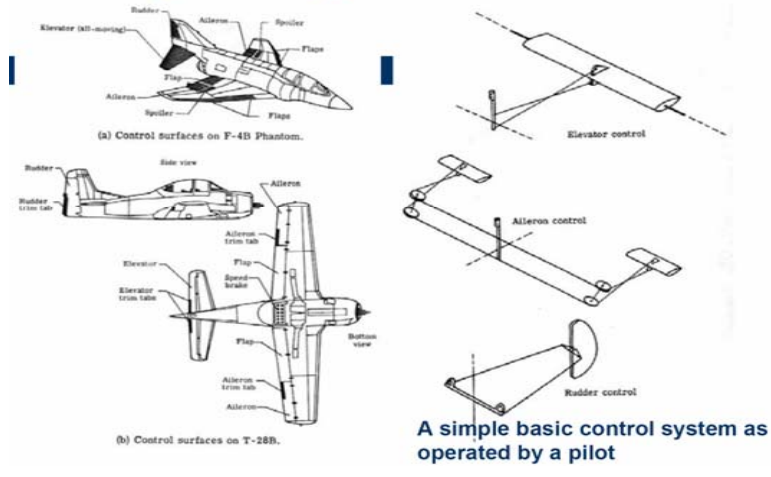
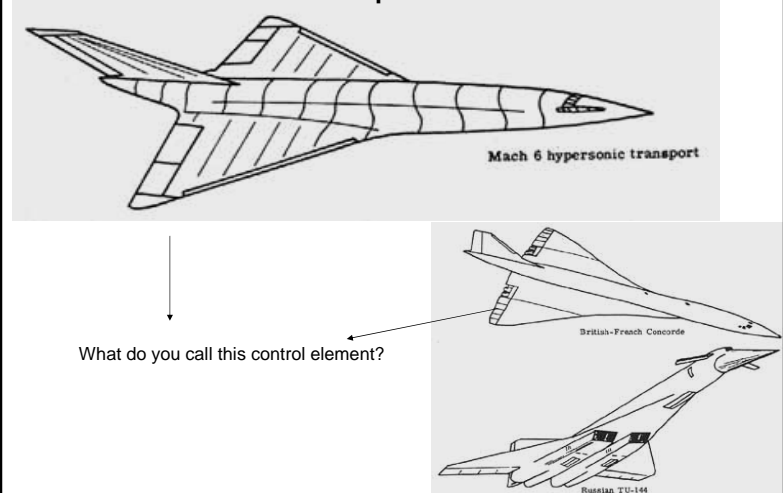


## Primary Aerodynamic Controls



What About this plane ?



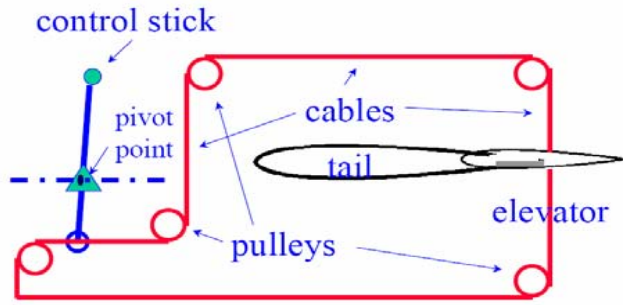
What About this plane ?



