Jet Aircraft Propulsion

Prof. Bhaskar Roy, Prof. A M Pradeep
Department of Aerospace Engineering,
IIT Bombay

Lect-27

In this lecture...

- Intakes for powerplant
  - Transport aircraft
  - Military aircraft

Prof. Bhaskar Roy, Prof. A M Pradeep, Department of Aerospace, IIT Bombay

Intakes

- Air intakes form the first component of all air breathing propulsion systems.
- The word Intake is normally used in the UK and Inlet in the United States.
- Air intakes are usually manufactured by the airframe manufacturer in coordination with the engine manufacturer.
- An aircraft may have one or more intakes depending upon the engine.

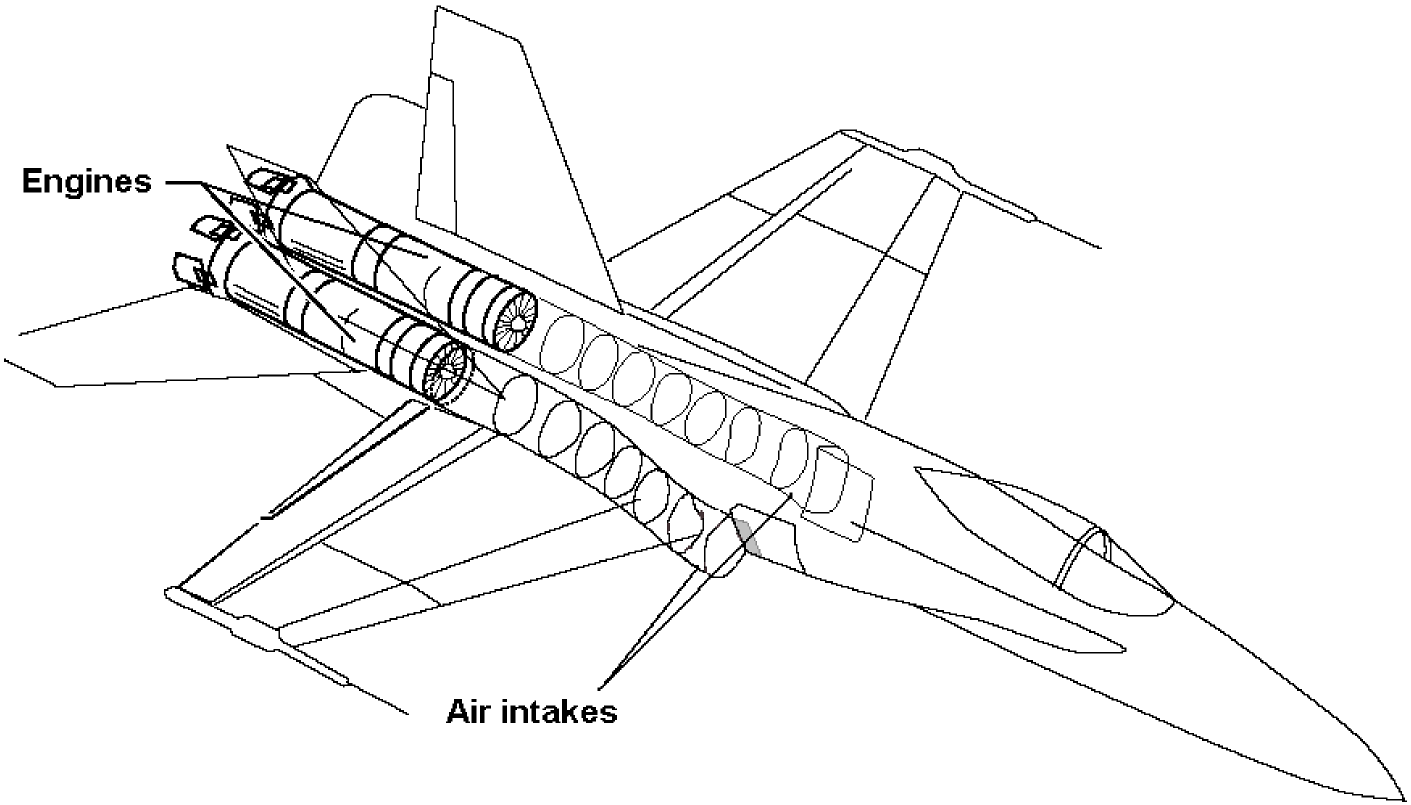
Prof. Bhaskar Roy, Prof. A M Pradeep, Department of Aerospace, IIT Bombay

