IPAC - Inlet Performance Analysis Code

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Abstract

A series of analyses have been developed which permit the calculation of the performance of common inlet designs. The methods presented are useful for determining the inlet weight flows, total pressure recovery, and aerodynamic drag coefficients for given inlet geometric designs. Limited geometric input data is required to use this inlet performance prediction methodology. The analyses presented here may also be used to perform inlet preliminary design studies. The calculated inlet performance parameters may be used in subsequent engine cycle analyses or installed engine performance calculations for existing uninstalled engine data.

Introduction

Propulsion installations can have a significant effect on the overall efficiency of airbreathing engine systems, particularly for supersonic and hypersonic flight vehicles. To assess the impact of an inlet design on the net thrust and specific fuel consumption for a given engine design, either the inlet performance characteristics must be known in advance, or they must be calculated from a simple geometric design, or in the worst case the inlet system must be designed from scratch and then analyzed to determine performance. This report describes a series of analyses which have been developed into a performance prediction methodology for engine inlet systems. The methodology can be used to predict performance for a given inlet geometric design. Additionally, the methodology can be employed to perform preliminary inlet system design, and subsequent performance analyses.

Inlet performance is typically comprised by determining three quantities: delivered engine airflow, W_2, total pressure recovery, P_{T2}/P_{T0}, and aerodynamic drag coefficient, C_D. It is also very important to be able to characterize inlet performance over the entire vehicle flight and engine operation range, not just at the inlet design point. The methodology presented covers the calculation procedures used to determine inlet performance, both on and off-design, for the broad classification of inlet geometries shown in Figure 1.

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The geometric input used for the analysis modeling is simple and flexible. This permits rapid performance calculations and quick turn-around times for inlet design assessments. The analyses are capable of modeling three broad inlet design classifications: pitot, axisymmetric, and two-dimensional.

Method of Analysis

Figure 2 shows the basic modeling elements used to develop the inlet performance analysis methodology. The action of airflow ingestion through the inlet is broken up into a series of distinct processes. Changes in flow properties from the free stream flow station, 0, to the inlet local flow station, *L*, are modeled as vehicle effects. Flow changes through shock waves ahead of the cowl lip station, 1, are modeled as external compression. Flow changes within the cowl lip to the inlet throat station, *TH*, are modeled as internal compression. Flow changes downstream of the throat to the engine face station, 2, are modeled as subsonic diffusion.

Aerodynamic drags modeled include spillage, bleed, and bypass. Spillage drag is the sum of the momentum change incurred by air being diverted around the inlet lip, additive drag, and cowl lip suction, if present. Bleed drag results from the momentum change in air which is dumped overboard as required by inlet stability considerations and boundary layer control. Bypass drag results from the momentum change in air which is dumped overboard for inlet/engine weight flow matching requirements. Additional calculations for cowl lip and wave drag are also included.

The relative amounts of airflow ingested into the inlet, lost to bleed, bypass, or spillage are shown in Figure 2 as the free stream tube areas, A. These areas are usually presented in analyses as a ratio with respect to the forward projected cowl lip area, A_C.

Figure 3 shows the different modes of operation which are possible for mixed-compression inlets in supersonic flight. Of particular importance is the location of the normal shock wave since this will dramatically effect the inlet airflow capture characteristics. The top diagram in Figure 3 shows the inlet operating with the normal shock wave outside of the cowl lip. In this mode of operation the inlet can deliver less (or within limits more) air to the engine by spilling air around the lip as subsonic flow behind the normal shock wave. Thus the engine demand can influence the inlet operation and the location of the normal shock wave. This operation is called sub-critical and the inlet is unstarted. External compression inlets always operate sub-critical.

As the engine demands more airflow, the normal shock wave is drawn up to the cowl lip. When the normal shock wave just reaches the cowl lip, the inlet is ingesting the maximum airflow possible. The center diagram in Figure 3 shows this operation, called critical, but the inlet is still unstarted since the throat Mach number is subsonic. When the normal shock wave is swallowed and located downstream of the throat the operation is called super-critical and the inlet is now started since the throat Mach number is supersonic. The airflow captured by the inlet lip cannot be increased or decreased by the engine operation, but is fixed by the external shock wave structure as shown in the bottom diagram of Figure 3. Inlet/engine airflow matching can only be accomplished in this mode using a bypass system.

Engine Weight Flows

The primary function of an inlet is to deliver the proper amount of airflow to the engine. The amount of airflow delivered to the engine depends on many factors. The usual requirements for inlet design specify the desired altitude corrected weight flow delivered to the engine face as a function of flight Mach number. Equation 1 shows the relation between engine corrected weight flow and inlet performance and design variables. The leading term in Equation 1 is the inlet capture area, A_C. The larger the inlet the greater the engine weight flow. The second term is the free stream-tube area ratio and it is a strong function of the inlet design and mode of operation. Stream-tube area ratios will be discussed in a later section.

The inlet total pressure recovery is also an important factor in Equation 1, however, the corrected airflow is inversely proportional to recovery. A higher recovery will result in a lower specific corrected airflow at the engine face, and hence will necessitate a larger inlet, A_C. And this in turn will result in a propulsion system capturing more absolute airflow, resulting in greater thrust. A lower recovery results in a smaller inlet, less absolute airflow, and lower thrust.

Equations 2 through 8 show how the absolute engine weight flow, W_2, is calculated from the corrected weight flow. Equation 9 indicates that the free stream static pressure and temperature are known from standard atmosphere tables or curve fits. Equations 7 and 8 are the isentropic flow relations between total and static quantities as a function of Mach number. Equation 6 is a statement of the first law of thermodynamics, and is only valid if the inlet does not transfer heat or shaft work to or from the airflow. Equation 10 may be used to determine the actual weight flow directly from free stream static properties. Equations 1 through 10, as written, imply the use of English units.

Real Gas Effects

Implicit in Equations 1 through 8 is the ideal gas assumption. This is usually valid for free stream Mach numbers below two. At higher flight speeds real gas effects need to be accounted for. Equations 11 through 15 are used for a calorically imperfect gas model. Primed values correspond to the real gas property. Equation 11 is used to calculate a real gas ratio of specific heats from the ideal gas γ and the static temperature. For a known flight Mach number Equation 12 is solved by iteration to yield a real gas total temperature. Equation 13 is used to determine the total pressure for the real gas model. These total quantities are used to replace the ideal gas values calculated by Equations 7 and 8. Equation 1 must also be modified for stream-tube area variations using Equation 14. Additional information on this real gas model can be found in reference 1.

Inlet Mass Flow Ratios

Figure 2 shows a rather standard airflow accounting system in terms of idealized free stream-tube areas. If these stream-tube areas are normalized by the inlet capture area, a series of relations can be developed. Equations 16 through 18 show the stream-tube area build-up. These ratios are also called mass flow ratios, since the mass flow is equal to density times velocity times area. The density and velocity terms drop out in the ratio format. If there are no vehicle effects on the airflow ahead of the inlet, the right hand side of Equation 18 is equal to one. The airflow captured by the cowl lip and ingested into the inlet is represented by the mass flow ratio A_{0l}/A_C, while the airflow passed through the inlet throat is represented by the mass flow ratio A_0/A_C.

Vehicle Effects

The effects of a vehicle flow field ahead of an inlet can be simply described as changes to the total pressure, Mach number, and stream-tube area between stations 0 and L. Equations 19 through 25 show the effects of Mach number and total pressure changes on the stream tube area. The analysis extends from the principle of conservation of mass in Equation 19. Equation 25 provides a simple expression for determining the right hand side of Equation 18 if the total pressure ratio and Mach number ratio are known from stations 0 to L.

All of the subsequent analyses are performed in the inlet local reference frame, as if there were no vehicle effects present and the inlet was simply in a free stream of different Mach number and total pressure. However, the overall inlet performance must be represented in the free stream reference, and thus all results from the inlet local reference must be adjusted. Equations 26 through 31 show how a drag coefficient calculated in the inlet local reference is adjusted to represent the same force described as a drag coefficient in the free stream reference frame.

Vehicle Forebody Model

Figure 4 shows a simple vehicle forebody model employed in the methodology. This model can be used to represent vehicle underbody precompression surfaces, upperbody expansion surfaces, aircraft wings, or slender fuselages. The stream tube area shown in Figure 4 can be seen to decrease as the streamline crosses subsequent shock waves from the free stream to the inlet local stations. Equations 32 and 33 show how the ratios of total pressure and Mach number, from free stream to inlet local, are determined from the changes across each individual flow deflection region. Positive angles, α, are modeled as oblique shock wave compression regions. Negative angles are modeled as discrete Prandtl-Meyer expansion regions. Conic shock waves are also an included option, in addition to the default planar shock wave calculations. Since shock wave calculations are a central part of the inlet performance methodology, a description of these types of calculations follows.

Normal Shock Wave Relations

A shock wave is a very thin layer interaction between two distinct compressible flow regions. The simplest shock wave type is the normal shock wave, shown in the top diagram of Figure 5. Supersonic flow is shocked down to subsonic flow across a normal shock wave. All flow properties are determined by the upstream conditions. Equations 34-38 show the standard normal shock wave flow relations for Mach number, pressure, temperature, and density. Note that all of these relations are only a function of upstream Mach number, and are thus easy to apply.

Oblique Shock Wave Relations

The center diagram in Figure 5 shows the elements of an oblique shock wave. A planar oblique shock wave is produced by a downstream boundary turning an incoming supersonic flow through an angle θ. As a result, a shock wave forms, inclined to the incoming flow direction at an angle β. The components of the flow perpendicular to the oblique shock wave are described by the normal shock wave relations. The velocity components parallel to the shock wave are unchanged. Equation 39 gives a relation between the flow turning and shock wave angles. Typically the flow deflection angle is known, and the shock wave angle must be found. Although most references suggest solving Equation 39 iteratively, this is not necessary.

By some algebraic manipulation, Equation 39 can be rewritten in the form of a 6th order polynomial in terms of the sine of the shock wave angle, shown in Equation 40. The coefficient terms of the resulting polynomial are given in Equations 41 through 43. Since Equation 40 only has even power terms, a generalized solution for 3rd order polynomials can be employed. This gives a relation for the square of the sine of the shock wave angle as a function of the flow deflection angle and the upstream Mach number. Equations 44 and 45 show this direct solution. Once the shock wave angle is known, the normal components of the Mach number are found in Equations 46 and 47. The changes in flow properties are then calculated by application of the normal shock wave relations.

Conical Supersonic Flow Relations

The calculations involved in determining supersonic flow in conical shock fields are a bit more complex. The elements in the conical shock wave problem are shown in the bottom diagram of Figure 5. Equation 48 gives the reduced differential equation describing the flow field between the conical shock wave and the cone surface. The dependent variable in Equation 48, V_r', is the radial component of a non-dimensionalized velocity in the conic flow field. Equations 49 through 52 give definitions of the non-dimensional velocity components and their relation to the polar angle ϕ and flow direction angle θ. Equations 53 and 54 are the two required boundary conditions of tangent flow to the cone surface and the correct flow turning angle behind an oblique shock wave.

Equation 48 can be solved numerically by a scheme commonly known as the Taylor-Maccoll solution. A conic shock wave angle is first guessed, and with Equation 54 provides a value for the shock wave boundary condition. Equation 48 is then solved at small increments of ϕ using standard Runge-Kutta integration schemes. The solution is then marched by ϕ through the flow field to the cone angle θ_c. If the tangent flow boundary condition, Equation 53 is satisfied, then the initial guess on the conic shock wave angle is correct. Otherwise another guess on the angle β is chosen, and the process is repeated, iterating to a correct solution. Once solved, the flow properties across the conic shock wave are determined from the oblique shock wave relations. Also, the flow velocity variations from the conic shock wave to the cone surface are known from the solution of Equation 48. Other flow properties can be then determined from the isentropic flow relations given below. Reference 2 is a good starting point for further information on calculating conical shock waves.

Isentropic Flow Relations

Equations 55 through 59 are a series of often used isentropic flow relations found throughout the methodology, and are given here for convenience. Equations 55 through 57 calculate the static pressure, temperature, and density as functions of Mach number only. For example, the static pressure field behind the conic shock wave is determined by Equation 56, since the Mach number field is known from the solution to Equation 48 and the total pressure is a constant, whose value is determined from the oblique shock wave relations. Equation 58 describes the required stream-tube flow area as a function of Mach number, where A_* is the flow area at the sonic condition.

Equation 59 is the Prandtl-Meyer function and it is used to determine the change in Mach number as a supersonic flow isentropically expands through a turning angle. Typically an initial Mach number is known as well as the turning angle. Equation 59 determines the initial Prandtl-Meyer function value explicitly. By adding the expansion angle (in radians) a new Prandtl-Meyer function value is calculated, from which Equation 59 must be solved iteratively to yield a new value of the Mach number downstream of the expansion. This technique is used as part of the vehicle forebody model for supersonic flow expansions.

Total Pressure Recovery

The total pressure recovery for the entire inlet is calculated as the product of a series of total pressure ratios across elements of the inlet system. Equation 60 shows this relation, where the terms on the right hand side are the total pressure ratios from: free stream to inlet local, inlet local to inlet lip, inlet lip to throat, and throat to engine face. Each of these terms is calculated in the subsequent modeling elements, with the exception of the free stream to inlet local term, which is calculated in the vehicle forebody model previously discussed.

External Compression

The changes in flow properties from the inlet local station to the inlet lip are determined by models of the external compression processes for a given inlet design. Figure 6 shows the elements of the external compression models used in the methodology. Each basic inlet type must be modeled separately, since the external flow is highly dependent on the inlet geometry.

The top diagram in Figure 6 shows the elements of the external compression model for pitot inlets. The total pressure ratio from inlet local to inlet lip is given in Equation 61 and the total pressure loss is only generated by a normal shock wave at the inlet local Mach number. If the inlet local Mach number is subsonic, then the total pressure ratio is one. There is an incurred drag penalty for air which is spilled around the cowl lip called additive drag. Reference 3 gives a procedure for calculating this drag coefficient and Equations 62 through 64 summarize the analysis. The last term in Equation 62 is the mass flow ratio ingested by the inlet lip, A_{LI}/A_C, and this number is determined by the engine airflow requirements. Equations 63 and 64 result from conservation of mass and the isentropic flow functions.

The center diagram in Figure 6 shows the elements of the external compression model for axisymmetric inlets. This type of inlet is capable of operating either super-critical or sub-critical, and the model must distinguish the difference. Equations 65-67 pertain to the super-critical operation mode. The total pressure ratio is produced entirely by the inlet conic shock wave. The additive drag coefficient can be determined either by Equation 66 or 67. However, since the conic flow field is known for supersonic operation, Equation 67 is employed using numerical integration techniques. The integration path corresponds to the streamline intersecting the cowl lip. For subsonic flows Equation 66 must be used and the total pressure ratio is one.

For sub-critical operation, a normal shock wave exists outside of the inlet cowl lip. This results in a greater pressure loss, higher additive drag coefficient, and lower mass flow ratio. Equations 68 through 74 show these calculations for sub-critical inlet operation. The position of the normal shock wave outside of the cowl lip is approximated as standoff distance which is proportional to the inlet capture mass flow ratio relative to critical operation, as indicated by Equation 73. The proportionality factor, K, is a function of Mach number (indicated by Equation 74) and this function was determined from curve fits to data found in reference 4. The functional form of the shock wave standoff factor, K, is shown graphically in Figure 7.

The bottom diagram in Figure 6 shows the elements of the external compression model for multi-ramp two-dimensional inlets. These inlet types can also operate both sub-critical and super-critical. Equations 75-78 show the calculations for super-critical operation. The total pressure ratio in Equation 75 is the product of all the external oblique shock wave total pressure ratios. For sub-critical operation, Equations 79-82 show the calculations used in the model. A normal shock wave can exist outside of the cowl lip and the relations computing the total pressure ratio and additive drag need to account for the position of the normal shock wave, and on which ramp it is located.

Internal Compression

Figure 8 shows the elements of the internal compression model. For started inlet operation, an oblique shock wave train is used to model the losses in the internal portion of the inlet from the cowl lip to the throat. The net turning angle is the sum of the last external surface angle and the internal cowl lip angle. The flow properties across each shock wave reflection are determined from the oblique shock wave relations previously discussed. Equation 83 shows the relation between the flow properties in the model and the geometric throat area constraint. Equation 83 is again a statement of conservation of mass for compressible flows.

The reflecting oblique shock wave model, Equations 85 through 87, is primarily used to determine the total pressure loss in the internal compression region. The model may also be used to determine a throat Mach number, M_{TH}, for a given throat area ratio, A_{TH}/A_C, by iterative solution of Equation 83. Often the throat Mach number is specified instead and the throat area ratio is then determined directly by Equation 83. If both the throat Mach number and throat area ratio are specified, then the inlet capture mass flow ratio, A_{LI}/A_C, must then be determined from these constraints.

Subsonic Diffusion

Figure 9 shows the elements of the subsonic diffusion model. Depending on the inlet operation mode, a terminal normal shock wave may or may not exist downstream of the inlet throat within the subsonic diffuser. Equations 88 through 94 show the calculation procedure for operation with subsonic flow at the inlet throat. The model used here closely follows that given in reference 5. For inlet operation with a subsonic throat, the throat Mach number and area are usually specified, consistent with the desired engine weight flow delivered. For inlet operation with a supersonic throat, or started operation, Equations 95 through 97 are used. The strength of the terminal normal shock wave can be used to provide inlet/engine corrected mass flow matching in some instances. Curve fits are used for the loss factor functions in Equations 90 and 94 corresponding to divergence and throat Mach number loss mechanisms. Figures 10 and 11 show the functional forms for the divergence and throat Mach number loss mechanisms graphically. The friction factor given in Equation 93 is a nominal value, and may be changed if desired.

Bleed Drag

Bleed drag seems to be a necessary evil required for supersonic inlet designs. Since inlets produce large positive pressure gradients, some severe in shock wave interactions, the boundary layers are prone to separation. To alleviate this problem, portions of the boundary layer are removed through wall suction, and then dumped overboard. If done correctly, this usually results in improved inlet recoveries, however, a momentum drag is incurred. Equations 98 through 109 show the procedure used to calculate the bleed drag coefficient. These relations follow the procedures outlined in reference 6. Total pressure losses up to the bleed system plenum are modeled, as well as the effective bleed nozzle exit pressure and flow area. Non-axial nozzle exit flow losses are also included.

A number of inputs must be specified for the design and operation of the bleed system. In a high speed inlet the bleed system is typically comprised of a series of discrete bleed regions, each having its own type of wall perforation, plenum, and exhaust nozzle. The total bleed drag is thus the sum of the individual bleed system elements. Equation 98 is used to describe the bleed drag for a discrete bleed element. The bleed mass flow ratio, A_{LBLD}/A_C, nozzle exhaust flow angle, θ_X, and nozzle exhaust velocity coefficient, η_V, must all be specified. Additionally, the bleed plenum recovery, P_{TBL}/P_{TL}, must also be specified. To choose these values extensive experience in the design and operation of bleed systems is usually required. To alleviate this requirement default values have been implemented in the methodology.

Figure 12 shows typical bleed system operating characteristics which are incorporated as user selectable defaults for inputs to the bleed drag model. The bleed plenum recovery is shown as a function of inlet local Mach number for a variety of bleed system design wall perforations. The total bleed mass flow ratio required for typical inlet operation is also shown in Figure 12 over the same Mach number range. The data which comprises the basis for Figure 12 is taken from reference 7.

There are two additional empirical relations embedded within the bleed drag model. Equation 99 shows the functional dependence for the oblique exit nozzle drag factor, C_{TL}, and Figure 13 shows this functional relationship graphically. The relationship for the effective nozzle discharge pressure, Equation 103, is shown graphically in Figure 14. The bleed exhaust nozzle area ratio, A_X/A_{TH}, is the final input required for the bleed drag model. The nozzle area ratio should be chosen depending on the bleed exhaust nozzle pressure ratio. The operating pressure ratio for the bleed exhaust nozzle is given in Equation 102. Based on this value, Figure 15 can be used to pick the appropriate nozzle area ratio for the bleed element. Other area ratio choices will result in over or under expansion losses which will further increase the resulting bleed drag. Since bleed plenum recoveries are typically low this usually results in the use of convergent nozzles for bleed systems. Bypass systems can have much higher recoveries, and thus may be able to utilize convergent-divergent nozzle designs.

Bypass Drag

Bypass flows are used to dump air overboard in the subsonic diffuser ahead of the engine face, and are typically employed for inlet/engine flow matching. The resulting drag coefficient is calculated in a manner analogous to that used for the bleed system. Equations 110 through 115 show the modifications made to the bleed drag relations required to model bypass flow. The required inputs to the bypass drag model parallel those necessary for the bleed drag model. As in the bleed system model, the bypass system can be comprised from a series of distinct bypass elements. Each element can be defined with different design and performance characteristics. The total bypass drag thus being the sum of the drags of all the distinct elements. The bypass plenum recovery is typically a function of the amount of bypass flow dumped overboard. Figure 16 shows the methodology default for the relation of the bypass recovery, P_{TBP}/P_{T2}, as the bypass mass flow ratio, A_{LBYP}/A_C, varies. The data on which Figure 16 is based can be found from reference 7.

Cowl Lip Suction

As a result of sub-critical airflow spillage around the inlet cowl lip, the static pressure over the cowl leading edges is decreased, thus reducing the effective cowl pressure drag. This effect, known as cowl lip suction, can be viewed as a correction to the additive drag calculation as presented previously in the external compression model. The net combination of the additive drag and cowl lip suction is the total inlet spillage drag. Equation 116 shows the definition of the cowl lip suction coefficient. This model for the cowl lip suction coefficient is based entirely on empirical relations which can be found in reference 6.

Equations 117 through 124 detail the empirical terms used in Equation 116. The functional form of Equation 117, the first cowl lip suction factor, K_α, is shown graphically in Figure 17. The effective cowl lip angle correction factor, σ, defined in Equation 118 is shown graphically in Figure 18. The procedure for computing the effective cowl lip angle is given in Equations 119 through 121. Equation 119 is an approximation for the effective cowl lip angle, in degrees, determined from the integral parameter, Ω, which is defined by Equation 120. This integral parameter evaluates the cowl surface curvature from the cowl lip leading edge to the maximum of the cowl forward projected area location. In Equations 120 and 121, the cowl profile is defined by coordinates (X,Y) and the cowl lip leading edge is located at (X_C,Y_C).

The second cowl lip suction factor, K_β, defined in Equation 122 is shown graphically in Figure 19. The final empirical cowl lip suction factor, C_{D2}, is defined in Equation 123 and is also shown graphically in Figure 20. Once the cowl lip suction factors are determined from curve fits and the cowl lip suction coefficient calculated, the inlet spillage drag coefficient is then found by Equation 124.

Cowl Lip and Wave Drag

The pressure drag acting on the inlet cowl surfaces can typically be broken into two parts; drag due to a blunt inlet lip and wave drag due to the area growth along the remainder of the cowl surfaces. Equation 125 shows this drag decomposition. For sharp lip inlets, the drag component due to a blunt lip is necessarily zero. For non-sharp lip inlets, the blunt leading edge will produce a pressure drag at supersonic local Mach numbers resulting from a detached normal shock wave which is formed over the leading edge radius of the cowl lip. Equation 126 shows the computation of the lip drag coefficient based on the assumption that an average pressure rise produced by a normal shock wave at the inlet local Mach number acts over the forward projected cowl lip surface area. This average pressure rise is modeled as the simple arithmetic mean of the stagnation and static pressures behind a normal shock wave. The forward projection of the blunt cowl lip area is denoted as A_x in Equation 126.

The pressure drag acting on the rest of the cowl surface area is wave drag. The wave drag coefficient is defined by Equation 127 for two-dimensional inlet geometries. If the cowl profile is comprised by a series of flat plates, the integration in Equation 127 can be replaced by a discrete summation as shown in Equation 128. The pressure acting on each cowl plate segment, P_i, is calculated by the shock wave and expansion models previously described. The forward facing projected area of each cowl segment plate is denoted as A_{xi} in Equation 128.

The computations of the wave drag for axisymmetric cowls are given in Equations 129 through 143. The wave drag coefficient is defined as an integration of the pressure coefficient over the cowl surface as shown in Equation 129. Equation 129 is an equivalent statement to Equation 127 which defined the wave drag coefficient for two-dimensional inlet geometries. The computation of the pressure coefficient, C_P, over an axisymmetric cowl geometry, however, is substantially more complex than the two-dimensional flat plate cowl model of Equation 128. The pressure coefficient in the axisymmetric wave drag model, given in Equation 130, is calculated by a first order approximation using the perturbation velocities determined from the solution of a linearized supersonic slender body theory.

The axisymmetric form of the governing partial differential equation for the perturbation velocity potential by supersonic slender body theory is given in Equation 131. The generalized solution of the perturbation velocity potential, ϕ, and the axial and radial perturbation velocities, u and v respectively, are found in reference 8 and given in Equations 132 through 135. In Equations 133 and 134, $f'(\xi)$ is a singularity distribution along the centerline axis which uniquely determines the flow field on and about the slender body surface. A statement that the flow is tangent to the body surface on the body surface can be used as a boundary condition to determine the singularity distribution for that body. A more detailed description of the analyses which follow can be found in reference 9.

If the axisymmetric cowl surface profile is described by the coordinate pairs (X,R) then the body surface tangent flow boundary condition can be written as Equation 136. Furthermore, if the cowl surface profile is discretized and the singularity distribution, f', can be assumed piece-wise constant over a small interval $[\xi_{i-1},\xi_i]$, then the discrete elements of the singularity distribution can be moved outside of the integration, as shown in Equation 137. The initial and final bounds of the piece-wise integrations are given in Equations 138 and 139 as they apply to Equation 137. The piece-wise integral is now readily evaluated in closed form, and the solution becomes Equation 140. A marching scheme can easily be developed to determine the value of a discrete singularity, f_n', corresponding to a location (X_n,R_n) on the cowl surface in terms of a summation of all the upstream singularities, as shown in Equation 141. Therefore, the entire singularity distribution can be determined by simply marching down the cowl surface using Equation 141.

Once the discrete singularity distribution is known, the pressure coefficient can be determined by an analogous procedure, as shown in Equation 142, which is developed from Equations 130 and 133. Again, the resulting piece-wise integral in Equation 142 can be evaluated in closed form, yielding Equation 143, and the pressure coefficient at discrete points along the cowl surface is subsequently known as a function of the discretized singularity distribution. The axisymmetric wave drag coefficient is then determined by numerical integration of Equation 130 using the values found from Equation 143.

Lip Losses

The inlet cowl lip can have additional effects on the inlet recovery, particularly at low speeds. At take-off conditions, the inlet must ingest mass by drawing a large volume of initially stationary air from the surroundings around the cowl lip and then into the engine face. For sharp lip inlets, as the airflow is drawn around the cowl lip, the flow will accelerate and separate as it turns, producing a subsequent fluid dynamic loss and drop in total pressure recovery. Equation 144 shows the total pressure recovery as produced by a theoretical sharp lip loss mechanism. Reference 10 presents the theoretical derivations of Equation 144. The Mach number at the cowl lip, M_1, can be determined from continuity. Equation 145 is solved iteratively to find the inlet lip Mach number as a function of the inlet throat Mach number and the contraction area ratio from the inlet lip to the inlet throat. For cowl lips which are not sharp, but have some degree of bluntness, Equation 146 has been developed by the author to account for the effects of a non-zero cowl lip radius on the lip loss recovery given by Equation 144. Data from reference 11 was used to determine the exponential damping constant used in Equation 146.

Results

Results from the IPAC methodology are presented for three sample cases: a Mach 2.0 pitot inlet, a Mach 2.4 axisymmetric inlet, and a Mach 5.0 two-dimensional inlet. Example case output files, each containing copies of the respective input sets, can be found in Appendices II through IV. Additionally, a program User's Guide which describes the input set and program usage can be found in Appendix I.

The geometry of the pitot inlet sample case is shown in Figure 21. The pitot inlet is axisymmetric for this particular design and has a blunt cowl lip for improved low speed total pressure recoveries. Figure 22 shows a performance summary over the entire Mach number operating range for the inlet. The corrected airflow has been matched to a typical engine demand schedule, as shown in the top plot of Figure 22. The inlet throat Mach number was varied and used as an inlet control parameter in order to provide inlet/engine airflow matching. The resulting total pressure recovery and inlet drags are shown in the middle and lower plots in Figure 22. Note that the cowl drag is the dominant drag for this inlet design. This is an expected result of the blunt cowl lip feature of the inlet.

Figure 23 shows the design and variable geometry features for the axisymmetric sample case. Both internal cowl surface variable geometry and a translating centerbody are used to control the operation of this inlet. Figure 24 shows a performance summary for the axisymmetric sample case over the entire Mach number range of inlet operation. Again, the inlet was designed and operated in accordance with a typical engine airflow demand schedule. The axisymmetric inlet is a mixed compression design with a starting Mach number of 1.6. This inlet also requires a boundary layer bleed system. The sharp inlet lip can be seen to result in relatively lower take-off total pressure recoveries for this particular design.

The inlet design and variable geometry features for the two-dimensional sample case is shown in Figure 25. This inlet uses a three ramp compression surface shock-on-lip design at Mach 5.0. The second and third ramps are movable and are used for inlet operation control. Figure 26 shows a performance summary for the two-dimensional design. The inlet employs both a boundary layer bleed system and an engine bypass system. The variable geometry ramp positions and bypass mass flow variations are used to provide matched airflow for a typical engine demand schedule. The inlet starting Mach number is 2.0 for this particular design. As is typical for high speed inlet systems, severe transonic drags are seen in the lower plot of Figure 26.

Summary

A series of analyses have been developed which permit the calculation of the performance of common inlet designs. The methods presented are useful for determining the inlet weight flows, total pressure recovery, and aerodynamic drag coefficients for given inlet geometric designs. Limited geometric input data is required to use this inlet performance prediction methodology. The analyses presented here may also be used to perform inlet preliminary design studies. The calculated inlet performance parameters may be used in subsequent engine cycle analyses or installed engine performance calculations for existing uninstalled engine data.

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List of Symbols

A	area, or cross-sectional flow area
A_C	inlet capture area
C_D	drag coefficient
C_{D2}	empirical cowl lip suction factor
C_P	pressure coefficient
C_T	oblique exit nozzle drag factor
D	drag force, or diameter
f	singularity distribution for the perturbation velocity potential
f_D	diffuser friction factor
g	gravitational constant
K	empirical normal shock wave standoff factor
K_D	empirical subsonic diffuser total pressure loss factor
K_F	empirical subsonic diffuser friction loss factor
K_M	empirical subsonic diffuser throat Mach number factor
K_O	empirical subsonic diffuser offset loss factor
K_α	empirical cowl lip suction factor
K_β	empirical cowl lip suction factor
L	inlet local location, or axial length
L_D	diffuser axial length
M	Mach number
N	number of surface segments
P	pressure
P_T	total pressure
q	dynamic pressure
r, R	radial coordinate
R	gas constant
T	temperature
T_T	total temperature
u	axial perturbation velocity
v	radial perturbation velocity
V	velocity
W	weight flow rate
x, X	axial coordinate
y, Y	normal coordinate
Y_O	diffuser offset normal length
α	forebody model angle
β	shock wave angle
γ	ratio of specific heats
η_V	discharge nozzle velocity coefficient
θ	referenced total temperature, or a flow/surface angle
θ_D	diffuser half-angle
Θ	reference temperature for real gas model
δ	referenced total pressure
ρ	density

λ	Mach number parameter in slender body theory
ν	Prandtl-Meyer function
ξ	integration parameter in slender body theory
σ	correction factor for effective cowl angle
ϕ	perturbation velocity potential, or a polar angle
Ω	cowl curvature function

Subscripts

0	free stream
1	upstream, or cowl lip
2	downstream, or engine face
ADD	additive
BL	boundary layer bleed
BLD	bleed
BP	engine bypass
BYP	bypass
c	cone
C	cowl lip
CWL	cowl
cr	critical operation
e	effective
eff	effective
ENG	engine flow
i	general index, or ideal condition
I	inlet capture
L	inlet local
LIP	inlet lip
LS	lip suction
n	general index, or inlet ramp number
N	normal component
NS	normal shock wave
r	radial component
S	centerbody or ramp surface
sl	sharp lip
SPL	spillage
sub	sub-critical operation, or subsonic throat
sup	supersonic throat
SY	centerbody or ramp surface behind unstarted inlet normal shock wave
TH	inlet throat, or discharge nozzle throat
WAV	wave
x	axial component
X	discharge nozzle exit
*	sonic conditions
ϕ	polar component

Superscripts

′ thermally perfect (non-ideal) gas property, or normalized velocity

Equations

Engine Weight Flows

$$\frac{W_2\sqrt{\theta_2}}{\delta_2} = A_C\left(\frac{A_{0ENG}}{A_C}\right)\left(\frac{P_{T2}}{P_{T0}}\right)^{-1}\frac{2116}{\sqrt{519}}\sqrt{\frac{\gamma g}{R}}M_0\left[1+\frac{\gamma-1}{2}M_0^2\right]^{-\frac{\gamma+1}{2(\gamma-1)}} \tag{1}$$

$$W_2 = \left(\frac{W_2\sqrt{\theta_2}}{\delta_2}\right)\frac{\delta_2}{\sqrt{\theta_2}} \tag{2}$$

$$\delta_2 = \frac{P_{T2}}{2116} \tag{3}$$

$$\theta_2 = \frac{T_{T2}}{519} \tag{4}$$

$$P_{T2} = P_{T0}\left(\frac{P_{T2}}{P_{T0}}\right) \tag{5}$$

$$T_{T2} = T_{T0} \tag{6}$$

$$P_{T0} = P_0\left[1+\frac{\gamma-1}{2}M_0^2\right]^{\frac{\gamma}{\gamma-1}} \tag{7}$$

$$T_{T0} = T_0\left[1+\frac{\gamma-1}{2}M_0^2\right] \tag{8}$$

$$P_0, T_0 = f(alt) \tag{9}$$

$$W_2 = A_C\left(\frac{A_{0ENG}}{A_C}\right)\frac{P_0}{\sqrt{T_0}}\sqrt{\frac{\gamma g}{R}}M_0 \tag{10}$$

Real Gas Effects

$$\gamma' = 1+\frac{\gamma-1}{1+(\gamma-1)\left[\left(\frac{\Theta}{T}\right)^2\frac{e^{\Theta/T}}{(e^{\Theta/T}-1)^2}\right]} \tag{11}$$

$$M^2 = \frac{2}{\gamma'}\frac{T_T'}{T}\left[\frac{\gamma}{\gamma-1}\left(1-\frac{T}{T_T'}\right)+\frac{\Theta}{T_T'}\left(\frac{1}{e^{\Theta/T_T'}-1}-\frac{1}{e^{\Theta/T}-1}\right)\right] \tag{12}$$

$$\frac{P}{P_T'} = \left(\frac{e^{\Theta/T_T'}-1}{e^{\Theta/T}-1}\right)\left(\frac{T}{T_T'}\right)^{\frac{\gamma}{\gamma-1}}\exp\left[\left(\frac{\Theta}{T}\right)\frac{e^{\Theta/T}}{e^{\Theta/T}-1}-\left(\frac{\Theta}{T_T'}\right)\frac{e^{\Theta/T_T'}}{e^{\Theta/T_T'}-1}\right] \tag{13}$$

$$\frac{A}{A_*'} = \frac{1}{M}\sqrt{\frac{T_*'}{T}}\,\frac{\left(\frac{e^{\Theta/T_T'}-1}{e^{\Theta/T_*'}-1}\right)\left(\frac{T_*'}{T_T'}\right)^{\frac{1}{\gamma-1}}\exp\left[\left(\frac{\Theta}{T_*'}\right)\frac{e^{\Theta/T_*'}}{e^{\Theta/T_*'}-1}-\left(\frac{\Theta}{T_T'}\right)\frac{e^{\Theta/T_T'}}{e^{\Theta/T_T'}-1}\right]}{\left(\frac{e^{\Theta/T_T'}-1}{e^{\Theta/T}-1}\right)\left(\frac{T}{T_T'}\right)^{\frac{1}{\gamma-1}}\exp\left[\left(\frac{\Theta}{T}\right)\frac{e^{\Theta/T}}{e^{\Theta/T}-1}-\left(\frac{\Theta}{T_T'}\right)\frac{e^{\Theta/T_T'}}{e^{\Theta/T_T'}-1}\right]} \tag{14}$$

$$\Theta = 5{,}500^\circ\mathrm{R} \tag{15}$$

Inlet Mass Flow Ratios

$$\frac{A_0}{A_C} = \frac{A_{0ENG}}{A_C} + \frac{A_{0BYP}}{A_C} \tag{16}$$

$$\frac{A_{0I}}{A_C} = \frac{A_0}{A_C} + \frac{A_{0BLD}}{A_C} \tag{17}$$

$$\frac{A_{0I}}{A_C} + \frac{A_{0SPL}}{A_C} = \left(\frac{A_L}{A_0}\right)^{-1} \tag{18}$$

Vehicle Effects

$$(\rho V A)_0 = (\rho V A)_L \tag{19}$$

$$\left(\frac{A_L}{A_0}\right) = \left(\frac{\rho_0}{\rho_L}\right)\left(\frac{V_0}{V_L}\right) \tag{20}$$

$$V = M\sqrt{\gamma R T} \tag{21}$$

$$\left(\frac{V_0}{V_L}\right) = \left(\frac{M_0}{M_L}\right)\left[\frac{1+\frac{\gamma-1}{2}M_0^2}{1+\frac{\gamma-1}{2}M_L^2}\right]^{-\frac{1}{2}} \tag{22}$$

$$\rho = \frac{P}{RT} \tag{23}$$

$$\left(\frac{\rho_0}{\rho_L}\right) = \left(\frac{P_{TL}}{P_{T0}}\right)^{-1}\left[\frac{1+\frac{\gamma-1}{2}M_0^2}{1+\frac{\gamma-1}{2}M_L^2}\right]^{-\frac{1}{\gamma-1}} \tag{24}$$

$$\left(\frac{A_L}{A_0}\right) = \left(\frac{M_L}{M_0}\right)^{-1}\left(\frac{P_{TL}}{P_{T0}}\right)^{-1}\left[\frac{1+\frac{\gamma-1}{2}M_0^2}{1+\frac{\gamma-1}{2}M_L^2}\right]^{-\frac{\gamma+1}{2(\gamma-1)}} \tag{25}$$

$$C_D = \frac{D}{qA_C} \tag{26}$$

$$q = \frac{\gamma}{2}PM^2 \tag{27}$$

$$(C_D q A_C)_0 = (C_D q A_C)_L \tag{28}$$

$$C_{D0} = C_{DL}\left(\frac{P_L}{P_0}\right)\left(\frac{M_L}{M_0}\right)^2 \tag{29}$$

$$\left(\frac{P_L}{P_0}\right) = \left(\frac{P_{TL}}{P_{T0}}\right)\left[\frac{1+\frac{\gamma-1}{2}M_0^2}{1+\frac{\gamma-1}{2}M_L^2}\right]^{\frac{\gamma}{\gamma-1}} \tag{30}$$

$$C_{D0} = C_{DL}\left(\frac{P_{TL}}{P_{T0}}\right)\left(\frac{M_L}{M_0}\right)^2\left[\frac{1+\frac{\gamma-1}{2}M_0^2}{1+\frac{\gamma-1}{2}M_L^2}\right]^{\frac{\gamma}{\gamma-1}} \tag{31}$$

Vehicle Forebody Model

$$\left(\frac{P_{TL}}{P_{T0}}\right) = \prod_{i=1}^{n} \left(\frac{P_{Ti}}{P_{Ti-1}}\right) \tag{32}$$

$$\left(\frac{M_L}{M_0}\right) = \prod_{i=1}^{n} \left(\frac{M_i}{M_{i-1}}\right) \tag{33}$$

Normal Shock Wave Relations

$$M_2 = \sqrt{\frac{(\gamma-1)\,M_1^2+2}{2\gamma M_1^2-(\gamma-1)}} \tag{34}$$

$$\frac{P_2}{P_1} = \frac{2\gamma M_1^2-(\gamma-1)}{\gamma+1} \tag{35}$$

$$\frac{P_{T2}}{P_{T1}} = \left[\frac{(\gamma+1)\,M_1^2}{(\gamma-1)\,M_1^2+2}\right]^{\frac{\gamma}{\gamma-1}} \left[\frac{\gamma+1}{2\gamma M_1^2-(\gamma-1)}\right]^{\frac{1}{\gamma-1}} \tag{36}$$

$$\frac{T_2}{T_1} = \frac{\left[2\gamma M_1^2-(\gamma-1)\right]\left[(\gamma-1)\,M_1^2+2\right]}{(\gamma+1)^2\,M_1^2} \tag{37}$$

$$\frac{\rho_2}{\rho_1} = \frac{(\gamma+1)\,M_1^2}{(\gamma-1)\,M_1^2+2} \tag{38}$$

Oblique Shock Wave Relations

$$\tan\theta = 2\cot\beta\frac{M_1^2\sin^2\beta-1}{M_1^2\,(\gamma+\cos 2\beta)+2} \tag{39}$$

$$\sin^6\beta + b\sin^4\beta + c\sin^2\beta + d = 0 \tag{40}$$

$$b = -\frac{M_1^2+2}{M_1^2} - \gamma\sin^2\theta \tag{41}$$

$$c = \frac{2M_1^2+1}{M_1^4} + \left[\frac{(\gamma+1)^2}{4} + \frac{\gamma-1}{M_1^2}\right]\sin^2\theta \tag{42}$$

$$d = -\frac{\cos^2\theta}{M_1^4} \tag{43}$$

$$\sin^2\beta = -\frac{b}{3} + \frac{2}{3}\sqrt{b^2-3c}\cos\left(\frac{\psi+4\pi}{3}\right) \tag{44}$$

$$\cos\psi = \frac{9bc-2b^3-27d}{2\sqrt{(b^2-3c)^3}} \tag{45}$$

$$M_{1N} = M_1\sin\beta \tag{46}$$

$$M_{2N} = M_2\sin(\beta-\theta) \tag{47}$$

Conical Supersonic Flow Relations

$$\frac{\gamma-1}{2}\left[1-V_r'^2-\left(\frac{dV_r'}{d\phi}\right)^2\right]\left(2V_r'+\frac{dV_r'}{d\phi}\cot\phi+\frac{d^2V_r'}{d\phi^2}\right)-\frac{dV_r'}{d\phi}\left(V_r'\frac{dV_r'}{d\phi}+\frac{dV_r'}{d\phi}\frac{d^2V_r'}{d\phi^2}\right)=0 \quad (48)$$

$$V'=\sqrt{V_r'^2+V_\phi'^2} \quad (49)$$

$$V_\phi'=\frac{dV_r'}{d\phi} \quad (50)$$

$$V'=\frac{1}{\sqrt{\frac{2}{(\gamma-1)M^2}+1}} \quad (51)$$

$$\tan(\phi-\theta)=\frac{V_\phi'}{V_r'} \quad (52)$$

$$\left.\frac{dV_r'}{d\phi}\right|_{\phi=\theta_c}=0 \quad (53)$$

$$\left.\frac{V_\phi'}{V_r'}\right|_{\phi=\beta}=\tan\beta\frac{(\gamma-1)M_1^2\sin^2\beta+2}{(\gamma+1)M_1^2\sin^2\beta} \quad (54)$$

Isentropic Flow Relations

$$\frac{T}{T_T}=\left[1+\frac{\gamma-1}{2}M^2\right]^{-1} \quad (55)$$

$$\frac{P}{P_T}=\left[1+\frac{\gamma-1}{2}M^2\right]^{-\frac{\gamma}{\gamma-1}} \quad (56)$$

$$\frac{\rho}{\rho_T}=\left[1+\frac{\gamma-1}{2}M^2\right]^{-\frac{1}{\gamma-1}} \quad (57)$$

$$\frac{A}{A_*}=\left(\frac{\gamma+1}{2}\right)^{-\frac{\gamma+1}{2(\gamma-1)}}\frac{1}{M}\left[1+\frac{\gamma-1}{2}M^2\right]^{\frac{\gamma+1}{2(\gamma-1)}} \quad (58)$$

$$\nu(M)=\sqrt{\frac{\gamma+1}{\gamma-1}}\tan^{-1}\sqrt{\frac{\gamma-1}{\gamma+1}(M^2-1)}-\tan^{-1}\sqrt{M^2-1} \quad (59)$$

Total Pressure Recovery

$$\frac{P_{T2}}{P_{T0}}=\left(\frac{P_{TL}}{P_{T0}}\right)\left(\frac{P_{T1}}{P_{TL}}\right)\left(\frac{P_{TTH}}{P_{T1}}\right)\left(\frac{P_{T2}}{P_{TTH}}\right) \quad (60)$$

External Compression

Pitot Inlets

$$\frac{P_{T1}}{P_{TL}} = \left[\frac{(\gamma+1)\,M_L^2}{(\gamma-1)\,M_L^2+2}\right]^{\frac{\gamma}{\gamma-1}} \left[\frac{\gamma+1}{2\gamma M_L^2-(\gamma-1)}\right]^{\frac{1}{\gamma-1}} \tag{61}$$

$$C_{D_{ADD}} = \frac{2}{\gamma M_L^2}\left[\left(\frac{P_1}{P_L}\right)(1+\gamma M_1^2)-1\right] - 2\left(\frac{A_{LI}}{A_C}\right) \tag{62}$$

$$\left(\frac{A_{LI}}{A_C}\right) = \left(\frac{P_{T1}}{P_{TL}}\right)\left(\frac{M_1}{M_L}\right)\left[\frac{1+\frac{\gamma-1}{2}M_1^2}{1+\frac{\gamma-1}{2}M_L^2}\right]^{-\frac{\gamma+1}{2(\gamma-1)}} \tag{63}$$

$$\left(\frac{P_1}{P_L}\right) = \left(\frac{P_{T1}}{P_{TL}}\right)\left[\frac{1+\frac{\gamma-1}{2}M_1^2}{1+\frac{\gamma-1}{2}M_L^2}\right]^{-\frac{\gamma}{\gamma-1}} \tag{64}$$

