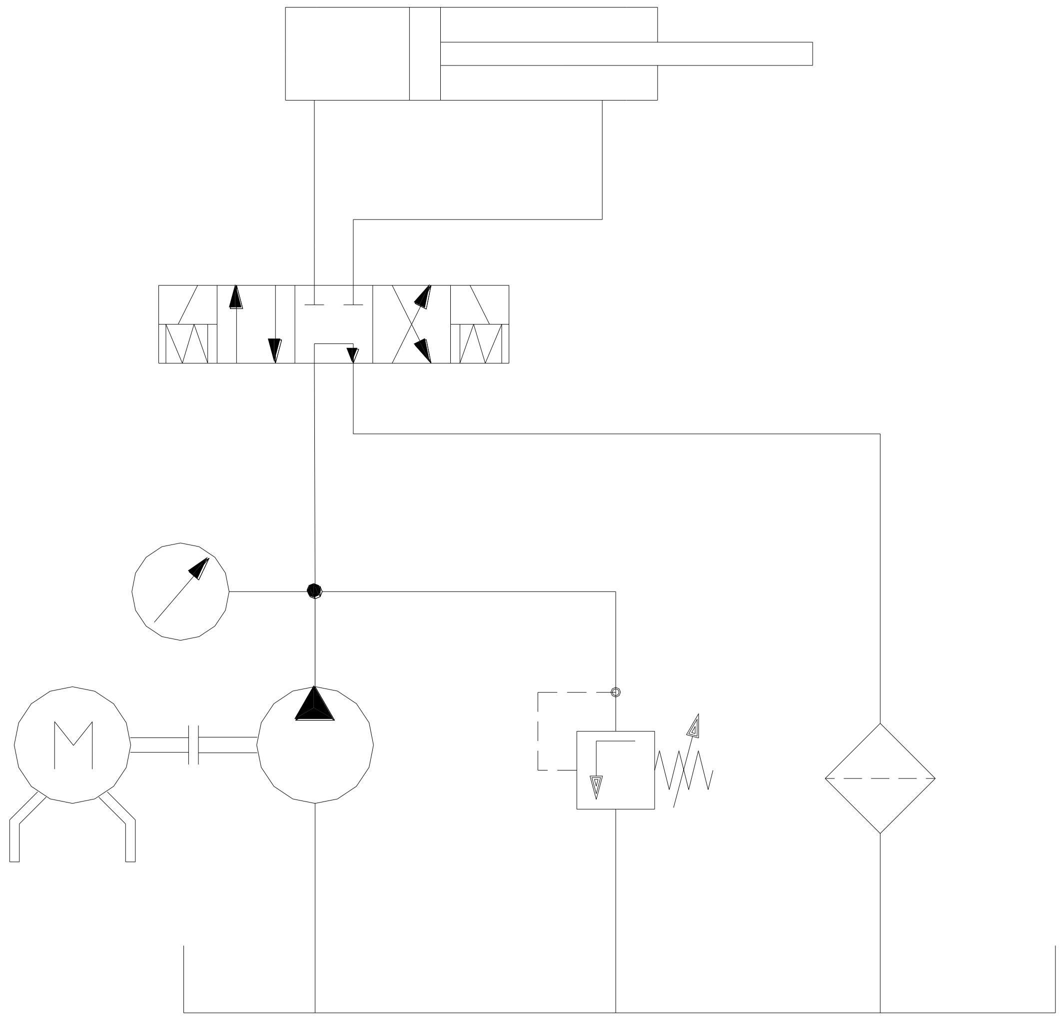


Accumulators with membrane:

Accumulators with piston:



Typical hydraulic system:



Pressure reservoirs = Accumulators

Serve three purposes:

- damping of pressure and volumetric flow rate oscillations,
- supplying the flow rate at variable demand,
- hydropneumatic spring.

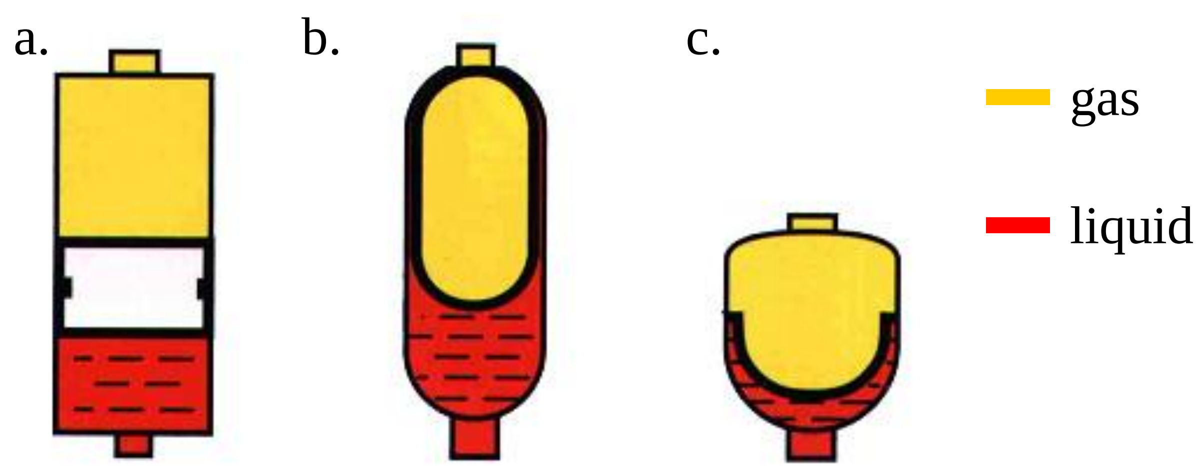
They use the compressibility of a gas but the gas and liquid surface may not touch because then the gas will be dissolved in the liquid.

Three constructions:

a. Piston

b. Bladder (bag)

c. Membrane



UNIT - II

AIRCRAFT CONTROL SYSTEMS

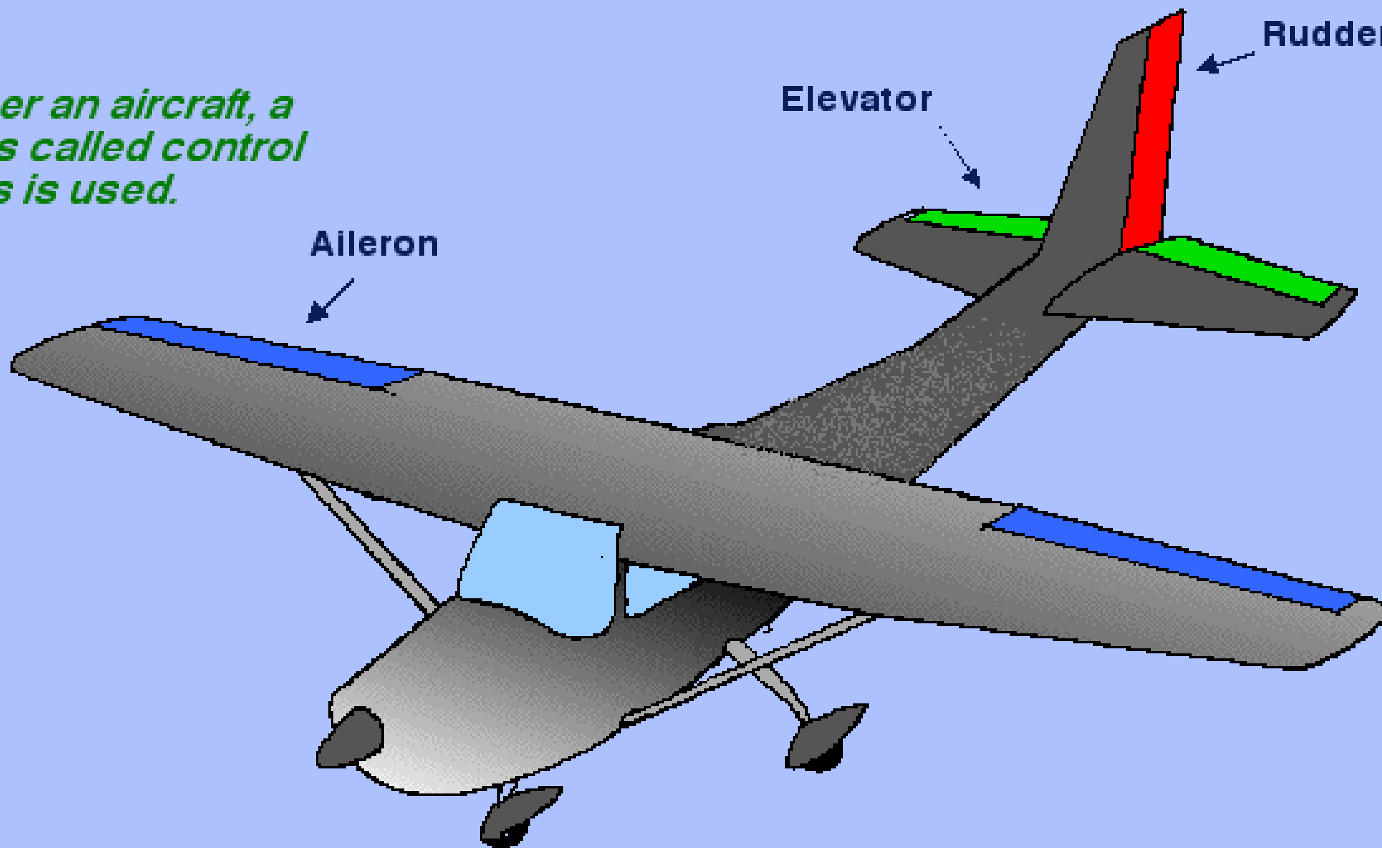
What is an Aircraft Control System?

- A control system is a collection of mechanical and electronic equipment that allows an aircraft to be flown with exceptional precision and reliability.

- A control system consists of cockpit controls, sensors, actuators (hydraulic, mechanical or electrical) and computers.

Aircraft Maneuvers are produced by moving Control Surfaces

In order to steer an aircraft, a system of flaps called control surfaces is used.

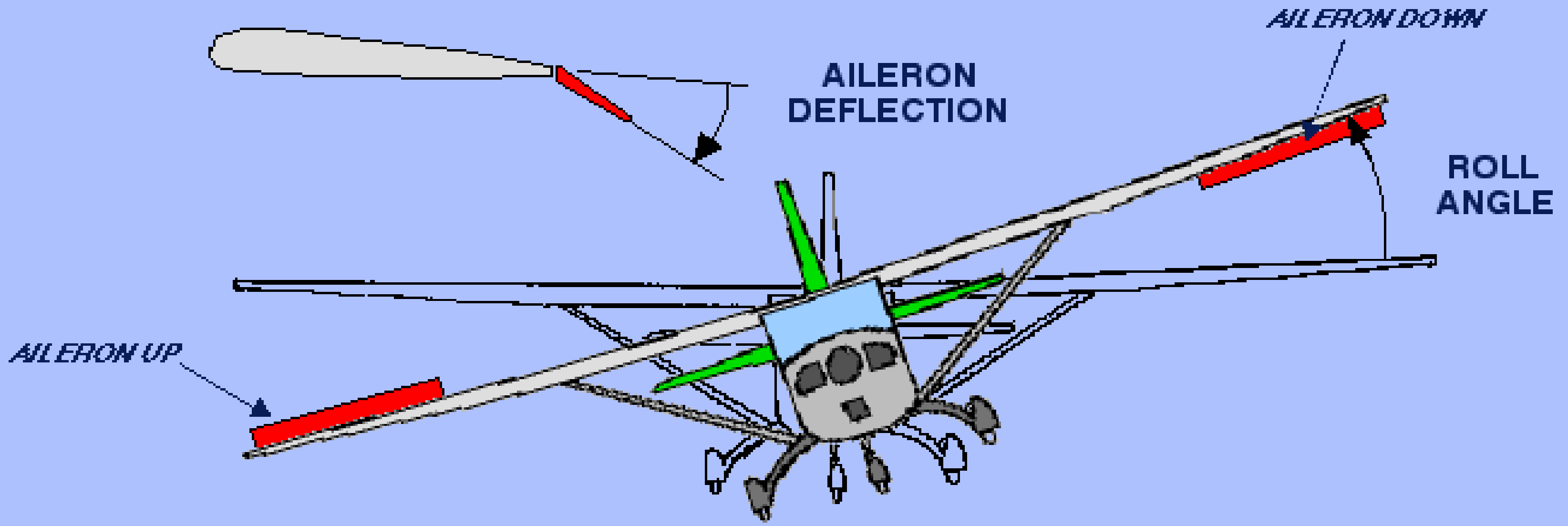


Control surfaces deflect the air flow around an aircraft and turn or twist the aircraft so that it rotates about the center of gravity.

The main control surfaces that perform movement are the ailerons, elevators, and rudder. This movement is made by a control stick and pedals.

The Ailerons Control the Roll Angle

***Ailerons** are used to roll or rotate the aircraft .*

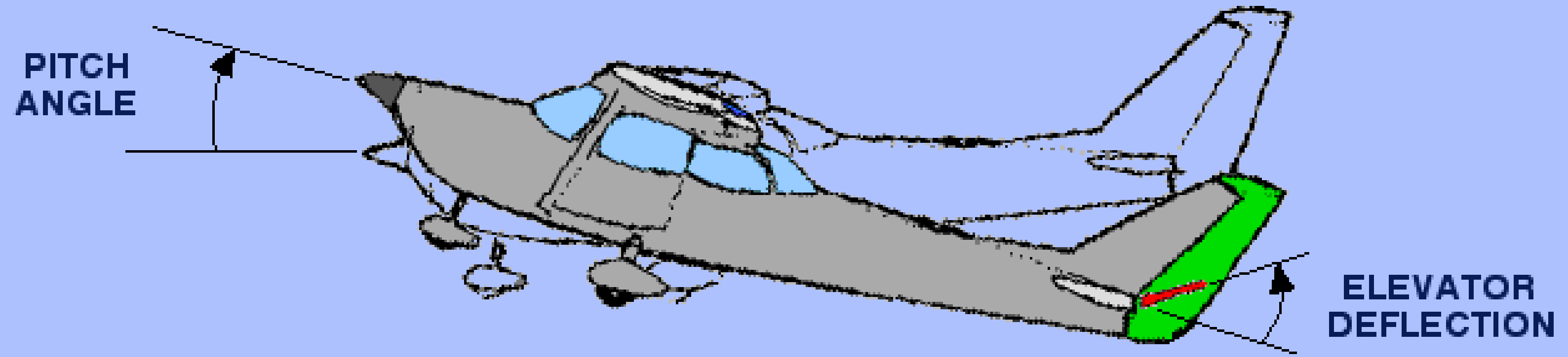


Aileron deflections are necessary for smooth coordinated turns. The combination of roll and yaw causes the aircraft to "lean" into turns.

When the pilot moves the control stick to the right the right aileron moves up and the left moves down. This causes more lift on the left wing and less lift on the right wing. The difference in forces causes the aircraft to roll to the right.

The Elevator Controls the Pitch Angle

Elevatorsare used
to pitch the aircraft up or down
causing it to climb or dive.



To climb, the pilot pulls the control stick back causing the elevators to be deflected up. This in turn causes the airflow to force the tail down and the nose up thereby increasing the pitch angle as shown.

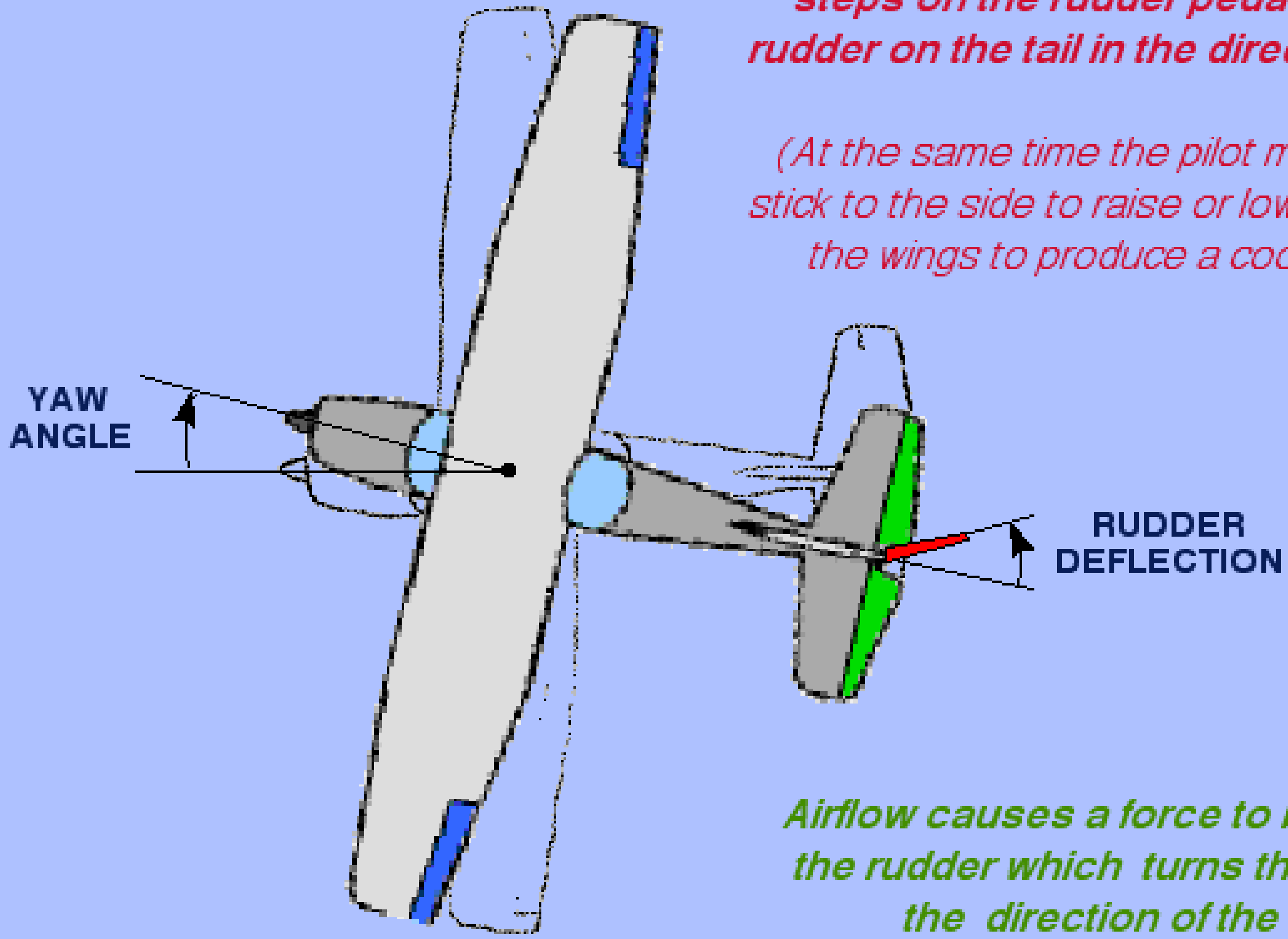
To dive, the pilot pushes the control stick forward causing the elevator to deflect down. This in turn causes the airflow to lift the tail up and the nose down thereby decreasing the pitch angle.

The Rudder Controls the Yaw Angle

The rudder turns the aircraft right or left, this is called yawing

To yaw right or left, the pilot steps on the rudder pedals to swivel the rudder on the tail in the direction of the turn.

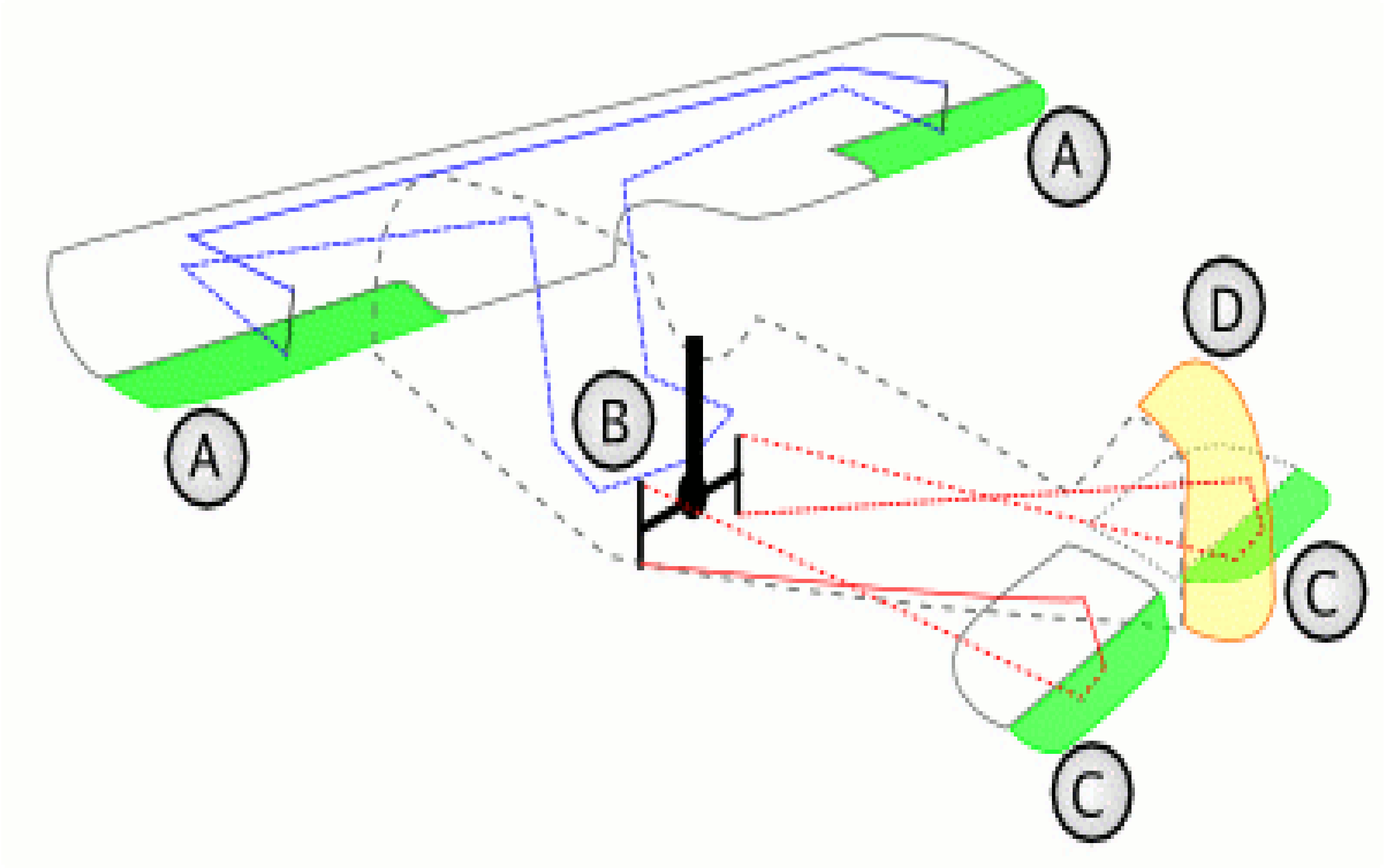
(At the same time the pilot moves the control stick to the side to raise or lower the ailerons on the wings to produce a coordinated turn.)



Airflow causes a force to be applied to the rudder which turns the aircraft in the direction of the force.

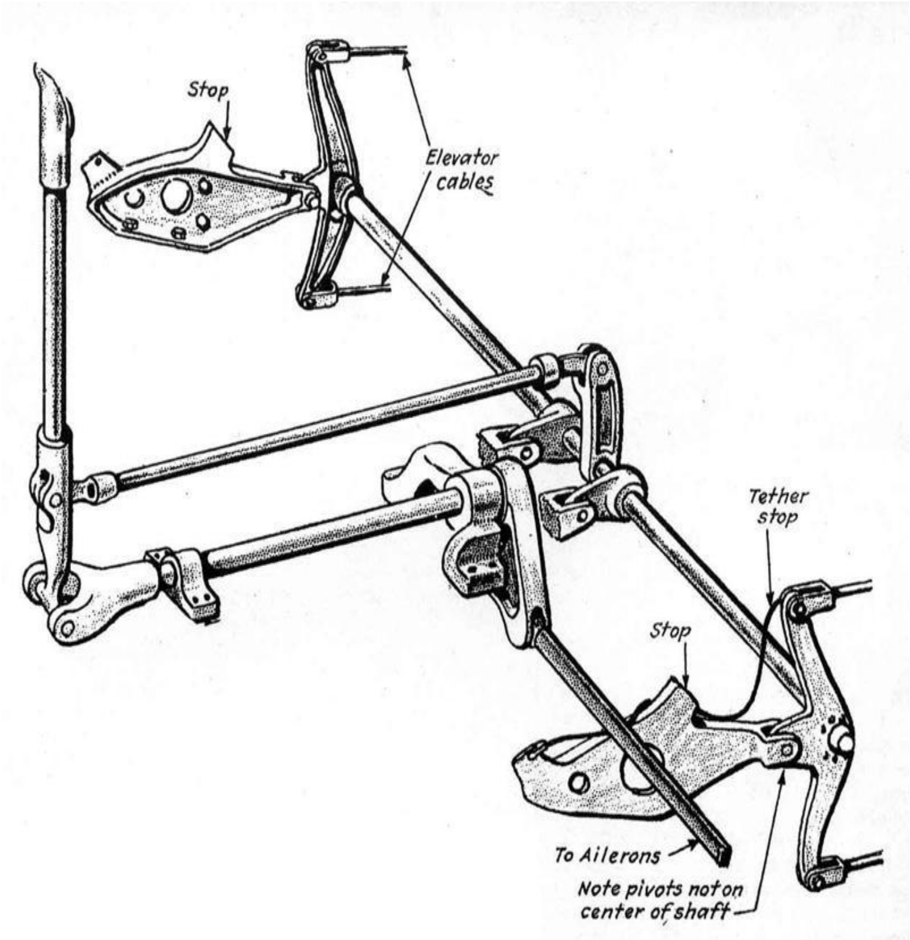
Control Column (or) Control Yoke

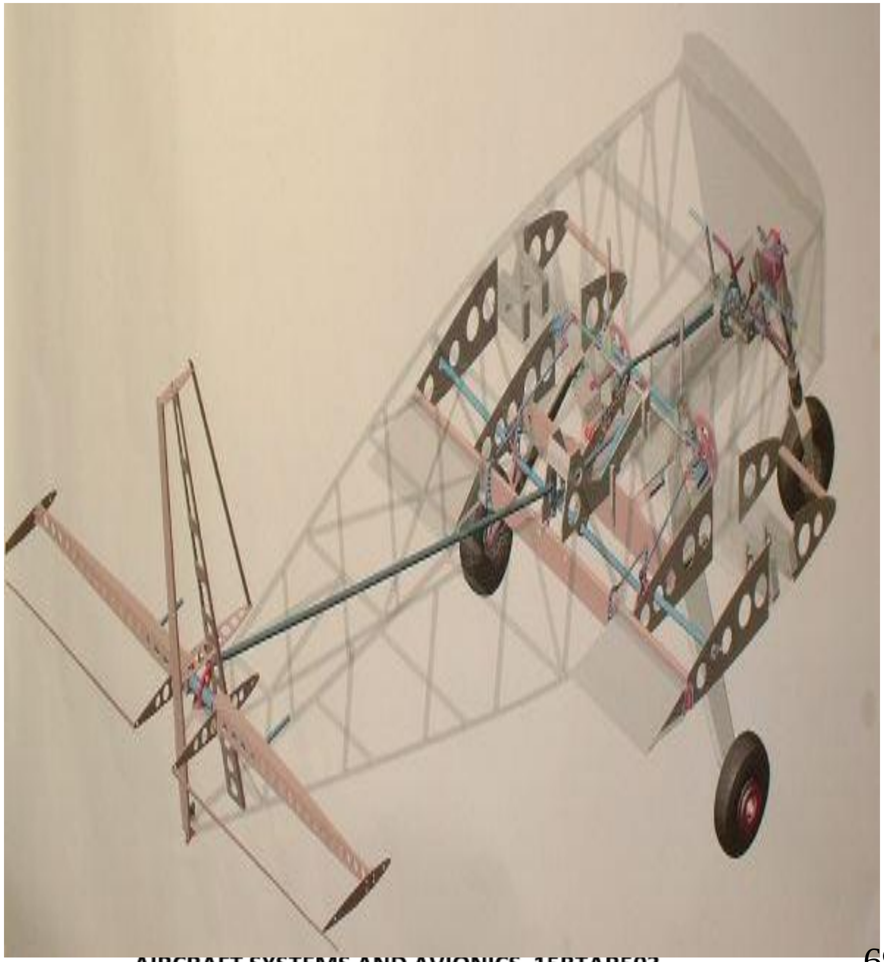
Aircraft Primary Flight Controls In Motion



Conventional Flight Control System Components

Push Pull Rods





Turnbuckles

A **turnbuckle**, **stretching screw** or **bottlescrew** is a device for adjusting the tension or length of ropes, cables, tie rods and other tensioning systems.

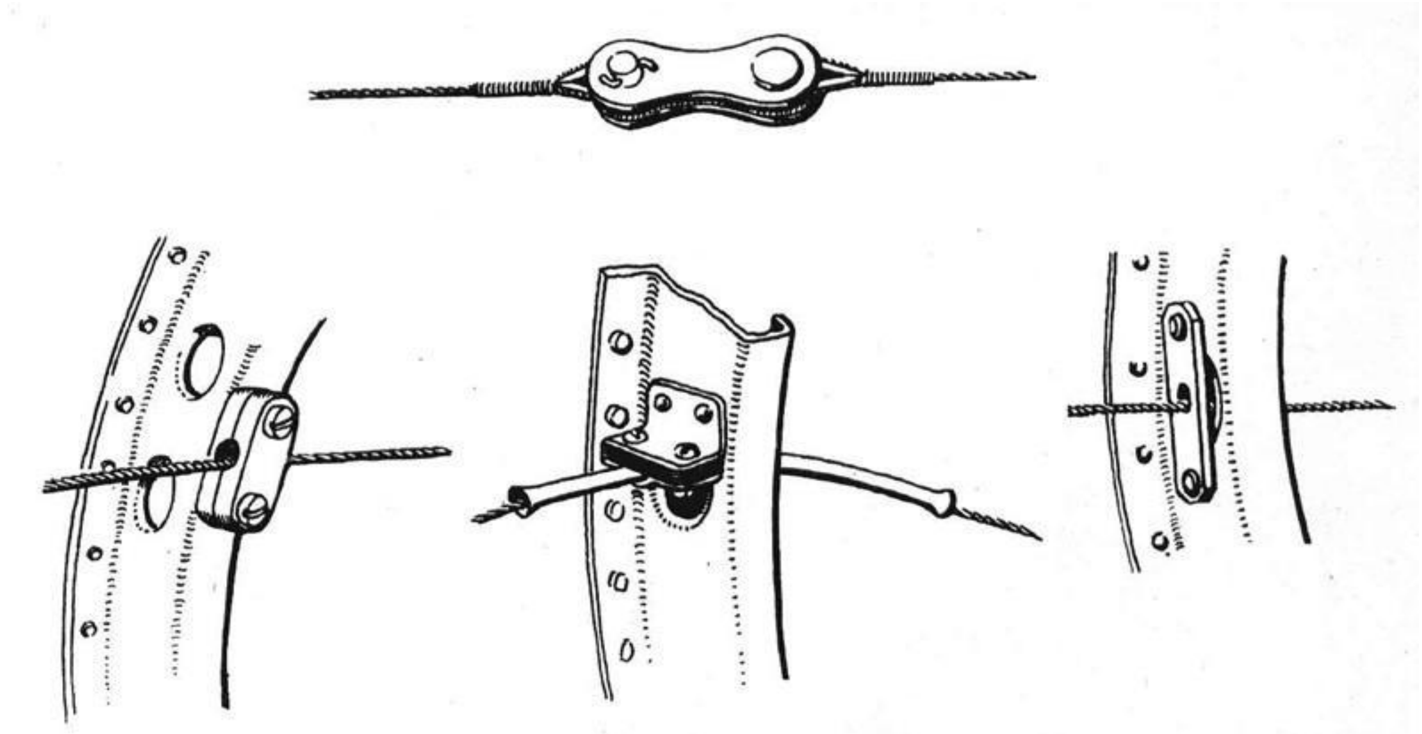
Torque Tube

A tube in an aircraft control system that transmits a torsional force from the operating control to the control surface. Torque tubes are often used to actuate ailerons and flaps.

Bell Crank

A double lever in an aircraft control system used to change the direction of motion. Bell cranks are normally used in aileron controls and in the steering system of nosewheels.

Fairleads



A **fairlead** is a device to guide a line, rope or cable around an object, out of the way or to stop it from moving laterally. Typically a fairlead will be a ring or hook. The fairlead may be a separate piece of hardware, or it could be a hole in the structure.

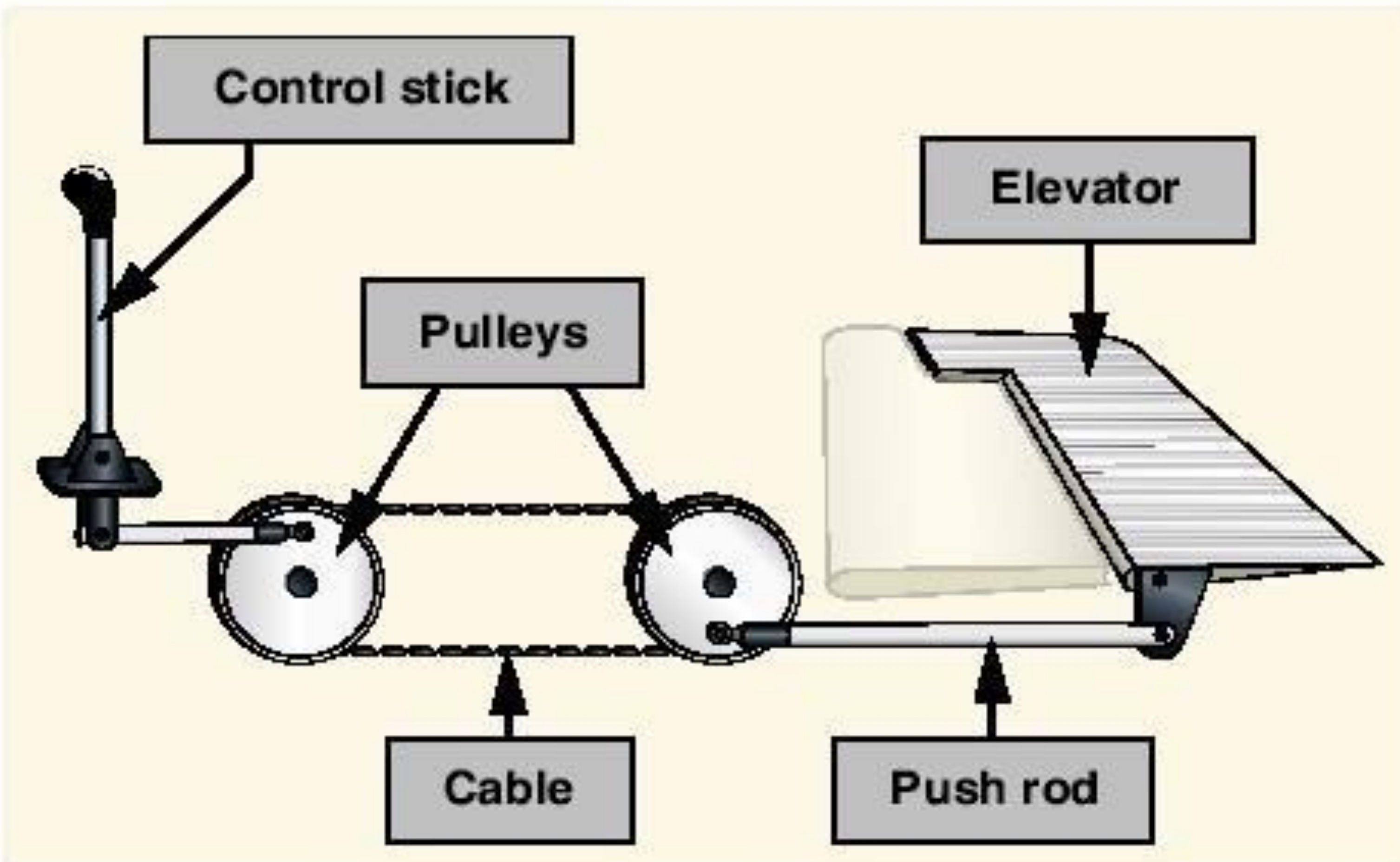
Mechanical Flight Control System

- Basic method of controlling an aircraft

- Used in early aircraft and currently in small aircraft where the aerodynamic forces are not excessive.

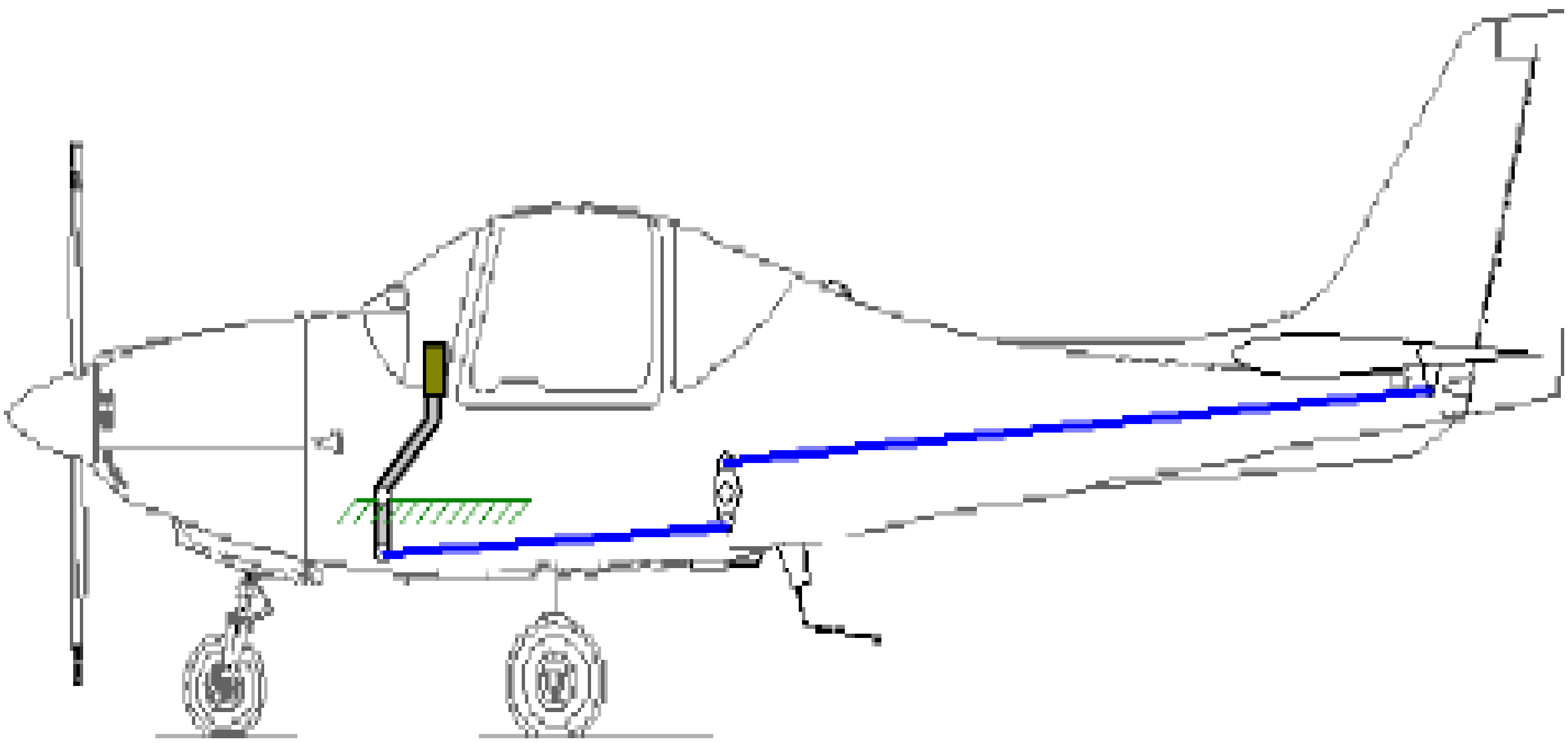
- It uses a collection of mechanical parts such as rods, tension cables, pulleys, counterweights, and sometimes chains to transmit the forces applied from the cockpit controls directly to the control surfaces

Mechanical Flight Control System



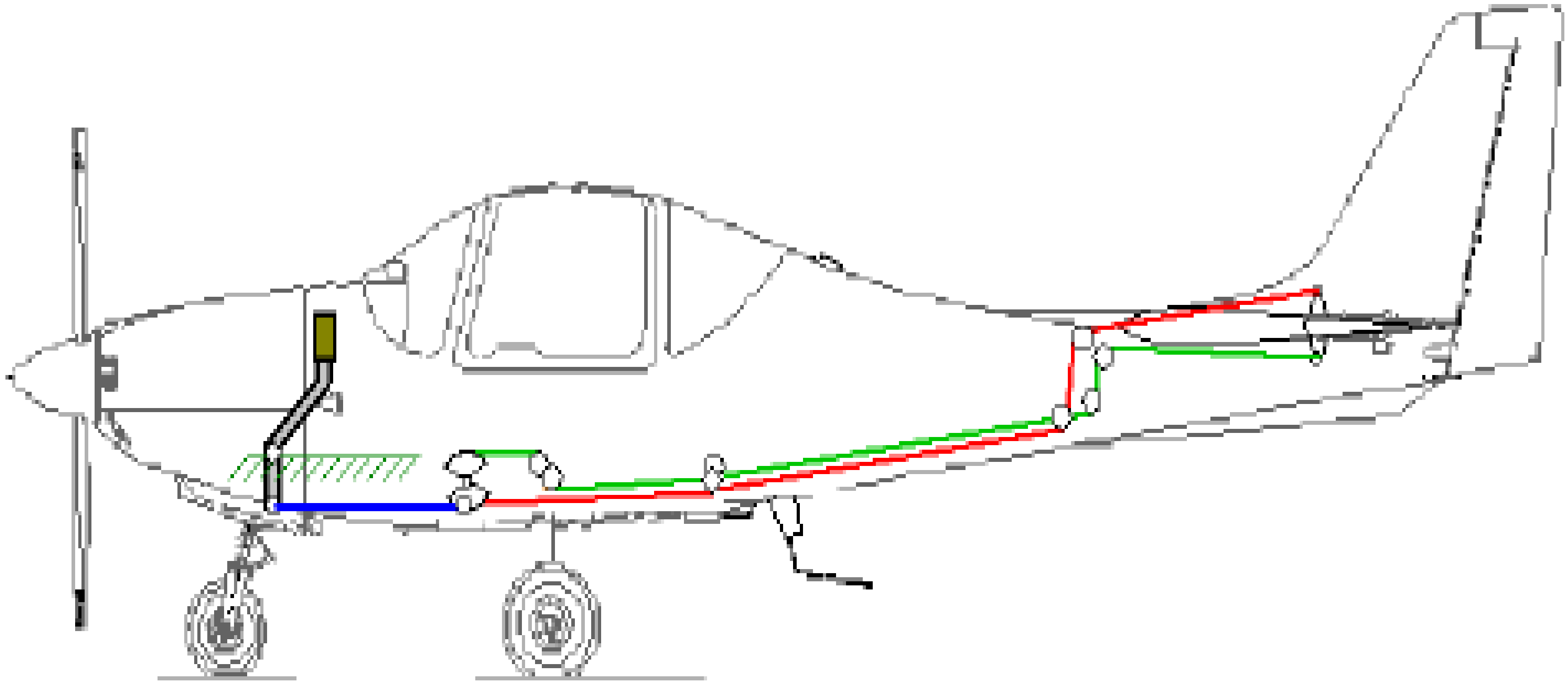
Mechanical Flight Control System

Push Pull Rod System for Elevator Control



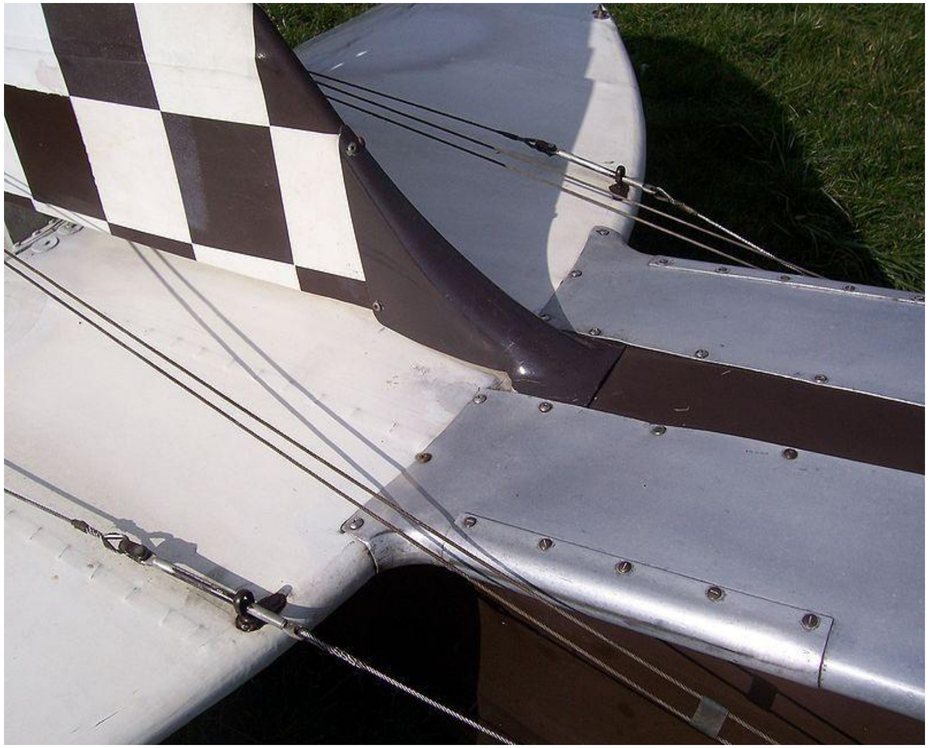
Mechanical Flight Control System

Cables & Pulleys System for Elevator Control



Mechanical Flight Control System

- Gust locks are often used on parked aircraft with mechanical systems to protect the control surfaces and linkages from damage from wind



Mechanical Flight Control System

- Increases in the control surface area required by large aircraft or higher loads caused by high airspeeds in small aircraft lead to a large increase in the forces needed to move them, consequently complicated mechanical gearing arrangements were developed to extract maximum mechanical advantage in order to reduce the forces required from the pilots. This arrangement can be found on bigger or higher performance propeller aircraft such as the Fokker 50.