Intakes

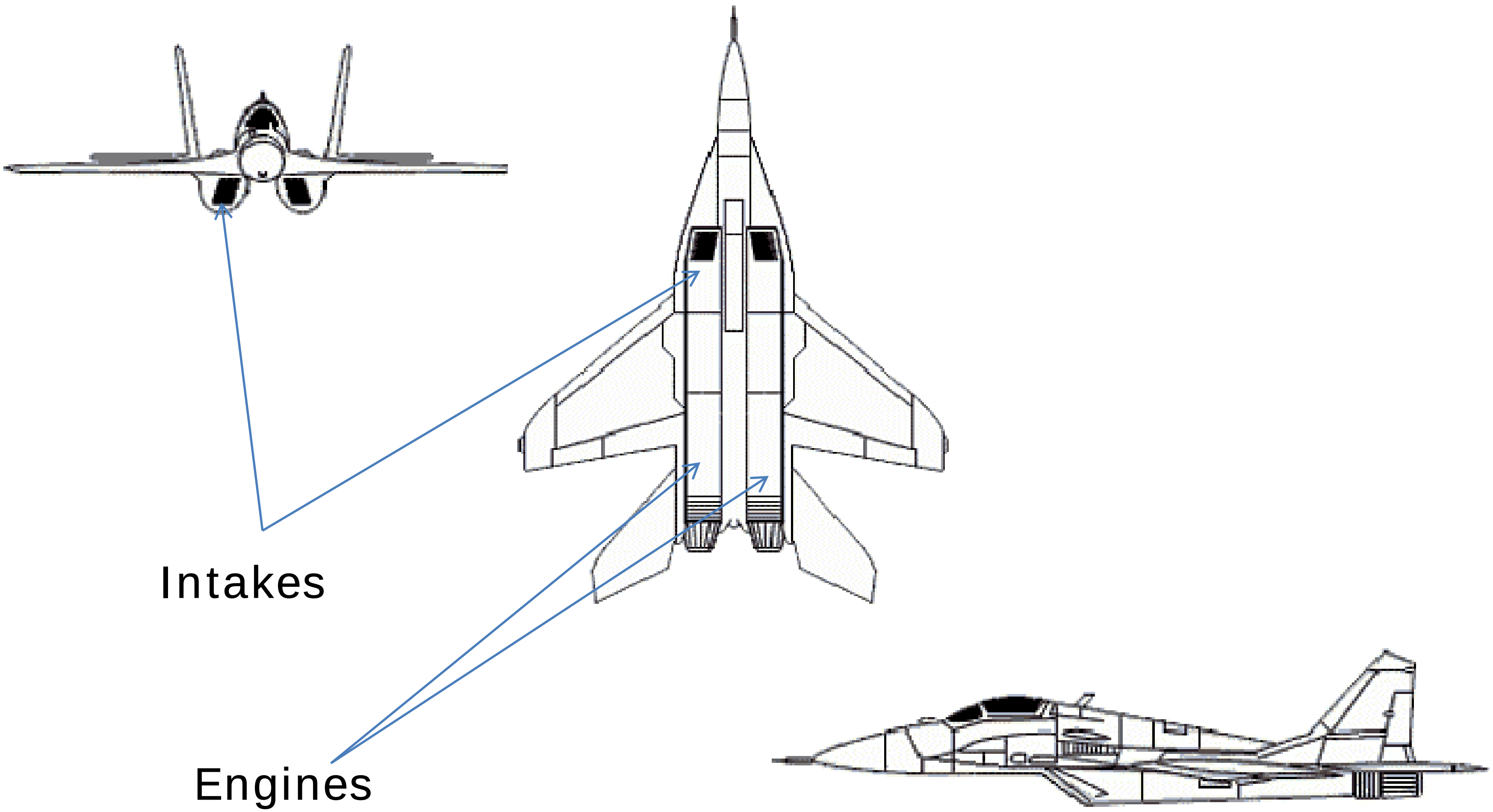
- Air intakes are required to capture freestream air, sometimes change its direction and then supply this to the engine.
- This must be with as little flow distortion (non-uniformity) as possible.
- The intake must also not result in excessive external drag to the aircraft.
- Intake must ensure proper operation over the entire flight regime.
- Modern aircraft intakes also contain noise-absorbing materials.