Axisymmetric Inlets

$$\left.\frac{P_{T1}}{P_{TL}}\right|_{cr} = \left[\frac{(\gamma+1)\,M_L^2\sin^2\beta}{(\gamma-1)\,M_L^2\sin^2\beta+2}\right]^{\frac{\gamma}{\gamma-1}} \left[\frac{\gamma+1}{2\gamma M_L^2\sin^2\beta-(\gamma-1)}\right]^{\frac{1}{\gamma-1}} \tag{65}$$

$$\left.C_{D_{ADD}}\right|_{cr} = \frac{2}{\gamma M_L^2}\left[\frac{P_1}{P_L}\left(1-\frac{A_S}{A_C}\right)(1+\gamma M_1^2)+\frac{P_S}{P_L}\frac{A_S}{A_C}-1\right] - 2\left(\frac{A_{LI}}{A_C}\right) \tag{66}$$

$$\left.C_{D_{ADD}}\right|_{cr} = \frac{2}{\gamma M_L^2}\int_L^1\left(\frac{P}{P_L}-1\right)\frac{dA}{A_C} \tag{67}$$

$$\left.\frac{P_{T1}}{P_{TL}}\right|_{sub} = \left.\frac{P_{T1}}{P_{TL}}\right|_{cr}\left[\frac{(\gamma+1)\,M_S^2}{(\gamma-1)\,M_S^2+2}\right]^{\frac{\gamma}{\gamma-1}} \left[\frac{\gamma+1}{2\gamma M_S^2-(\gamma-1)}\right]^{\frac{1}{\gamma-1}} \tag{68}$$

$$\left.C_{D_{ADD}}\right|_{sub} = \left.C_{D_{ADD}}\right|_{cr} + \frac{2}{\gamma M_L^2}\left(\frac{\overline{P}-P_S}{P_L}\right)\frac{A_{SY}}{A_C} \tag{69}$$

$$\frac{\left(\frac{A_{LI}}{A_C}\right)}{\left(1-\frac{A_S}{A_C}\right)} = \left.\frac{P_{T1}}{P_{TL}}\right|_{sub}\left(\frac{M_1}{M_L}\right)\left[\frac{1+\frac{\gamma-1}{2}M_1^2}{1+\frac{\gamma-1}{2}M_L^2}\right]^{-\frac{\gamma+1}{2(\gamma-1)}} \tag{70}$$

$$\overline{P} = \frac{P_Y+P_1}{2} \tag{71}$$

$$\frac{P_Y}{P_S} = \frac{2\gamma M_S^2-(\gamma-1)}{\gamma+1} \tag{72}$$

$$\frac{L_{SY}}{Y_C} = K\left[1-\frac{\left(\frac{A_{LI}}{A_C}\right)}{\left(\frac{A_{LI}}{A_C}\right)_{cr}}\right] \tag{73}$$

$$K = f\,(M_L) \tag{74}$$

Two-Dimensional Inlets

$$\left.\frac{P_{T1}}{P_{TL}}\right|_{cr} = \prod_{i=1}^{n}\left(\frac{P_{Ti}}{P_{Ti-1}}\right) \tag{75}$$

$$\left(\frac{P_{Ti}}{P_{Ti-1}}\right) = \left[\frac{(\gamma+1)\,M_{i-1}^2 \sin^2\beta_i}{(\gamma-1)\,M_{i-1}^2 \sin^2\beta_i + 2}\right]^{\frac{\gamma}{\gamma-1}} \left[\frac{\gamma+1}{2\gamma M_{i-1}^2 \sin^2\beta_i - (\gamma-1)}\right]^{\frac{1}{\gamma-1}} \tag{76}$$

$$M_i = \frac{1}{\sin(\beta_i - \theta_i)}\sqrt{\frac{(\gamma-1)\,M_{i-1}^2 \sin^2\beta_i + 2}{2\gamma M_{i-1}^2 \sin^2\beta_i - (\gamma-1)}} \tag{77}$$

$$\left.C_{D_{ADD}}\right|_{cr} = \frac{2}{\gamma M_L^2}\left[\frac{P_1}{P_L}\left(1 - \sum_{i=1}^{n}\frac{A_{Si}}{A_C}\right)(1+\gamma M_1^2) + \sum_{i=1}^{n}\frac{P_{Si}}{P_L}\frac{A_{Si}}{A_C} - 1\right] - 2\left(\frac{A_{LI}}{A_C}\right) \tag{78}$$

$$\left.\frac{P_{T1}}{P_{TL}}\right|_{sub} = \left.\frac{P_{T1}}{P_{TL}}\right|_{cr}\left[\frac{(\gamma+1)\,M_n^2}{(\gamma-1)\,M_n^2+2}\right]^{\frac{\gamma}{\gamma-1}}\left[\frac{\gamma+1}{2\gamma M_n^2 - (\gamma-1)}\right]^{\frac{1}{\gamma-1}} \tag{79}$$

$$\left.C_{D_{ADD}}\right|_{sub} = \left.C_{D_{ADD}}\right|_{cr} + \frac{2}{\gamma M_L^2}\left(\frac{\overline{P} - P_{Sn}}{P_L}\right)\frac{A_{SY}}{A_C} \tag{80}$$

$$\frac{\left(\frac{A_{LI}}{A_C}\right)}{\left(1 - \sum_{i=1}^{n}\frac{A_{Si}}{A_C}\right)} = \left.\frac{P_{T1}}{P_{TL}}\right|_{sub}\left(\frac{M_1}{M_L}\right)\left[\frac{1+\frac{\gamma-1}{2}M_1^2}{1+\frac{\gamma-1}{2}M_L^2}\right]^{-\frac{\gamma+1}{2(\gamma-1)}} \tag{81}$$

$$\frac{P_Y}{P_{Sn}} = \frac{2\gamma M_n^2 - (\gamma-1)}{\gamma+1} \tag{82}$$

Internal Compression

$$\left(\frac{A_{TH}}{A_C}\right) = \left[1 - \left(\frac{A_{LBLD}}{A_C}\right)\left(\frac{A_{LI}}{A_C}\right)^{-1}\right]\left(\frac{A_{LI}}{A_C}\right)\left(\frac{P_{TTH}}{P_{TL}}\right)^{-1}\left(\frac{M_{TH}}{M_L}\right)^{-1}\left[\frac{1+\frac{\gamma-1}{2}M_{TH}^2}{1+\frac{\gamma-1}{2}M_L^2}\right]^{\frac{\gamma+1}{2(\gamma-1)}} \tag{83}$$

$$\frac{P_{TTH}}{P_{TL}} = \left(\frac{P_{T1}}{P_{TL}}\right)\left(\frac{P_{TTH}}{P_{T1}}\right) \tag{84}$$

$$\frac{P_{TTH}}{P_{T1}} = \prod_{i=1}^{n}\left(\frac{P_{Ti}}{P_{Ti-1}}\right) \tag{85}$$

$$\left(\frac{P_{Ti}}{P_{Ti-1}}\right) = \left[\frac{(\gamma+1)\,M_{i-1}^2 \sin^2\beta_i}{(\gamma-1)\,M_{i-1}^2 \sin^2\beta_i + 2}\right]^{\frac{\gamma}{\gamma-1}} \left[\frac{\gamma+1}{2\gamma M_{i-1}^2 \sin^2\beta_i - (\gamma-1)}\right]^{\frac{1}{\gamma-1}} \tag{86}$$

$$M_i = \frac{1}{\sin(\beta_i - \theta)}\sqrt{\frac{(\gamma-1)\,M_{i-1}^2 \sin^2\beta_i + 2}{2\gamma M_{i-1}^2 \sin^2\beta_i - (\gamma-1)}} \tag{87}$$

Subsonic Diffusion

$$\left.\frac{P_{T2}}{P_{TTH}}\right|_{sub} = 1 - \left[K_D\left(1-\frac{A_{TH}}{A_2}\right)^2 + K_O + K_F\right] K_M \left[1-\left(1+\frac{\gamma-1}{2}M_{TH}^2\right)^{-\frac{\gamma}{\gamma-1}}\right] \tag{88}$$

$$\frac{A_{TH}}{A_2} = \left(\frac{A_{TH}}{A_C}\right)\left(\frac{A_2}{A_C}\right)^{-1} \tag{89}$$

$$K_D = f\left(2\theta_D\right) \tag{90}$$

$$K_O \simeq 1.2\left(\frac{Y_O}{L_D}\right) \tag{91}$$

$$K_F = 4f_D\left(\frac{L_D}{D_2}\right) \tag{92}$$

$$f_D \simeq 0.0025 \tag{93}$$

$$K_M = f\left(M_{TH}\right) \tag{94}$$

$$\left.\frac{P_{T2}}{P_{TTH}}\right|_{sup} = 1 - \left[K_D\left(1-\frac{A_{TH}}{A_2}\right)^2 + K_O + K_F\right] K_M \times \left[1-\left(1+\frac{(\gamma-1)^2 M_{TH}^2 + 2(\gamma-1)}{4\gamma M_{TH}^2 - 2(\gamma-1)}\right)^{-\frac{\gamma}{\gamma-1}}\right]\left(\frac{P_{T2}}{P_{T1}}\right)_{NS} \tag{95}$$

$$K_M = f\left(\sqrt{\frac{(\gamma-1)\,M_{TH}^2+2}{2\gamma M_{TH}^2-(\gamma-1)}}\right) \tag{96}$$

$$\left(\frac{P_{T2}}{P_{T1}}\right)_{NS} = \left[\frac{(\gamma+1)\,M_{NS}^2}{(\gamma-1)\,M_{NS}^2+2}\right]^{\frac{\gamma}{\gamma-1}}\left[\frac{\gamma+1}{2\gamma M_{NS}^2-(\gamma-1)}\right]^{\frac{1}{\gamma-1}} \tag{97}$$

Bleed Drag

$$C_{D_{BLD}} = 2\left(\frac{A_{LBLD}}{A_C}\right)\left[1 - C_{TL}\cos\theta_X \eta_v C_T\left(\frac{V_{Xi}}{V_L}\right)\right] \tag{98}$$

$$C_{TL} = f\left(M_L, \frac{A_X}{A_{TH}}, \theta_X\right) \tag{99}$$

$$C_T = \frac{1}{\gamma M_{Xieff}^2}\left(\frac{A_X}{A_{Xieff}}\right)\left[\left(\frac{P_X}{P_{Leff}}\right)\left(1+\gamma M_X^2\right)-1\right] \tag{100}$$

$$M_{Xieff} = \sqrt{\frac{2}{\gamma-1}\left[\left(\frac{P_{TBL}}{P_{Leff}}\right)^{\frac{\gamma-1}{\gamma}}-1\right]} \tag{101}$$

$$\frac{P_{TBL}}{P_{Leff}} = \left(\frac{P_{TBL}}{P_{TL}}\right)\left[1+\frac{\gamma-1}{2}M_L^2\right]^{\frac{\gamma}{\gamma-1}}\left(\frac{P_L}{P_{Leff}}\right) \tag{102}$$

$$\frac{P_L}{P_{Leff}} = f\left(M_L, \theta_X\right) \tag{103}$$

$$\frac{A_X}{A_{Xieff}} = \left(\frac{A_X}{A_{TH}}\right)\left(\frac{\gamma+1}{2}\right)^{\frac{\gamma+1}{2(\gamma-1)}} M_{Xieff}\left[1+\frac{\gamma-1}{2}M_{Xieff}^2\right]^{-\frac{\gamma+1}{2(\gamma-1)}} \tag{104}$$

$$\left(\frac{A_X}{A_{TH}}\right) = \left(\frac{\gamma+1}{2}\right)^{-\frac{\gamma+1}{2(\gamma-1)}} \frac{1}{M_X}\left[1+\frac{\gamma-1}{2}M_X^2\right]^{\frac{\gamma+1}{2(\gamma-1)}} \tag{105}$$

$$\frac{P_X}{P_{Leff}} = \left(\frac{P_{TBL}}{P_{Leff}}\right)\left[1+\frac{\gamma-1}{2}M_X^2\right]^{-\frac{\gamma}{\gamma-1}} \tag{106}$$

$$\frac{V_{Xi}}{V_L} = \left(\frac{M_{Xi}}{M_L}\right)\left[\frac{1+\frac{\gamma-1}{2}M_{Xi}^2}{1+\frac{\gamma-1}{2}M_L^2}\right]^{-\frac{1}{2}} \tag{107}$$

$$M_{Xi} = \sqrt{\frac{2}{\gamma-1}\left[\left(\frac{P_{TBL}}{P_L}\right)^{\frac{\gamma-1}{\gamma}}-1\right]} \tag{108}$$

$$\frac{P_{TBL}}{P_L} = \left(\frac{P_{TBL}}{P_{Leff}}\right)\left(\frac{P_{Leff}}{P_L}\right) \tag{109}$$

Bypass Drag

$$C_{D_{BYP}} = 2\left(\frac{A_{LBYP}}{A_C}\right)\left[1 - C_{TL}\cos\theta_X\,\eta_v C_T\left(\frac{V_{Xi}}{V_L}\right)\right] \tag{110}$$

$$M_{Xieff} = \sqrt{\frac{2}{\gamma-1}\left[\left(\frac{P_{TBP}}{P_{Leff}}\right)^{\frac{\gamma-1}{\gamma}}-1\right]} \tag{111}$$

$$\frac{P_{TBP}}{P_{Leff}} = \left(\frac{P_{TBP}}{P_{T2}}\right)\left(\frac{P_{T2}}{P_{TL}}\right)\left[1+\frac{\gamma-1}{2}M_L^2\right]^{\frac{\gamma}{\gamma-1}}\left(\frac{P_L}{P_{Leff}}\right) \tag{112}$$

$$\frac{P_X}{P_{Leff}} = \left(\frac{P_{TBP}}{P_{Leff}}\right)\left[1+\frac{\gamma-1}{2}M_X^2\right]^{-\frac{\gamma}{\gamma-1}} \tag{113}$$

$$M_{Xi} = \sqrt{\frac{2}{\gamma-1}\left[\left(\frac{P_{TBP}}{P_L}\right)^{\frac{\gamma-1}{\gamma}}-1\right]} \tag{114}$$

$$\frac{P_{TBP}}{P_L} = \left(\frac{P_{TBP}}{P_{Leff}}\right)\left(\frac{P_{Leff}}{P_L}\right) \tag{115}$$

Cowl Lip Suction

$$C_{LS} = (1 - K_\alpha) C_{D_{ADD}} - (K_\beta - K_\alpha) C_{D2} \tag{116}$$

$$K_\alpha = f(\sigma\theta_e, M_L) \tag{117}$$

$$\sigma = \begin{cases} 1, & M_L > 0.8 \\ f\left(\frac{A_{LI}}{A_C}, \theta_e\right), & M_L \leq 0.8 \end{cases} \tag{118}$$

$$\theta_e \approx \sqrt{2}\Omega \tag{119}$$

$$\Omega = \int_1^{\max} \frac{\left(\frac{Y}{Y_C}\right)\cos\overline{\psi}}{1 + 2\pi\left(\frac{X - X_C}{Y_C}\right)^2} d\left(\frac{Y}{Y_C}\right) \tag{120}$$

$$\overline{\psi} = \tan^{-1}\left(\frac{Y - Y_C}{X - X_C}\right) \tag{121}$$

$$K_\beta = \begin{cases} f(\theta_e, M_L), & M_L \geq 1 \\ 0, & M_L < 1 \end{cases} \tag{122}$$

$$C_{D2} = \begin{cases} f\left(\frac{A_{LI}}{A_C}, M_L\right), & M_L > 1 \\ 0, & M_L \leq 1 \end{cases} \tag{123}$$

$$C_{D_{SPL}} = C_{D_{ADD}} - C_{LS} \tag{124}$$

Cowl Lip and Wave Drag

$$C_{D_{CWL}} = C_{D_{LIP}} + C_{D_{WAV}} \tag{125}$$

$$C_{D_{LIP}} = \frac{2}{\gamma M_L^2}\left\{\frac{1}{2}\left[\frac{(\gamma+1)M_L^2}{2}\right]^{\frac{\gamma}{\gamma-1}}\left[\frac{\gamma+1}{2\gamma M_L^2 - (\gamma-1)}\right]^{\frac{1}{\gamma-1}} + \frac{1}{2}\left[\frac{2\gamma M_L^2 - (\gamma-1)}{\gamma+1}\right] - 1\right\}\frac{A_x}{A_C} \tag{126}$$

Two-Dimensional Inlets

$$C_{D_{WAV}} = \frac{2}{\gamma M_L^2}\int\left(\frac{P}{P_L} - 1\right)\frac{dA_x}{A_C} \tag{127}$$

$$C_{D_{WAV}} = \frac{2}{\gamma M_L^2}\sum_i^{N_C}\left(\frac{P_i}{P_L} - 1\right)\frac{A_{xi}}{A_C} \tag{128}$$

Axisymmetric Inlets

$$C_{D_{WAV}} = \int C_P \frac{dA_x}{A_C} \tag{129}$$

$$C_P = -2u = -2\frac{\partial\phi}{\partial x} \tag{130}$$

$$(1-M_L^2)\frac{\partial^2\phi}{\partial x^2}+\frac{\partial^2\phi}{\partial r^2}+\frac{1}{r}\frac{\partial\phi}{\partial r}=0 \tag{131}$$

$$\phi(x,r)=\int_0^{x-\lambda r}\frac{f(\xi)d\xi}{\sqrt{(x-\xi)^2-\lambda^2r^2}} \tag{132}$$

$$u(x,r)=\int_0^{x-\lambda r}\frac{f'(\xi)d\xi}{\sqrt{(x-\xi)^2-\lambda^2r^2}} \tag{133}$$

$$v(x,r)=-\frac{1}{r}\int_0^{x-\lambda r}\frac{(x-\xi)f'(\xi)d\xi}{\sqrt{(x-\xi)^2-\lambda^2r^2}} \tag{134}$$

$$\lambda^2=M_L^2-1 \tag{135}$$

$$\frac{dR}{dX}=R'(X)=-\frac{1}{R}\int_0^{X-\lambda R}\frac{(X-\xi)f'(\xi)d\xi}{\sqrt{(X-\xi)^2-\lambda^2R^2}} \tag{136}$$

$$-R_n'=\sum_{i=1}^{n}f_i'\frac{1}{R_n}\int_{\xi_{i-1}}^{\xi_i}\frac{(X_n-\xi)d\xi}{\sqrt{(X_n-\xi)^2-\lambda^2R_n^2}} \tag{137}$$

$$\xi_0=0 \tag{138}$$

$$\xi_n=X_n-\lambda R_n \tag{139}$$

$$-R_n'R_n=-\sum_{i=1}^{n}f_i'\left(\sqrt{(X_n-\xi_i)^2-\lambda^2R_n^2}-\sqrt{(X_n-\xi_{i-1})^2-\lambda^2R_n^2}\right) \tag{140}$$

$$f_n'=\frac{-R_n'R_n+\sum_{i=1}^{n-1}f_i'\left(\sqrt{(X_n-\xi_i)^2-\lambda^2R_n^2}-\sqrt{(X_n-\xi_{i-1})^2-\lambda^2R_n^2}\right)}{\sqrt{(X_n-\xi_{n-1})^2-\lambda^2R_n^2}} \tag{141}$$

$$C_P=-2\sum_{i=1}^{n}f_i'\int_{\xi_{i-1}}^{\xi_i}\frac{d\xi}{\sqrt{(X_n-\xi)^2-\lambda^2R_n^2}} \tag{142}$$

$$C_P=-2\sum_{i=1}^{n}f_i'\ln\left[\frac{X_n-\xi_{i-1}+\sqrt{(X_n-\xi_{i-1})^2-\lambda^2R_n^2}}{X_n-\xi_i+\sqrt{(X_n-\xi_i)^2-\lambda^2R_n^2}}\right] \tag{143}$$

$$\left.\frac{P_{T1}}{P_{TL}}\right|_{sl} = \frac{\left[\dfrac{1+\dfrac{\gamma-1}{2}M_1^2}{1+\dfrac{\gamma-1}{2}M_L^2}\right]^{\frac{\gamma+1}{2(\gamma-1)}}}{(1+\gamma M_1^2)\left[\dfrac{1+\dfrac{\gamma-1}{2}M_1^2}{1+\dfrac{\gamma-1}{2}M_L^2}\right]^{-\frac{1}{2}} - \gamma M_1 M_L} \tag{144}$$

$$\frac{1}{M_1}\left[1+\frac{\gamma-1}{2}M_1^2\right]^{\frac{\gamma+1}{2(\gamma-1)}} = \left(\frac{A_{TH}}{A_1}\right)^{-1}\frac{1}{M_{TH}}\left[1+\frac{\gamma-1}{2}M_{TH}^2\right]^{\frac{\gamma+1}{2(\gamma-1)}} \tag{145}$$

$$\frac{P_{T1}}{P_{TL}} = \frac{1}{1+\exp^{-1}\left[4.66\left(\frac{r_C}{Y_C}\right)\right]\left[\left(\left.\frac{P_{T1}}{P_{TL}}\right|_{sl}\right)^{-1} - 1\right]} \tag{146}$$