Mechanical Flight Control System

- Some mechanical flight control systems use **Servo tabs** that provide aerodynamic assistance. Servo tabs are small surfaces hinged to the control surfaces. The flight control mechanisms move these tabs, aerodynamic forces in turn move, or assist the movement of the control surfaces reducing the amount of mechanical forces needed. This arrangement was used in early piston-engined transport aircraft and in early jet transports. The Boeing 737 incorporates a system, whereby in the unlikely event of total hydraulic system failure, it automatically and seamlessly reverts to being controlled via servo-tab.

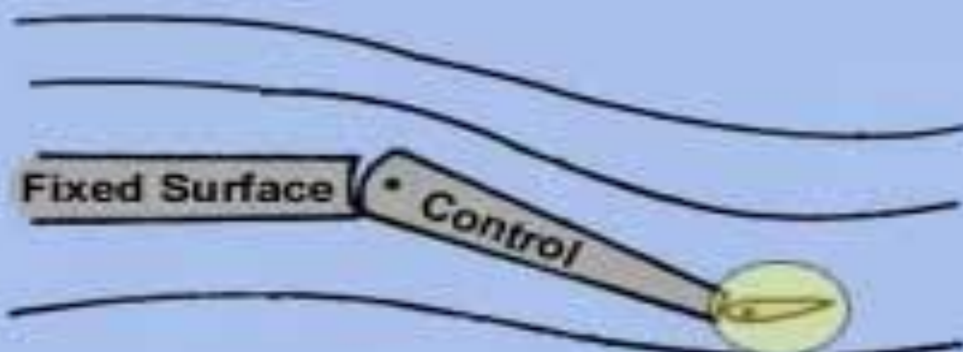
Servo Tabs

- In large aircrafts the control surfaces are operated by power operated hydraulic actuators controlled by valves moved by control yoke and rudder pedals. An artificial feel system gives the pilot resistance that is proportional to the flight loads on the surfaces.

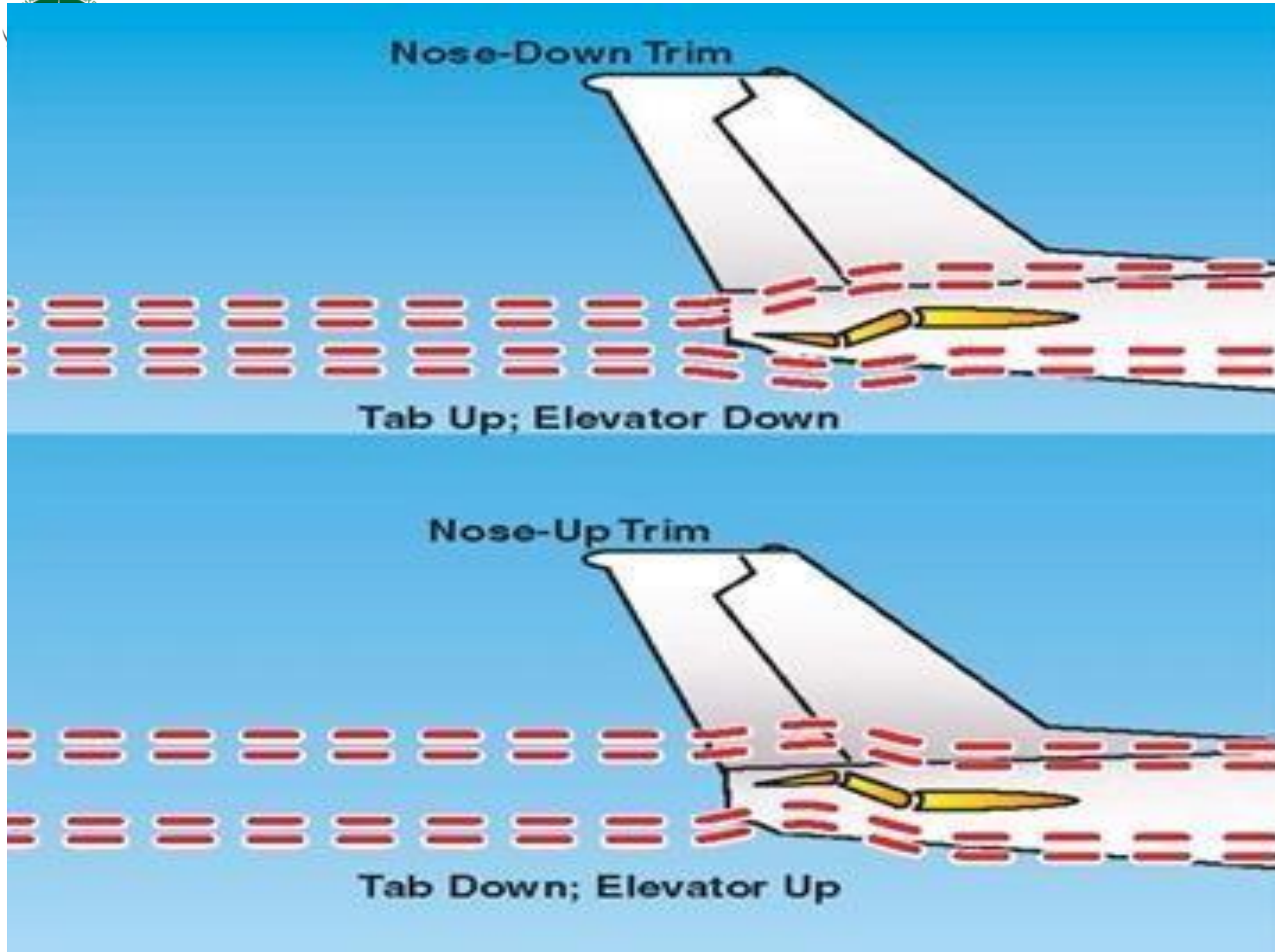
- In the event of hydraulic system failure , the control surfaces are controlled by servo tabs in a process known as manual reversion.

- In the manual mode the flight control column moves the tab on the c/surface and the aerodynamic forces caused by the deflected tab moves the main control surface

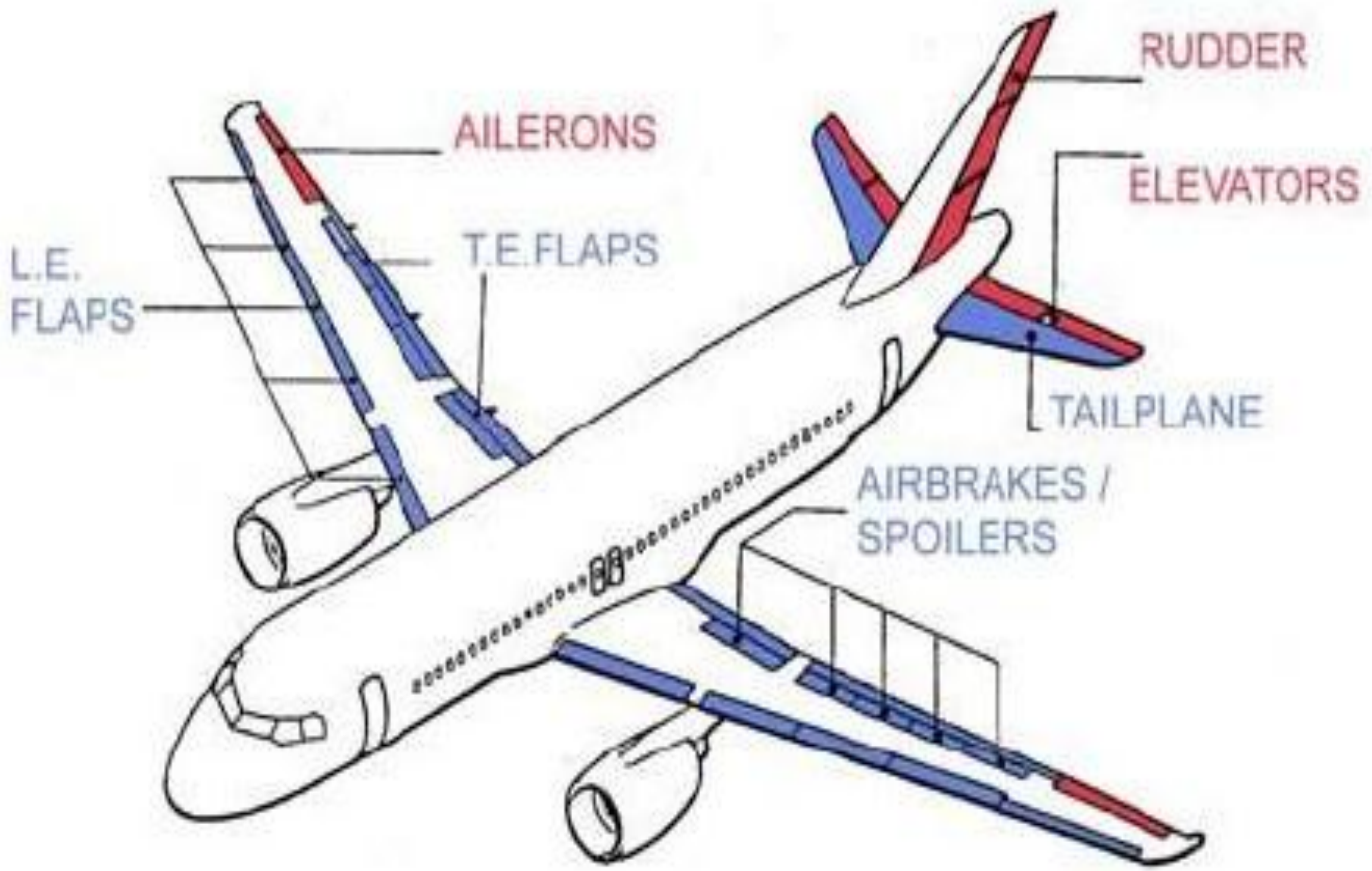
Elevator Trim Tab



The trim tab holds a control surface in a fixed position, without effort from the pilot.

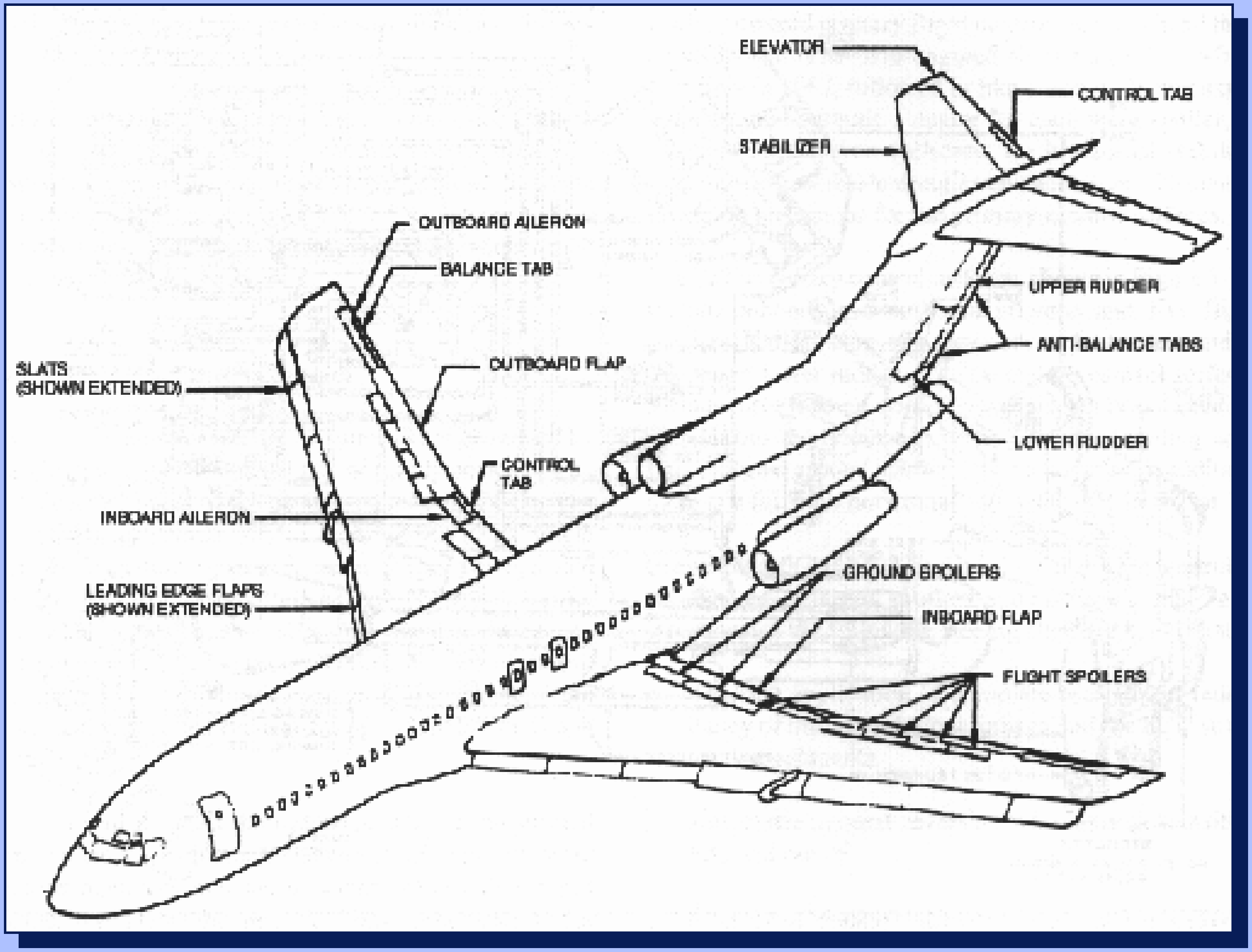

Nose-Down Trim
Tab Up; Elevator Down
Nose-Up Trim
Tab Down; Elevator Up

Flight Control Surfaces On An Modern Advanced Aircraft



Modern Advanced Aircraft Have Many Control Surfaces

- Each set of control surfaces has a different purpose
- The pilot cannot control each surface directly - there are just too many!
- A flight control system is used to tell which control surfaces to move, and by how much, based on simple inputs from the pilot.



Need for Powered Control System

- The Complexity and Weight of the system (Mechanical) increased with Size and Performance of the aircraft.
- When the pilot's action is not directly sufficient for the control, the main option is a powered system that assists the pilot.
- The hydraulic system has demonstrated to be a more suitable solution for actuation in terms of reliability, safety, weight per unit power and flexibility, with respect to the electrical system

Powered Assisted Control System

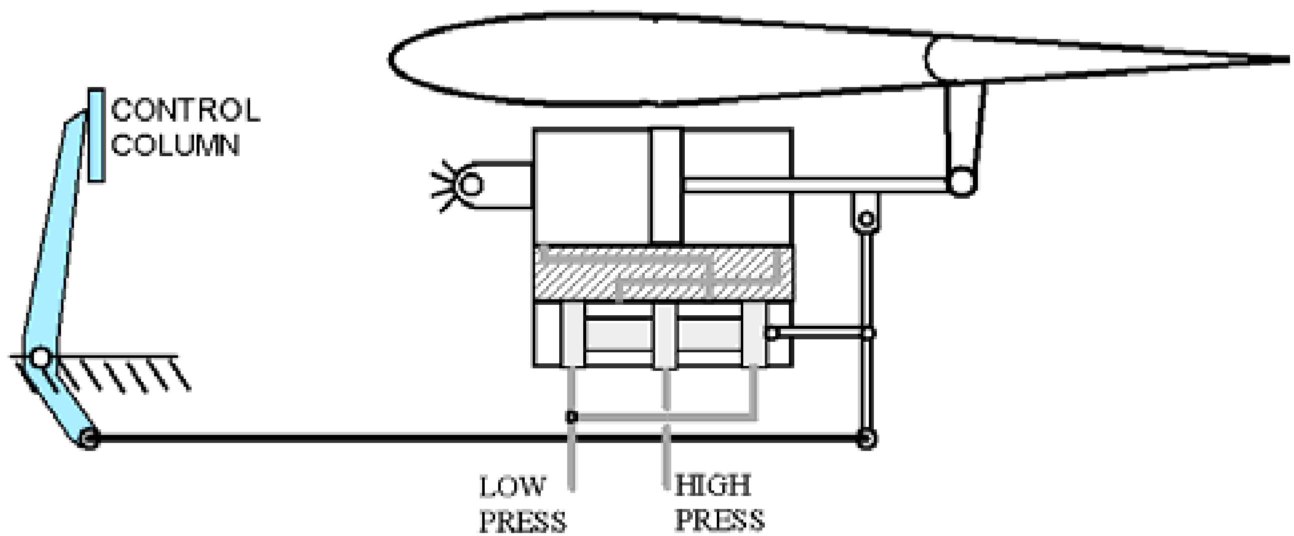
- The pilot, via the cabin components, sends a signal, or demand, to a valve that opens ports through which high pressure hydraulic fluid flows and operates one or more actuators.
- The valve, that is located near the actuators, can be signalled in two different ways: mechanically or electrically
- Mechanical signalling is obtained by push-pull rods, or more commonly by cables and pulleys
- Electrical signalling is a solution of more modern and sophisticated vehicles

Powered Assisted Control System

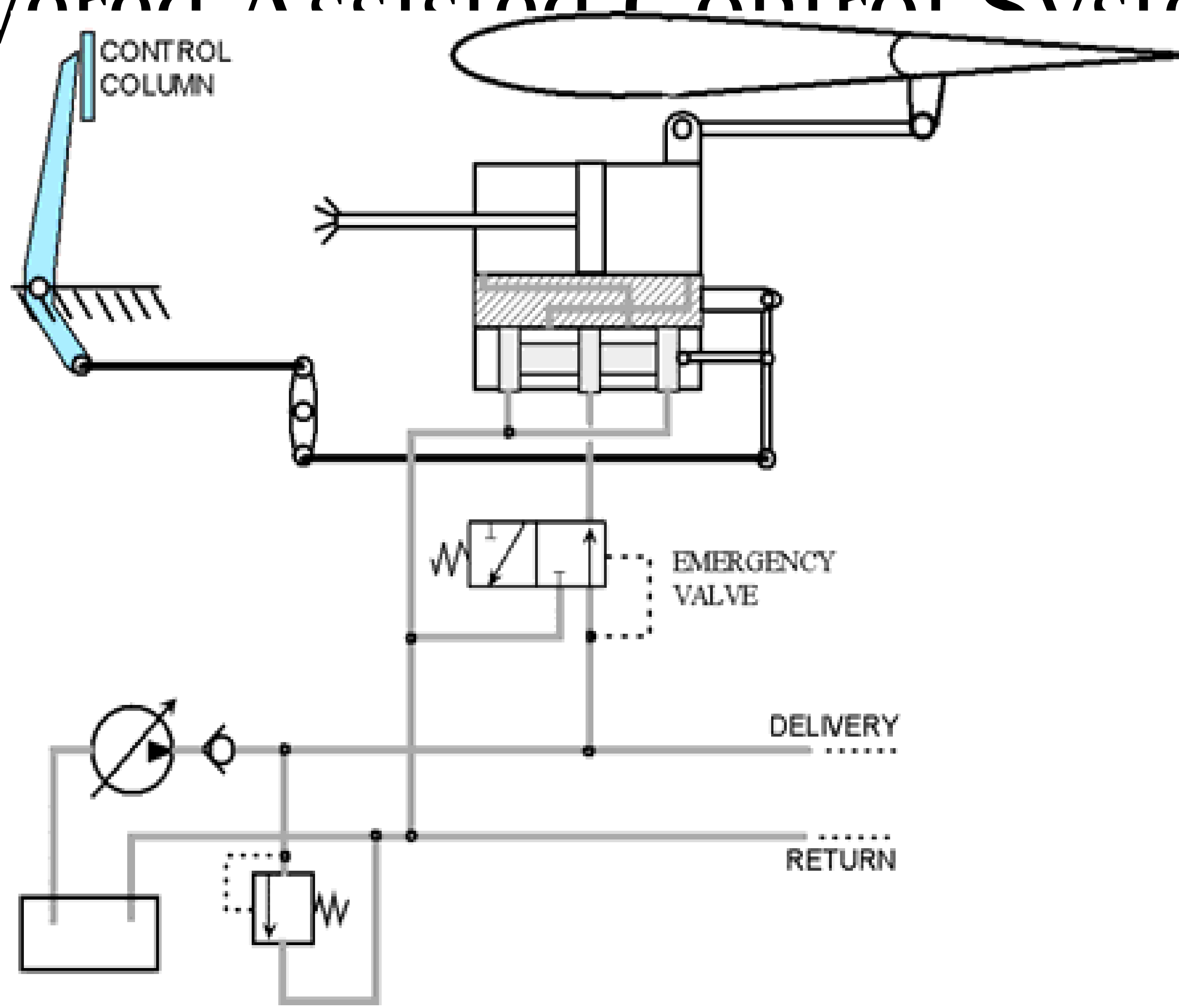
- The basic principle of the hydraulic control is simple, but two aspects must be noticed when a powered control is introduced:
- The system must control the surface in a proportional way, i.e. the surface response (deflection) must be function to the pilot's demand (stick deflection, for instance)
- The pilot that with little effort acts on a control valve must have a feedback on the maneuver intensity

Powered Assisted Control System

- The first problem is solved by using (hydraulic) servo-mechanisms, where the components are linked in such a way to introduce an actuator stroke proportional to the pilot's demand



Powered Assisted Control System



Powered Assisted Control System

- The pilot, in normal hydraulic operating conditions, is requested for a very low effort, necessary to contrast the mechanical frictions of the linkage and the movement of the control valve
- The pilot is then no more aware of the load condition being imposed to the aircraft.
- An artificial feel is introduced in powered systems, acting directly on the cabin control stick or pedals.

Powered Assisted Control System

- The simplest solution is a spring system, then responding to the pilot’s demand with a force proportional to the stick deflection; this solution has of course the limit to be not sensitive to the actual flight conditions.
- A more sophisticated artificial feel is the so-called Q feel. This system receives data from the pitot-static probes, reading the dynamic pressure, or the difference between total (pt) and static (ps) pressure, that is proportional to the aircraft speed v through the air density ρ:

$$p_t - p_s = \frac{1}{2}\rho v^2 .$$

Powered Assisted Control System

- This signal is used to modulate a hydraulic cylinder that increases the stiffness in the artificial feel system, in such a way that the pilot is given a contrast force in the pedals or stick that is also proportional to the aircraft speed.

Disadvantages of Mechanical and Hydro-Mechanical Systems

- Heavy and require careful routing of flight control cables through the aircraft using pulleys, cranks, tension cables and hydraulic pipes.
- They require redundant backup to deal with failures, which again increases weight.
- Limited ability to compensate for changing aerodynamic conditions

Disadvantages of Mechanical and Hydro-Mechanical Systems

- Dangerous characteristics such as stalling, spinning and pilot-induced oscillation (PIO), which depend mainly on the stability and structure of the aircraft concerned rather than the control system itself, can still occur with these systems

- By using electrical control circuits combined with computers, designers can save weight, improve reliability, and use the computers to mitigate the undesirable characteristics mentioned above. Modern advanced fly-by-wire systems are also used to control unstable fighter aircraft

Fly –By –Wire System (FBW)

- The term "fly-by-wire" implies a purely electrically-signalled control system
- It is a computer-configured controls, where a computer system is interposed between the operator and the final control actuators or surfaces
- It modifies the manual inputs of the pilot in accordance with control parameters
- These are carefully developed and validated in order to produce maximum operational effect without compromising safety

FBW – Introduction

- The FBW architecture was developed in 1970's

- Initially starting as an analogue technique and later on transformed into digital.

- It was first developed for military aviation, where it is now a common solution

- The supersonic Concorde can be considered a first and isolated civil aircraft equipped with a (analogue) fly-by-wire system

FBW – Introduction

- In the 80's the digital technique was imported from military into civil aviation by Airbus, first with the A320, then followed by A319, A321, A330, A340, Boeing 777 and A380 (scheduled for 2005).
- This architecture is based on computer signal processing

Operation

- The pilot's demand is first of all transduced into electrical signal in the cabin and sent to a group of independent computers (Airbus architecture substitute the cabin control column with a side stick)

- The computers sample also data concerning the flight conditions and servo-valves and actuators positions

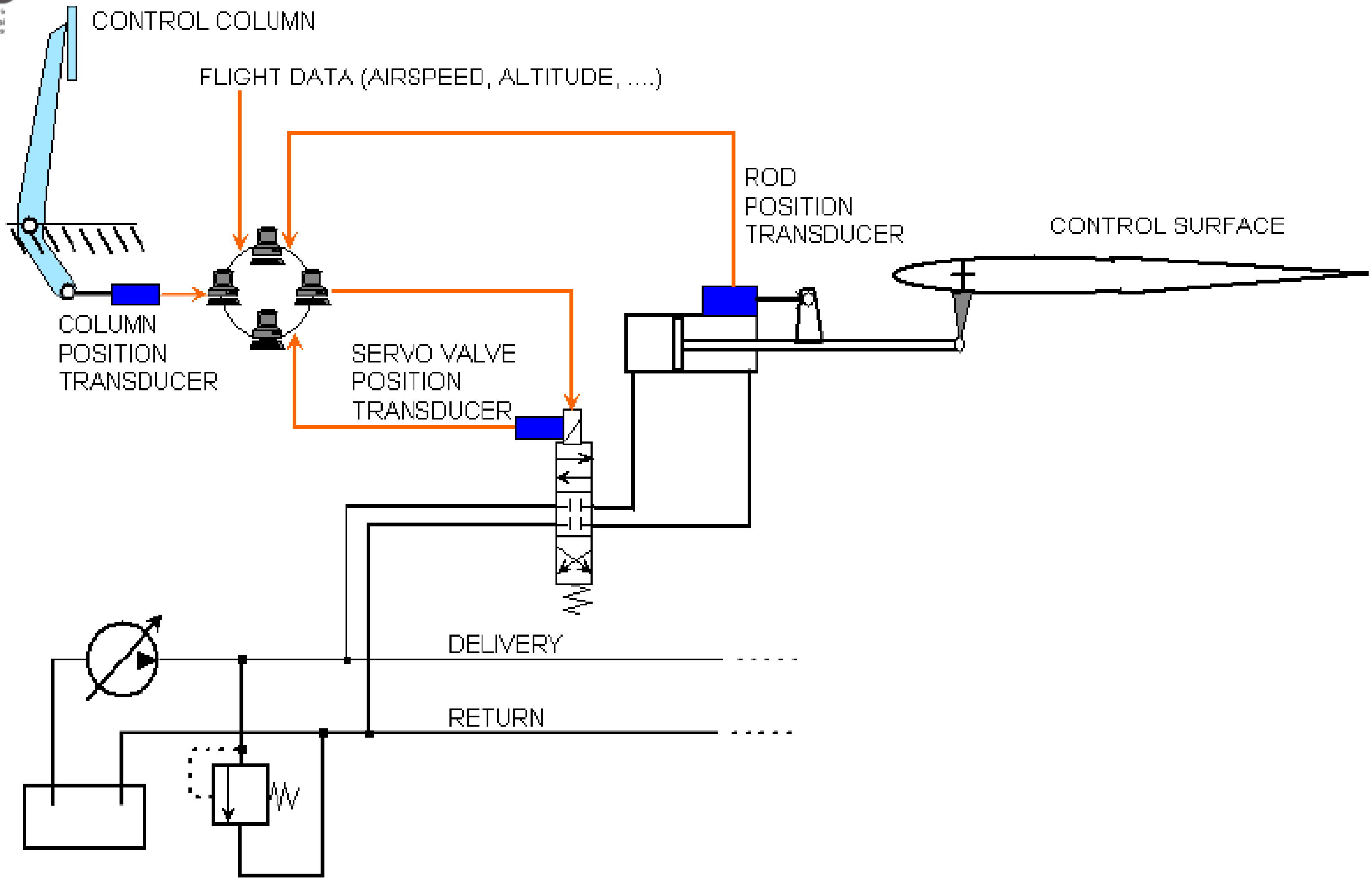
- The pilot's demand is then processed and sent to the actuator, properly tailored to the actual flight status.

Operation

- The flight data used by the system mainly depend on the aircraft category; in general the following data are sampled and processed:
  - pitch, roll, yaw rate and linear accelerations
  - Angle of attack and sideslip
  - Airspeed/Mach number, Pressure, Altitude and radio altimeter indications
  - Stick and pedal demands
  - Other cabin commands such as landing gear condition, thrust lever position, etc.

Operation

- The full system has high redundancy to restore the level of reliability of a mechanical or hydraulic system, in the form of multiple (triplex or quadruplex) parallel and independent lanes to generate and transmit the signals, and independent computers that process them



Fly-By-Wire System

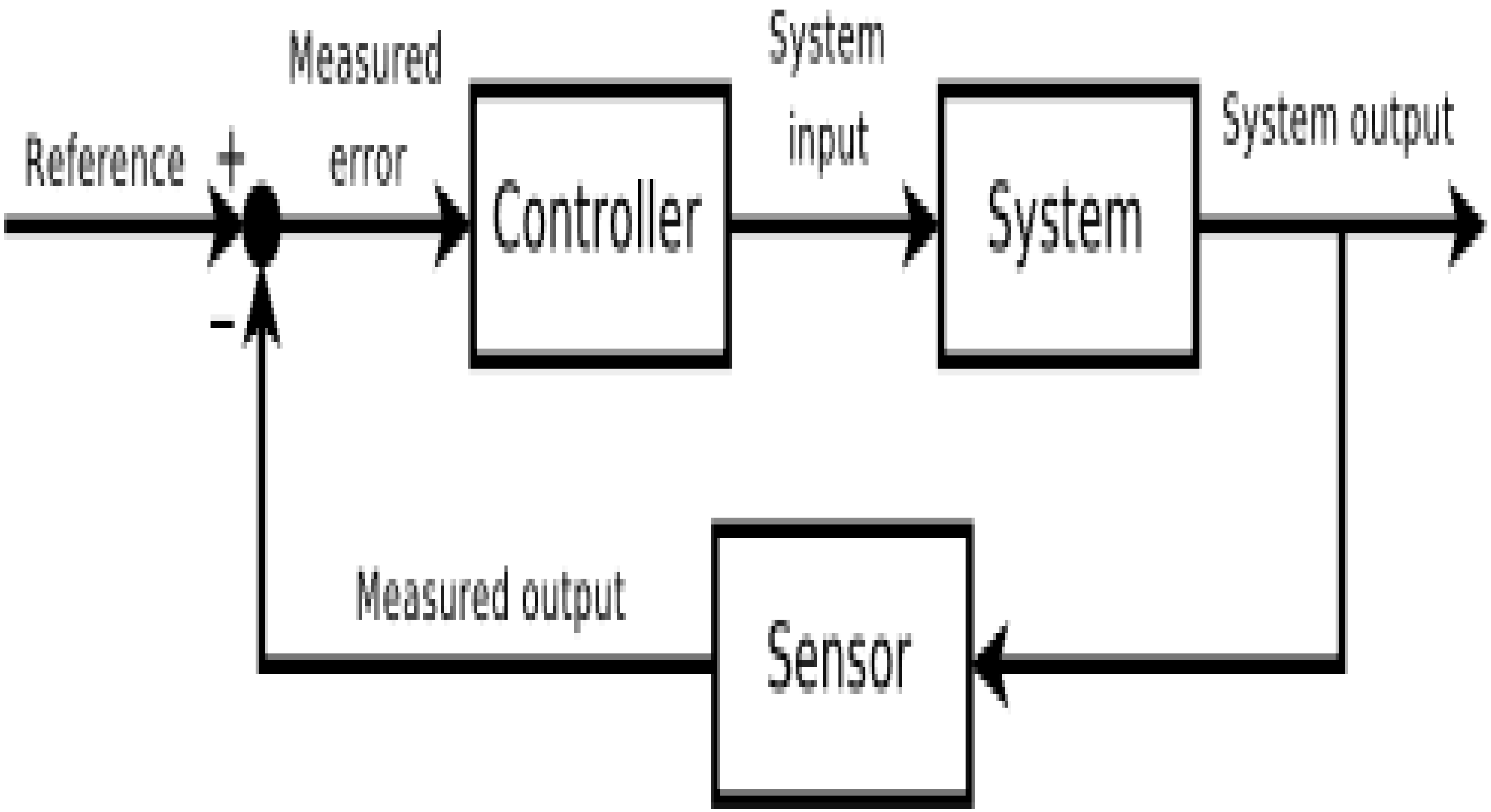
FBW – Basic Operation

- When a pilot moves the control, a signal is sent to a computer, this is analogous to moving a game controller, the signal is sent through multiple wires (channels) to ensure that the signal reaches the computer.
- When there are three channels being used this is known as 'Triplex'.
- The computer receives the signals, performs a calculation (adds the signal voltages and divides by the number of signals received to find the mean average voltage) and adds another channel.

FBW – Basic Operation

- These four 'Quadruplex' signals are then sent to the control surface actuator and the surface begins to move.
- Potentiometers in the actuator send a signal back to the computer (usually a negative voltage) reporting the position of the actuator.
- When the actuator reaches the desired position the two signals (incoming and outgoing) cancel each other out and the actuator stops moving (completing a feedback loop).

FBW – Basic Operation

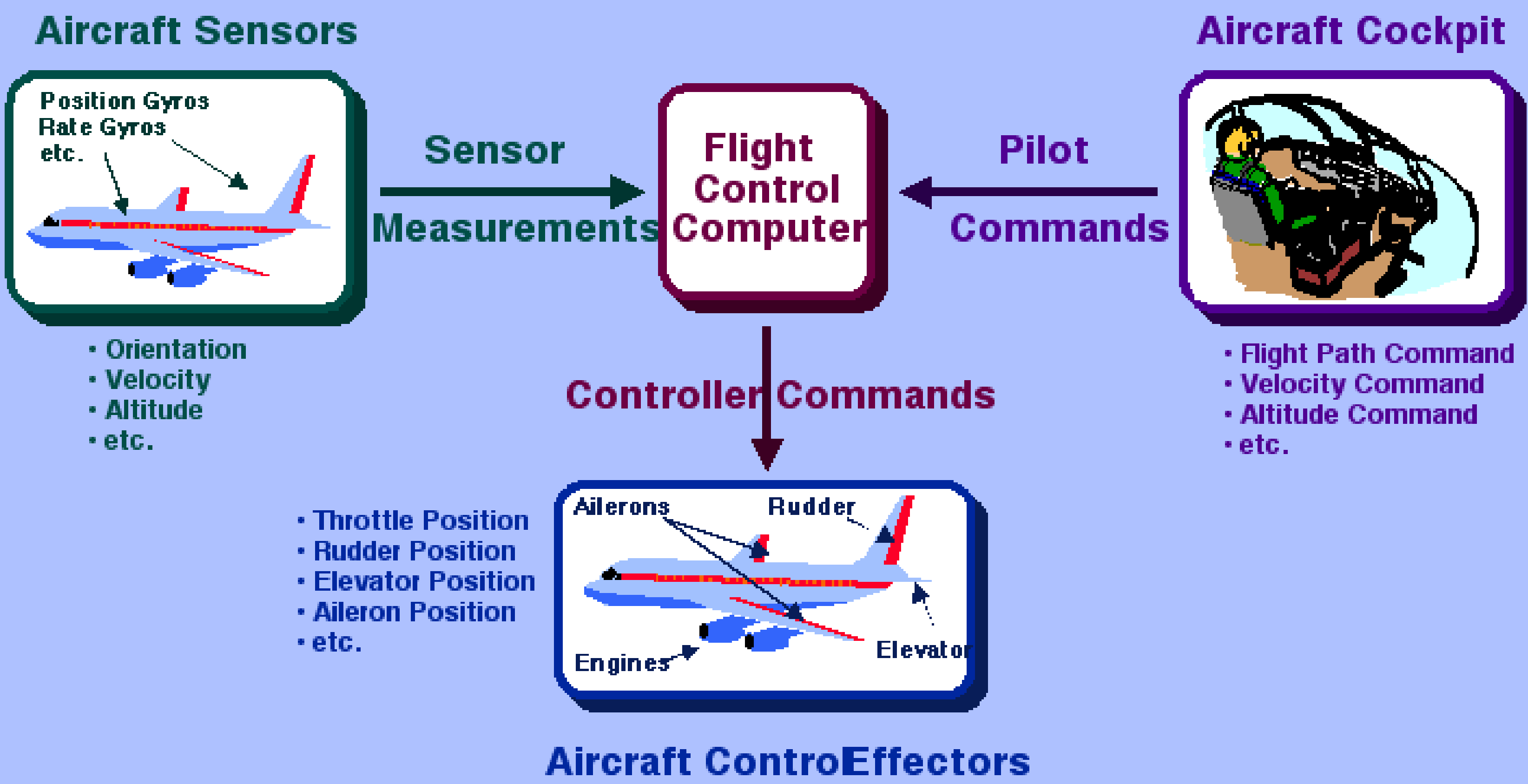


FBW – Stability

- Three gyroscopes fitted with sensors are fitted in the aircraft to sense movement changes in the pitch, roll and yaw axes.
- Any movement (from straight and level flight for example) results in signals being sent to the computer which again moves the relevant control actuators, however, the input is done without the pilot's knowledge; the cockpit controls do not move

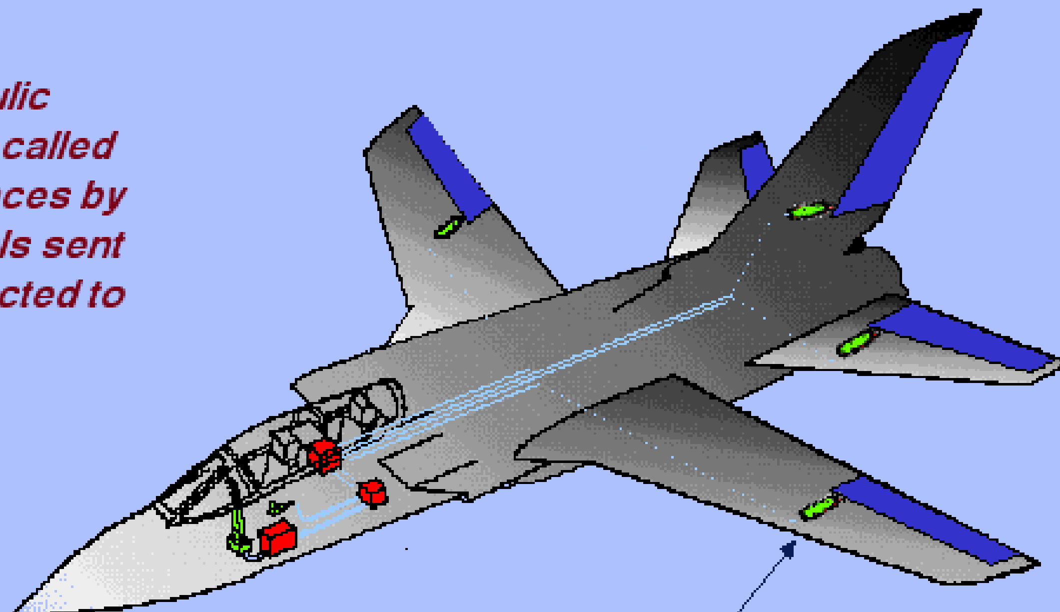
“Putting it All Together”

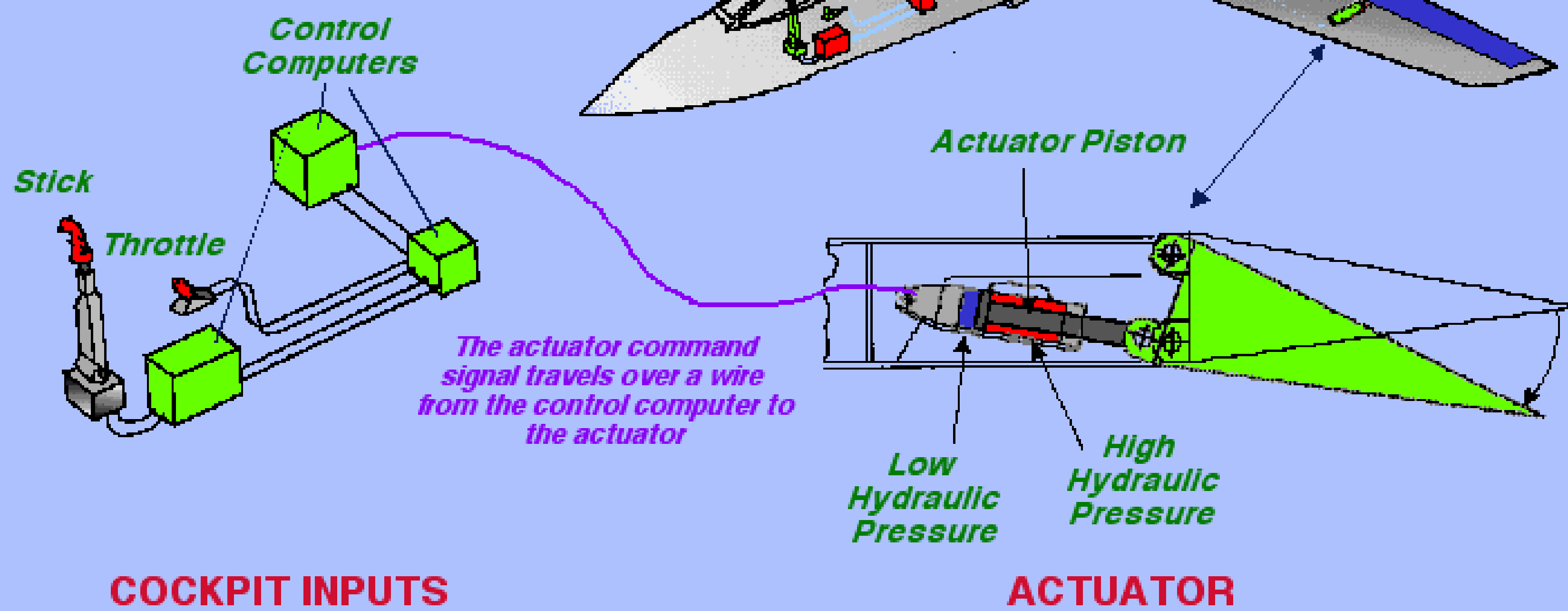
Flight Control System



Control Surfaces are Moved with Actuators

In modern aircraft, hydraulic systems or electric motors called actuatorsmove control surfaces by responding to control signals sent from a flight computer connected to the control stick.





FBW – Safety and Redundancy

- Aircraft systems may be quadruplexed (four independent channels) in order to prevent loss of signals in the case of failure of one or even two channels.
- High performance aircraft that have FBW controls (also called CCVs or Control-Configured Vehicles) may be deliberately designed to have low or even negative aerodynamic stability in some flight regimes, the rapid-reacting CCV controls compensating for the lack of natural stability

FBW – Safety and Redundancy

- Pre-flight safety checks of a fly-by-wire system are often performed using Built-In Test Equipment (BITE).

- On programming the system, either by the pilot or ground crew, a number of control movement steps are automatically performed.

- Any failure will be indicated to the crews

FBW – Advantages

- Flight envelope protection (the computers will reject and tune pilot's demands that might exceed the airframe load factors)
- Increase of stability and handling qualities across the full flight envelope, including the possibility of flying unstable vehicles
- Turbulence suppression and consequent decrease of fatigue loads and increase of passenger comfort

FBW – Advantages

- Use of thrust vectoring to augment or replace lift aerodynamic control, then extending the aircraft flight envelope
- Drag reduction by an optimised trim setting
- Higher stability during release of tanks and weapons

FBW – Advantages

- Easier interfacing to auto-pilot and other automatic flight control systems
- Weight reduction (mechanical linkages are substituted by wirings)
- Maintenance reduction
- Reduction of airlines' pilot training costs (flight handling becomes very similar in an whole aircraft family)

F-8C Crusader
Digital fly-by-wire test bed
(1972)

The Airbus A320,
First airliner with Digital fly-by-wire controls
(1984)

A Dassault Falcon 7X,
The first business jet with Digital fly-by-wire controls
(2005)

Digital Fly-By-Wire (DFBW)

- A digital fly-by-wire flight control system is similar to analog system. However, the signal processing is done by digital computers and the pilot literally can "fly-via-computer".
- Increases in flexibility of the flight control system, since the digital computers can receive input from any aircraft sensor (such as the altimeters and the pitot tubes).
- Increase in electronic stability - system is less dependent on the values of critical electrical components in an analog controller

Digital Fly-By-Wire (DFBW)

- The computers "read" position and force inputs from the pilot's controls and aircraft sensors.
- They solve differential equations to determine the appropriate command signals that move the flight controls in order to carry out the intentions of the pilot
- The programming of the digital computers enable flight envelope protection.

Digital Fly-By-Wire (DFBW)

- Aircraft designers precisely tailor an aircraft's handling characteristics, to stay within the overall limits of what is possible given the aerodynamics and structure of the aircraft.
- Flight-control computers continuously "fly" the aircraft, pilot's workloads can be reduced
- In military and naval applications, it is now possible to fly military aircraft that have relaxed stability.

Digital Fly-By-Wire (DFBW)

- Better maneuverability during combat and training flights and " carefree handling" because stalling, spinning. and other undesirable performances are prevented automatically by the computers
- Enable inherently unstable combat aircraft, such as the F-117 Nighthawk and the B-2 Spirit flying wing to fly in usable and safe manners

DFBW - Redundancy

- If one of the flight-control computers crashes - or is damaged in combat; or suffers from "insanity" caused by electromagnetic pulses - the others overrule the faulty one (or even two of them), they continue flying the aircraft safely, and they can either turn off or re-boot the faulty computers.
- Any flight-control computer whose results disagree with the others is ruled to be faulty, and it is either ignored or re-booted.

DFBW - Redundancy

- Most of the early digital fly-by-wire aircraft also had an analog electrical, a mechanical, or a hydraulic back-up flight control system
- The Space Shuttle has, in addition to its redundant set of four digital computers running its primary flight-control software, a fifth back-up computer running a separately developed, reduced-function, software flight-control system - one that can be commanded to take over in the event that a fault ever affects all of the computers in the other four.