Prof. Bhaskar Roy, Prof. A M Pradeep, Department of Aerospace, IIT Bombay

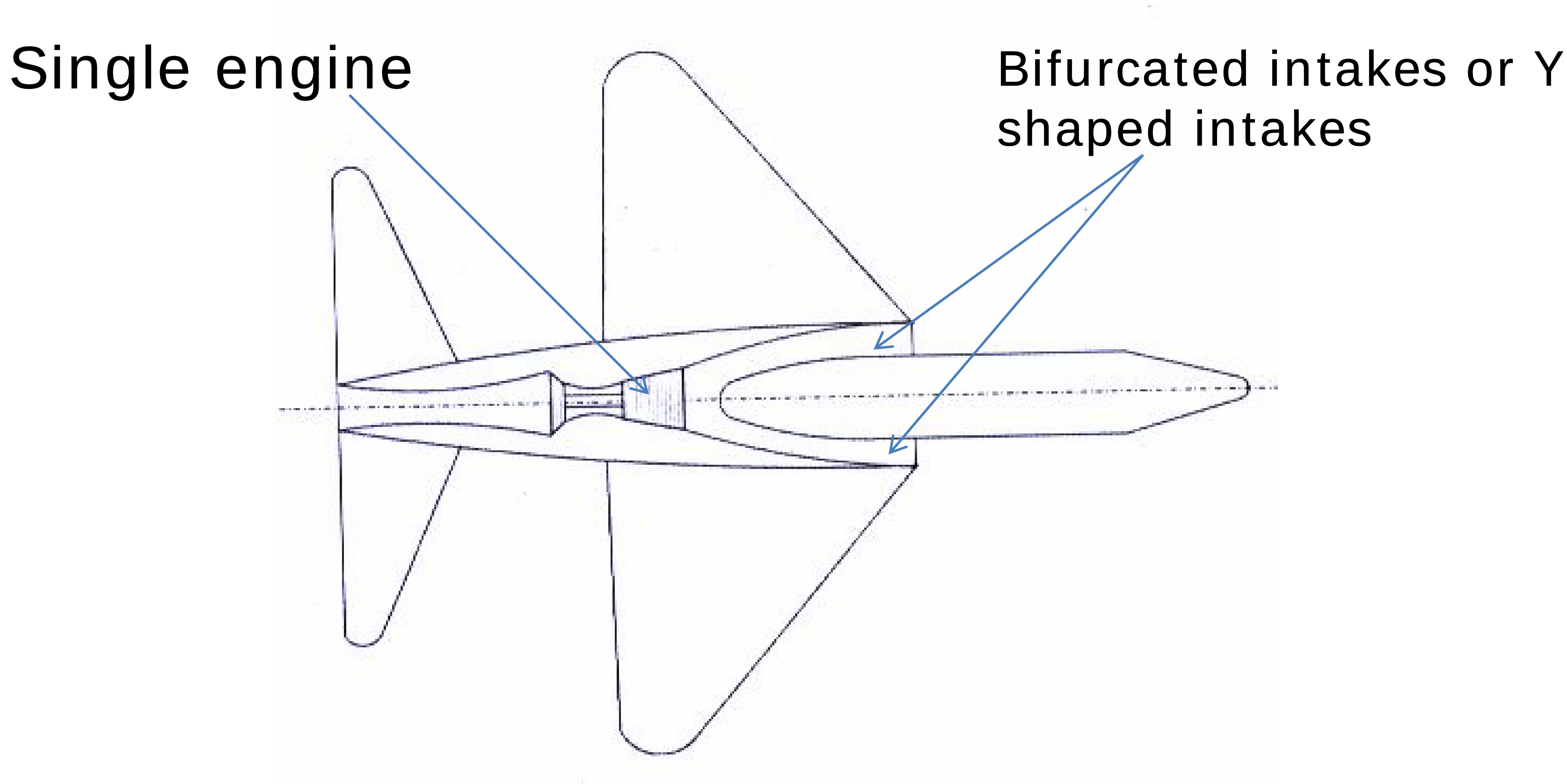
Intakes



Intakes



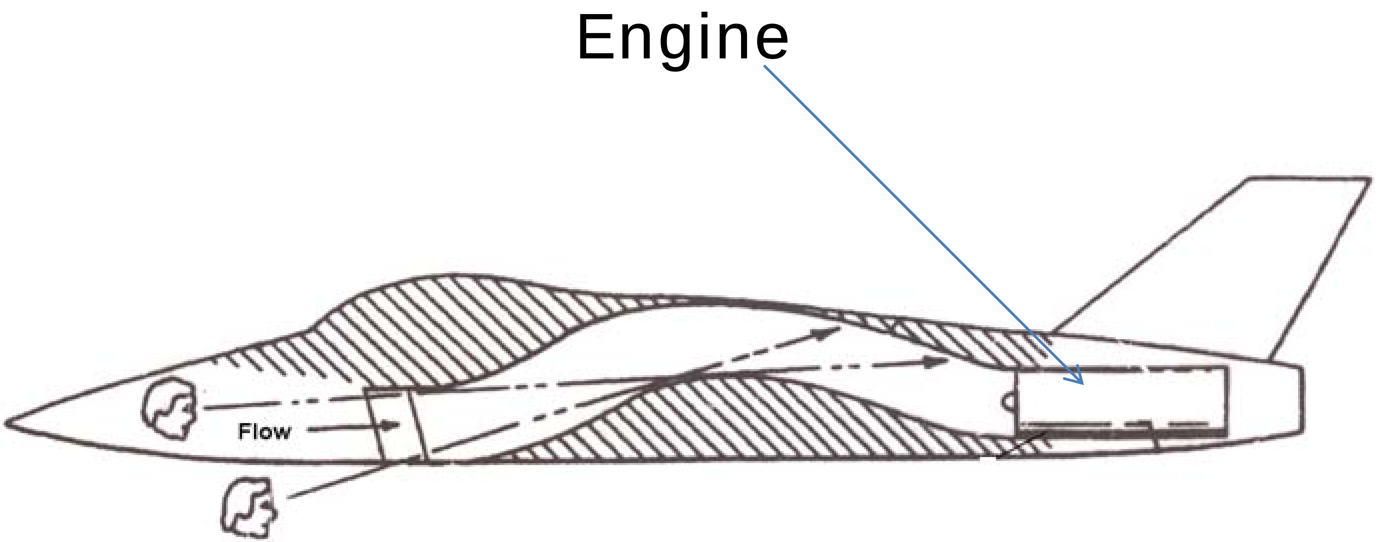
Intakes



Bifurcated or Y-shaped intakes

Prof. Bhaskar Roy, Prof. A M Pradeep, Department of Aerospace, IIT Bombay

Intakes



Serpentine intakes for next generation military aircraft

Prof. Bhaskar Roy, Prof. A M Pradeep, Department of Aerospace, IIT Bombay

Intakes

- Intakes used in transport aircraft are quite different from the military air intakes.
- All operational transport aircraft are subsonic.
- Subsonic intakes consist of surfaces with smooth continuous curves.
- Usually such intakes have a thick leading edge: lip.
- Intakes of turboprops are slightly more complicated due to the presence of the propeller and the gearbox.