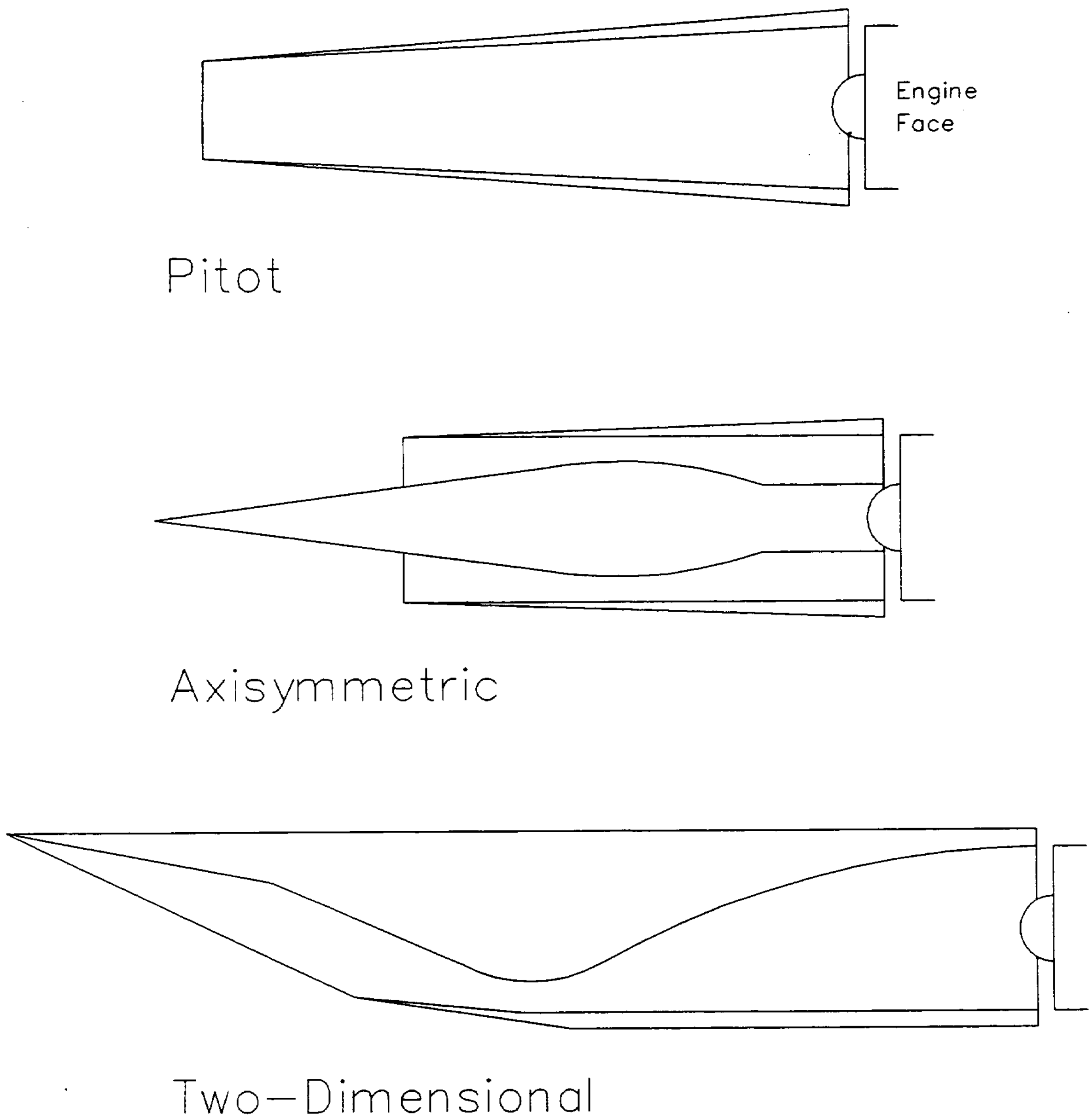


Figure 1 Common Inlet Geometric Types

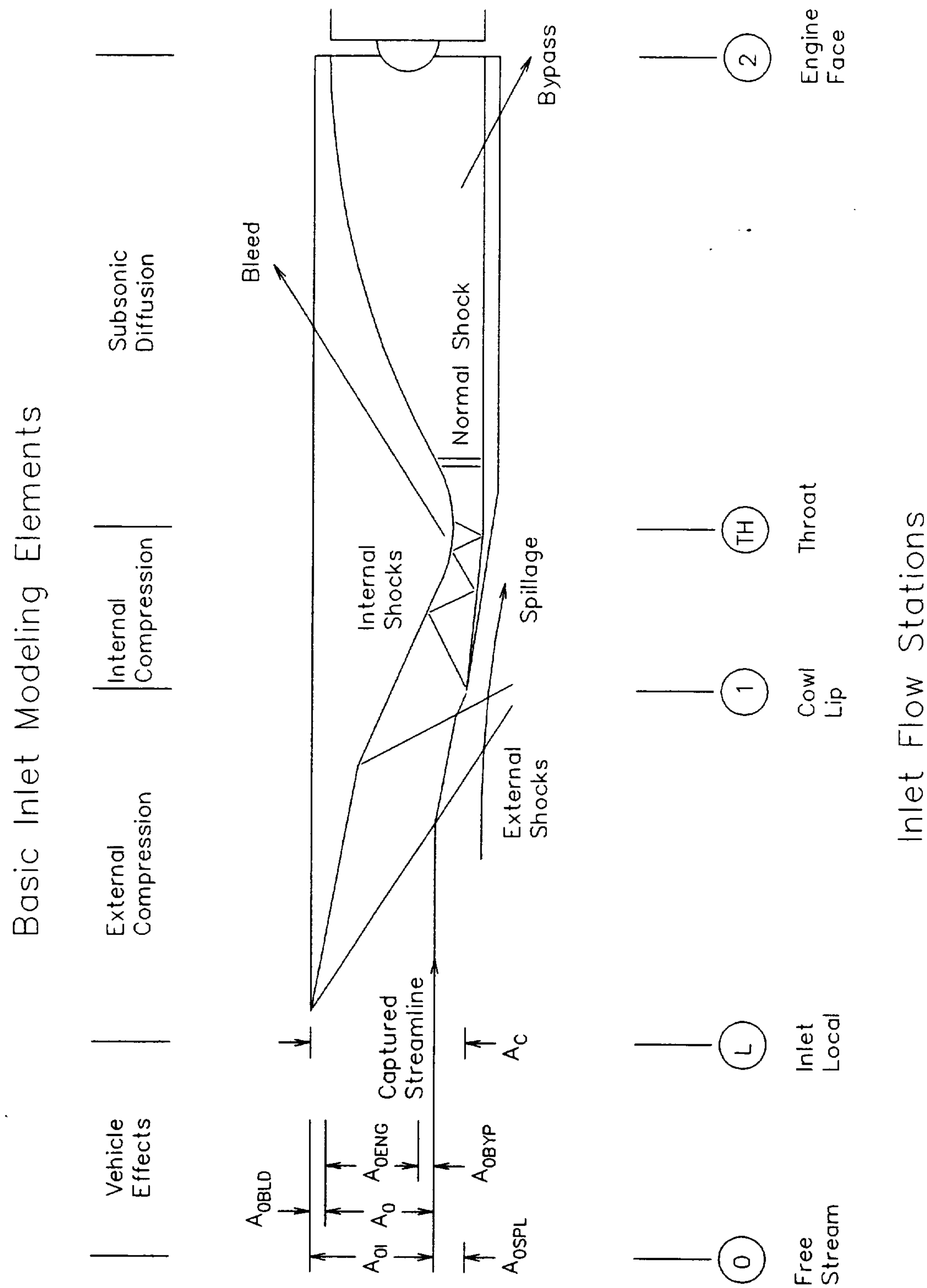


Figure 2 **Basic Inlet Modeling Elements Incorporated in the Analyses**

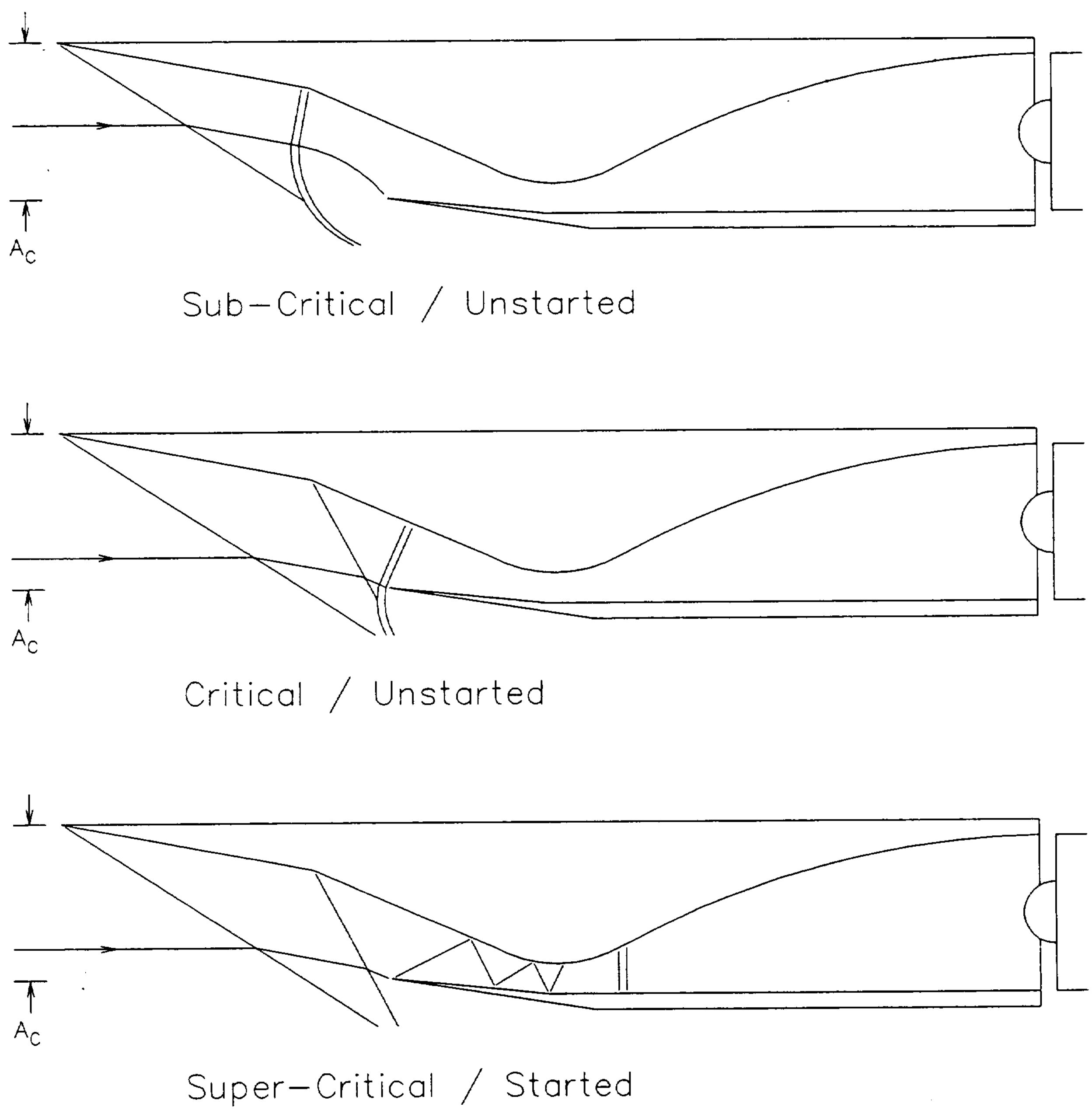


Figure 3 **Mixed-Compression Inlet Modes of Operation**

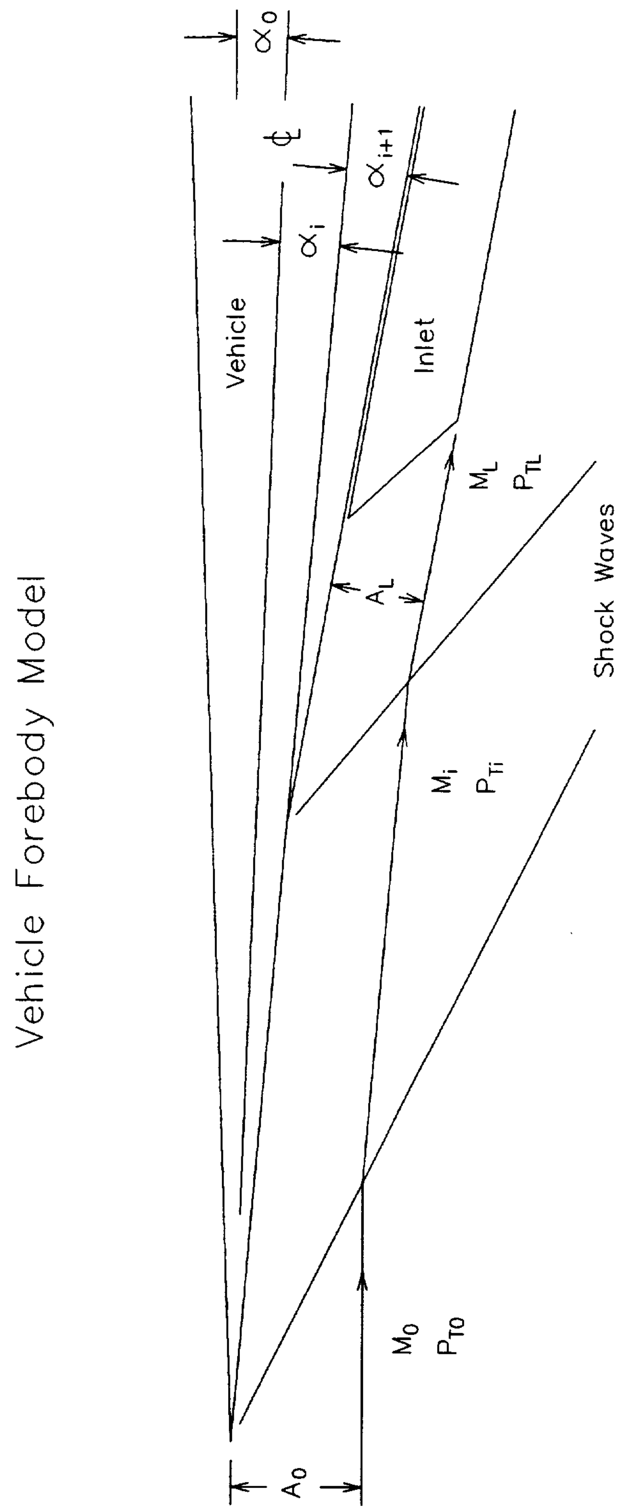


Figure 4 Vehicle Forebody Modeling Elements

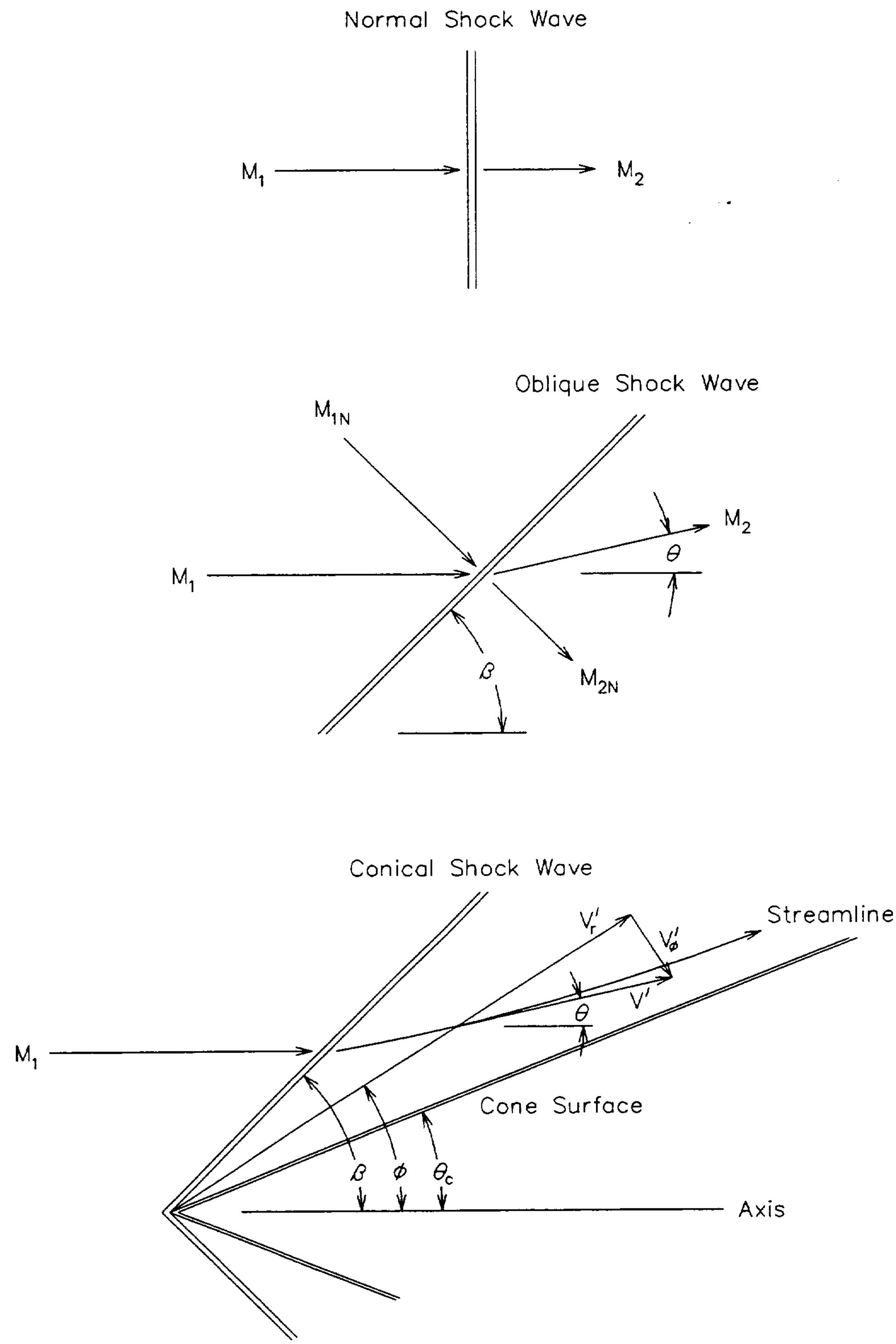


Figure 5 **Basic Shock Wave Types Incorporated in the Analyses**

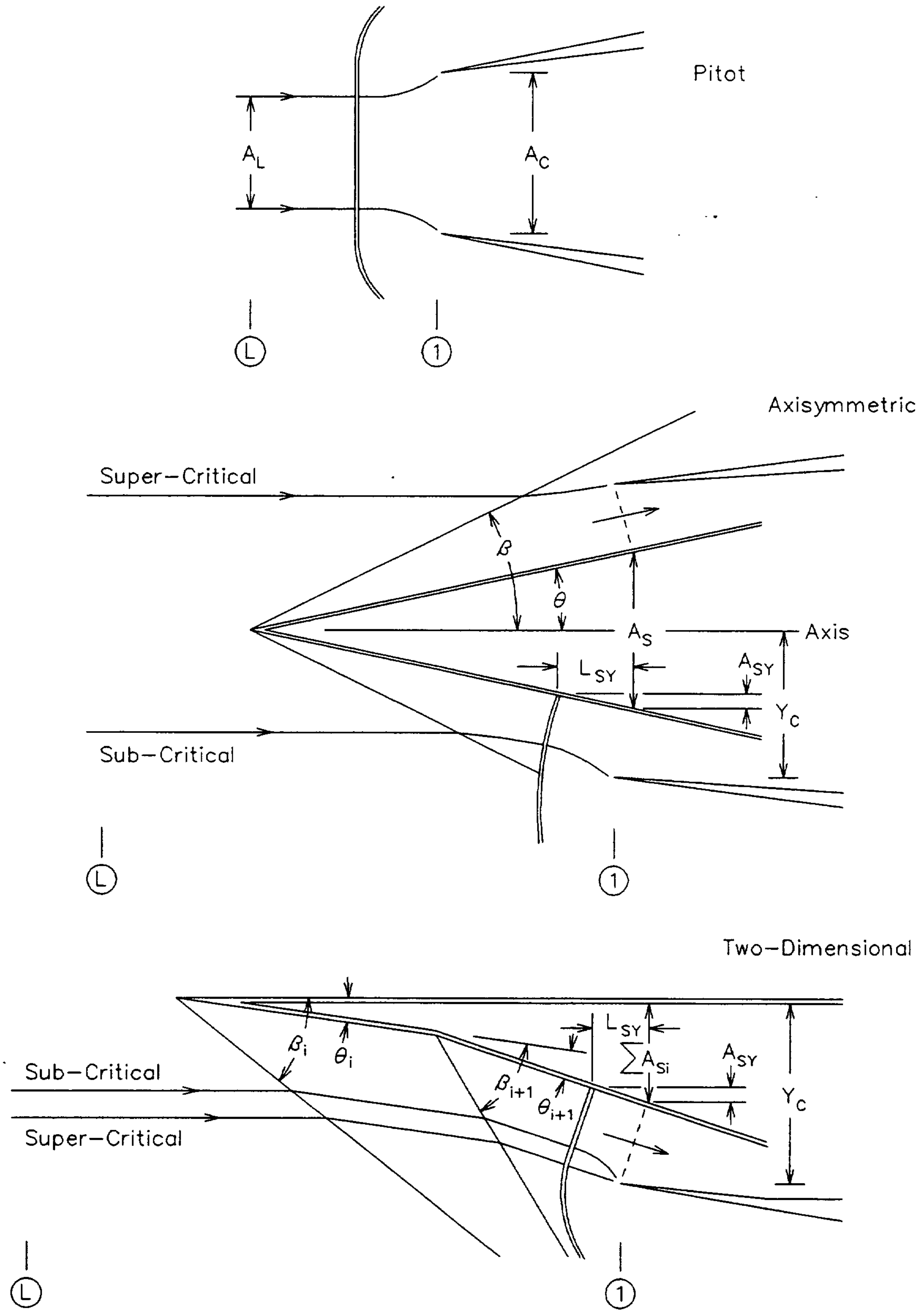


Figure 6 **External Compression Modeling Elements**

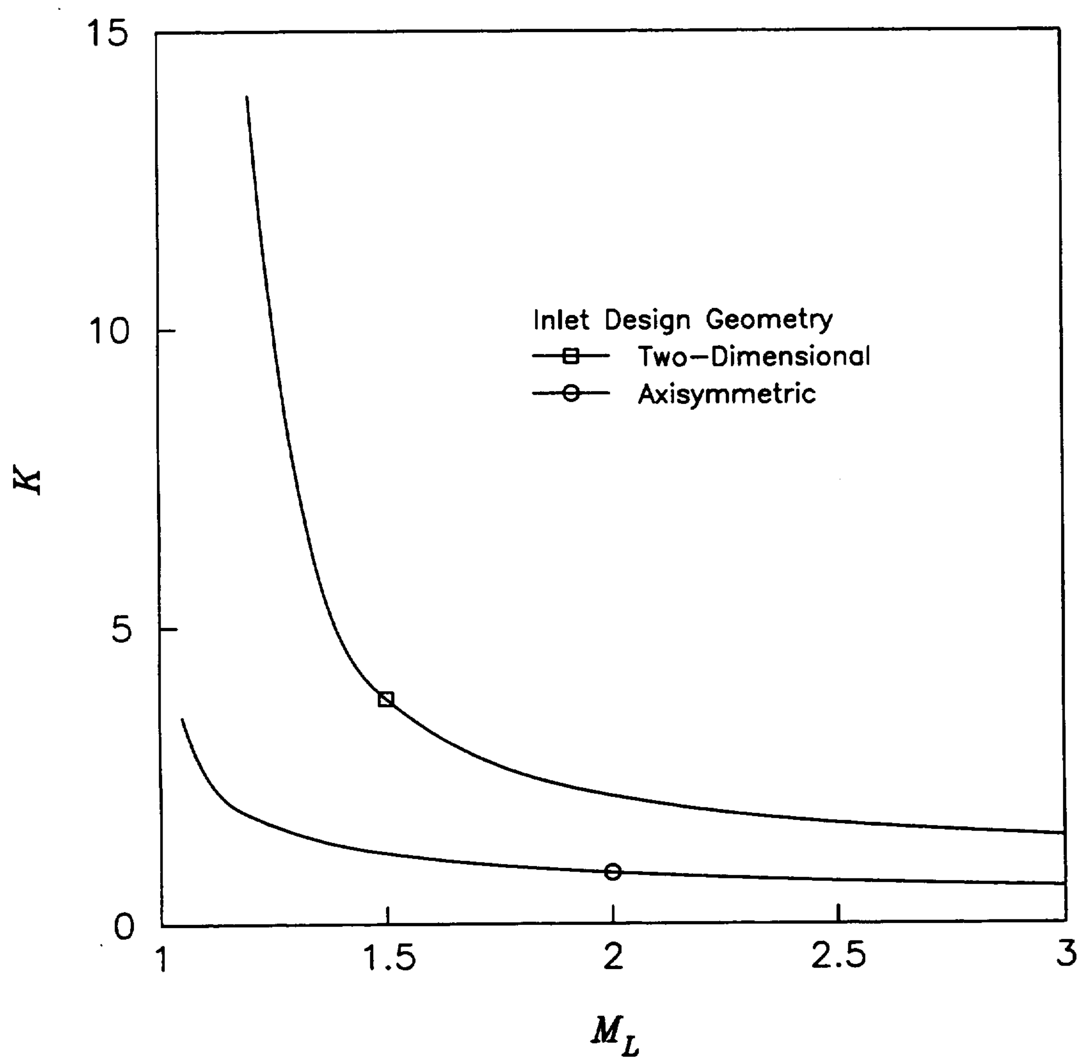


Figure 7 Unstarted Inlet Shock Wave Standoff Factor, K

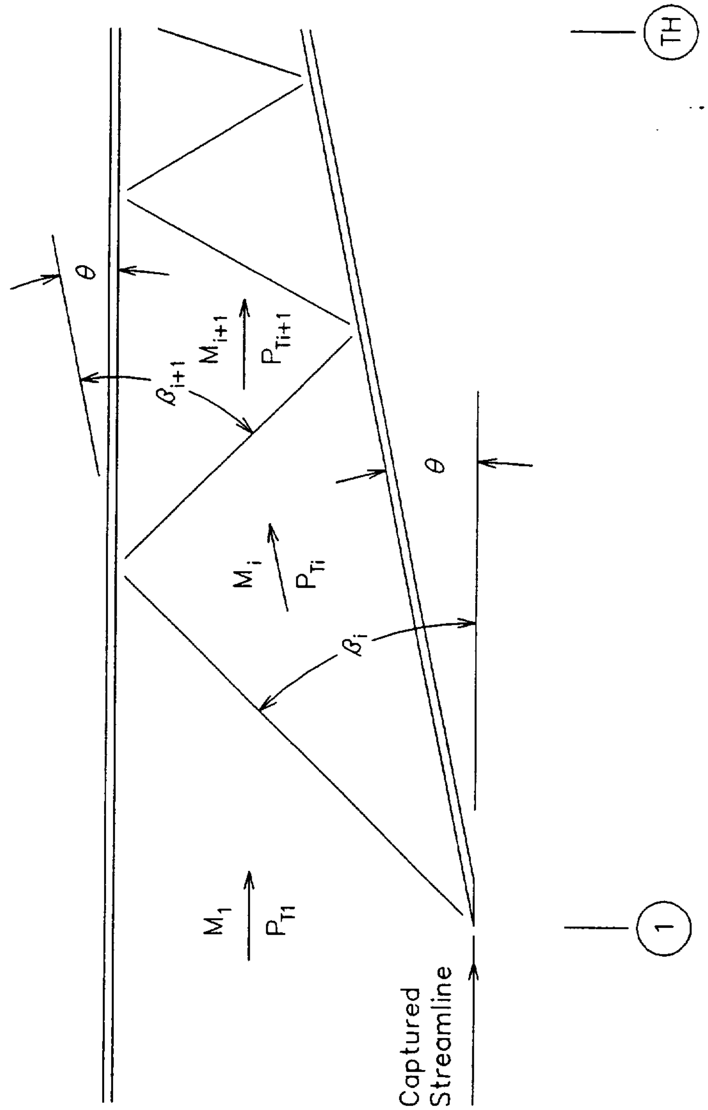


Figure 8 Internal Compression Modeling Elements

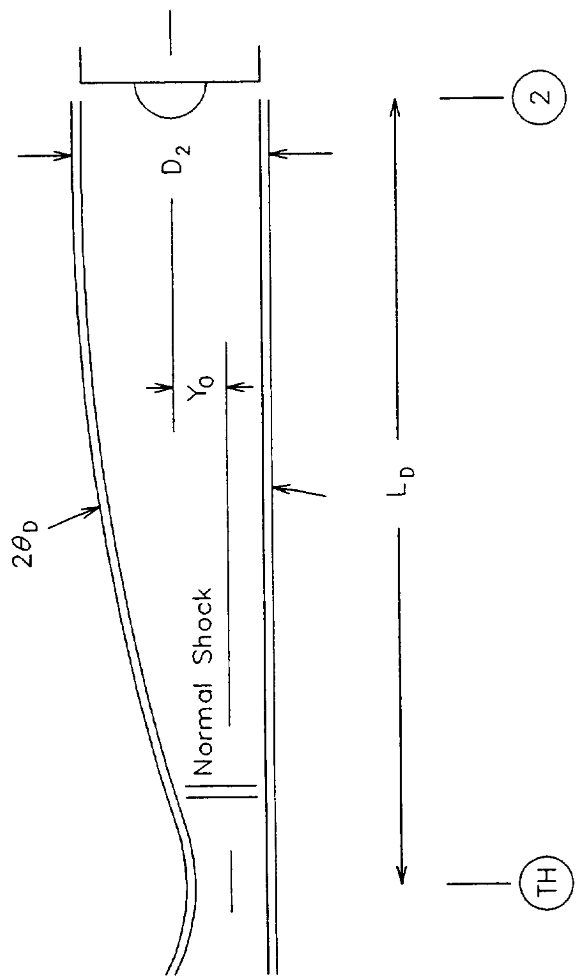


Figure 9 Subsonic Diffusion Modeling Elements

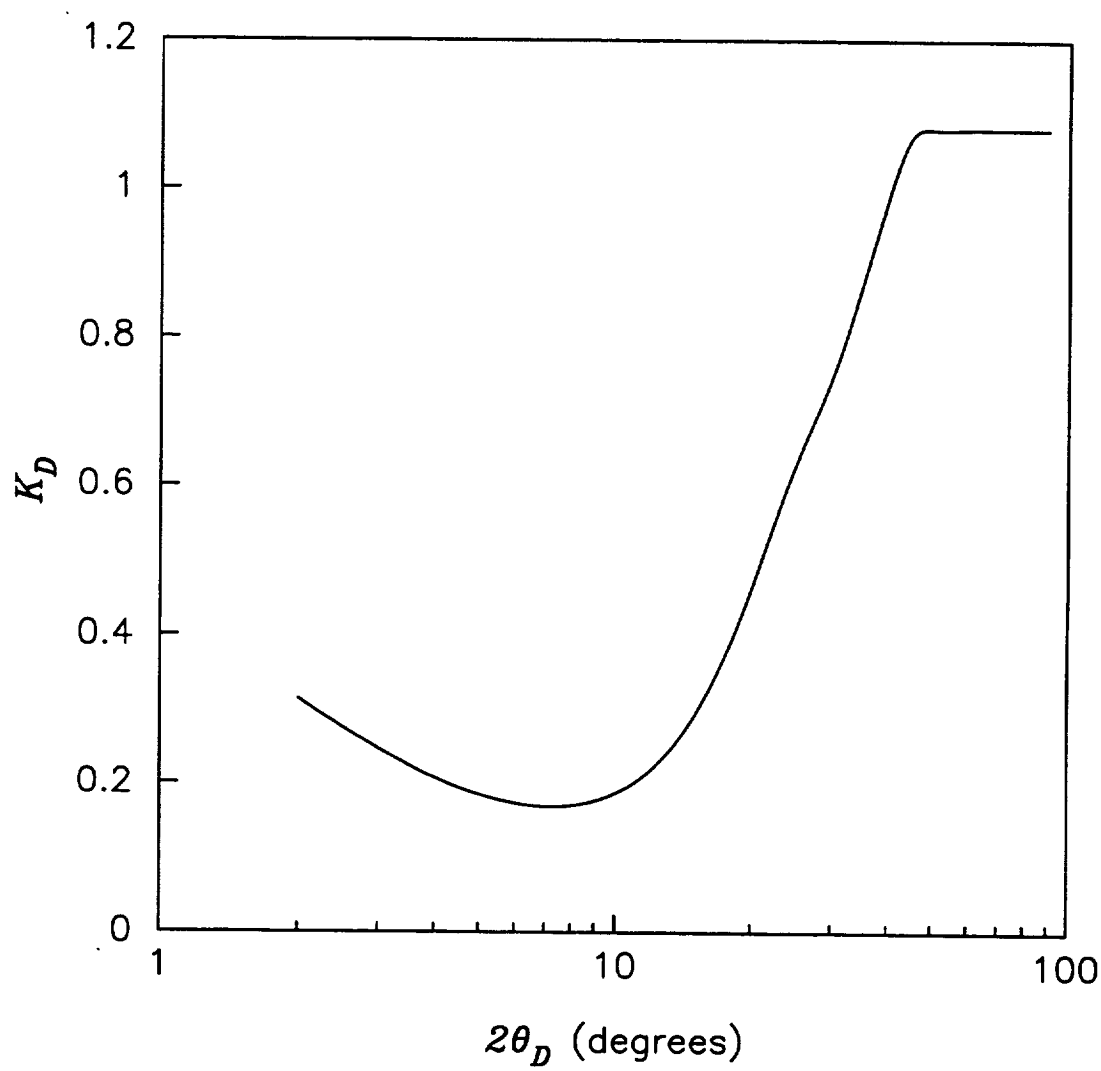


Figure 10 Subsonic Diffuser Total Pressure Loss Factor, K_D

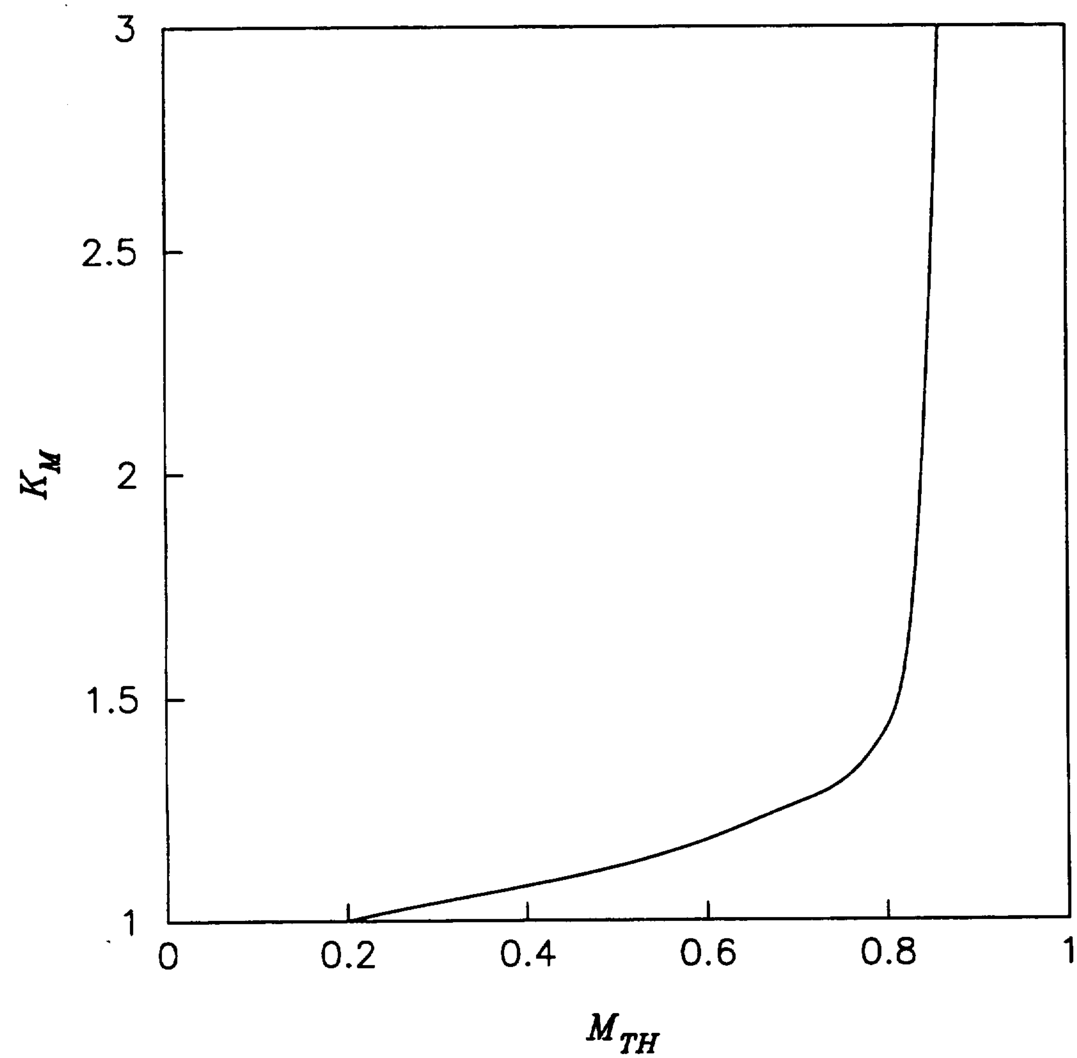


Figure 11 Subsonic Diffuser Throat Mach Number Factor, K_M

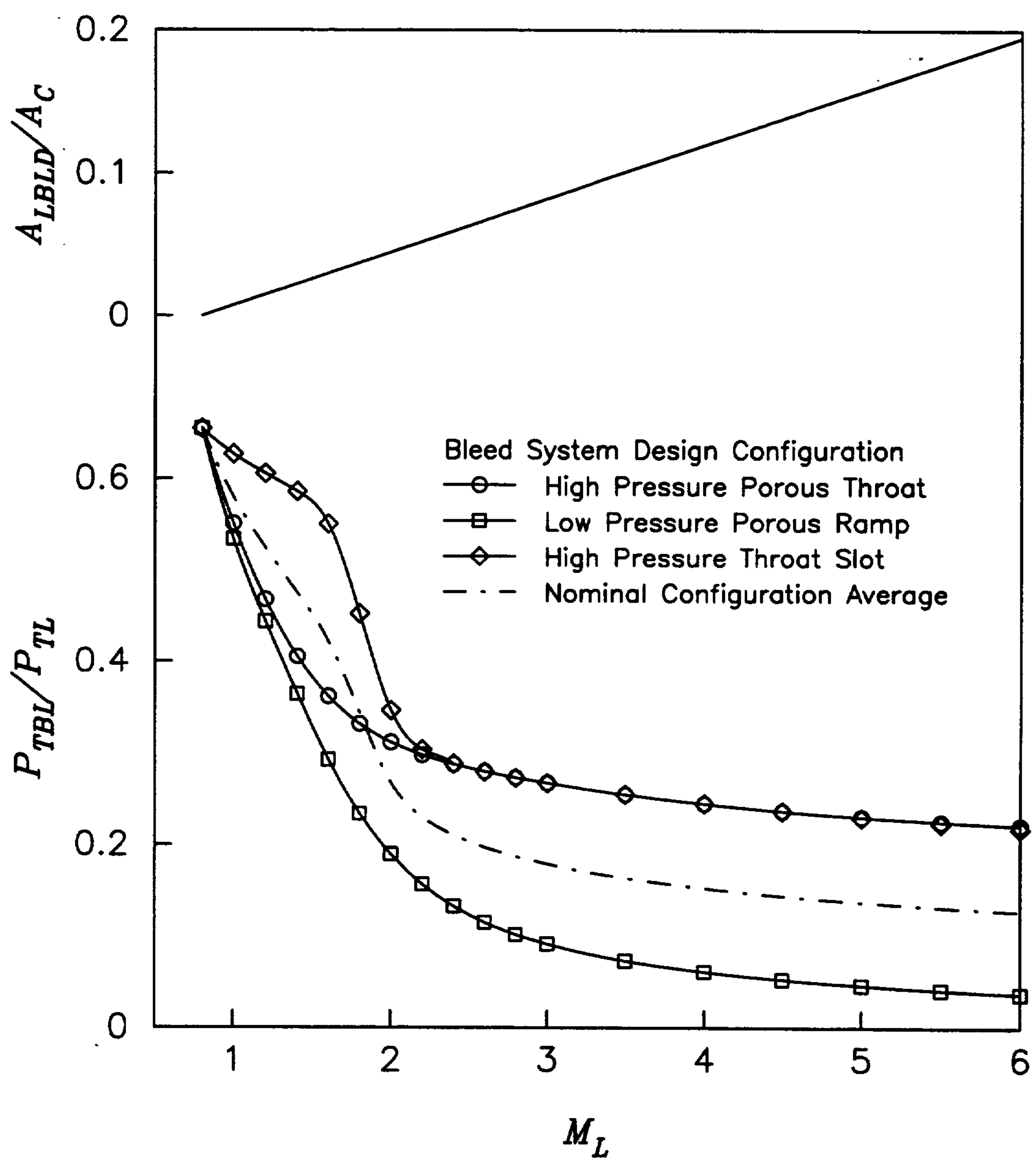


Figure 12 Bleed System Operating Characteristics

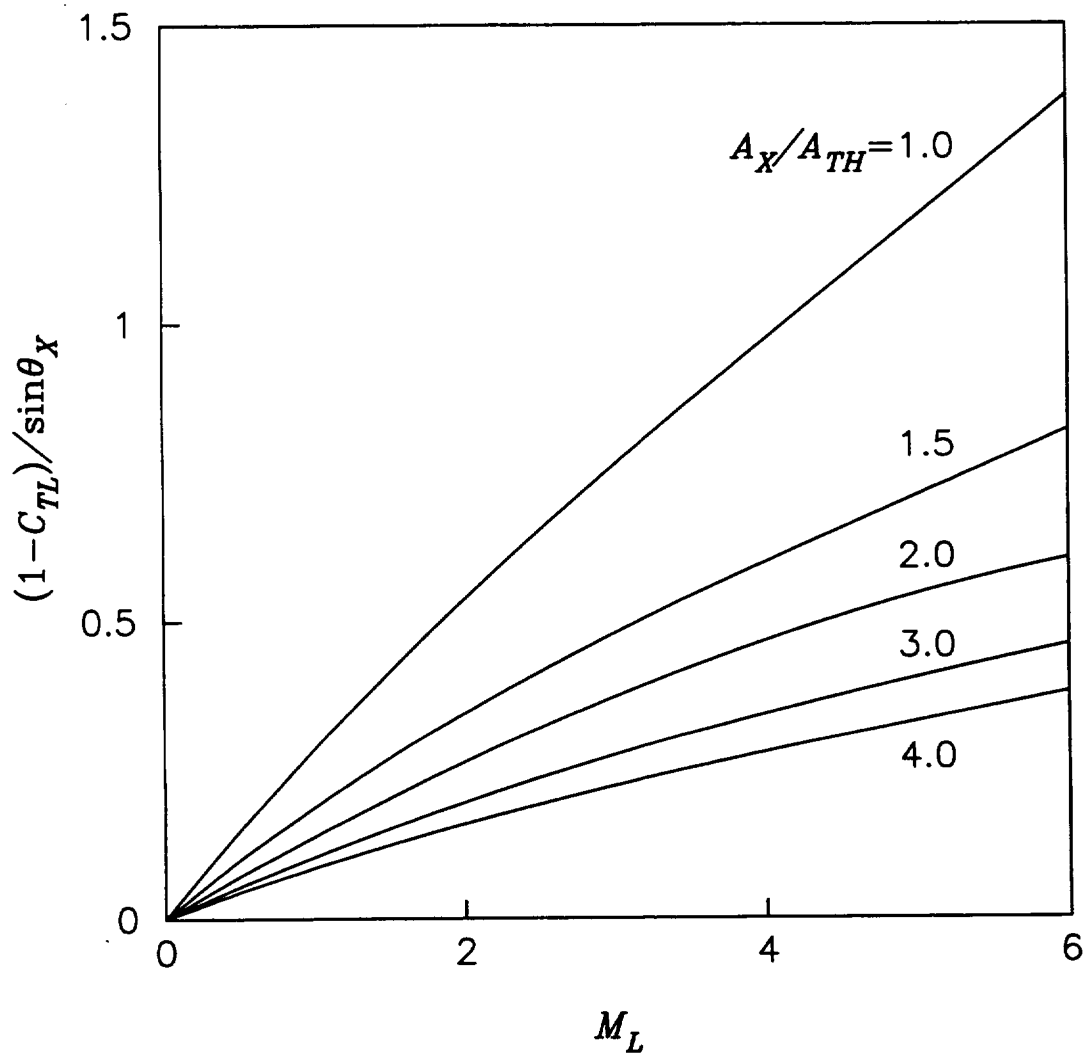


Figure 13 Oblique Exit Nozzle Drag Factor

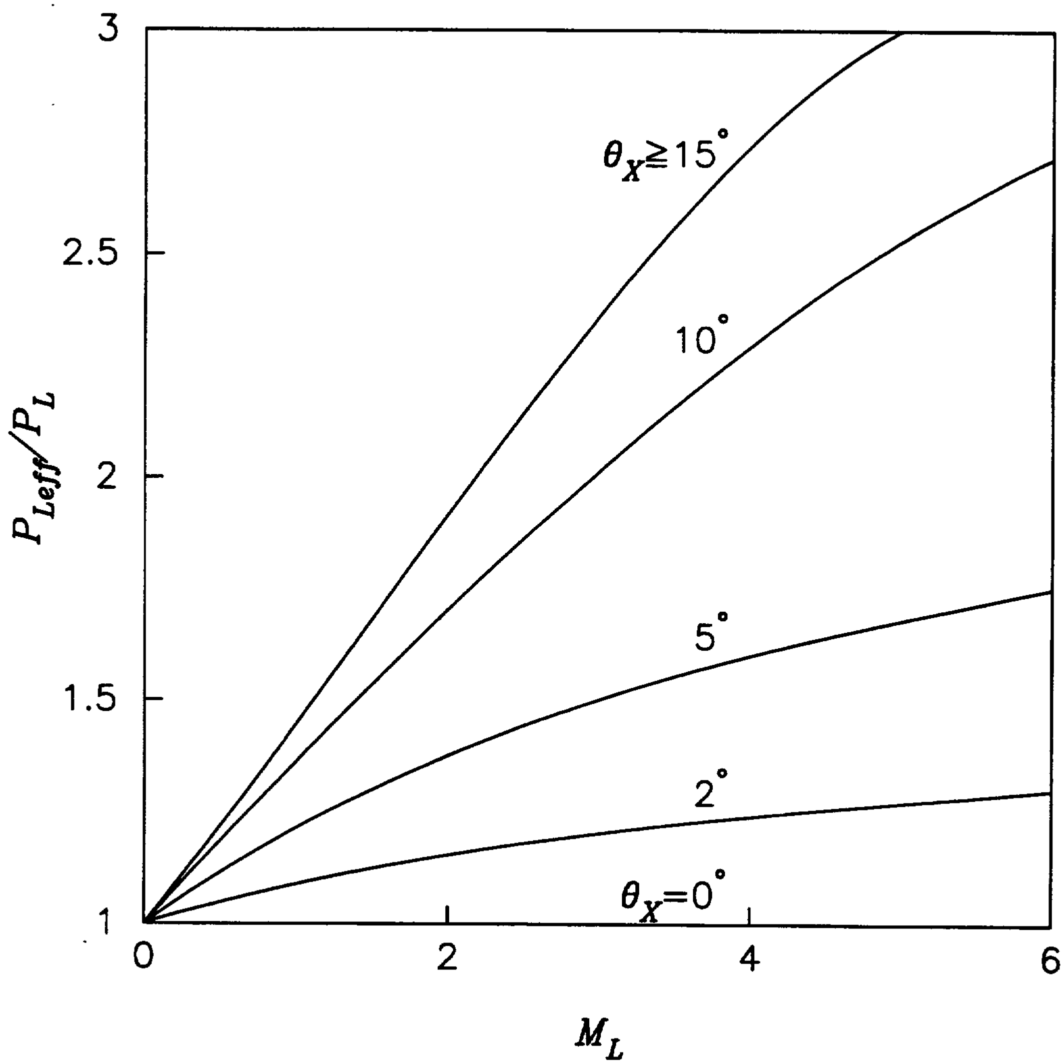


Figure 14 Effective Nozzle Discharge Pressure for Oblique Exits

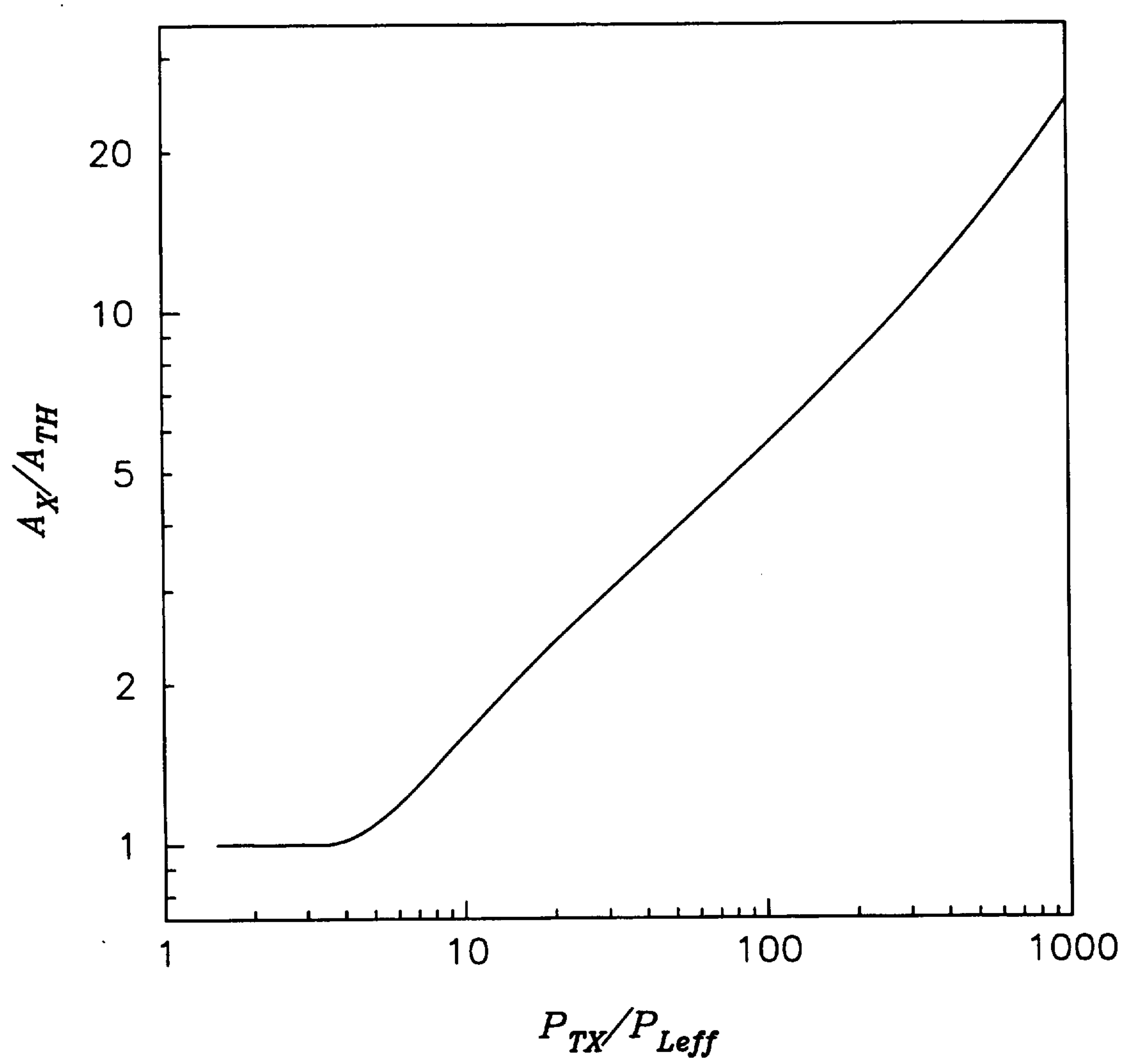


Figure 15 Bleed and Bypass System Nozzle Exit Area Ratio

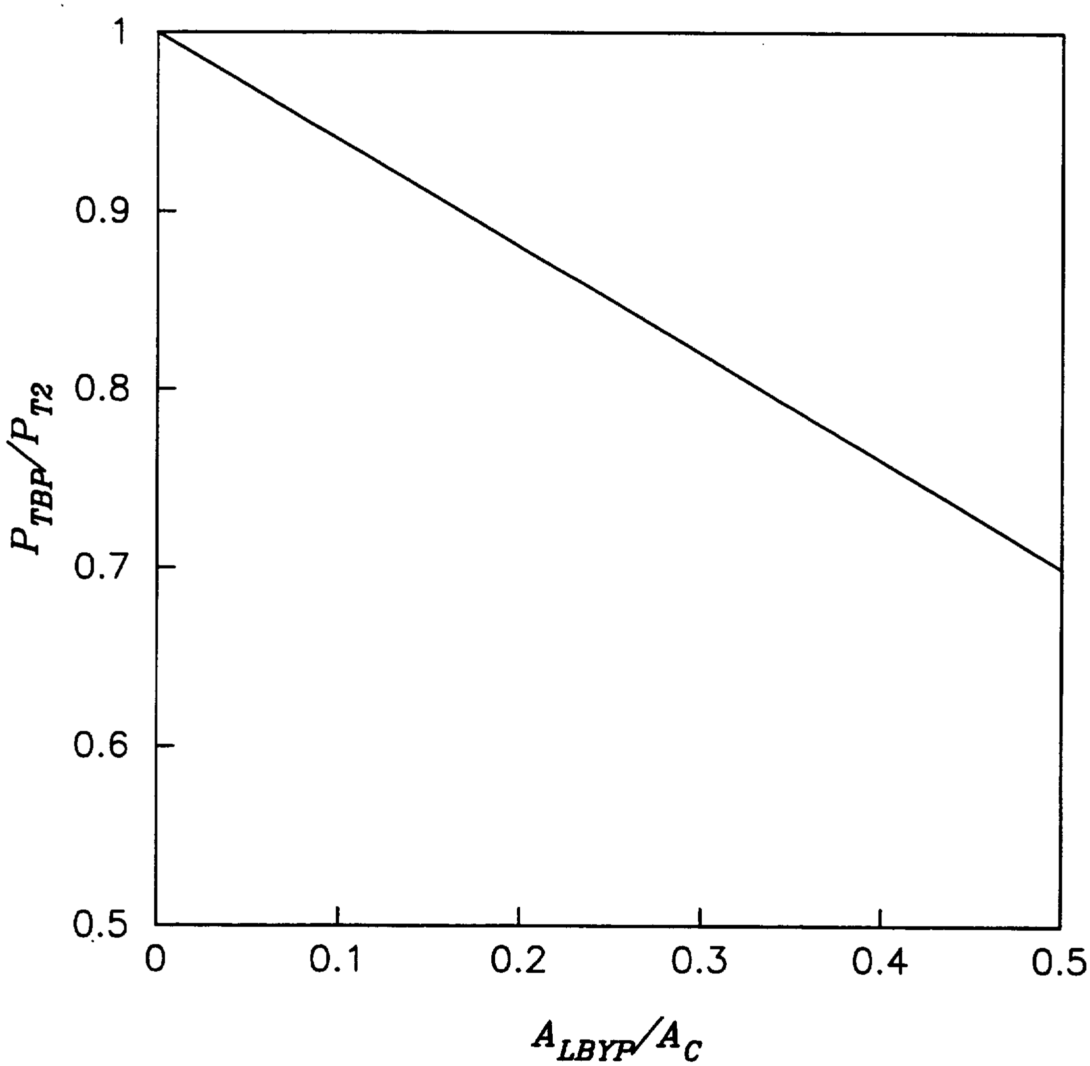


Figure 16 Bypass System Total Pressure Loss

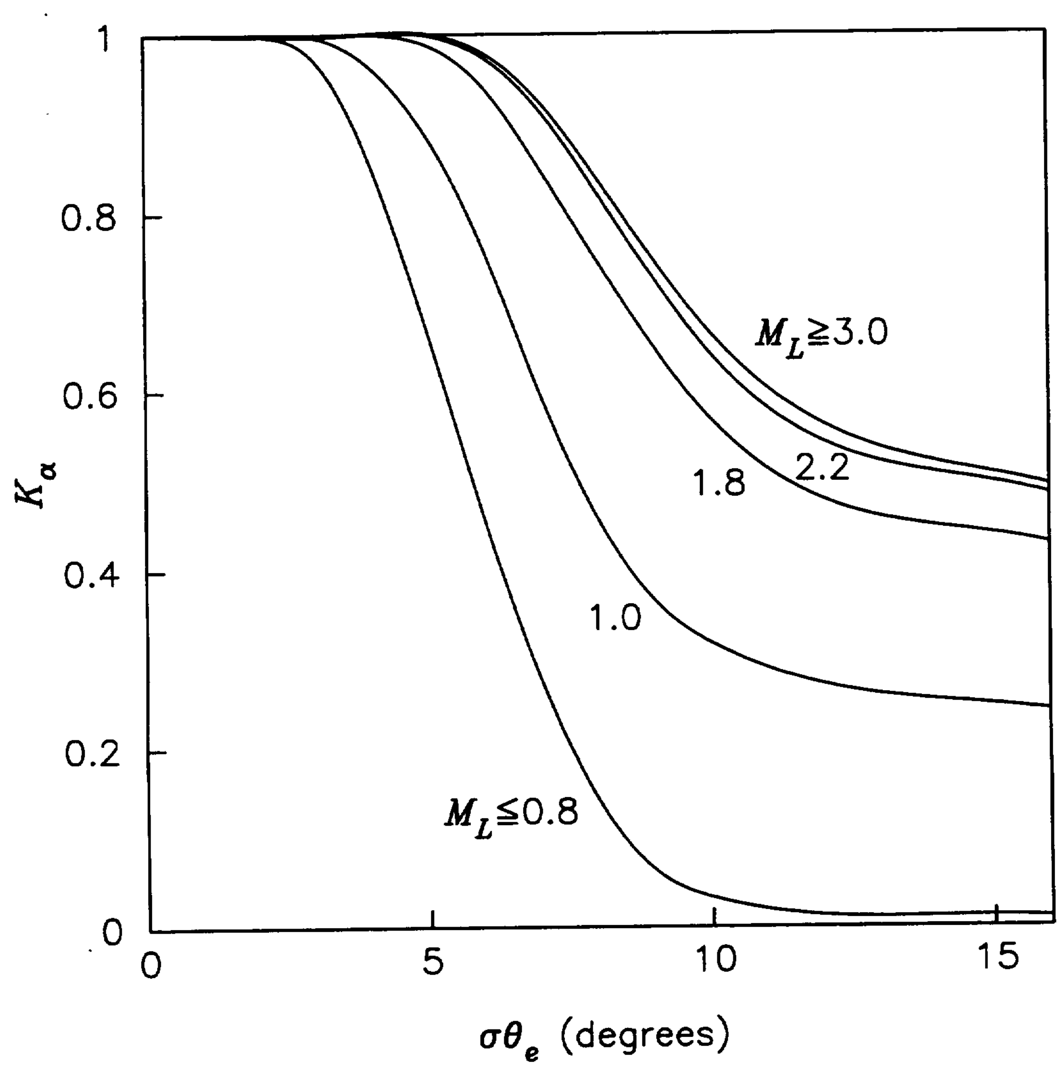


Figure 17 Cowl Lip Suction Factor, K_α

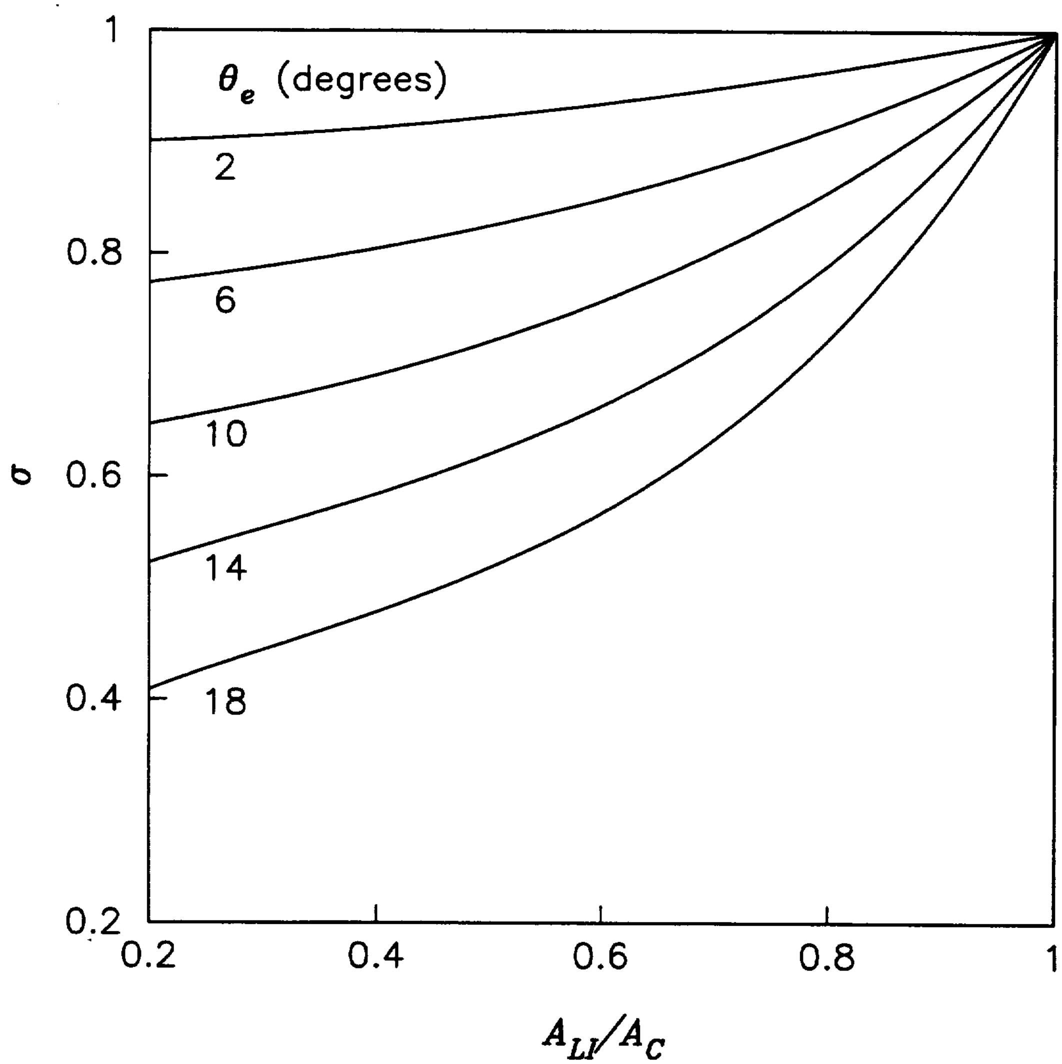


Figure 18 Cowl Lip Angle Correction Factor, σ

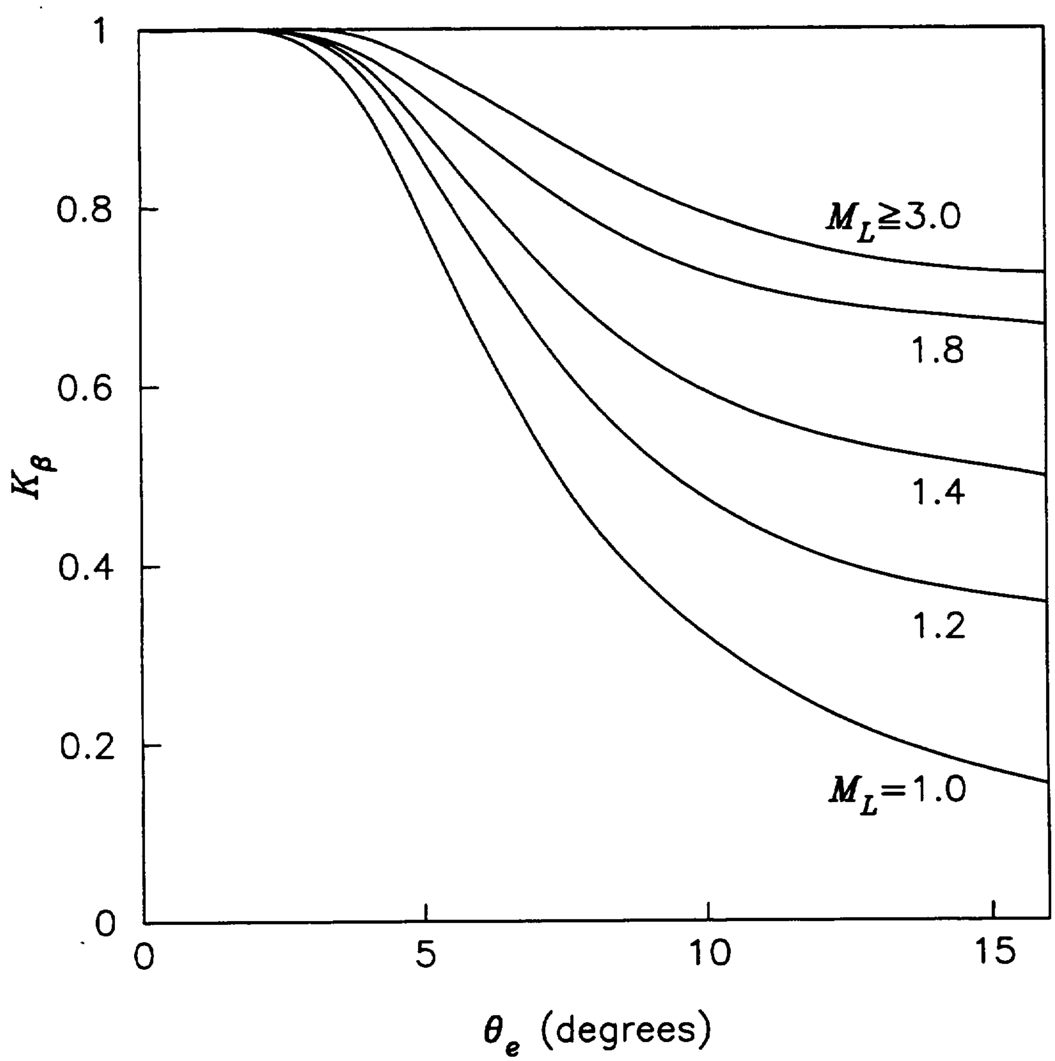


Figure 19 Cowl Lip Suction Factor, K_β

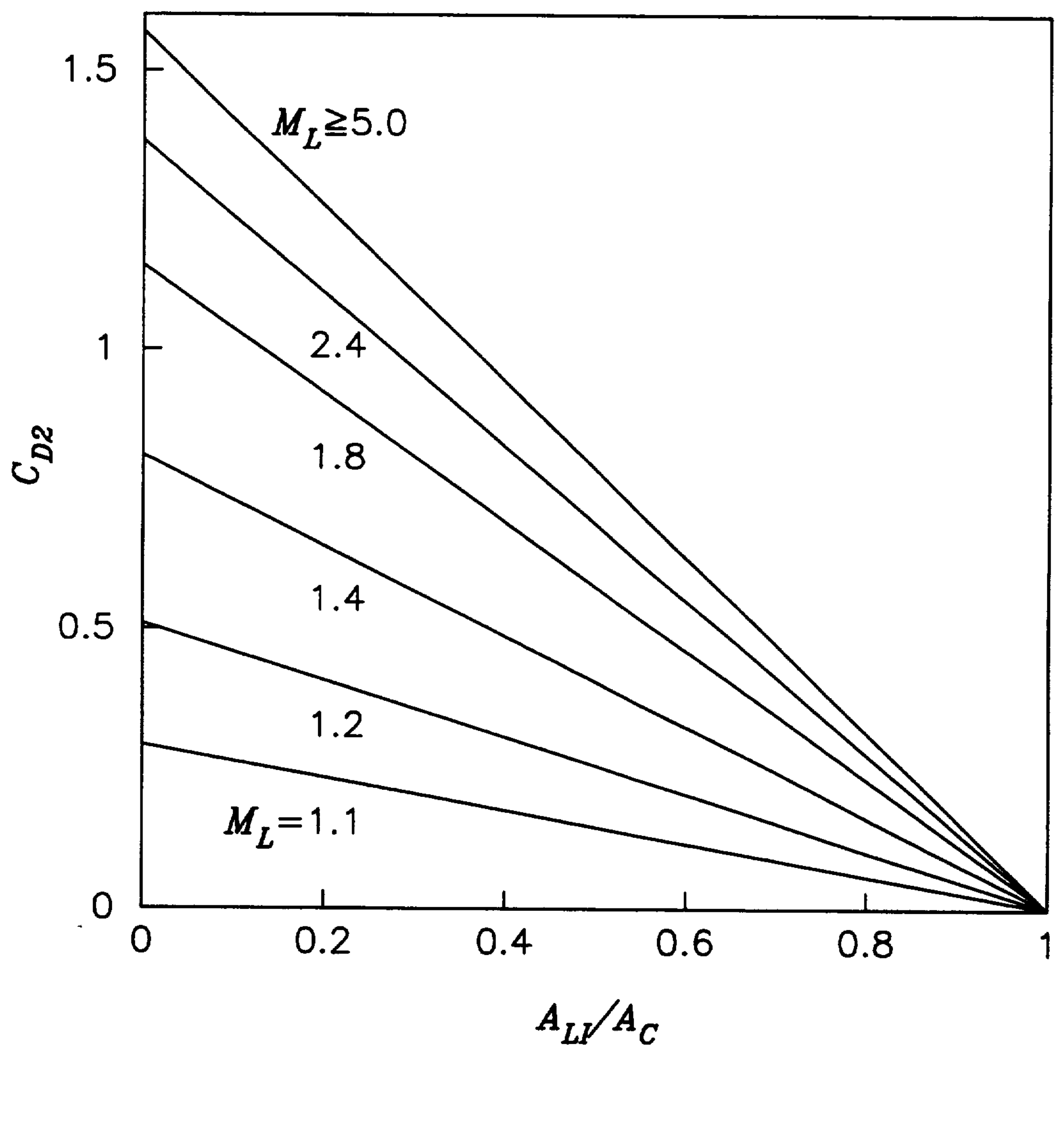


Figure 20 Cowl Lip Suction Factor, C_{D2}

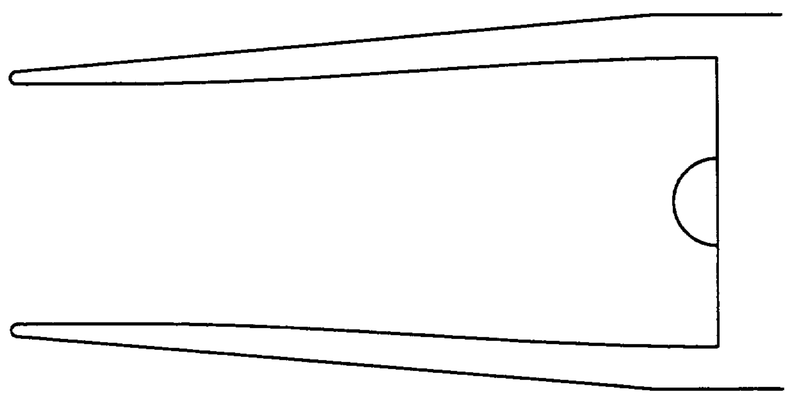


Figure 21 Pitot Inlet Geometry

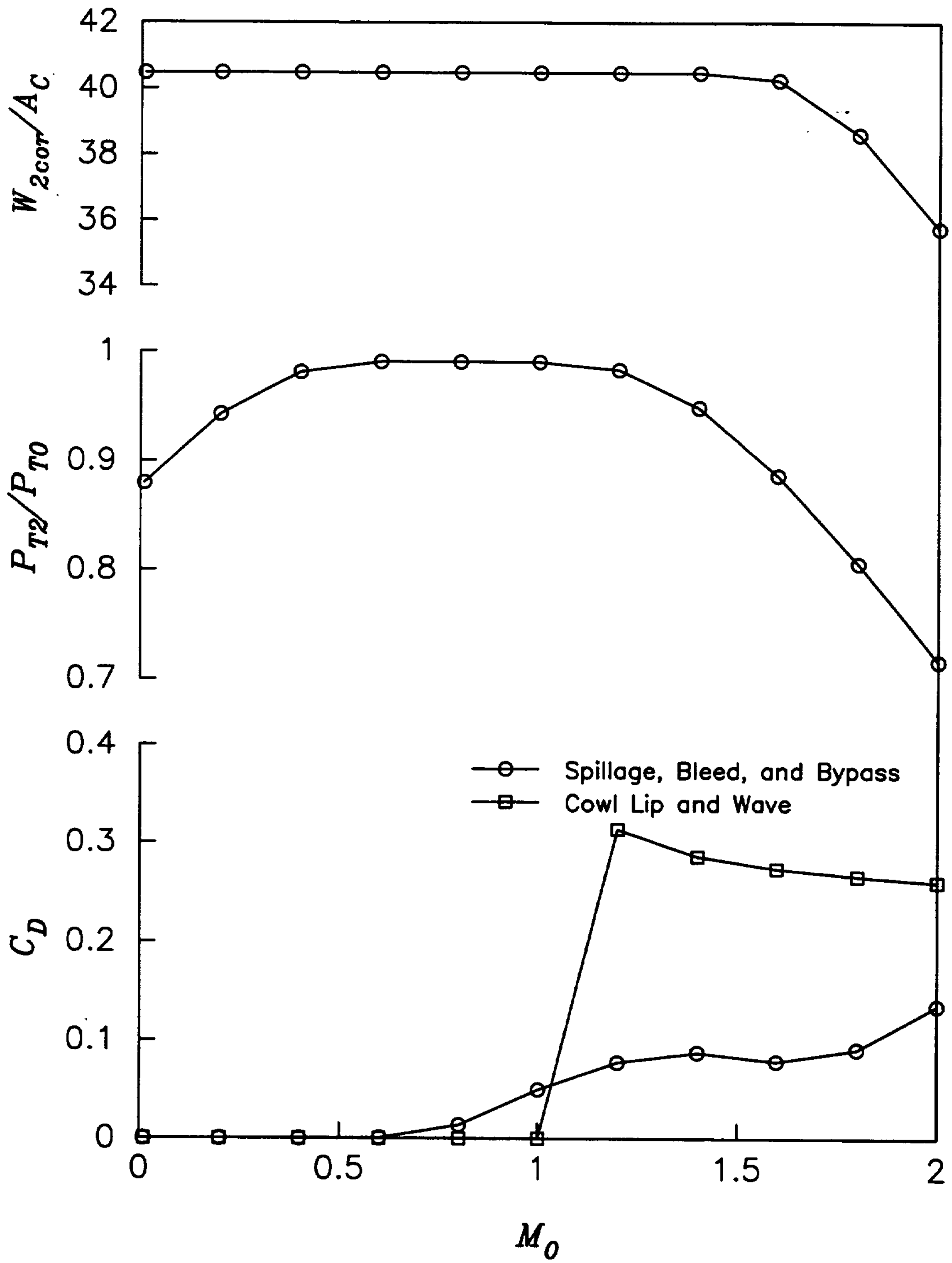


Figure 22 Pitot Inlet Performance Summary

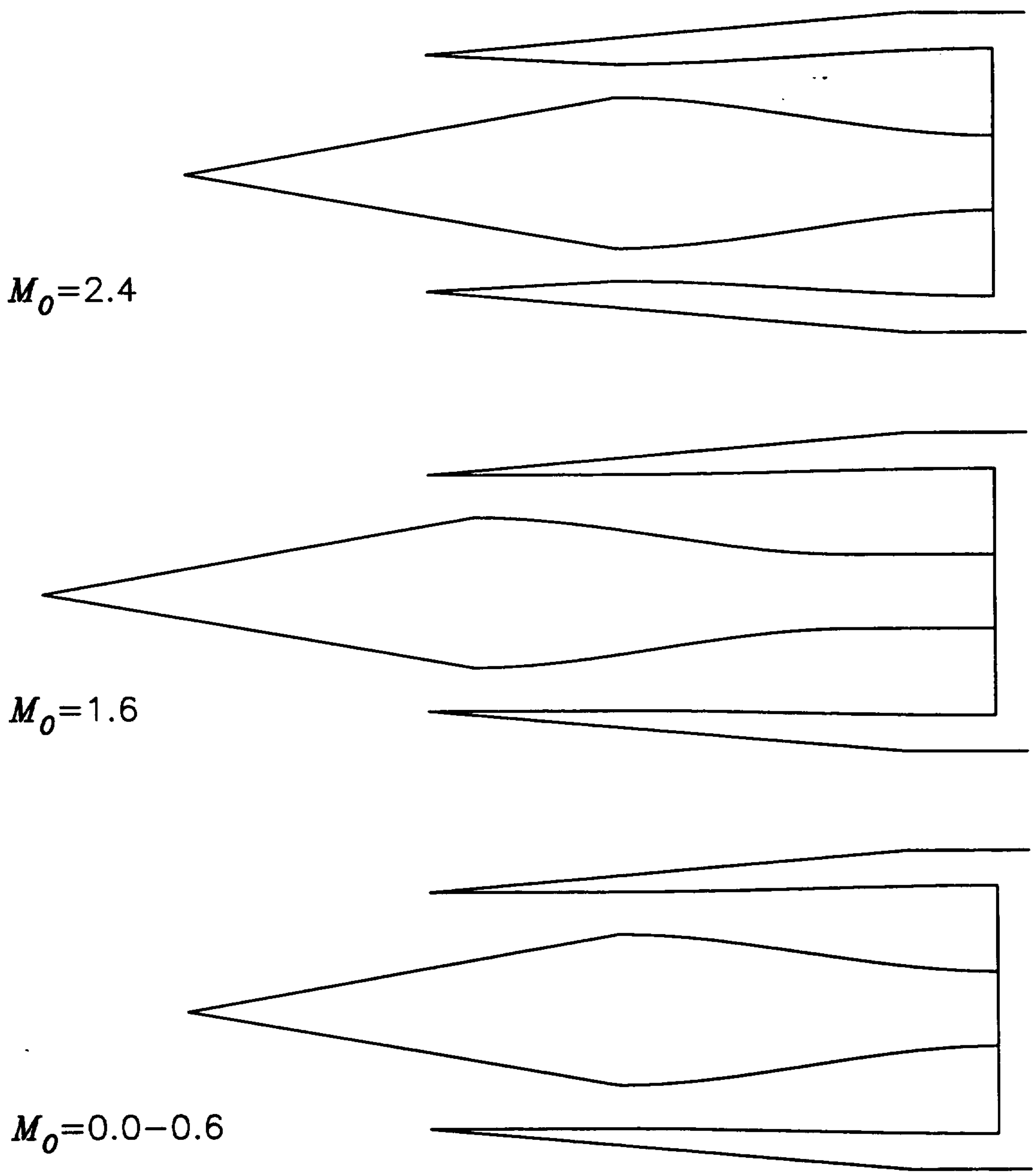


Figure 23 Axisymmetric Inlet Variable Geometry

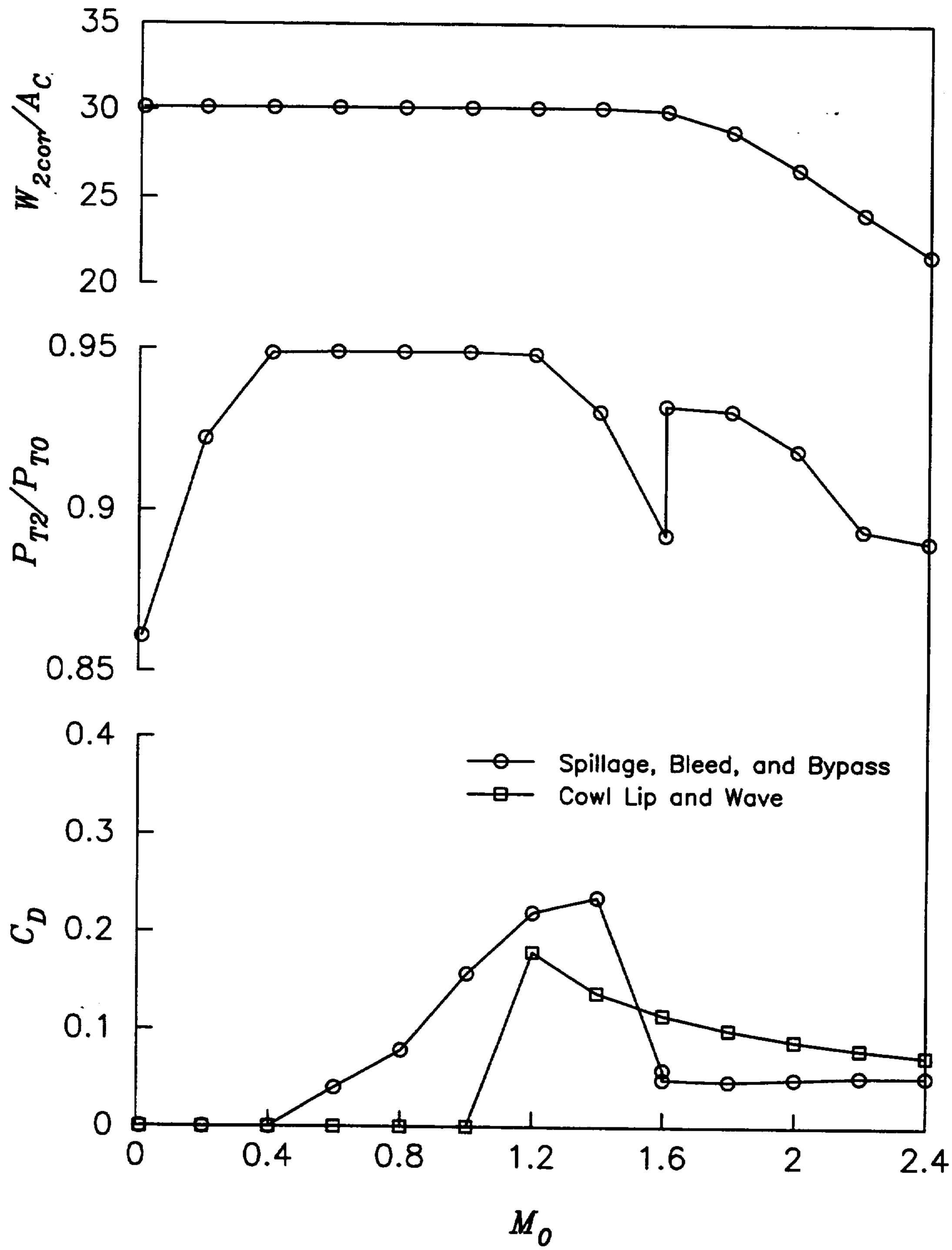


Figure 24 Axisymmetric Inlet Performance Summary

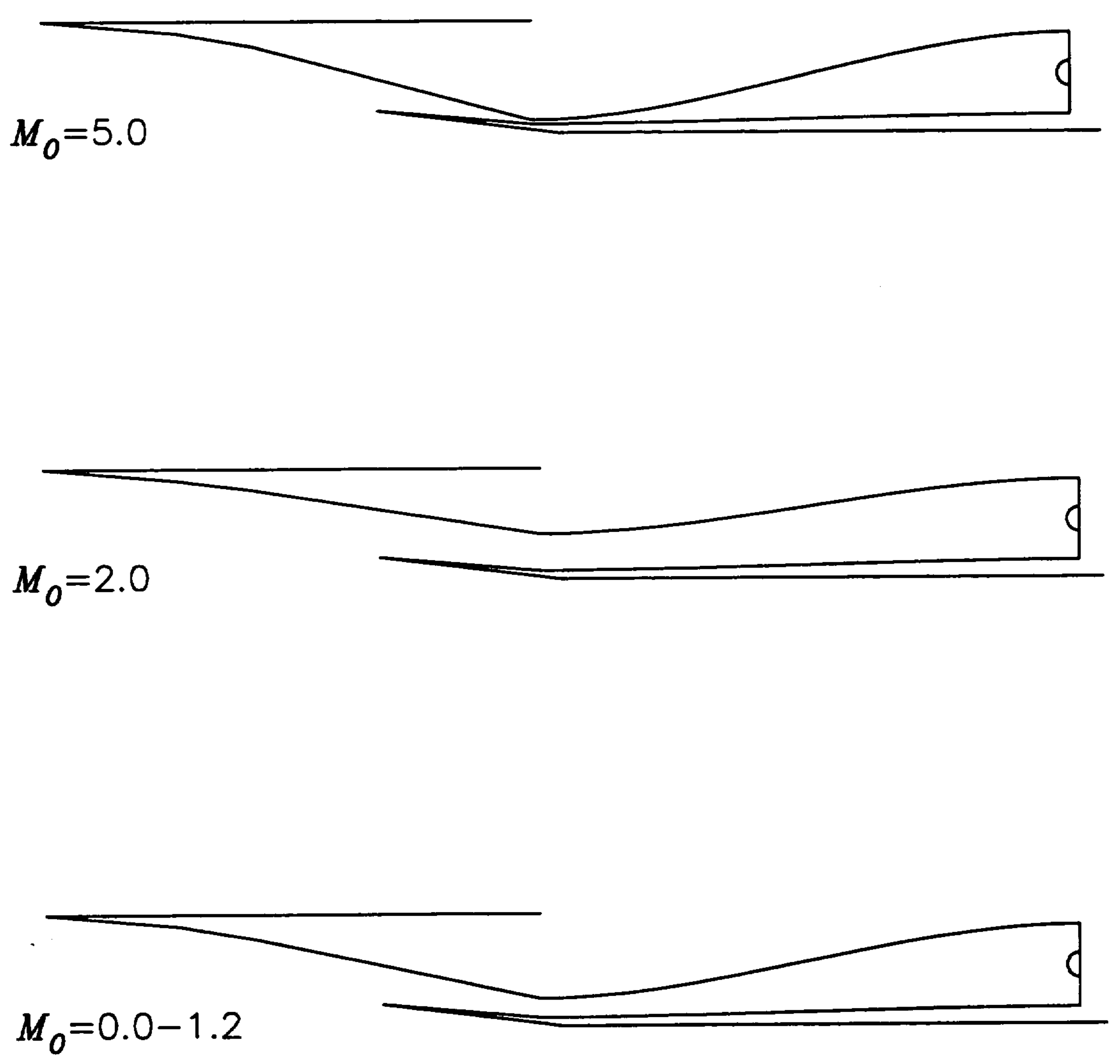


Figure 25 · Two-Dimensional Inlet Variable Geometry

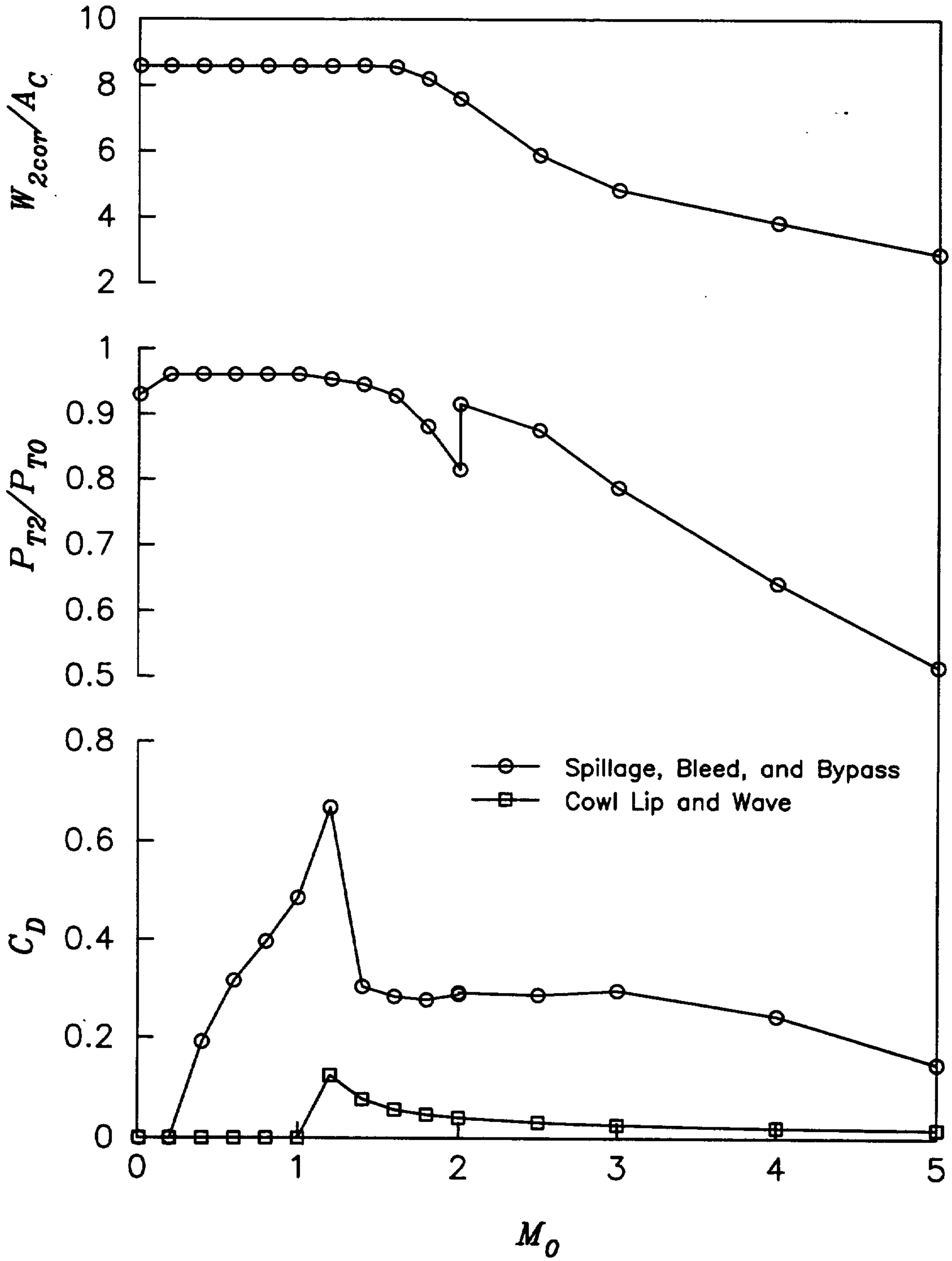


Figure 26 Two-Dimensional Inlet Performance Summary

Appendix I

IPAC User's Guide

IPAC - Inlet Performance Analysis Code

Input List Description

All variables are defined as implicit real*4 (a-h,o-z) unless otherwise noted in the following description. Variables beginning with the letters i-n are defined as integer unless otherwise noted. Any array variables are noted below with dimensions, ie. var(10). Default values are listed in the given assignments below.

```
&ipac          - namelist input set identifier, required

 table='ipac.dat' - tabular output data file name, character*80

 title=' '     - input case title, character*80

 echo=0        - echo flag, echoes input set to output if =1,
                 integer

 iout=4*1      - output control flag array, setting each element of
                 iout =1 writes additional data to output file,
                 iout(1)    program execution status messages
                 iout(2)    formatted performance summary pages
                 iout(3)    inlet flow station properties table
                 iout(4)    inlet geometry data summary
                 iout(5)

 figure=0      - figure output flag, writes inlet figure data and
                 output files if =1, integer

 npts=10,20    - number of points defining the engine face spinner
                 or blunt cowl lip, npts(1), and subsonic diffuser
                 contours, npts(2), when output is written using
                 the figure=1 option, npts(2)

 xmach0=0.01 - flight free stream Mach number

 alt=0..0      - flight altitude (ft)

 alpha0=0.0    - flight vehicle angle of attack (degrees)

 gama=1.4      - ratio of specific heats for atmosphere

 igas=0        - real gas effects flag, real gas calculations are
                 performed if =1, typically only needed if xmach0
                 is greater than 2.0

 forbdy=0      - vehicle forebody effects flag, no forebody if =0,
                 initial conic forebody if =1, initial ramp
                 forebody if =2, if =-1 then forebody effects are
```

directly input through variables xmlm0 and ptlpt0, integer

alphai=0.0 - array of forebody relative angles (degrees) used if forbdy =1 or 2, alphai(10) [=1st_angle,2nd_angle,...]

xmlm0=1.0 - ratio of inlet local to free stream Mach numbers, used only if forbdy=-1

ptlpt0=1.0 - total pressure recovery ahead of inlet, used only if forbdy=-1

idim=1 - inlet type flag, symmetric 2-D pitot if =-1, axisymmetric pitot if =0, 2-D pitot if =1, 2-dimensional if =2, axisymmetric if =3, bifurcated 2-dimensional if =4

ac=1.0 - inlet capture area (ft**2), area will be computed if =-1 and engine corrected weight flow data is supplied

ar=1.0 - inlet capture area aspect ratio, square or circular if =1

ramps=0 - number of external 2-D inlet ramps (max 10), or for an axisymmetric inlet conic centerbody set =1, integer

theta=0.0 - array of relative angles (degrees) of 2-D inlet ramps, or for an axisymmetric inlet conic centerbody set equal to the cone half-angle, theta(10) [=1st_angle,2nd_angle,...]

rleng=0.0 - array of radial lengths (ft) of 2-D inlet ramps, or the axisymmetric inlet conic centerbody length, do not use if the variable xleng is used, rleng(10) [=1st_length,2nd_length,...]

xleng=0.0 - array of axial lengths (ft) of 2-D inlet ramps, or the axisymmetric inlet conic centerbody length, do not use if the variable rleng is used, xleng(10) [=1st_length,2nd_length,...]

xcowl=0.0 - cowl lip axial distance from inlet origin (ft)

ycowl=1.0 - cowl lip normal distance from inlet origin (ft)

cowls=0 - number of segments defining the external cowl surface (max 10), integer

cowlth=0.0 - relative angles (degrees) of external cowl surfaces, cowlth(10) [=1st_angle,2nd_angle,...]

cowlrl=0.0 - normalized radial lengths of external cowl surfaces, do not use if the input variable cowlxl is used, cowlrl(10) [=1st_length,2nd_length,...]

cowlxl=0.0 - normalized axial lengths of external cowl surfaces, do not use if the input variable cowlrl is used, cowlxl(10) [=1st_length,2nd_length,...]

rclip=0.0 - normalized cowl lip radius, sharp lip =0

a2ac=1.0 - engine face flow area to inlet capture area ratio

xldd2=3.0 - subsonic diffuser axial length to engine face diameter ratio

cloff=0.0 - normalized inlet origin to engine face centerline offset distance

hubtip=0.3 - engine face spinner to fan tip radius ratio

thetac=0.0 - cowl lip internal angle (degrees)

nishck=-1 - number of inlet internal shock wave reflections, calculate number of shocks if =-1

xlipth=-1 - normalized length of inlet internal duct from cowl lip to throat, calculate length if =-1

athac=-1 - inlet throat area to inlet capture area ratio, calculate if =-1

xmth=1.3 - inlet throat Mach number, calculate throat Mach number if =-1

xmns=1.35 - inlet supercritical normal shock Mach number

xtrans=0.0 - normalized centerbody translation distance

a0ac=1.0 - stream tube capture area ratio, usually calculated and not used as an input variable

athal=-1 - inlet throat area to cowl lip flow area ratio, calculate if =-1

ptrec=-1 - inlet total pressure recovery, calculate if =-1

ptrob=-1 - total pressure recovery across oblique shock waves, calculate if =-1

ptreb=-1 - total pressure recovery across external oblique shock waves, calculate if =-1

ptrib=-1 - total pressure recovery across internal oblique shock waves, calculate if =-1 ptrns=-1 - total pressure recovery across normal shock wave, calculate if =-1

ptrfr=-1 - total pressure recovery factor resulting from inlet surface friction ahead of the throat, calculate if =-1

ptrdf=-1 - total pressure recovery factor resulting from subsonic diffuser behind the inlet throat, calculate if =-1

ptrlp=-1 - total pressure recovery factor resulting from cowl lip flow losses, calculate if =-1

fd=0.0025 - subsonic diffuser friction loss factor

bleed=0.0 - array of inlet bleed flow mass fractions for each bleed system, up to 10 separate bleed systems can be defined,
bleed(10) [=1st_sys_frac,2nd_sys_frac,...]

pblpt0=0.0 - array of total pressure recovery in bleed plenum to freestream for each separate bleed system,
pblpt0(10) [=1st_sys_rec,2nd_sys_rec,...]

thexbl=15.0 - array of bleed flow discharge angles (degrees) relative to freestream for each bleed system,
thexbl(10) [=1st_sys_angle,2nd_sys_angle,...]

nvbl=0.98 - array of bleed flow discharge nozzle velocity coefficients for each separate bleed system,
real*4 nvbl(10) [=1st_sys_coef,2nd_sys_coef,...]

nozzbl=1 - array of the type of bleed flow discharge nozzle used for each separate bleed system, convergent nozzle if =1, convergent-divergent nozzle if =2,
nozzbl(10) [=1st_sys_type,2nd_sys_type,...]

axthbl=1.0 - array of bleed flow discharge nozzle exit area to nozzle throat area ratio for each separate bleed system, set =1 if the nozzle is convergent,
axthbl(10) [=1st_sys_ratio,2nd_sys_ratio,...]

bypass=0.0 - array of inlet bypass flow mass fractions for each bypass system, up to 10 separate bypass systems can be defined,
bypass(10) [=1st_sys_frac,2nd_sys_frac,...]

pbppt2=0.0 - array of total pressure recovery in bypass plenum to engine face for each separate bypass system,
pbppt2(10) [=1st_sys_rec,2nd_sys_rec,...]

thexbp=15.0 - array of bypass flow discharge angles (degrees) relative to freestream for each bypass system, thexbp(10) [=1st_sys_angle,2nd_sys_angle,...]

nvbp=0.98 - array of bypass flow discharge nozzle velocity coefficients for each separate bypass system, real*4 nvbp(10) [=1st_sys_coef,2nd_sys_coef,...]

nozzbp=1 - array of the type of bypass flow discharge nozzle used for each separate bypass system, convergent nozzle if =1, convergent-divergent nozzle if =2, nozzbp(10) [=1st_sys_type,2nd_sys_type,...]

axthbp=1.0 - array of bypass flow discharge nozzle exit area to nozzle throat area ratio for each separate bypass system, set =1 if the nozzle is convergent, axthbp(10) [=1st_sys_ratio,2nd_sys_ratio,...]

cdcowl=-1 - cowl drag coefficient, sum of lip and wave drags, calculate if =-1

refcd=-1 - reference inlet drag coefficient, will be set equal to -cdcowl if =-1

etype=0 - array of engine type for each engine in an engine module, up to 10 engines per module, set =1 for a ramjet engine, set =2 for a turbojet engine, integer etype(10) [=1st_eng_typ,2nd_eng_typ,...]

escale=1.0 - array of sizing scale factors for each engine, escale(10) [=1st_eng_size,2nd_eng_size,...]

fn=0.0 - array of the uninstalled net thrust (lb) for each engine in an engine module, fn(10) [=1st_eng_thrust,2nd_eng_thrust,...]

sfc=0.0 - array of the uninstalled specific fuel consumption (lbm/hr/lbf) for each engine in an engine module, sfc(10) [=1st_eng_sfc,2nd_eng_sfc,...]

w2cor=0.0 - array of the uninstalled engine face corrected weight flow (lb/s) for each engine, w2cor(10) [=1st_eng_flow,2nd_eng_flow,...]

w2abs=0.0 - array of the uninstalled engine face absolute weight flow (lb/s) for each engine, w2abs(10) [=1st_eng_flow,2nd_eng_flow,...]

pt8pt2=1.0 - array of the total pressure ratio across the engine, from nozzle throat to engine face, pt8pt2(10) [=1st_eng_ratio,2nd_eng_ratio,...]

refrec=-1 - array of the reference total pressure recovery used for each engine, set =-1 for MIL-SPEC, refrec(10) [=1st_eng_rec,2nd_eng_rec,...]

```
nozzle        - array of engine module nozzle data, real*4
                nozzle(1) uninstalled engine data Cfg
                nozzle(2) actual nozzle gross thrust coefficient
                nozzle(3) actual nozzle drag coefficient
                nozzle(4) reference area (ft**2) for nozzle Cd

noeng=1       - number of engine modules on vehicle

aero          - array of the flight vehicle aerodynamic data
                aero(1)   lift coefficient
                aero(2)   drag coefficient
                aero(3)   angle of attack
                aero(4)   reference area (ft**2) for Cl and Cd

&end          - namelist identifier, required
```

<u>Notes on Input Usage</u>

The input and output filenames may be specified on the command line after the program name. The extensions .in and .out may be left off the filenames and will automatically be appended.

system_prompt> **ipac ipac.in ipac.out**

The program IPAC reads the namelist input set from an input file (the default is ipac.in) and executes the required calculations for that case. The output is written to an output file (the default is ipac.out) and to another tabular data file specified by the input variable **table** in the namelist input set. If there are subsequent namelist input sets in the file, they in turn are executed, and in this manner numerous cases can be run to design and/or analyze an inlet system over a range of operating conditions. Since the program uses namelist input reads, if a variable is defined once in an input set, it is not necessary to redefine it again in subsequent input sets, unless the value changes. Also, since nearly all of the input variables have predefined defaults, it is usually only necessary to assign values to a few variables to run the program properly. The character string pairs /* ...comments... */ are parsed and discarded by the input set read routine, thus allowing for the inclusion of comments, or the exclusion of commented out inputs, in the input file.

There are a few subtleties which the user needs to be aware of to effectively use IPAC. The following paragraphs describe some of the ways the various input variables are used to model inlet systems.

<u>General Output Control</u>: The first 6 variables listed above determine the output features for IPAC. The data file defined by the **table** variable will contain a summary tabular dataset of inlet operation and performance quantities such as: pressure recovery, mass flow ratios, and drag coefficients. These

quantities are sufficient to compose a set of inlet performance maps. To facilitate the generation of performance maps, more than one data file can be defined by the **table** variable in subsequent namelist input sets. Thus, a range of inlet operating points can be written to different tabular datasets. The user must then re-format these datasets to construct inlet map files appropriate for other analysis codes.

The **title** variable is printed for each output case if defined. The **echo** variable can, and is recommended, to be set to 1. This will print the namelist input set ahead of each output case. Additionally, if **echo** is set to 2 then the entire input file will be printed at the top of the output file. The array variable **iout** is used to control the level of data written to the output file, ipac.out. Setting the elements of **iout** =1 will result in additional output data. Currently there are 4 elements in **iout** which can be used for output control. Status messages of program execution information are enabled/disabled by **iout(1)** =1/0. These single line printouts of pertinent variable values from each major analysis segment (as the code executes) are useful for quickly assessing the progress of the inlet design, operation, and performance modeling. Printout of formatted inlet performance summary data is enabled/disabled by **iout(2)** =1/0. A formatted data table of flow properties at each of the inlet flow stations is enabled/disabled by **iout(3)** = 1/0. A brief inlet geometry data summary is enabled/disabled by **iout(4)** = 1/0. The program defaults will print all of the above information for each input case. Complete inlet performance data is written to 4 other tabular datasets *.dat for all input cases executed. This information is very easily graphed by a plotting package of the user's choice.

Printout of the inlet geometry contours is enabled by setting the **figure** variable =1. Additional output files *.fig are written which contain (x,y) coordinate pairs that can be used to construct a simple line drawing of the inlet geometry, and which can be viewed by the user's own plotting package of choice. The **figure** variable should be set to 1 in only one input set, and then reset to 0 for the rest of the cases since the *.fig output files are overwritten for each case. The array input variable **npts** can be used to increase the number of points written which define the subsonic diffuser, blunt cowl lips, and engine face segments of the figure. This allows for greater resolution of the curved surfaces in the geometry.

<u>Flight Conditions</u>: The Mach number and altitude for flight are set in variables **xmach0** and **alt**. If a positive number is assigned to **alt** then the program will use that value for the altitude in ft. If **alt** is assigned a negative number, then the program will assume that the user has entered a flight dynamic pressure (in psf) instead, and will find an appropriate altitude for the specified flight Mach number. This is a convenient feature for finding constant Q flight paths. If the vehicle is situated at an angle of attack to the freestream, the variable

alpha0 should be used. If the user feels it is necessary to adjust the ratio of specific heats constant for the atmosphere, the variable **gama** can be used. If flight conditions exceed Mach 2.0, it is recommended that **igas** be set to 1 to adjust ideal gas assumptions for real gas effects which become important for high speed flight.