DFBW - Redundancy

- This back-up system serves to reduce the risk of total flight-control-system failure ever happening because of a general-purpose flight software fault has escaped notice in the other four computers.
- For airliners, flight-control redundancy improves their safety
- Fly-by-wire control systems also improve economy in flight because they are lighter, and they eliminate the need for many mechanical, and heavy, flight-control mechanisms

DFBW - Redundancy

- Most modern airliners have computerized systems that control their jet engine throttles, air inlets, fuel storage and distribution system, in such a way to minimize their consumption of jet fuel. Thus, digital control systems do their best to reduce the cost of flights

Engine Control Systems

- To allow the engine to perform at maximum efficiency for a given condition
- Aids the pilot to control and monitor the operation of the aircraft's power plant
- Originally, engine control systems consisted of simple mechanical linkages controlled by the pilot then evolved and became the responsibility of the third pilot-certified crew member, the flight engineer

Engine Control Systems

- By moving throttle levers directly connected to the engine, the pilot or the flight engineer could control fuel flow, power output, and many other engine parameters.
- Following mechanical means of engine control came the introduction of analog electronic engine control.
- Analog electronic control varies an electrical signal to communicate the desired engine settings

Engine Control Systems

- It had its drawbacks including common electronic noise interference and reliability issues
- Full authority analogue control was used in the 1960s.
- It was introduced as a component of the Rolls Royce Olympus 593 engine of the supersonic transport aircraft Concorde. However the more critical inlet control was digital on the production aircraft.

Engine Control Systems

- In the 1970s NASA and Pratt and Whitney experimented with the first experimental FADEC, first flown on an F-111 fitted with a highly modified Pratt & Whitney TF30 left engine

Rolls Royce Olympus 593 engine

F-111C - Fighter - Bomber

Engine Control Systems

- Pratt & Whitney F100 – First Military Engine
- Pratt & Whitney PW2000 - First Civil Engine fitted with FADEC
- Pratt & Whitney PW4000 - First commercial "dual FADEC" engine.
- The Harrier II Pegasus engine by Dowty & Smiths Industries Controls - The first FADEC in service

Harrier II

Pegasus Engine

Functions

- FADEC works by receiving multiple input variables of the current flight condition including air density, throttle lever position, engine temperatures, engine pressures, and many other parameters
- The inputs are received by the EEC and analyzed up to 70 times per second
- Engine operating parameters such as fuel flow, stator vane position, bleed valve position, and others are computed from this data and applied as appropriate

Functions

- It controls engine starting and restarting.
- Its basic purpose is to provide optimum engine efficiency for a given flight condition.
- It also allows the manufacturer to program engine limitations and receive engine health and maintenance reports. For example, to avoid exceeding a certain engine temperature, the FADEC can be programmed to automatically take the necessary measures without pilot intervention.

Functions

- The flight crew first enters flight data such as wind conditions, runway length, or cruise altitude, into the flight management system (FMS). The FMS uses this data to calculate power settings for different phases of the flight.
- At takeoff, the flight crew advances the throttle to a predetermined setting, or opts for an auto-throttle takeoff if available.
- The FADECs now apply the calculated takeoff thrust setting by sending an electronic signal to the engines

Functions

- There is no direct linkage to open fuel flow. This procedure can be repeated for any other phase of flight
- In flight, small changes in operation are constantly made to maintain efficiency.
- Maximum thrust is available for emergency situations if the throttle is advanced to full, but limitations can’t be exceeded
- The flight crew has no means of manually overriding the FADEC

Functions

- True full authority digital engine controls have no form of manual override available, placing full authority over the operating parameters of the engine in the hands of the computer
- If a total FADEC failure occurs, the engine fails
- If the engine is controlled digitally and electronically but allows for manual override, it is considered solely an EEC or ECU.
- An EEC, though a component of a FADEC, is not by itself FADEC. When standing alone, the EEC makes all of the decisions until the pilot wishes to intervene.

Safety

- With the operation of the engines so heavily relying on automation, safety is a great concern.
- Redundancy is provided in the form of two or more, separate identical digital channels.
- Each channel may provide all engine functions without restriction.
- FADEC also monitors a variety of analog, digital and discrete data coming from the engine subsystems and related aircraft systems, providing for fault tolerant engine control

Applications

- FADECs are employed by almost all current generation jet engines, and increasingly in piston engines for fixed-wing aircraft and helicopters.
- The system replaces both magnetos in piston-engined aircraft, which makes costly magneto maintenance obsolete and eliminates carburetor heat, mixture controls and engine priming.
- Since, it controls each engine cylinder independently for optimum fuel injection and spark timing, the pilot no longer needs to monitor fuel mixture.

Applications

- More precise mixtures create less engine wear, which reduces operating costs and increases engine life for the average aircraft.

- Tests have also shown significant fuel savings

Advantages

- Better fuel efficiency
- Automatic engine protection against out-of-tolerance operations
- Safer as the multiple channel FADEC computer provides redundancy in case of failure
- Care-free engine handling, with guaranteed thrust settings
- Ability to use single engine type for wide thrust requirements by just reprogramming the FADECs

Advantages

- Provides semi-automatic engine starting

- Better systems integration with engine and aircraft systems

- Can provide engine long-term health monitoring and diagnostics

- Reduces the number of parameters to be monitored by flight crews

Advantages

- Due to the high number of parameters monitored, the FADEC makes possible "Fault Tolerant Systems" (where a system can operate within required reliability and safety limitation with certain fault configurations)
- Can support automatic aircraft and engine emergency responses (e.g. in case of aircraft stall, engines increase thrust automatically).

Disadvantages

- No form of manual override available, placing full authority over the operating parameters of the engine in the hands of the computer.
- If a total FADEC failure occurs, the engine fails.
- In the event of a total FADEC failure, pilots have no way of manually controlling the engines for a restart, or to otherwise control the engine.
- With any single point of failure, the risk can be mitigated with redundant FADECs

Disadvantages

- High system complexity compared to hydromechanical, analogue or manual control systems

- High system development and validation effort due to the complexity

Autopilot System

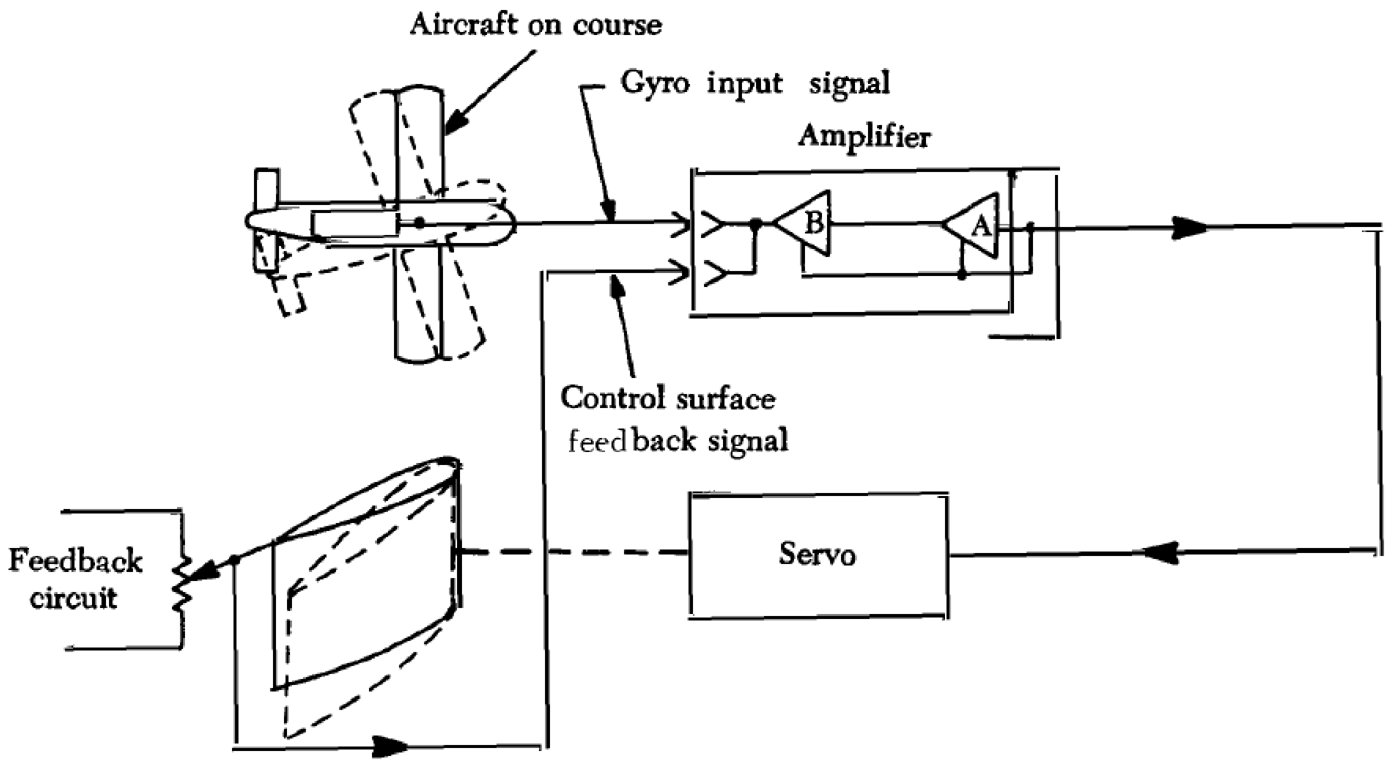


FIGURE 12–73. Basic autopilot system.

Autopilot Controller

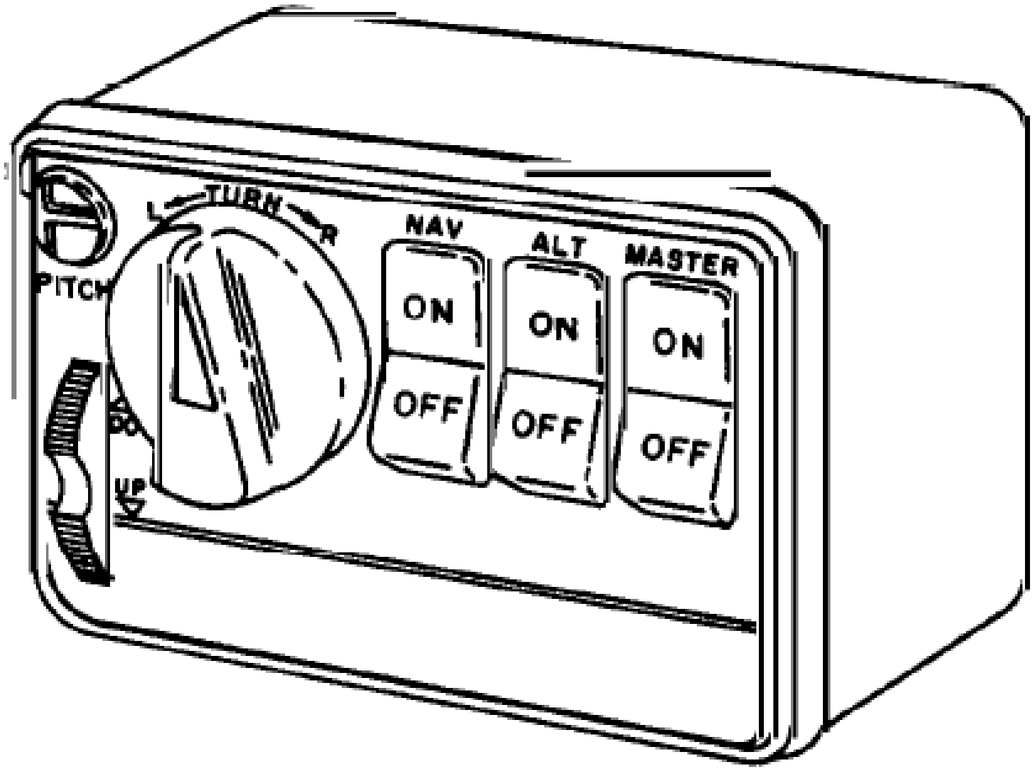


FIGURE 12–76. Typical autopilot controller.

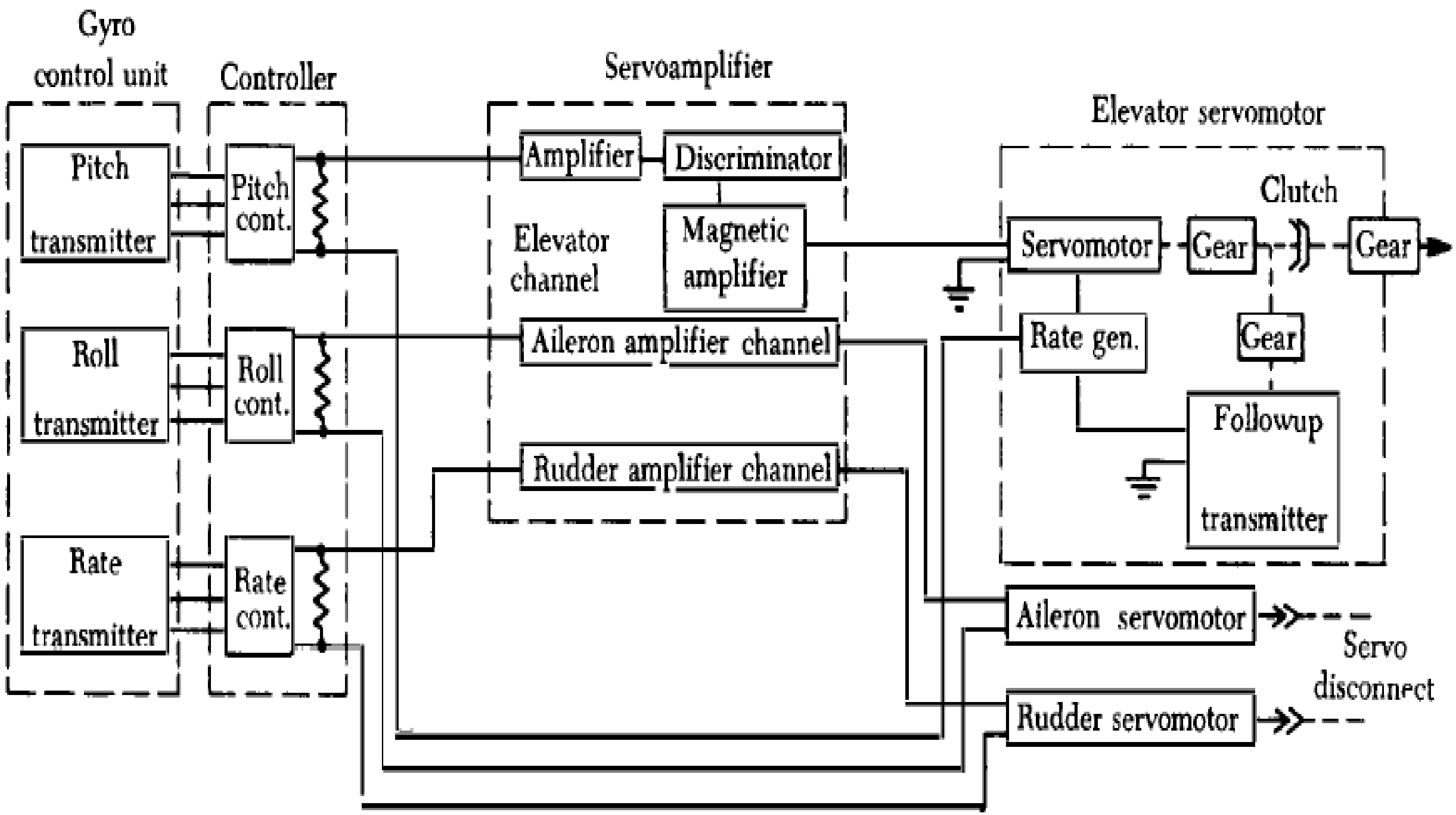


FIGURE 12-74. Autopilot block diagram.

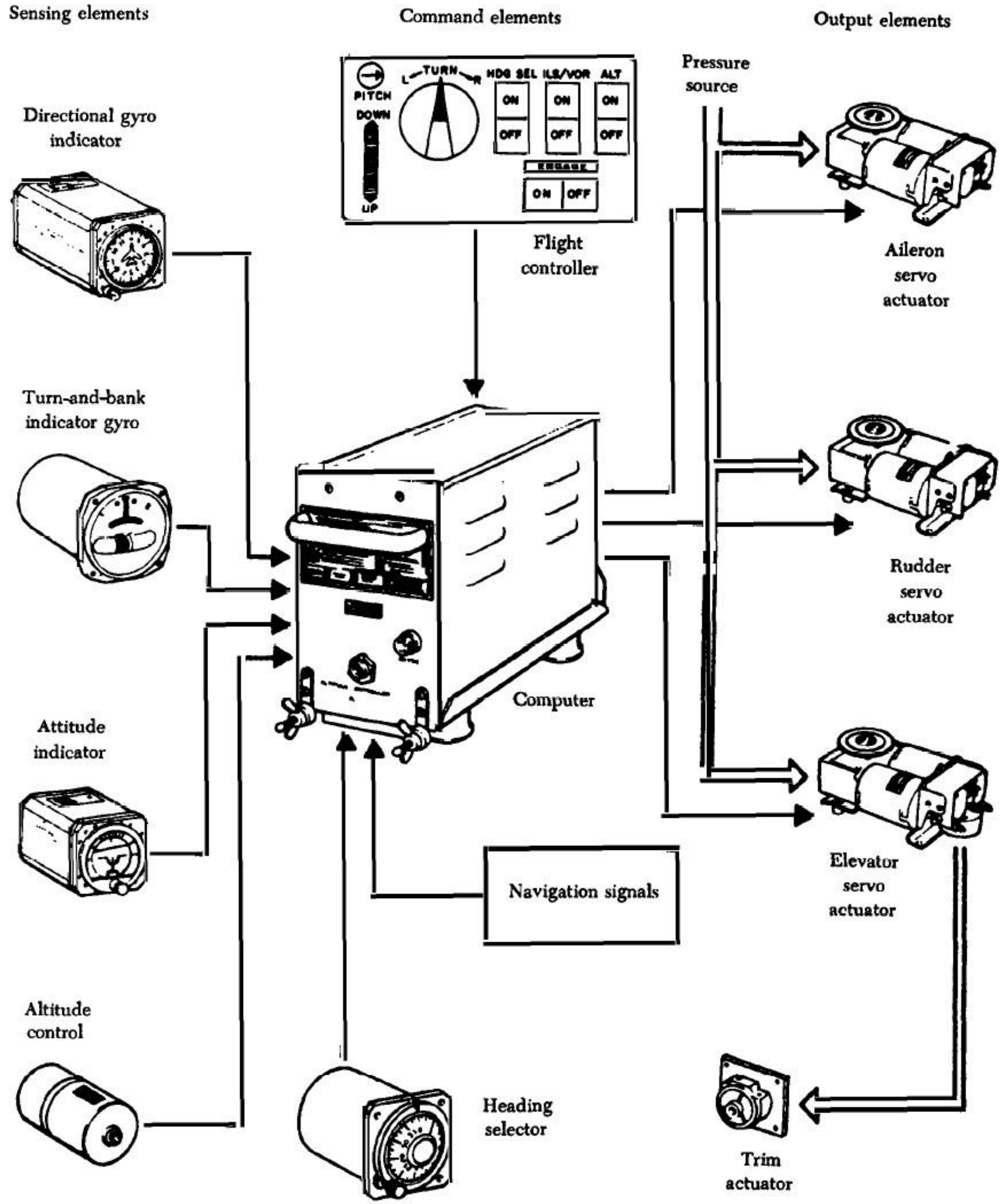


FIGURE 12-75. Typical autopilot system components.

COMMUNICATION AND NAVIGATION SYSTEMS

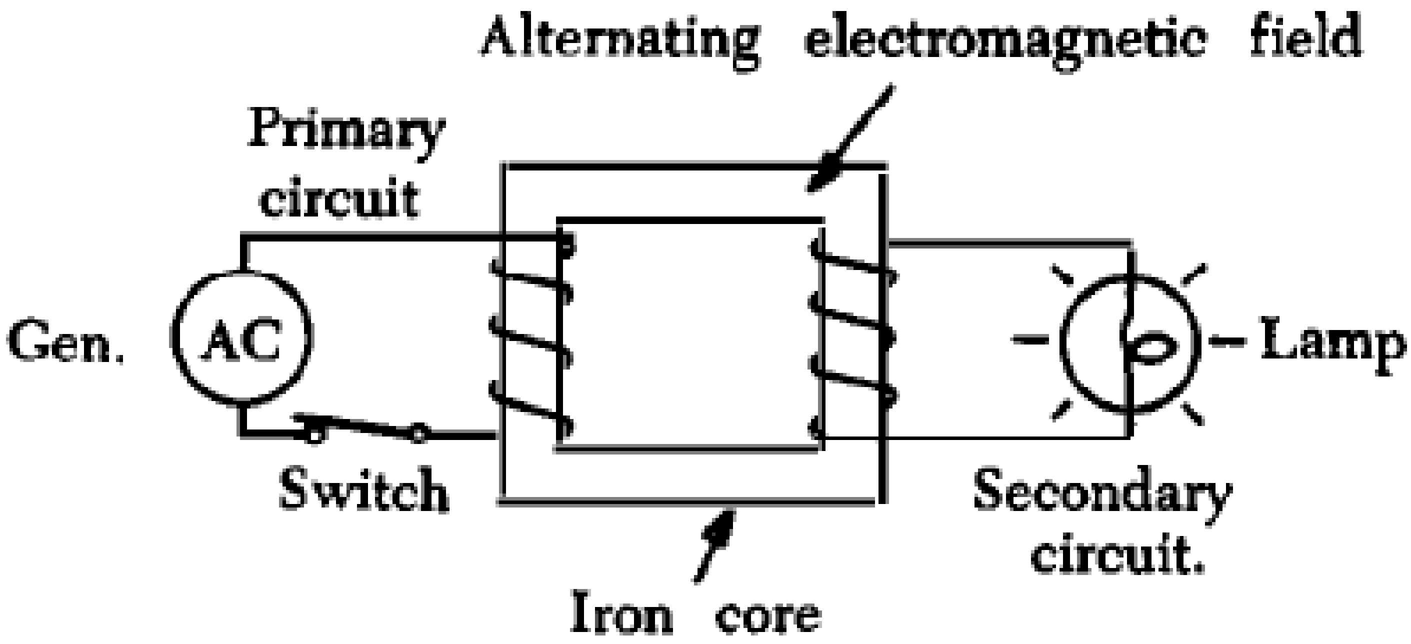


FIGURE 13–1. A simple transformer circuit.

Frequency Bands

Frequency Range	*Band*
Low frequency (L/F)	30 to 300 kHz
Medium frequency (M/F)	300 to 3,000 kHz
High frequency (H/F)	3,000 kHz to 30 MHz
Very high frequency (VHF)	30 to 300 MHz
Ultra high frequency (UHF)	300 to 3,000 MHz
Superhigh frequency (SHF)	3,000 to 30,000 MHz

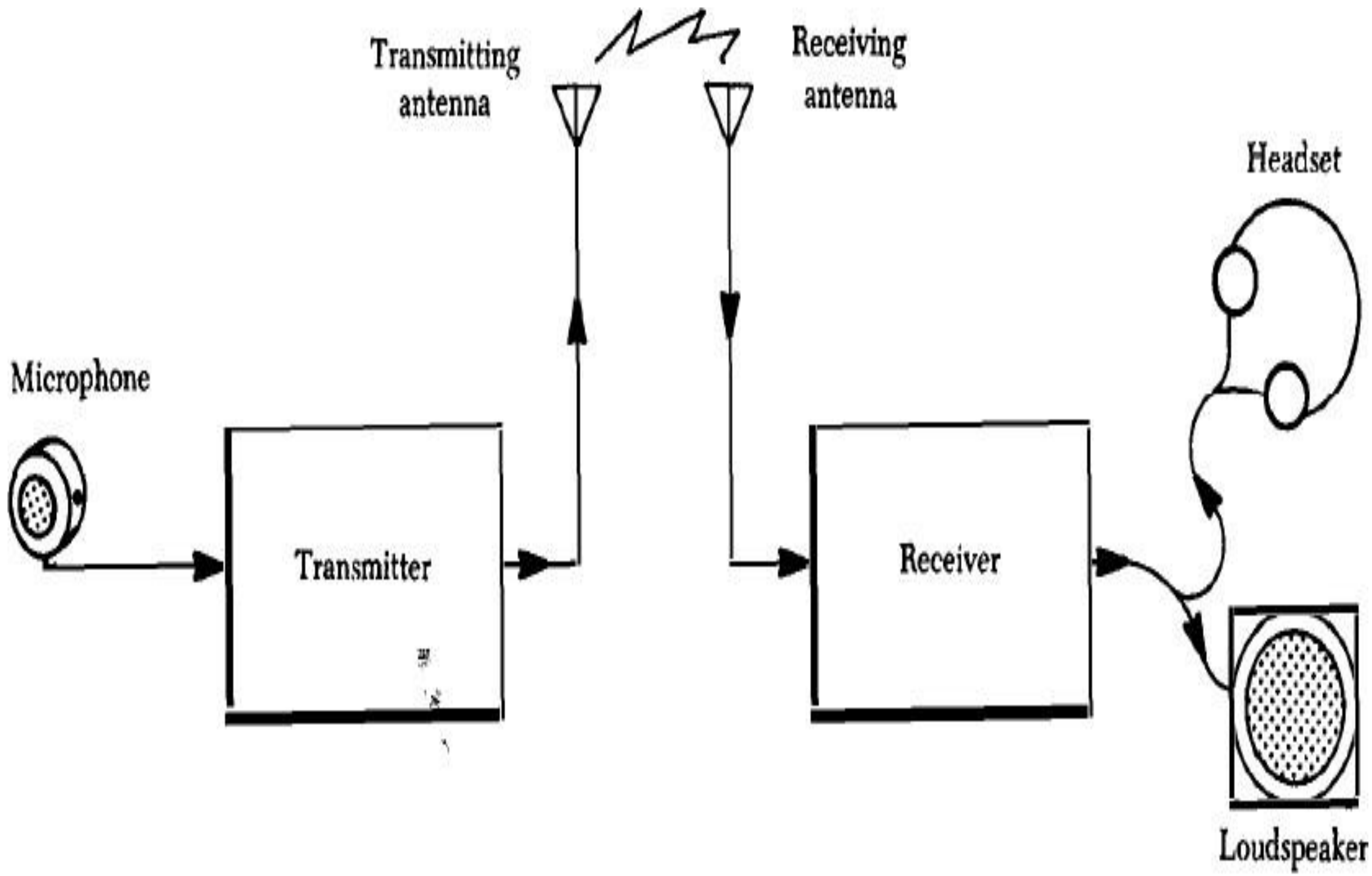


FIGURE 13–2. Basic communication equipment.

Antennas

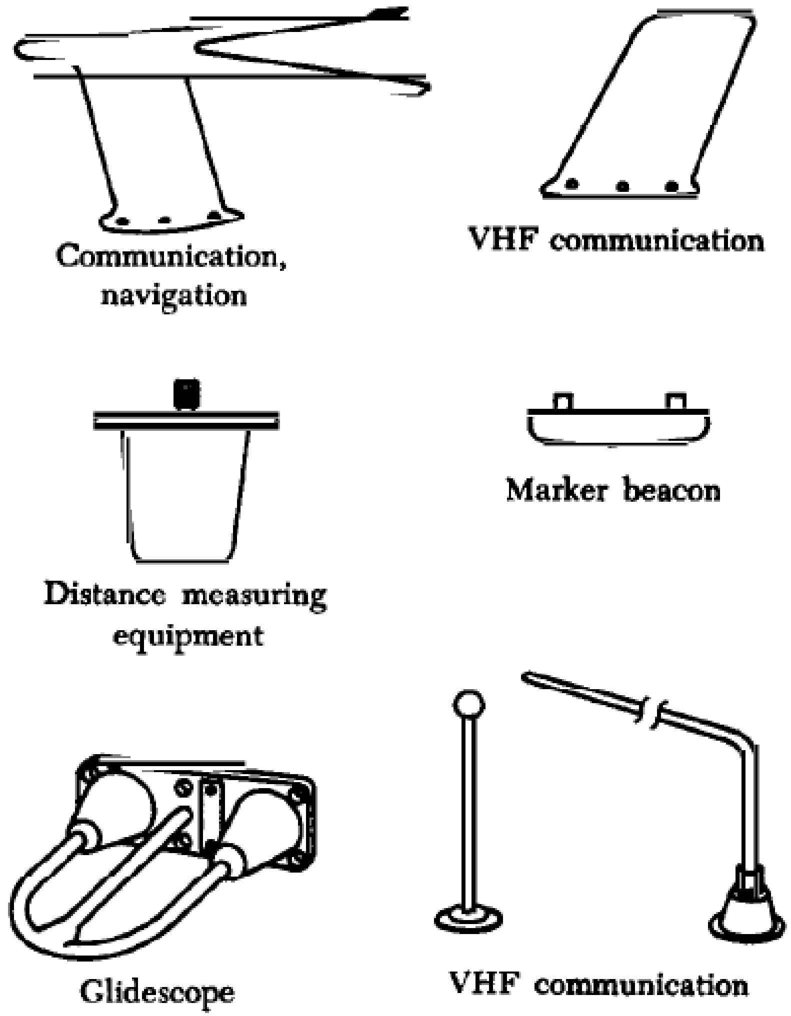


FIGURE 13-3. Antennas.

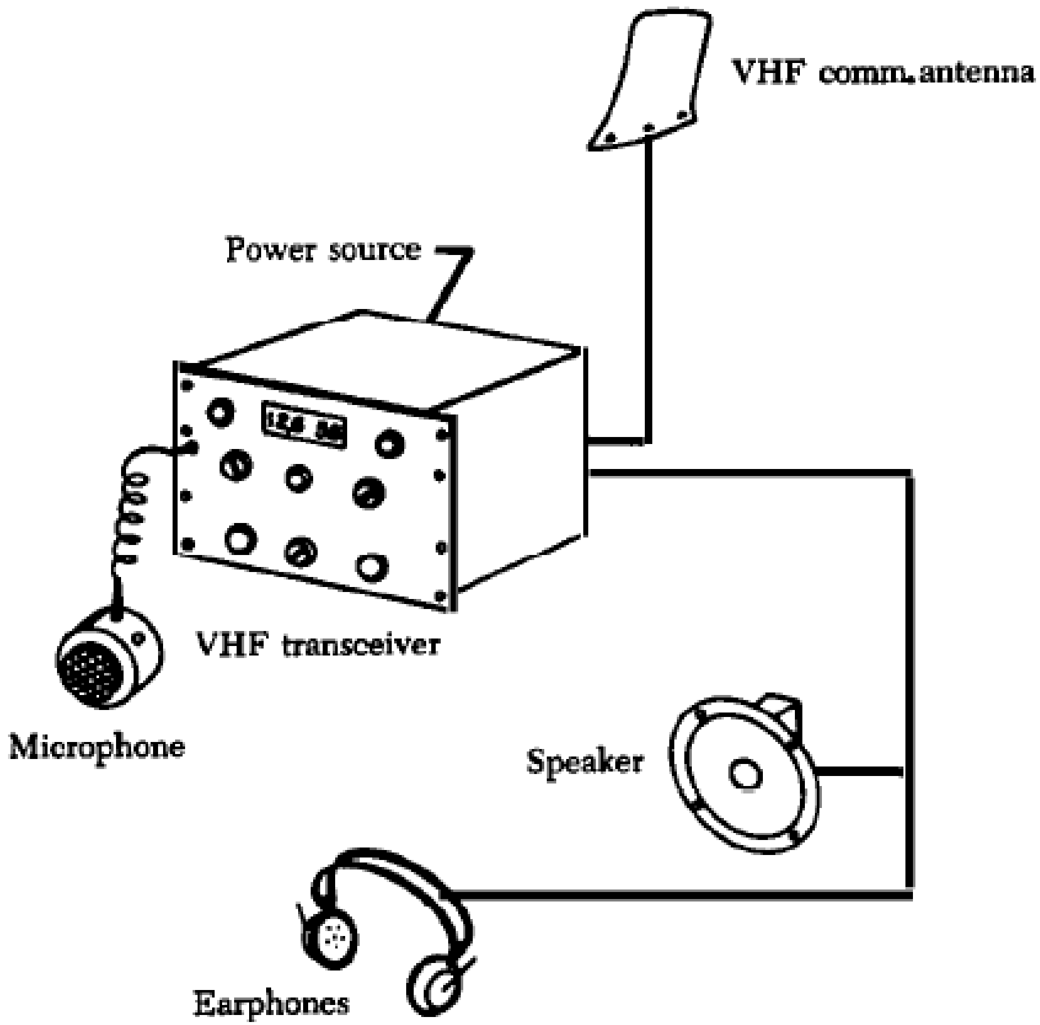


FIGURE 13–4. VHF system diagram.

Instrument Landing System (ILS)

What Is ILS?

- ILS is stand for **Instrument Landing System**.
- It has been existence for over 60 years.
- But today, it is still the most accurate **approach** and **landing** aid that is used by the airliners.
- Why need ILS?

History of ILS

The first scheduled passenger airliner to land using ILS was in 1938.

The Uses of ILS

- To guide the pilot during the approach and landing.
  - It is very helpful when visibility is limited and the pilot cannot see the airport and runway.
- To provide an aircraft with a **precision final approach.**
- To help the aircraft to a runway **touchdown point.**
- To provide an aircraft guidance to the runway both in the **horizontal and vertical** planes.
- To increase safety and situational awareness.

Flight Profile

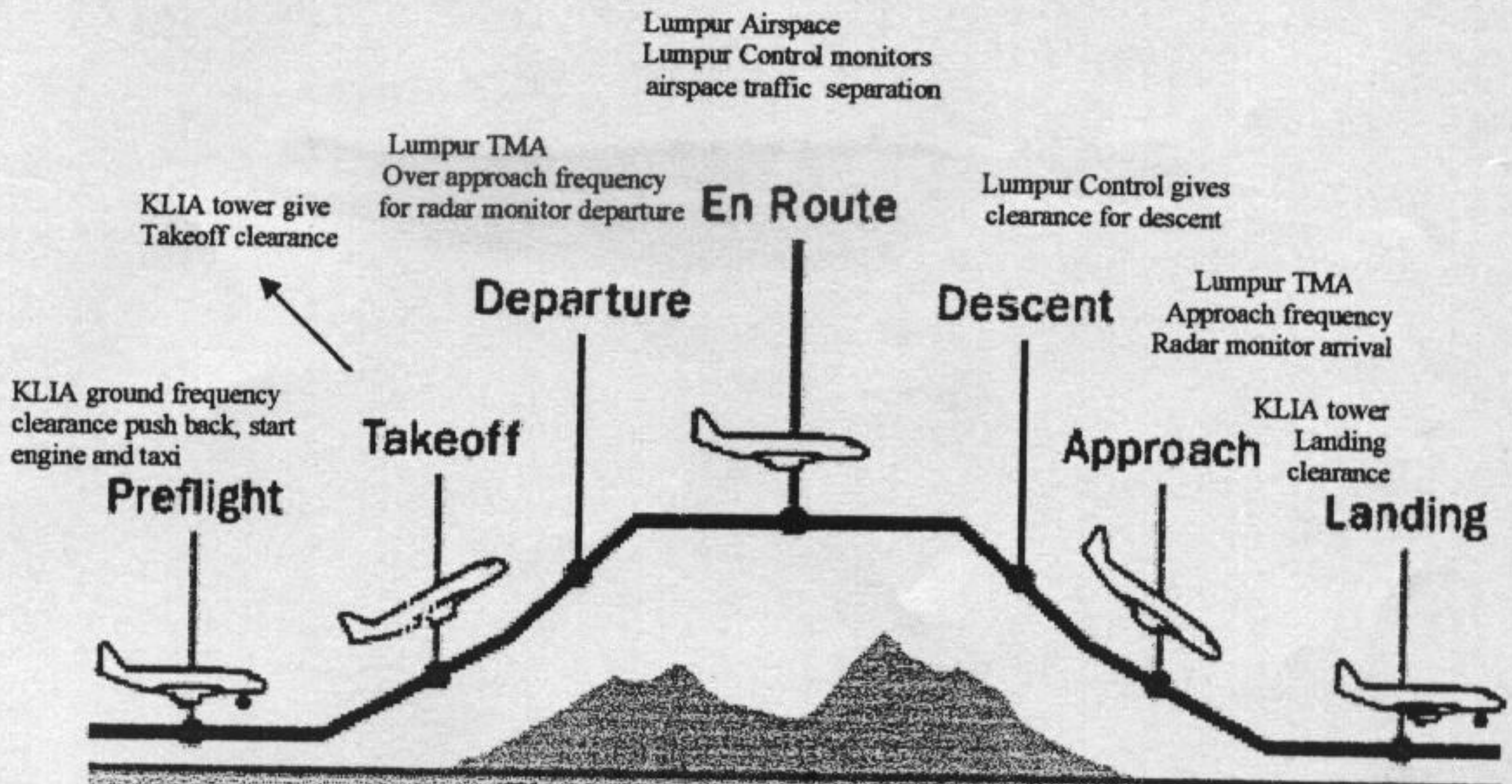
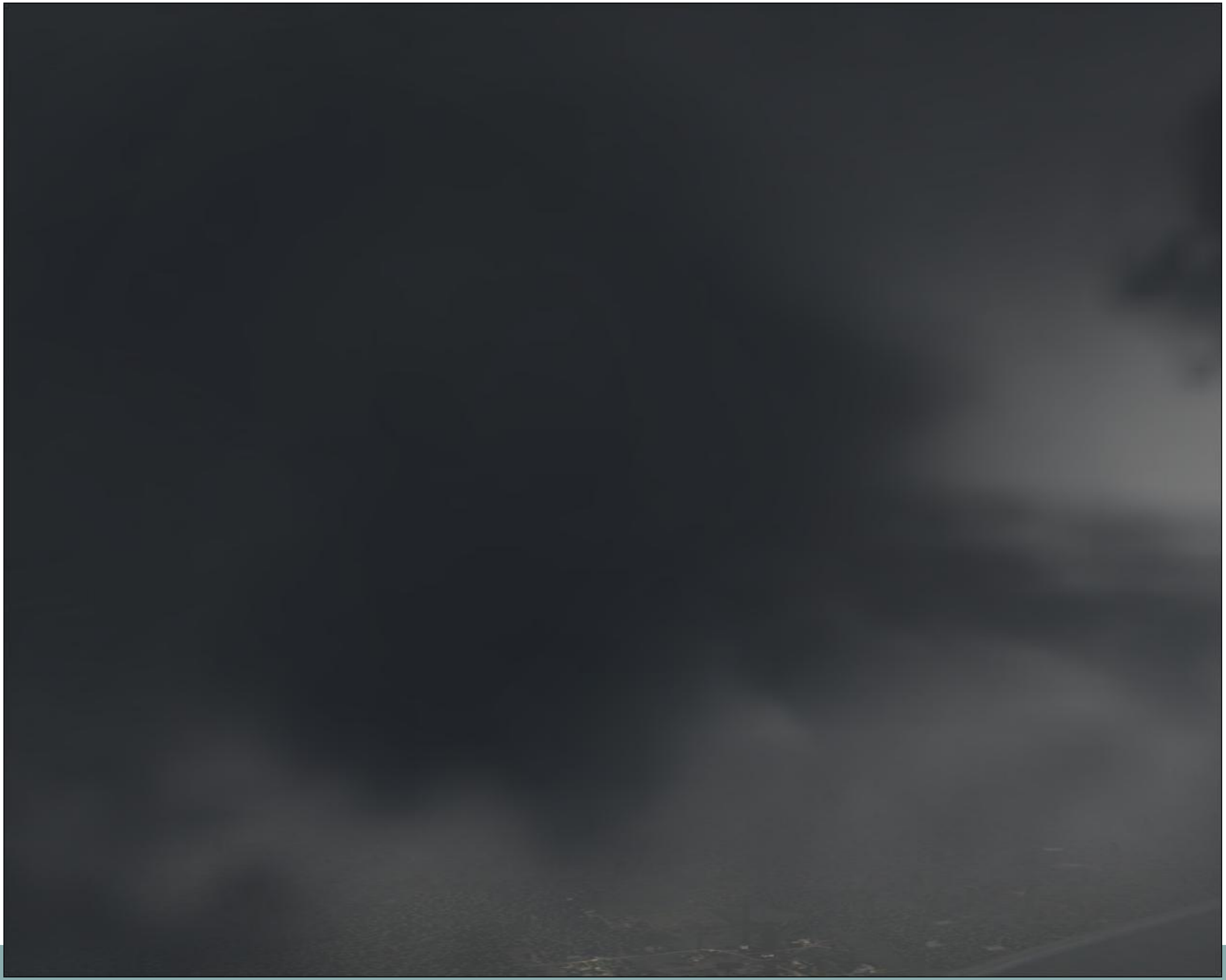


Figure 4.13 indicate the profile of a flight

Poor Visibility Landings

- Scheduled service would be impossible without a way to land in poor weather.

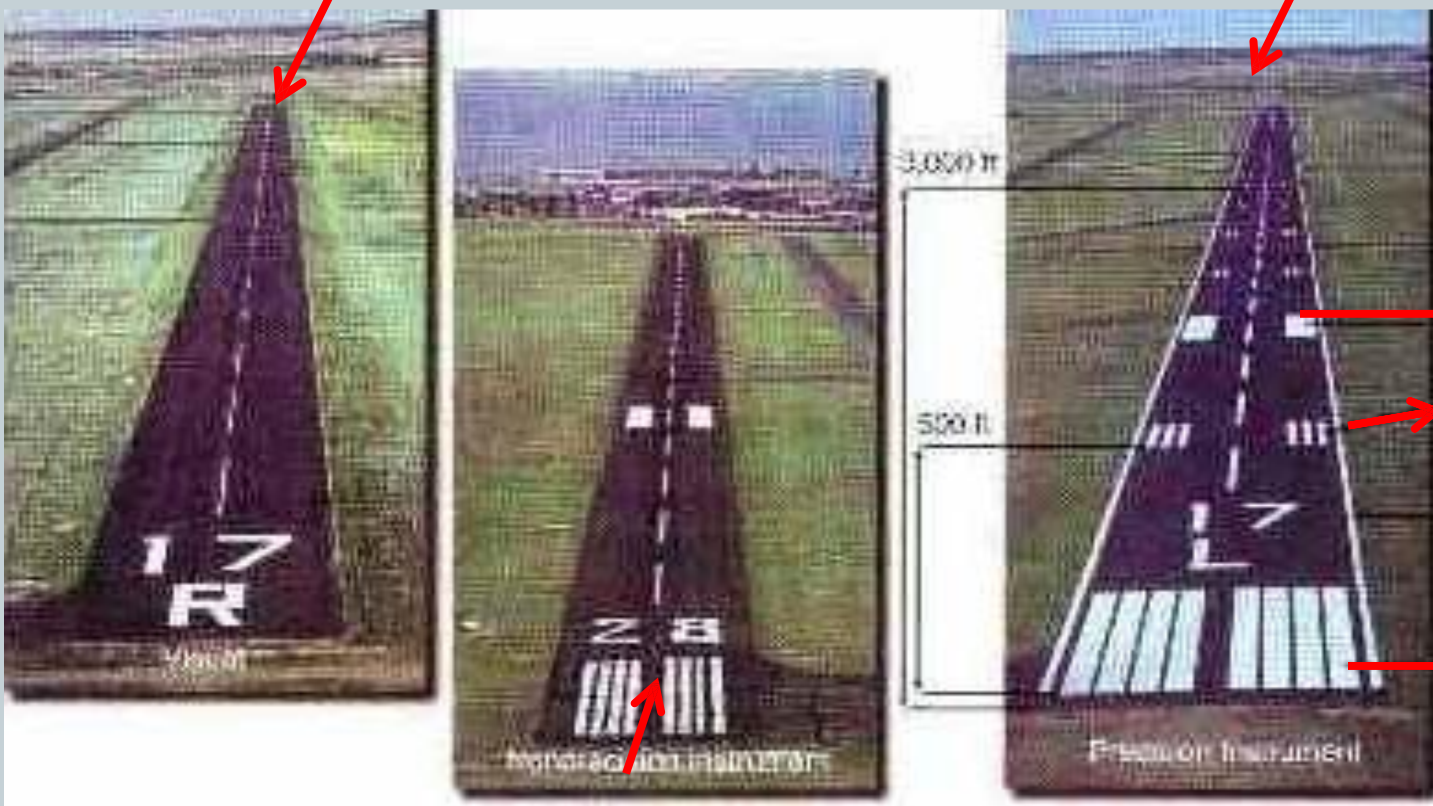
Poor Visibility Landings



Runway Approach

Non-Instrument Runway (NI)

Precision Runway (P)



Aiming point

Touchdown zone

Threshold

Non-Precision Runway (NP)

Types of Runway Approach

1. Non-Instrument Runway (NI)

- A runway intended for the operation of aircraft using visual approach procedure

2. Instrument Runway

- A runway intended for the operation of aircraft using **instrument approach procedures**

a) **Non-Precision Runway (NP)**

- An instrument runway served by visual aids and a non-visual aid providing at least lateral guidance adequate for a straight-in approach

b) **Precision Runway (P)**

- **Allow operations with a decision height and visibility corresponding to Category 1, or II, or III**

Precision Runway (P) Categories

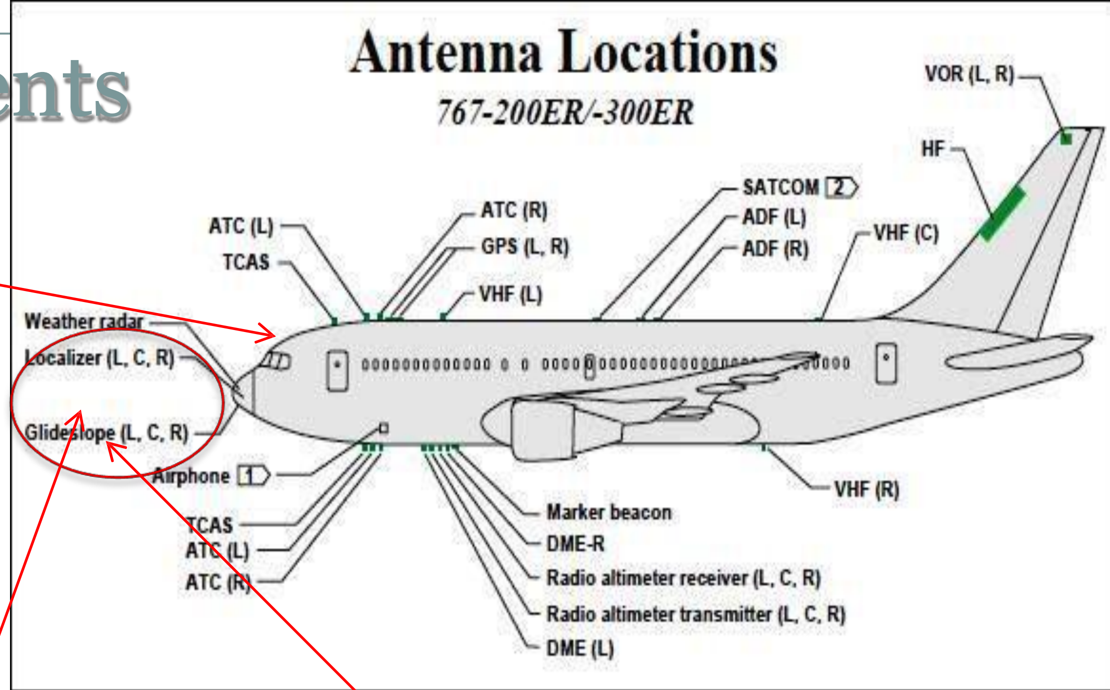
- **Runway Threshold:** Beginning of runway for landing.
- **Touchdown zone**: The first point for the aircraft should touch the runway during landing.
- **Aiming point:** serves as a visual aiming point for a landing aircraft.