Prof. Bhaskar Roy, Prof. A M Pradeep, Department of Aerospace, IIT Bombay

Intakes

Transport aircraft intakes

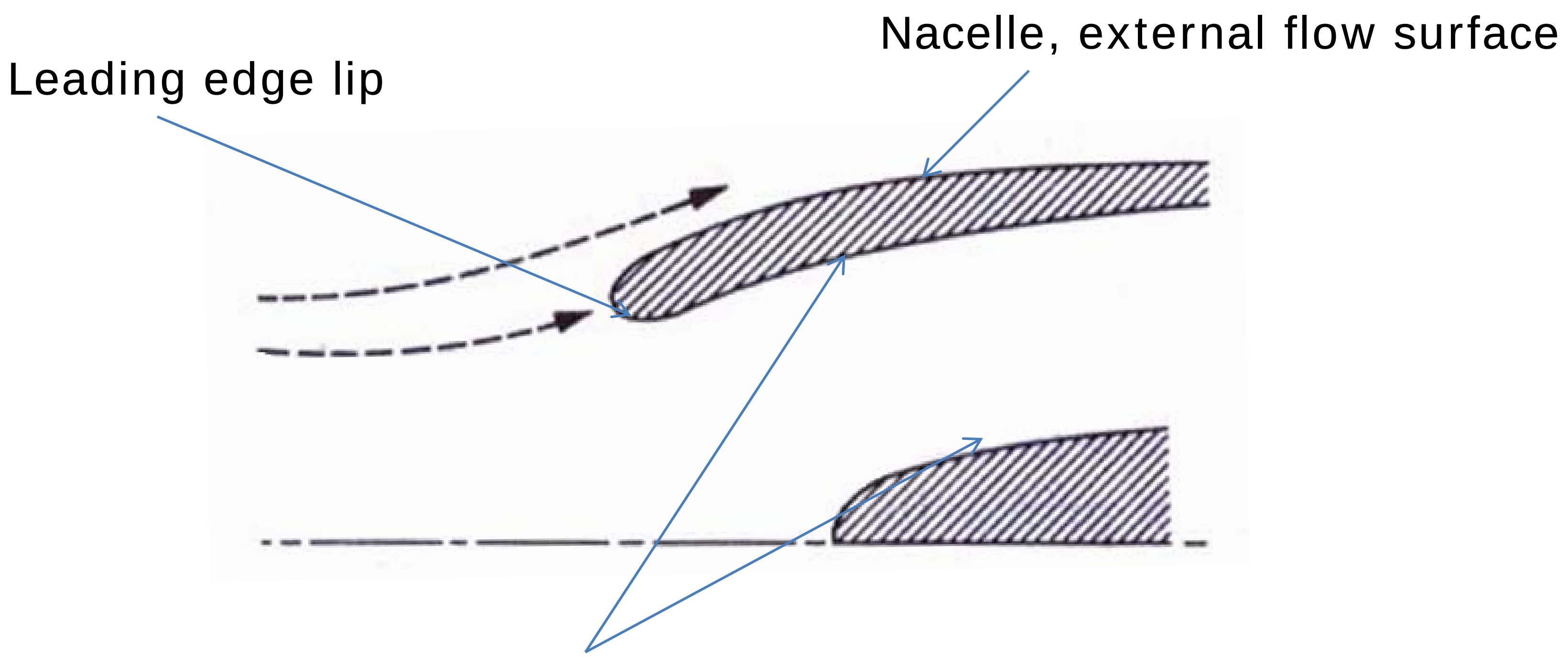
Military aircraft intakes

Subsonic intakes

- Most subsonic intakes have fixed geometries.
- Some of the high bypass ratio turbofans have blow-in-doors.
- These are designed to deliver additional air to the engine during take-off and climb.
- This is to cater to the fact that under these conditions, the engine requires maximum thrust and hence more mass flow rate of air.

Prof. Bhaskar Roy, Prof. A M Pradeep, Department of Aerospace, IIT Bombay

Subsonic intakes



Typical subsonic (Pitot type) intake geometry

Pitot intakes

- The most common type of a subsonic intake is the Pitot intake.
- Pitot intakes make the best use of the ram effect due to forward motion.
- These intakes also suffers the minimum loss of ram pressure during changes in altitude.
- However these intakes are primarily for subsonic operation.