Vehicle Effects: If the inlet is located close to the body/wing of the vehicle it may be necessary to account for changes in flow conditions entering the inlet as a result of vehicle effects. The variable **forbdy** controls how the vehicle effects are modeled. Values of 1 or 2 assigned to **forbdy** can model simple combinations of conic and ramp configurations. The necessary relative angles (degrees) are input through the array variable **alphai**. Compressive turning is denoted by a positive angle, and expansions are denoted by a negative angle. If a very complex flowfield is produced by the vehicle, the changes in Mach number and total pressure can be directly input in variables **xmlm0** and **ptlpt0** (provided these values are known) if **forbdy** is set to -1.

Inlet Geometry: A number of variables are used to describe the inlet geometry to be modeled. The first is **idim** which specifies the basic inlet type: pitot, axisymmetric, or 2-dimensional. The permitted values of **idim** follow.

idim =-1	symmetric 2-D pitot inlet
0	axisymmetric pitot inlet
1	2-D pitot inlet
2	2-dimensional inlet
3	axisymmetric inlet
4	bifurcated 2-dimensional inlet

If the inlet is 2-D the aspect ratio, variable **ar**, is the inlet width divided by height. If the inlet is axisymmetric then **ar** is interpreted as fraction of a full-circle. Thus, for a hemi-circular axisymmetric inlet, **ar** would be set to 0.5. The variable determining the gross size of the inlet is the capture area, **ac** in square ft. This can be simply set to 1 for easy normalizations, any physical size in square feet, or if set to -1 will be calculated and automatically sized to match the engine demand airflow requirements if this data is supplied.

External Compression Surfaces: The variables **ramps**, **theta**, **rleng**, and **xleng** define the inlet external compression surfaces for axisymmetric and 2-D inlets. For axisymmetric inlets, **ramps** must be set to 1, and **theta** is set to the conic centerbody half-angle. Either **rleng** or **xleng**, in ft, can be used to define the centerbody length, but not both. For 2-D inlets, **ramps** can be set up to a maximum of 10, and **theta** is then set to the relative angles (degrees) of each ramp. Either **rleng** or **xleng** can be used to define the lengths of each ramp, but not both. It is recommended that **rleng** be used since it does not change as the ramp angles are varied.

Cowl Lip & Shock-On-Lip Design Feature: The location of the cowl lip is specified by variables **xcowl** and **ycowl** in ft. These variables are used in both axisymmetric and 2-D inlets. For axisymmetric inlets **ycowl** is the radial distance from the inlet centerline. There is a feature in IPAC which will automatically calculate the location of the cowl lip for the shock-on-lip condition. Also, this feature will calculate the ramp lengths for multiple ramp 2-D inlets, placing all of the shock waves on the cowl lip, provided that the ramp angles are specified. This is a very useful design feature. To use this automatic design capability do the following in the very first namelist input set.

(1) set **ramps** to the number of ramps or 1 for a centerbody
(2) set **theta** to the ramp or centerbody relative angle(s)
(3) set **rleng** and **xleng** to 0.0, this is the program default
(4) set **xcowl** =0 and **ycowl** =1, also the program default

IPAC will then calculate the location of the cowl lip, and the lengths of all the ramps for shocks-on-lip for the specified flight Mach number, **xmach0**. These results will be remembered for subsequent cases, and there is no need to input these values by hand.

External Cowl Surfaces: The variables **cowls**, **cowlth**, **cowlrl**, and **cowlxl** define the external contour of the inlet cowl surface. The number of segments is specified in **cowls**, the relative angles (degrees) in **cowlth**, and the lengths in either **cowlrl** or **cowlxl**. The lengths are normalized by **ycowl** and thus specified as multiples of **ycowl**. A blunt cowl lip radius can be specified by the variable **rclip** and this radius is also normalized by the length **ycowl**.

Subsonic Diffuser: There are 4 input variables which are used to define the geometry of the subsonic diffuser element in an inlet. The engine face flow area is defined as a ratio relative to the inlet capture area through the variable **a2ac**. The axial length of the diffuser is defined as a ratio relative to the engine face diameter through the variable **xldd2**. The vertical offset location of the engine face is defined as a normalized distance from the inlet origin to the engine centerline, through the variable **cloff**, as a multiple of the distance **ycowl**. The variable **hubtip** performs a number of functions. If **hubtip** is a positive number then it defines the engine face spinner to fan tip radius ratio. If **hubtip** equals 0.0 then no engine spinner exists but the engine face is still assumed to be circular. If **hubtip** is a negative number then the program will recognize that the user has indicated that the engine face is not circular, but rather 2-dimensional, and that the value specified in **hubtip** is now the aspect ratio for the 2-D engine face duct area.

<u>Internal Shocks</u>: For supercritical operation of mixed compression inlets, internal shock waves are formed between the cowl lip and the inlet throat. The model used in IPAC is relatively simple for this internal supersonic duct. A

constantly converging channel is used to model the flow from inlet cowl lip to throat regions. The difference between the internal cowl lip angle (degrees), **thetac**, and the last external ramp angle forms the net convergence angle for the duct model. A single shock wave train, reflecting off each duct wall, is used to model the supersonic flow. The variable **nishck** is used to specify how many shock waves will be permitted in the duct, and this value will be calculated if set to -1. The variable **xlipth** is the normalized length (multiple of **ycowl**) of the duct from the cowl lip to the throat, and will also be calculated if set to -1. The variable **athac** is the inlet throat area to capture area ratio. This variable is critical in determining the inlet operation. If **athac** is set to -1 this ratio will be calculated. The variable **xmth** is the inlet throat Mach number. By specifying an inlet throat Mach number and area, the mass flow of the inlet is uniquely determined.

In a typical design point calculation it is easiest to specify the throat Mach number, **xmth**, and then for supercritical operation the rest of the variables, **nishck**, **xlipth**, and **athac** will be determined. For subsequent calculations, the inlet throat area will then be determined from the inlet geometry, and the throat Mach number will in turn be calculated. The variable **xmns** is the Mach number ahead of the internal terminal normal shock. Note that for supercritical operation **xmns** must be greater than the throat Mach number **xmth**. As the normal shock Mach number is increased, the shock will be pulled further downstream from the inlet throat into the subsonic diffuser. This will also decrease the inlet recovery. Specifying **xmns** is another control variable which can be used to match the inlet supply corrected airflow to the engine demand. If **xmns** is set =0 and the inlet is operating supercritical, then the flow at the engine face will be calculated as supersonic flow. This permits the modeling of supersonic through-flow fan and scramjet inlets.

<u>Variable Geometry</u>: After the inlet design point is calculated in the first namelist input set, the throat area can be increased or decreased by variable geometry features for off-design operation. For multi-ramp inlets, the ramp angles **theta** can be redefined by the user in subsequent namelist input sets. The cowl internal angle **thetac** can also be changed. A very common variable geometry mechanism for axisymmetric inlets is the translating centerbody, and the input variable **xtrans** can be used to move the centerbody forward a specified distance which is a multiple of **ycowl**. Note that **xtrans** works only for axisymmetric inlets, and produces no translation for two-dimensional inlets.

Two additional, although not typically used, input variables are the stream tube capture area ratio, **a0ac**, and the throat to cowl lip flow area ratio, **athal**. The stream tube capture area ratio is usually calculated by the program, however, it is possible that for some inlets the capture area ratio can be defined, and then for a given geometry the inlet throat Mach number would be calculated.

Recovery Overrides: All of the input variables beginning with **ptr__** are the total pressure ratios for various loss producing mechanisms and are normally calculated in the program. The user has the option of overriding these calculations and directly entering values for any and all of these terms. Normally this is not done, however, if other more complex analyses have been performed for an inlet design, then the user can use those values instead of the ones that IPAC would normally calculate.

An additional input variable is the friction loss factor, **fd**, which is used in the subsonic diffuser loss model. The default value is 0.0025 and this value is suitable for most typical subsonic diffuser designs.

Bleed and Bypass Systems: Boundary layer bleed is a necessary component for all high speed inlet systems. In order to stabilize the shock wave boundary layer interactions, a small amount of air is removed through the walls of the inlet. This air is then dumped overboard and a momentum drag is incurred. Mass removed and dumped ahead of the inlet throat is called bleed, and is necessary for inlet operation. Mass removed and dumped behind the throat is called bypass, and is sometimes necessary for inlet/engine matching. Up to ten independent bleed and ten independent bypass systems can be defined. Both bleed and bypass inputs work the same way, and therefore, only the bleed variables will be directly discussed. The user must specify the variable **bleed**, the fraction of captured airflow which is to be dumped. The variable **pblpt0** is the total pressure ratio (bleed plenum to freestream) for the bleed system and must also be chosen. The rest of the variables, **thexbl**, **nvbl**, **nozzbl**, and **axthbl** may be left at the default values. For bypass systems, since there is typically much more pressure available for expansion, a convergent-divergent nozzle may be used.

The input variable **bleed** can be defaulted to any negative number to automatically calculate the amount of boundary layer bleed as a function of inlet local Mach number. If **bleed** set =-1, then a single bleed system will use the default bleed rate. If **bleed** is set =-0.8, then a single bleed system will use 80% of the default bleed rate. If **bleed** is =-1.5, then a single bleed system will use 150% of the default bleed rate. If **bleed** =-0.4,-0.5, then two bleed systems will use a total of 90% of the default bleed rate. The bleed plenum total pressure recovery variable, **pblpt0**, can also be defaulted to an internal calculation, again as a function of inlet local Mach number. Set **pblpt0** to: -1 for the nominal average recovery, -2 for the high pressure porous recovery, -3 for the low pressure porous recovery, and -4 for the throat slot recovery. Each individual bleed system can use any appropriate bleed configuration recovery.

For the bypass system, the total pressure recovery in the bypass duct, **pbppt2**, can be calculated from a bypass duct loss as a function of bypass fraction. To calculate, set **pbppt2** =-1. Typically, when matching inlet supply and engine demand the inlet provides excess airflow which must be bypassed. If engine data is supplied, and the inlet has excess airflow capacity, set **bypass** =-1 to automatically match the inlet and engine airflows by adjusting the bypass fraction. This feature only works on the first bypass system, the other bypass systems if defined cannot be automatically matched but must be directly input.

Drag Accounting: The exact details of which inlet drag components should be charged to propulsion or airframe are a subject of continual debate. Most notable is the cowl drag, which is comprised of cowl blunt lip and cowl wave drags. IPAC calculates these drag components if the input variable **cdcowl** is set =-1, the program default. If any other positive value is assigned to **cdcowl** that value will be used, and the lip and wave drag calculations will be skipped. Since the external drag on an engine nacelle is often accounted for in the vehicle aerodynamic performance, another input variable **refcd** has been included. This variable represents the reference drag coefficient for the inlet installation, and thus part of the inlet drag can be accounted for in the vehicle aerodynamic data.

The net inlet drag at an engine operating point is called the power setting drag, and the power setting drag is equal to the total of all the inlet drags (spillage, bleed, bypass, cowl lip and wave) less the reference drag. Often the cowl drag components are accounted for in the vehicle aerodynamic data. If **refcd** is set =-1, then the reference drag will be set equal to the inlet cowl drag. This will result in an inlet power setting drag comprised of only spillage, bleed, and bypass drags. This is the default for the program, where **refcd** is =-1.

Engine Data: Engine data can be supplied to the program, and IPAC will perform installation calculations and re-calculate engine data if desired. It is assumed that engines are in separate modules, and there can be more than one engine (up to 10) in a module. However, each module has a single inlet, and possibly a common nozzle. The variable **etype** specifies the types of engines in a module. The only types are turbojet and ramjet at this time. A turbofan can be modeled as two separate turbojets, one with and one without fuel. The variable **escale** can be used to adjust the size of the engines for inlet/engine matching and sizing studies.

Each engine in the engine module is specified as an element in the array variables: **fn**, **sfc**, **w2cor**, **w2abs**, **pt8pt2**, and **refrec**. The engine net thrust and specific fuel consumption are specified by the input variables **fn** and **sfc**. To perform the installation calculations the total pressure ratio across the engine, **pt8pt2**, and the inlet recovery used in determining the uninstalled engine data, **refrec**, must also be supplied. The user may specify that a MIL-SPEC inlet recovery was used in the uninstalled engine data by setting **refrec** =-1, which is the program default. The absolute engine weight flow must be specified in the input variable **w2abs** in lb/s. The corrected engine airflow is also required in the variable **w2cor** in lb/s. To perform engine installation calculations correctly, the uninstalled engine corrected weight flow must be the same as the inlet supply corrected weight flow.

The equality of inlet supply and engine demand corrected weight flow is called inlet/engine matching. All proper inlet designs must be matched to an engine demand corrected airflow schedule. If the user is designing an inlet and there is no engine data available, the program will construct an engine demand corrected weight flow schedule automatically for a "typical" engine. If **w2cor** is set =-1 at the inlet design point, then the program will automatically calculate an engine demand corrected weight flow which matches the inlet supply corrected weight flow. By leaving **w2cor** =-1 for the rest of the inlet operating points, the program will calculate the "typical" engine demand corrected weight flow schedule as a function of flight Mach number. The user may then use this schedule of engine demand corrected weight flow for inlet/engine matching over the off-design operating points.

The installed thrust for the engine module will be equal to the uninstalled engine thrust adjusted for the actual inlet recovery less the inlet power setting drag. Note that engine data that is installed but not properly matched with the inlet supply corrected weight flow is fundamentally incorrect since conservation of mass will be violated.

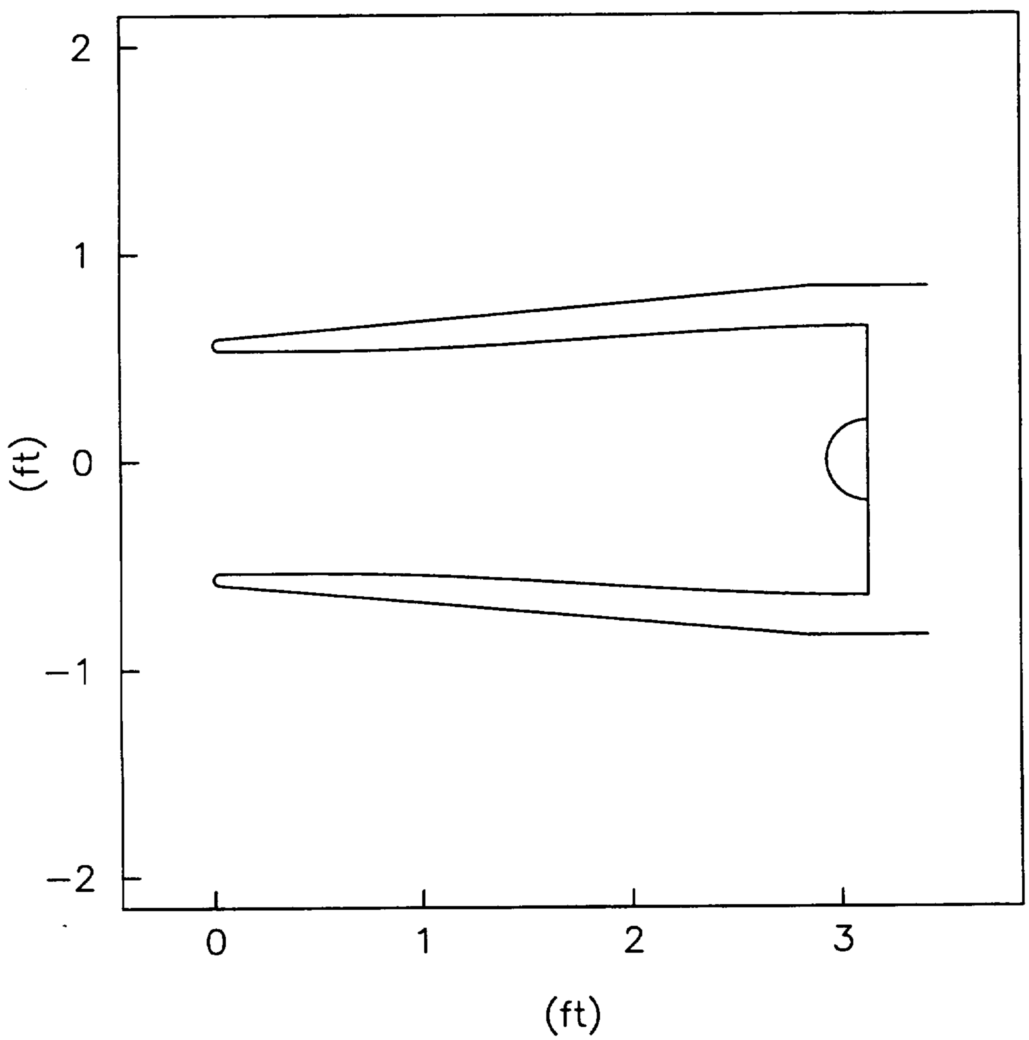
<u>Nozzle Data</u>: If nozzle data is available, the installation calculations will also adjust the engine data for nozzle effects. The inputs are in the array variable **nozzle**, and include the gross thrust coefficient used in the engine data, the actual gross thrust coefficient for the nozzle used, a drag coefficient for the nozzle, and a reference area. Note that when using the **nozzle** input variable it is assumed that only one nozzle is used for each engine module, even though more than one engine can be in a module.

<u>Vehicle Data</u>: Since it is often of interest to see how engine systems size on the vehicle, IPAC can accept vehicle aerodynamic data. Thus engine sizing studies can also be performed. The variable **noeng** sets the number of engine modules on the vehicle. The array variable **aero** contains the vehicle lift and drag coefficients, angle of attack, and reference area. Thus, the program can install engines with an inlet design, and can then determine if the propulsion system is capable of powering the aircraft throughout the flight regime.

