Inlet Introduction

1 Categories

1.1 Supersonic Inlet Configurations

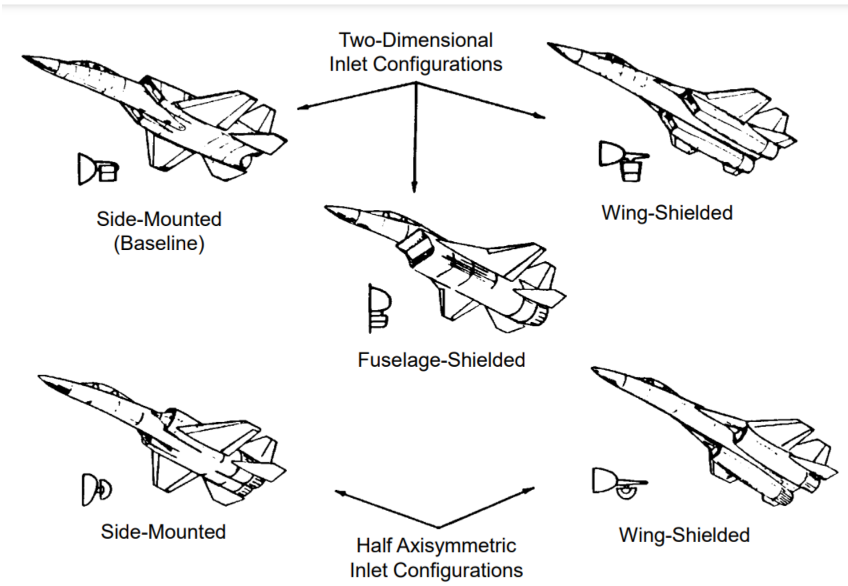

Figure 1: Supersonic Inlet Configuration

1.2 Aerodynamic Classification

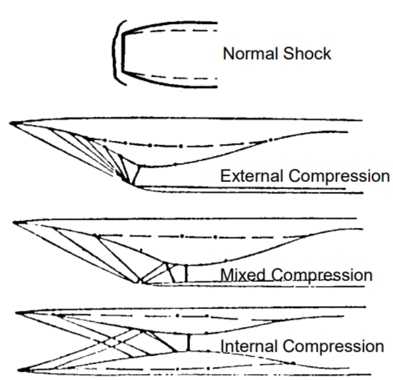

Figure 2: Supersonic Inlet Configuration

1.3 Geometric Classification

1. Axisymmetric
2. Two Dimensional
3. Fixed Geometry
4. Pod Mounted
5. Integrated with Fuselage

2 Design Considerations

2.1 Inlet Aerodynamics

1. Design point recovery and distortion.
2. Inlet sizing:
   (a) Margin for cold day airflow
   (b) Margin for engine airflow variation
   (c) Buzz margin on hot day
3. Requirement for auxiliary airflow
   (a) Airflow
   (b) Bypass
   (c) Boundary layer bleed

2.2 System Aerodynamics

1. Distortion during maneuvering conditions
2. Maximum aircraft Mach
3. Inlet and nozzle propulsion drags
4. Diffuser flowpath

2.3 Mechanical/Other

1. Inlet signal required for engine operation
2. Allowable duct over-pressure during engine surge
3. Inlet Radar Cross Section (RCS)

3 Inlet Geometry and Nomenclature

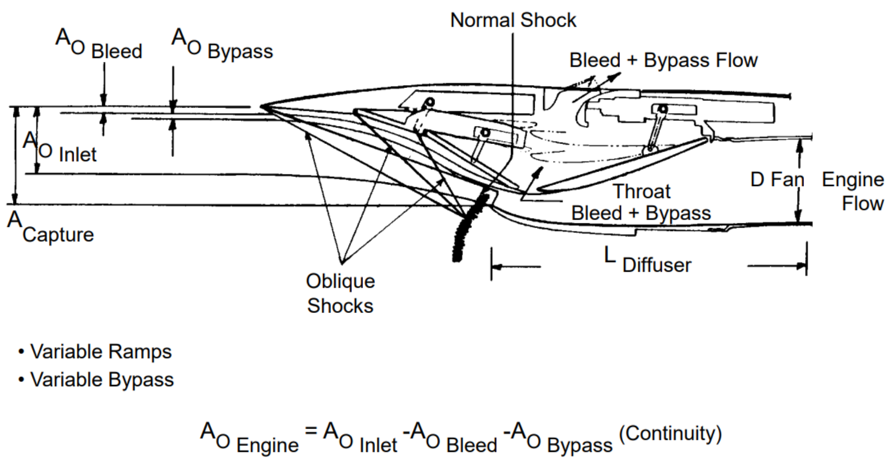

Figure 3: Inlet Geometry

Some remarks:

1. The inlet capture area is traditionally defined as the area corresponding to the **inlet highlite and ramp structure.**
2. During supersonic flight with an **external compression** inlet, the **engine** plus **bleed flows** must be supplied by the inlet downstream of the **oblique shock structure** on the ramps.
3. If there is excess flow between the **supply and engine plus bleed demand**, the excess flow must be spilled **subsonically behind the normal shock upstream of the cowl lip** or bypassed out.