ILS Components

- ILS consists of **<u>Ground Installations</u>** and **<u>Airborne Equipments</u>**
- There are ***3 equipments for <u>Ground Installations</u>,*** which are:
  1. **Ground Localizer (LLZ) Antenna** – To provide horizontal navigation
  2. **Ground Glide path (GP) Antenna** – To provide vertical navigation
  3. **Marker Beacons** – To enable the pilot cross check the aircraft's height.
- There are ***2 equipments for <u>Airborne Equipments</u>,*** which are:
  1. **LLZ and GP antennas located on the aircraft nose.**
  2. **ILS indicator inside the cockpit**

ILS Components

ILS Indicator inside the cockpit



Ground Localizer Antenna

Ground Glide Path Antenna

ILS Indicator

Signal Integrity Flag
Indicates if instrument is unreliable

Glidepath
Deviation from optimal glide path

Localizer
Deviation from runway centre line

"Dots"
Each "dot" on the instrument represents 2° of deviation

How ILS works?

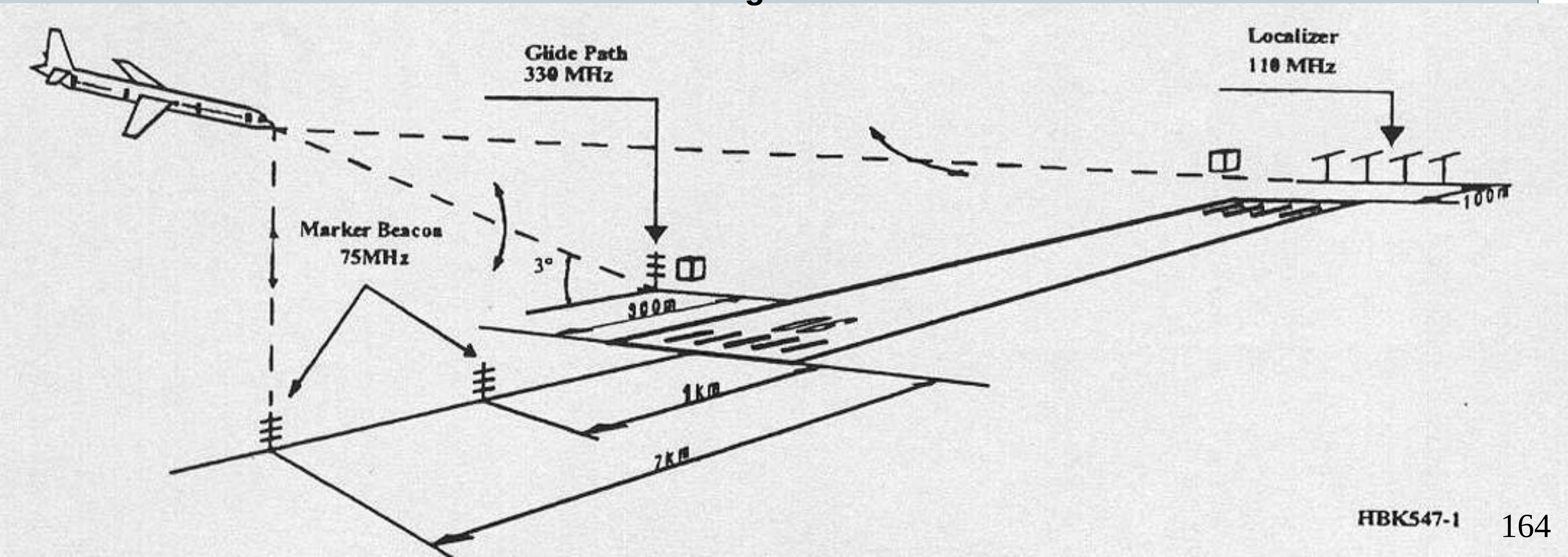
- **Ground localizer antenna transmit VHF signal** in direction opposite of runway **to horizontally** guide aircraft to the runway centre line.
- **Ground Glide Path antenna transmit UHF signal** in vertical direction **to vertically** guide aircraft to the touchdown point.
- **Localizer and Glide Path antenna located at aircraft nose receives both signals** and **sends it to ILS indicator in the cockpit.**
- **These signals activate the vertical and horizontal needles inside the ILS indicator to tell the pilot either go left/right or go up/down.**
- **By keeping both needles centered, the pilot can guide his aircraft down to end of landing runway aligned with the runway center line and aiming the touch down.**

ILS Components

Marker Beacons: **the height aircraft**

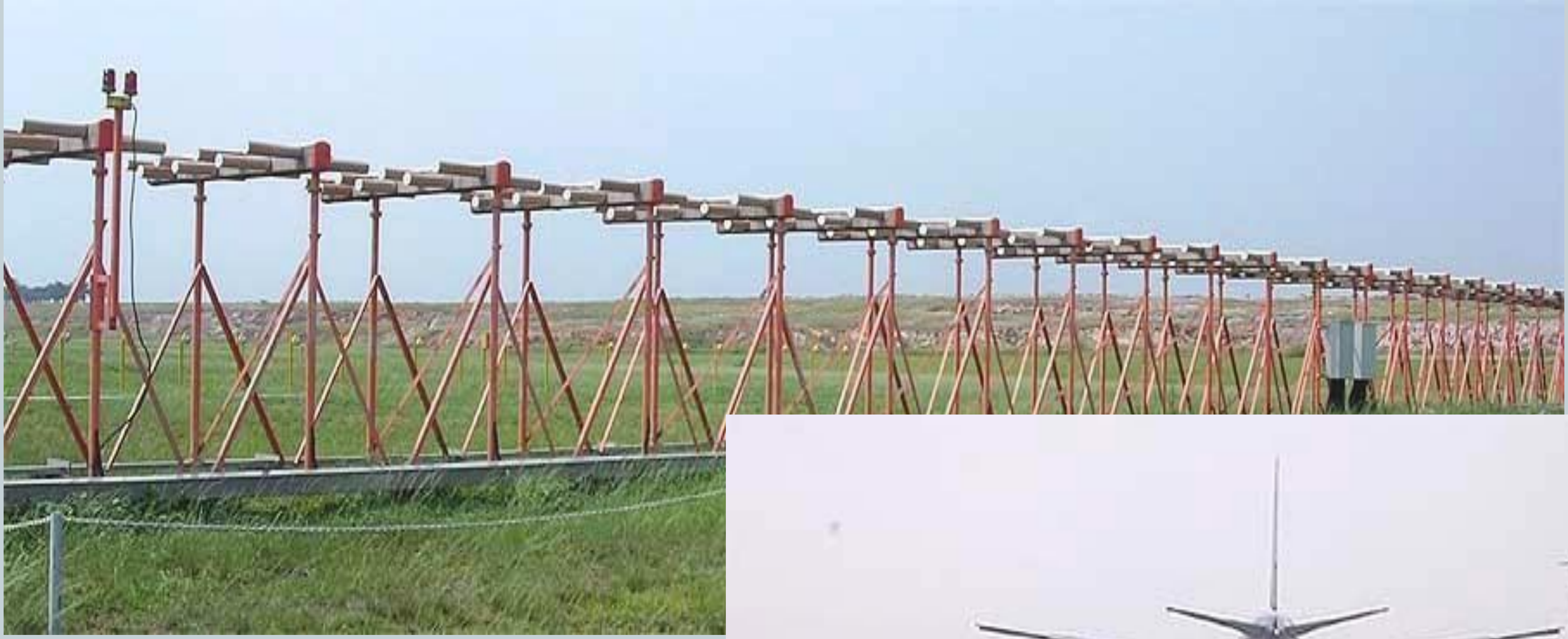
Glide Path: ***v*ertical guidance**

Localizer: horizontal guidance



Localizer

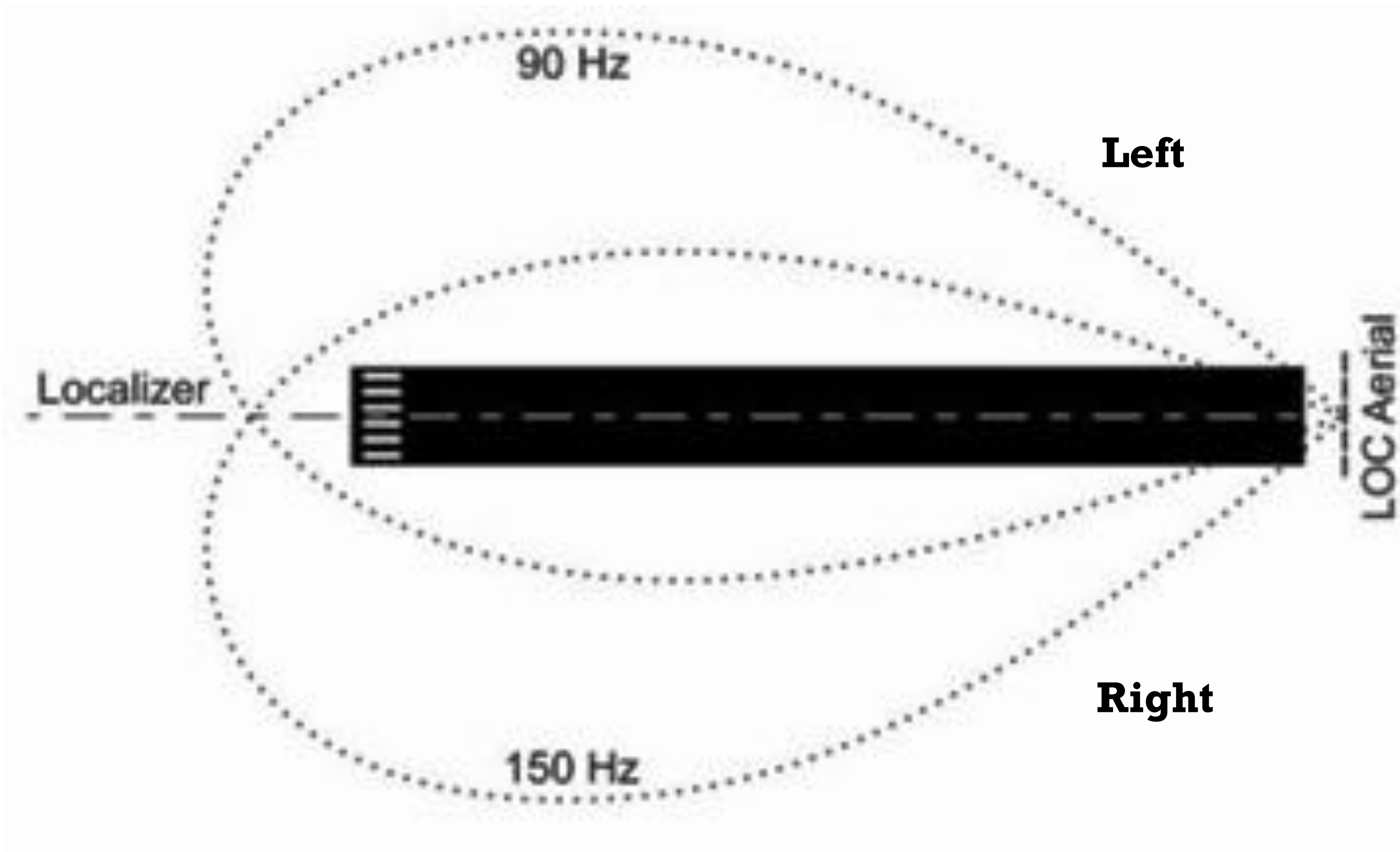
- Localizer is the horizontal antenna array located at the opposite end of the runway.
- **Localizer** operates in **VHF band between 108 to 111.975 MHz**



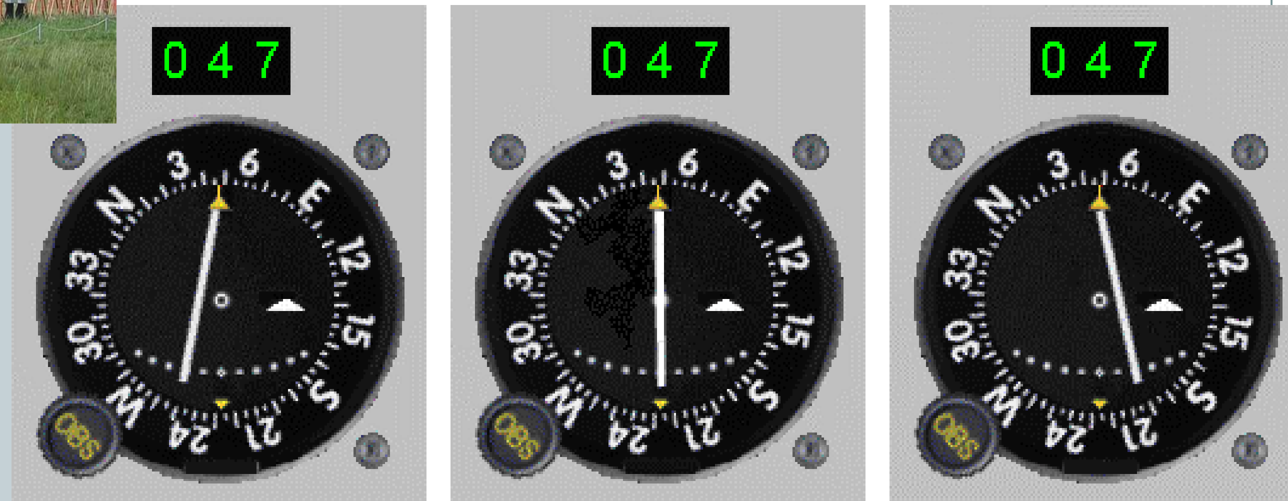
How Localizer Works

- Localizer transmit two signals which overlap at the centre.
- The left side has a 90 Hz modulation and the right has a 150 Hz modulation.
- The overlap area provides the on-track signal.
- For example, if an aircraft approaching the runway centre line **from the right, it** will **receive more of the 150 Hz modulation** than 90Hz modulation.
- Difference in **Depth of Modulation** will **energizes the vertical needle of ILS indicator**.
- Thus, aircraft will be given the direction to **GO LEFT.**

How Localizer Works



Localizer



Needle indicates direction of runway.

Centered Needle = Correct Alignment

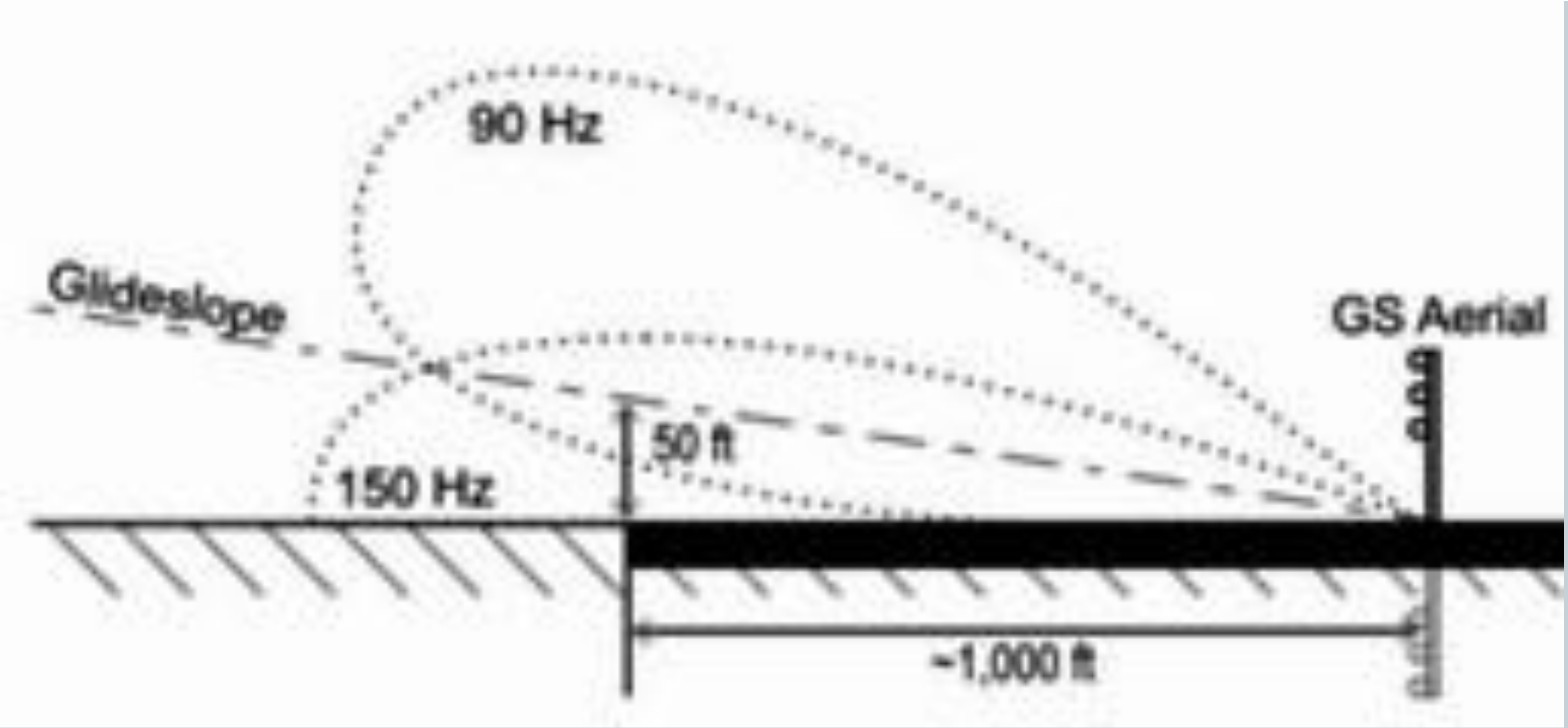
Glide Path Antenna Array

- Glide Path is the vertical antenna located on one side of the runway about 300 m to the end of runway.
- **Glide Path** operates in **UHF band between 329.15 and 335 MHz**

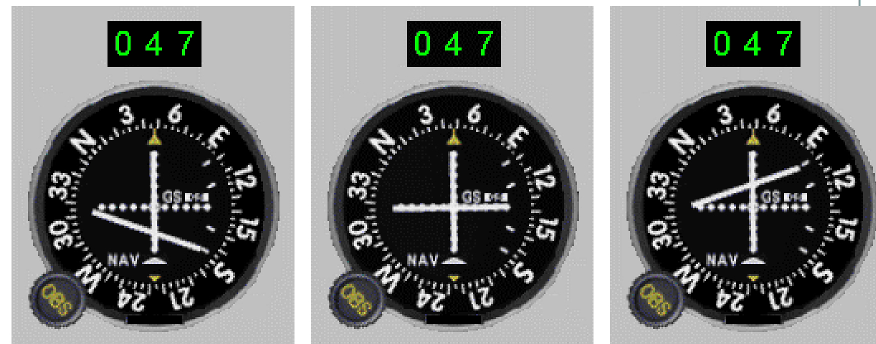
How Glide Path Works

- Glide path produces two signals in the vertical plane.
- The upper has a 90 Hz modulation and the bottom has a 150 Hz modulation.
- For example, if an aircraft approaching the runway too high**, it** will **receive more of the 90 Hz modulation** than 150Hz modulation.
- Difference in **Depth of Modulation** will **energizes the horizontal needle of ILS indicator**.
- Thus, aircraft will be given the direction to **GO DOWN.**

How Glide Path Works



Glide Path



Needle indicates above/below glide path.

Centered Needle = Correct Glide path

Marker Beacons

- Marker beacons operating at a carrier frequency of 75 MHz are provided.
- When the transmission from a marker beacon is received it activates an indicator on the pilot's instrument panel.
- The correct height the aircraft should be at when the signal is received in an aircraft.

Marker Beacons

Outer marker

- The outer marker should be located about 7.2 km from the threshold.
- The modulation is repeated Morse-style dashes of a 400 Hz tone.
- The cockpit indicator is a blue lamp that flashes accordingly with the received audio code.
- The purpose of this beacon is to provide height, distance and equipment functioning checks to aircraft on intermediate and final approach.

Marker Beacons

Middle marker

- The middle marker should be located so as to indicate, in low visibility conditions.
- Ideally at a distance of 1050m from the threshold.
- The cockpit indicator is an amber lamp that flashes in accordingly with the received audio code.

Marker Beacons

Inner marker

- The inner marker, shall be located so as to indicate in low visibility conditions.
- This is typically the position of an aircraft on the ILS as it reaches Category II minima.
- The cockpit indicator is a white lamp that flashes in accordingly with the received audio code.

ILS Categories

- There are three categories of ILS the operation.
- **Category I** - A precision instrument approach and landing with a decision height not lower than 60 m (200 ft) above touchdown zone elevation and with either a visibility not less than 800 m or a runway visual range not less than 550 m.
- An aircraft equipped with an Enhanced Flight Vision System may, under certain circumstances, continue an approach to CAT II minimums.
- **Category II** - Category II operation: A precision instrument approach and landing with a decision height lower than 60 m (200 ft) above touchdown zone elevation but not lower than 30 m (100 ft), and a runway visual range not less than 350 m.

ILS Categories

- **Category III** is further subdivided
  - **Category III A** - A precision instrument approach and landing with:
    - a) a decision height lower than 30 m (100 ft) above touchdown zone elevation, or no decision height; and
    - b) a runway visual range not less than 200 m.
  - **Category III B** - A precision instrument approach and landing with:
    - a) a decision height lower than 15 m (50 ft) above touchdown zone elevation, or no decision height; and
    - b) a runway visual range less than 200 m but not less than 50 m.
  - **Category III C** - A precision instrument approach and landing with no decision height and no runway visual range limitations. A Category III C system is capable of using an aircraft's autopilot to land the aircraft and can also provide guidance along the runway.

Advantages of ILS

- The most accurate **approach** and **landing** aid that is used by the airliners.

Disadvantages of ILS

- Interference due to large reflecting objects, other vehicles or moving objects.
- This interference can reduce the strength of the directional signals.

VOR : VHF Omnidirectional Range

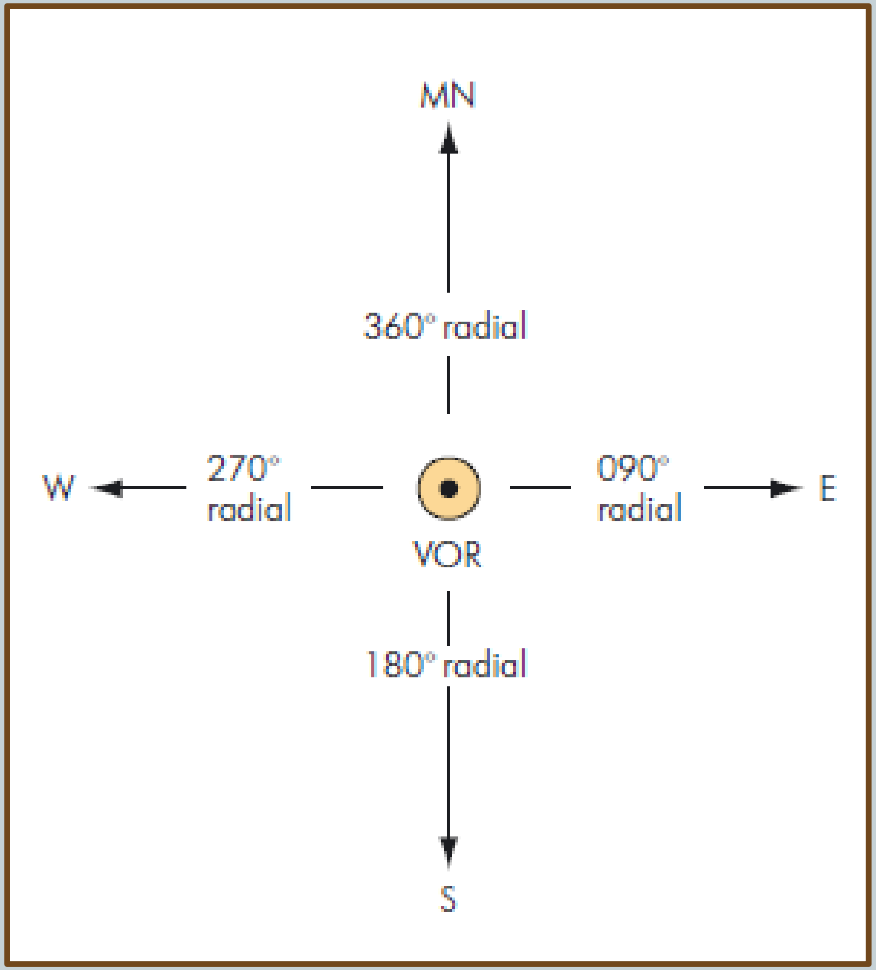
Introduction

- VOR, short for **VHF Omni-directional Range**, is a type of radio navigation system for aircraft.
- VOR navigation system is one of the most **significant aviation invention.**
- With it, a pilot can **simply, accurately**, and without ambiguity **navigate** from Point A to Point B.

Introduction

- As opposed to the NDB, which transmits a non-directional signal, the signal transmitted by the VOR contains directional information.
- VOR provide MAGNETIC BEARING information to and from the station.
- "Omni-" means all and an Omni-directional range means VOR station transmits signal in all directions.

Signal Transmission



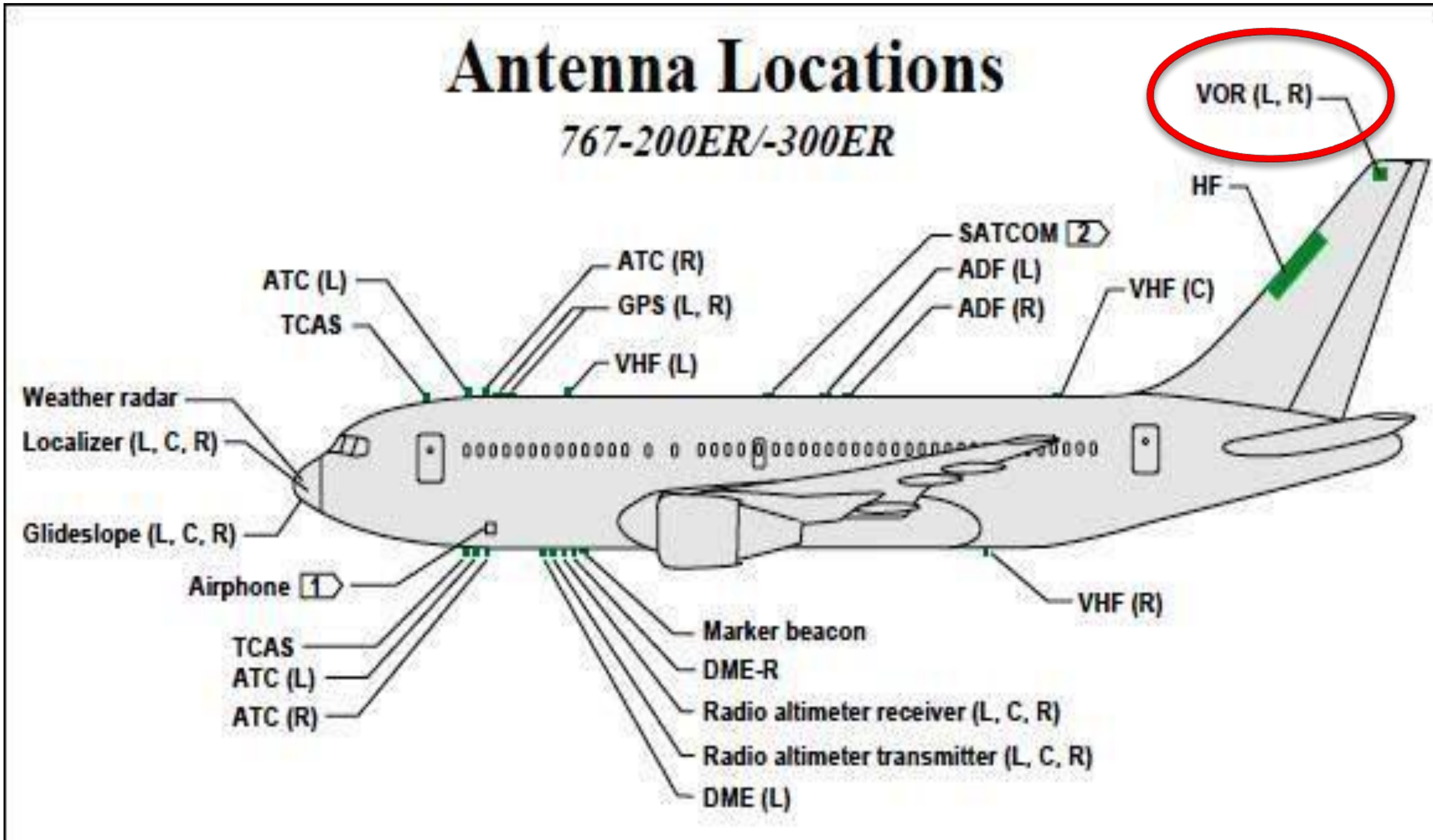
"Omni-" means all and an Omni-directional range means VOR station **transmits signal in all directions.**

VOR Equipments

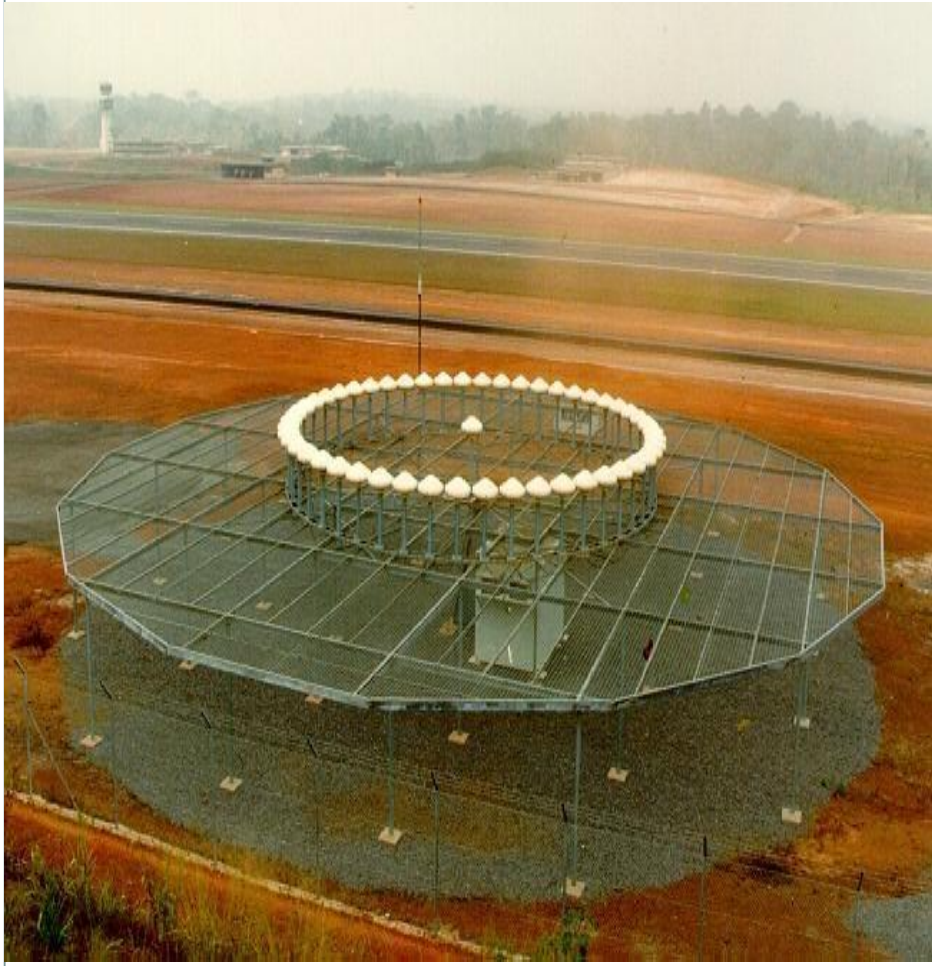
- VOR equipments can be divided into three equipments:
  - Aerial / Antenna
  - Receiver
  - Indicator
- As for aircraft, VOR consist of VOR antenna, at vertical tail and VOR receiver and indicator inside cockpit.
- As for ground station (also known as VOR beacon) consist of antenna (transmitter and receiver).

VOR Equipments

VOR Equipments



VOR Equipments

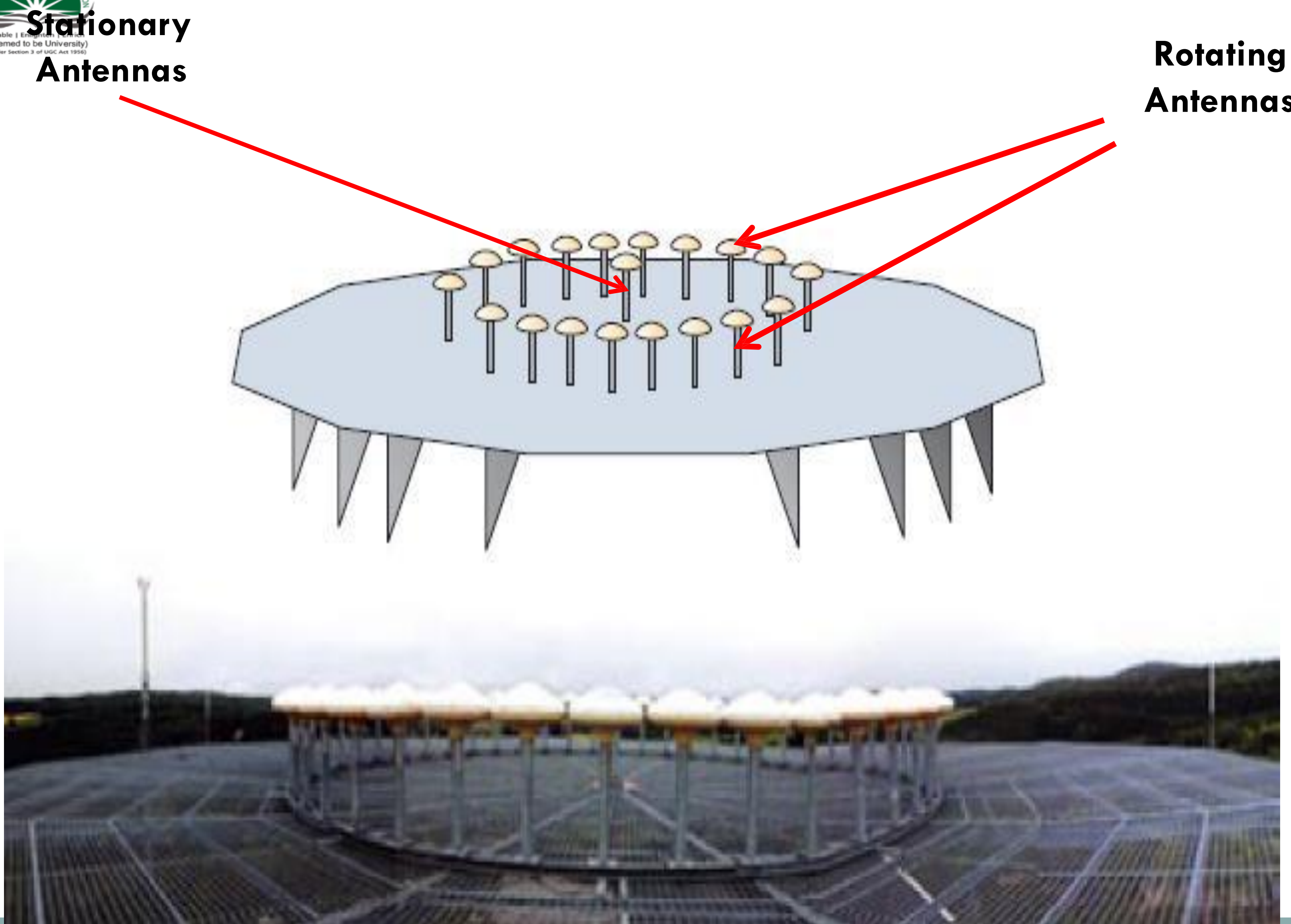


VOR Ground Antenna

Stationary Antennas

Rotating Antennas

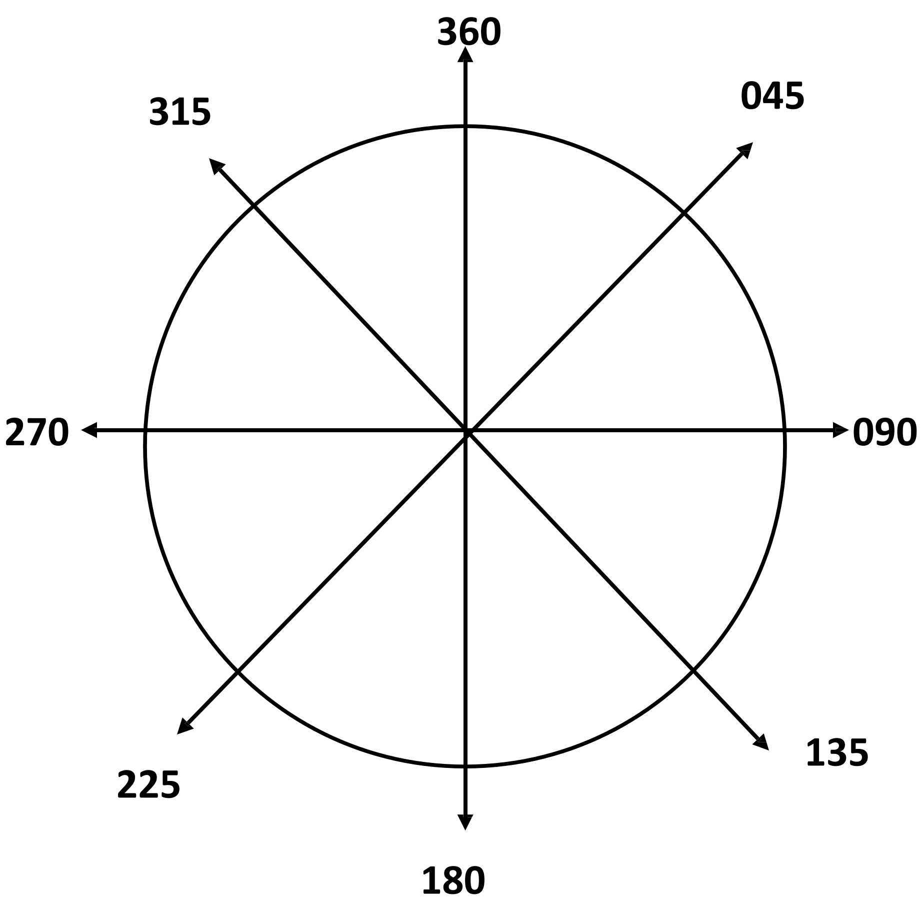
VOR station for broadcast the signal

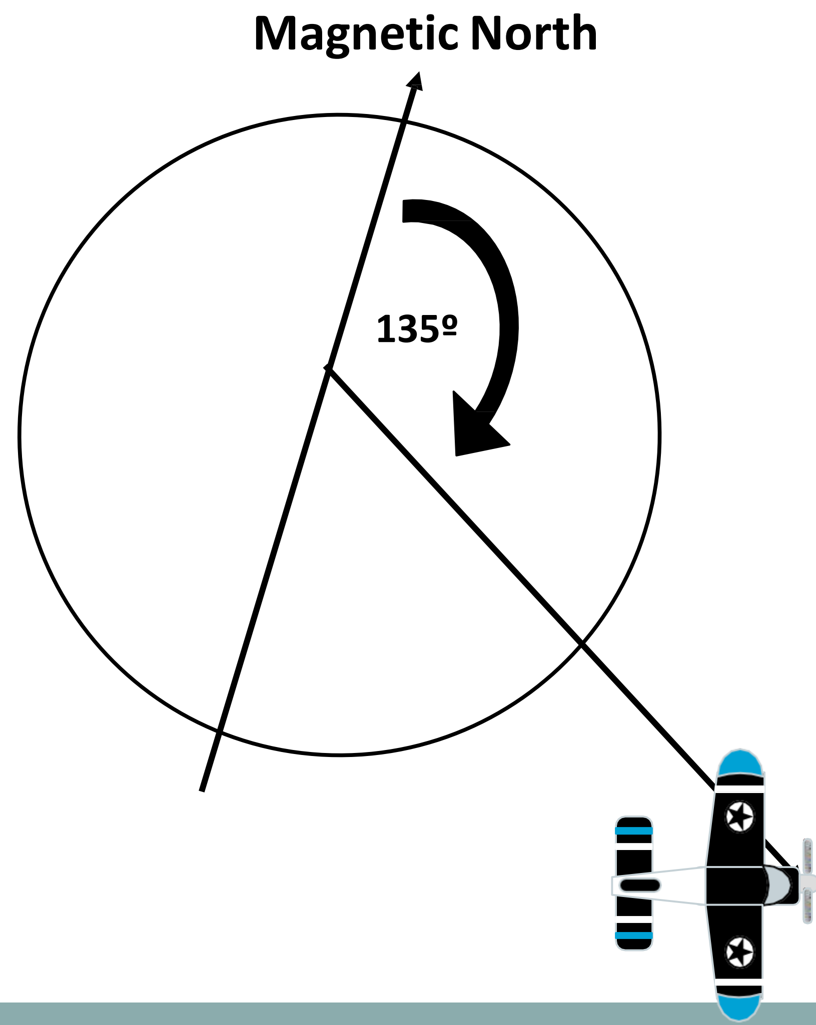

Stationary Antennas
Rotating Antennas

VOR ground antenna

- The VOR ground antenna is oriented to magnetic north.
- Consists of :
  - Single Stationary Antenna at the centre
  - Rotating antennas
- It produces 360° radials/tracks at 1° spacing.
- These 360 bearings are known as RADIALS
- VOR ground installations are strategically located along air routes and airport to ensure continuity of guidance.

RADIALS





PRINCIPLE OPERATION OF VOR

How VOR works

- VOR receiver in the cockpit is tuning to the specific frequencies assigned for that VOR 's airport.
- It is VHF frequency which is between 108-117.95 MHz.
- After entering the frequency, the volume control should be turned up in order to confirm that the **three letter identification code (Morse Code)** is correct.
  - **For example, KLIA airport has a VOR known as VKL-Victor Kilo Lima**

How VOR works

- The VOR station on the ground **transmits two signals** at the same time; one signal is constant in all directions, while the other signal is rotated about a point.
- One from stationary antenna, while the other from rotating antenna.
- When aircraft receives these two signals, an aircraft VOR receiver electronically measures the **phase angle different** between these two signals.
- This phase angle different is translated as the **MAGNETIC BEARING** which tell the pilot the aircraft angle direction to the VOR station.
- This bearing angle also known as **RADIALS.**

VOR Indicator Display

VOR Indicator Display

A Display

A Rotating Course Card, calibrated from 0 to 360°, which **indicates the VOR bearing** chosen as the reference to fly TO or FROM. Here, the 345° radial has been set into the display. This VOR gauge also digitally **displays the VOR bearing, which simplifies setting the desired navigation track**

B Display

The Omni Bearing Selector, or OBS knob, used to **manually rotate the course card.**

VOR Indicator Display

C Display

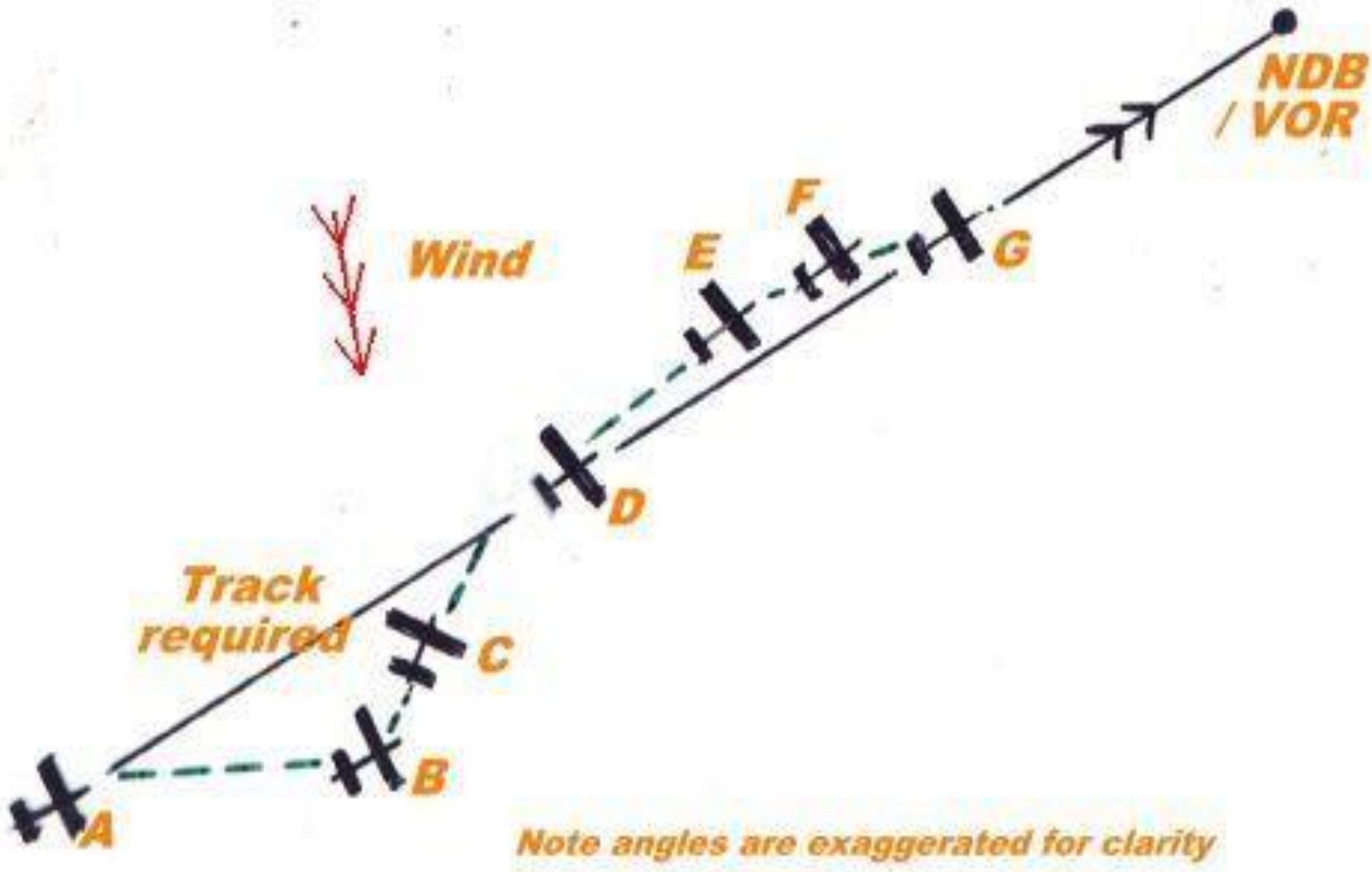
The CDI, or **Course Deviation Indicator**. This needle swings left or right indicating the direction to turn to return to course. When the needle is to the left, turn left and when the needle is to the right, turn right, When centered, the aircraft is on course. Each dot in the arc under the needle represents a 2° deviation from the desired course.