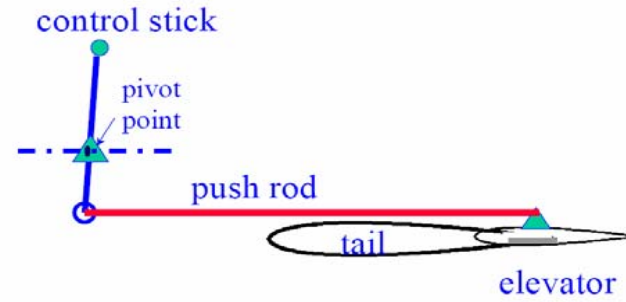
## Types of Controls

- Cable and Pulley
- Push-Rod
- Hydraulic
- Fly-By-Wire

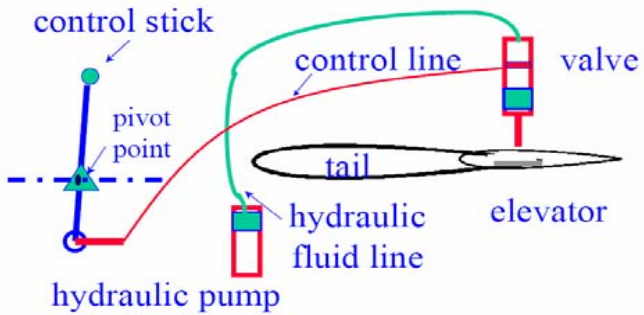
### Cable Controls



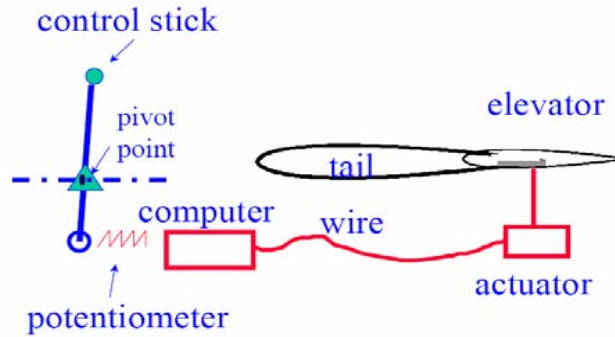
### Push-rod Controls



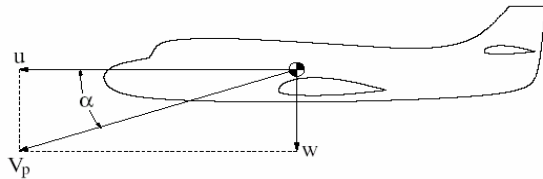
### Hydraulic Controls



### Fly By Wire



### Angle of attack



$V_p$  is projection of  $V$  onto  $x_b, z_b$  plane where

$$V = (u^2 + v^2 + w^2)^{1/2}.$$

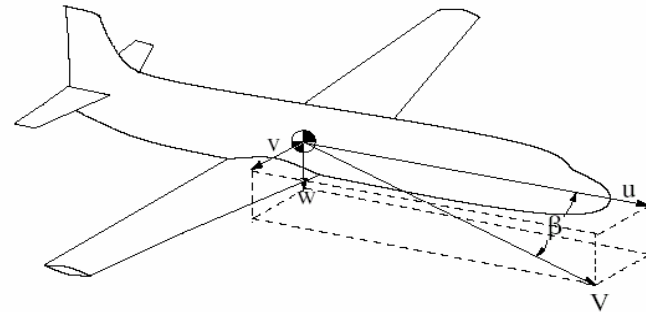
Angle of attack,

$$\alpha = \tan^{-1} \frac{w}{u}.$$

For  $\alpha < 15^\circ$

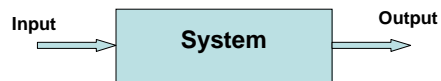
$$\alpha \approx \frac{w}{u}.$$

### Sideslip



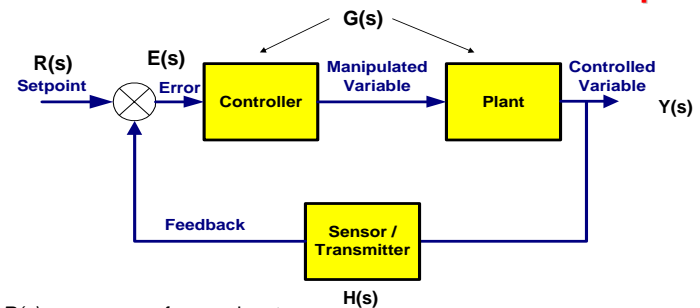
$$\beta = \sin^{-1} \frac{v}{V} \approx \frac{v}{u}$$

### Control System Terminology



- ◆ **System** - Group of elements put together to form a function. System is defined by differential equations governs the relation between input and output (Transfer function).
- ◆ **Input** - Excitation applied to a control system from an external source.
- ◆ **Output** - The response obtained from a system.
- ◆ **Feedback** - The output of a system that is returned to modify the input.
- ◆ **Error** - The difference between the input and the output.

### Elements of a Feedback Control Loop



- $R(s)$  reference input.
- $C(s)$  or  $Y(s)$  output signal (variable to be controlled).
- $E(s)$  error signal.
- $G(s)$   $Y(s)/E(s)$  forward path or open-loop transfer function.
- $M(s)$   $Y(s)/R(s)$  the closed-loop transfer function.
- $H(s)$  feedback transfer function.
- $G(s)H(s)$  open-loop transfer function.

## Types of Control Systems

### Open-Loop

- Simple control system which performs its function with-out concerns for initial conditions or external inputs.
- Must be closely monitored.

### Closed-Loop (feedback)

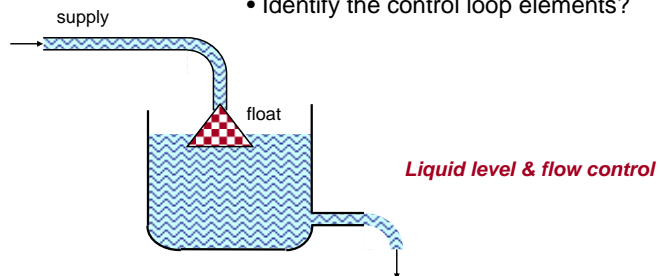
- Uses the output of the process to modify the process to produce the desired result.
- Continually adjusts the process.

## Control Modes in Feedback Loops

- Regulation
  - Constant set point.
  - Set point normally changed by human
  - Example
    - Level Control in a Tank.
- Servo (Tracking).
  - Dynamically Variable set point
  - Setpoint normally manipulated by another controller
  - Example
    - radar trackers.

### Example 1

- Open or closed loop?
- regulation or tracking ?
- Identify the control loop elements?



### Simple Feedback Systems