4 Basic Inlet Sizing

4.1 Capture Area Selection

The max engine flow, engine flow and inlet pressure recovery Mach number dependencies are shown below:

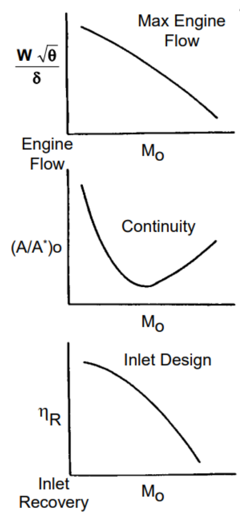

Figure 4: Mach Number Dependence

Recall the geometry graph:

$$A_c = A_{Eng} + A_{Spillage} + A_{Bypass} + A_{Bleed} + A_{Leakage} \tag{1}$$

And from the Mach dependence, we define $K = 1.03$ to account for engine to engine airflow variation:

$$A_{Eng} = K(\frac{W\sqrt{\theta}}{\delta})_{Eng}\frac{(A/A^*)\eta_R}{49.4} \tag{2}$$

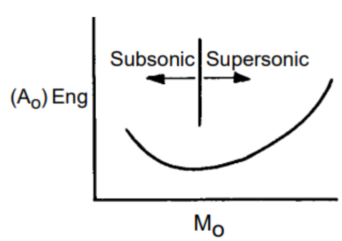

Figure 5: Engine Area Mach Dependence

4.2 Inlet/Engine Matching and Allocation

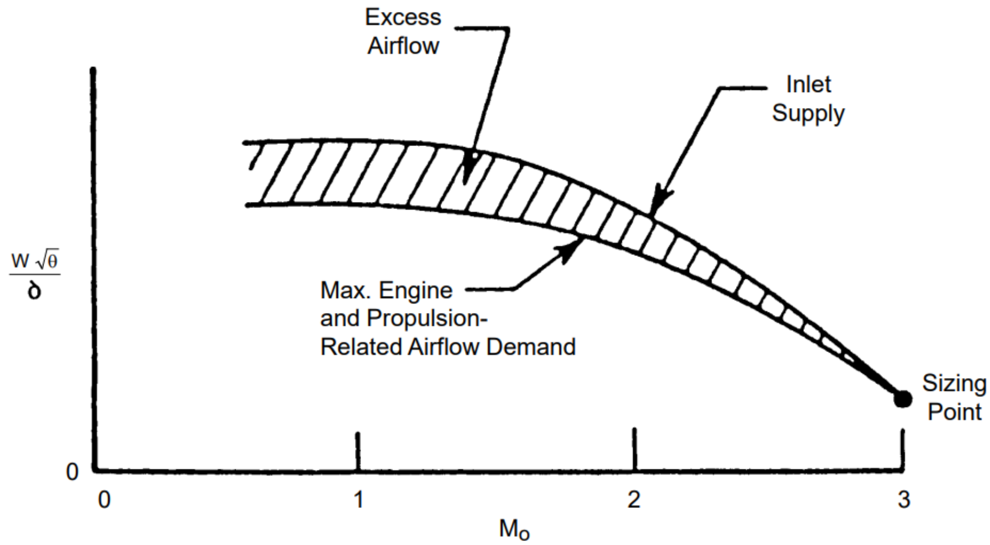

Figure 6: Inlet/Engine Airflow Matching

Some remarks:

1. Supersonic inlet matching usually occurs **near the highest operating Mach number**
2. The engine plus other propulsion flows (inlet bleed, nozzle cooling air, environmental cooling system (ECS) air) match the inlet supply **at the sizing point** and cause the **excess flow** at all lower Mach operating conditions.
3. The excess airflow results in **additional inlet drag** to either **spill the airflow** before entering the inlet or take the airflow into the inlet duct then **bypass it by louvers or doors prior to entering engine.**

4.3 Capture Area Verification

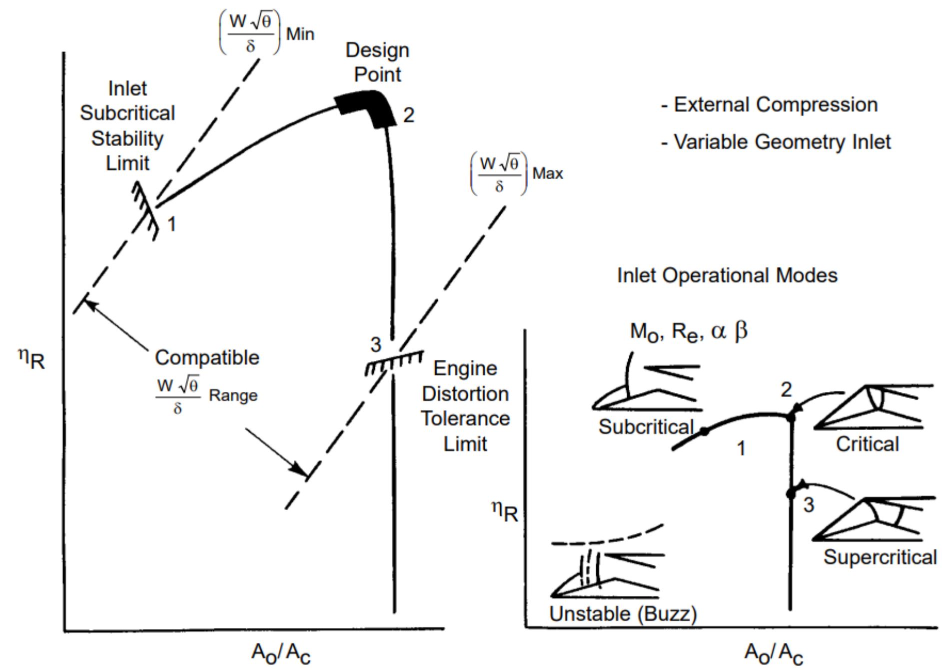

Figure 7: Capture Area Verification

Some remarks:

1. After inlet is designed and tested, the inlet **distortion and recovery characteristics** must be checked versus desired operational values
2. If the inlet operating mass flow ratio is higher than the point where the engine distortion limit is exceeded, the inlet area must be increased.
3. Conversely, if the minimum engine airflow is less than the subcritical stability limit, either the inlet would be downsized or the engine airflow rescheduled higher (if possible) to eliminate inlet buzz.