VOR Indicator Display

D Display

The TO-FROM indicator. This arrow will **point up**, or towards the nose of the aircraft, **when flying TO the VOR station**. The arrow reverses direction, **points downward**, when **flying away FROM the VOR station**.

A **red flag** replaces these TO-FROM arrows when the VOR is **beyond reception range**, has **not been properly tuned in**, or the **VOR receiver is turned off**. Similarly, the flag appears if the VOR station itself is inoperative, or down for maintenance.



VHF OMNIDIRECTIONAL RANGE (VOR)

Advantages of VOR

- **More accurate & precise flying:**
  - The accuracy of course alignment of the VOR is excellent, being generally plus or minus 1 degree.
- **Reliable:**
  - Can be used day and night.
- **Multiple number of route :**
  - Provide **multiple number of route 'towards'** or away from each station.
  - These routes are like **invisible highways** , which the pilot can navigate to @ away from any location.

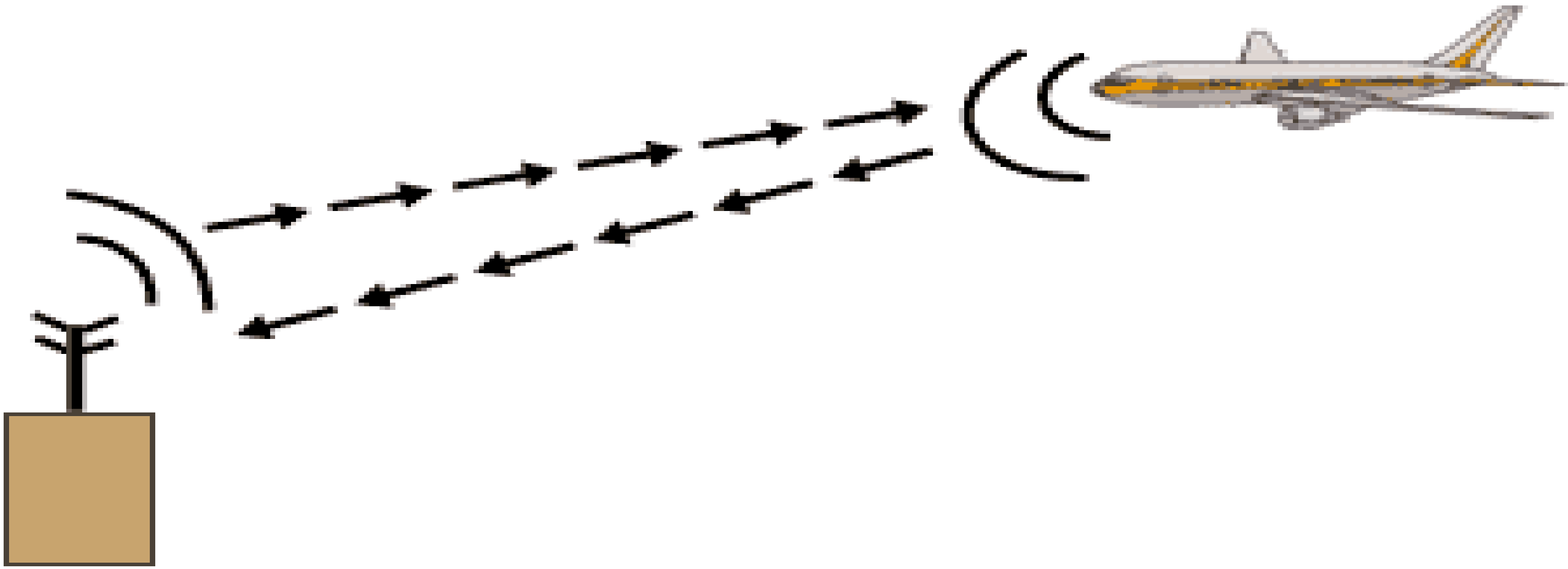
Disadvantages of VOR

- **Signals cannot be received at low altitudes** (below 1000ft)
- VORs are **sensitive to the interference of terrain**. The nearest mountains and buildings cause the VOR bearings to be stopped and interrupted.
- Other disadvantages is VOR equipments are **costly to maintain.**

Distance Measuring Equipment (DME)

Definition

- **DME is stand for Distance Measuring Equipment.**
- DME is a type of **en-route navigation system** for aircraft.
- DME often installed near VOR stations so as to provide combined **bearing** and **distance**.
- When DME is installed with the VOR, it is referred to as a **VOR/DME.**

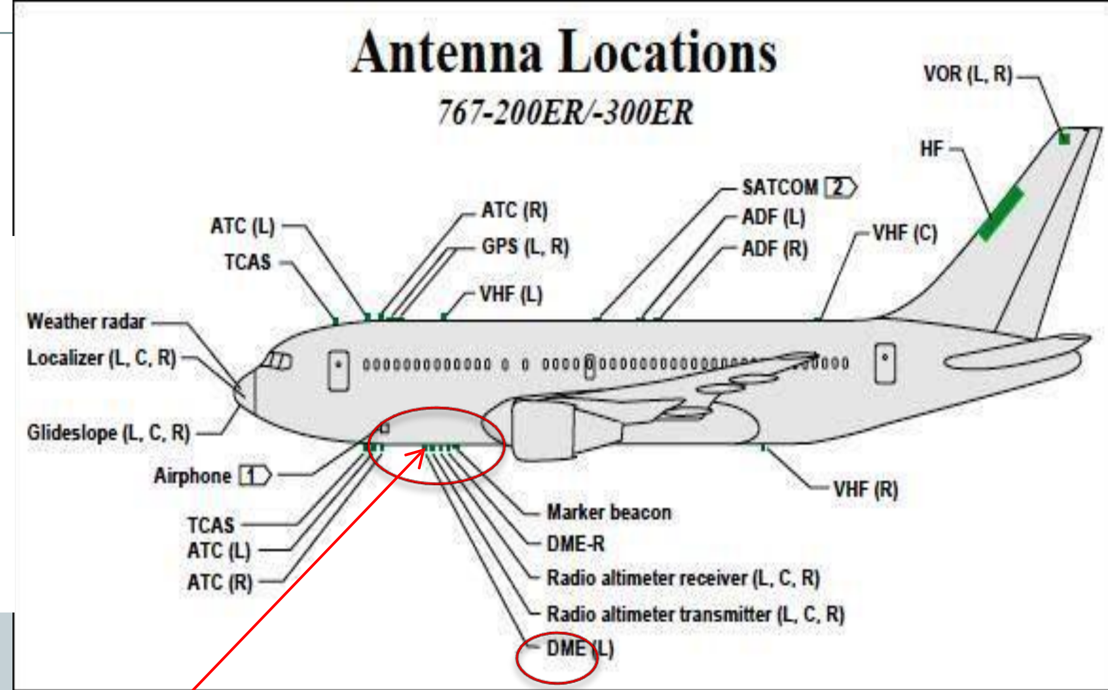


Airborne DME measures elapsed time required for exchange of signals and converts into distance and ground speed.

The uses of DME

- DME provides the physical **distance from the aircraft to the ground DME transponder** expressed in Nautical Miles (NM).
- DME also calculates **ground speed and the time needed to reach the station** if the aircraft is fitted with appropriate computer.

5.1 080 04
NM KT MIN
BENDIX/KING
N1
N2



Antenna Locations
767-200ER/-300ER
VOR (L, R)
HF
SATCOM 2
ADF (L)
ADF (R)
VHF (C)
ATC (R)
GPS (L, R)
VHF (L)
ATC (L)
TCAS
Weather radar
Localizer (L, C, R)
Glideslope (L, C, R)
Airphone 1
TCAS
ATC (L)
ATC (R)
VHF (R)
Marker beacon
DME-R
Radio altimeter receiver (L, C, R)
Radio altimeter transmitter (L, C, R)
DME (L)

DME System Components:

The DME system consists of three basic components which are:

- DME antenna on the aircraft body
- DME navigation display unit in aircraft cockpit
- DME transmitter/receiver in the ground

DME INDICATOR IN THE COCKPIT

DME Indicator

- **DME** enables aircraft to establish its range to the ground station: Distance in nautical miles, Ground speed in knots, Flying time to the station in minutes

DME distance = 92.4 nm

Corresponding VHF frequency = 112.3 Mhz

DME distance = 107.9 nm

Ground speed = 250 kt

Time to station = 25 minutes

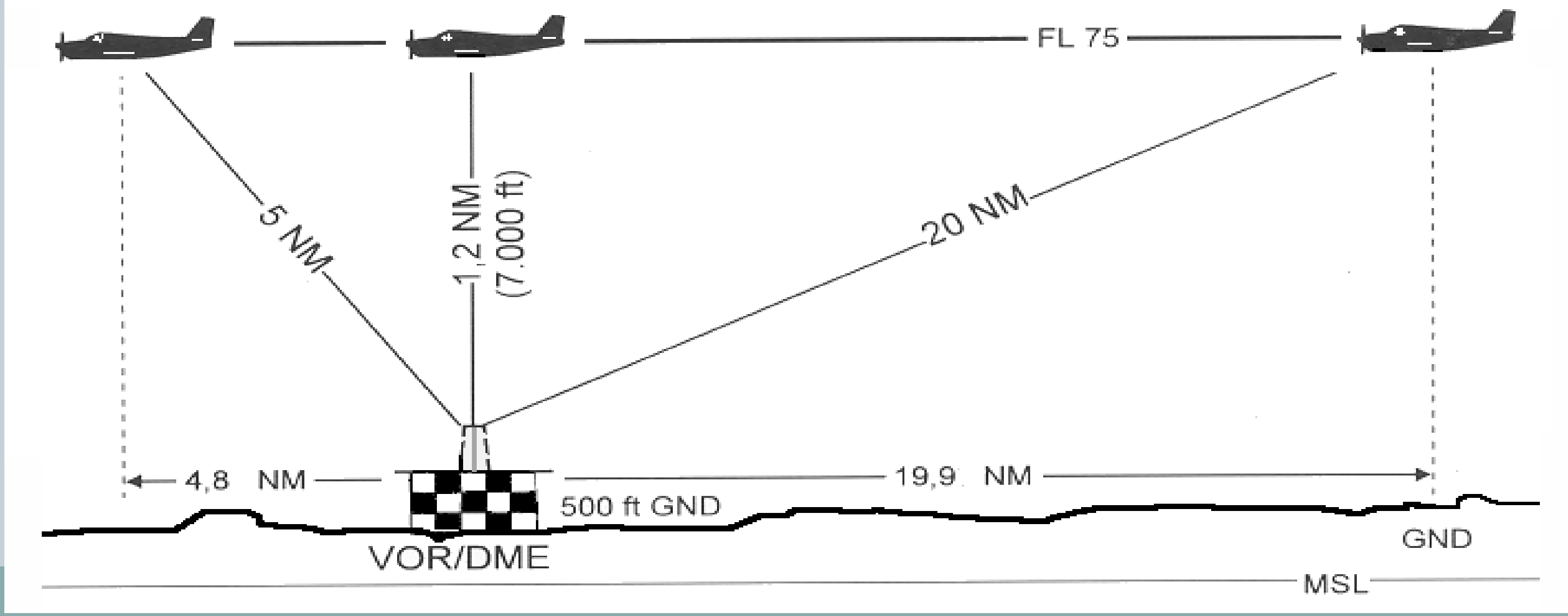
DME PRINCIPLE

How DME works?

- DME provides **distance (slant range) from the aircraft to the ground DME.**
- DME operates on Ultra High Frequency (UHF) which is between 962 to 1213 MHz.
- DME works based on pulse techniques, where pulse means a single vibration of electric current.
- The aircraft's antenna sends out paired pulses at specific spacing.
- The ground DME station receives the pulses and then responds with paired pulses at the same spacing but a different frequency.

How DME works?

- The aircraft receiver measures the time taken to transmit and receive the signal which is transmitted into distance.
- Beside that, the distance formula is also used by the DME receiver to calculate the distance from DME station in Nautical Miles.



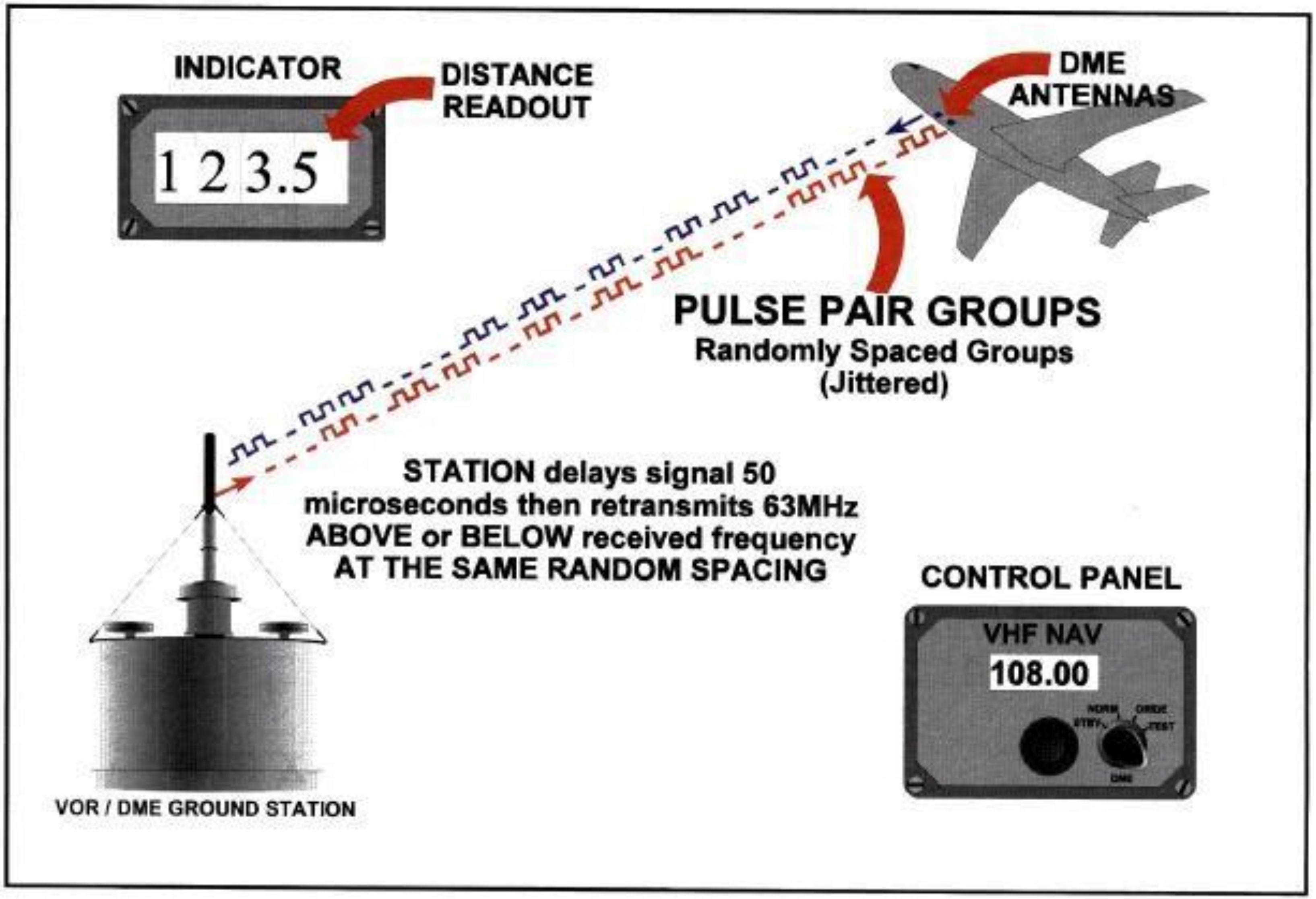


Figure 12.8. The Principle of Range Measurement.

Advantages of DME

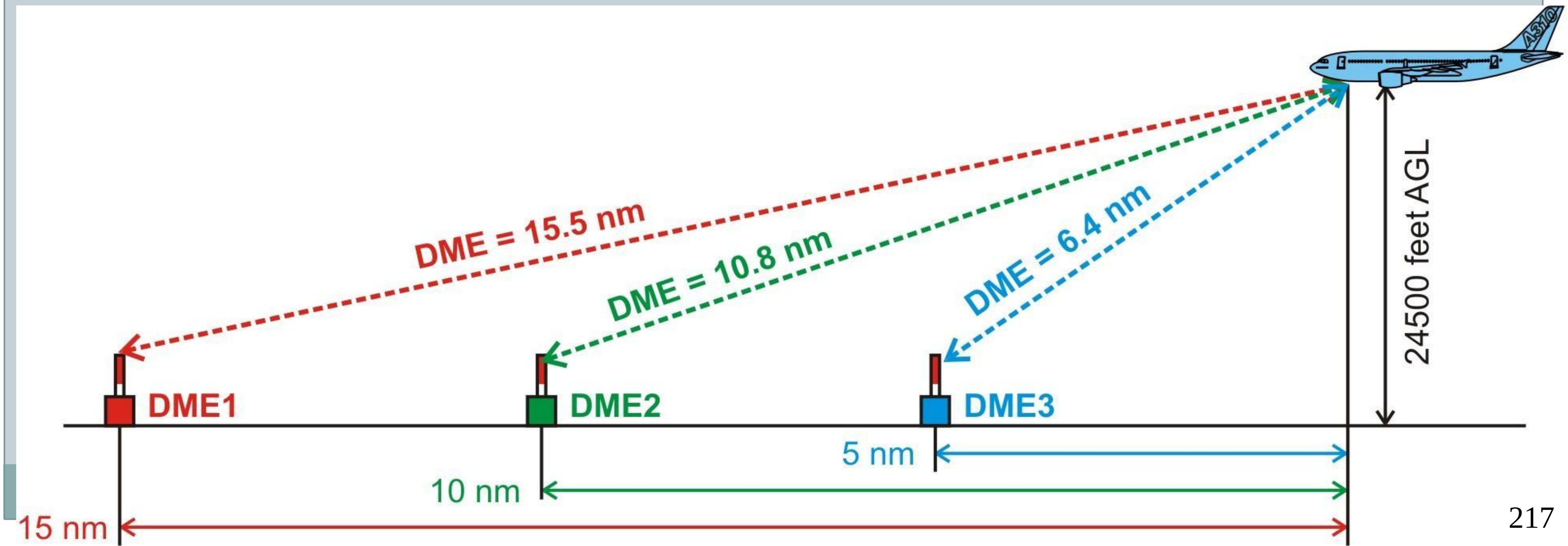
- **DME is extremely accurate:** Provide continuous and accurate indication of the slant range distance.
- **Aircraft Handling Capability:** The transponder equipment should be capable of handling 100 to 200 aircrafts.
- **Large coverage:** DME facility provides coverage up to 200 NM.

Disadvantages of DME

- As VOR the DME is **also restricted to line-of-sight transmission**. For example, the aircraft at altitude below 10'000 ft is unable to detect the DME signal.

Disadvantages of DME

- **Errors and abnormal indications:**
  - **Slant range**
  - **Speed and time calculation**
  - **Ground system saturation – 100 aircraft**
  - **System error**



Automatic Direction Finder (ADF) & Non Directional Beacon (NDB)

INTRODUCTION TO NDB & ADF

Automatic Directional Finder

Non Directional Beacon

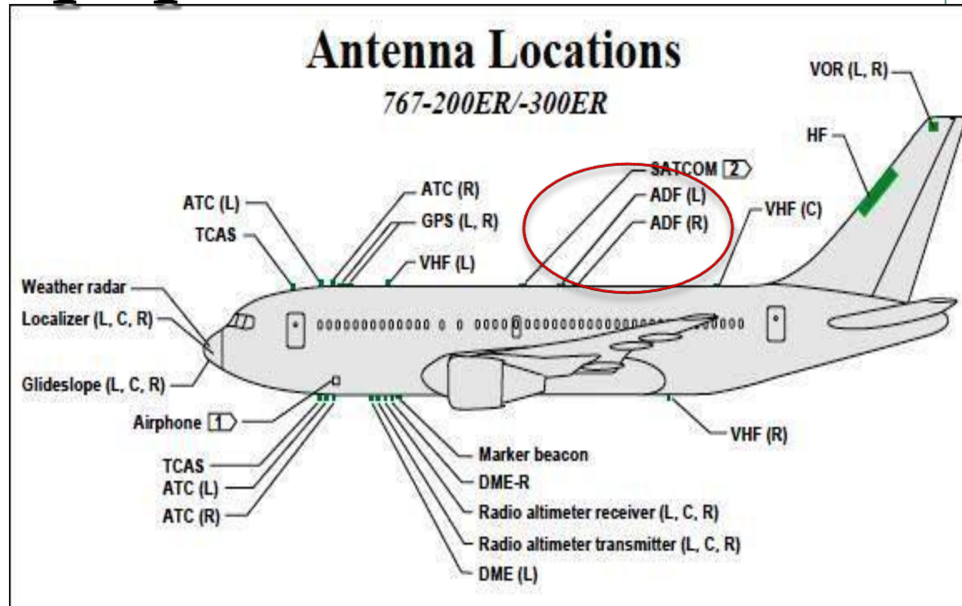
Definition

- **ADF is stand for Automatic Direction Finder.**
- **NDB is stand for Non Directional Beacon.**
- **ADF & NDB** is the **one of the older types of radio navigation system** that still in use today.
- They still in use today because of its simplicity.
- As it name, the signal transmitted by NDB does not included directional information, but ADF automatically searching for NDB signal.

ADF & NDB Equipments

- Non Directional Beacon (NDB) is used in conjunction with Automatic Direction Finder (ADF) in the cockpit.
- ADF equipments consists of 1) **ADF antenna** (transmitter & receiver) **outside aircraft's body**, 2) an **ADF indicator inside the cockpit**.
- NDB equipment only consist of **ground NDB antenna** located near the airport (airfield area).
- ADF determines the direction to ground NDB station.

ADF & NDB Equipment



ADF indicator inside the cockpit

ADF antenna outside aircraft 's body

Ground NDB stations is the Tall antenna located near the airfield

Purpose

- The purpose of ADF/NDB is to provide aid for aircraft navigation by **provide bearing information of aircraft location** to the airport. (aircraft direction or heading to the airport in degrees(angle))
- **Bearing: the angle which measured in a clockwise direction.
- NDB bearings provide a consistent method for defining paths aircraft can fly. NDB can define "airways" in the sky.

NDB Frequencies

- ICAO has assigned **Low Frequency (LF)** and **Medium Frequency (MF)** band for NDB,
- It is within 200 – 1750 KHz.
- However, most of NDB equipments are found operating within frequency band of **200-525 KHz.**

How ADF & NDB works

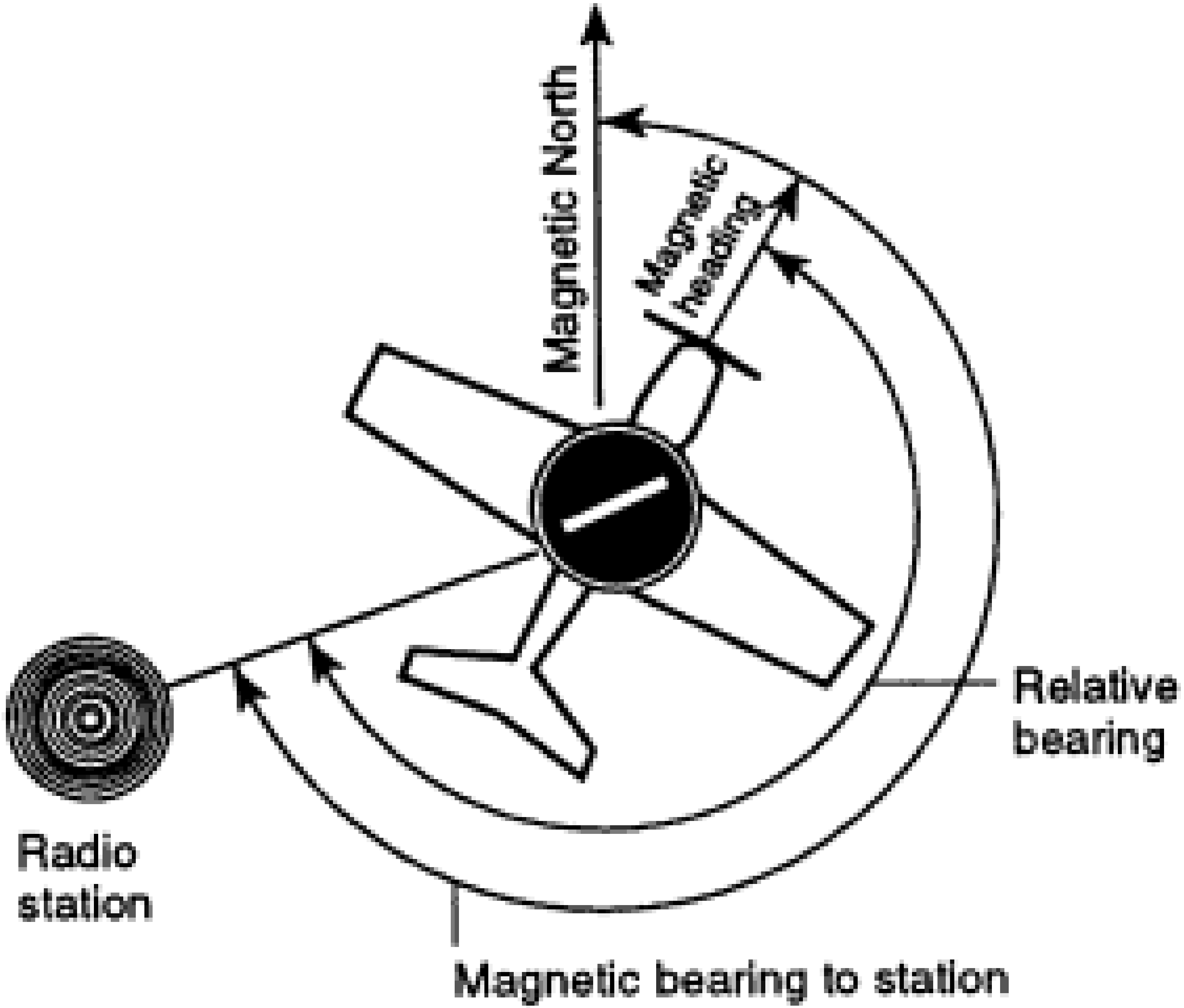
NDB station **radiates a** **non-directional signal** **in all directions** around its antenna (transmitter).

Station identification code(callsign) in the form **Morse code** is also transmitted by the NDB.

An ADF **selector** **in aircraft will** **tune to** NDB**'s frequency in order to search its signals.**

After NDB call sign is identified, the **direction of aircraft in bearing to the NDB station will be indicated.**

ADF indicator in the cockpit will display the bearing to the NDB station *relative to the heading* of the aircraft.


Magnetic North
Magnetic heading
Relative bearing
Radio station
Magnetic bearing to station

The uses of NDB

- Used for FLYING FROM NDB or HOMING TO NDB when maintaining airway centre-lines.
- Used for en-route navigational bearing
- Used for HOLDING system before landing.
- Used as markers for an **Instrument Landing System (**ILS) approach

FLYING FROM or HOMING TO NDB station

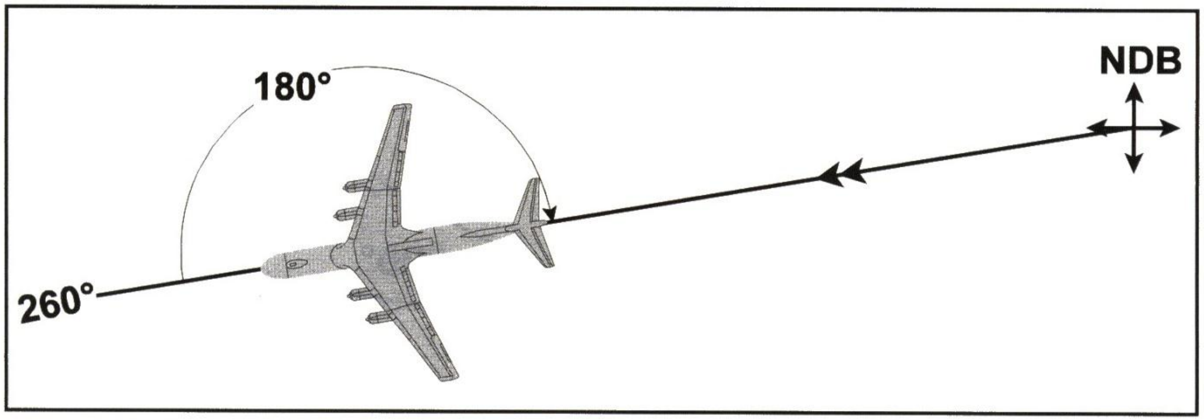


Figure 4.14.

Flying From

Homing To

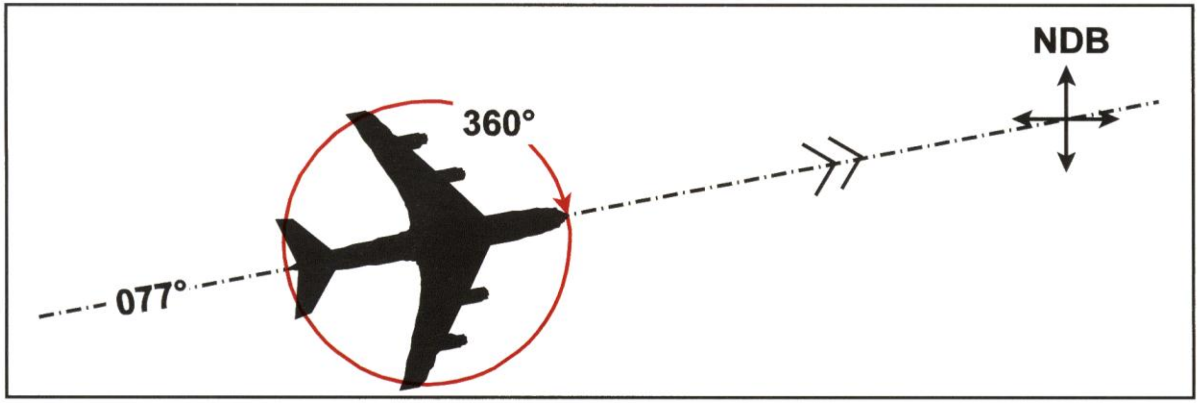
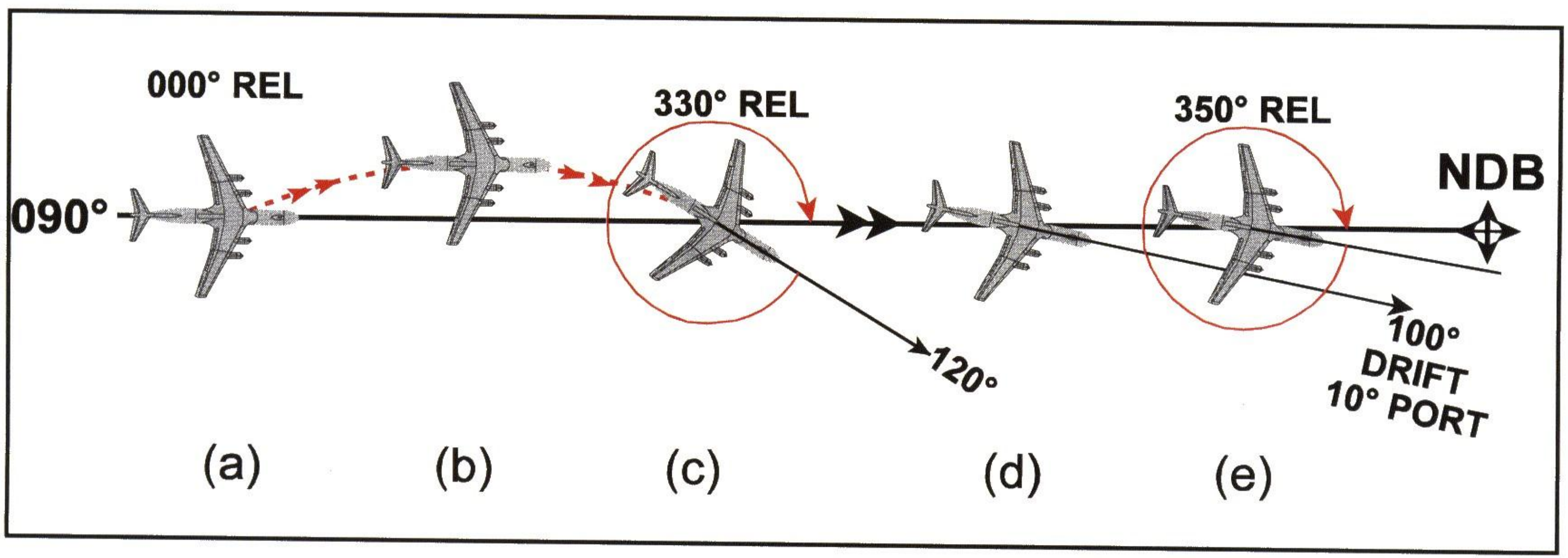


Figure 4.10 Homing in Zero Drift.

En-Route Navigation

- Aircraft must maintain their heading using the Automatic Direction Finding (ADF) in the cockpit.
- Pilot must always watch the relative bearing indicator to maintain the airway center line.



Holding System

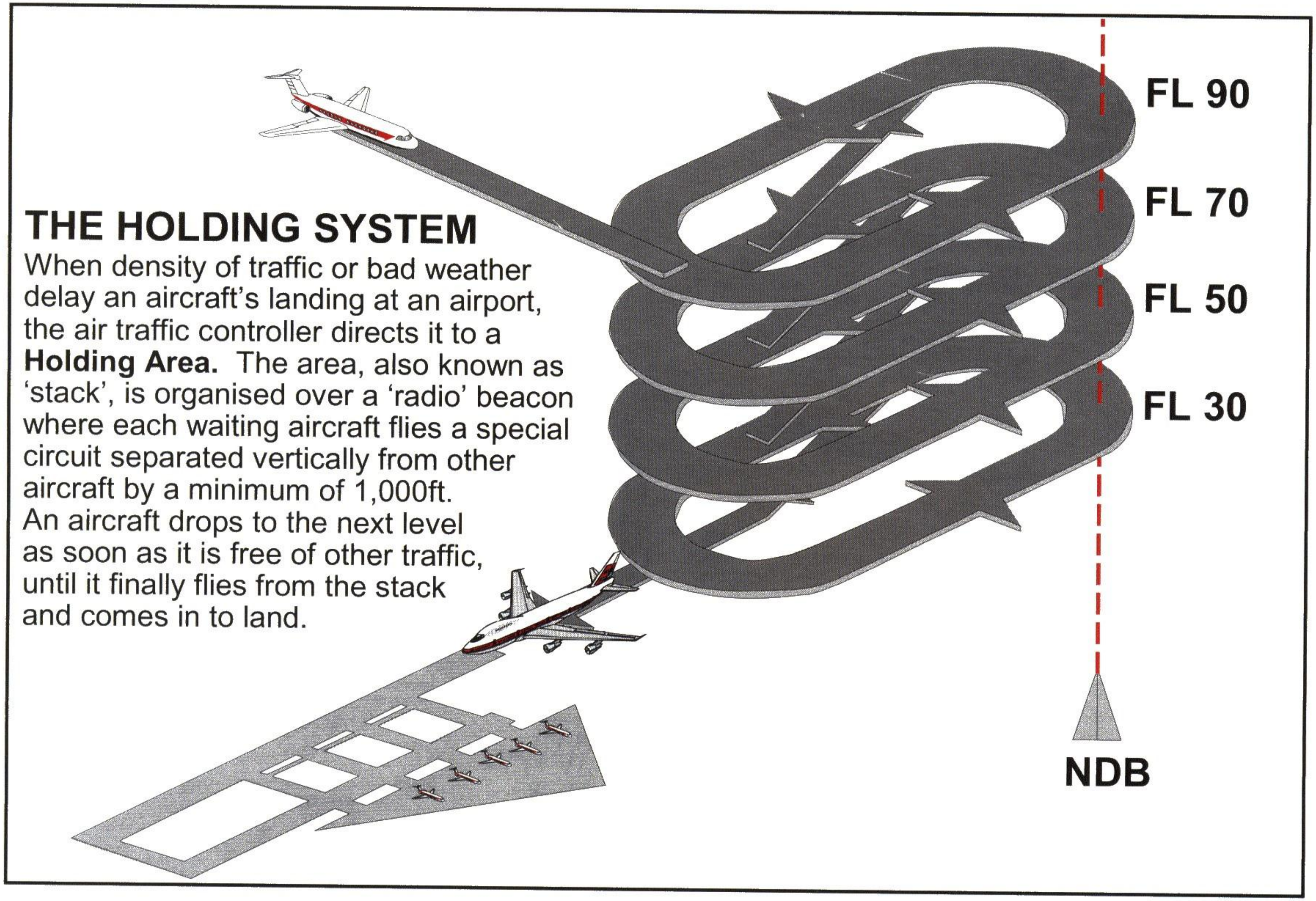


Figure 4.20 The Holding System.

Markers for an ILS approach

- NDB also can used as the **markers for Instrument Landing System (ILS) approach**.
- This type of NDB is also known as LOCATOR.

- Locator is a low power NDB.
- It has signal range within 10 to 25 Nautical Miles.

Advantages of NDB

- NDB signal can be received at low altitudes.
- This is because NDB signal is based on surface wave propagation (signal not limited to 'line of sight').
- NDB also can be used as the Back-Up system. For example, during no signal given by the VHF Omni-directional Range (VOR) system.
- NDB system only requires low cost for their maintenances.
- NDB still important for many small airports.

Disadvantages of NDB

- Limited Signal because of several factors including:
  1. **Interference Effect**
  2. **Thunderstorm Effect**
  3. **Mountain Effect**
  4. **Night Effect**
  5. **Coastal Refractions**

Disadvantages of NDB

- **Interference Effect** –interference occurs if an ADF receives two or more signals radiated by NDB.
- **Thunderstorm Effect** – Thunderstorm have very powerful discharges of static electricity that can interrupt the NDB signal. Needle of ADF indicator sometimes points toward the storm.
- **Mountain Effect** – Mountain areas can cause reflections and diffractions and lead to the error direction reading by ADF.

Disadvantages of NDB

- **Night Effect** – Low signal or no signal during night time because contamination of radio wave.

- **Coastal Refractions**– Also known as **Shoreline Effect .** Surface wave travel in one direction over land, but another direction over water (refraction). This can cause error reading in ADF indicator.

Accuracy

- The accuracy of NDB is +/- 5 degree for approach and +/- 10 for en-route.

- The accuracy of an NDB at any given time is difficult to determine when considering all the factors creating error.

RADAR BEACON TRANSPONDER

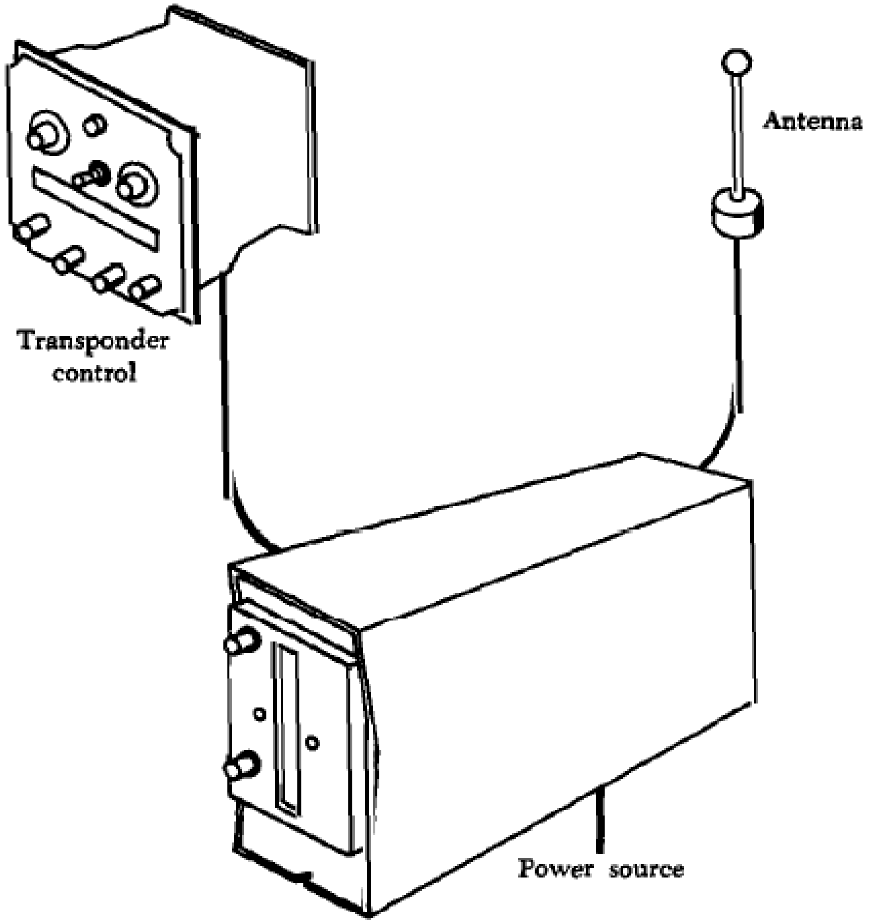


FIGURE 13–16. Typical transponder system.

DOPPLER NAVIGATION SYSTEMS

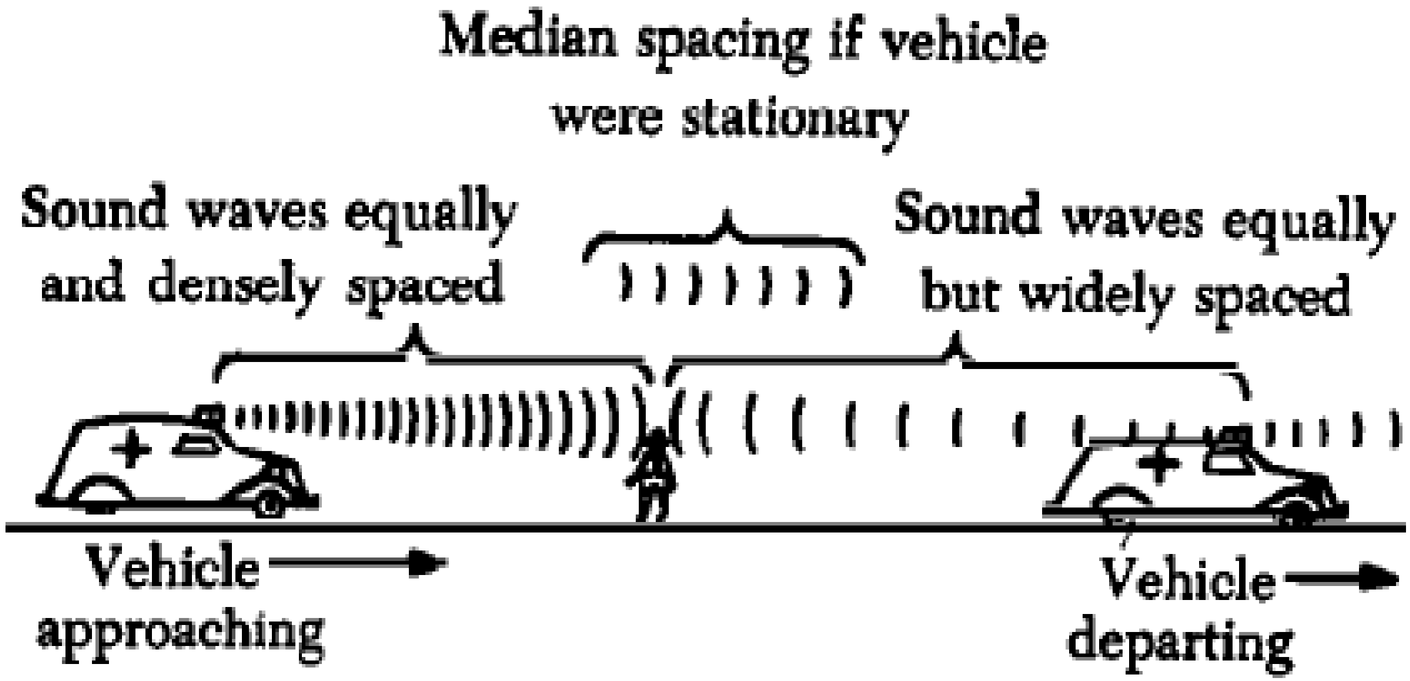


FIGURE 13–17. Doppler effect with sound waves.