Appendix II

Mach 2.0 Pitot Inlet

Example Case



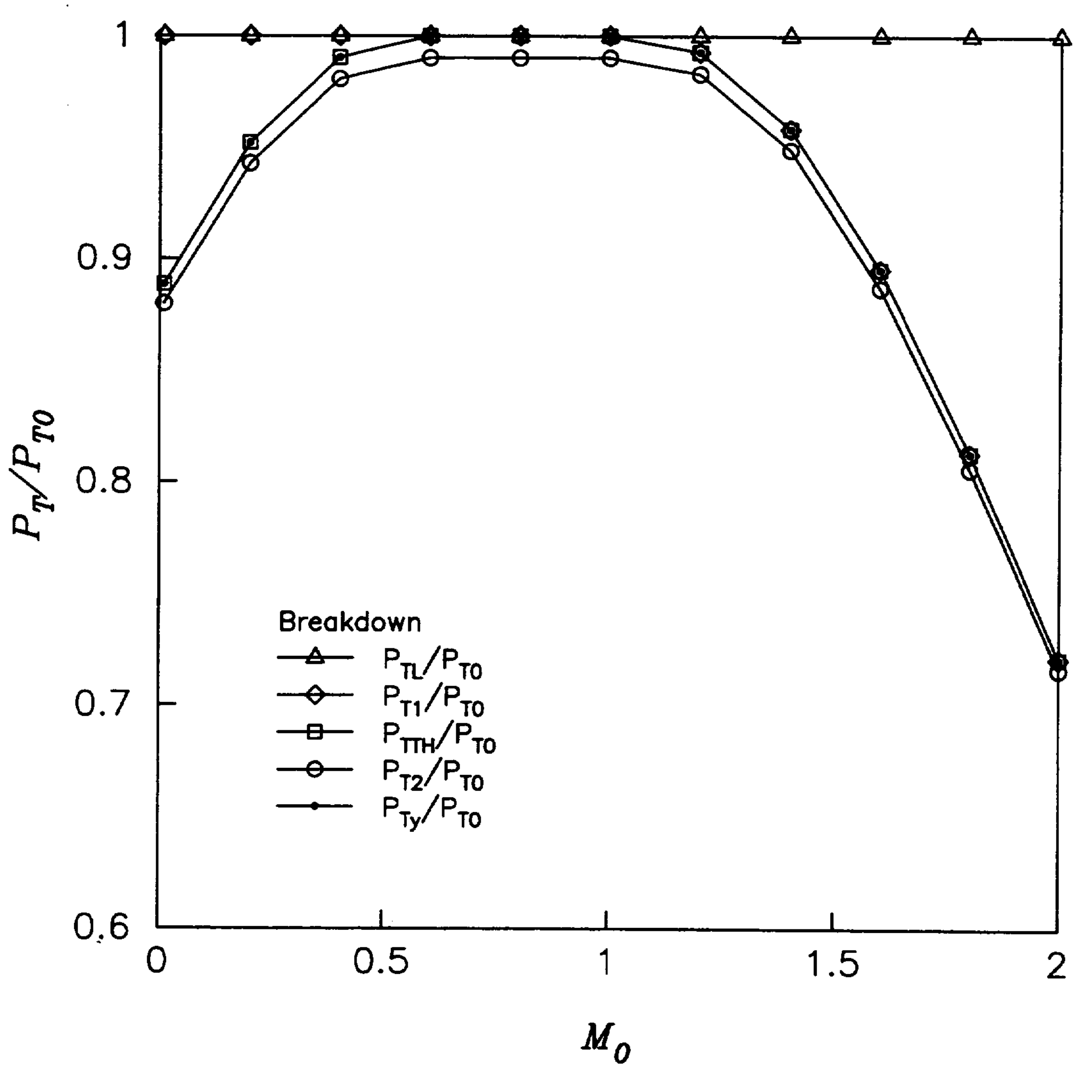


Figure II.1 Total Pressure Recoveries

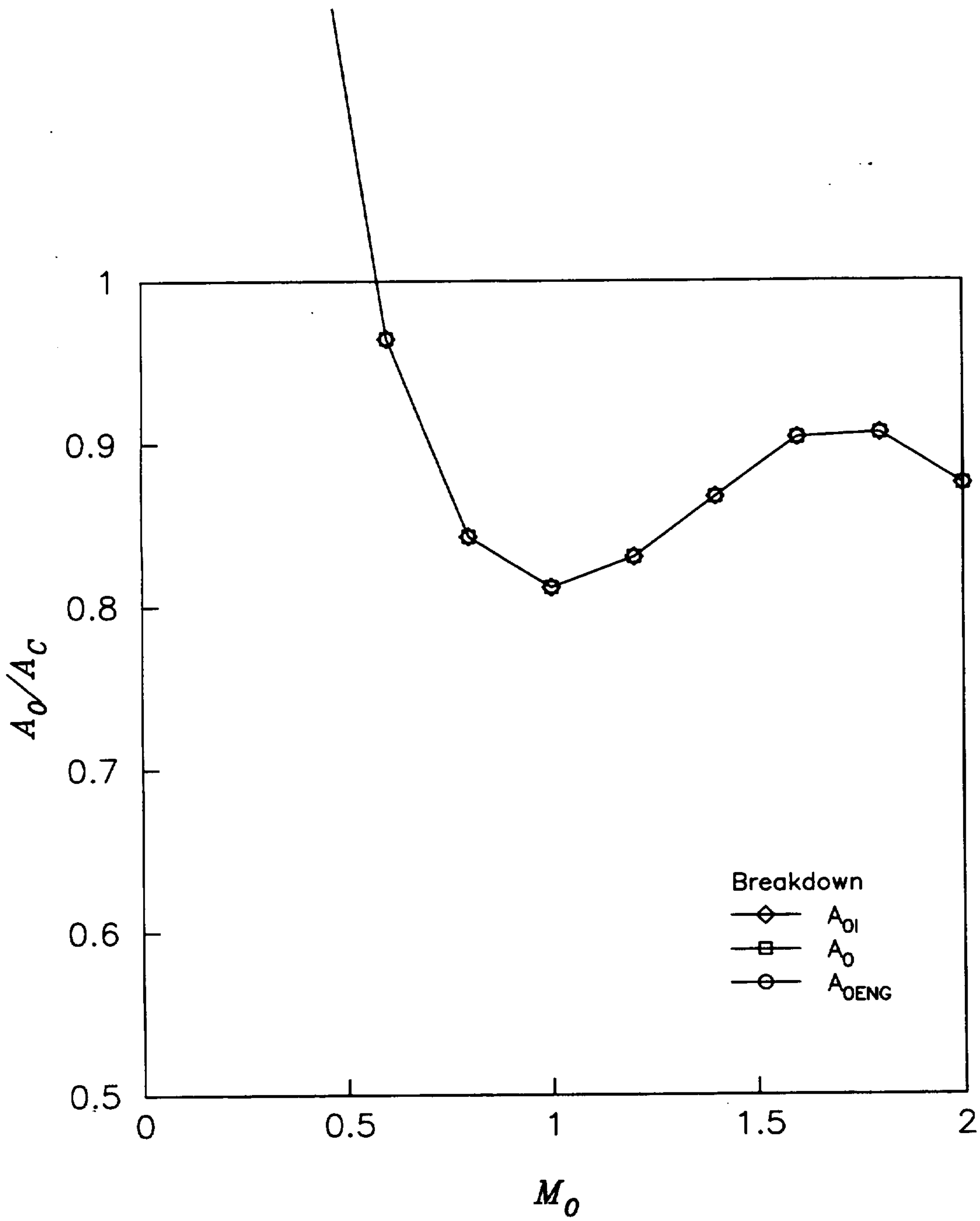


Figure II.2 Mass Flow Ratios

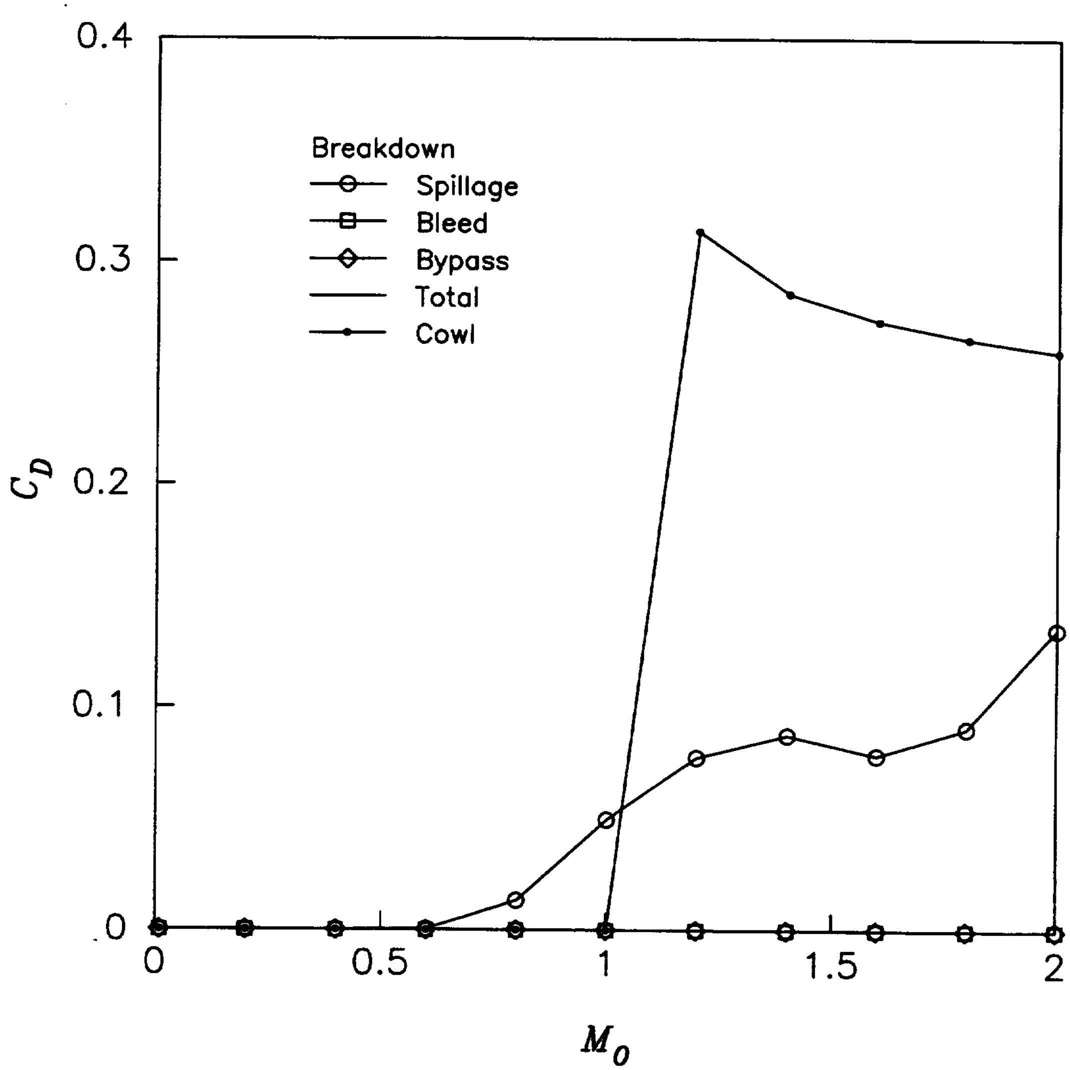


Figure II.3 Drag Coefficients

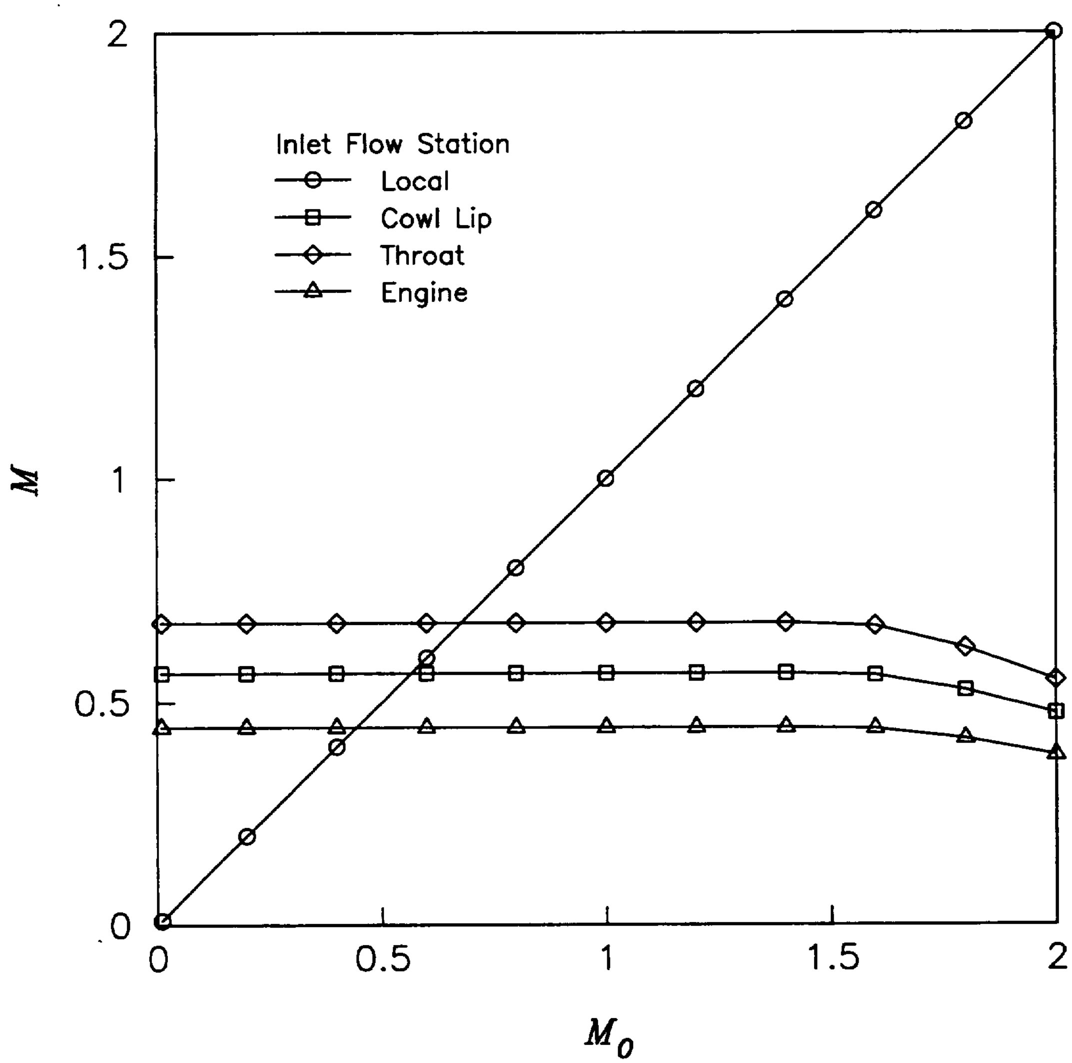


Figure II.4 Mach Numbers

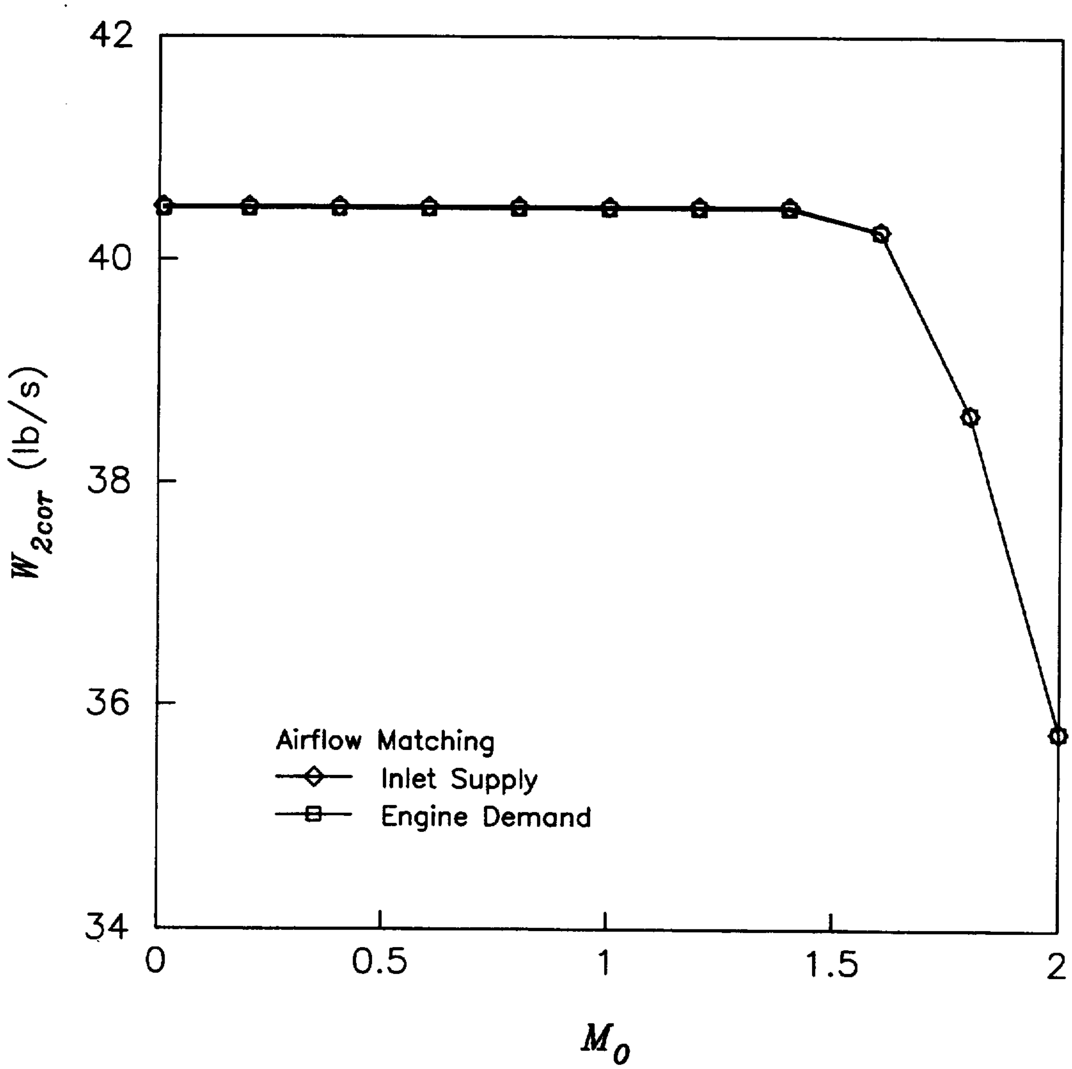


Figure II.5 Corrected Airflows

```
&ipac
 title='Pitot Inlet Example Case',
 echo=1,figure=1,npts=10,20,iout=1,1,1,1,
 xmach0=2.0,alt=-1000,
 idim=0,ac=1.0,
 rclip=0.05,xlipth=1.0,thetac=0.0,
 cowls=2,cowlth=5,-5,cowlxl=5,1,
 a2ac=1.20,xldd2=2.0,hubtip=0.3,
 w2cor=-1,
 xmth=0.550,
&end

forebd: xmachx= 2.000E+00,xmach0= 2.000E+00, xmlm0= 1.000E+00,ptlpt0= 1.000E+00,  ala0= 1.000E+00,
cdpito: xmach0= 2.000E+00, a0iac= 1.000E+00,xmach1= 5.774E-01,pt1pt0= 7.209E-01,   cda=-5.079E-07,
cdpito: xmach0= 2.000E+00, a0iac= 9.990E-01,xmach1= 5.764E-01,pt1pt0= 7.209E-01,   cda= 1.250E-03,
 ptrcv: xmach0= 2.000E+00,  a0ac= 8.748E-01,  xmns= 1.300E+00,pt2pt0= 7.160E-01,thetad= 2.472E+00,
          xmth= 5.500E-01, athac= 9.025E-01,nishck=-1.000E+00,pthpt0= 7.209E-01,xlipth= 1.000E+00,
cdpito: xmach0= 2.000E+00, a0iac= 8.748E-01,xmach1= 4.751E-01,pt1pt0= 7.209E-01,   cda= 1.646E-01,
cdwave: xmach0= 2.000E+00, cdwav= 1.101E-01,
cdblip: xmach0= 2.000E+00, cdlip= 1.490E-01,
 clsuc: xmach0= 2.000E+00, a0iac= 8.748E-01,   cls= 2.960E-02, cdspl= 1.350E-01,thetae= 7.682E+00,
      : xmach0= 2.000E+00, a0iac= 8.748E-01, cdtot= 1.350E-01, cdspl= 1.350E-01, cdref= 2.591E-01,
      : xmach0= 2.000E+00,a0enac= 8.748E-01,   w2c= 3.576E+01,    w2= 2.913E+01,
      : xmachx= 2.000E+00,a0enac= 8.748E-01,w2ceng= 3.576E+01,

IPAC   Pitot Inlet Example Case

Flight Conditions

          Mach number                     2.000E+00

             altitude   (ft)              4.189E+04

                                           ambient     total

             pressure   (lbf/ft**2)       3.578E+02  2.800E+03
          temperature   (R)               3.900E+02  7.019E+02
     dynamic pressure   (lbf/ft**2)       1.002E+03

Vehicle Effects

                ML/M0                     1.000E+00
              PTL/PT0                     1.000E+00
                AL/A0                     1.000E+00

Inlet Mass Flow Ratios
```

```
                A0I/AC                   8.748E-01
              A0SPL/AC                   1.252E-01
              A0BLD/AC                   0.000E-01
                A0/AC                    8.748E-01
              A0BYP/AC                   0.000E-01
              A0ENG/AC                   8.748E-01

Inlet Total Pressure Recoveries

               PT2/PT0                   7.160E-01

               PTL/PT0                   1.000E+00
               PT1/PTL                   7.209E-01
              PTTH/PT1                   1.000E+00
              PT2/PTTH                   9.933E-01

               PTx/PTy                   1.000E+00

Inlet Drag Breakdown

                    AC  (ft**2)          1.000E+00

                                            CD      D  (lbf)

              spillage                   1.350E-01  1.353E+02
                 bleed                   0.000E-01  0.000E-01
                bypass                   0.000E-01  0.000E-01
                  cowl                   2.591E-01  2.595E+02
                 total                   3.941E-01  3.948E+02
             reference                   2.591E-01  2.595E+02
         power setting                   1.350E-01  1.353E+02

Engine Performance Data               uninstalled  installed

            net thrust  (lbf)            0.000E-01 -3.948E+02
                   SFC  (lbm/hr/lbf)     0.000E-01 -0.000E-01
                    W2  (lbm/s)          0.000E-01  2.913E+01
          corrected W2  (lbm/s)          3.576E+01  3.576E+01

    reference recovery                   9.250E-01

Inlet Flow Properties                      free      inlet      cowl     throat     engine
                                          stream     local      lip                  face

               station                      0          L         1         TH          2
```

flow area	(ft**2)	8.748E-01	8.748E-01	1.000E+00	9.025E-01	1.200E+00
Mach number		2.000E+00	2.000E+00	4.751E-01	5.500E-01	3.804E-01
pressure	(lbf/ft**2)	3.578E+02	3.578E+02	1.729E+03	1.643E+03	1.814E+03
temperature	(R)	3.900E+02	3.900E+02	6.716E+02	6.619E+02	6.822E+02
density	(slg/ft**3)	5.346E-04	5.346E-04	1.500E-03	1.446E-03	1.549E-03
velocity	(ft/s)	1.936E+03	1.936E+03	6.036E+02	6.936E+02	4.870E+02
total pressure	(lbf/ft**2)	2.800E+03	2.800E+03	2.018E+03	2.018E+03	2.004E+03
total temperature	(R)	7.019E+02	7.019E+02	7.019E+02	7.019E+02	7.019E+02
weight flow	(lbm/s)	3.330E+01	3.330E+01	2.913E+01	2.913E+01	2.913E+01
corrected weight flow	(lbm/s)	2.927E+01	2.927E+01	3.552E+01	3.552E+01	3.576E+01

Geometry Data for Axisymmetric Pitot Inlet

inlet capture, AC	(ft**2)	1.000E+00
wrap angle	(degrees)	3.600E+02
radius	(ft)	5.642E-01
engine face, A2	(ft**2)	1.200E+00
diameter	(ft)	1.296E+00
H/T		3.000E-01

Figure Data for Inlet Geometry

		X	Y
internal cowl surface	(ft)		
		0.000E-01	5.642E-01
		4.286E-04	5.593E-01
		1.701E-03	5.545E-01
		3.779E-03	5.501E-01
		6.600E-03	5.461E-01
		1.008E-02	5.426E-01
		1.410E-02	5.398E-01
		1.856E-02	5.377E-01
		2.331E-02	5.364E-01
		2.821E-02	5.360E-01
		5.360E-01	5.360E-01

```
                                     5.360E-01  5.360E-01
                                     6.724E-01  5.369E-01
                                     8.088E-01  5.394E-01
                                     9.452E-01  5.435E-01
                                     1.082E+00  5.488E-01
                                     1.218E+00  5.551E-01
                                     1.354E+00  5.624E-01
                                     1.491E+00  5.704E-01
                                     1.627E+00  5.788E-01
                                     1.764E+00  5.875E-01
                                     1.900E+00  5.963E-01
                                     2.036E+00  6.051E-01
                                     2.173E+00  6.135E-01
                                     2.309E+00  6.215E-01
                                     2.446E+00  6.287E-01
                                     2.582E+00  6.351E-01
                                     2.718E+00  6.404E-01
                                     2.855E+00  6.444E-01
                                     2.991E+00  6.470E-01
                                     3.128E+00  6.479E-01

external cowl surface  (ft)              X          Y

                                     0.000E-01  5.642E-01
                                     3.824E-04  5.688E-01
                                     1.519E-03  5.733E-01
                                     3.379E-03  5.776E-01
                                     5.913E-03  5.815E-01
                                     9.051E-03  5.849E-01
                                     1.271E-02  5.878E-01
                                     1.679E-02  5.900E-01
                                     2.117E-02  5.915E-01
                                     2.575E-02  5.923E-01
                                     2.847E+00  8.391E-01
                                     3.411E+00  8.391E-01

  engine face spinner  (ft)              X          Y

                                     3.128E+00  1.944E-01
                                     3.094E+00  1.914E-01
                                     3.061E+00  1.826E-01
                                     3.030E+00  1.683E-01
                                     3.003E+00  1.489E-01
                                     2.979E+00  1.249E-01
                                     2.959E+00  9.718E-02
                                     2.945E+00  6.648E-02
```

```
                                            2.936E+00  3.375E-02
                                            2.933E+00  0.000E-01
                                            2.936E+00 -3.375E-02
                                            2.945E+00 -6.648E-02
                                            2.959E+00 -9.718E-02
                                            2.979E+00 -1.249E-01
                                            3.003E+00 -1.489E-01
                                            3.030E+00 -1.683E-01
                                            3.061E+00 -1.826E-01
                                            3.094E+00 -1.914E-01
                                            3.128E+00 -1.944E-01


&ipac  xmach0=1.8,xmth=0.621, figure=0,iout=1,1,0,0,  &end

forebd: xmachx= 1.800E+00,xmach0= 1.800E+00, xmlm0= 1.000E+00,ptlpt0= 1.000E+00,  ala0= 1.000E+00,
cdpito: xmach0= 1.800E+00, a0iac= 1.000E+00,xmach1= 6.165E-01,pt1pt0= 8.127E-01,   cda=-3.233E-07,
cdpito: xmach0= 1.800E+00, a0iac= 9.990E-01,xmach1= 6.154E-01,pt1pt0= 8.127E-01,   cda= 1.152E-03,
 ptrcv: xmach0= 1.800E+00,  a0ac= 9.063E-01,  xmns= 1.300E+00,pt2pt0= 8.057E-01,thetad= 2.472E+00,
          xmth= 6.210E-01, athac= 9.025E-01,nishck=-1.000E+00,pthpt0= 8.127E-01,xlipth= 1.000E+00,
cdpito: xmach0= 1.800E+00, a0iac= 9.063E-01,xmach1= 5.276E-01,pt1pt0= 8.127E-01,   cda= 1.136E-01,
cdwave: xmach0= 1.800E+00, cdwav= 1.231E-01,
cdblip: xmach0= 1.800E+00, cdlip= 1.420E-01,
 clsuc: xmach0= 1.800E+00, a0iac= 9.063E-01,   cls= 2.273E-02, cdspl= 9.085E-02,thetae= 7.682E+00,
      : xmach0= 1.800E+00, a0iac= 9.063E-01, cdtot= 9.085E-02, cdspl= 9.085E-02, cdref= 2.651E-01,
      : xmach0= 1.800E+00,a0enac= 9.063E-01,   w2c= 3.861E+01,    w2= 3.389E+01,
      : xmachx= 1.800E+00,a0enac= 9.063E-01,w2ceng= 3.861E+01,

IPAC   Pitot Inlet Example Case

Flight Conditions

          Mach number                  1.800E+00

             altitude  (ft)            3.729E+04

                                        ambient     total

             pressure  (lbf/ft**2)     4.464E+02  2.565E+03
          temperature  (R)             3.900E+02  6.427E+02
     dynamic pressure  (lbf/ft**2)     1.012E+03

Vehicle Effects

                ML/M0                  1.000E+00
              PTL/PT0                  1.000E+00
```

```
                 AL/A0                1.000E+00

Inlet Mass Flow Ratios

                 A0I/AC               9.063E-01
               A0SPL/AC               9.373E-02
               A0BLD/AC               0.000E-01
                 A0/AC                9.063E-01
               A0BYP/AC               0.000E-01
               A0ENG/AC               9.063E-01

Inlet Total Pressure Recoveries

                PT2/PT0               8.057E-01

                PTL/PT0               1.000E+00
                PT1/PTL               8.127E-01
               PTTH/PT1               1.000E+00
               PT2/PTTH               9.914E-01

                PTx/PTy               1.000E+00

Inlet Drag Breakdown

                    AC  (ft**2)       1.000E+00

                                         CD       D  (lbf)

               spillage               9.085E-02  9.197E+01
                  bleed               0.000E-01  0.000E-01
                 bypass               0.000E-01  0.000E-01
                   cowl               2.651E-01  2.684E+02
                  total               3.559E-01  3.603E+02
              reference               2.651E-01  2.684E+02
          power setting               9.085E-02  9.197E+01

Engine Performance Data             uninstalled  installed

           net thrust  (lbf)          0.000E-01 -3.603E+02
                  SFC  (lbm/hr/lbf)   0.000E-01 -0.000E-01
                   W2  (lbm/s)        0.000E-01  3.389E+01
         corrected W2  (lbm/s)        3.861E+01  3.861E+01

   reference recovery                 9.445E-01
```

```
&ipac  xmach0=1.6,xmth=0.670,   &end

forebd: xmachx= 1.600E+00,xmach0= 1.600E+00, xmlm0= 1.000E+00,ptlpt0= 1.000E+00,  ala0= 1.000E+00,
cdpito: xmach0= 1.600E+00, a0iac= 1.000E+00,xmach1= 6.684E-01,pt1pt0= 8.952E-01,   cda=-2.856E-07,
cdpito: xmach0= 1.600E+00, a0iac= 9.990E-01,xmach1= 6.671E-01,pt1pt0= 8.952E-01,   cda= 1.017E-03,
 ptrcv: xmach0= 1.600E+00,  a0ac= 9.036E-01,  xmns= 1.300E+00,pt2pt0= 8.866E-01,thetad= 2.472E+00,
          xmth= 6.700E-01, athac= 9.025E-01,nishck=-1.000E+00,pthpt0= 8.952E-01,xlipth= 1.000E+00,
cdpito: xmach0= 1.600E+00, a0iac= 9.036E-01,xmach1= 5.611E-01,pt1pt0= 8.952E-01,   cda= 1.054E-01,
cdwave: xmach0= 1.600E+00, cdwav= 1.408E-01,
cdblip: xmach0= 1.600E+00, cdlip= 1.323E-01,
 clsuc: xmach0= 1.600E+00, a0iac= 9.036E-01,   cls= 2.665E-02, cdspl= 7.874E-02,thetae= 7.682E+00,
      : xmach0= 1.600E+00, a0iac= 9.036E-01, cdtot= 7.874E-02, cdspl= 7.874E-02, cdref= 2.730E-01,
      : xmach0= 1.600E+00,a0enac= 9.036E-01,   w2c= 4.026E+01,    w2= 3.770E+01,
      : xmachx= 1.600E+00,a0enac= 9.036E-01,w2ceng= 4.025E+01,

IPAC   Pitot Inlet Example Case

Flight Conditions

          Mach number                  1.600E+00

             altitude  (ft)            3.209E+04

                                        ambient     total

             pressure  (lbf/ft**2)     5.706E+02  2.425E+03
          temperature  (R)             4.042E+02  6.112E+02
     dynamic pressure  (lbf/ft**2)     1.023E+03

Vehicle Effects

                ML/M0                  1.000E+00
              PTL/PT0                  1.000E+00
                AL/A0                  1.000E+00

Inlet Mass Flow Ratios

               A0I/AC                  9.036E-01
             A0SPL/AC                  9.643E-02
             A0BLD/AC                  0.000E-01
                A0/AC                  9.036E-01
             A0BYP/AC                  0.000E-01
             A0ENG/AC                  9.036E-01

Inlet Total Pressure Recoveries
```

```
               PT2/PT0                 8.866E-01

               PTL/PT0                 1.000E+00
               PT1/PTL                 8.952E-01
              PTTH/PT1                 1.000E+00
              PT2/PTTH                 9.904E-01

               PTx/PTy                 1.000E+00

Inlet Drag Breakdown

                    AC  (ft**2)        1.000E+00

                                          CD       D  (lbf)

              spillage                 7.874E-02  8.052E+01
                 bleed                 0.000E-01  0.000E-01
                bypass                 0.000E-01  0.000E-01
                  cowl                 2.730E-01  2.792E+02
                 total                 3.518E-01  3.597E+02
             reference                 2.730E-01  2.792E+02
         power setting                 7.874E-02  8.052E+01

Engine Performance Data              uninstalled  installed

            net thrust  (lbf)          0.000E-01 -3.597E+02
                   SFC  (lbm/hr/lbf)   0.000E-01 -0.000E-01
                    W2  (lbm/s)        0.000E-01  3.770E+01
          corrected W2  (lbm/s)        4.025E+01  4.026E+01

   reference recovery                  9.624E-01


&ipac  xmach0=1.4,xmth=0.677,  &end

forebd: xmachx= 1.400E+00,xmach0= 1.400E+00, xmlm0= 1.000E+00,ptlpt0= 1.000E+00,   ala0= 1.000E+00,
cdpito: xmach0= 1.400E+00, a0iac= 1.000E+00,xmach1= 7.397E-01,pt1pt0= 9.582E-01,    cda=-6.867E-07,
cdpito: xmach0= 1.400E+00, a0iac= 9.990E-01,xmach1= 7.379E-01,pt1pt0= 9.582E-01,    cda= 8.180E-04,
 ptrcv: xmach0= 1.400E+00,  a0ac= 8.670E-01,  xmns= 1.300E+00,pt2pt0= 9.488E-01,thetad= 2.472E+00,
           xmth= 6.770E-01, athac= 9.025E-01,nishck=-1.000E+00,pthpt0= 9.582E-01,xlipth= 1.000E+00,
cdpito: xmach0= 1.400E+00, a0iac= 8.670E-01,xmach1= 5.657E-01,pt1pt0= 9.582E-01,    cda= 1.273E-01,
cdwave: xmach0= 1.400E+00, cdwav= 1.672E-01,
cdblip: xmach0= 1.400E+00, cdlip= 1.184E-01,
 clsuc: xmach0= 1.400E+00, a0iac= 8.670E-01,   cls= 3.947E-02, cdspl= 8.779E-02,thetae= 7.682E+00,
      : xmach0= 1.400E+00, a0iac= 8.670E-01, cdtot= 8.779E-02, cdspl= 8.779E-02, cdref= 2.856E-01,
      : xmach0= 1.400E+00,a0enac= 8.670E-01,   w2c= 4.048E+01,    w2= 4.045E+01,
```

```
      : xmachx= 1.400E+00,a0enac= 8.670E-01,w2ceng= 4.046E+01,

IPAC   Pitot Inlet Example Case

Flight Conditions

         Mach number                      1.400E+00

            altitude  (ft)                2.611E+04

                                           ambient     total

            pressure  (lbf/ft**2)         7.481E+02  2.381E+03
         temperature  (R)                 4.256E+02  5.924E+02
    dynamic pressure  (lbf/ft**2)         1.026E+03

Vehicle Effects

               ML/M0                      1.000E+00
             PTL/PT0                      1.000E+00
               AL/A0                      1.000E+00

Inlet Mass Flow Ratios

              A0I/AC                      8.670E-01
            A0SPL/AC                      1.330E-01
            A0BLD/AC                      0.000E-01
               A0/AC                      8.670E-01
            A0BYP/AC                      0.000E-01
            A0ENG/AC                      8.670E-01

Inlet Total Pressure Recoveries

             PT2/PT0                      9.488E-01

             PTL/PT0                      1.000E+00
             PT1/PTL                      9.582E-01
            PTTH/PT1                      1.000E+00
            PT2/PTTH                      9.902E-01

             PTx/PTy                      1.000E+00

Inlet Drag Breakdown

                  AC  (ft**2)             1.000E+00
```

```
                                          CD        D  (lbf)

             spillage                8.779E-02  9.011E+01
                bleed                0.000E-01  0.000E-01
               bypass                0.000E-01  0.000E-01
                 cowl                2.856E-01  2.931E+02
                total                3.733E-01  3.832E+02
            reference                2.856E-01  2.931E+02
        power setting                8.779E-02  9.011E+01

Engine Performance Data            uninstalled  installed

           net thrust  (lbf)         0.000E-01 -3.832E+02
                  SFC  (lbm/hr/lbf)  0.000E-01 -0.000E-01
                   W2  (lbm/s)       0.000E-01  4.045E+01
         corrected W2  (lbm/s)       4.046E+01  4.048E+01

   reference recovery                9.782E-01


&ipac  xmach0=1.2,  &end

forebd: xmachx= 1.200E+00,xmach0= 1.200E+00, xmlm0= 1.000E+00,ptlpt0= 1.000E+00,  ala0= 1.000E+00,
cdpito: xmach0= 1.200E+00, a0iac= 1.000E+00,xmach1= 8.422E-01,pt1pt0= 9.928E-01,   cda=-5.840E-06,
cdpito: xmach0= 1.200E+00, a0iac= 9.990E-01,xmach1= 8.389E-01,pt1pt0= 9.928E-01,   cda= 5.070E-04,
 ptrcv: xmach0= 1.200E+00,  a0ac= 8.302E-01,  xmns= 1.300E+00,pt2pt0= 9.831E-01,thetad= 2.472E+00,
          xmth= 6.770E-01, athac= 9.025E-01,nishck=-1.000E+00,pthpt0= 9.928E-01,xlipth= 1.000E+00,
cdpito: xmach0= 1.200E+00, a0iac= 8.302E-01,xmach1= 5.657E-01,pt1pt0= 9.928E-01,   cda= 1.309E-01,
cdwave: xmach0= 1.200E+00, cdwav= 2.160E-01,
cdblip: xmach0= 1.200E+00, cdlip= 9.766E-02,
 clsuc: xmach0= 1.200E+00, a0iac= 8.302E-01,   cls= 5.322E-02, cdspl= 7.772E-02,thetae= 7.682E+00,
      : xmach0= 1.200E+00, a0iac= 8.302E-01, cdtot= 7.772E-02, cdspl= 7.772E-02, cdref= 3.136E-01,
      : xmach0= 1.200E+00,a0enac= 8.302E-01,   w2c= 4.048E+01,    w2= 4.362E+01,
      : xmachx= 1.200E+00,a0enac= 8.302E-01,w2ceng= 4.046E+01,

IPAC   Pitot Inlet Example Case

Flight Conditions

          Mach number                1.200E+00

             altitude  (ft)          1.906E+04

                                      ambient     total

             pressure  (lbf/ft**2)   1.012E+03  2.453E+03
```

```
            temperature   (R)              4.507E+02  5.805E+02
       dynamic pressure   (lbf/ft**2)      1.020E+03

Vehicle Effects

                  ML/M0                    1.000E+00
                PTL/PT0                    1.000E+00
                  AL/A0                    1.000E+00

Inlet Mass Flow Ratios

                 A0I/AC                    8.302E-01
               A0SPL/AC                    1.698E-01
               A0BLD/AC                    0.000E-01
                  A0/AC                    8.302E-01
               A0BYP/AC                    0.000E-01
               A0ENG/AC                    8.302E-01

Inlet Total Pressure Recoveries

                PT2/PT0                    9.831E-01

                PTL/PT0                    1.000E+00
                PT1/PTL                    9.928E-01
               PTTH/PT1                    1.000E+00
               PT2/PTTH                    9.902E-01

                PTx/PTy                    1.000E+00

Inlet Drag Breakdown

                     AC   (ft**2)          1.000E+00

                                              CD       D  (lbf)

               spillage                    7.772E-02  7.925E+01
                  bleed                    0.000E-01  0.000E-01
                 bypass                    0.000E-01  0.000E-01
                   cowl                    3.136E-01  3.198E+02
                  total                    3.914E-01  3.990E+02
              reference                    3.136E-01  3.198E+02
          power setting                    7.772E-02  7.925E+01

Engine Performance Data                  uninstalled  installed

             net thrust   (lbf)            0.000E-01 -3.990E+02
```

```
               SFC  (lbm/hr/lbf)   0.000E-01 -0.000E-01
                W2  (lbm/s)        0.000E-01  4.362E+01
      corrected W2  (lbm/s)        4.046E+01  4.048E+01

  reference recovery               9.915E-01


&ipac  xmach0=1.0,  &end

forebd: xmachx= 1.000E+00,xmach0= 1.000E+00, xmlm0= 1.000E+00,ptlpt0= 1.000E+00,  ala0= 1.000E+00,
 ptrcv: xmach0= 1.000E+00,  a0ac= 8.115E-01,  xmns= 1.300E+00,pt2pt0= 9.902E-01,thetad= 2.472E+00,
          xmth= 6.770E-01, athac= 9.025E-01,nishck=-1.000E+00,pthpt0= 1.000E+00,xlipth= 1.000E+00,
cdpito: xmach0= 1.000E+00, a0iac= 8.115E-01,xmach1= 5.657E-01,ptlpt0= 1.000E+00,   cda= 9.982E-02,
 clsuc: xmach0= 1.000E+00, a0iac= 8.115E-01,   cls= 5.017E-02, cdspl= 4.965E-02,thetae= 7.682E+00,
      : xmach0= 1.000E+00, a0iac= 8.115E-01, cdtot= 4.965E-02, cdspl= 4.965E-02, cdref= 0.000E-01,
      : xmach0= 1.000E+00,a0enac= 8.115E-01,   w2c= 4.048E+01,    w2= 4.869E+01,
      : xmachx= 1.000E+00,a0enac= 8.115E-01,w2ceng= 4.046E+01,

IPAC   Pitot Inlet Example Case

Flight Conditions

         Mach number               1.000E+00

            altitude  (ft)         1.040E+04

                                    ambient    total

            pressure  (lbf/ft**2)  1.433E+03  2.712E+03
         temperature  (R)          4.816E+02  5.779E+02
    dynamic pressure  (lbf/ft**2)  1.003E+03

Vehicle Effects

               ML/M0               1.000E+00
             PTL/PT0               1.000E+00
               AL/A0               1.000E+00

Inlet Mass Flow Ratios

              A0I/AC               8.115E-01
            A0SPL/AC               1.885E-01
            A0BLD/AC               0.000E-01
               A0/AC               8.115E-01
            A0BYP/AC               0.000E-01
            A0ENG/AC               8.115E-01
```

```

Inlet Total Pressure Recoveries

                 PT2/PT0                  9.902E-01

                 PTL/PT0                  1.000E+00
                 PT1/PTL                  1.000E+00
                PTTH/PT1                  1.000E+00
                PT2/PTTH                  9.902E-01

                 PTx/PTy                  1.000E+00

Inlet Drag Breakdown

                      AC  (ft**2)         1.000E+00

                                              CD       D  (lbf)

                spillage                  4.965E-02  4.979E+01
                   bleed                  0.000E-01  0.000E-01
                  bypass                  0.000E-01  0.000E-01
                    cowl                  0.000E-01  0.000E-01
                   total                  4.965E-02  4.979E+01
               reference                  0.000E-01  0.000E-01
           power setting                  4.965E-02  4.979E+01

Engine Performance Data                 uninstalled  installed

              net thrust  (lbf)           0.000E-01 -4.979E+01
                     SFC  (lbm/hr/lbf)    0.000E-01 -0.000E-01
                      W2  (lbm/s)         0.000E-01  4.869E+01
            corrected W2  (lbm/s)         4.046E+01  4.048E+01

   reference recovery                     1.000E+00


&ipac  xmach0=0.8,  &end

forebd: xmachx= 8.000E-01,xmach0= 8.000E-01, xmlm0= 1.000E+00,ptlpt0= 1.000E+00,  ala0= 1.000E+00,
 ptrcv: xmach0= 8.000E-01,  a0ac= 8.426E-01,  xmns= 1.300E+00,pt2pt0= 9.902E-01,thetad= 2.472E+00,
          xmth= 6.770E-01, athac= 9.025E-01,nishck=-1.000E+00,pthpt0= 1.000E+00,xlipth= 1.000E+00,
cdpito: xmach0= 8.000E-01, a0iac= 8.426E-01,xmach1= 5.657E-01,pt1pt0= 1.000E+00,   cda= 4.807E-02,
 clsuc: xmach0= 8.000E-01, a0iac= 8.426E-01,   cls= 3.470E-02, cdspl= 1.337E-02,thetae= 7.682E+00,
      : xmach0= 8.000E-01, a0iac= 8.426E-01, cdtot= 1.337E-02, cdspl= 1.337E-02, cdref= 0.000E-01,
      : xmach0= 8.000E-01,a0enac= 8.426E-01,   w2c= 4.048E+01,    w2= 5.756E+01,
      : xmachx= 8.000E-01,a0enac= 8.426E-01,w2ceng= 4.046E+01,
```

```
IPAC   Pitot Inlet Example Case

Flight Conditions

          Mach number                 8.000E-01

             altitude   (ft)          0.000E-01

                                       ambient     total

             pressure   (lbf/ft**2)   2.116E+03   3.226E+03
          temperature   (R)           5.187E+02   5.851E+02
     dynamic pressure   (lbf/ft**2)   9.481E+02

Vehicle Effects

                ML/MO                 1.000E+00
              PTL/PTO                 1.000E+00
                AL/AO                 1.000E+00

Inlet Mass Flow Ratios

               AOI/AC                 8.426E-01
             AOSPL/AC                 1.574E-01
             AOBLD/AC                 0.000E-01
                AO/AC                 8.426E-01
             AOBYP/AC                 0.000E-01
             AOENG/AC                 8.426E-01

Inlet Total Pressure Recoveries

              PT2/PTO                 9.902E-01

              PTL/PTO                 1.000E+00
              PT1/PTL                 1.000E+00
             PTTH/PT1                 1.000E+00
             PT2/PTTH                 9.902E-01

              PTx/PTy                 1.000E+00

Inlet Drag Breakdown

                   AC  (ft**2)        1.000E+00

                                         CD       D  (lbf)
```

```
               spillage                      1.337E-02  1.268E+01
                  bleed                      0.000E-01  0.000E-01
                 bypass                      0.000E-01  0.000E-01
                   cowl                      0.000E-01  0.000E-01
                  total                      1.337E-02  1.268E+01
              reference                      0.000E-01  0.000E-01
          power setting                      1.337E-02  1.268E+01

Engine Performance Data                    uninstalled  installed

             net thrust  (lbf)               0.000E-01 -1.268E+01
                    SFC  (lbm/hr/lbf)        0.000E-01 -0.000E-01
                     W2  (lbm/s)             0.000E-01  5.756E+01
           corrected W2  (lbm/s)             4.046E+01  4.048E+01

   reference recovery                        1.000E+00


&ipac  xmach0=0.6,  &end

forebd: xmachx= 6.000E-01,xmach0= 6.000E-01, xmlm0= 1.000E+00,ptlpt0= 1.000E+00,  ala0= 1.000E+00,
 ptrcv: xmach0= 6.000E-01,  a0ac= 9.643E-01,  xmns= 1.300E+00,pt2pt0= 9.902E-01,thetad= 2.472E+00,
          xmth= 6.770E-01, athac= 9.025E-01,nishck=-1.000E+00,pthpt0= 1.000E+00,xlipth= 1.000E+00,
cdpito: xmach0= 6.000E-01, a0iac= 9.643E-01,xmach1= 5.657E-01,pt1pt0= 1.000E+00,   cda= 1.934E-03,
 clsuc: xmach0= 6.000E-01, a0iac= 9.643E-01,   cls= 1.543E-03, cdspl= 3.909E-04,thetae= 7.682E+00,
      : xmach0= 6.000E-01, a0iac= 9.643E-01, cdtot= 3.909E-04, cdspl= 3.909E-04, cdref= 0.000E-01,
      : xmach0= 6.000E-01,a0enac= 9.643E-01,   w2c= 4.048E+01,    w2= 4.940E+01,
      : xmachx= 6.000E-01,a0enac= 9.643E-01,w2ceng= 4.046E+01,

IPAC   Pitot Inlet Example Case

Flight Conditions

          Mach number                        6.000E-01

             altitude  (ft)                  0.000E-01

                                              ambient     total

             pressure  (lbf/ft**2)           2.116E+03  2.699E+03
          temperature  (R)                   5.187E+02  5.560E+02
     dynamic pressure  (lbf/ft**2)           5.333E+02

Vehicle Effects
```

```
                  ML/M0                  1.000E+00
                PTL/PT0                  1.000E+00
                  AL/A0                  1.000E+00

Inlet Mass Flow Ratios

                 A0I/AC                  9.643E-01
               A0SPL/AC                  3.573E-02
               A0BLD/AC                  0.000E-01
                  A0/AC                  9.643E-01
               A0BYP/AC                  0.000E-01
               A0ENG/AC                  9.643E-01

Inlet Total Pressure Recoveries

                PT2/PT0                  9.902E-01

                PTL/PT0                  1.000E+00
                PT1/PTL                  1.000E+00
               PTTH/PT1                  1.000E+00
               PT2/PTTH                  9.902E-01

                PTx/PTy                  1.000E+00

Inlet Drag Breakdown

                     AC  (ft**2)         1.000E+00

                                            CD       D  (lbf)

               spillage                  3.909E-04  2.085E-01
                  bleed                  0.000E-01  0.000E-01
                 bypass                  0.000E-01  0.000E-01
                   cowl                  0.000E-01  0.000E-01
                  total                  3.909E-04  2.085E-01
              reference                  0.000E-01  0.000E-01
          power setting                  3.909E-04  2.085E-01

Engine Performance Data                uninstalled  installed

             net thrust  (lbf)           0.000E-01 -2.085E-01
                    SFC  (lbm/hr/lbf)    0.000E-01 -0.000E-01
                     W2  (lbm/s)         0.000E-01  4.940E+01
           corrected W2  (lbm/s)         4.046E+01  4.048E+01

     reference recovery                  1.000E+00
```

```
&ipac  xmach0=0.4,  &end

forebd: xmachx= 4.000E-01,xmach0= 4.000E-01, xmlm0= 1.000E+00,ptlpt0= 1.000E+00,  ala0= 1.000E+00,
 ptrcv: xmach0= 4.000E-01,  a0ac= 1.278E+00,  xmns= 1.300E+00,pt2pt0= 9.808E-01,thetad= 2.472E+00,
          xmth= 6.770E-01, athac= 9.025E-01,nishck=-1.000E+00,pthpt0= 9.904E-01,xlipth= 1.000E+00,
      : xmach0= 4.000E-01, a0iac= 1.278E+00,   cda= 0.000E-01,
      : xmach0= 4.000E-01, a0iac= 1.278E+00, cdtot= 0.000E-01, cdspl= 0.000E-01, cdref= 0.000E-01,
      : xmach0= 4.000E-01,a0enac= 1.278E+00,   w2c= 4.048E+01,    w2= 4.366E+01,
      : xmachx= 4.000E-01,a0enac= 1.278E+00,w2ceng= 4.046E+01,

IPAC   Pitot Inlet Example Case

Flight Conditions

           Mach number                  4.000E-01

              altitude  (ft)            0.000E-01

                                         ambient     total

              pressure  (lbf/ft**2)     2.116E+03  2.363E+03
           temperature  (R)             5.187E+02  5.353E+02
      dynamic pressure  (lbf/ft**2)     2.370E+02

Vehicle Effects

                 ML/M0                  1.000E+00
               PTL/PT0                  1.000E+00
                 AL/A0                  1.000E+00

Inlet Mass Flow Ratios

                AOI/AC                  1.278E+00
               A0SPL/AC                -2.781E-01
               A0BLD/AC                 0.000E-01
                 A0/AC                  1.278E+00
               A0BYP/AC                 0.000E-01
               A0ENG/AC                 1.278E+00

Inlet Total Pressure Recoveries

               PT2/PT0                  9.808E-01

               PTL/PT0                  1.000E+00
```

```
                PT1/PTL                  1.000E+00
               PTTH/PT1                  9.904E-01
               PT2/PTTH                  9.902E-01

                PTx/PTy                  1.000E+00

Inlet Drag Breakdown

                     AC  (ft**2)         1.000E+00

                                            CD       D  (lbf)

               spillage                  0.000E-01  0.000E-01
                  bleed                  0.000E-01  0.000E-01
                 bypass                  0.000E-01  0.000E-01
                   cowl                  0.000E-01  0.000E-01
                  total                  0.000E-01  0.000E-01
              reference                  0.000E-01  0.000E-01
          power setting                  0.000E-01  0.000E-01

Engine Performance Data                uninstalled  installed

             net thrust  (lbf)           0.000E-01  0.000E-01
                    SFC  (lbm/hr/lbf)    0.000E-01  0.000E-01
                     W2  (lbm/s)         0.000E-01  4.366E+01
           corrected W2  (lbm/s)         4.046E+01  4.048E+01

   reference recovery                    1.000E+00


&ipac  xmach0=0.2,  &end

forebd: xmachx= 2.000E-01,xmach0= 2.000E-01, xmlm0= 1.000E+00,ptlpt0= 1.000E+00,  ala0= 1.000E+00,
 ptrcv: xmach0= 2.000E-01,  a0ac= 2.290E+00,  xmns= 1.300E+00,pt2pt0= 9.427E-01,thetad= 2.472E+00,
          xmth= 6.770E-01, athac= 9.025E-01,nishck=-1.000E+00,pthpt0= 9.520E-01,xlipth= 1.000E+00,
      : xmach0= 2.000E-01, a0iac= 2.290E+00,   cda= 0.000E-01,
      : xmach0= 2.000E-01, a0iac= 2.290E+00, cdtot= 0.000E-01, cdspl= 0.000E-01, cdref= 0.000E-01,
      : xmach0= 2.000E-01,a0enac= 2.290E+00,   w2c= 4.048E+01,    w2= 3.910E+01,
      : xmachx= 2.000E-01,a0enac= 2.290E+00,w2ceng= 4.046E+01,

IPAC   Pitot Inlet Example Case

Flight Conditions

          Mach number                    2.000E-01