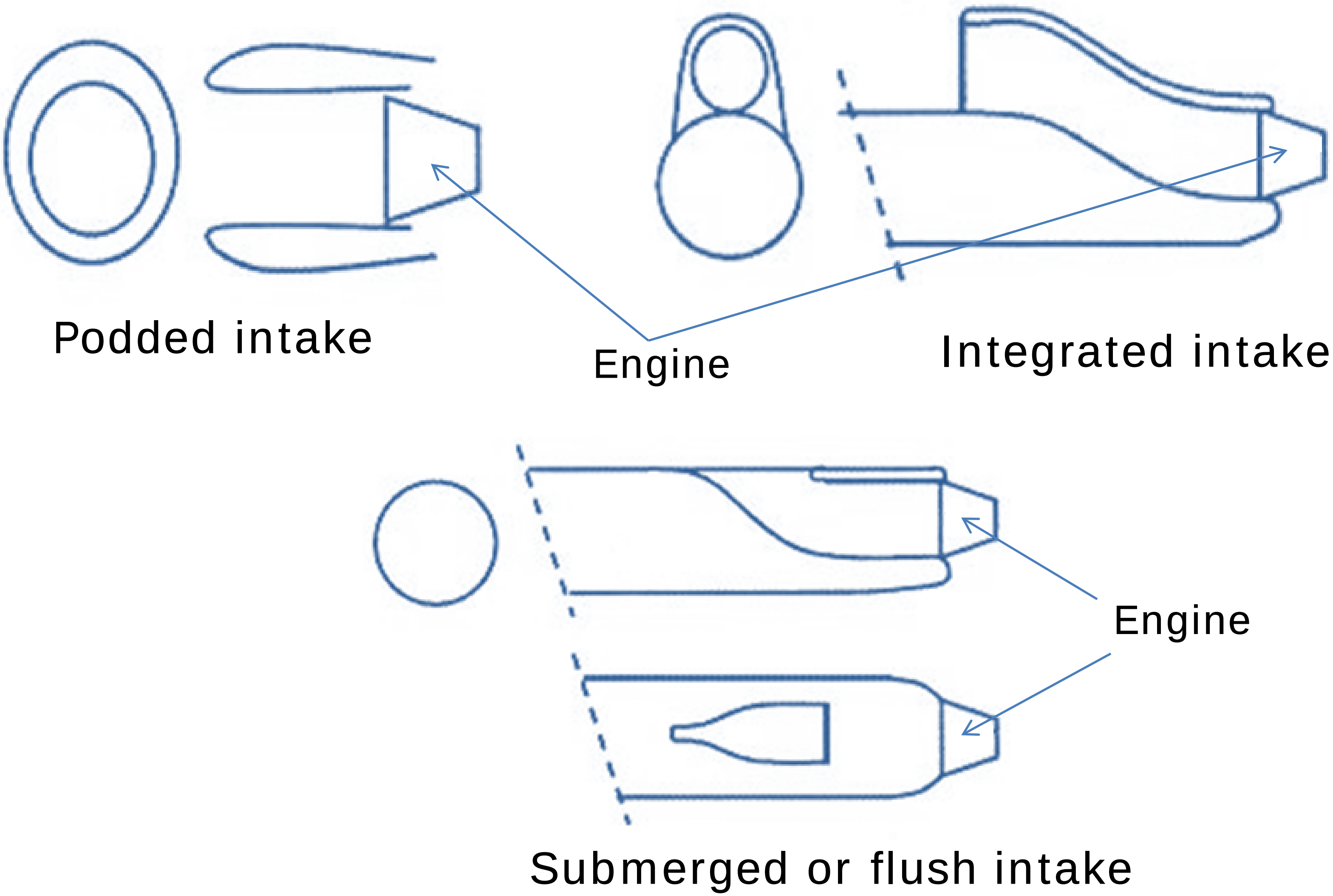
Prof. Bhaskar Roy, Prof. A M Pradeep, Department of Aerospace, IIT Bombay

Pitot intakes

- There are three types of Pitot intakes:
  - Podded intakes
  - Integrated intakes
  - Flush intakes
- Podded intakes are commonly used in transport aircraft (civil or military).
- Integrated intakes are used in combat aircraft.
- Flush intakes are used in missiles.

Prof. Bhaskar Roy, Prof. A M Pradeep, Department of Aerospace, IIT Bombay

Pitot intakes



Prof. Bhaskar Roy, Prof. A M Pradeep, Department of Aerospace, IIT Bombay

Podded intakes

- Usually the friction losses in podded intakes are insignificant.
- Flow separation may drastically affect the performance.
- The leading edge of the intake captures a certain streamtube and then divides this stream into internal flow and external flow.
- The design of the duct must be such that it preserves good aerodynamics of the airframe and an internal flow with minimal loss.

Integrated and flush intakes

- For integrated intakes, the internal flow problems are of concern.
  - The duct is usually longer and with bend(s).
  - The aircraft fuselage ahead of the intake feeds a boundary layer into the intake.
- Curvature of the intake also leads to generation of secondary flows leading to flow distortion.
- Flush intakes are used in missiles as these can be easily accommodated into missile airframes as well as for canister launching.

Supersonic intakes

- Supersonic intakes are usually more complicated than subsonic intakes.
- Design of supersonic intakes often involve trade-offs between efficiency, complexity, weight and cost.
- Supersonic intakes consists to two segments: a supersonic diffuser where the flow is decelerated from supersonic to subsonic through a series of shocks; this is followed by a subsonic diffuser where the flow is decelerated from high subsonic to lower subsonic speeds.