INERTIAL NAVIGATION SYSTEM

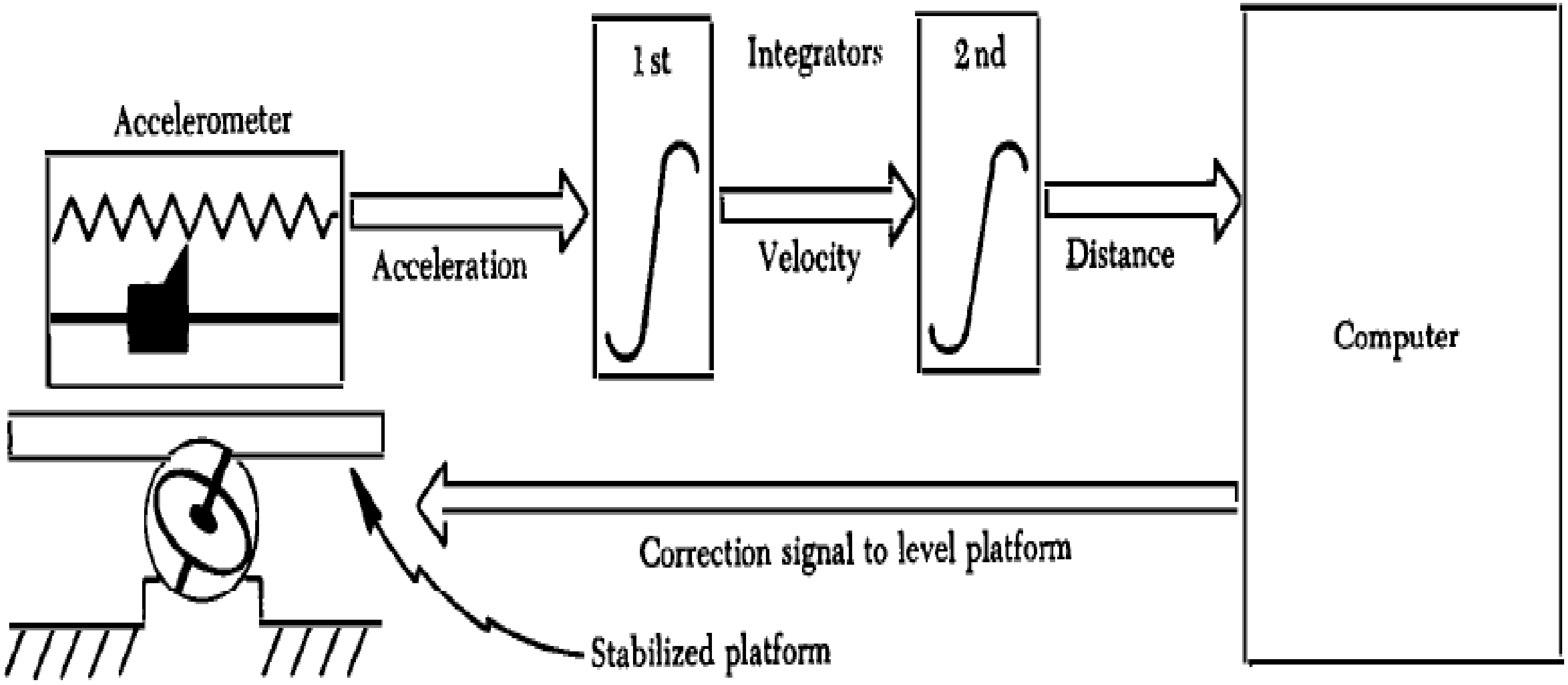


FIGURE 13–18. A basic inertial navigation system.

AIRBORNE WEATHER RADAR SYSTEM

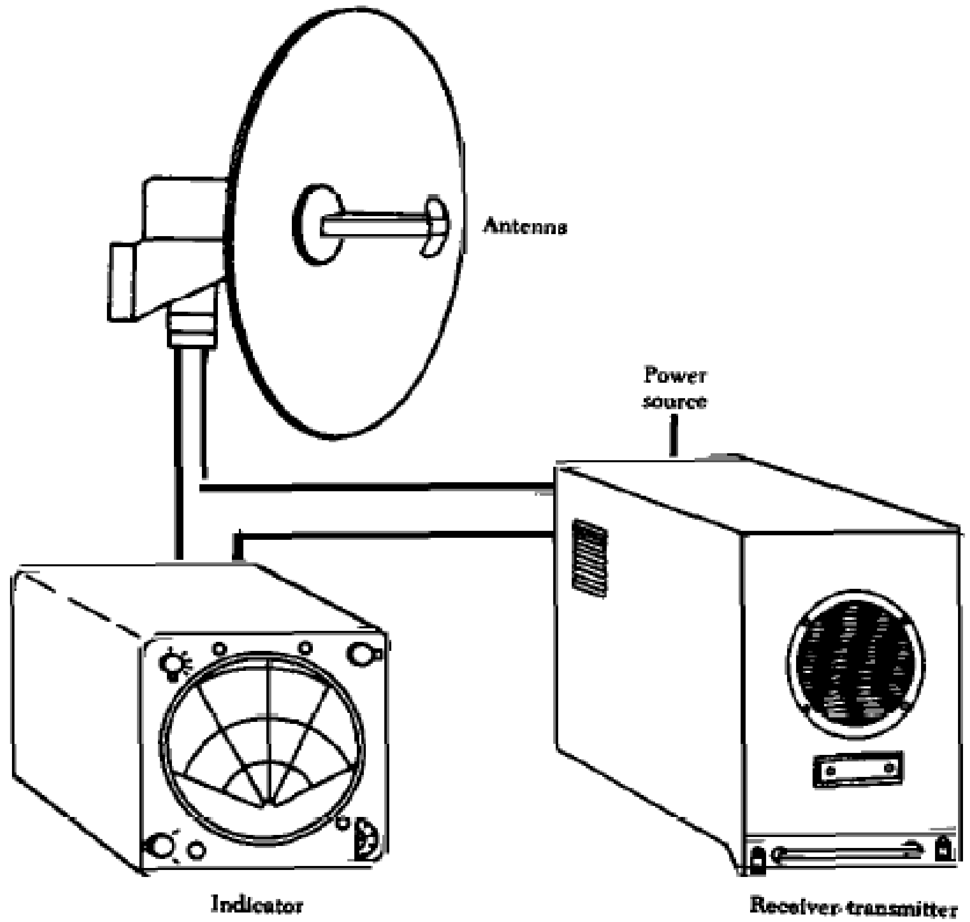


FIGURE 13–19. Weather radar system diagram.

RADIO ALTIMETER

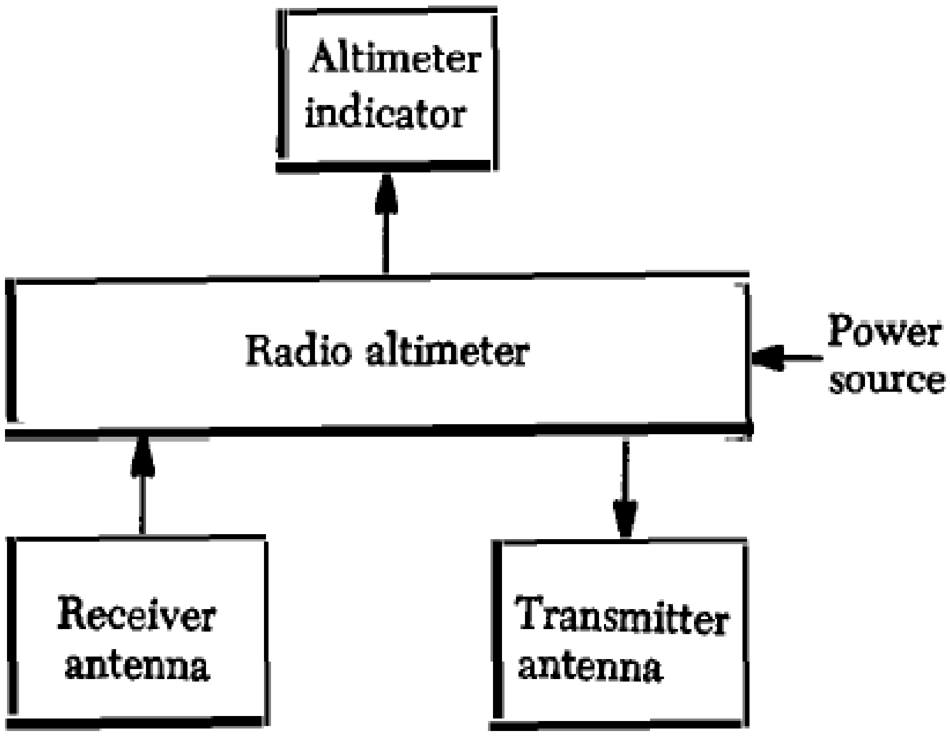


FIGURE 13–20. Typical radio altimeter system diagram.

EMERGENCY LOCATOR TRANSMITTER (ELT)

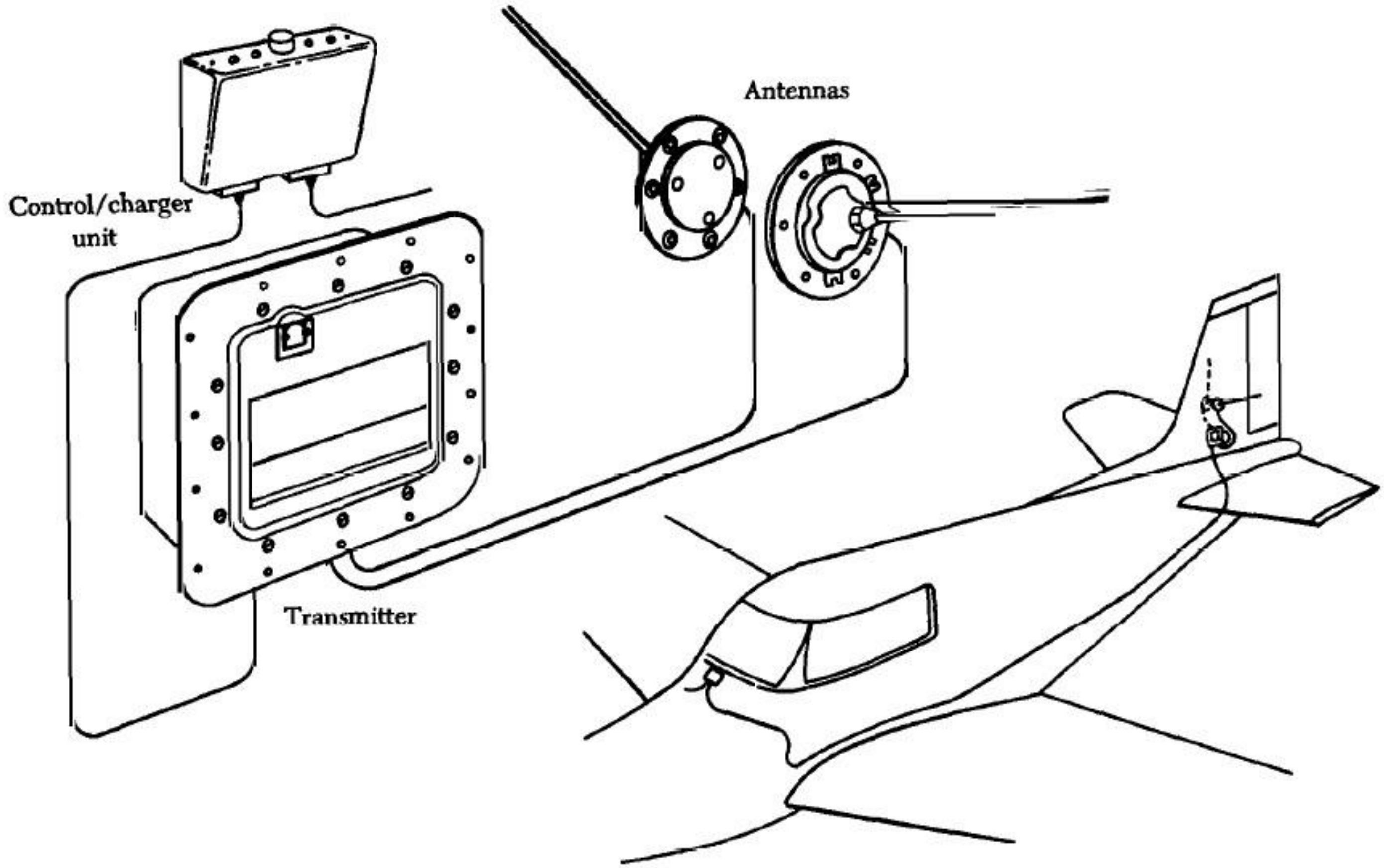


FIGURE 13-21. Emergency locator transmitter (ELT).

Aircraft Fuel Systems

Business and Commercial Aviation Magazine

- “An aircraft's fuel system has a more profound effect on aircraft performance than any other airframe system. Without fuel, the mission inevitably comes to an abrupt stop and, unless the flight crew is very, very lucky, the ensuing forced landing will cause severe or catastrophic aircraft damage.” ~ Fred George, 6/20/06

Fuel Types

- Civilian
  - Jet A
  - Jet A-1
  - Jet B
- Military
  - JP-4
  - JP-5
  - JP-8

Typical Fuel Tanks

- Integral
- Rigid Removable
- Bladder
- Rule of Thumb for max. fuel volume: 85% for wing tanks and 92% for fuselage tanks, measured to the external skin surface (exception: bladder tanks, 77% and 83%, respectively)
- External

Components

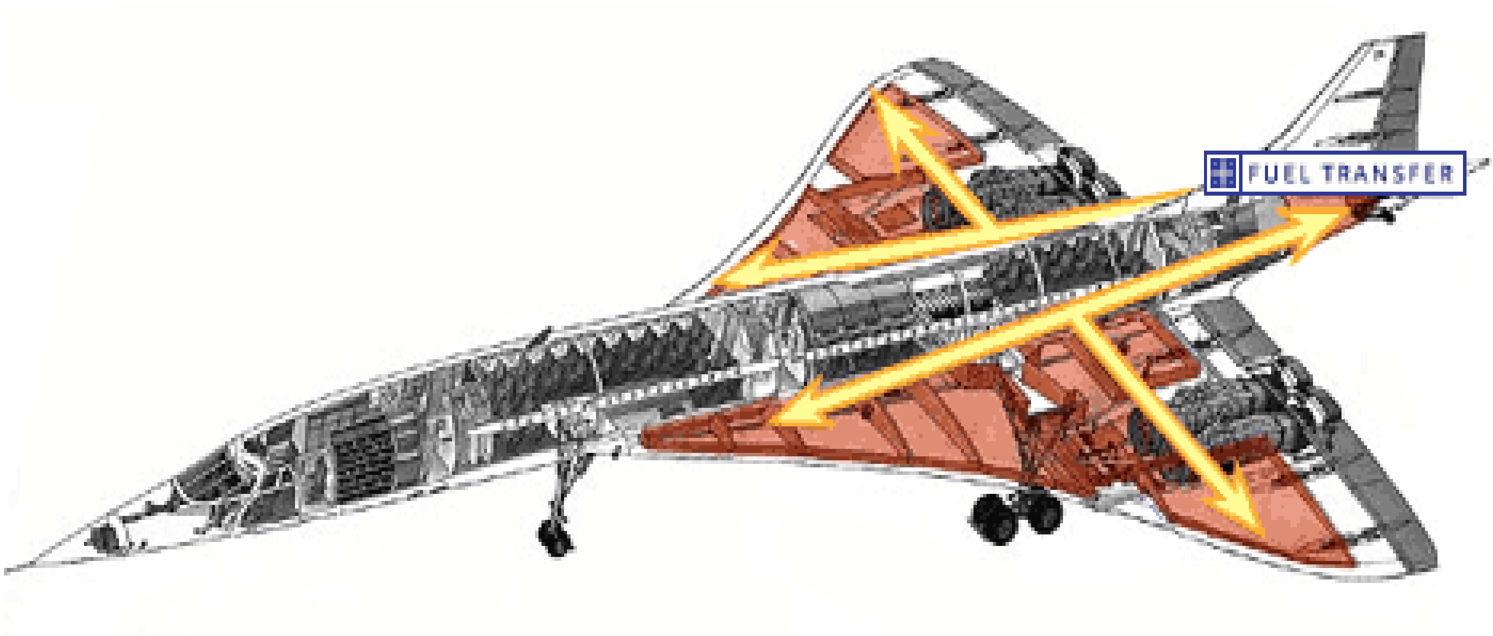
Main Tanks

Header Tank (separate from main tanks, holds enough fuel for engines to run during complicated maneuvers)

Gravity Feed (small aircraft only)

Electric/Engine-driven Fuel Pumps

Fuel distributed around center of gravity



Fuel Dumping Systems

- Needed to meet landing weight limits of landing gear or runway length
- System of fuel pumps and valves
- Usually ejected from wingtips
- Sometimes from aft-most point of fuselage
- Usually designed to allow the plane to go from max take-off weight to max landing weight in 15 minutes or less.

777 Fuel Dumping http://www.aerospaceweb.org/question/planes/q0245b.shtml

Boeing B-52H refueled by Boeing KC-135A
©USAF Museum Photo Archives

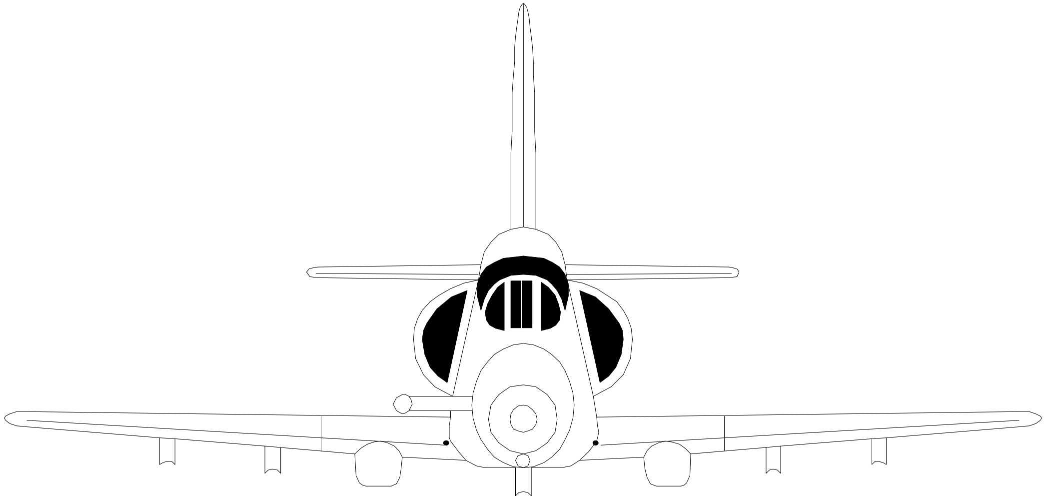
http://www.centennialofflight.gov/essay/Evolution_of_Technology/refueling/Tech22G5.htm

In-Flight Refueling

- Original motivation: endurance records
- Currently used only in the military sector
- Two main types:
  - – Boom and Receptacle
  - – Probe and Drogue

http://www.answers.com/topic/aerial-refueling

Oxygen Systems



Oxygen System

LOX Quantity Indicator

A-4

TA-4

Aircraft Systems

Oxygen System

Oxygen Regulator control Panel (A-4N)

Aircraft Systems

Oxygen System

NORMAL OXYGEN position - the user will receive a mixture of ambient air and oxygen up to FL 340?

100 PERCENT OXYGEN position - 100 percent oxygen will be provided at any altitude.

RED EMERGENCY TOGGLE - Located on the left side of the regulator, provides a means of manually supplying positive pressure for testing mask fit and for emergency use.

- **Directs a steady stream of 100 percent oxygen to the mask, making it operate as a continuous flow system regardless of altitude.**
- **Use with suspected hypoxia, unconsciousness or serious leakage in the mask or delivery hose.**
- **Use of the emergency setting, however, depletes the oxygen supply in a relatively short time and causes difficulty exhaling when wearing the face mask.**

Oxygen System

A-4N

Before Flight (engine running and normal power on aircraft)

Prior to each flight, the oxygen system and mask shall be checked for proper operation.

1. Connect the oxygen supply hose and tube
2. Observe and check the white blinker on normal and 100% Oxygen setting.
3. Select Test and check for positive pressure flow

Note

If exhalation is difficult, there is inhalation valve leakage

Oxygen System

In the TA-4 the Oxygen control is commanded from the aircrew services panel located on the left aft console. It is a simple ON OFF toggle to control flow.

Oxygen System

Before Flight (engine running and normal power on aircraft)

TA-4

1. Prior to each flight, the oxygen system and mask shall be checked for proper operation.
2. Connect the oxygen supply tube to the connector on the survival kit with the mask turned away from the face. Place the oxygen switch in ON. Listen for free flow of oxygen. Put on the mask. Inhalation should be almost effortless if the regulator is delivering oxygen at a slight positive pressure. Exhalation should also be possible but will require some effort in order to close the inhalation valve.

Note

If exhalation is difficult, there is inhalation valve leakage

Aircraft Systems

Oxygen System

Oxygen Duration

DATA AS OF: 1 FEBRUARY 196[illegible]
DATA BASIS: SPECIFICATION MIL-1-19326 (WEPS)

HOURS REMAINING

CABIN PRESSURE ALTITUDE FEET	GAGE READING (LITERS)					
	10	8	6	4	2	1
40,000 UP ►	60.6	48.5	36.4	24.2	12.0	4.8
35,000 ►	37.0	29.6	22.2	14.8	7.4	3.6
30,000 ►	27.2	21.8	16.4	10.8	5.4	2.8
25,000 ►	20.4	16.4	12.4	8.2	4.0	2.0
20,000 ►	16.0	12.8	9.6	6.4	3.2	1.6
15,000 ►	12.8	10.2	7.6	5.2	2.6	1.2
10,000 ►	10.0	8.0	6.0	4.0	2.0	1.0
5,000 ►	8.4	6.6	5.0	3.2	1.6	0.8
SEA LEVEL ►	7.0	5.6	4.2	2.8	1.4	0.6

REMARKS:

(1) BASED ON 800 LITERS OF GASEOUS OXYGEN PER LITER OF LIQUID OXYGEN.

(2) DATA ASSUME THE USE OF A PROPERLY FITTED MASK.

(3) DATA BASED ON SINGLE PILOT OPERATION DIVIDE BY TWO FOR DUAL PILOT OPERATION.

Figure 2-9. Liquid Oxygen Duration

Oxygen System

EMERGENCY OXYGEN SYSTEM

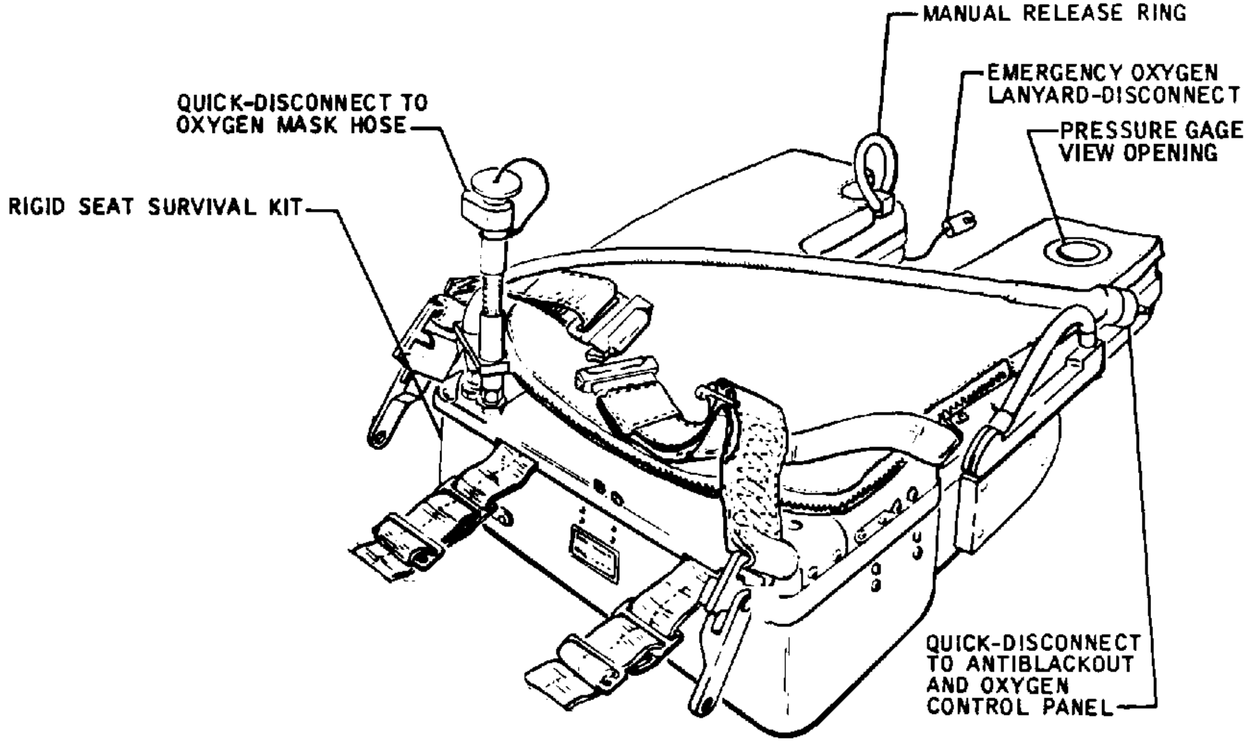
The emergency oxygen system supplies oxygen to the pilot automatically during seat ejection.
Provides a supplemental quantity of oxygen for in-flight usage when the pilot pulls the green ring on the left-hand side of the seat pan cutout.
Oxygen flows from the bottle for 4 to 20 minutes or longer, depending upon the altitude at the time the release mechanism is actuated.
The principal components of the emergency oxygen system are as follows:

1. Emergency oxygen bottle
2. Pressure reducer valve
3. Emergency oxygen bottle check valve.
4. Filler valve
5. Oxygen hose.

Aircraft Systems

Oxygen System

RSSK SEAT PAN



Emergency Oxygen System is contained within the RSSK seat pan/survival kit.

Oxygen System

PRESSURE REDUCER VALVE

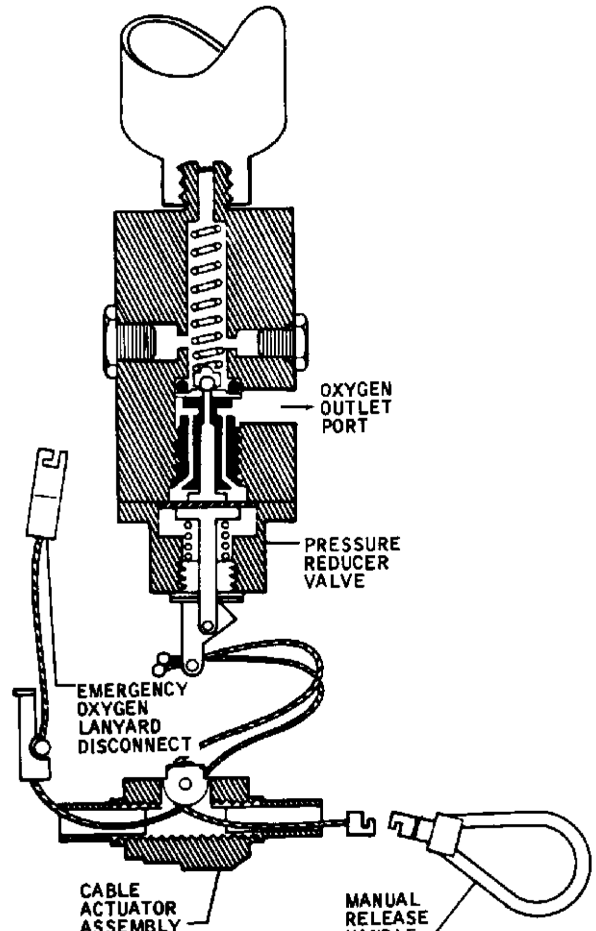
Actuation of the pressure reducer valve is accomplished automatically (from the emergency lanyard) or manually by

pullling the green ring.

– Releases the emergency oxygen at a pressure of 50±10 psi

The integral relief valve will operate to vent the oxygen supply if the orifice fails to reduce the pressure below 125 ±5 psi.

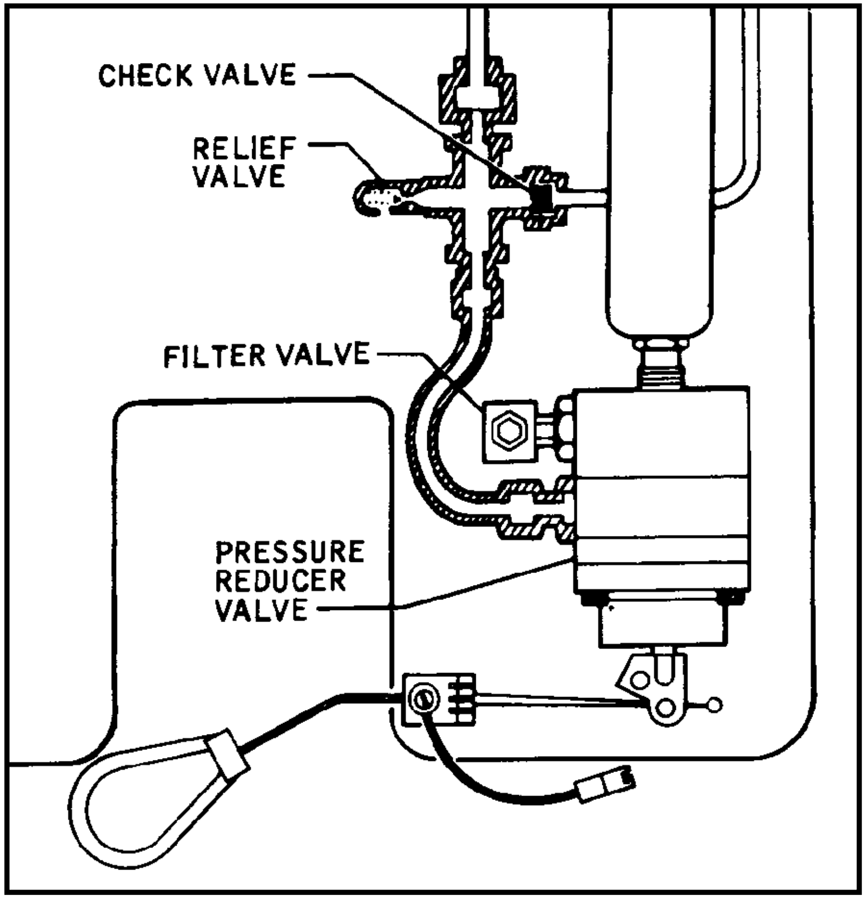
integral relief valve will not permit release of the emergency oxygen supply unless the output pressure of the OBOGS oxygen system is below 50±10 psi



Oxygen System

CHECK & FILLER VALVES

The emergency oxygen bottle CHECK VALVE prevents oxygen in the emergency oxygen bottle from entering the OBOGS oxygen system before ejection, or from escaping to the atmosphere after ejection.
The FILLER VALVE provides a means for replenishing the gaseous oxygen supply in the bottle.



Oxygen System

NORMAL PROCEDURES

EMERGENCY OXYGEN PREFLIGHT

Prior to flight, the following inspection of emergency oxygen should be made:

1. Check pressure gage for adequate supply (1800psi) gauge in green region.
2. Check that emergency oxygen actuator lanyard located on cockpit floor is attached to the aircraft.
3. With the mask-to-survival kit hoses connected and the Aircrew Service Panel flow switch “OFF”, check that there is no oxygen flow.

OXYGEN EMERGENCY OPERATIONS

(TA-4 REGULATOR MASK)

1. **Oxygen quantity—CHECK**

If able to descend:

2. **Cabin altitude to less than 10,000 ft**

If unable to descend:

3. **Green O-ring on seat—PULL** 1N
4. **Oxygen supply lever—OFF**
5. **Connections—CHECK SECURITY**
6. **Land as soon as conditions permit**

1N **Once emergency oxygen is actuated oxygen flows until the emergency bottle is depleted (approximately 4 to 20 minutes).**

Oxygen System

OXYGEN EMERGENCY OPERATIONS

1N

Once emergency oxygen is actuated oxygen flows until the emergency bottle is depleted (approximately 4 to 20 minutes).

2W

Oxygen supply is rapidly reduced when either or both crew members demand 100% oxygen or when the emergency lever is held in the EMERGENCY position.

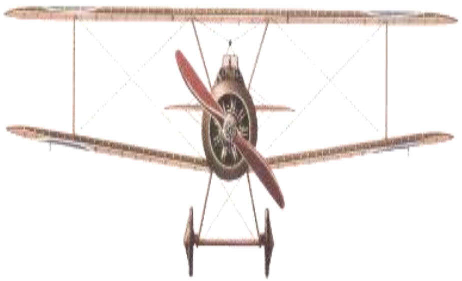
(A-4 DILUTER REGULATOR)

1. Supply lever—ON
2. Diluter lever—100% OXYGEN
3. Emergency lever—EMERGENCY 2W

If no positive pressure or suspect oxygen Contamination and unable to descend:

4. Green O-ring on seat—PULL 1N
5. Oxygen supply lever—OFF
6. Connections—CHECK SECURITY
7. Breathe at a rate and depth slightly less than normal until symptoms disappear.
8. Cabin altitude—DESCEND BELOW 10,000 FT
9. Land as soon as conditions permit

1940s



2000s

Evolution of Avionics

Architecture & Data Buses

AVIONICS

DEFINITION

Avionics : Aviation Electr**onics**

Avionics : All electronic and electromechanical systems and subsystems (hardware and software) installed in an aircraft or attached to it. (MIL-1553A-HDBK)

Avionics has become an equal partner and is surpassing aircraft structures and propulsion in terms of cost and its mission effectiveness of modern aircraft

AVIONICS SYSTEM ARCHITECTURE

- **Establishing the basic architecture is the first and the most fundamental challenge faced by the designer**

- **The architecture must conform to the overall aircraft mission and design while ensuring that the avionics system meets its performance requirements**

- **These architectures rely on the data buses for intra and intersystem communications**

- **The optimum architecture can only be selected after a series of exhaustive design tradeoffs that address the evaluation factors**

AVIONICS ARCHITECTURE

First Generation Architecture (1940's –1950's)

- Disjoint or Independent Architecture (MiG-21)
- Centralized Architecture (F-111)

Second Generation Architecture (1960's –1970's)

- Federated Architecture (F-16 A/B)
- Distributed Architecture (DAIS)
- Hierarchical Architecture (F-16 C/D, EAP)

Third Generation Architecture (1980's –1990's)

- Pave Pillar Architecture (F-22)

Fourth Generation Architecture (Post 2005)

- Pave Pace Architecture- JSF
- Open System Architecture

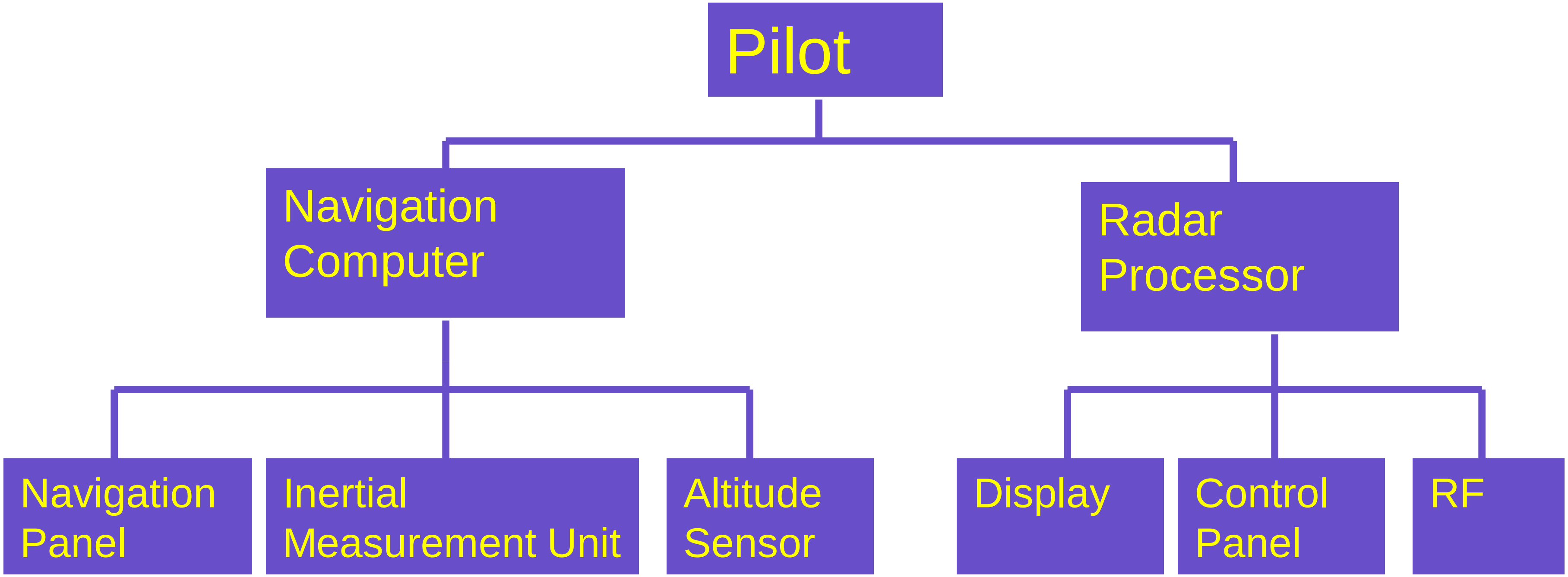
FGA - DISJOINT ARCHITECTURE

The early avionics systems were stand alone black boxes where each functional area had separate, dedicated sensors, processors and displays and the interconnect media is point to point wiring

The system was integrated by the air-crew who had to look at various dials and displays connected to disjoint sensors correlate the data provided by them, apply error corrections, orchestrate the functions of the sensors and perform mode and failure management in addition to flying the aircraft

This was feasible due to the simple nature of tasks to be performed and due to the availability of time

FGA - DISJOINT ARCHITECTURE



FGA - CENTRALIZED ARCHITECTURE

- As the digital technology evolved,a central computer was added to integrate the information from the sensors and subsystems
- The central computing complex is connected to other subsystems and sensors through analog,digital, synchro and other interfaces
- When interfacing with computer a variety of different transmission methods , some of which required signal conversion (A/D) when interfacing with computer
- Signal conditioning and computation take place in one or more computers in a LRU located in an avionics bay , with signals transmitted over one way data bus
- Data are transmitted from the systems to the central computer and the DATA CONVERSION TAKES PLACE AT THE CENTRAL COMPUTER

FGA - CENTRALIZED ARCHITECTURE

ADVANTAGES

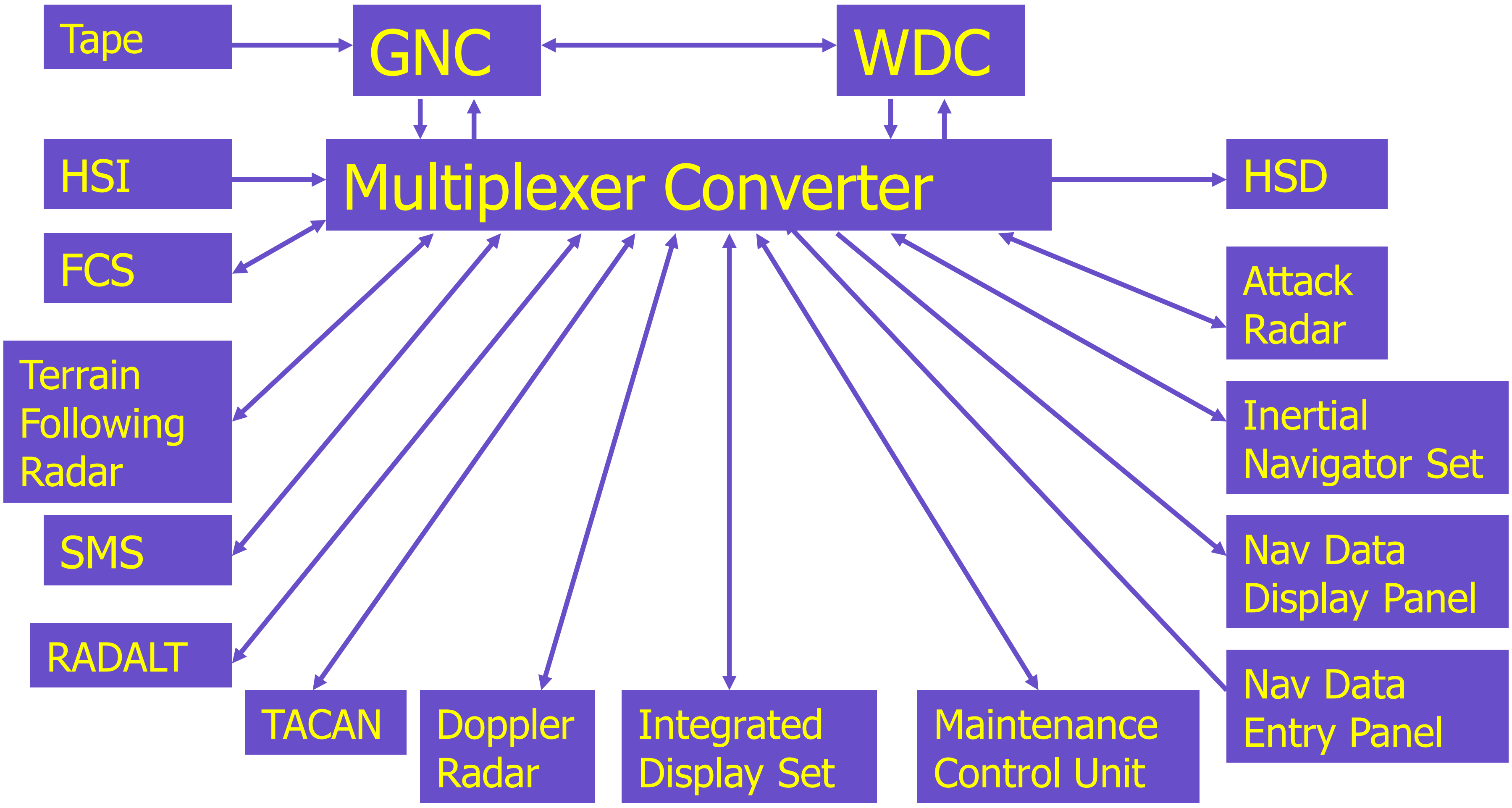
- Simple Design
- Software can be written easily
- Computers are located in readily accessible bay

DISADVANTAGES

- Requirement of long data buses
- Low flexibility in software
- Increased vulnerability to change
- Different conversion techniques needed at Central Computer

Motivated to develop a *COMMON STANDARD INTERFACE* for interfacing the different avionics systems.