```

```
                 altitude  (ft)            0.000E-01

                                            ambient     total

                 pressure  (lbf/ft**2)     2.116E+03  2.176E+03
              temperature  (R)             5.187E+02  5.228E+02
         dynamic pressure  (lbf/ft**2)     5.925E+01

Vehicle Effects

                    ML/M0                  1.000E+00
                  PTL/PT0                  1.000E+00
                    AL/A0                  1.000E+00

Inlet Mass Flow Ratios

                   A0I/AC                  2.290E+00
                 A0SPL/AC                 -1.290E+00
                 A0BLD/AC                  0.000E-01
                    A0/AC                  2.290E+00
                 A0BYP/AC                  0.000E-01
                 A0ENG/AC                  2.290E+00

Inlet Total Pressure Recoveries

                  PT2/PT0                  9.427E-01

                  PTL/PT0                  1.000E+00
                  PT1/PTL                  1.000E+00
                 PTTH/PT1                  9.520E-01
                 PT2/PTTH                  9.902E-01

                  PTx/PTy                  1.000E+00

Inlet Drag Breakdown

                       AC  (ft**2)         1.000E+00

                                              CD       D  (lbf)

                 spillage                  0.000E-01  0.000E-01
                    bleed                  0.000E-01  0.000E-01
                   bypass                  0.000E-01  0.000E-01
                     cowl                  0.000E-01  0.000E-01
                    total                  0.000E-01  0.000E-01
                reference                  0.000E-01  0.000E-01
```

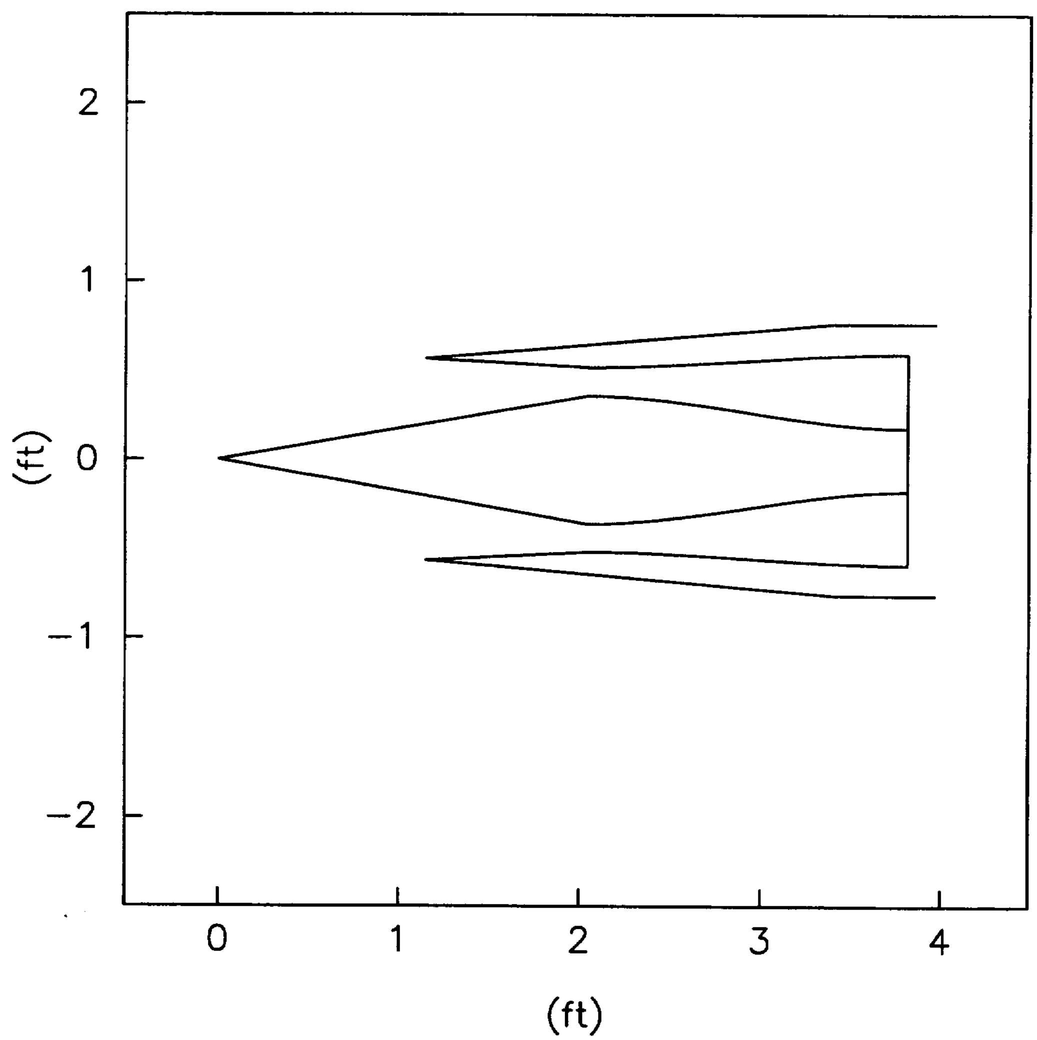
```
        power setting                     0.000E-01  0.000E-01

Engine Performance Data                 uninstalled  installed

           net thrust  (lbf)              0.000E-01  0.000E-01
                  SFC  (lbm/hr/lbf)       0.000E-01  0.000E-01
                   W2  (lbm/s)            0.000E-01  3.910E+01
         corrected W2  (lbm/s)            4.046E+01  4.048E+01

   reference recovery                     1.000E+00


&ipac  xmach0=0.01, &end

forebd: xmachx= 1.000E-02,xmach0= 1.000E-02, xmlm0= 1.000E+00,ptlpt0= 1.000E+00,  ala0= 1.000E+00,
 ptrcv: xmach0= 1.000E-02,  a0ac= 4.172E+01,  xmns= 1.300E+00,pt2pt0= 8.795E-01,thetad= 2.472E+00,
          xmth= 6.770E-01, athac= 9.025E-01,nishck=-1.000E+00,pthpt0= 8.882E-01,xlipth= 1.000E+00,
     : xmach0= 1.000E-02, a0iac= 4.172E+01,   cda= 0.000E-01,
     : xmach0= 1.000E-02, a0iac= 4.172E+01, cdtot= 0.000E-01, cdspl= 0.000E-01, cdref= 0.000E-01,
     : xmach0= 1.000E-02,a0enac= 4.172E+01,   w2c= 4.048E+01,    w2= 3.562E+01,
     : xmachx= 1.000E-02,a0enac= 4.172E+01,w2ceng= 4.046E+01,

IPAC   Pitot Inlet Example Case

Flight Conditions

          Mach number                     1.000E-02

             altitude  (ft)               0.000E-01

                                           ambient     total

             pressure  (lbf/ft**2)        2.116E+03  2.116E+03
          temperature  (R)                5.187E+02  5.187E+02
     dynamic pressure  (lbf/ft**2)        1.481E-01

Vehicle Effects

                ML/M0                     1.000E+00
               PTL/PT0                    1.000E+00
                AL/A0                     1.000E+00

Inlet Mass Flow Ratios

               A0I/AC                     4.172E+01
             A0SPL/AC                    -4.072E+01
```

```
              A0BLD/AC                  0.000E-01
                 A0/AC                  4.172E+01
              A0BYP/AC                  0.000E-01
              A0ENG/AC                  4.172E+01

Inlet Total Pressure Recoveries

               PT2/PT0                  8.795E-01

               PTL/PT0                  1.000E+00
               PT1/PTL                  1.000E+00
              PTTH/PT1                  8.882E-01
              PT2/PTTH                  9.902E-01

               PTx/PTy                  1.000E+00

Inlet Drag Breakdown

                    AC  (ft**2)         1.000E+00

                                           CD       D  (lbf)

              spillage                  0.000E-01  0.000E-01
                 bleed                  0.000E-01  0.000E-01
                bypass                  0.000E-01  0.000E-01
                  cowl                  0.000E-01  0.000E-01
                 total                  0.000E-01  0.000E-01
             reference                  0.000E-01  0.000E-01
         power setting                  0.000E-01  0.000E-01

Engine Performance Data               uninstalled  installed

            net thrust  (lbf)           0.000E-01  0.000E-01
                   SFC  (lbm/hr/lbf)    0.000E-01  0.000E-01
                    W2  (lbm/s)         0.000E-01  3.562E+01
          corrected W2  (lbm/s)         4.046E+01  4.048E+01

    reference recovery                  1.000E+00
```

Appendix III

Mach 2.4 Axisymmetric Inlet

Example Case



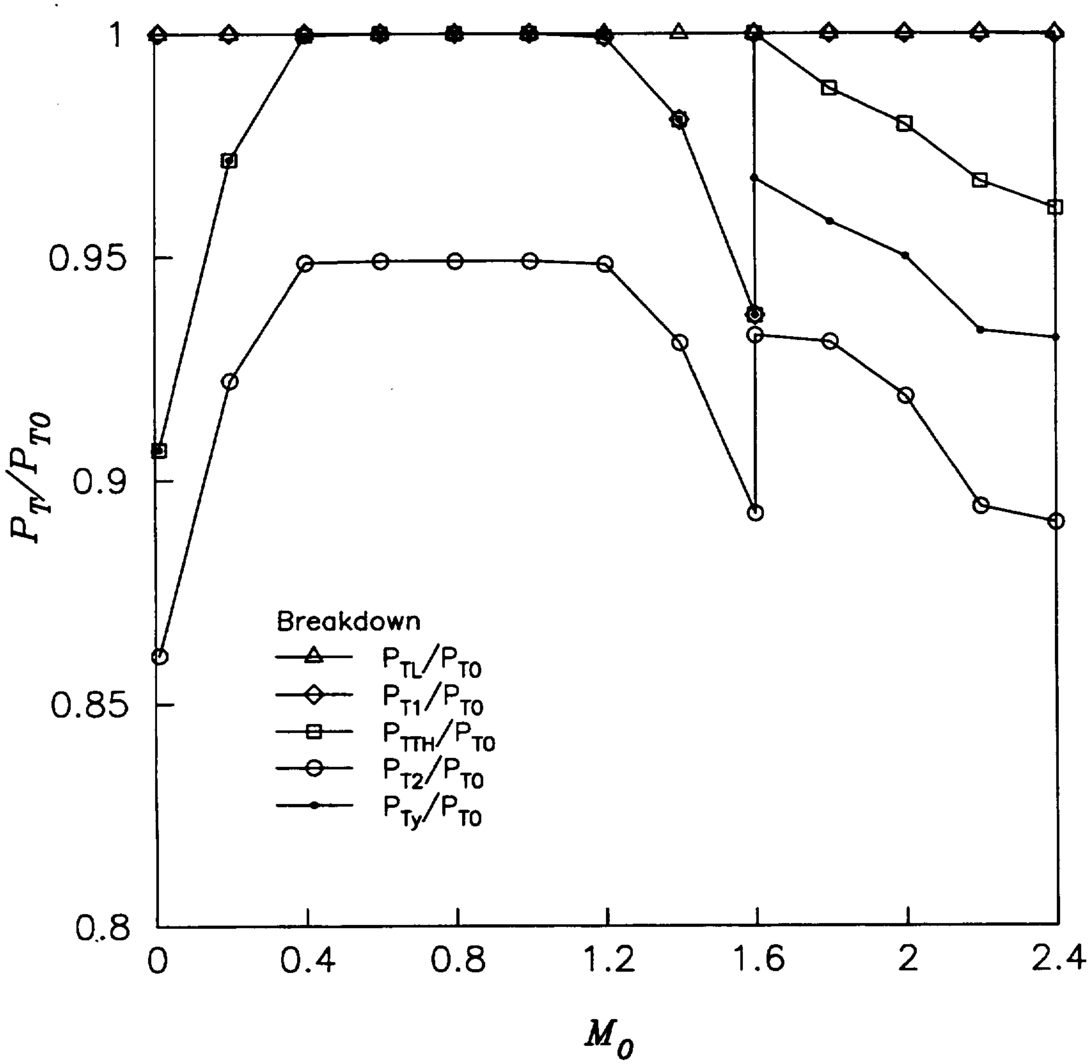


Figure III.1 Total Pressure Recoveries

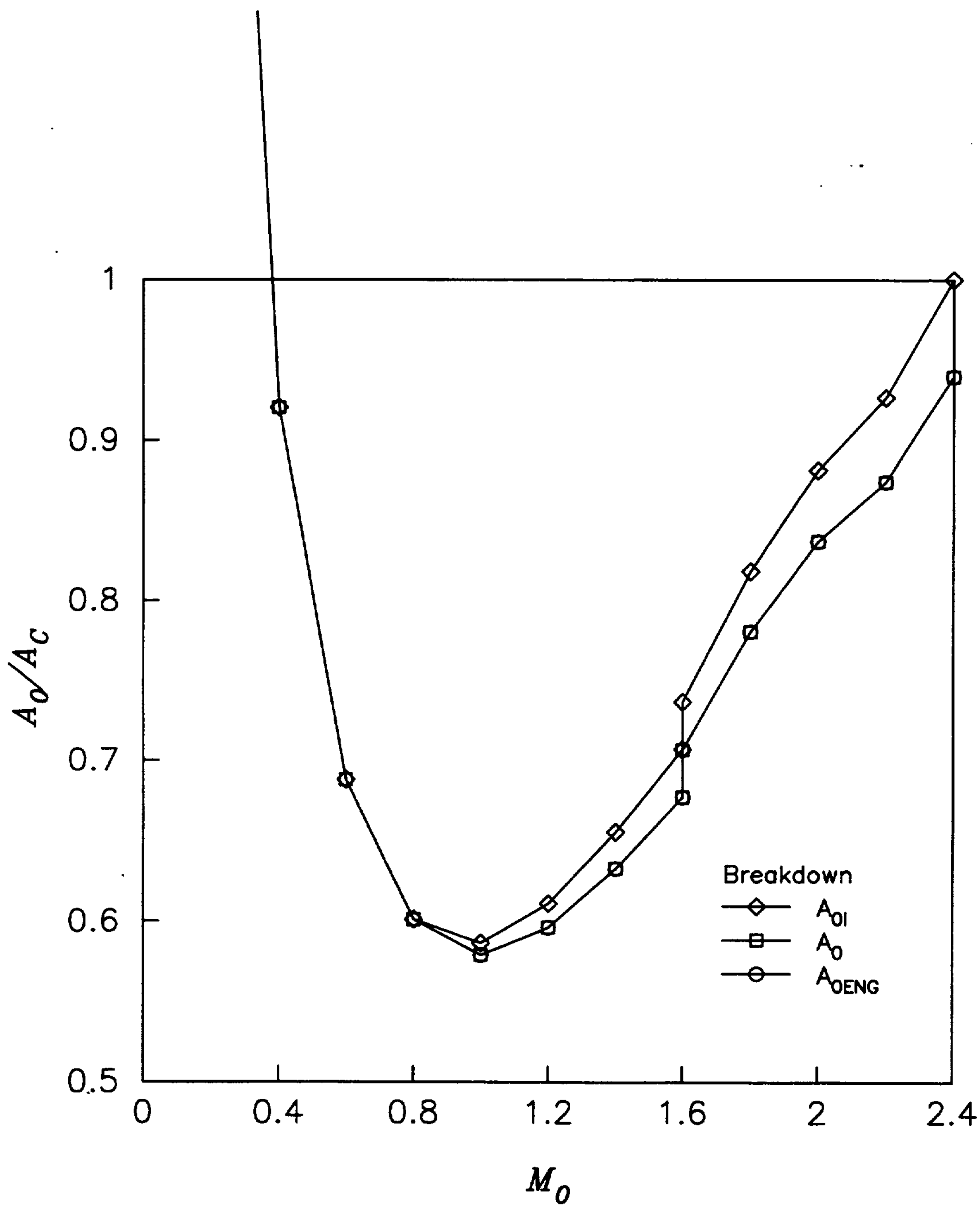


Figure III.2 Mass Flow Ratios

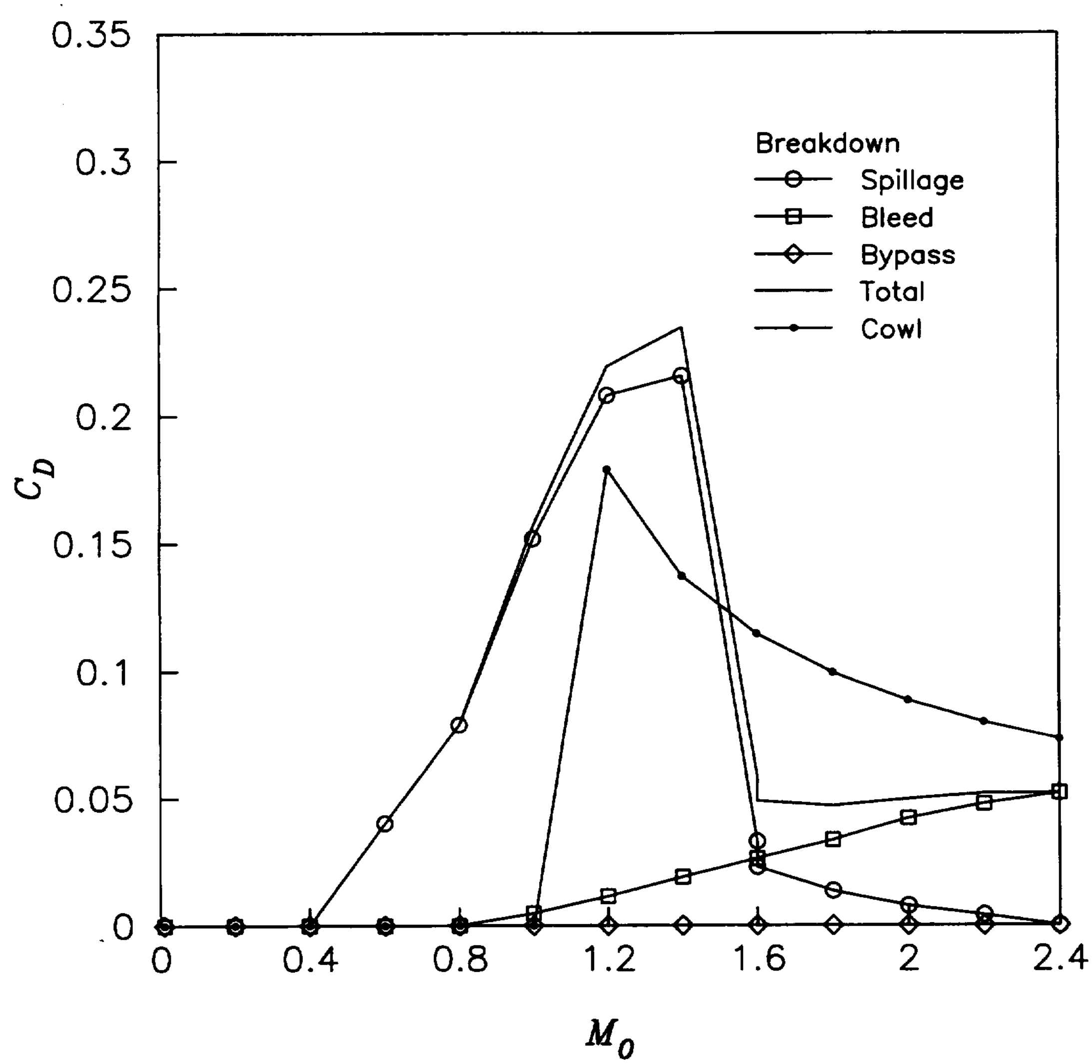


Figure III.3 Drag Coefficients

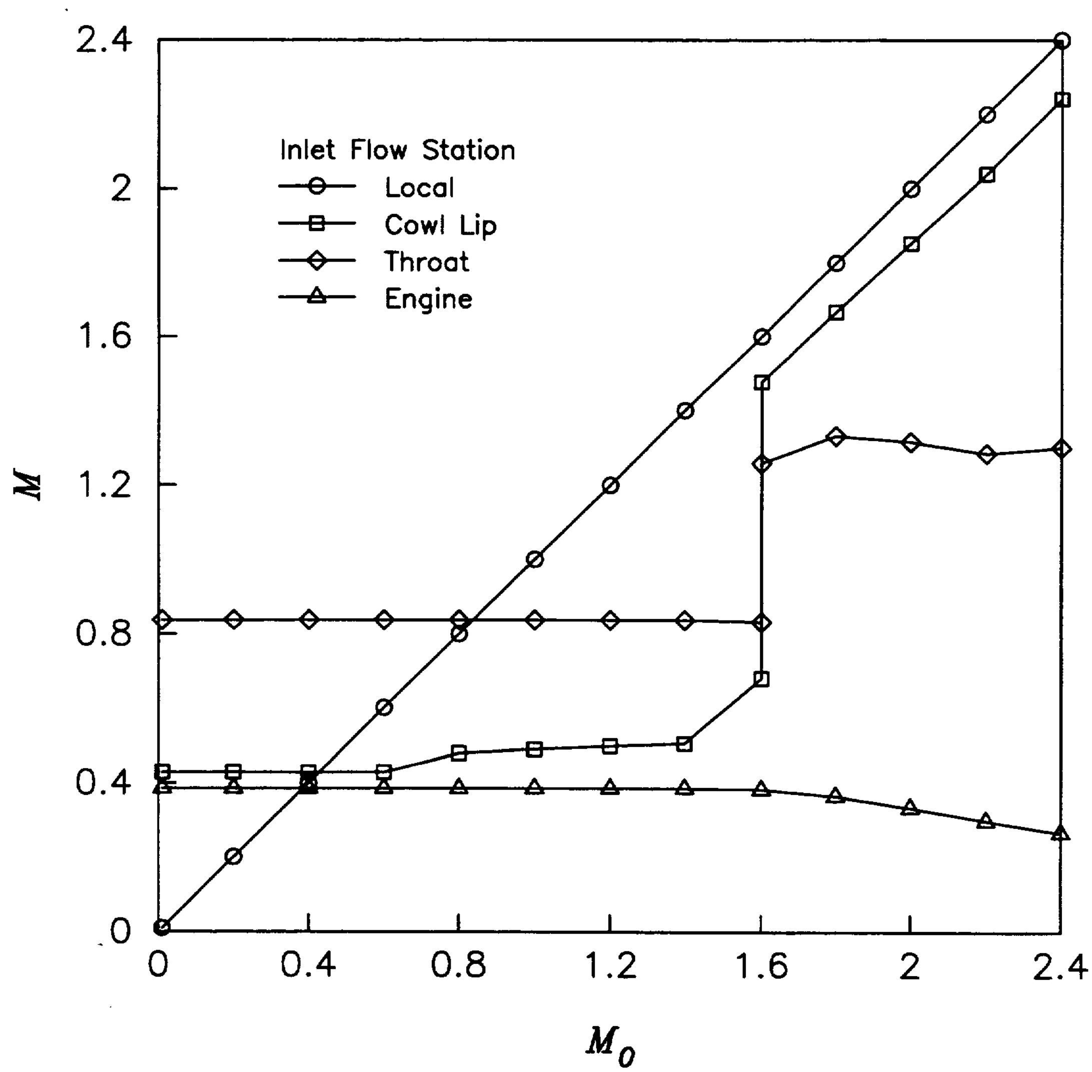


Figure III.4 Mach Numbers

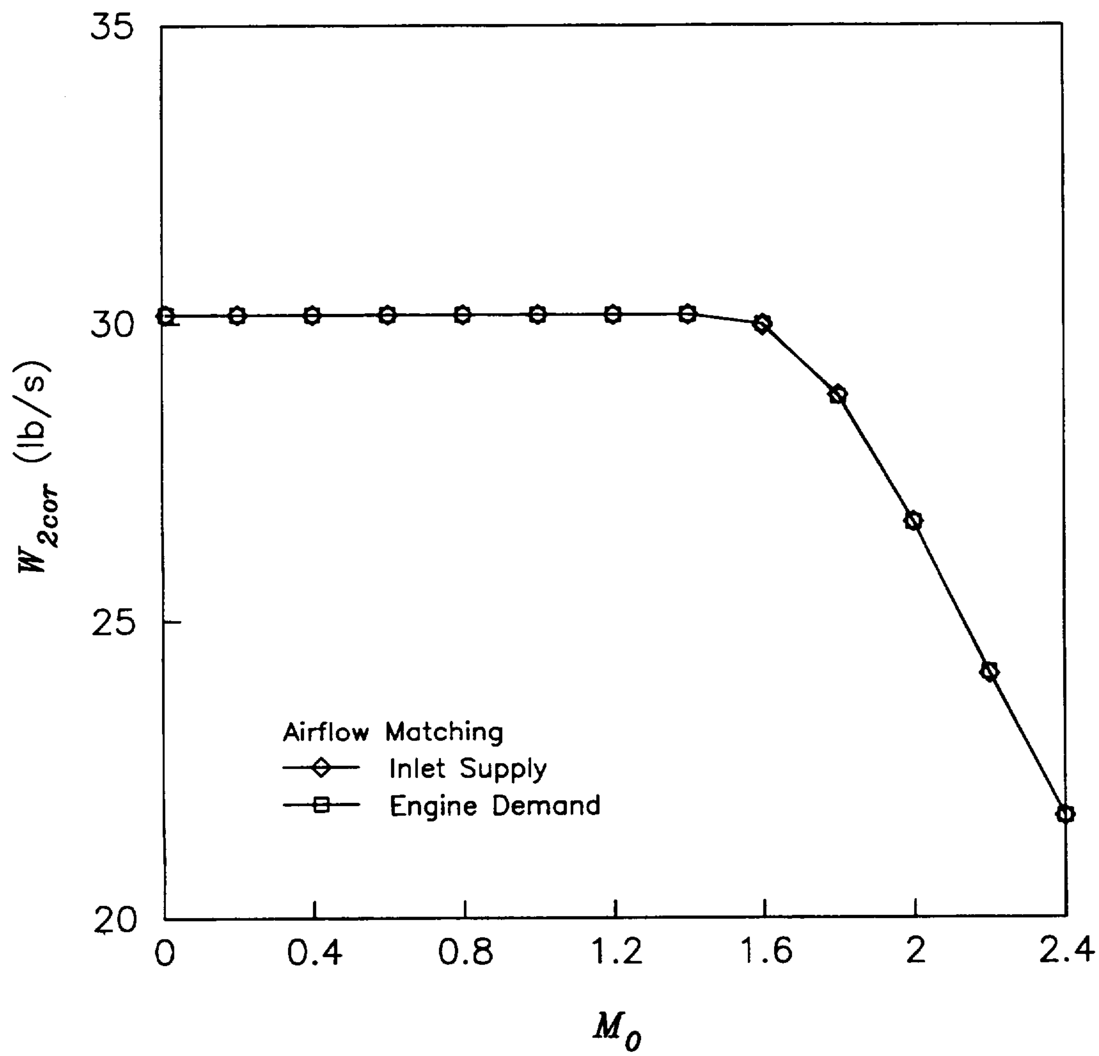


Figure III.5 Corrected Airflows

```
&ipac
 title='Axisymmetric Inlet Example Case',
 echo=1,figure=1,npts=10,20,iout=1,1,1,1,
 xmach0=2.4,alt=-1000,
 idim=3,ac=1.0,ar=1,
 ramps=1,theta=10,
 xcowl=0.0,ycowl=1.0,
 rclip=0.0,thetac=3.0,
 cowls=2,cowlth=5,-5,cowlxl=4,1,
 a2ac=1.00,xldd2=1.5,hubtip=0.3,
 nishck=-1,xmth=-1.30,xmns=1.35,
 athac=-1,
 w2cor=-1,
 bleed=-1,pblpt0=-1,
&end

forebd: xmachx= 2.400E+00,xmach0= 2.400E+00, xmlm0= 1.000E+00,ptlpt0= 1.000E+00,  ala0= 1.000E+00,
 cdaxi: xmach0= 2.400E+00, a0iac= 9.999E-01,xmach1= 2.241E+00,pt1pt0= 9.997E-01,   cda= 3.023E-06,
 cdaxi: xmach0= 2.400E+00, a0iac= 9.989E-01,xmach1= 5.360E-01,pt1pt0= 6.095E-01,   cda= 8.542E-03,
 ptrcv: xmach0= 2.400E+00,  a0ac= 9.400E-01,  xmns= 1.350E+00,pt2pt0= 8.903E-01,thetad= 4.057E+00,
          xmth= 1.300E+00, athac= 4.341E-01,nishck= 1.000E+00,pthpt0= 9.606E-01,xlipth= 9.118E-01,
 cdaxi: xmach0= 2.400E+00, a0iac= 9.999E-01,xmach1= 2.241E+00,pt1pt0= 9.997E-01,   cda= 3.023E-06,
cdwave: xmach0= 2.400E+00, cdwav= 7.306E-02,
 cdbld: xmach0= 2.400E+00, a0iac= 9.999E-01, bleed= 6.000E-02, cdbld= 5.186E-02,ptblpe= 1.465E+00,
      : xmach0= 2.400E+00, a0iac= 9.999E-01, bleed= 6.000E-02, cdbld= 5.186E-02,
      : xmach0= 2.400E+00, a0iac= 9.999E-01, cdtot= 5.186E-02, cdspl= 3.023E-06, cdref= 7.306E-02,
      : xmach0= 2.400E+00,a0enac= 9.399E-01,   w2c= 2.170E+01,    w2= 2.574E+01,
      : xmachx= 2.400E+00,a0enac= 9.399E-01,w2ceng= 2.170E+01,

IPAC   Axisymmetric Inlet Example Case

Flight Conditions

          Mach number                     2.400E+00

             altitude  (ft)               4.974E+04

                                           ambient     total

             pressure  (lbf/ft**2)        2.452E+02  3.585E+03
          temperature  (R)                3.900E+02  8.392E+02
     dynamic pressure  (lbf/ft**2)        9.888E+02

Vehicle Effects

                ML/M0                     1.000E+00
```

```
                  PTL/PT0           1.000E+00
                   AL/A0            1.000E+00

Inlet Mass Flow Ratios

                   A0I/AC           9.999E-01
                 A0SPL/AC           8.440E-05
                 A0BLD/AC           6.000E-02
                   A0/AC            9.399E-01
                 A0BYP/AC           0.000E-01
                 A0ENG/AC           9.399E-01

Inlet Total Pressure Recoveries

                  PT2/PT0           8.903E-01

                  PTL/PT0           1.000E+00
                  PT1/PTL           9.997E-01
                 PTTH/PT1           9.609E-01
                 PT2/PTTH           9.268E-01

                  PTx/PTy           9.697E-01

Inlet Drag Breakdown

                       AC  (ft**2)        1.000E+00

                                             CD       D  (lbf)

                 spillage           3.023E-06  2.990E-03
                    bleed           5.186E-02  5.128E+01
                   bypass           0.000E-01  0.000E-01
                     cowl           7.306E-02  7.224E+01
                    total           1.249E-01  1.235E+02
                reference           7.306E-02  7.224E+01
            power setting           5.186E-02  5.128E+01

Engine Performance Data            uninstalled  installed

           net thrust  (lbf)        0.000E-01 -1.235E+02
                  SFC  (lbm/hr/lbf) 0.000E-01 -0.000E-01
                   W2  (lbm/s)      0.000E-01  2.574E+01
         corrected W2  (lbm/s)      2.170E+01  2.170E+01

   reference recovery               8.819E-01
```

Inlet Flow Properties

		free stream	inlet local	cowl lip	throat	engine face
station		0	L	1	TH	2
flow area	(ft**2)	9.999E-01	9.999E-01	8.706E-01	4.341E-01	1.000E+00
Mach number		2.400E+00	2.400E+00	2.241E+00	1.300E+00	2.651E-01
pressure	(lbf/ft**2)	2.452E+02	2.452E+02	3.145E+02	1.243E+03	3.040E+03
temperature	(R)	3.900E+02	3.900E+02	4.187E+02	6.273E+02	8.276E+02
density	(slg/ft**3)	3.664E-04	3.664E-04	4.377E-04	1.155E-03	2.140E-03
velocity	(ft/s)	2.323E+03	2.323E+03	2.248E+03	1.596E+03	3.738E+02
total pressure	(lbf/ft**2)	3.585E+03	3.585E+03	3.585E+03	3.444E+03	3.192E+03
total temperature	(R)	8.392E+02	8.392E+02	8.392E+02	8.392E+02	8.392E+02
weight flow	(lbm/s)	2.739E+01	2.739E+01	2.739E+01	2.574E+01	2.574E+01
corrected weight flow	(lbm/s)	2.055E+01	2.055E+01	2.056E+01	2.011E+01	2.170E+01

Geometry Data for Axisymmetric Inlet

inlet capture, AC	(ft**2)	1.000E+00
wrap angle	(degrees)	3.600E+02
radius	(ft)	5.642E-01
engine face, A2	(ft**2)	1.000E+00
diameter	(ft)	1.183E+00
H/T		3.000E-01