Prof. Bhaskar Roy, Prof. A M Pradeep, Department of Aerospace, IIT Bombay

Supersonic intakes

- Supersonic intake design is more complicated due to the following reasons:
  - Shock waves cause significant loss in total pressure.
  - Large variation in the capture area between subsonic and supersonic flight.
  - With higher Mach number the inlet compression ratio is a larger fraction of overall pressure ratio, thrust becomes more sensitive to diffuser performance.
  - Efficient operation of the intake in both subsonic and supersonic flight regimes.

Prof. Bhaskar Roy, Prof. A M Pradeep, Department of Aerospace, IIT Bombay

Supersonic intakes

- Supersonic intakes may be classified in the following ways:
  - Axisymmetric or two-dimensional
    - Axisymmetric: central cone for shock fixture
    - Two-dimensional: rectangular cross-section
  - Variable or fixed geometry
    - Variable: the central cone may be movable or in a rectangular intake, one of the walls may be adjustable
    - Fixed: Geometry is fixed

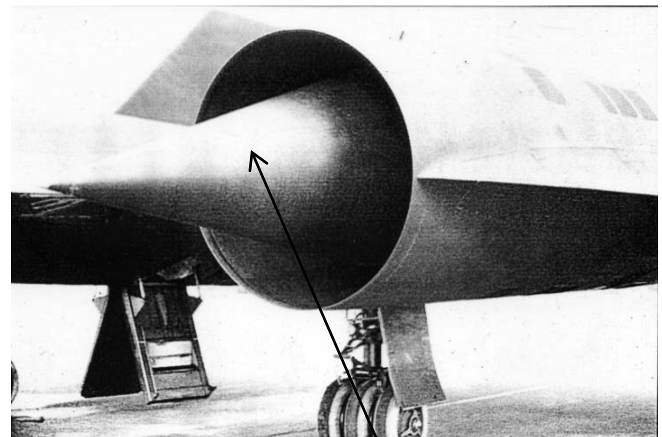
Prof. Bhaskar Roy, Prof. A M Pradeep, Department of Aerospace, IIT Bombay

Supersonic intakes

- Internal, external or mixed compression
  - Depending upon the location of the shocks
  - Internal compression intakes have shocks that are located within the intake geometry
  - External compression intakes have shocks located outside the intake
  - Mixed compression intakes have shock that are located within as well as outside the intake geometry.

Prof. Bhaskar Roy, Prof. A M Pradeep, Department of Aerospace, IIT Bombay

Supersonic intakes



Centerbody

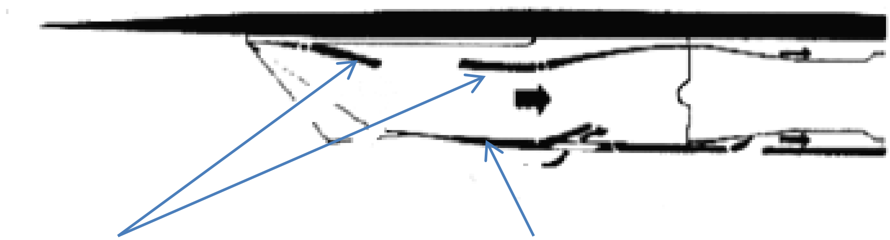
Intakes

Axisymmetric intake with spiked centerbody

Supersonic intakes

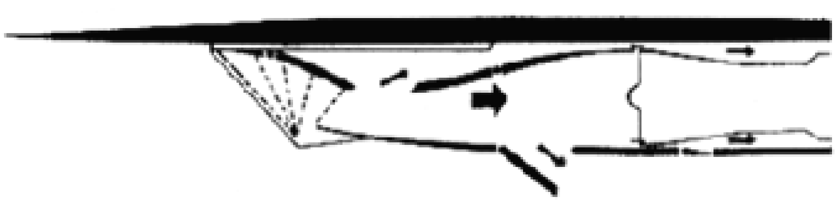
2D intakes of Concorde

Supersonic intakes



Intake during take-off

Supersonic cruise



Engine shut down

Modes of operation of a variable geometry 2D intake

Prof. Bhaskar Roy, Prof. A M Pradeep, Department of Aerospace, IIT Bombay

In this lecture...

- Intakes for powerplant
  – Transport aircraft
  – Military aircraft

Prof. Bhaskar Roy, Prof. A M Pradeep, Department of Aerospace, IIT Bombay

In the next lecture...

- Performance of intakes
  - Performance parameters
  - Sources of losses
  - Starting problem in supersonic intakes