FGA - CENTRALIZED ARCHITECTURE



SGA – FEDERATED ARCHITECTURE

Federated : Join together, Become partners

Each system acts independently but united

(Loosely Coupled)

- Unlike FGA – CA , Data conversion occurs at the system level and the datas are send as digital form – called Digital Avionics Information Systems(DAIS)
- Several standard data processors are often used to perform a variety of Low – Bandwidth functions such as navigation, weapon delivery , stores management and flight control
- Systems are connected in a Time – Shared Multiplex Highway
- Resource sharing occurs at the last link in the information chain – via controls and displays
- Programmability and versatility of the data processors

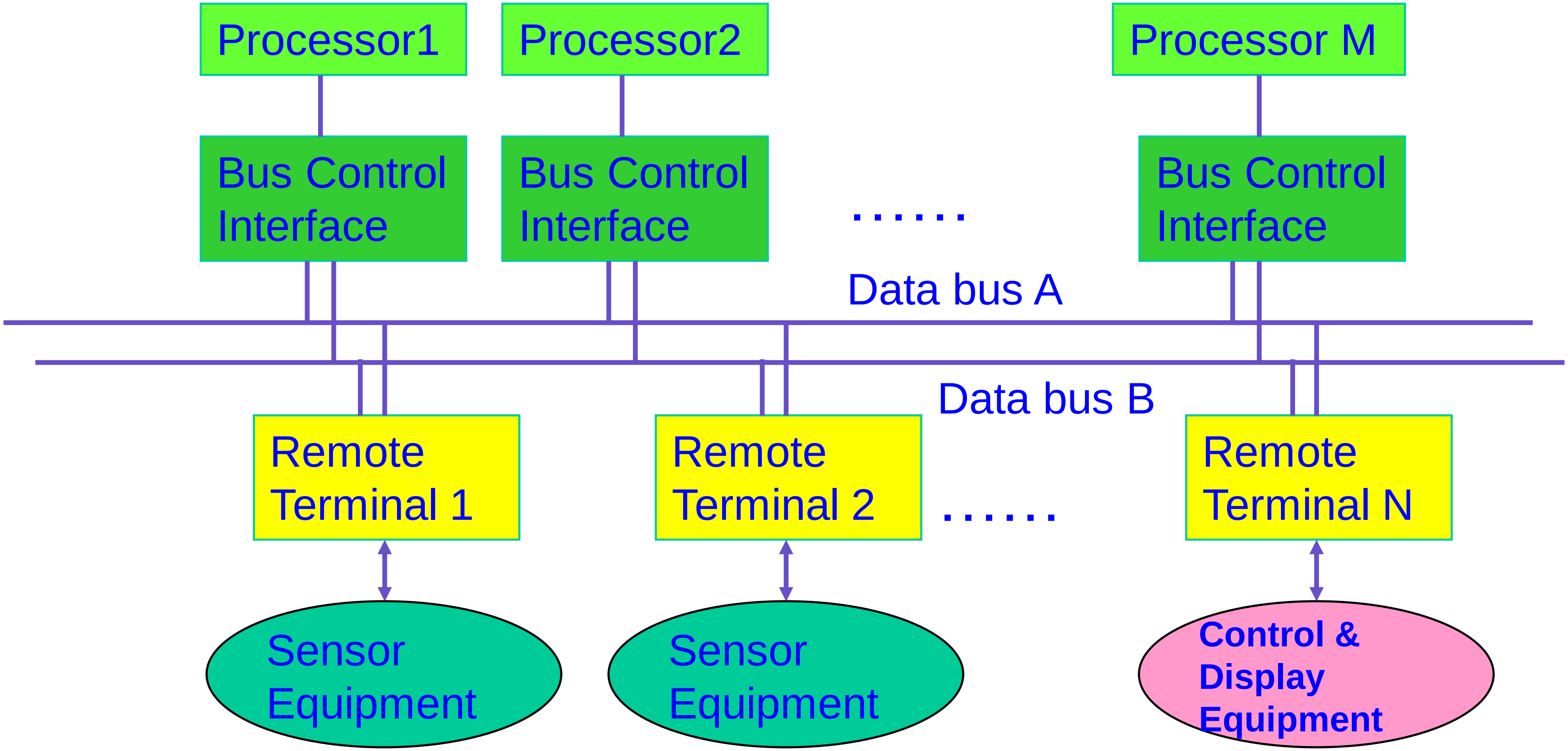
SGA – FEDERATED ARCHITECTURE

ADVANTAGES

- Contrast to analog avionics – DDP provide precise solutions over long range of flight , weapon and sensor conditions
- Sharing of Resources
- Use of TDMA saves hundreds of pounds of wiring
- Standardization of protocol makes the interchangeability of equipments easier
- Allows Independent system design and optimization of major systems
- Changes in system software and hardware are easy to make
- Fault containment – Failure is not propagated

DISADVANTAGES : Profligate of resources

SGA - DAIS HARDWARE ARCHITECTURE



SGA - DISTRIBUTED ARCHITECTURE

- It has multiple processors throughout the aircraft that are designed for computing takes on a real-time basis as a function of mission phase and/or system status

- Processing is performed in the sensors and actuators

ADVANTAGES

- Fewer,Shorter buses
- Faster program execution
- Intrinsic Partitioning

DISADVANTAGES

- Potentially greater diversity in processor types which aggravates software generation and validation

SGA – HIERARCHICAL ARCHITECTURE

- This architecture is derived from the federated architecture
- It is based on the TREE Topology

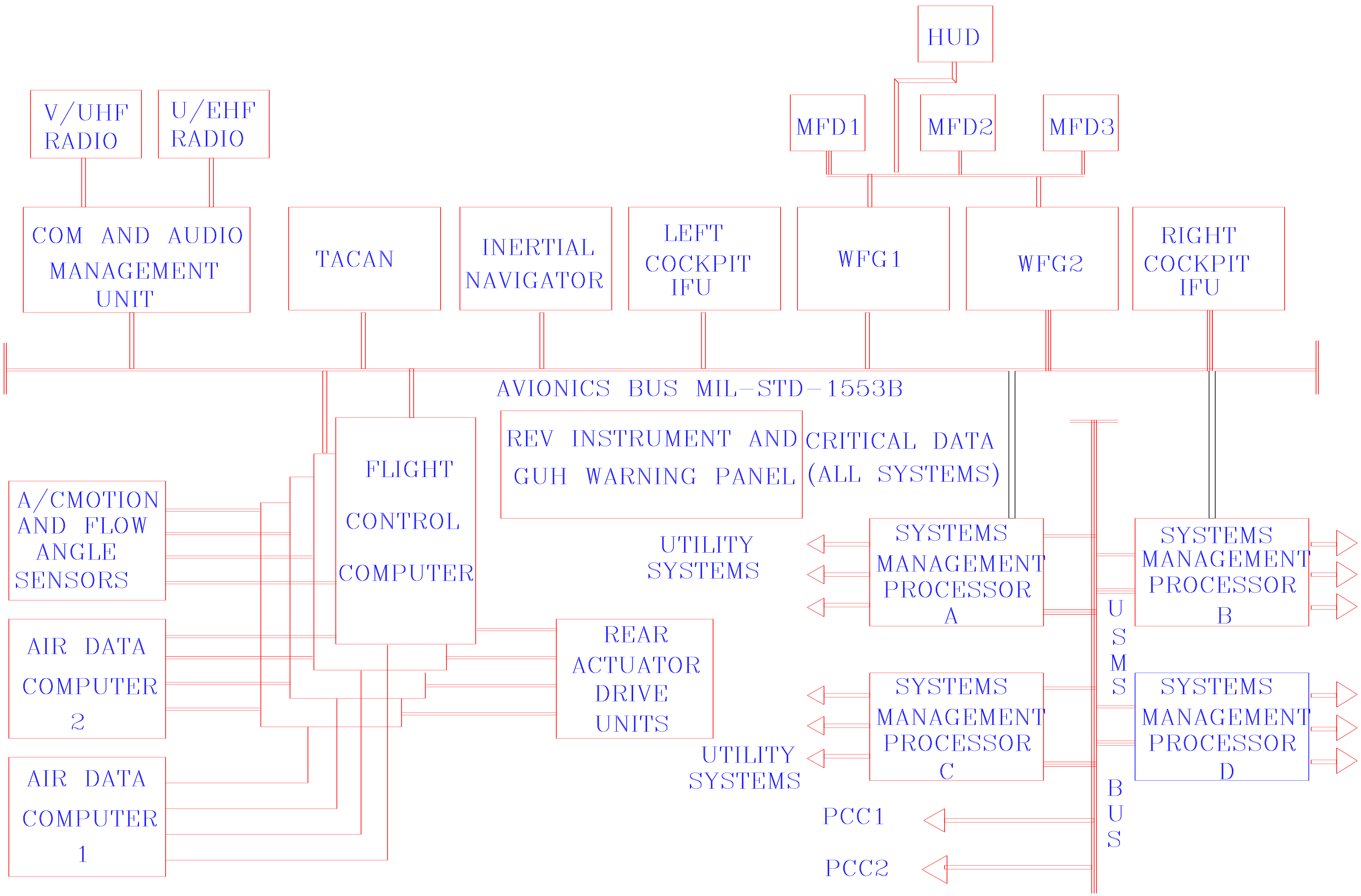
ADVANTAGES

- Critical functions are placed in a separate bus and Non-Critical functions are placed in another bus
- Failure in non – critical parts of networks do not generate hazards to the critical parts of network
- The communication between the subsystems of a particular group are confined to their particular group
- The overload of data in the main bus is reduced

Most of the military avionics flying today based on

HIERARCHICAL ARCHITECTURE

SGA - HIERARCHICAL SYSTEM



EAP AVIONICS SYSTEM

TGA - WHY PAVE PILLAR

Pave Pillar is a USAF program to define the requirements and avionics architecture for fighter aircraft of the 1990s

The Program Emphasizes

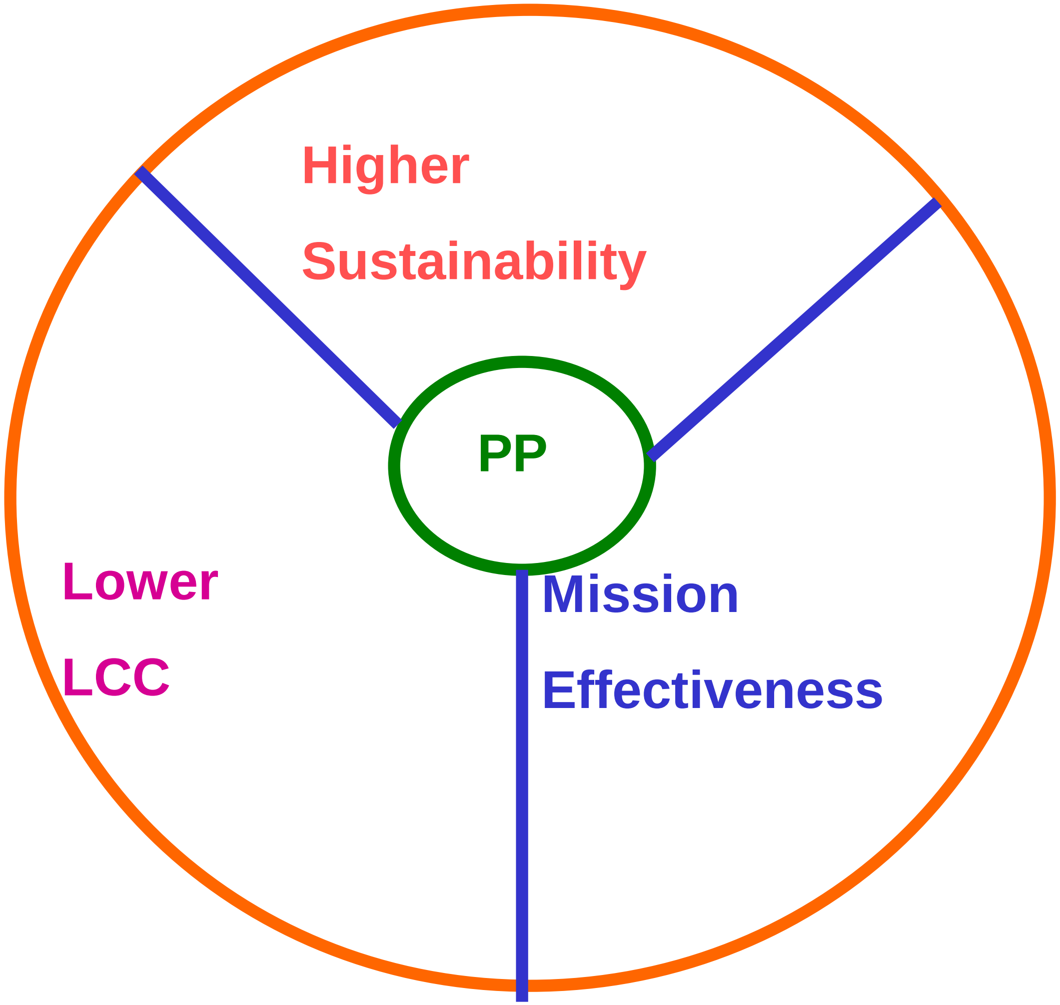
- **Increased Information Fusion**
- **Higher levels and complexity of software**
- **Standardization for maintenance simplification**
- **Lower costs**
- **Backward and growth capability while making use of emerging technology – VHSIC, Voice Recognition /synthesis and Artificial Intelligence**

Contd…

TGA - WHY PAVE PILLAR

- Provides capability for rapid flow of data in, through and from the system as well as between and within the system
- Higher levels of avionics integration and resource sharing of sensor and computational capabilities
- Pilot plays the role of a *WEAPON SYSTEM MANAGER* as opposed to subsystem operator/information integrator
- Able to sustain operations with minimal support, fly successful mission day and night in any type of weather
- Face a numerically and technologically advanced enemy aircraft and defensive systems

TGA - PAVE PILLAR



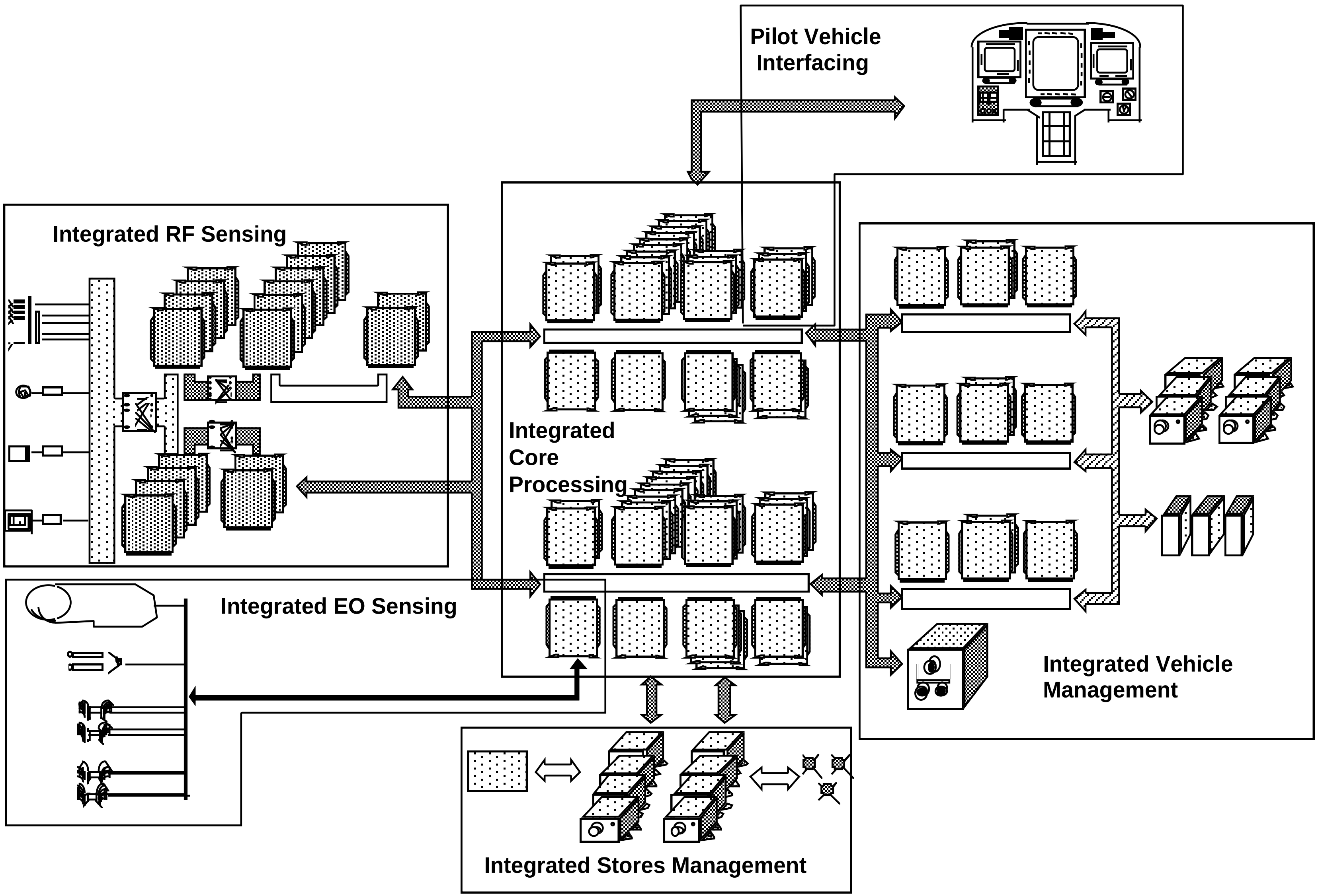
TGA – PAVE PILLAR ARCHITECTURE

- Component reliability gains
- Use of redundancy and resource sharing
- Application of fault tolerance
- Reduction of maintenance test and repair time
- Increasing crew station automation
- Enhancing stealth operation
- Wide use of common modules (HW & SW))
- Ability to perform in-aircraft test and maintenance of avionics
- Use of VHSIC technology and
- Capability to operate over extended periods of time at austere, deployed locations and be maintainable without the Avionics Intermediate Shop

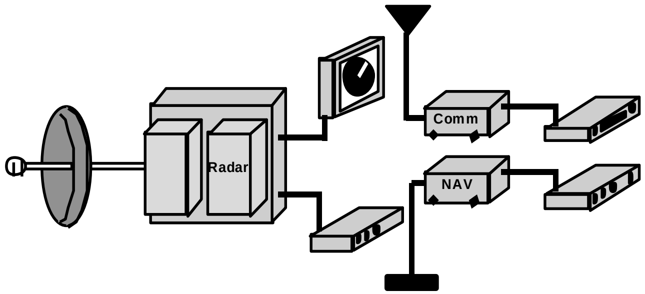
FTGA - WHY PAVE PACE

- Modularity concepts cuts down the cost of the avionics related to VMS, Mission Processing, PVI and SMS
- The sensor costs accounts for 70% of the avionics cost
- USAF initiated a study project to cut down the cost of sensors used in the fighter aircraft
- In 1990, Wright Laboratory – McDonnell Aircraft, Boeing aircraft company and Lockheed launched the Pave Pace Program
- Come with the Concept of Integrated Sensor System(IS^2)
- Pave Pace takes Pave Pillar as a base line standard
- The integration concept extends to the skin of the aircraft – Integration of the RF & EO sensors
- Originally designed for Joint Strike Fighter (JSF)

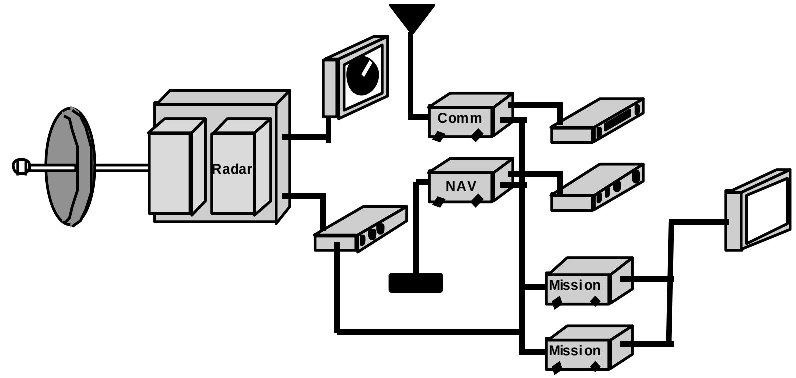
FTGA – PAVE PACE



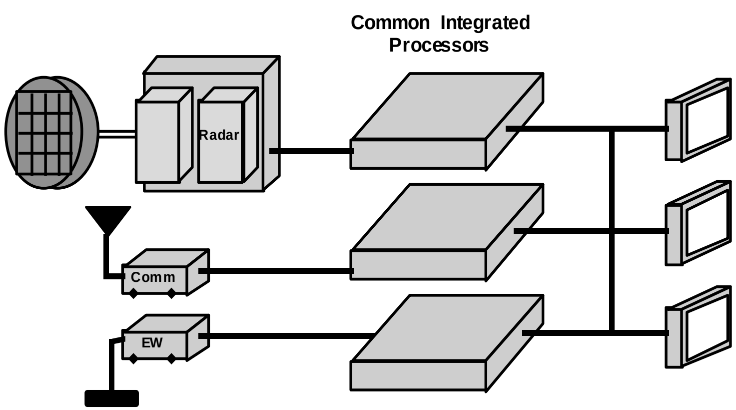
AVIONICS SYSTEM EVOLUTION



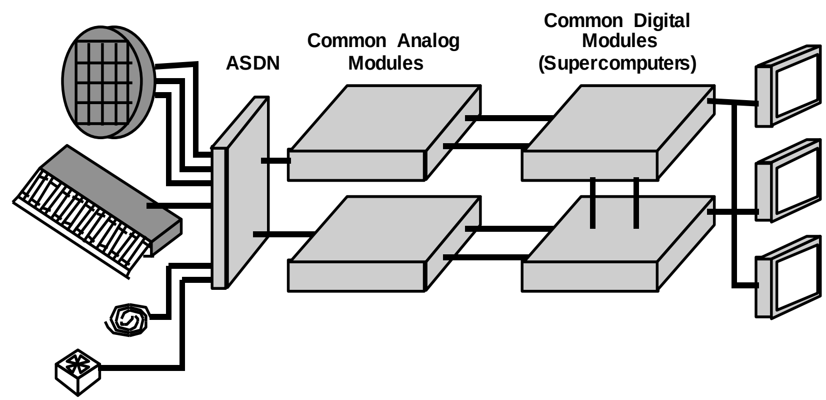
Independent Avionics
(40's - 50's)



Federated Avionics
(60's - 70's)



Integrated Avionics
(80's - 90's)



Advanced Integrated Avionics
(Post 2000)

KEY OBSERVATIONS

AVIONICS ARCHITECTURAL EVOLUTION

- Increased Digitization of Functions
- Increased sharing and modularization of functions
- Integration/ sharing concepts increased to the skin of the aircraft
- Functionality has increasingly obtained through software
- Complex hardware architecture modules
- Complex software modules
- Increased network complexity and speed

Data Bus

It provides a medium for the exchange of data and information between various Avionics subsystems

Integration of Avionics subsystems in military or civil aircraft and spacecraft.

Protocol

- set of formal rules and conventions governing the flow of information among the systems
- Low level protocols define the electrical and physical standards
- High level protocols deal with the data formatting, including the syntax of messages and its format

TYPES OF PROTOCOLS

Command/Response :**Centralized Control Method**

Token Passing : **Decentralized Control Method (Free token)**

CSMA/CA : **Random Access Method**

Topology

How the systems are interconnected in a particular fashion

LINEAR NETWORK

- Linear Cable
- All the systems are connected in across the Cable

RING NETWORK

- Point to Point interconnection
- Datas flow through the next system from previous system

SWITCHED NETWORK

- Similar to telephone network
- Provides communications paths between terminals

MIL-STD 1553B

History of the MIL-STD-1553B

- Developed at Wright Patterson Air Force Base in 1970s
- Published First Version 1553A in 1975
- Introduced in service on F-15 Programme
- Published Second version 1553B in 1978

MILITARY STANDARD 1553

- **MIL-STD-1553**, ***Command / Response Aircraft Internal Time Division Multiplex Data Bus***, **is a Military standard (presently in revision B), which has become one of the basic tools being used today for integration of Avionics subsystems**

- **This standard describes the method of communication and the electrical interface requirements for the subsystems connected in the data bus**

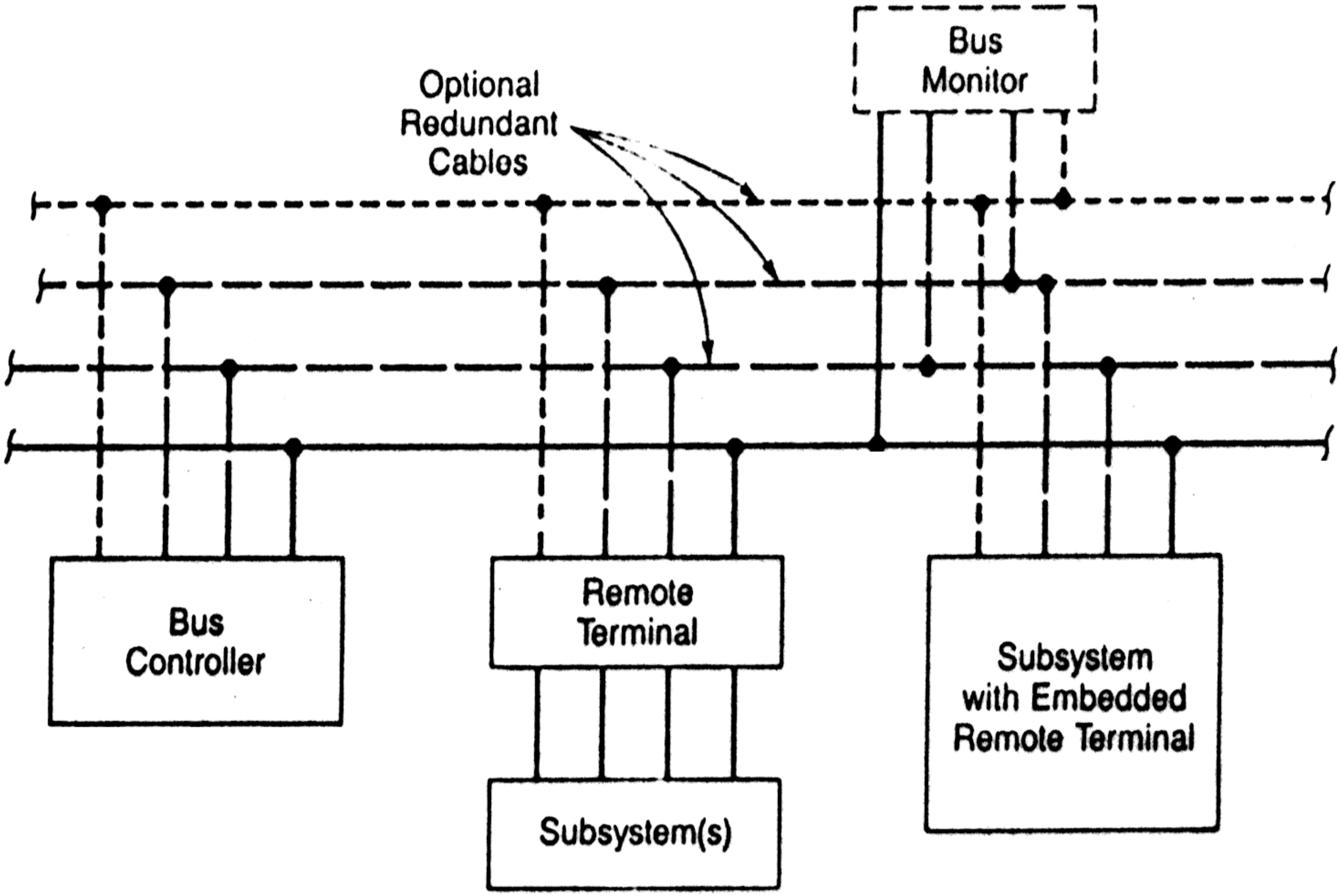
SPECIFICATION OVERVIEW

Data Rate	1 Mbps
Word Length	20 Bits
Message Length	32 Word Strings(maximum)
Data Bits per Word	16 Bits
Transmission Technique	Half - Duplex
Encoding	Manchester II Bi-phase
Protocol	Command Response
Transmission Mode	Voltage Mode

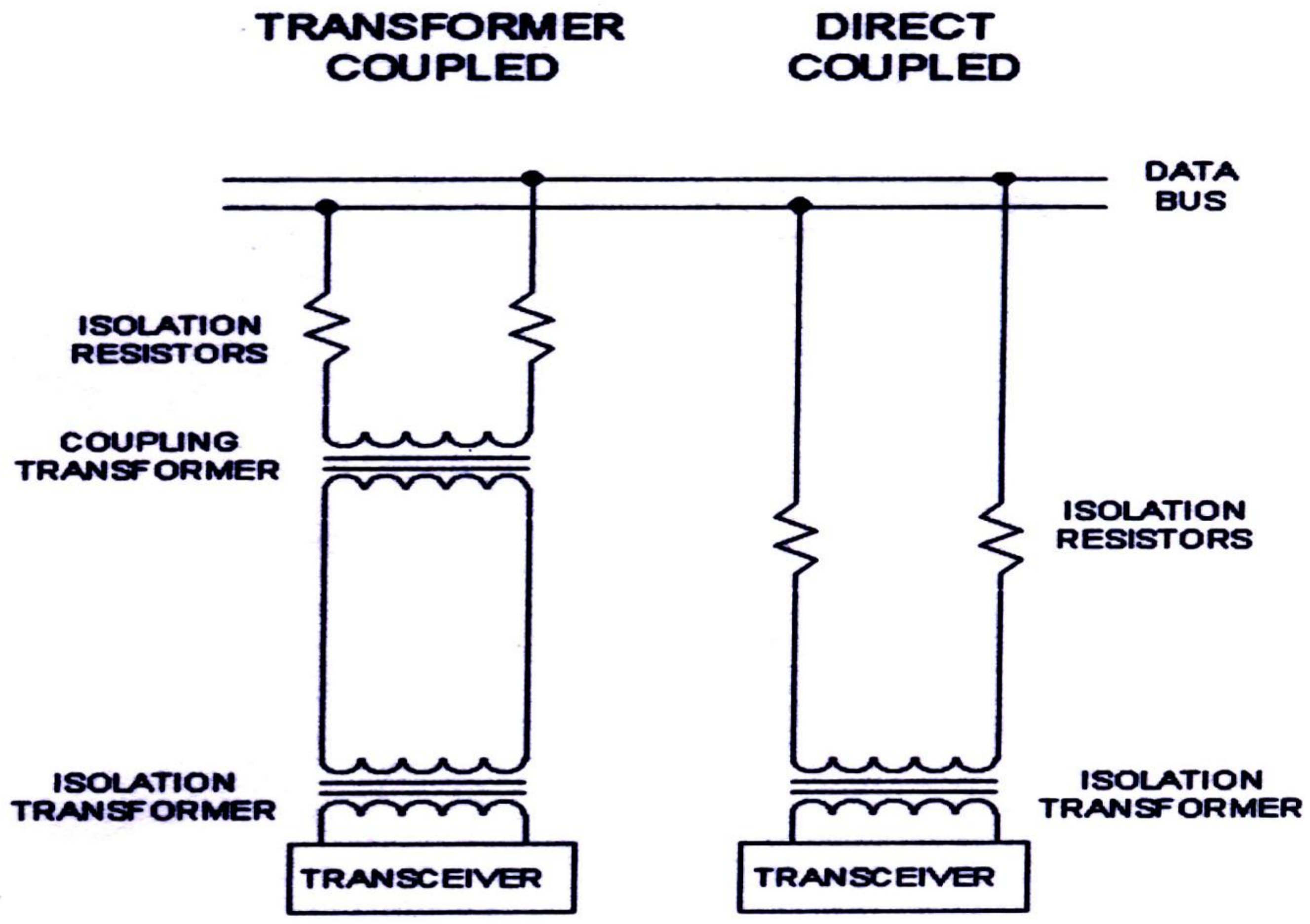
ELEMENTS OF MIL-STD-1553B

- **BUS CONTROLLER (BC)**
- **REMOTE TERMINAL (RT)**
- **MONITORING TERMINAL (MT)**
- **TRANSMISSION MEDIA**

BUS ARCHITECTURE



COUPLING METHODS



ARINC 429

HISTORY & MOTIVATION

- Single point failure in 1553B leads to certificability problem in civil aircraft
- Addition of remote terminal requires changes in BC software which requires frequent certification
- Standard adopted in the year 1977
- Made its appearance in the C-17 transport aircraft
- Point to Point Protocol

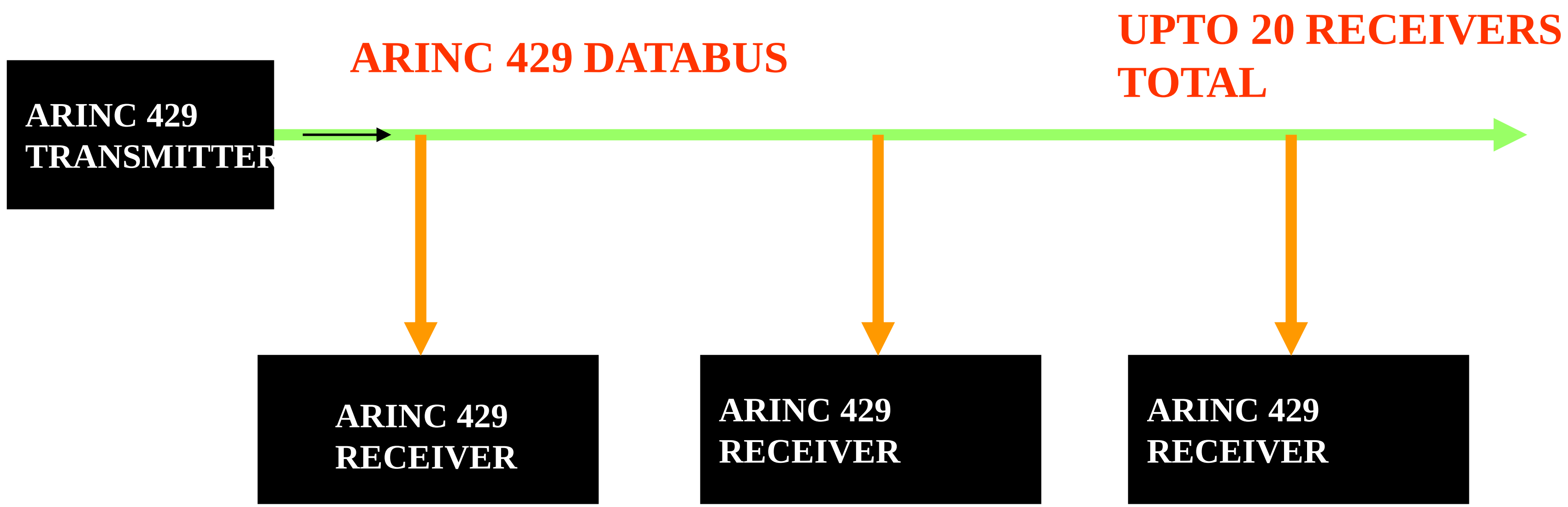
ARINC SPECIFICATION 429

- It is a specification that defines a local area network for transfer of digital data between avionics system elements in civil aircraft.
- It is simplex data bus using one transmitter but no more than twenty receivers for each bus implementation
- There are no physical addressing. But the data are sent with proper identifier or label

Contd…

- ARINC 429 is viewed as a permanent as a broadcast or multicast operation
- Two alternative data rates of 100kbps and 12-14 Kbps
- There is no bus control in the data buses as found in MIL-STD 1553B
- It has direct coupling of transmitter and receiving terminals

ARINC 429 ARCHITECTURE



ARINC 629

BIRTH OF ARINC 629

1977 => Boeing began to work on "DATAC" project

1977 - 85 => DATAC Emerged as ARINC 629

1989 => ARINC 629 was adopted by AEEC

1990 => ARINC 629 was first implemented in BOEING-777

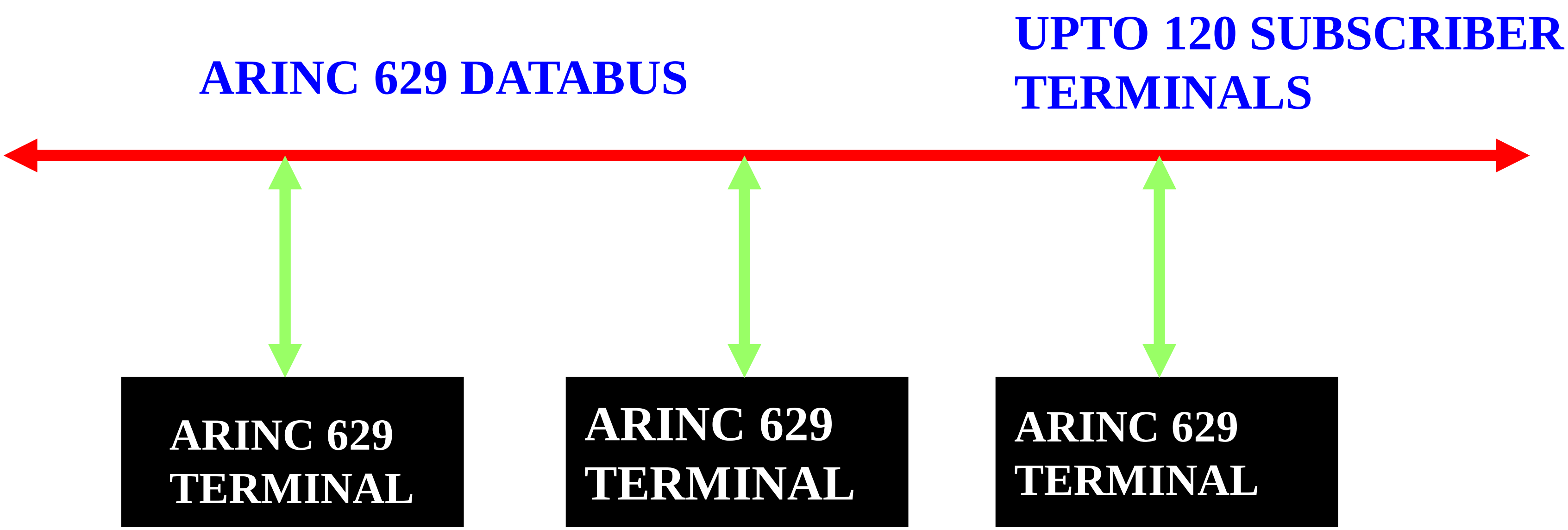
ARINC 629 DATA BUS

- Time Division Multiplex
- Linear Bus
- Multiple Transmitter Access
- 2 Mbps Data Rate
- Current Mode Coupling (Present implementation)

SPECIFICATION OVERVIEW

Data Rate	2 Mbps
Word Length	20 Bits
Message Length	31 Word Strings(maximum)
Data Bits per Word	16 Bits
Transmission Technique	Half - Duplex
Encoding	Manchester II Bi-phase
Protocol	Carrier Sense Multiple Access Collision avoidance
Transmission Mode	Voltage Mode,Current Mode, Fiber Optic Mode

ARNIC 629 ARCHITECTURE



AFDX

Avionics Fully Duplex Switched Ethernet is an advanced Protocol Standard to interconnect avionics subsystems

- It can accommodate future system bandwidth demands
- Increase flexibility in Avionics design
- Reduce aircraft wire counts, thus lowering aircraft weight and cost
- Its first major use in A3xx

- Since the Ethernet is a switched architecture rather than a point-point link, aircraft designers can create redundant sub networks

- Faults can be isolated and analysed without impacting the system as a whole

- ARINC 429 data bus may still be used but the main Avionics data pipe will be Ethernet (AFDX) of 100 Mbps

HSDB

- Used in F-22 Advanced tactical fighter
- Generic version SAE Aerospace Standard 4074.1
- 50 Mbps- linear bus
- for optical medium implementation – star topology
- HSDB uses distributed control in which each terminal is permitted to transmit only when it receives the token frame.

SCI

- IEEE –STD-1596-1992
- SCI is an interconnect system for both backplane and LAN usage.
- It is a system of rings and switches in its basic format
- Operates at 1 Gbps
- Electrical links upto 30m and optical links upto several kms.
- Same Bandwidth as today's 155Mbits/sec ATM links , 32 times that of today's fiber optic channel and 800 times that of Ethernet.

DATABUS COMPARISION

	1553B	ARINC629	ARINC 429	ETHERNET
Standard	**Def-Stan STANAG 3838**	**ARINC**	**ARINC**	**IEEE 802.3 ISO 8802.3**
Status	**Published**	**Published**	**Published**	**Published**
Primary Support	**US DOD USAF**	**Boeing**	**Civil Airlines**	**INTEL**

PERFORMANCE

Signaling Rate

1553B	-	1Mbps
Ethernet(AFDX)	-	100Mbps
ARINC 429	-	100Kbps or 12-14.5Kbps
ARINC 629	-	2Mbps

BUS ACCESS

1553B - Predetermined

Ethernet - Not Determined

ARINC 429 - Fixed

ARINC 629 - Multitransmitter

Coupling

1553B	-	Transformer
Ethernet	-	Transformer
ARINC 429	-	Direct
ARINC 629	-	Transformer

Protocol Features

Access Method

1553B	-	Time Division
Ethernet	-	CSMA/CD
ARINC 429	-	Fixed (Single Transmitter)
ARINC 629	-	CSMA/CA

Hierarchy

1553B	- Master/Slave
Ethernet	- No Master
ARINC 429	- No Master
ARINC 629	- No Master

NUMBER OF NODES

1553B	-	31(RT) + BM + BC
Ethernet	-	100 +
ARINC 429	-	20
ARINC 629	-	120

MIL-STD 1773

WHY OPTICAL FIBER?

- Though 1553B is used in various modern aircraft, it is recognised that buses operate in extremly severe environment like
- EMI from intersystem and intrasystem
- Lightning
- Electrostatic discharge
- High Altitude Electromagnetic pulse

About 1773

- Fiber-optic version of 1553B
- It also operates at the rate of 1Mbps
- It also have the same 20 bit word and three words such as command word, status word and data word
- stronger immunity to radiation-induced electromagnetic interference


STANAG 3910

HISTORY OF STANAG 3910

- Motivation of the STANAG 3910
- Draft Created in Germany during 1987
- Draft Submission on 1988
- A Project EFA Bus was issued on 1989
- Selected by the Euro fighter consortium in 1989

STANAG 3910

- To meet the Demands of Avionics requirements for Highly Sophisticated fighter aircraft
- Allow Evolution from MIL-STD-1553B Bus to "Higher Speed" Avionics Bus System
- Stay with a Deterministic Master/Slave Protocol
- "Low Risk" approach to EF2000 Prototypes using MIL-STD-1553B only

SPECIFICATION OVERVIEW

Data Rate	**1 Mbps (LS), 20Mbps (HS)**
Word Length	**16 Bits**
Message Length	**32 Word(LS), 4096 Word (HS)**
Max No. of Stations	**32**
Transmission Technique	**Half - Duplex**
Access Protocol	**Command /Response**

COMPARISON BETWEEN MIL-STD-1773 and STANG 3910

- MIL-STD-1773 is same as the 1553B with Fiber-Optic Media

- STANAG 3910 operates under the control of STANAG 3838 (1553)

- The data rate in 1773 is 1Mbps

- The STANAG 3910 has 2 data rates
  - 1 Mbps in 3838
  - 20 Mbps in Optical bus

CAN BUS

- **Controller Area Network (CAN) is the network Established among microcontrollers.**
- **CSMA/CA Protocol**
- **Two wire high speed network system which was firstly Established to overcome the problems (wire harness,Communication) faced in automobiles.**
- **Linked up to 2032 devices(assuming one node with one identifier) on a single network.**
- **CAN offers high speed communication up to 1Mbps, thus allowing real time control.**


DIGIBUS

Digibus

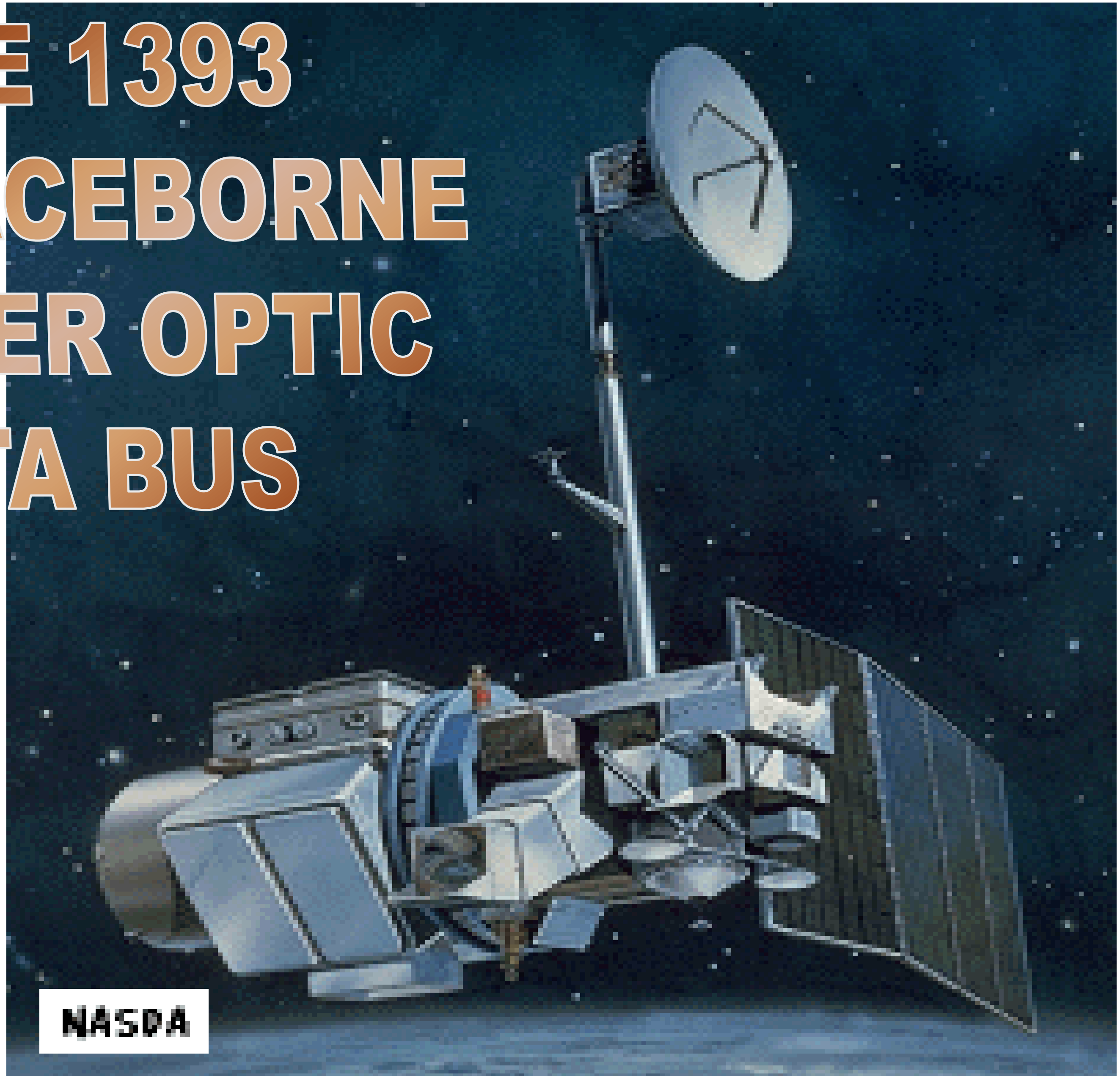
- Originally **Ginabus (G**estion des **I**nformations **N**umeriques **A**eroportees – Airborne Digital Data Management)
- Designed jointly by Electronique Serge Dassault (ESD) and Avions Marcel Dassault- Breguet Aviation (AMD-BA) and SAGEM between 1973 and 76
- Digibus is now standard for all branches of French Military is defined in the Specification GAM-T-101

SPECIFICATIONS

- **Digibus operates at 1 Mbits /sec.**
- **Uses two twisted cable pairs shielded with two mesh screens, one cable pair conveys data and the other carries protocol messages.**
- **The protocol messages are similar to MIL-STD-1553.**
- Maximum bus length is 100meters. But active repeaters allow extension up to 300 meters plus sub-bus couplers that can be used to connect sub buses (each up to 100 meters long) on to the main bus.

DATA BUSES IN SPACE APPLICATIONS

IEEE 1393 SPACEBORNE FIBER OPTIC DATA BUS



- ON Board Data Handling networks

- High Speed payloads

- SFODB is 1 Gbps, support real time and On Board Data handling requirement of Remote Sensing satellites

- Highly reliable, fault tolerant, and capable of withstanding the rigors of launch and the harsh space environment.