Figure Data for Inlet Geometry

internal cowl surface	(ft)	X	Y
		1.147E+00	5.642E-01
		2.040E+00	5.173E-01
		2.040E+00	5.173E-01
		2.134E+00	5.179E-01
		2.227E+00	5.196E-01
		2.321E+00	5.223E-01
		2.414E+00	5.258E-01

```
                                      2.507E+00  5.300E-01
                                      2.601E+00  5.348E-01
                                      2.694E+00  5.401E-01
                                      2.788E+00  5.457E-01
                                      2.881E+00  5.515E-01
                                      2.974E+00  5.573E-01
                                      3.068E+00  5.631E-01
                                      3.161E+00  5.687E-01
                                      3.254E+00  5.739E-01
                                      3.348E+00  5.787E-01
                                      3.441E+00  5.830E-01
                                      3.535E+00  5.865E-01
                                      3.628E+00  5.891E-01
                                      3.721E+00  5.908E-01
                                      3.815E+00  5.914E-01

  external cowl surface   (ft)            X          Y

                                      1.147E+00  5.642E-01
                                      3.403E+00  7.616E-01
                                      3.967E+00  7.616E-01

     centerbody surface   (ft)            X          Y

                                      0.000E-01  0.000E-01
                                      2.040E+00  3.598E-01
                                      2.040E+00  3.598E-01
                                      2.134E+00  3.583E-01
                                      2.227E+00  3.542E-01
                                      2.321E+00  3.476E-01
                                      2.414E+00  3.389E-01
                                      2.507E+00  3.286E-01
                                      2.601E+00  3.167E-01
                                      2.694E+00  3.038E-01
                                      2.788E+00  2.900E-01
                                      2.881E+00  2.758E-01
                                      2.974E+00  2.614E-01
                                      3.068E+00  2.472E-01
                                      3.161E+00  2.334E-01
                                      3.254E+00  2.205E-01
                                      3.348E+00  2.087E-01
                                      3.441E+00  1.983E-01
                                      3.535E+00  1.896E-01
                                      3.628E+00  1.831E-01
                                      3.721E+00  1.789E-01
                                      3.815E+00  1.774E-01
```

```
                                       3.815E+00  1.774E-01


&ipac
 xmach0=2.2,figure=0,iout=1,1,0,0,
 xmth=-1.3,xlipth=-1,
 xtrans=0.45,xmns=1.37,
&end

forebd: xmachx= 2.200E+00,xmach0= 2.200E+00, xmlm0= 1.000E+00,ptlpt0= 1.000E+00,  ala0= 1.000E+00,
 cdaxi: xmach0= 2.200E+00, a0iac= 9.268E-01,xmach1= 2.039E+00,pt1pt0= 9.999E-01,   cda= 4.079E-03,
 cdaxi: xmach0= 2.200E+00, a0iac= 9.259E-01,xmach1= 5.708E-01,pt1pt0= 7.024E-01,   cda= 1.631E-03,
 ptrcv: xmach0= 2.200E+00,  a0ac= 8.743E-01,  xmns= 1.370E+00,pt2pt0= 8.939E-01,thetad= 3.789E+00,
          xmth= 1.284E+00, athac= 4.780E-01,nishck= 1.000E+00,pthpt0= 9.668E-01,xlipth= 7.176E-01,
 cdaxi: xmach0= 2.200E+00, a0iac= 9.268E-01,xmach1= 2.039E+00,pt1pt0= 9.999E-01,   cda= 4.079E-03,
cdwave: xmach0= 2.200E+00, cdwav= 7.992E-02,
 cdbld: xmach0= 2.200E+00, a0iac= 9.268E-01, bleed= 5.250E-02, cdbld= 4.766E-02,ptblpe= 1.225E+00,
      : xmach0= 2.200E+00, a0iac= 9.268E-01, bleed= 5.250E-02, cdbld= 4.766E-02,
      : xmach0= 2.200E+00, a0iac= 9.268E-01, cdtot= 5.174E-02, cdspl= 4.079E-03, cdref= 7.992E-02,
      : xmach0= 2.200E+00,a0enac= 8.743E-01,   w2c= 2.410E+01,    w2= 2.627E+01,
      : xmachx= 2.200E+00,a0enac= 8.743E-01,w2ceng= 2.413E+01,

IPAC   Axisymmetric Inlet Example Case

Flight Conditions

          Mach number                    2.200E+00

             altitude  (ft)              4.601E+04

                                          ambient     total

             pressure  (lbf/ft**2)       2.934E+02  3.138E+03
          temperature  (R)               3.900E+02  7.675E+02
     dynamic pressure  (lbf/ft**2)       9.942E+02

Vehicle Effects

                ML/M0                    1.000E+00
              PTL/PT0                    1.000E+00
                AL/A0                    1.000E+00

Inlet Mass Flow Ratios

               A0I/AC                    9.268E-01
             A0SPL/AC                    7.319E-02
```

```
                AOBLD/AC                5.250E-02
                  A0/AC                 8.743E-01
                AOBYP/AC                0.000E-01
                AOENG/AC                8.743E-01

 Inlet Total Pressure Recoveries

                 PT2/PT0                8.939E-01

                 PTL/PT0                1.000E+00
                 PT1/PTL                9.999E-01
                PTTH/PT1                9.670E-01
                PT2/PTTH                9.245E-01

                 PTx/PTy                9.653E-01

 Inlet Drag Breakdown

                      AC  (ft**2)       1.000E+00

                                           CD       D  (lbf)

                spillage                4.079E-03  4.055E+00
                   bleed                4.766E-02  4.739E+01
                  bypass                0.000E-01  0.000E-01
                    cowl                7.992E-02  7.946E+01
                   total                1.317E-01  1.309E+02
               reference                7.992E-02  7.946E+01
           power setting                5.174E-02  5.144E+01

 Engine Performance Data              uninstalled  installed

             net thrust  (lbf)          0.000E-01 -1.309E+02
                    SFC  (lbm/hr/lbf)   0.000E-01 -0.000E-01
                     W2  (lbm/s)        0.000E-01  2.627E+01
           corrected W2  (lbm/s)        2.413E+01  2.410E+01

    reference recovery                  9.041E-01


 &ipac
  xmach0=2.0,figure=0,
  xtrans=0.61,xmns=1.35,
  thetac= 1.5,
 &end
```

```
forebd: xmachx= 2.000E+00,xmach0= 2.000E+00, xmlm0= 1.000E+00,ptlpt0= 1.000E+00,  ala0= 1.000E+00,
 cdaxi: xmach0= 2.000E+00, a0iac= 8.816E-01,xmach1= 1.853E+00,pt1pt0= 9.999E-01,   cda= 7.564E-03,
 cdaxi: xmach0= 2.000E+00, a0iac= 8.807E-01,xmach1= 6.086E-01,pt1pt0= 7.889E-01,   cda= 9.161E-04,
 ptrcv: xmach0= 2.000E+00,  a0ac= 8.366E-01,  xmns= 1.350E+00,pt2pt0= 9.187E-01,thetad= 3.383E+00,
          xmth= 1.315E+00, athac= 5.429E-01,nishck= 1.000E+00,pthpt0= 9.796E-01,xlipth= 6.263E-01,
 cdaxi: xmach0= 2.000E+00, a0iac= 8.816E-01,xmach1= 1.853E+00,pt1pt0= 9.999E-01,   cda= 7.564E-03,
cdwave: xmach0= 2.000E+00, cdwav= 8.844E-02,
 cdbld: xmach0= 2.000E+00, a0iac= 8.816E-01, bleed= 4.500E-02, cdbld= 4.195E-02,ptblpe= 1.093E+00,
      : xmach0= 2.000E+00, a0iac= 8.816E-01, bleed= 4.500E-02, cdbld= 4.195E-02,
      : xmach0= 2.000E+00, a0iac= 8.816E-01, cdtot= 4.951E-02, cdspl= 7.564E-03, cdref= 8.844E-02,
      : xmach0= 2.000E+00,a0enac= 8.366E-01,   w2c= 2.665E+01,    w2= 2.786E+01,
      : xmachx= 2.000E+00,a0enac= 8.366E-01,w2ceng= 2.664E+01,

IPAC   Axisymmetric Inlet Example Case

Flight Conditions

          Mach number                  2.000E+00

             altitude  (ft)            4.189E+04

                                        ambient     total

             pressure  (lbf/ft**2)     3.578E+02  2.800E+03
          temperature  (R)             3.900E+02  7.019E+02
     dynamic pressure  (lbf/ft**2)     1.002E+03

Vehicle Effects

                ML/M0                  1.000E+00
              PTL/PT0                  1.000E+00
                AL/A0                  1.000E+00

Inlet Mass Flow Ratios

               A0I/AC                  8.816E-01
             A0SPL/AC                  1.184E-01
             A0BLD/AC                  4.500E-02
                A0/AC                  8.366E-01
             A0BYP/AC                  0.000E-01
             A0ENG/AC                  8.366E-01

Inlet Total Pressure Recoveries

              PT2/PT0                  9.187E-01
```

```
                  PTL/PT0                1.000E+00
                  PT1/PTL                9.999E-01
                 PTTH/PT1                9.796E-01
                 PT2/PTTH                9.379E-01
                    .
                  PTx/PTy                9.697E-01

Inlet Drag Breakdown

                       AC  (ft**2)       1.000E+00

                                            CD       D  (lbf)

                 spillage                7.564E-03  7.578E+00
                    bleed                4.195E-02  4.202E+01
                   bypass                0.000E-01  0.000E-01
                     cowl                8.844E-02  8.860E+01
                    total                1.380E-01  1.382E+02
                reference                8.844E-02  8.860E+01
            power setting                4.951E-02  4.960E+01

Engine Performance Data                 uninstalled  installed

              net thrust  (lbf)          0.000E-01 -1.382E+02
                     SFC  (lbm/hr/lbf)   0.000E-01 -0.000E-01
                      W2  (lbm/s)        0.000E-01  2.786E+01
            corrected W2  (lbm/s)        2.664E+01  2.665E+01

   reference recovery                    9.250E-01


&ipac
 xmach0=1.8,figure=0,
 xtrans=0.87,xmns=1.35,
 thetac= 0.0,
&end

forebd: xmachx= 1.800E+00,xmach0= 1.800E+00, xmlm0= 1.000E+00,ptlpt0= 1.000E+00,  ala0= 1.000E+00,
 cdaxi: xmach0= 1.800E+00, a0iac= 8.182E-01,xmach1= 1.666E+00,pt1pt0= 1.000E+00,   cda= 1.342E-02,
 cdaxi: xmach0= 1.800E+00, a0iac= 8.174E-01,xmach1= 6.631E-01,pt1pt0= 8.697E-01,   cda=-2.811E-05,
 ptrcv: xmach0= 1.800E+00,  a0ac= 7.807E-01,  xmns= 1.350E+00,pt2pt0= 9.309E-01,thetad= 3.060E+00,
           xmth= 1.331E+00, athac= 5.933E-01,nishck= 1.000E+00,pthpt0= 9.876E-01,xlipth= 5.039E-01,
 cdaxi: xmach0= 1.800E+00, a0iac= 8.182E-01,xmach1= 1.666E+00,pt1pt0= 1.000E+00,   cda= 1.342E-02,
cdwave: xmach0= 1.800E+00, cdwav= 9.942E-02,
 cdbld: xmach0= 1.800E+00, a0iac= 8.182E-01, bleed= 3.750E-02, cdbld= 3.344E-02,ptblpe= 1.082E+00,
      : xmach0= 1.800E+00, a0iac= 8.182E-01, bleed= 3.750E-02, cdbld= 3.344E-02,
```

```
      : xmach0= 1.800E+00, a0iac= 8.182E-01, cdtot= 4.686E-02, cdspl= 1.342E-02, cdref= 9.942E-02,
      : xmach0= 1.800E+00,a0enac= 7.807E-01,   w2c= 2.879E+01,    w2= 2.919E+01,
      : xmachx= 1.800E+00,a0enac= 7.807E-01,w2ceng= 2.876E+01,

IPAC   Axisymmetric Inlet Example Case

Flight Conditions

          Mach number                    1.800E+00

             altitude  (ft)              3.729E+04

                                          ambient     total

             pressure  (lbf/ft**2)       4.464E+02  2.565E+03
          temperature  (R)               3.900E+02  6.427E+02
     dynamic pressure  (lbf/ft**2)       1.012E+03

Vehicle Effects

                ML/M0                    1.000E+00
              PTL/PT0                    1.000E+00
                AL/A0                    1.000E+00

Inlet Mass Flow Ratios

               A0I/AC                    8.182E-01
             A0SPL/AC                    1.818E-01
             A0BLD/AC                    3.750E-02
                A0/AC                    7.807E-01
             A0BYP/AC                    0.000E-01
             A0ENG/AC                    7.807E-01

Inlet Total Pressure Recoveries

              PT2/PT0                    9.309E-01

              PTL/PT0                    1.000E+00
              PT1/PTL                    1.000E+00
             PTTH/PT1                    9.876E-01
             PT2/PTTH                    9.426E-01

              PTx/PTy                    9.697E-01

Inlet Drag Breakdown
```

```
                 AC   (ft**2)          1.000E+00

                                          CD       D   (lbf)

           spillage                    1.342E-02  1.358E+01
              bleed                    3.344E-02  3.386E+01
             bypass                    0.000E-01  0.000E-01
               cowl                    9.942E-02  1.007E+02
              total                    1.463E-01  1.481E+02
          reference                    9.942E-02  1.007E+02
      power setting                    4.686E-02  4.744E+01

Engine Performance Data               uninstalled  installed

         net thrust   (lbf)            0.000E-01 -1.481E+02
                SFC   (lbm/hr/lbf)     0.000E-01 -0.000E-01
                 W2   (lbm/s)          0.000E-01  2.919E+01
       corrected W2   (lbm/s)          2.876E+01  2.879E+01

   reference recovery                  9.445E-01


&ipac
 xmach0=1.6,figure=0,
 xtrans=1.2,xmns=1.36,
 thetac=0.0,
&end

forebd: xmachx= 1.600E+00,xmach0= 1.600E+00, xmlm0= 1.000E+00,ptlpt0= 1.000E+00,  ala0= 1.000E+00,
 cdaxi: xmach0= 1.600E+00, a0iac= 7.367E-01,xmach1= 1.477E+00,pt1pt0= 1.000E+00,   cda= 2.276E-02,
 cdaxi: xmach0= 1.600E+00, a0iac= 7.360E-01,xmach1= 7.419E-01,pt1pt0= 9.369E-01,   cda= 4.604E-03,
*** error ***  in program segment ptrint   (errflg=1)
 ptrcv: xmach0= 1.600E+00,  a0ac= 7.067E-01,  xmns= 1.360E+00,pt2pt0= 9.324E-01,thetad= 3.060E+00,
          xmth= 1.258E+00, athac= 5.933E-01,nishck= 0.000E-01,pthpt0= 1.000E+00,xlipth= 0.000E-01,
 cdaxi: xmach0= 1.600E+00, a0iac= 7.367E-01,xmach1= 1.477E+00,pt1pt0= 1.000E+00,   cda= 2.276E-02,
cdwave: xmach0= 1.600E+00, cdwav= 1.144E-01,
 cdbld: xmach0= 1.600E+00, a0iac= 7.367E-01, bleed= 3.000E-02, cdbld= 2.609E-02,ptblpe= 1.037E+00,
      : xmach0= 1.600E+00, a0iac= 7.367E-01, bleed= 3.000E-02, cdbld= 2.609E-02,
      : xmach0= 1.600E+00, a0iac= 7.367E-01, cdtot= 4.885E-02, cdspl= 2.276E-02, cdref= 1.144E-01,
      : xmach0= 1.600E+00,a0enac= 7.067E-01,   w2c= 2.995E+01,    w2= 2.949E+01,
      : xmachx= 1.600E+00,a0enac= 7.067E-01,w2ceng= 2.998E+01,

IPAC   Axisymmetric Inlet Example Case

Flight Conditions
```

```
          Mach number                      1.600E+00

             altitude  (ft)                3.209E+04

                                           ambient    total

             pressure  (lbf/ft**2)         5.706E+02  2.425E+03
          temperature  (R)                 4.042E+02  6.112E+02
     dynamic pressure  (lbf/ft**2)         1.023E+03

Vehicle Effects

                ML/MO                      1.000E+00
              PTL/PT0                      1.000E+00
                AL/A0                      1.000E+00

Inlet Mass Flow Ratios

               A0I/AC                      7.367E-01
             A0SPL/AC                      2.633E-01
             A0BLD/AC                      3.000E-02
                A0/AC                      7.067E-01
             A0BYP/AC                      0.000E-01
             A0ENG/AC                      7.067E-01

Inlet Total Pressure Recoveries

              PT2/PT0                      9.324E-01

              PTL/PT0                      1.000E+00
              PT1/PTL                      1.000E+00
             PTTH/PT1                      1.000E+00
             PT2/PTTH                      9.324E-01

              PTx/PTy                      9.676E-01

Inlet Drag Breakdown

                   AC  (ft**2)             1.000E+00

                                              CD      D  (lbf)

             spillage                      2.276E-02  2.328E+01
                bleed                      2.609E-02  2.667E+01
               bypass                      0.000E-01  0.000E-01
                 cowl                      1.144E-01  1.170E+02
```

```
                 total                       1.632E-01  1.669E+02
             reference                       1.144E-01  1.170E+02
         power setting                       4.885E-02  4.995E+01

Engine Performance Data                    uninstalled  installed

            net thrust  (lbf)                0.000E-01 -1.669E+02
                   SFC  (lbm/hr/lbf)         0.000E-01 -0.000E-01
                    W2  (lbm/s)              0.000E-01  2.949E+01
          corrected W2  (lbm/s)              2.998E+01  2.995E+01

   reference recovery                        9.624E-01


&ipac
 xmach0=1.6,figure=0,
 xtrans=1.2,
 thetac=0.0,
 xmth=0.832,
&end

forebd: xmachx= 1.600E+00,xmach0= 1.600E+00, xmlm0= 1.000E+00,ptlpt0= 1.000E+00,  ala0= 1.000E+00,
 cdaxi: xmach0= 1.600E+00, a0iac= 5.000E-01,xmach1= 4.061E-01,pt1pt0= 9.369E-01,   cda= 3.588E-01,
 ptrcv: xmach0= 1.600E+00,  a0ac= 6.772E-01,  xmns= 1.360E+00,pt2pt0= 8.924E-01,thetad= 3.060E+00,
          xmth= 8.320E-01, athac= 5.933E-01,nishck=-1.000E+00,pthpt0= 9.369E-01,xlipth=-1.000E+00,
 cdaxi: xmach0= 1.600E+00, a0iac= 7.072E-01,xmach1= 6.790E-01,pt1pt0= 9.369E-01,   cda= 4.048E-02,
cdwave: xmach0= 1.600E+00, cdwav= 1.144E-01,
 clsuc: xmach0= 1.600E+00, a0iac= 7.072E-01,   cls= 7.686E-03, cdspl= 3.280E-02,thetae= 3.811E+00,
 cdbld: xmach0= 1.600E+00, a0iac= 7.072E-01, bleed= 3.000E-02, cdbld= 2.609E-02,ptblpe= 1.037E+00,
      : xmach0= 1.600E+00, a0iac= 7.072E-01, bleed= 3.000E-02, cdbld= 2.609E-02,
      : xmach0= 1.600E+00, a0iac= 7.072E-01, cdtot= 5.888E-02, cdspl= 3.280E-02, cdref= 1.144E-01,
      : xmach0= 1.600E+00,a0enac= 6.772E-01,   w2c= 2.998E+01,    w2= 2.826E+01,
      : xmachx= 1.600E+00,a0enac= 6.772E-01,w2ceng= 2.998E+01,

IPAC   Axisymmetric Inlet Example Case

Flight Conditions

           Mach number                       1.600E+00

              altitude  (ft)                 3.209E+04

                                              ambient     total

              pressure  (lbf/ft**2)          5.706E+02  2.425E+03
           temperature  (R)                  4.042E+02  6.112E+02
```

```
      dynamic pressure  (lbf/ft**2)    1.023E+03

   Vehicle Effects

                 ML/MO                1.000E+00
                PTL/PT0               1.000E+00
                 AL/A0                1.000E+00

   Inlet Mass Flow Ratios

                A0I/AC                7.072E-01
               A0SPL/AC               2.928E-01
               A0BLD/AC               3.000E-02
                 A0/AC                6.772E-01
               A0BYP/AC               0.000E-01
               A0ENG/AC               6.772E-01

   Inlet Total Pressure Recoveries

                PT2/PT0               8.924E-01

                PTL/PT0               1.000E+00
                PT1/PTL               9.369E-01
               PTTH/PT1               1.000E+00
               PT2/PTTH               9.525E-01

                PTx/PTy               1.000E+00

   Inlet Drag Breakdown

                    AC  (ft**2)       1.000E+00

                                         CD       D  (lbf)

              spillage                3.280E-02  3.354E+01
                 bleed                2.609E-02  2.667E+01
                bypass                0.000E-01  0.000E-01
                  cowl                1.144E-01  1.170E+02
                 total                1.733E-01  1.772E+02
             reference                1.144E-01  1.170E+02
         power setting                5.888E-02  6.021E+01

   Engine Performance Data          uninstalled  installed

            net thrust  (lbf)         0.000E-01 -1.772E+02
                   SFC  (lbm/hr/lbf)  0.000E-01 -0.000E-01
```

```
                 W2  (lbm/s)         0.000E-01  2.826E+01
       corrected W2  (lbm/s)         2.998E+01  2.998E+01

  reference recovery                 9.624E-01


&ipac
 xmach0=1.4,figure=0,
 xtrans=0.5,
 thetac=0.0,
 xmth=0.837,
&end

forebd: xmachx= 1.400E+00,xmach0= 1.400E+00, xmlm0= 1.000E+00,ptlpt0= 1.000E+00,  ala0= 1.000E+00,
 cdaxi: xmach0= 1.400E+00, a0iac= 5.000E-01,xmach1= 3.580E-01,pt1pt0= 9.807E-01,   cda= 4.593E-01,
 ptrcv: xmach0= 1.400E+00,  a0ac= 6.331E-01,  xmns= 1.360E+00,pt2pt0= 9.307E-01,thetad= 3.060E+00,
          xmth= 8.370E-01, athac= 5.933E-01,nishck=-1.000E+00,pthpt0= 9.807E-01,xlipth=-1.000E+00,
 cdaxi: xmach0= 1.400E+00, a0iac= 6.556E-01,xmach1= 5.051E-01,pt1pt0= 9.807E-01,   cda= 2.239E-01,
cdwave: xmach0= 1.400E+00, cdwav= 1.369E-01,
 clsuc: xmach0= 1.400E+00, a0iac= 6.556E-01,   cls= 8.257E-03, cdspl= 2.156E-01,thetae= 3.811E+00,
*** error ***  in program segment cdbld    (errflg=2)
 cdbld: xmach0= 1.400E+00, a0iac= 6.556E-01, bleed= 2.250E-02, cdbld= 1.884E-02,ptblpe= 1.001E+00,
      : xmach0= 1.400E+00, a0iac= 6.556E-01, bleed= 2.250E-02, cdbld= 1.884E-02,
      : xmach0= 1.400E+00, a0iac= 6.556E-01, cdtot= 2.344E-01, cdspl= 2.156E-01, cdref= 1.369E-01,
      : xmach0= 1.400E+00,a0enac= 6.331E-01,   w2c= 3.014E+01,    w2= 2.954E+01,
      : xmachx= 1.400E+00,a0enac= 6.331E-01,w2ceng= 3.014E+01,

IPAC   Axisymmetric Inlet Example Case

Flight Conditions

          Mach number                  1.400E+00

             altitude  (ft)            2.611E+04

                                        ambient     total

             pressure  (lbf/ft**2)     7.481E+02  2.381E+03
          temperature  (R)             4.256E+02  5.924E+02
     dynamic pressure  (lbf/ft**2)     1.026E+03

Vehicle Effects

                ML/M0                  1.000E+00
              PTL/PT0                  1.000E+00
                AL/A0                  1.000E+00
```

```

Inlet Mass Flow Ratios

                 A0I/AC                 6.556E-01
               A0SPL/AC                 3.444E-01
               A0BLD/AC                 2.250E-02
                  A0/AC                 6.331E-01
               A0BYP/AC                 0.000E-01
               A0ENG/AC                 6.331E-01

Inlet Total Pressure Recoveries

                PT2/PT0                 9.307E-01

                PTL/PT0                 1.000E+00
                PT1/PTL                 9.807E-01
               PTTH/PT1                 1.000E+00
               PT2/PTTH                 9.490E-01

                PTx/PTy                 1.000E+00

Inlet Drag Breakdown

                     AC  (ft**2)        1.000E+00

                                           CD       D  (lbf)

               spillage                 2.156E-01  2.213E+02
                  bleed                 1.884E-02  1.934E+01
                 bypass                 0.000E-01  0.000E-01
                   cowl                 1.369E-01  1.406E+02
                  total                 3.714E-01  3.812E+02
              reference                 1.369E-01  1.406E+02
          power setting                 2.344E-01  2.407E+02

Engine Performance Data               uninstalled  installed

             net thrust  (lbf)          0.000E-01 -3.812E+02
                    SFC  (lbm/hr/lbf)   0.000E-01 -0.000E-01
                     W2  (lbm/s)        0.000E-01  2.954E+01
           corrected W2  (lbm/s)        3.014E+01  3.014E+01

     reference recovery                 9.782E-01


&ipac
```

```
 xmach0=1.2,figure=0,
 xtrans=0.5,
 thetac=0.0,
&end

forebd: xmachx= 1.200E+00,xmach0= 1.200E+00, xmlm0= 1.000E+00,ptlpt0= 1.000E+00,  ala0= 1.000E+00,
 cdaxi: xmach0= 1.200E+00, a0iac= 5.000E-01,xmach1= 3.845E-01,pt1pt0= 9.992E-01,   cda= 3.719E-01,
 ptrcv: xmach0= 1.200E+00,  a0ac= 5.962E-01,  xmns= 1.360E+00,pt2pt0= 9.483E-01,thetad= 3.060E+00,
          xmth= 8.370E-01, athac= 5.933E-01,nishck=-1.000E+00,pthpt0= 9.992E-01,xlipth=-1.000E+00,
 cdaxi: xmach0= 1.200E+00, a0iac= 6.112E-01,xmach1= 4.981E-01,pt1pt0= 9.992E-01,   cda= 2.157E-01,
cdwave: xmach0= 1.200E+00, cdwav= 1.789E-01,
 clsuc: xmach0= 1.200E+00, a0iac= 6.112E-01,   cls= 7.676E-03, cdspl= 2.080E-01,thetae= 3.811E+00,
*** error ***  in program segment cdbld    (errflg=2)
 cdbld: xmach0= 1.200E+00, a0iac= 6.112E-01, bleed= 1.500E-02, cdbld= 1.131E-02,ptblpe= 1.001E+00,
      : xmach0= 1.200E+00, a0iac= 6.112E-01, bleed= 1.500E-02, cdbld= 1.131E-02,
      : xmach0= 1.200E+00, a0iac= 6.112E-01, cdtot= 2.193E-01, cdspl= 2.080E-01, cdref= 1.789E-01,
      : xmach0= 1.200E+00,a0enac= 5.962E-01,   w2c= 3.014E+01,    w2= 3.132E+01,
      : xmachx= 1.200E+00,a0enac= 5.962E-01,w2ceng= 3.014E+01,

IPAC   Axisymmetric Inlet Example Case

Flight Conditions

          Mach number                  1.200E+00

             altitude  (ft)            1.906E+04

                                        ambient     total

             pressure  (lbf/ft**2)     1.012E+03  2.453E+03
          temperature  (R)             4.507E+02  5.805E+02
     dynamic pressure  (lbf/ft**2)     1.020E+03

Vehicle Effects

                ML/M0                  1.000E+00
               PTL/PT0                 1.000E+00
                AL/A0                  1.000E+00

Inlet Mass Flow Ratios

               A0I/AC                  6.112E-01
             A0SPL/AC                  3.888E-01
             A0BLD/AC                  1.500E-02
                A0/AC                  5.962E-01
             A0BYP/AC                  0.000E-01
```

```
               A0ENG/AC                    5.962E-01

Inlet Total Pressure Recoveries

                PT2/PT0                    9.483E-01

                PTL/PT0                    1.000E+00
                PT1/PTL                    9.992E-01
               PTTH/PT1                    1.000E+00
               PT2/PTTH                    9.490E-01

                PTx/PTy                    1.000E+00

Inlet Drag Breakdown

                     AC  (ft**2)           1.000E+00

                                              CD       D  (lbf)

               spillage                    2.080E-01  2.121E+02
                  bleed                    1.131E-02  1.153E+01
                 bypass                    0.000E-01  0.000E-01
                   cowl                    1.789E-01  1.824E+02
                  total                    3.982E-01  4.060E+02
              reference                    1.789E-01  1.824E+02
          power setting                    2.193E-01  2.236E+02

Engine Performance Data                  uninstalled  installed

             net thrust  (lbf)             0.000E-01 -4.060E+02
                    SFC  (lbm/hr/lbf)      0.000E-01 -0.000E-01
                     W2  (lbm/s)           0.000E-01  3.132E+01
           corrected W2  (lbm/s)           3.014E+01  3.014E+01

   reference recovery                      9.915E-01


&ipac
 xmach0=1.0,figure=0,
 xtrans=0.5,
 thetac=0.0,
&end

forebd: xmachx= 1.000E+00,xmach0= 1.000E+00, xmlm0= 1.000E+00,ptlpt0= 1.000E+00,  ala0= 1.000E+00,
 ptrcv: xmach0= 1.000E+00,  a0ac= 5.791E-01,  xmns= 1.360E+00,pt2pt0= 9.490E-01,thetad= 3.060E+00,
          xmth= 8.370E-01, athac= 5.933E-01,nishck=-1.000E+00,pthpt0= 1.000E+00,xlipth=-1.000E+00,
```

```
 cdaxi: xmach0= 1.000E+00, a0iac= 5.866E-01,xmach1= 4.898E-01,pt1pt0= 1.000E+00,   cda= 1.518E-01,
 clsuc: xmach0= 1.000E+00, a0iac= 5.866E-01,   cls= 0.000E-01, cdspl= 1.518E-01,thetae= 3.811E+00,
*** error ***  in program segment cdbld    (errflg=2)
 cdbld: xmach0= 1.000E+00, a0iac= 5.866E-01, bleed= 7.500E-03, cdbld= 4.803E-03,ptblpe= 1.001E+00,
      : xmach0= 1.000E+00, a0iac= 5.866E-01, bleed= 7.500E-03, cdbld= 4.803E-03,
      : xmach0= 1.000E+00, a0iac= 5.866E-01, cdtot= 1.567E-01, cdspl= 1.518E-01, cdref= 0.000E-01,
      : xmach0= 1.000E+00,a0enac= 5.791E-01,   w2c= 3.014E+01,    w2= 3.474E+01,
      : xmachx= 1.000E+00,a0enac= 5.791E-01,w2ceng= 3.014E+01,

IPAC   Axisymmetric Inlet Example Case

Flight Conditions

          Mach number                     1.000E+00

             altitude   (ft)              1.040E+04

                                           ambient     total

             pressure   (lbf/ft**2)       1.433E+03  2.712E+03
          temperature   (R)               4.816E+02  5.779E+02
     dynamic pressure   (lbf/ft**2)       1.003E+03

Vehicle Effects

                ML/M0                     1.000E+00
              PTL/PT0                     1.000E+00
                AL/A0                     1.000E+00

Inlet Mass Flow Ratios

               A0I/AC                     5.866E-01
             A0SPL/AC                     4.134E-01
             A0BLD/AC                     7.500E-03
                A0/AC                     5.791E-01
             A0BYP/AC                     0.000E-01
             A0ENG/AC                     5.791E-01

Inlet Total Pressure Recoveries

              PT2/PT0                     9.490E-01

              PTL/PT0                     1.000E+00
              PT1/PTL                     1.000E+00
             PTTH/PT1                     1.000E+00
             PT2/PTTH                     9.490E-01
```

```
                 PTx/PTy                     1.000E+00

Inlet Drag Breakdown

                      AC  (ft**2)            1.000E+00

                                                 CD      D  (lbf)

                spillage                     1.518E-01  1.523E+02
                   bleed                     4.803E-03  4.818E+00
                  bypass                     0.000E-01  0.000E-01
                    cowl                     0.000E-01  0.000E-01
                   total                     1.567E-01  1.571E+02
               reference                     0.000E-01  0.000E-01
           power setting                     1.567E-01  1.571E+02

Engine Performance Data                    uninstalled  installed

              net thrust  (lbf)              0.000E-01 -1.571E+02
                     SFC  (lbm/hr/lbf)       0.000E-01 -0.000E-01
                      W2  (lbm/s)            0.000E-01  3.474E+01
            corrected W2  (lbm/s)            3.014E+01  3.014E+01

   reference recovery                        1.000E+00


&ipac
 xmach0=0.8,figure-0,
 xtrans=0.5,
 thetac=0.0,
&end

forebd: xmachx= 8.000E-01,xmach0= 8.000E-01, xmlm0= 1.000E+00,ptlpt0= 1.000E+00,  ala0= 1.000E+00,
 ptrcv: xmach0= 8.000E-01,  a0ac= 6.012E-01,  xmns= 1.360E+00,pt2pt0= 9.490E-01,thetad= 3.060E+00,
          xmth= 8.370E-01, athac= 5.933E-01,nishck=-1.000E+00,pthpt0= 1.000E+00,xlipth=-1.000E+00,
 cdaxi: xmach0= 8.000E-01, a0iac= 6.012E-01,xmach1= 4.788E-01,pt1pt0= 1.000E+00,   cda= 8.446E-02,
 clsuc: xmach0= 8.000E-01, a0iac= 6.012E-01,   cls= 5.559E-03, cdspl= 7.890E-02,thetae= 3.811E+00,
*** error ***  in program segment cdbld    (errflg=2)
 cdbld: xmach0= 8.000E-01, a0iac= 6.012E-01, bleed= 2.310E-09, cdbld= 1.109E-09,ptblpe= 1.001E+00,
      : xmach0= 8.000E-01, a0iac= 6.012E-01, bleed= 2.310E-09, cdbld= 1.109E-09,
      : xmach0= 8.000E-01, a0iac= 6.012E-01, cdtot= 7.890E-02, cdspl= 7.890E-02, cdref= 0.000E-01,
      : xmach0= 8.000E-01,a0enac= 6.012E-01,   w2c= 3.014E+01,    w2= 4.107E+01,
      : xmachx= 8.000E-01,a0enac= 6.012E-01,w2ceng= 3.014E+01,

IPAC   Axisymmetric Inlet Example Case
```

```
Flight Conditions

          Mach number                    8.000E-01

             altitude  (ft)              0.000E-01

                                          ambient     total

             pressure  (lbf/ft**2)       2.116E+03  3.226E+03
          temperature  (R)               5.187E+02  5.851E+02
     dynamic pressure  (lbf/ft**2)       9.481E+02

Vehicle Effects

                ML/M0                    1.000E+00
               PTL/PT0                   1.000E+00
                AL/A0                    1.000E+00

Inlet Mass Flow Ratios

               A0I/AC                    6.012E-01
             A0SPL/AC                    3.988E-01
             A0BLD/AC                    2.310E-09
                A0/AC                    6.012E-01
             A0BYP/AC                    0.000E-01
             A0ENG/AC                    6.012E-01

Inlet Total Pressure Recoveries

              PT2/PT0                    9.490E-01

              PTL/PT0                    1.000E+00
              PT1/PTL                    1.000E+00
             PTTH/PT1                    1.000E+00
             PT2/PTTH                    9.490E-01

              PTx/PTy                    1.000E+00

Inlet Drag Breakdown

                   AC  (ft**2)           1.000E+00

                                            CD       D  (lbf)

             spillage                    7.890E-02  7.480E+01
```

```
                 bleed                           1.109E-09  1.052E-06
                bypass                           0.000E-01  0.000E-01
                  cowl                           0.000E-01  0.000E-01
                 total                           7.890E-02  7.480E+01
             reference                           0.000E-01  0.000E-01
         power setting                           7.890E-02  7.480E+01

Engine Performance Data                        uninstalled  installed

            net thrust  (lbf)                    0.000E-01 -7.480E+01
                   SFC  (lbm/hr/lbf)             0.000E-01 -0.000E-01
                    W2  (lbm/s)                  0.000E-01  4.107E+01
          corrected W2  (lbm/s)                  3.014E+01  3.014E+01

   reference recovery                            1.000E+00


&ipac
 xmach0=0.6,figure=0,
 xtrans=0.0,
 thetac=0.0,
&end

forebd: xmachx= 6.000E-01,xmach0= 6.000E-01, xmlm0= 1.000E+00,ptlpt0= 1.000E+00,  ala0= 1.000E+00,
 ptrcv: xmach0= 6.000E-01,  a0ac= 6.880E-01,  xmns= 1.360E+00,pt2pt0= 9.490E-01,thetad= 3.060E+00,
          xmth= 8.370E-01, athac= 5.933E-01,nishck=-1.000E+00,pthpt0= 1.000E+00,xlipth=-1.000E+00,
 cdaxi: xmach0= 6.000E-01, a0iac= 6.880E-01,xmach1= 4.284E-01,ptlpt0= 1.000E+00,   cda= 4.333E-02,
 clsuc: xmach0= 6.000E-01, a0iac= 6.880E-01,   cls= 3.203E-03, cdspl= 4.013E-02,thetae= 3.811E+00,
      : xmach0= 6.000E-01, a0iac= 6.880E-01, cdtot= 4.013E-02, cdspl= 4.013E-02, cdref= 0.000E-01,
      : xmach0= 6.000E-01,a0enac= 6.880E-01,   w2c= 3.014E+01,    w2= 3.525E+01,
      : xmachx= 6.000E-01,a0enac= 6.880E-01,w2ceng= 3.014E+01,

IPAC   Axisymmetric Inlet Example Case

Flight Conditions

          Mach number                           6.000E-01

             altitude   (ft)                    0.000E-01

                                                 ambient     total

             pressure   (lbf/ft**2)             2.116E+03  2.699E+03
          temperature   (R)                     5.187E+02  5.560E+02
     dynamic pressure   (lbf/ft**2)             5.333E+02
```

```
Vehicle Effects

              ML/M0              1.000E+00
             PTL/PT0             1.000E+00
              AL/A0              1.000E+00

Inlet Mass Flow Ratios

             A0I/AC              6.880E-01
           A0SPL/AC              3.120E-01
           A0BLD/AC              0.000E-01
              A0/AC              6.880E-01
           A0BYP/AC              0.000E-01
           A0ENG/AC              6.880E-01

Inlet Total Pressure Recoveries

            PT2/PT0              9.490E-01

            PTL/PT0              1.000E+00
            PT1/PTL              1.000E+00
           PTTH/PT1              1.000E+00
           PT2/PTTH              9.490E-01

            PTx/PTy              1.000E+00

Inlet Drag Breakdown

                 AC  (ft**2)     1.000E+00

                                    CD        D  (lbf)

           spillage              4.013E-02  2.140E+01
              bleed              0.000E-01  0.000E-01
             bypass              0.000E-01  0.000E-01
               cowl              0.000E-01  0.000E-01
              total              4.013E-02  2.140E+01
          reference              0.000E-01  0.000E-01
      power setting              4.013E-02  2.140E+01

Engine Performance Data        uninstalled  installed

         net thrust  (lbf)        0.000E-01 -2.140E+01
                SFC  (lbm/hr/lbf) 0.000E-01 -0.000E-01
                 W2  (lbm/s)      0.000E-01  3.525E+01
       corrected W2  (lbm/s)      3.014E+01  3.014E+01
```

```
   reference recovery                1.000E+00


&ipac
 xmach0=0.4,figure=0,
 xtrans=0.0,
 thetac=0.0,
&end

forebd: xmachx= 4.000E-01,xmach0= 4.000E-01, xmlm0= 1.000E+00,ptlpt0= 1.000E+00,  ala0= 1.000E+00,
 ptrcv: xmach0= 4.000E-01,  a0ac= 9.204E-01,  xmns= 1.360E+00,pt2pt0= 9.486E-01,thetad= 3.060E+00,
          xmth= 8.370E-01, athac= 5.933E-01,nishck=-1.000E+00,pthpt0= 9.996E-01,xlipth=-1.000E+00,
 cdaxi: xmach0= 4.000E-01, a0iac= 9.204E-01,xmach1= 4.281E-01,pt1pt0= 1.000E+00,   cda= 0.000E-01,
      : xmach0= 4.000E-01, a0iac= 9.204E-01, cdtot= 0.000E-01, cdspl= 0.000E-01, cdref= 0.000E-01,
      : xmach0= 4.000E-01,a0enac= 9.204E-01,   w2c= 3.014E+01,    w2= 3.144E+01,
      : xmachx= 4.000E-01,a0enac= 9.204E-01,w2ceng= 3.014E+01,

IPAC   Axisymmetric Inlet Example Case

Flight Conditions

          Mach number                4.000E-01

             altitude  (ft)          0.000E-01

                                      ambient     total

             pressure  (lbf/ft**2)   2.116E+03  2.363E+03
          temperature  (R)           5.187E+02  5.353E+02
     dynamic pressure  (lbf/ft**2)   2.370E+02

Vehicle Effects

                ML/M0                1.000E+00
              PTL/PT0                1.000E+00
                AL/A0                1.000E+00

Inlet Mass Flow Ratios

               A0I/AC                9.204E-01
             A0SPL/AC                7.962E-02
             A0BLD/AC                0.000E-01
                A0/AC                9.204E-01
             A0BYP/AC                0.000E-01
             A0ENG/AC                9.204E-01
```

```
Inlet Total Pressure Recoveries

                PT2/PT0                   9.486E-01

                PTL/PT0                   1.000E+00
                PT1/PTL                   1.000E+00
               PTTH/PT1                   9.996E-01
               PT2/PTTH                   9.490E-01

                PTx/PTy                   1.000E+00

Inlet Drag Breakdown

                     AC  (ft**2)          1.000E+00

                                             CD        D  (lbf)

               spillage                   0.000E-01  0.000E-01
                  bleed                   0.000E-01  0.000E-01
                 bypass                   0.000E-01  0.000E-01
                   cowl                   0.000E-01  0.000E-01
                  total                   0.000E-01  0.000E-01
              reference                   0.000E-01  0.000E-01
          power setting                   0.000E-01  0.000E-01

Engine Performance Data                 uninstalled  installed

             net thrust  (lbf)            0.000E-01  0.000E-01
                    SFC  (lbm/hr/lbf)     0.000E-01  0.000E-01
                     W2  (lbm/s)          0.000E-01  3.144E+01
           corrected W2  (lbm/s)          3.014E+01  3.014E+01

   reference recovery                     1.000E+00


&ipac
 xmach0=0.2,figure=0,
 xtrans=0.0,
 thetac=0.0,
&end

forebd: xmachx= 2.000E-01,xmach0= 2.000E-01, xmlm0= 1.000E+00,ptlpt0= 1.000E+00,  ala0= 1.000E+00,
 ptrcv: xmach0= 2.000E-01,  a0ac= 1.668E+00,  xmns= 1.360E+00,pt2pt0= 9.223E-01,thetad= 3.060E+00,
           xmth= 8.370E-01, athac= 5.933E-01,nishck=-1.000E+00,pthpt0= 9.718E-01,xlipth=-1.000E+00,
      : xmach0= 2.000E-01, a0iac= 1.668E+00,   cda= 0.000E-01,
```

```
        : xmach0= 2.000E-01, a0iac= 1.668E+00, cdtot= 0.000E-01, cdspl= 0.000E-01, cdref= 0.000E-01,
        : xmach0= 2.000E-01,a0enac= 1.668E+00,   w2c= 3.014E+01,    w2= 2.848E+01,
        : xmachx= 2.000E-01,a0enac= 1.668E+00,w2ceng= 3.014E+01,

 IPAC   Axisymmetric Inlet Example Case

 Flight Conditions

            Mach number                 2.000E-01

              altitude  (ft)            0.000E-01

                                         ambient     total

              pressure  (lbf/ft**2)     2.116E+03  2.176E+03
           temperature  (R)             5.187E+02  5.228E+02
      dynamic pressure  (lbf/ft**2)     5.925E+01

 Vehicle Effects

                 ML/M0                  1.000E+00
               PTL/PT0                  1.000E+00
                 AL/A0                  1.000E+00

 Inlet Mass Flow Ratios

                A0I/AC                  1.668E+00
              A0SPL/AC                 -6.676E-01
              A0BLD/AC                  0.000E-01
                 A0/AC                  1.668E+00
              A0BYP/AC                  0.000E-01
              A0ENG/AC                  1.668E+00

 Inlet Total Pressure Recoveries

               PT2/PT0                  9.223E-01

               PTL/PT0                  1.000E+00
               PT1/PTL                  1.000E+00
              PTTH/PT1                  9.718E-01
              PT2/PTTH                  9.490E-01

               PTx/PTy                  1.000E+00

 Inlet Drag Breakdown
```

```
                    AC   (ft**2)         1.000E+00

                                             CD        D  (lbf)

              spillage                   0.000E-01  0.000E-01
                 bleed                   0.000E-01  0.000E-01
                bypass                   0.000E-01  0.000E-01
                  cowl                   0.000E-01  0.000E-01
                 total                   0.000E-01  0.000E-01
             reference                   0.000E-01  0.000E-01
         power setting                   0.000E-01  0.000E-01

Engine Performance Data                uninstalled  installed

            net thrust  (lbf)            0.000E-01  0.000E-01
                   SFC  (lbm/hr/lbf)     0.000E-01  0.000E-01
                    W2  (lbm/s)          0.000E-01  2.848E+01
          corrected W2  (lbm/s)          3.014E+01  3.014E+01

   reference recovery                    1.000E+00


&ipac
 xmach0=0.01,figure=0,
 xtrans=0.0,
 thetac=0.0,
&end

forebd: xmachx= 1.000E-02,xmach0= 1.000E-02, xmlm0= 1.000E+00,ptlpt0= 1.000E+00,  ala0= 1.000E+00,
 ptrcv: xmach0= 1.000E-02,  a0ac= 3.039E+01,  xmns= 1.360E+00,pt2pt0= 8.607E-01,thetad= 3.060E+00,
          xmth= 8.370E-01, athac= 5.933E-01,nishck=-1.000E+00,pthpt0= 9.069E-01,xlipth=-1.000E+00,
      : xmach0= 1.000E-02, a0iac= 3.039E+01,   cda= 0.000E-01,
      : xmach0= 1.000E-02, a0iac= 3.039E+01, cdtot= 0.000E-01, cdspl= 0.000E-01, cdref= 0.000E-01,
      : xmach0= 1.000E-02,a0enac= 3.039E+01,   w2c= 3.014E+01,    w2= 2.595E+01,
      : xmachx= 1.000E-02,a0enac= 3.039E+01,w2ceng= 3.014E+01,

IPAC   Axisymmetric Inlet Example Case

Flight Conditions

           Mach number                   1.000E-02

              altitude   (ft)            0.000E-01

                                          ambient     total

```

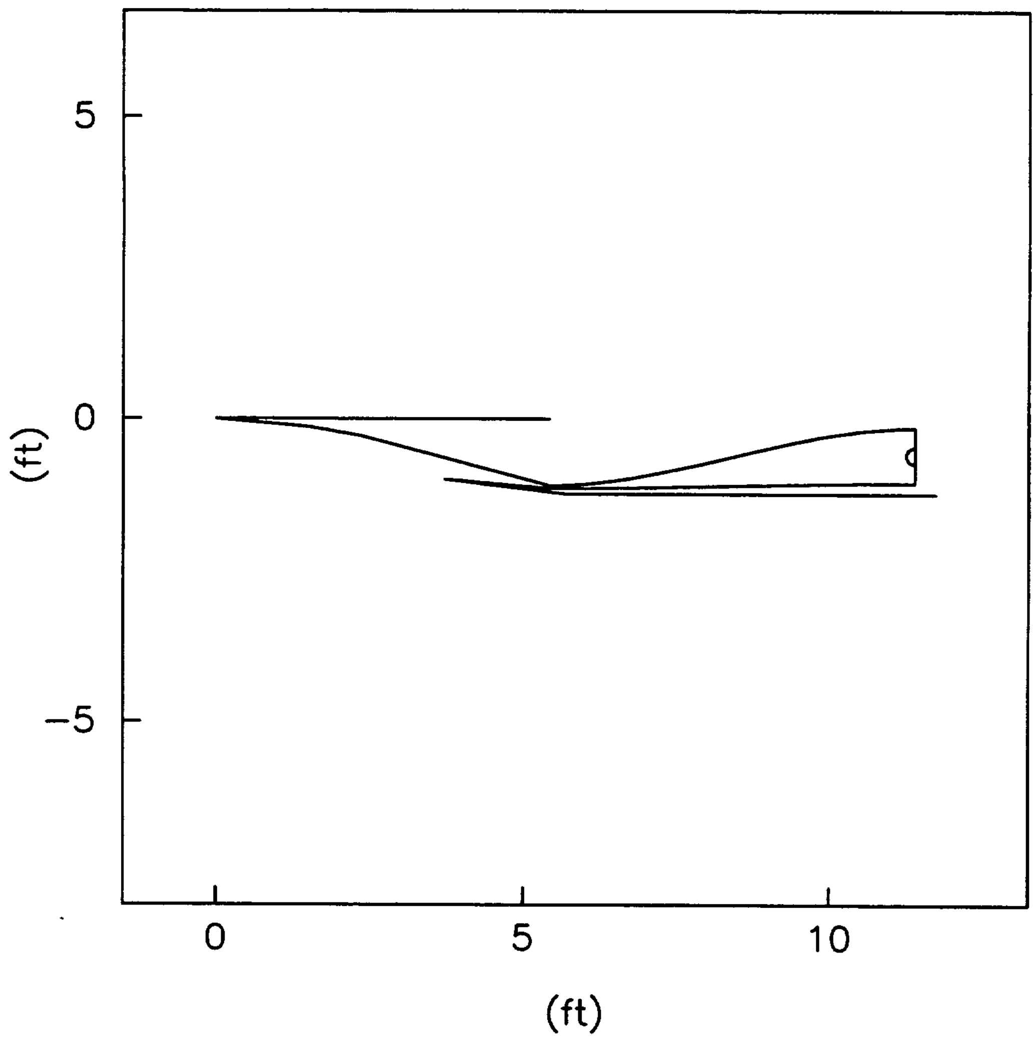
```
                pressure  (lbf/ft**2)      2.116E+03  2.116E+03
             temperature  (R)              5.187E+02  5.187E+02
        dynamic pressure  (lbf/ft**2)      1.481E-01

Vehicle Effects

                   ML/M0                   1.000E+00
                 PTL/PT0                   1.000E+00
                   AL/A0                   1.000E+00

Inlet Mass Flow Ratios

                  A0I/AC                   3.039E+01
                A0SPL/AC                  -2.939E+01
                A0BLD/AC                   0.000E-01
                   A0/AC                   3.039E+01
                A0BYP/AC                   0.000E-01
                A0ENG/AC                   3.039E+01

Inlet Total Pressure Recoveries

                 PT2/PT0                   8.607E-01

                 PTL/PT0                   1.000E+00
                 PT1/PTL                   1.000E+00
                PTTH/PT1                   9.069E-01
                PT2/PTTH                   9.490E-01

                 PTx/PTy                   1.000E+00

Inlet Drag Breakdown

                      AC  (ft**2)          1.000E+00

                                              CD      D  (lbf)

                spillage                   0.000E-01  0.000E-01
                   bleed                   0.000E-01  0.000E-01
                  bypass                   0.000E-01  0.000E-01
                    cowl                   0.000E-01  0.000E-01
                   total                   0.000E-01  0.000E-01
               reference                   0.000E-01  0.000E-01
           power setting                   0.000E-01  0.000E-01

Engine Performance Data                  uninstalled  installed

```

```
          net thrust  (lbf)           0.000E-01  0.000E-01
                 SFC  (lbm/hr/lbf)    0.000E-01  0.000E-01
                  W2  (lbm/s)         0.000E-01  2.595E+01
        corrected W2  (lbm/s)         3.014E+01  3.014E+01

   reference recovery                 1.000E+00
```