- Small size, light weight, and low power
- Architecture Redundant, Cross-Strapped Fiber Optic Ring with Passive Bypass
- Standard Protocol IEEE 1393-1999
- Node Capacity 127 Transmit & Receive Nodes

In Space shuttles

Two commonly used data buses

1. Multiplex interface adapter(MIA)

2. Multiplex/demultiplexer data bus (MDM)

MIA Data Bus

- Command/response protocol

- 24 bit words(plus sync&parity)

- Same as to 1553 data bus in speed and biphase Manchester encoding

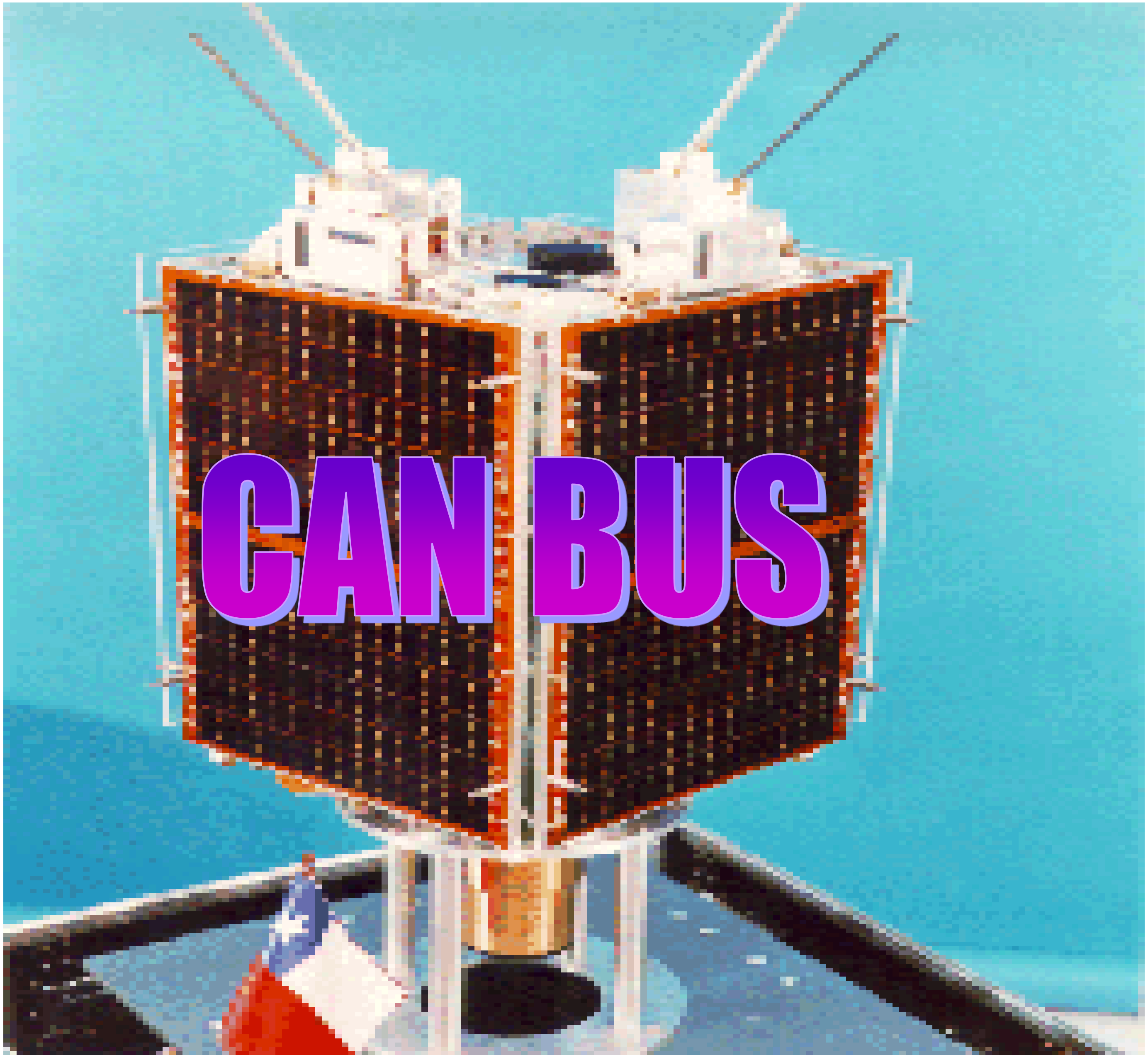
- Words are 24 bits long while in 1553 20 bits long

MDM DATA BUS

- Serial point to point communication Between space shuttle payload general support computer and various subsystems
- MDM interface consists of a serial data bus and three discretes (Message in, Message out and word)
- Discrete contains the timing , direction and No. of words on the serial data bus

- Serial data bus is bi-directional

- Discrete are driven by bus controller (the PGSC) and received by the remote Terminal
- Speed is 1 Mbps
- Words have 16 bits, messages upto 32 words


CAN BUS

CAN BUS

In Space Applications

- FASat-ALPHA(Chile) will carry an advanced OBDH system
- In this, Controller Area Network (CAN) bus is used to connect all processing nodes

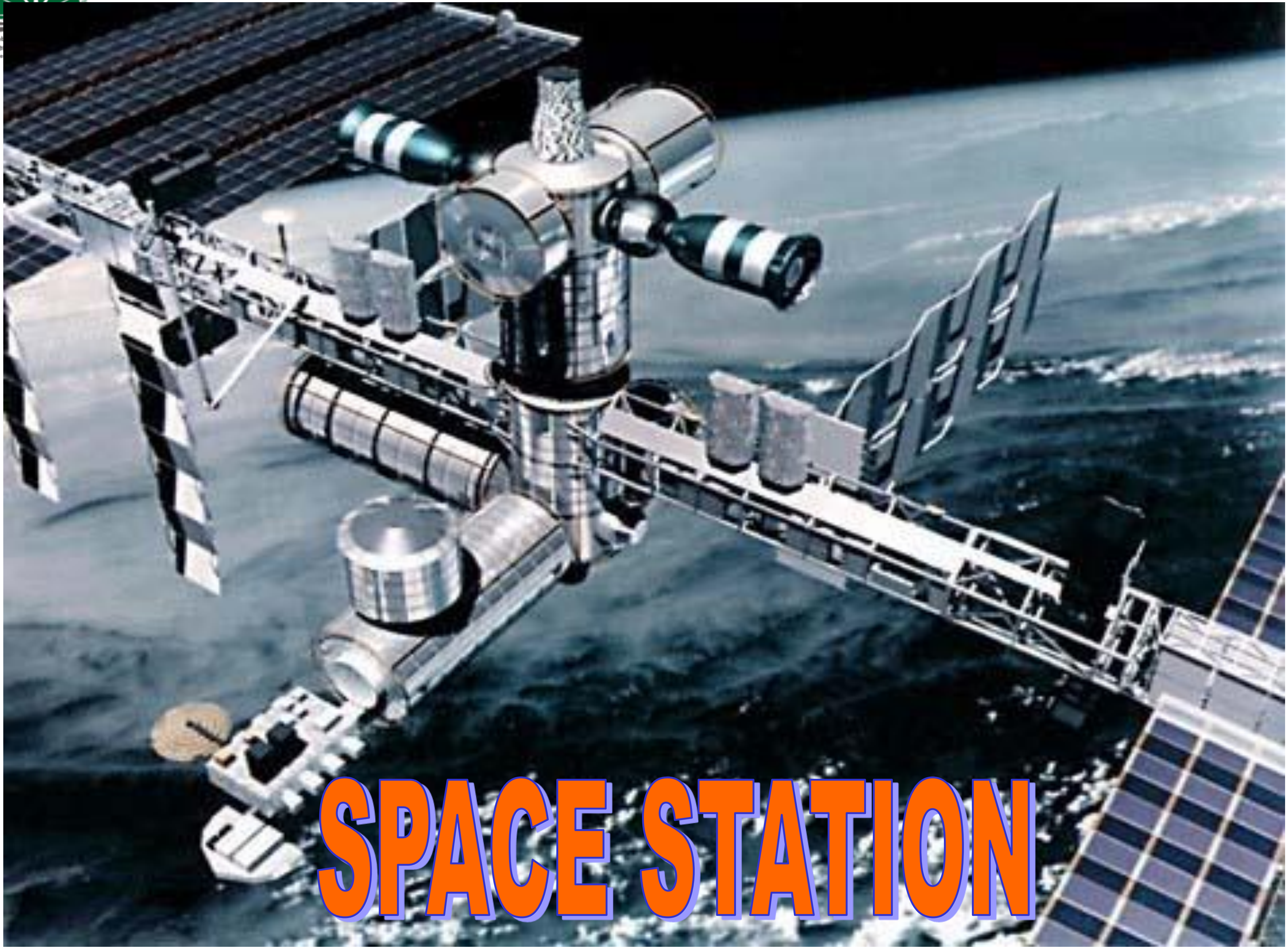
- ROMER-a DANISH satellite, ACS will be implemented on an on-board connected to a CANBUS in order to communicate with sensors and actuators of the ACS.
- CANBUS network is used for connecting all components via an interface,within the body in TG-A launch vehicles.

MIL-Std 1553 Data Bus in Space Applications

- TAOS-Technology for Autonomous Operational survivability

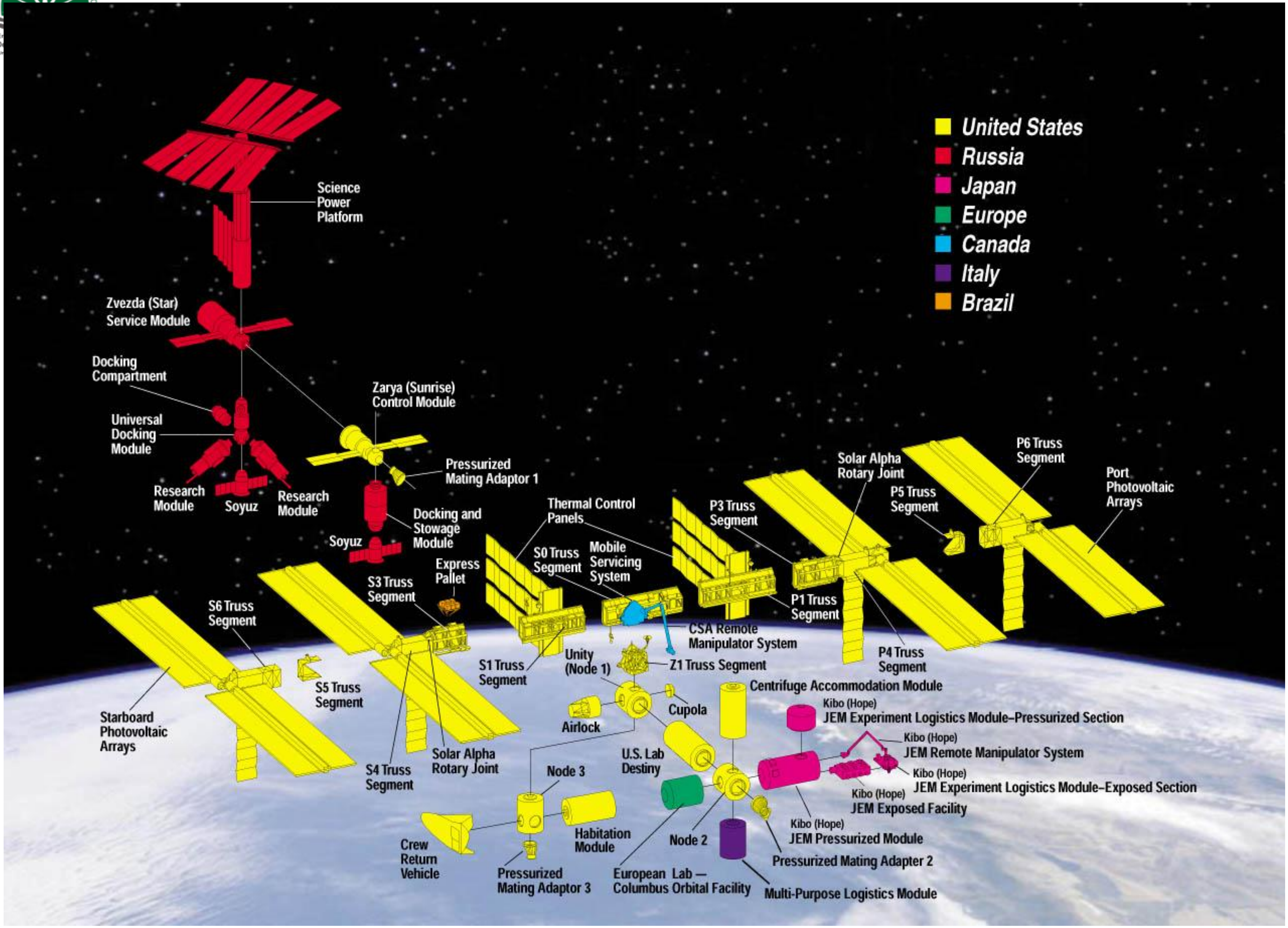
- In TAOS Satellite 1553 is used for intersatellite communications

- Two MIL-Std 1750A(Processor) are used for spacecraft control and payload operation


SPACE STATION

International Space Station

MIL-Std 1553 Data Buses are used for a common data link between all segments of U.S. laboratory Module, Russian Service Module and functional Cargo block, the European Columbus Orbital facility and the Japanese Experimental Modulej


United States
Russia
Japan
Europe
Canada
Italy
Brazil
Science Power Platform
Zvezda (Star) Service Module
Docking Compartment
Universal Docking Module
Research Module
Soyuz
Research Module
Zarya (Sunrise) Control Module
Pressurized Mating Adaptor 1
Docking and Stowage Module
Soyuz
Express Pallet
S3 Truss Segment
Thermal Control Panels
S0 Truss Segment
Mobile Servicing System
P3 Truss Segment
Solar Alpha Rotary Joint
P5 Truss Segment
P6 Truss Segment
Port Photovoltaic Arrays
P1 Truss Segment
CSA Remote Manipulator System
Z1 Truss Segment
P4 Truss Segment
S6 Truss Segment
S5 Truss Segment
Starboard Photovoltaic Arrays
S1 Truss Segment
Unity (Node 1)
Centrifuge Accommodation Module
Cupola
Airlock
Kibo (Hope)
JEM Experiment Logistics Module–Pressurized Section
Kibo (Hope)
JEM Remote Manipulator System
Kibo (Hope)
JEM Experiment Logistics Module–Exposed Section
Kibo (Hope)
JEM Exposed Facility
S4 Truss Segment
Solar Alpha Rotary Joint
Node 3
U.S. Lab Destiny
Kibo (Hope)
JEM Pressurized Module
Crew Return Vehicle
Habitation Module
Node 2
Pressurized Mating Adapter 2
Pressurized Mating Adaptor 3
European Lab — Columbus Orbital Facility
Multi-Purpose Logistics Module

- In SWAS , NASA's UBMILLIMETER WAVE ASTRONOMY SATELLITE use 1553 data bus for On-Board Data Handling system

- In TRACE, NASA TRANSITION REGION AND CORNAL EXPLORER employ 1553 to connect subsystems.

- Microstar Satellite platform uses 1553 Or 1773 Buses for payload data interface To accommodate high level interfaces.

- NASA's Goddard Space Flight Center use a common bus for several satellites Which is attained by 1553 and 1773 buses

- Globstar system consider 1553 as a common reference design

THANK YOU

UNIT I

Questions	opt1	opt2	opt3	opt4	opt5	opt6	Answer
A radio wave is an	electromagnetic wave	electric wave	mechanical wave	hydrallic wave			electromagnetic wave
A ground wave travels across the Earth on the	ozone layer	under ground	surface	space			surface
The ground wave frequency range is generally from 100 Hz to	250 Hz	500kHz	100 kHz	1,000 kHz			1,000 kHz
The sky wave frequencies range is 1MHz to	20 MHz	30 MHz	40MHz	50 MHz			30 MHz
When able to pass through the ionosphere, radio waves of 15 MHz and above till GHz are considered	space waves	sky waves	ground waves	radio waves			space waves
What is meant by NDB	national direct radio beacon	non distrubed radio beacon	non directional radio beacon	natural distrubed radio beacon			non directional radio beacon
The ADF, when used with an NDB, determines the bearing from the aircraft to the	receving station	signal detector	sky waves	ng station			transmitting station
Which of the following is not a function of the ADF	plot your position	plot the pressure distribution	track inbound and outbound	intercept a bearing			plot the pressure distribution
What is meant by GPS	positioning system	positioning system	positioning system	positioning system			global positioning system
What is meant by RB	relative bearing	readable bandwith	reliable bandwith	readable bearding			relative bearing
The purpose of autopilot is to reduce the work load of the	engine	wings	instruments	pilot			pilot
The autopilot system flies the aircraft by using electric signals developed in	ailerons	cock pit	gyro sensing unit	control unit			gyro sensing unit
Instrument landing system is one of the facilities of the	civil airways	military airways	federal airways	private airways			federal airways
The localizer equipment produce a radio course alinged with the centre of an	aircraft	aircraft runway	fuselage	cockpit			aircraft runway
Which system has been developed to overcome some of the problems and limitations associated with ILS	pitot tube	static tube	pressure tube	none of these			none of these
VOR is an	control system	magnetic system	mechanical system	electric navigational system			electric navigational system
The intelligence from the VOR receiver is displayed on the	FOR	VOR	MRI	CDI			CDI
The radio frequency portion of the electro-magnetic spectrum extends from approxmately from 30KHz to	300 MHZ	300 KHz	30,000 MHz	30,000 KHz			30,000 MHz
The transmitter may be considered as a generator which changes electric power into	radio waves	hydro power	electronic power	mechanical power			radio waves
The receiver contains a demodulator circuit to remove the	negative signals	positive ions	intelligence AM or FM	neutral power			intelligence AM or FM
The microphone converts acoustic energy to	voice	electric energy	sound	sound waves			electric energy
A special type of electrical circuit designed to radiate and receive the electromagnetic energy is called	control unit	system unit	electric navigational system	antenna			antenna
Very High Frequency Omni Range System is shortly called as	VOR	VHFOR	VFOR	VHOR			VOR
Components such as engine, propeller controls, trimming controls, fuel valves can be controlled by	engine system	tele flex control system	control unit	push pull rods			tele flex control system
In power assisted control system majority of work is done by the	piston	control rod	fluid	actuators			actuators

In PACS the pilot contribution of effort is	minimum	maximum	half the work	zero			zero
A basic chamber for storing hydraulic fluid under pressure is	accumulator	gyro	transmitter	altimeter			accumulator
Aircrafts are mede statically and dynamically stable in other words	weight stable	length stable	longitudinally and laterally stable	directionally and laterally stable			longitudinally and laterally stable
The full form of CCV is	control configured vehicle	construction configured vehicle	control circuit vehicle	control convertor vehicle			control configured vehicle
Which of the following is tubular in construction?	engine	fuselage	landing gear	wings			fuselage
Navigation system is used to _____________	Traffic control	Communication	Weather detection	Find position and direction			Find position and direction
During the First World War ___________ technology is used for communication.	wireless	Dopple	Radio	RADAR			wireless
DME stands for _________	Distance measuring equipment	Distance monitoring equipment	Direct measuring equipment	Doppler monitoring equipment			Distance measuring equipment
Following one is the type of navigation system	Medium frequency	pilotage	High frequency	Low frequency			pilotage
Electronic Warfare is mainly used to search the ____________	Communication signals	Ultrasonic waves	Sound waves	Radio frequency band			Radio frequency band
In communication system ___________ is used as a transmitter links.	fiber	iron	mica	Silver			fiber
___________ memory is require a power to maintain the stored information.	Non volatile	virtual	protected	volatile			volatile
In communication system ________ is used to convert the natural signal into an electrical signal.	antenna	compressor	Transducer	generator			Transducer
Fly-By-Wire system sends the information in the form of _____________	Electrical signals	Analog signals	Radio signals	Sky waves			Electrical signals
Loran stands for______________	Lost range navigation	Low range navigation	Least range navigation	Long range navigation			Long range navigation
Satellites are used in _____________	Global positioning system	Global point system	Global plane system	Galaxy positioning system			Global positioning system
Localizer is used in ____________	ILS	IOP	IAP	ISI			ILS
Doppler is used for ____________ communication.	Long range	Short range	Medium range	Pilotage			Long range
The signal using dots and dashes is called _____________.	Analog signal	Morse signal	Digital signal	Radio signal			Morse signal
ATC stands for ____________.	Air Traffic Control	Aviation Transport Control	Air Transport Control	Air Traffic Control			Air Traffic Control
UNIT II							
An automatic device that uses error-sensing negative feedback to correct the performance of a mechanism.	pump	servomechanism	actuator	undercarriage			servomechanism

A device whuch displaces a volume by physical or mechanical action.	servomechanism	actuator	pump	air speed indicator			pump
A mechanical device for moving or controlling a mechanism or system	actuator	altimeter	pump	servomechanism			actuator
The instruments in the cockpit of an aircraft that provide the pilot with information about the flight situation is called	actuator	pump	servomechanism	flight instruments			flight instruments
A ground-based instrument approach system that provides precision guidance to an aircraft approaching and landing on a runway is called	landing system	nt landing system	electrical system	indicator system			instrument landing system
The other name of landing gear is	undercarriage	wheels	base	stand			undercarriage
The height of the aircraft can be determined by	altimeter	variometer	air speed indicator	gyro horizon			altimeter
The speed of the aircraft is usually determined by the instrument	altimeter	air speed indicator	turn and bank indicator	mach meter			air speed indicator
The direction in which an aircraft is headed can be indicated by the	pitot static tube	electrical circuits	magnetic compass	altimeter			magnetic compass
The acceleration loads on the aircraft structure can be measured by the	variometer	accelerometer	vertical speed indicator	magnetic compass			accelerometer
The power for the operation of the landing gear retraction and extension can be given by	stable system	unstable system	pressure system	pneumatic system			pneumatic system
The purpose of the main plane is to generate	lift	decrease fuel ratio	increase angle of attack	manage relative wind			lift
According to newtons law, the gravitation is inversely proportional to	geometric altitude	geopotential altitude	absolute altitude	none of the given			absolute altitude
Hydrostatics is defined as the study of a body which is at rest in a	solid medium	liquid medium	gaseous medium	fluid medium			fluid medium
The other name of wing is	airfoil	ribs	main plane	spars			main plane
The Physical behaviour of water at rest and motion is called		Hydraulics					Hydraulics
A chamber for storing hydraulic fluid under pressure is called	Accumulator	servomechanism	fluids	jack			Accumulator
A device converting hydraulic pressure to mechanical motion is called	mechanical actuator	screw driver	Hydraulic Actuator	converter			Hydraulic Actuator
The valve used to set open at 26,201Kpa is called	valve	relief Valve	reveale valve	pressure valve			Relief Valve
A back pressure valve is installed in the	vacumn tube	velocity tube	air tube	Pressure tube			Pressure tube
The back pressure valve is similar in operation and construction to a	Check valve	contor valve	temp valve	pressure valve			Check valve
Pulley, cables etc are used in	hydraullic system	pnematic system	Mechanical Brake Systems	electronic brake system			Mechanical Brake Systems
Large Aircrafts use	ordinary brake system	oil brake system	dics brake system	Power Brake Systems			Power Brake Systems
Torque links is often referred to as	scalar system	Scissors assembly	pitot assembly	torsion assembly			Scissors assembly
The component located on the bottom of the strut piston and has the axles attached to it is called	axle	truck	pulley	ring			truck
The vertical member of the landing gear assembly that contains the shock absorbing mechanism is called	truck	Trunnion	Shimmy Damper	struts			struts
The top of the strut is attached to an integral part and is called as	truck	Trunnion	Shimmy Damper	Scissors assembly			Trunnion

The Strut is also called as	inner cylinder	ring	Outer Cylinder	piston			Outer Cylinder
The upper Bearing in strut keeps the inner cylinder aligned with the	Outer Cylinder	Trunnion	Shimmy Damper	Spring-oleo Type			Outer Cylinder
The portion of the landing gear assembly attachedto the airframe is called	truck	Shimmy Damper	Scissors assembly	Trunnion			Trunnion
The landing gear strut extends down from the approximate centre of the	landing system	Rigid landing gear	Trunnion	truss			Trunnion
A hydraulic snubbling unit that reduces the tendancy of the nose wheel to oscillator from side to side is called	Hydraulic Filter	Shimmy Damper	O-Rings	Omni-Radial			Shimmy Damper
Which of the following is a shock absorbing landing system	truck	Shimmy Damper	Scissors assembly	Spring-oleo Type			Spring-oleo Type
Non-Retractable landing gear usually works with the help of hydraulic or	Electric Power	motor	rotor	electric system			Electric Power
Retractable landing gear is designed to reduce	lift	weight	Drag	thrust			Drag
Non-Retractable landing gear is generallly called as	Movable Landing Gear	semi movable Landing Gear	Retractable landing gear	Fixed Landing Gear			Fixed Landing Gear
The landing gear which donot dissipate the energy of the aircraft contacting the groundduring landing is called	Movable Landing Gear	Non-Absorbing Landing Gear	semi movable Landing Gear	Retractable landing gear			Non-Absorbing Landing Gear
NALG are usually	Movable Landing Gear	Non-Absorbing Landing Gear	Rigid landing gear	Retractable landing gear			Rigid landing gear
The landing gear commonly found on the helicopters and the sail planes is called	Rigid landing Gear	Movable Landing Gear	semi movable Landing Gear	Retractable landing gear			Rigid landing Gear
which of the following does not come under landing gear classification	Hulls & Float	Retractable Gear	Fixed Gear	Non-Fixed Gear			Non-Fixed Gear
The number of the main wheels in conventional type of the landing gear is	One	Three	Two	Four			Two
The number of the Tail wheels in conventional type of the landing gear is	Three	One	Two	Four			One
The number of the landing gears used in Conventional landing gear is	One	Two	Four	Three			Three
The number of the nose wheels in Tricycle type landing gears is	Five	Four	One	Three			One
The number of wheels in Tricycle type of landing gears is	Three	Four	Five	Six			Three
which of the following is used during landing	Cockpit	Landing Gear	Wings	Tail			Landing Gear
The component which filters any particle that enter hydraulic fluid is called	Hulls & Float	Shimmy Damper	Hydraulic Filter	Scissors assembly			Hydraulic Filter
Hydraulic filters use	O-Rings	M-Rings	T-Rings	F-Rings			O-Rings
Which of the following does not come under Hydraulic Fluids	Vegetable base fluid	Mineral Base Fluids	Phosphate ester base Fluids	Sodium Nitrate base fluids			Sodium Nitrate base fliuds
ACT is called	Passive Control Technology	Active Control Technology	Aircraft Control Technology	Adaptive Control Technology			Active Control Technology
Aircrafs are made statically and	Statically stable	Statically unstable	Dynamically unstable	Dynamically Stable			Dynamically Stable
Teleflux can be operated from	Rudder	Fuselage	Cockpit	Engine			Cockpit

By moving the control column fore&after the movement achieved is called	Yaw	Pitch	Roll	damping			Pitch
By moving the control column side to side the movement achieved is called	Pitch	Roll	damping	Roll			Roll
The rudder pedals controls the	Pitch	Roll	Yaw	damping			Yaw
The To-From indicator presents the direction to or from the station along the	Omni-vertical	Omni-Radial	Omni-stable	all the given			Omni-Radial
Guidance in Poor Visiblity condition can be done using	IFS	IRS	ISF	ILS			ILS
Auto Pilot system can be used during	Steady Flight	Unsteady Flight	Moderate flight	High flight			Steady Flight
Which of the following system use control cables	Power assisted	Fully powered	Conventional system	Control system			Conventional system
UNIT III							
Fuel systems can be sub-divided into	Aircraft fuel system & Engine fuel system	Rocket fuel system	Jet fuel system	Turbine fuel system			Aircraft fuel system & Engine fuel system
Fuel tanks of aircraft are constructed by this metal	Fuel resistant synthetic rubber	nickel	Titanium	Iron			Fuel resistant synthetic rubber
The material selected for the construction of a particular fuel tank of the aircraft	Dependant	Independent	Affects	Causes damage			Dependant
The fuel tank construction can be divided into basic systems of	1	2	3	4			3
The fuel tank construction can be classified into	Integral type	Rigid removal type	Bladder type	All the given			All the given
Fuel pumps are used to move fuel through the fuel system when which flow is insufficient?	Air	Gravity	Pressure	Gyro			Gravity
Fuel systems for reciprocating engines and turbine-engines require main pumps and which pumps?	Reciprocating	Emergency	Ignition	centrifugal			Emergency
Fuel pumps have how many types	1	2	3	4			4
Fuel contamination can be reduced by using	Strainers	Filtrarates	Bothers	Nanotubes			Strainers
Fuel systems used in modern aircrafts is	Gravity-Feed fuel system	Pressure-Feed fuel System	Electronically controlled Pressure-Feed fuel System	Electronically controlled Gravity-Feed fuel System			Electronically controlled Pressure-Feed fuel System
In which wing aircraft Gravity-feed fuel system is accomplished.	Swept	High	Delta	Low			High
The engine driven pump supplies the fuel necessary for normal operation of.	Flow	Pressure	Suction	Elements			Pressure
The most common type of filters are	Micron	Wafer	Plain screen mesh filter	cloth			Micron
Simplex and Duplex are types of types of	Spray nozzle	Flow divider	Flow equaliser	Dump valves			Spray nozzle
The integral part of duplex nozzle.	Fuel	Drain valve	Spray nozzle	Flow divider			Flow divider
A lubricant oil requirement is maximum	Wear	Compatability	Fluidity	Tear			Fluidity
The contacts between surfaces moving in relation with each other produces	Wear	Friction	Tear	motion			Friction

The function of fuel heater is to protect the engine fuel system from	Early frost	Climate regularity	formation	Climate change			Ice formation
High pressure filter between fuel pump and various control devices is to protect the fuel from	Drain	Contaminations	Valve separator	icing			Contaminations
Piston engine lubrication is classified into how many types.	1	2	3	4			2
what serves as a cushion between parts where impact loads are involved.	Engine oil	Lubrication oil	Filter oil	Strainer Liquid			Engine oil
Whichis the non-adjustable pressure valve that permits excess pressure to return to the inlet of pump.	Drain	spray	Filter	Relief			Relief
Drilled and cored passages carry oil from the oil cooler to all parts of the engine requring________	Fluidity	Contamination	Lubrication	Viscosity			Lubrication.
Oil from the system is also routed through ________ for control of pitch & engine rpm.	Control surface	Propellor	Wing	engine			Propellor
Modern aircraft uses __________ ignition system.	Hand crank	Battery	Fluid	external			Battery
In battery ignition syatem, which is driven by the engine.	Rotor	Stator	Cam	piston			Cam
The magneto ignition system is superior to which ignition system	voltage	Battery	Electric	Spark			Battery
During engine starting output of magneto is	Very high	Very low	High	Low			Low
The purpose of spark plug is to conduct a short	Spark	Impulse	Ignition	Inductance			Impulse
Which engine system is more trouble free than piston engine	Jet	Low Tension	High tension	Reciprocating			Jet
The battery current is cutoff , and the plug does	Fire	Not fire	Rammed	Packed			Not fire
This type of starter provides instant and continual cranking when energised	Direct cranking	High cranking	Low cranking	Indirect cranking			Direct cranking
The engine is cranked directly when the starter solenoid is	Open	Closed	Semi-open	All the given			Closed
The main cables leading from the starter to the battery are	Light	Weihtless	Very heavy	Heavy			Heavy
The torque of the motor is transmitted through reductioN	Valves	Gears	Pipes	Tubes			Gears
Provision must be made for ignition of the air/fuel mixture in which system	Combustion`	Heat transfer	Ignition	Heat absorption.			Combustion
Commercial aircraft requires the engine to be started with the minimum	Heat loss	Heat transfer	No disturbance	Disturbance			Disturbance
The type and power source for the various starter varies inaccordance with which requirements.	Engine	Turbine	Compressor	Propellor			Engine
During engine starting the two engines must operate	Simultaneously	Non-simultaneously	Free	Restrictively			Simultaneously
Two separate systems required to ensure that gas turbine engine will start	Non-suppotive	Satisfactorily	Properly	Uniformly			stisfactorily
The electric starter is usually a	A.C	D.C	MESH	NON-MESH			D.C
The electric supply may be of low or high	Current	voltage	Ampere	power			Voltage
The electrical supply is automatically cancelled when the started load is reduced after the engine has satisfactor	Stopped	Ignited	Started	Wayfared			Started
The starter motor is basically a small impulse type	Compresor	Cooler	Igniter	Turbine			Turbine
The turbine is rotated by high pressure gases resulting from the combustion of	Hydrochloric acid	Nitrous acid	Alcoholic spirit	Isopropyl nitrate			Isopropyl nitrate
Air starting is used in which aircrafts	Commercial	Non-commercial	Jet	Pontoons			Commercial
Air starter motor transmits	Wave	Frequency	Current	Power			Power
The starter turbine is rotated by air taken from an external	Ground	Force	Elecricity	Runner			Ground
Gas Turbine starter is economical to operate and provides a high	Power	Electricity	Weight	Ignition			Power

Anti-collision lights are used in conjunction with the:	master warning lights	Engine inspection lights	wing inspection lights	navigation lights.			wing inspection lights
Red warning lights in the instrument panel indicate the existence of:	unsafe conditions	Normal Conditions	abnormal conditions	safe conditions.			safe conditions.
Master caution and warning lights are located on the	lower instrument panel	Side panel	upper instrument panel	overhead panel.			lower instrument panel
. To assist ram air recovery, some aircraft use:	modulating vanes on the ram air exhaust	modulating vanes on the air exit	modulating vanes on the ram air inlet	modulating vanes on the ACM outlet.			modulating vanes on the ram air exhaust
Satellite communication systems use a low earth orbit to:	provide greater coverage	maximize voice delays.	maintain a geostationary position	minimize voice delays.			maintain a geostationary position
Audio-video on demand (AVOD) entertainment enables passengers to:	stop a programme	send voice message via satellite communication	make phone calls via satellite communication	ignore PA system voice announcements			ignore PA system voice announcements
. Supplemental oxygen is generally required fl ight operations above	3000 ft	30000 ft	10,000 ft	sea level.			3000 ft
The optical fi bre receiver unit consists of a photodiode or phototransistor that passes a:	negligible current when not illuminated	no current when not illuminated	high current when not illuminated	low current when not illuminated.			high current when not illuminated
The gasper fan is used in cabin ventilation systems to:	increase air pressure in the air outlets	increase oxygen	re-circulate filtered cabin air	assist with ram air recovery.			assist with ram air recovery.
Cabin altitude is typically	cruising altitude	between 2000–7000 feet	sea level	between 6000–7000 feet			cruising altitude
The cargo compartment is normally pressorized to be	equal to cabin pressure	zero pressure	above cabin pressure	below cabin pressure.			above cabin pressure
UNIT IV							
Avionics is the combination of _____________	Airline and Electronics	Aviation and Electronics	Aircraft and Electrical	Aviation and Electrical			Aviation and Electronics
Navigation system is used to _____________	Traffic control	Communication	Weather detection	Find position and direction			Find position and direction
During the First World War ___________ technology is used for communication.	wireless	Dopple	Radio	RADAR			wireless

DME stands for _________	Distance measuring equipment	Distance monitoring equipment	Direct measuring equipment	Doppler monitoring equipment			Distance measuring equipment
Following one is the type of navigation system	Medium frequency	pilotage	High frequency	Low frequency			pilotage
Electronic Warfare is mainly used to search the ___________	Communication signals	Ultrasonic waves	Sound waves	Radio frequency band			Radio frequency band
In communication system __________ is used as a transmitter links.	fiber	iron	mica	Silver			fiber
__________ memory is require a power to maintain the stored information.	Non volatile	virtual	protected	volatile			volatile
In communication system _______ is used to convert the natural signal into an electrical signal.	antenna	compressor	Transducer	generator			Transducer
Fly-By-Wire system sends the information in the form of ____________	Electrical signals	Analog signals	Radio signals	Sky waves			Electrical signals
Loran stands for_____________	Lost range navigation	Low range navigation	Least range navigation	Long range navigation			Long range navigation
Satellites are used in ____________	Global positioning system	Global point system	Global plane system	Galaxy positioning system			Global positioning system
Localizer is used in ___________	ILS	IOP	IAP	ISI			ILS
Doppler is used for ___________ communication.	Long range	Short range	Medium range	Pilotage			Long range
The signal using dots and dashes is called ____________.	Analog signal	Morse signal	Digital signal	Radio signal			Morse signal
ATC stands for ___________.	Air Traffic Control	Aviation Transport Control	Air Transport Control	Air Traffic Control			Air Traffic Control
Sky wave propagation is suitable for ____________	Very high frequency	Medium frequency	low frequency	High frequency			High frequency
VOR stands for____________	Very High Frequency Omni range	Very High distance Omni range	Very High signal Omni range	Very low FrequencyOmni range			Very High Frequency Omni range
ADF is used in ____________	Communication system	Navigation system	ILS	GPS			Navigation system
Doppler RADAR uses the _____________	Microwave signal	Digital signal	Direct signal	Pulse signal			Microwave signal
Critical frequency is the ____________ frequency of the radio wave.	minimum	maximum	Maximum usable	medium			maximum
RADAR stands for ____________	Radio organization	Radio detection and ranging	Radio development organization	Radio communication			Radio detection and ranging
Another name for primary surveillance RADAR is _______________	Mirror image radar	Low frequency radar	Skin paint radar	INR			Skin paint radar

ADF is used in _______________	Communication system	Navigation system	ILS	GPS			Navigation system
In communication system receiver contains ______________	IN	Doppler	Sensitive amplifier	Loud speaker			Sensitive amplifier
INS system contains ______________	Gyros and sensitive accelerometer	Doopler radar	Primary surveillance radar	holes			Gyros and sensitive accelerometer
FBW system first introduced in ________Aircraft	YF-16	cessna	Sukai	vikas			YF-16
Primary memory stored in secondary memory is called _____________	ROM	PROM	Virtual memory	Flash memory			Virtual memory
Instrument Landing System consist of_____________	localizer	slope	Doppler	Gyros			localizer
AIRCOM stands for	Air computers	Airbone communication	Air communication services	Air computation			Air communication services
SITA stands for	Society international telecommunication aeronautics	Satellite international telecommunication aeronautics	society international topographic aeronautics	None of the given option			Society international telecommunication aeronautics
VHF stands for	Very high flow	Varying high frequency	Very high frequency	Vertical high frequency			Very high frequency
………..is form of a semi-conductor device.	intrinsic	doping	junction	pole			intrinsic
Doping is a process of adding	ions	Electric field	Foreign atoms	cells			Foreign atoms
…………is a separate bits of semiconductor in use.	p-type	c-type	b-type	c-type			p-type
……..diode is designed to operate in reverse direction.	rectifier	zener	ideal	real			zener
The principle element of a radar transmitter is	duplexer	receiver	Magnetron tube	mixer			Magnetron tube
………….is a electronic switching device.	duplexer	receiver	indicator	mixer			duplexer
………..type memory, that can only read.	ROM	PROM	RAM	EPROM			ROM
CCV stands for	coupled circuit voltage	Closed circuit voltage	Closed current voltage	coupled current voltage			Closed circuit voltage
RLG is a form of …………technology.	Radar	airborne	strap down	laser			strap down
………….stores energy in analog radar systems.	duplexer	synchronizer	indicator	mixer			mixer
CDS stands for	Co-Pilot display unit	Co-Pilot decision unit	Co-Pilot direction unit	Co-Polar display unit			Co-Pilot display unit
SAS is used for	Stability and control of aircraft	Only stability	augmentation	storage			Stability and control of aircraft
SATCOM stands for	Scale communication	Satellite vision communication	Satellite communication	Scalar communication			Satellite communication
…………..provides timing for radar signals.	duplexer	synchronizer	indicator	mixer			synchronizer

Air and fuel have dielectrics of approximately	unity and zero respectively	unity and unity respectively	unity and two respectively	two and unity respectively			unity and zero respectively
When fuel level decreases, the capacitance of the fuel quantity sensor	decreases and the reactance increases	becomes zero	increases and the reactance increases	increases and the reactance decreases.			increases and the reactance increases
Under-wing fuel quantity measurements are used during	level flight	Cruise	all flight conditions	ground servicing only.			ground servicing only.
A high-intensity white flash is produced from a	strobe light	cabin light	fluorescent tube	landing light.			landing light.
UNIT V							
………….is used to convert sound d energy into electric energy.	transmitter	accumulator	Loop antenna	microphone			microphone
…………….cells are called as small button batteries.	Mercury	primary	dry	alkaline			Mercury
Earlier radar systems were ……….	Light weight	heavy	medium	Easy assessable			heavy
PDS stands for	Pilot display unit	Pilot decision unit	Pilot direction unit	Polar display unit			Pilot display unit
The tilt control is used to change ……….of the antenna.	Rotation	angle	Sensing capacity	Receiving signals			angle
LED has ___________Junction	p-n	n-p	r-p	s-p			p-n
EICAS warning messages are:	red, accompanied by an audio alert (prompt action is required by the crew)	yellow, accompanied by an audio alert (timely action is required by the crew)	yellow, no audio alert (time available attention is required by the crew)	red, accompanied by an video alert			red, accompanied by an audio alert (prompt action is required by the crew)
Engine pressure ratio (EPR) is used to measure a gas turbine engine's:	torque	thrust	temperature	pressure			thrust
Low-, intermediate- and high-pressure shafts are also referred to as:	N1, N2 and N3	N2, N3 and N1	N3, N1 and N2	N2, N1 and N0			N1, N2 and N3
Typical units of fuel mass flow are given in:	pounds or kilograms per hour	gallons per hour	litres per hour	kg			pounds or kilograms per hour
A gas turbine engine's self-sustaining speed is when sufficient energy is being developed by the engine to provide continuous operation:	with the starting device still engaged	with the ignition system in operation	without the starting device and ignition	without the ignition system in operation			without the starting device and ignition
In turboprop engines, power is measured from:	engine pressure ratio	torque	torque × speed.	EGT			torque × speed.

Ground idle speed occurs when the engine has:	stabilized (slightly above self-sustaining speed)	stabilized (slightly below self-sustaining speed)	just been started	minimum speed			stabilized (slightly above self-sustaining speed)
Power from an engine is derived from measuring:	torque and speed	temperature and speed	engine pressure ratio (EPR)	FADEC			torque and speed
When lube oil operates at high temperatures, its viscosity:	reduces and its lubrication performance decreases	reduces and its lubrication performance increases	increases and its lubrication performance increases	reamins constant			reduces and its lubrication performance decreases
The starting sequence for a gas turbine engine is to:	turn on the ignition, develop sufficient airfl ow to compress the air, and then open the fuel valves	develop sufficient airfl ow to compress the air, open the fuel valves and then turn on the ignition	develop suffi cient airflow to compress the air, turn on the ignition and then open the fuel valves	develop sufficient lift to compress the air, open the fuel valves and then turn on the ignition			develop suffi cient airfl ow to compress the air, turn on the ignition and then open the fuel valves
The thermocouple principle is based on the Seebeck effect; when heat is applied:	a change of resistance is measured	this causes the element to bend	an electromotive force (e.m.f.) is generated	this causes the element to straighten			an electromotive force (e.m.f.) is generated
A rheostat performs the same function as a:	resistance temperature detector	potentiometer	Wheatstone bridge	voltmeter			potentiometer
The solenoid is a type of transducer that converts:	electrical energy into linear motion	linear motion into electrical energy	electrical energy into thermal energy	thermal energy			electrical energy into linear motion
Proximity switches perform the same function as:	micro-switches	relays	toggle switches	short switched			micro-switches
ECAM system employs ………….number of CRT displays	3	1	4	2			2
TMC stands for	Torque management computer	Thrust management control	Thrust management computer	None of the given option			Thrust management computer
Central Air-data computers employs …….number of computers.	3	4	2	1			2
Turn bank indicator is used to determine	Rate of turn	Ratio of turn	Turn angle	All the given option			Rate of turn
DPU stands for	Digital processor unit	Display processor unit	Display plan unit	Digital path unit			Display processor unit

RLG stands for	Ring laser gyro	Radar laser gyro	Ring layout gyro	Ring layer gyro			Ring laser gyro
If arithmetic operation is zero………..flag is set in microprocessor.	zero	Sign	null	parity			zero
____________is used to convert sound energy into electric energy.	transmitter	accumulator	microphone	Doppler			microphone
Satellite communication provide reliable method of communication using __________	INMARSAT	INTR	VHF	VOR			INMARSAT
__________is generated during radio transmission.	Electromagnetic waves	Magnetic flux	Electric field	magnitude			Electromagnetic waves
____________ flag is not available in microprocessor.	Zero	sign	null	parity			null
Satellite navigation is using a ____________ for its operation.	GPS	pilotage	frequency	Doppler			GPS
Materials like GaAs, GaAsP are used in _________	LED	LCD	CRT	EL			LED
LCD stands for __________	Light Crystal Display	Liquid Crystal Display	Light Copper Display	Liquid Crystal Display			Liquid Crystal Display
Single LED is used as _________	Indicator lights	Induction lights	Indicator switch	Induction switch			Indicator lights
The light of an LED comes when the diode is __________	Forward biased	Backward biased	unbiased	over biased			Forward biased
Pilotage is used to find the direction with the help of ____________	Land marks	Radio signals	radar	maps			Land marks
RLG stands for __________	Real Laser Gyro	Ring Laser Gas	Ring Laser Gyro	Ring large Gyro			Ring Laser Gyro
EL stands for_____________	Electro Luminescence	Electro Light	Electro Laser	Electronic Laser			Electro Luminescence
Following one is the principle of touch screen________	Scanning infrared	radar	Radio	Digital display			Scanning infrared
LED has_________ Junction	p-n	n-p	r-p	s-p			p-n
The linear variable differential transformer (LVDT) is used for measuring:	small rotary displacements	variable resistance	small linear displacements	variable current			small linear displacements
RADAR in the aircraft is used for __________	Communication	navigation	Warning of storms	All of these			All of these
ASPP is responsible for control of ___________	weapons	radar	Rudder	rotar			weapons
A command word in MIL STD 1553 B is transmitted only by ______________	Bus monitor	Remote terminal	Bus controller	Remote display			Bus controller
____________ is the largest fraction of units in a 1553 system.	Digital display	Bus moniter	Remote terminal	Control bus			Remote terminal
ARINC stands for	Air speed Radio Incorporated	Aeronautical Radio Incorporated	Aeronautical Radar Incorporated	Aeronautical Radio Installation			Aeronautical Radio Incorporated
INTR is	Interrupt request	Inter request	Interrupt ratio	Inter resistance			Interrupt request

In arithmetic operation CY is	Carry hold	Carry over	Carry flag	Carrier			Carry flag
………..is not a form of a transistor.	npn	pnp	anp	Option a & option b			anp
In ………the results are stored.	demodulator	accumulator	rectifier	ALU			accumulator
The presence of unwanted voltages or currents in systems is caused by	EMC	FDR	ESSD	HIRF.			HIRF.
ACARS is a digital data link system transmitted in the:	VHF range	VVHF range	LF range	UHF range			VHF range
Bonding is categorized as primary or secondary determined by the:	use of composite or metal structure	locations of dynamic wicks	locations of static wicks	magnitude of current being conducted			magnitude of current being conducted
The use of composite materials for aircraft structures results in:	less natural paths for bonding	lesser probability of a lightning strike.	more natural paths for bonding	higher probability of a lightning strike.			less natural paths for bonding
Bonding is made between components and structure using:	coaxial cable	general-purpose cable	purpose-made straps	general-purpose wiring.			purpose-made straps
Static electricity is discharged from the aircraft to atmosphere through:	composite structure	metal structure	earth stations	static wicks			static wicks
HEIUs can remain charged for several:	seconds	minutes	hours	days			minutes
Data loader in a FMS is a	cell	memory	disk	Disk or tape			Disk or tape
FCC in FMS stands for	Federal communication computer	Federal communication counter	Flight control computer	Federal communication commission			Flight control computer