Appendix IV

Mach 5.0 Two-Dimensional Inlet

Example Case



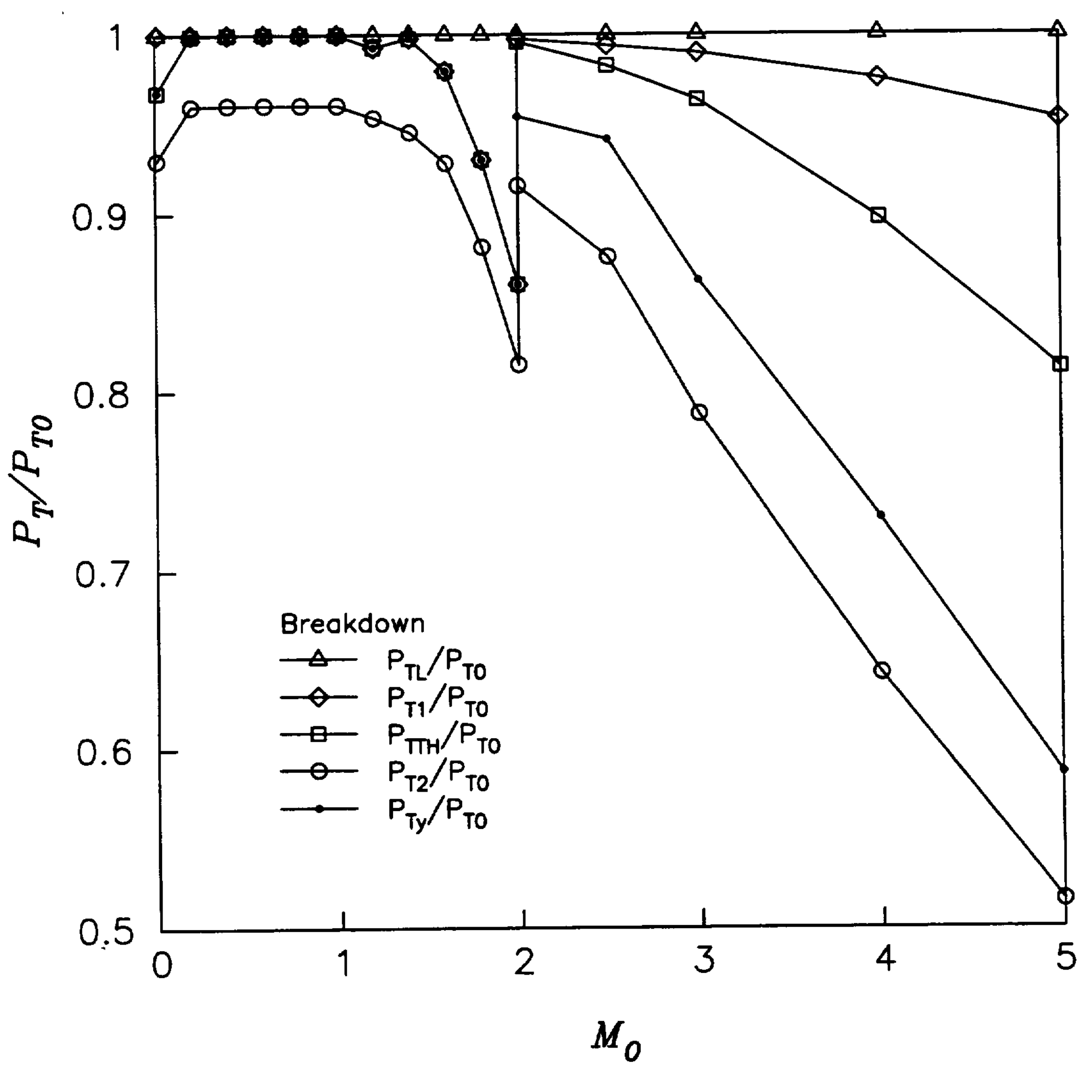


Figure IV.1 Total Pressure Recoveries

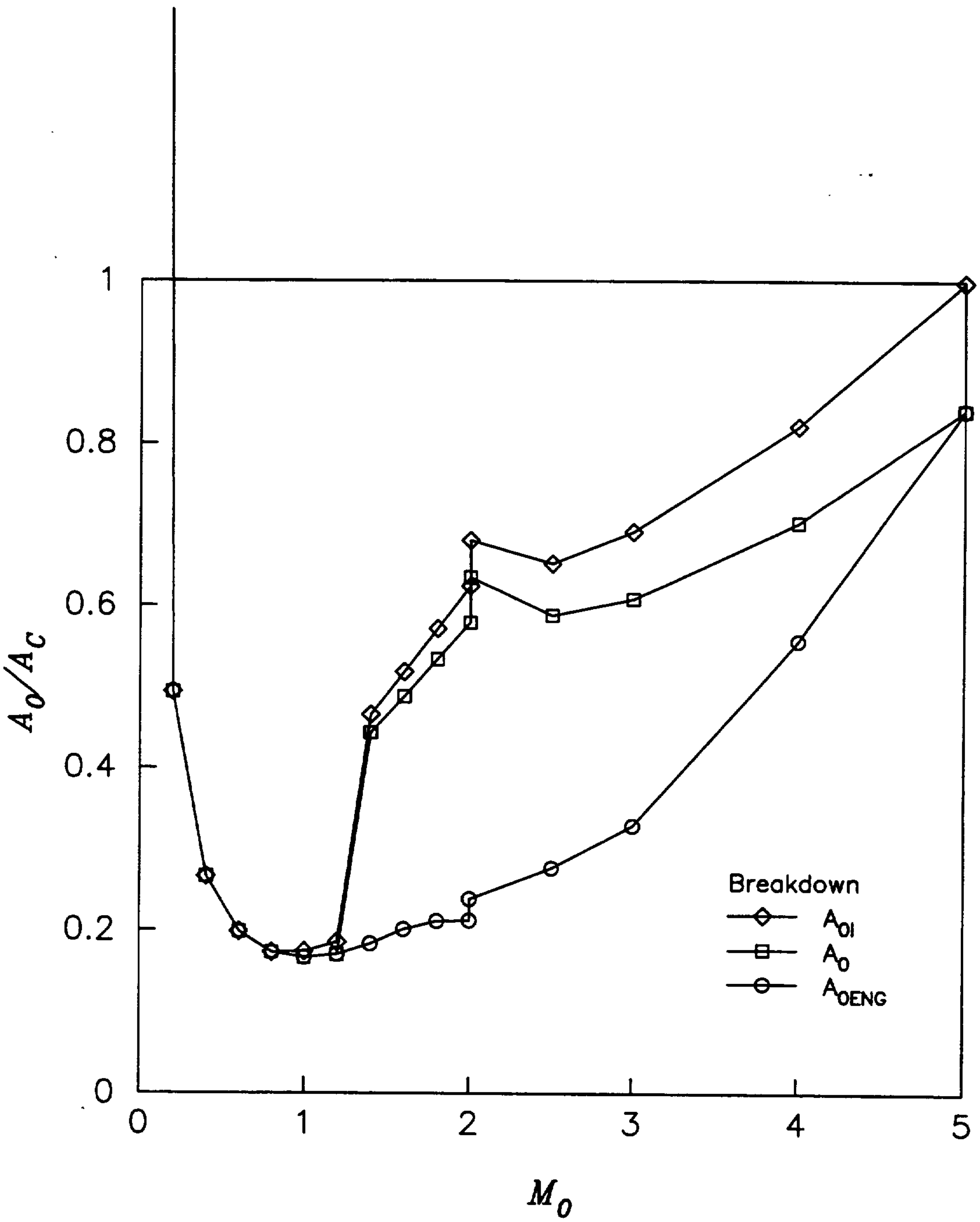


Figure IV.2 Mass Flow Ratios

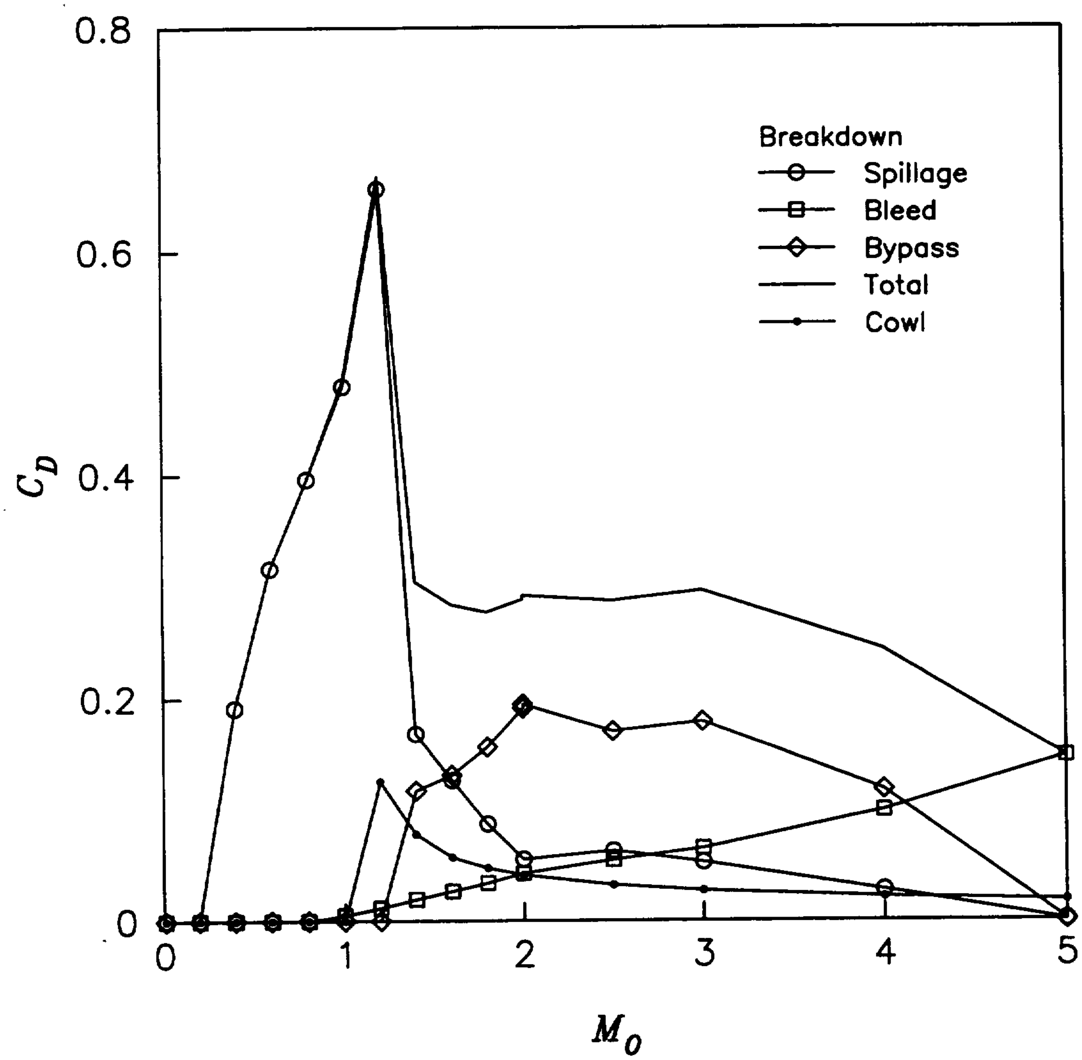


Figure IV.3 Drag Coefficients

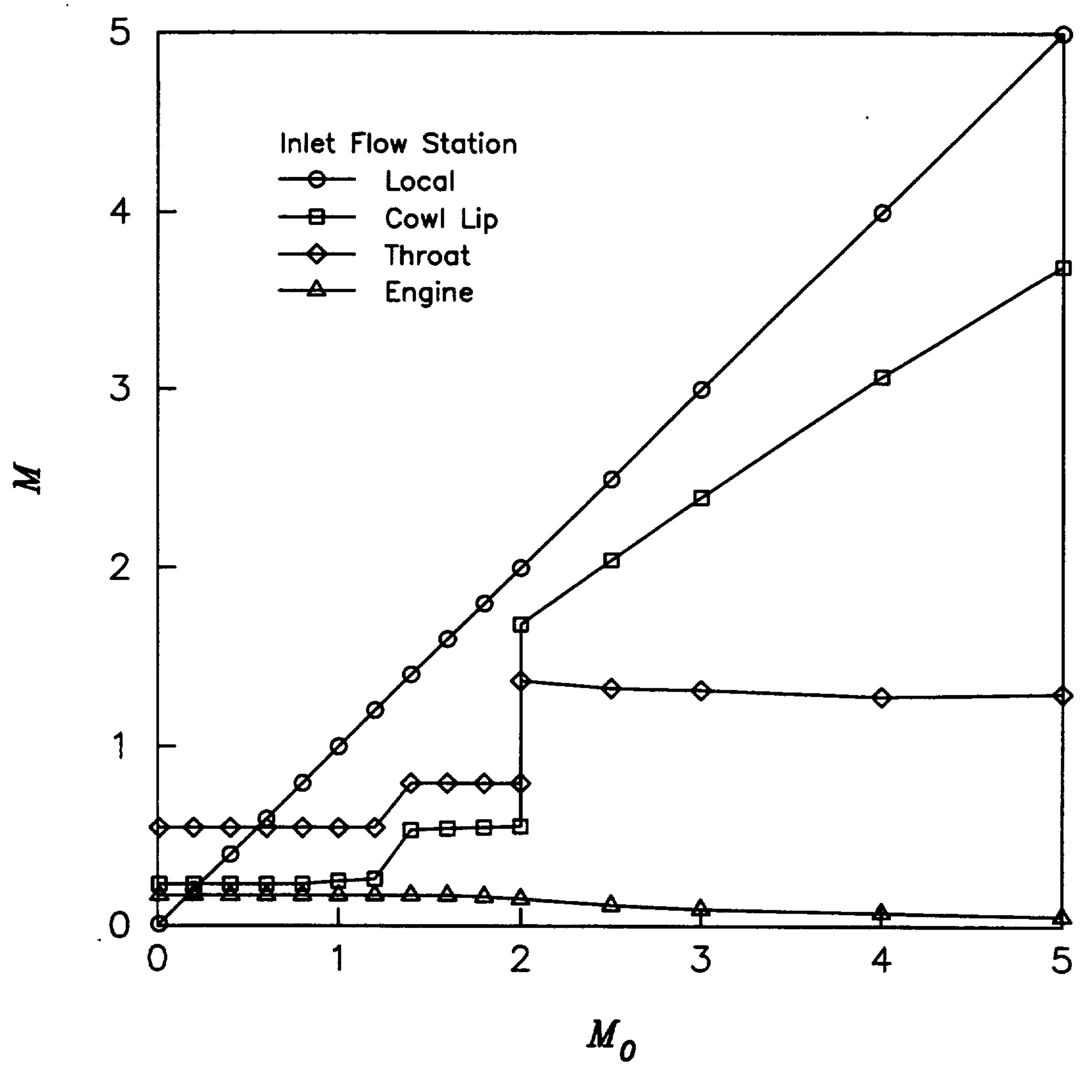


Figure IV.4 Mach Numbers

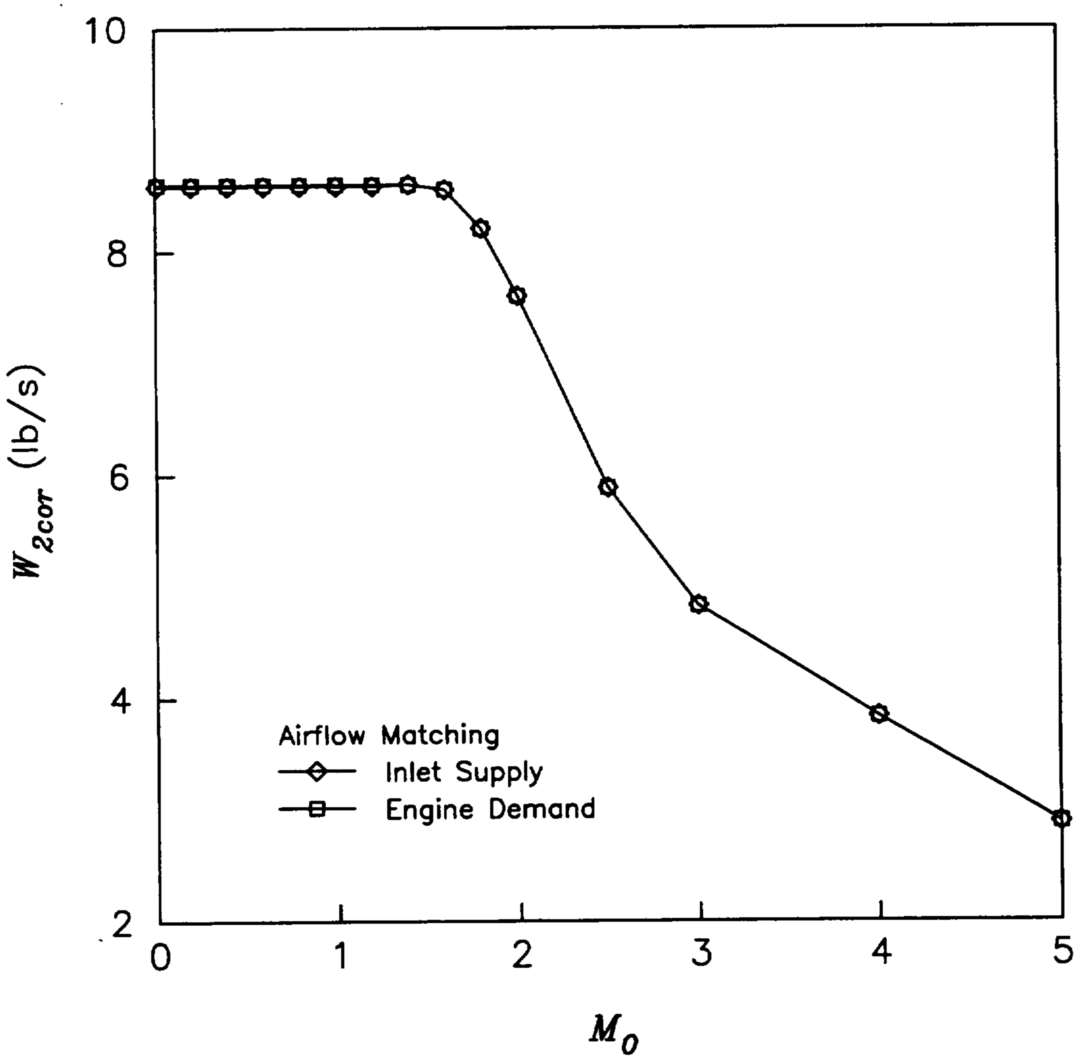


Figure IV.5 Corrected Airflows

```
&ipac
 title='2-D Inlet Example Case',
 echo=1,figure=1,npts=10,20,iout=1,1,1,1,
 xmach0=5.0,alt=-1000,igas=1,
 idim=2,ac=1.0,ar=1,
 ramps=3,theta=5,5,5,rleng=0,0,0,
 xcowl=0,ycowl=1,
 rclip=0.0,thetac=-5,
 cowls=2,cowlth=7,-7,cowlxl=2,6,
 a2ac=0.6,xldd2=6.5,hubtip=0.3,cloff=0.6,
 xmth=-1.3,xmns=2.0,nishck=-1,
 athac=-1,
 w2cor=-1,
 bleed=-1,pblpt0=-1,
&end

forebd: xmachx= 5.000E+00,xmach0= 5.000E+00, xmlm0= 1.000E+00,ptlpt0= 1.000E+00,  ala0= 1.000E+00,
  cd2d: xmach0= 5.000E+00, a0iac= 9.985E-01,xmach1= 3.694E+00,pt1pt0= 9.528E-01,   cda= 2.723E-04,
  cd2d: xmach0= 5.000E+00, a0iac= 9.975E-01,xmach1= 4.436E-01,pt1pt0= 1.716E-01,   cda= 1.604E-03,
 ptrcv: xmach0= 5.000E+00,  a0ac= 8.425E-01,  xmns= 2.000E+00,pt2pt0= 5.151E-01,thetad= 3.393E+00,
          xmth= 1.296E+00, athac= 4.411E-02,nishck= 5.000E+00,pthpt0= 8.132E-01,xlipth= 1.569E+00,
  cd2d: xmach0= 5.000E+00, a0iac= 9.985E-01,xmach1= 3.694E+00,pt1pt0= 9.528E-01,   cda= 2.723E-04,
cdwave: xmach0= 5.000E+00, cdwav= 1.746E-02,
 cdbld: xmach0= 5.000E+00, a0iac= 9.985E-01, bleed= 1.575E-01, cdbld= 1.477E-01,ptblpe= 2.408E+01,
      : xmach0= 5.000E+00, a0iac= 9.985E-01, bleed= 1.575E-01, cdbld= 1.477E-01,
      : xmach0= 5.000E+00, a0iac= 9.985E-01, cdtot= 1.480E-01, cdspl= 2.723E-04, cdref= 1.746E-02,
calimp: xmachx= 5.000E+00,  gama= 1.400E+00,pratio= 9.074E-01,tratio= 1.066E+00,aratio= 1.117E+00,
      : xmach0= 5.000E+00,a0enac= 8.410E-01,   w2c= 2.888E+00,    w2= 1.100E+01,
      : xmachx= 5.000E+00,a0enac= 8.410E-01,w2ceng= 2.888E+00,

IPAC   2-D Inlet Example Case

Flight Conditions

          Mach number                 5.000E+00

             altitude  (ft)           8.047E+04

                                       ambient     total

             pressure  (lbf/ft**2)    5.677E+01  3.310E+04
          temperature  (R)            3.979E+02  2.240E+03
     dynamic pressure  (lbf/ft**2)    9.935E+02

Vehicle Effects
```

```
                 ML/M0                1.000E+00
                PTL/PT0               1.000E+00
                 AL/A0                1.000E+00

Inlet Mass Flow Ratios

                AOI/AC                9.985E-01
              AOSPL/AC                1.457E-03
              AOBLD/AC                1.575E-01
                 A0/AC                8.410E-01
              AOBYP/AC                0.000E-01
              AOENG/AC                8.410E-01

Inlet Total Pressure Recoveries

               PT2/PT0                5.151E-01

               PTL/PT0                1.000E+00
               PT1/PTL                9.528E-01
              PTTH/PT1                8.535E-01
              PT2/PTTH                6.335E-01

               PTx/PTy                7.209E-01

Inlet Drag Breakdown

                    AC  (ft**2)       1.000E+00

                                         CD       D  (lbf)

              spillage                2.723E-04  2.706E-01
                 bleed                1.477E-01  1.467E+02
                bypass                0.000E-01  0.000E-01
                  cowl                1.746E-02  1.734E+01
                 total                1.654E-01  1.643E+02
             reference                1.746E-02  1.734E+01
         power setting                1.480E-01  1.470E+02

Engine Performance Data             uninstalled  installed

            net thrust  (lbf)         0.000E-01 -1.643E+02
                   SFC  (lbm/hr/lbf)  0.000E-01 -0.000E-01
                    W2  (lbm/s)       0.000E-01  1.100E+01
          corrected W2  (lbm/s)       2.888E+00  2.888E+00

   reference recovery                 5.126E-01
```

Inlet Flow Properties

		free stream	inlet local	cowl lip	throat	engine face
station		0	L	1	TH	2
flow area	(ft**2)	9.985E-01	9.985E-01	3.406E-01	4.411E-02	6.000E-01
Mach number		5.000E+00	5.000E+00	3.694E+00	1.296E+00	5.546E-02
pressure	(lbf/ft**2)	5.677E+01	5.677E+01	2.858E+02	8.868E+03	1.544E+04
temperature	(R)	3.979E+02	3.979E+02	6.403E+02	1.788E+03	2.386E+03
density	(slg/ft**3)	8.313E-05	8.313E-05	2.601E-04	2.891E-03	3.770E-03
velocity	(ft/s)	4.889E+03	4.889E+03	4.582E+03	2.685E+03	1.328E+02
total pressure	(lbf/ft**2)	3.310E+04	3.310E+04	3.154E+04	2.692E+04	1.705E+04
total temperature	(R)	2.240E+03	2.240E+03	2.240E+03	2.240E+03	2.240E+03
weight flow	(lbm/s)	1.308E+01	1.308E+01	1.306E+01	1.100E+01	1.100E+01
corrected weight flow	(lbm/s)	1.737E+00	1.737E+00	1.820E+00	1.796E+00	2.835E+00

Geometry Data for 2-D Inlet

inlet capture, AC	(ft**2)	1.000E+00
width	(ft)	1.000E+00
height	(ft)	1.000E+00
engine face, A2	(ft**2)	6.000E-01
diameter	(ft)	9.162E-01
H/T		3.000E-01

Figure Data for Inlet Geometry

internal cowl surface	(ft)	X	Y
		3.715E+00	1.000E+00
		5.424E+00	1.150E+00
		5.424E+00	1.150E+00
		5.738E+00	1.149E+00
		6.051E+00	1.147E+00
		6.365E+00	1.143E+00

6.678E+00	1.139E+00
6.992E+00	1.134E+00
7.305E+00	1.128E+00
7.619E+00	1.121E+00
7.932E+00	1.115E+00
8.245E+00	1.107E+00
8.559E+00	1.100E+00
8.872E+00	1.093E+00
9.186E+00	1.086E+00
9.499E+00	1.080E+00
9.813E+00	1.074E+00
1.013E+01	1.069E+00
1.044E+01	1.064E+00
1.075E+01	1.061E+00
1.107E+01	1.059E+00
1.138E+01	1.058E+00

external cowl surface (ft)

X	Y
3.715E+00	1.000E+00
5.715E+00	1.246E+00
1.172E+01	1.246E+00

2-D ramp surface (ft)

X	Y
0.000E-01	0.000E-01
1.494E+00	1.307E-01
2.350E+00	2.816E-01
5.424E+00	1.105E+00
5.424E+00	1.105E+00
5.738E+00	1.098E+00
6.051E+00	1.076E+00
6.365E+00	1.041E+00
6.678E+00	9.953E-01
6.992E+00	9.404E-01
7.305E+00	8.779E-01
7.619E+00	8.094E-01
7.932E+00	7.368E-01
8.245E+00	6.617E-01
8.559E+00	5.857E-01
8.872E+00	5.105E-01
9.186E+00	4.379E-01
9.499E+00	3.695E-01
9.813E+00	3.069E-01
1.013E+01	2.520E-01
1.044E+01	2.064E-01

```
                                              1.075E+01  1.717E-01
                                              1.107E+01  1.496E-01
                                              1.138E+01  1.419E-01

   engine face spinner  (ft)                     X          Y

                                              1.138E+01 -4.626E-01
                                              1.136E+01 -4.647E-01
                                              1.133E+01 -4.709E-01
                                              1.131E+01 -4.810E-01
                                              1.129E+01 -4.947E-01
                                              1.127E+01 -5.117E-01
                                              1.126E+01 -5.313E-01
                                              1.125E+01 -5.530E-01
                                              1.124E+01 -5.761E-01
                                              1.124E+01 -6.000E-01
                                              1.124E+01 -6.239E-01
                                              1.125E+01 -6.470E-01
                                              1.126E+01 -6.687E-01
                                              1.127E+01 -6.883E-01
                                              1.129E+01 -7.053E-01
                                              1.131E+01 -7.190E-01
                                              1.133E+01 -7.291E-01
                                              1.136E+01 -7.353E-01
                                              1.138E+01 -7.374E-01


 &ipac
  xmach0=4.0,figure=0,iout=1,1,0,0,
  xmth=-1.3,xlipth=-1,
  bypass=-1,pbppt2=-1,
  theta=5,5,4.4,
  xmns=1.8,
 &end

 forebd: xmachx= 4.000E+00,xmach0= 4.000E+00, xmlm0= 1.000E+00,ptlpt0= 1.000E+00,  ala0= 1.000E+00,
   cd2d: xmach0= 4.000E+00, a0iac= 8.215E-01,xmach1= 3.072E+00,pt1pt0= 9.753E-01,   cda= 2.687E-02,
   cd2d: xmach0= 4.000E+00, a0iac= 8.207E-01,xmach1= 4.705E-01,pt1pt0= 3.010E-01,   cda= 2.791E-02,
  ptrcv: xmach0= 4.000E+00,  a0ac= 7.015E-01,  xmns= 1.800E+00,pt2pt0= 6.427E-01,thetad= 3.069E+00,
           xmth= 1.279E+00, athac= 7.709E-02,nishck= 4.000E+00,pthpt0= 8.978E-01,xlipth= 1.494E+00,
   cd2d: xmach0= 4.000E+00, a0iac= 8.215E-01,xmach1= 3.072E+00,pt1pt0= 9.753E-01,   cda= 2.687E-02,
 cdwave: xmach0= 4.000E+00, cdwav= 2.061E-02,
  cdbld: xmach0= 4.000E+00, a0iac= 8.215E-01, bleed= 1.200E-01, cdbld= 9.915E-02,ptblpe= 8.449E+00,
       : xmach0= 4.000E+00, a0iac= 8.215E-01, bleed= 1.200E-01, cdbld= 9.915E-02,
       : xmach0= 4.000E+00, a0iac= 8.215E-01, cdtot= 1.260E-01, cdspl= 2.687E-02, cdref= 2.061E-02,
 calimp: xmachx= 4.000E+00,  gama= 1.400E+00,pratio= 9.659E-01,tratio= 1.032E+00,aratio= 1.040E+00,
```

```
cdbyp: xmach0= 4.000E+00, a0iac= 8.215E-01,bypass= 1.450E-01, cdbyp= 1.178E-01,ptbppe= 3.248E+01,
     : xmach0= 4.000E+00, a0iac= 8.215E-01, cdtot= 2.644E-01,pt2pt0= 6.427E-01,
     : xmach0= 4.000E+00,a0enac= 5.566E-01,   w2c= 3.839E+00,     w2= 9.122E+00,
     : xmachx= 4.000E+00,a0enac= 5.566E-01,w2ceng= 3.839E+00,

IPAC   2-D Inlet Example Case

Flight Conditions

           Mach number                4.000E+00

              altitude  (ft)          7.125E+04

                                       ambient    total

              pressure  (lbf/ft**2)   8.839E+01  1.389E+04
           temperature  (R)           3.929E+02  1.598E+03
      dynamic pressure  (lbf/ft**2)   9.899E+02

Vehicle Effects

                 ML/M0                1.000E+00
               PTL/PT0                1.000E+00
                 AL/A0                1.000E+00

Inlet Mass Flow Ratios

                A0I/AC                8.215E-01
              A0SPL/AC                1.785E-01
              A0BLD/AC                1.200E-01
                 A0/AC                7.015E-01
              A0BYP/AC                1.450E-01
              A0ENG/AC                5.566E-01

Inlet Total Pressure Recoveries

               PT2/PT0                6.427E-01

               PTL/PT0                1.000E+00
               PT1/PTL                9.753E-01
              PTTH/PT1                9.205E-01
              PT2/PTTH                7.159E-01

               PTx/PTy                8.127E-01

Inlet Drag Breakdown
```

```

                 AC  (ft**2)        1.000E+00

                                       CD       D  (lbf)

           spillage                 2.687E-02  2.660E+01
              bleed                 9.915E-02  9.815E+01
             bypass                 1.178E-01  1.166E+02
               cowl                 2.061E-02  2.040E+01
              total                 2.644E-01  2.618E+02
          reference                 2.061E-02  2.040E+01
      power setting                 2.438E-01  2.414E+02

Engine Performance Data           uninstalled  installed

         net thrust  (lbf)          0.000E-01 -2.618E+02
                SFC  (lbm/hr/lbf)   0.000E-01 -0.000E-01
                 W2  (lbm/s)        0.000E-01  9.122E+00
       corrected W2  (lbm/s)        3.839E+00  3.839E+00

   reference recovery               6.695E-01


&ipac
 xmach0=3.0,figure=0,
 theta=5,5,2.9,
 xmns=1.6,
&end

forebd: xmachx= 3.000E+00,xmach0= 3.000E+00, xmlm0= 1.000E+00,ptlpt0= 1.000E+00,  ala0= 1.000E+00,
  cd2d: xmach0= 3.000E+00, a0iac= 6.905E-01,xmach1= 2.399E+00,pt1pt0= 9.897E-01,   cda= 5.196E-02,
  cd2d: xmach0= 3.000E+00, a0iac= 6.898E-01,xmach1= 5.225E-01,pt1pt0= 5.351E-01,   cda= 5.271E-02,
 ptrcv: xmach0= 3.000E+00,  a0ac= 6.080E-01,  xmns= 1.600E+00,pt2pt0= 7.876E-01,thetad= 2.483E+00,
           xmth= 1.314E+00, athac= 1.598E-01,nishck= 3.000E+00,pthpt0= 9.637E-01,xlipth= 1.377E+00,
  cd2d: xmach0= 3.000E+00, a0iac= 6.905E-01,xmach1= 2.399E+00,pt1pt0= 9.897E-01,   cda= 5.196E-02,
cdwave: xmach0= 3.000E+00, cdwav= 2.632E-02,
 cdbld: xmach0= 3.000E+00, a0iac= 6.905E-01, bleed= 8.250E-02, cdbld= 6.451E-02,ptblpe= 2.782E+00,
      : xmach0= 3.000E+00, a0iac= 6.905E-01, bleed= 8.250E-02, cdbld= 6.451E-02,
      : xmach0= 3.000E+00, a0iac= 6.905E-01, cdtot= 1.165E-01, cdspl= 5.196E-02, cdref= 2.632E-02,
calimp: xmachx= 3.000E+00,  gama= 1.400E+00,pratio= 9.936E-01,tratio= 1.009E+00,aratio= 1.007E+00,
 cdbyp: xmach0= 3.000E+00, a0iac= 6.905E-01,bypass= 2.794E-01, cdbyp= 1.792E-01,ptbppe= 1.019E+01,
      : xmach0= 3.000E+00, a0iac= 6.905E-01, cdtot= 3.220E-01,pt2pt0= 7.876E-01,
      : xmach0= 3.000E+00,a0enac= 3.286E-01,   w2c= 4.834E+00,    w2= 7.172E+00,
      : xmachx= 3.000E+00,a0enac= 3.286E-01,w2ceng= 4.834E+00,

IPAC   2-D Inlet Example Case
```

```
Flight Conditions

          Mach number                3.000E+00

             altitude  (ft)          5.922E+04

                                      ambient    total

             pressure  (lbf/ft**2)   1.563E+02  5.780E+03
          temperature  (R)           3.900E+02  1.082E+03
     dynamic pressure  (lbf/ft**2)   9.849E+02

Vehicle Effects

                ML/M0                1.000E+00
              PTL/PT0                1.000E+00
                AL/A0                1.000E+00

Inlet Mass Flow Ratios

               A0I/AC                6.905E-01
             A0SPL/AC                3.095E-01
             A0BLD/AC                8.250E-02
                A0/AC                6.080E-01
             A0BYP/AC                2.794E-01
             A0ENG/AC                3.286E-01

Inlet Total Pressure Recoveries

              PT2/PT0                7.876E-01

              PTL/PT0                1.000E+00
              PT1/PTL                9.897E-01
             PTTH/PT1                9.737E-01
             PT2/PTTH                8.172E-01

              PTx/PTy                8.952E-01

Inlet Drag Breakdown

                   AC  (ft**2)       1.000E+00

                                        CD       D  (lbf)

             spillage                5.196E-02  5.118E+01
```

```
               bleed                      6.451E-02  6.353E+01
              bypass                      1.792E-01  1.765E+02
                cowl                      2.632E-02  2.593E+01
               total                      3.220E-01  3.172E+02
           reference                      2.632E-02  2.593E+01
       power setting                      2.957E-01  2.913E+02

Engine Performance Data                 uninstalled  installed

          net thrust  (lbf)               0.000E-01 -3.172E+02
                 SFC  (lbm/hr/lbf)        0.000E-01 -0.000E-01
                  W2  (lbm/s)             0.000E-01  7.172E+00
        corrected W2  (lbm/s)             4.834E+00  4.834E+00

   reference recovery                     8.088E-01


&ipac
 xmach0=2.5,figure=0,
 theta=5,4.9,1.5,
 xmns=1.4,
&end

forebd: xmachx= 2.500E+00,xmach0= 2.500E+00, xmlm0= 1.000E+00,ptlpt0= 1.000E+00,  ala0= 1.000E+00,
  cd2d: xmach0= 2.500E+00, a0iac= 6.516E-01,xmach1= 2.045E+00,pt1pt0= 9.939E-01,   cda= 6.234E-02,
  cd2d: xmach0= 2.500E+00, a0iac= 6.509E-01,xmach1= 5.689E-01,pt1pt0= 6.954E-01,   cda= 6.293E-02,
 ptrcv: xmach0= 2.500E+00,  a0ac= 5.878E-01,  xmns= 1.400E+00,pt2pt0= 8.761E-01,thetad= 2.029E+00,
          xmth= 1.324E+00, athac= 2.443E-01,nishck= 3.000E+00,pthpt0= 9.827E-01,xlipth= 1.407E+00,
  cd2d: xmach0= 2.500E+00, a0iac= 6.516E-01,xmach1= 2.045E+00,pt1pt0= 9.939E-01,   cda= 6.234E-02,
cdwave: xmach0= 2.500E+00, cdwav= 3.144E-02,
 cdbld: xmach0= 2.500E+00, a0iac= 6.516E-01, bleed= 6.375E-02, cdbld= 5.382E-02,ptblpe= 1.619E+00,
      : xmach0= 2.500E+00, a0iac= 6.516E-01, bleed= 6.375E-02, cdbld= 5.382E-02,
      : xmach0= 2.500E+00, a0iac= 6.516E-01, cdtot= 1.162E-01, cdspl= 6.234E-02, cdref= 3.144E-02,
calimp: xmachx= 2.500E+00,  gama= 1.400E+00,pratio= 9.985E-01,tratio= 1.003E+00,aratio= 1.002E+00,
 cdbyp: xmach0= 2.500E+00, a0iac= 6.516E-01,bypass= 3.120E-01, cdbyp= 1.704E-01,ptbppe= 5.668E+00,
      : xmach0= 2.500E+00, a0iac= 6.516E-01, cdtot= 3.180E-01,pt2pt0= 8.761E-01,
      : xmach0= 2.500E+00,a0enac= 2.759E-01,   w2c= 5.884E+00,    w2= 7.237E+00,
      : xmachx= 2.500E+00,a0enac= 2.759E-01,w2ceng= 5.884E+00,

IPAC   2-D Inlet Example Case

Flight Conditions

          Mach number                     2.500E+00

             altitude  (ft)               5.149E+04
```

```
                                            ambient      total

             pressure  (lbf/ft**2)        2.255E+02  3.859E+03
          temperature  (R)                3.900E+02  8.744E+02
     dynamic pressure  (lbf/ft**2)        9.866E+02

Vehicle Effects

                ML/M0                     1.000E+00
               PTL/PT0                    1.000E+00
                AL/A0                     1.000E+00

Inlet Mass Flow Ratios

               A0I/AC                     6.516E-01
             A0SPL/AC                     3.484E-01
             A0BLD/AC                     6.375E-02
                A0/AC                     5.878E-01
             A0BYP/AC                     3.120E-01
             A0ENG/AC                     2.759E-01

Inlet Total Pressure Recoveries

              PT2/PT0                     8.761E-01

              PTL/PT0                     1.000E+00
              PT1/PTL                     9.939E-01
             PTTH/PT1                     9.887E-01
             PT2/PTTH                     8.915E-01

              PTx/PTy                     9.582E-01

Inlet Drag Breakdown

                   AC  (ft**2)            1.000E+00

                                            CD        D  (lbf)

             spillage                     6.234E-02  6.150E+01
                bleed                     5.382E-02  5.310E+01
               bypass                     1.704E-01  1.681E+02
                 cowl                     3.144E-02  3.102E+01
                total                     3.180E-01  3.137E+02
            reference                     3.144E-02  3.102E+01
        power setting                     2.866E-01  2.827E+02
```

```
Engine Performance Data              uninstalled  installed

             net thrust  (lbf)          0.000E-01 -3.137E+02
                    SFC  (lbm/hr/lbf)   0.000E-01 -0.000E-01
                     W2  (lbm/s)        0.000E-01  7.237E+00
           corrected W2  (lbm/s)        5.884E+00  5.884E+00

   reference recovery                   8.703E-01


&ipac
 xmach0=2.0,figure=0,igas=0,
 theta=5,2.5,1.5,
&end

forebd: xmachx= 2.000E+00,xmach0= 2.000E+00, xmlm0= 1.000E+00,ptlpt0= 1.000E+00,  ala0= 1.000E+00,
  cd2d: xmach0= 2.000E+00, a0iac= 6.796E-01,xmach1= 1.684E+00,pt1pt0= 9.976E-01,   cda= 5.461E-02,
  cd2d: xmach0= 2.000E+00, a0iac= 6.789E-01,xmach1= 6.436E-01,pt1pt0= 8.604E-01,   cda= 5.503E-02,
 ptrcv: xmach0= 2.000E+00,  a0ac= 6.346E-01,  xmns= 1.400E+00,pt2pt0= 9.158E-01,thetad= 1.312E+00,
          xmth= 1.365E+00, athac= 4.140E-01,nishck= 2.000E+00,pthpt0= 9.960E-01,xlipth= 1.139E+00,
  cd2d: xmach0= 2.000E+00, a0iac= 6.796E-01,xmach1= 1.684E+00,pt1pt0= 9.976E-01,   cda= 5.461E-02,
cdwave: xmach0= 2.000E+00, cdwav= 4.051E-02,
 cdbld: xmach0= 2.000E+00, a0iac= 6.796E-01, bleed= 4.500E-02, cdbld= 4.195E-02,ptblpe= 1.093E+00,
      : xmach0= 2.000E+00, a0iac= 6.796E-01, bleed= 4.500E-02, cdbld= 4.195E-02,
      : xmach0= 2.000E+00, a0iac= 6.796E-01, cdtot= 9.656E-02, cdspl= 5.461E-02, cdref= 4.051E-02,
 cdbyp: xmach0= 2.000E+00, a0iac= 6.796E-01,bypass= 3.968E-01, cdbyp= 1.948E-01,ptbppe= 2.847E+00,
      : xmach0= 2.000E+00, a0iac= 6.796E-01, cdtot= 3.318E-01,pt2pt0= 9.158E-01,
      : xmach0= 2.000E+00,a0enac= 2.378E-01,   w2c= 7.602E+00,    w2= 7.920E+00,
      : xmachx= 2.000E+00,a0enac= 2.378E-01,w2ceng= 7.602E+00,

IPAC   2-D Inlet Example Case

Flight Conditions

           Mach number                  2.000E+00

              altitude  (ft)            4.189E+04

                                         ambient     total

              pressure  (lbf/ft**2)     3.578E+02  2.800E+03
           temperature  (R)             3.900E+02  7.019E+02
      dynamic pressure  (lbf/ft**2)     1.002E+03

Vehicle Effects
```

```
                ML/M0                 1.000E+00
               PTL/PT0                1.000E+00
                AL/A0                 1.000E+00

Inlet Mass Flow Ratios

               A0I/AC                 6.796E-01
             A0SPL/AC                 3.204E-01
             A0BLD/AC                 4.500E-02
                A0/AC                 6.346E-01
             A0BYP/AC                 3.968E-01
             A0ENG/AC                 2.378E-01

Inlet Total Pressure Recoveries

              PT2/PT0                 9.158E-01

              PTL/PT0                 1.000E+00
              PT1/PTL                 9.976E-01
             PTTH/PT1                 9.984E-01
             PT2/PTTH                 9.194E-01

              PTx/PTy                 9.582E-01

Inlet Drag Breakdown

                   AC   (ft**2)       1.000E+00

                                         CD         D  (lbf)

             spillage                 5.461E-02  5.471E+01
                bleed                 4.195E-02  4.202E+01
               bypass                 1.948E-01  1.951E+02
                 cowl                 4.051E-02  4.058E+01
                total                 3.318E-01  3.324E+02
            reference                 4.051E-02  4.058E+01
        power setting                 2.913E-01  2.919E+02

Engine Performance Data              uninstalled  installed

           net thrust   (lbf)         0.000E-01 -3.324E+02
                  SFC   (lbm/hr/lbf)  0.000E-01 -0.000E-01
                   W2   (lbm/s)       0.000E-01  7.920E+00
         corrected W2   (lbm/s)       7.602E+00  7.602E+00
```

```
    reference recovery                     9.250E-01


 &ipac
  xmach0=2.0,figure=0,
  theta=5,2.5,1.5,
  xmth=0.80,xmns=0,
 &end

 forebd: xmachx= 2.000E+00,xmach0= 2.000E+00, xmlm0= 1.000E+00,ptlpt0= 1.000E+00,  ala0= 1.000E+00,
   cd2d: xmach0= 2.000E+00, a0iac= 5.000E-01,xmach1= 4.128E-01,pt1pt0= 8.604E-01,   cda= 1.806E-01,
  ptrcv: xmach0= 2.000E+00,  a0ac= 5.790E-01,  xmns= 0.000E-01,pt2pt0= 8.153E-01,thetad= 1.312E+00,
           xmth= 8.000E-01, athac= 4.140E-01,nishck=-1.000E+00,pthpt0= 8.604E-01,xlipth=-1.000E+00,
   cd2d: xmach0= 2.000E+00, a0iac= 6.240E-01,xmach1= 5.587E-01,pt1pt0= 8.604E-01,   cda= 9.095E-02,
 cdwave: xmach0= 2.000E+00, cdwav= 4.051E-02,
  clsuc: xmach0= 2.000E+00, a0iac= 6.240E-01,   cls= 3.637E-02, cdspl= 5.458E-02,thetae= 5.412E+00,
  cdbld: xmach0= 2.000E+00, a0iac= 6.240E-01, bleed= 4.500E-02, cdbld= 4.195E-02,ptblpe= 1.093E+00,
       : xmach0= 2.000E+00, a0iac= 6.240E-01, bleed= 4.500E-02, cdbld= 4.195E-02,
       : xmach0= 2.000E+00, a0iac= 6.240E-01, cdtot= 9.653E-02, cdspl= 5.458E-02, cdref= 4.051E-02,
  cdbyp: xmach0= 2.000E+00, a0iac= 6.240E-01,bypass= 3.673E-01, cdbyp= 1.912E-01,ptbppe= 2.593E+00,
       : xmach0= 2.000E+00, a0iac= 6.240E-01, cdtot= 3.283E-01,pt2pt0= 8.153E-01,
       : xmach0= 2.000E+00,a0enac= 2.117E-01,   w2c= 7.602E+00,    w2= 7.050E+00,
       : xmachx= 2.000E+00,a0enac= 2.117E-01,w2ceng= 7.602E+00,

 IPAC   2-D Inlet Example Case

 Flight Conditions

           Mach number                     2.000E+00

              altitude  (ft)               4.189E+04

                                            ambient     total

              pressure  (lbf/ft**2)        3.578E+02  2.800E+03
           temperature  (R)                3.900E+02  7.019E+02
      dynamic pressure  (lbf/ft**2)        1.002E+03

 Vehicle Effects

                 ML/M0                     1.000E+00
               PTL/PT0                     1.000E+00
                 AL/A0                     1.000E+00

 Inlet Mass Flow Ratios

```

```
                  A0I/AC                 6.240E-01
                A0SPL/AC                 3.760E-01
                A0BLD/AC                 4.500E-02
                   A0/AC                 5.790E-01
                A0BYP/AC                 3.673E-01
                A0ENG/AC                 2.117E-01

Inlet Total Pressure Recoveries

                 PT2/PT0                 8.153E-01

                 PTL/PT0                 1.000E+00
                 PT1/PTL                 8.604E-01
                PTTH/PT1                 1.000E+00
                PT2/PTTH                 9.476E-01

                 PTx/PTy                 1.000E+00

Inlet Drag Breakdown

                      AC  (ft**2)        1.000E+00

                                            CD       D  (lbf)

                spillage                 5.458E-02  5.468E+01
                   bleed                 4.195E-02  4.202E+01
                  bypass                 1.912E-01  1.916E+02
                    cowl                 4.051E-02  4.058E+01
                   total                 3.283E-01  3.289E+02
               reference                 4.051E-02  4.058E+01
           power setting                 2.877E-01  2.883E+02

Engine Performance Data                uninstalled  installed

              net thrust  (lbf)          0.000E-01 -3.289E+02
                     SFC  (lbm/hr/lbf)   0.000E-01 -0.000E-01
                      W2  (lbm/s)        0.000E-01  7.050E+00
            corrected W2  (lbm/s)        7.602E+00  7.602E+00

   reference recovery                    9.250E-01


&ipac  xmach0=1.8,figure=0,  &end

forebd: xmachx= 1.800E+00,xmach0= 1.800E+00, xmlm0= 1.000E+00,ptlpt0= 1.000E+00,  ala0= 1.000E+00,
  cd2d: xmach0= 1.800E+00, a0iac= 5.000E-01,xmach1= 4.580E-01,pt1pt0= 9.303E-01,   cda= 1.795E-01,
```

```
 ptrcv: xmach0= 1.800E+00,  a0ac= 5.339E-01,  xmns= 0.000E-01,pt2pt0= 8.816E-01,thetad= 1.312E+00,
          xmth= 8.000E-01, athac= 4.140E-01,nishck=-1.000E+00,pthpt0= 9.303E-01,xlipth=-1.000E+00,
  cd2d: xmach0= 1.800E+00, a0iac= 5.714E-01,xmach1= 5.527E-01,pt1pt0= 9.303E-01,   cda= 1.253E-01,
cdwave: xmach0= 1.800E+00, cdwav= 4.670E-02,
 clsuc: xmach0= 1.800E+00, a0iac= 5.714E-01,   cls= 3.838E-02, cdspl= 8.688E-02,thetae= 5.412E+00,
 cdbld: xmach0= 1.800E+00, a0iac= 5.714E-01, bleed= 3.750E-02, cdbld= 3.344E-02,ptblpe= 1.082E+00,
      : xmach0= 1.800E+00, a0iac= 5.714E-01, bleed= 3.750E-02, cdbld= 3.344E-02,
      : xmach0= 1.800E+00, a0iac= 5.714E-01, cdtot= 1.203E-01, cdspl= 8.688E-02, cdref= 4.670E-02,
 cdbyp: xmach0= 1.800E+00, a0iac= 5.714E-01,bypass= 3.231E-01, cdbyp= 1.561E-01,ptbppe= 2.238E+00,
      : xmach0= 1.800E+00, a0iac= 5.714E-01, cdtot= 3.232E-01,pt2pt0= 8.816E-01,
      : xmach0= 1.800E+00,a0enac= 2.108E-01,   w2c= 8.206E+00,    w2= 7.880E+00,
      : xmachx= 1.800E+00,a0enac= 2.108E-01,w2ceng= 8.206E+00,

IPAC   2-D Inlet Example Case

Flight Conditions

          Mach number                   1.800E+00

             altitude  (ft)             3.729E+04

                                         ambient     total

             pressure  (lbf/ft**2)      4.464E+02  2.565E+03
          temperature  (R)              3.900E+02  6.427E+02
     dynamic pressure  (lbf/ft**2)      1.012E+03

Vehicle Effects

                ML/M0                   1.000E+00
              PTL/PT0                   1.000E+00
                AL/A0                   1.000E+00

Inlet Mass Flow Ratios

               A0I/AC                   5.714E-01
             A0SPL/AC                   4.286E-01
             A0BLD/AC                   3.750E-02
                A0/AC                   5.339E-01
             A0BYP/AC                   3.231E-01
             A0ENG/AC                   2.108E-01

Inlet Total Pressure Recoveries

              PT2/PT0                   8.816E-01
```

```
               PTL/PT0                 1.000E+00
               PT1/PTL                 9.303E-01
              PTTH/PT1                 1.000E+00
              PT2/PTTH                 9.476E-01

               PTx/PTy                 1.000E+00

Inlet Drag Breakdown

                    AC  (ft**2)        1.000E+00

                                          CD       D  (lbf)

              spillage                 8.688E-02  8.796E+01
                 bleed                 3.344E-02  3.386E+01
                bypass                 1.561E-01  1.581E+02
                  cowl                 4.670E-02  4.728E+01
                 total                 3.232E-01  3.272E+02
             reference                 4.670E-02  4.728E+01
         power setting                 2.765E-01  2.799E+02

Engine Performance Data              uninstalled  installed

            net thrust  (lbf)          0.000E-01 -3.272E+02
                   SFC  (lbm/hr/lbf)   0.000E-01 -0.000E-01
                    W2  (lbm/s)        0.000E-01  7.880E+00
          corrected W2  (lbm/s)        8.206E+00  8.206E+00

   reference recovery                  9.445E-01


&ipac  xmach0=1.6,figure=0,  &end

forebd: xmachx= 1.600E+00,xmach0= 1.600E+00, xmlm0= 1.000E+00,ptlpt0= 1.000E+00,  ala0= 1.000E+00,
  cd2d: xmach0= 1.600E+00, a0iac= 5.000E-01,xmach1= 5.173E-01,pt1pt0= 9.798E-01,   cda= 1.812E-01,
 ptrcv: xmach0= 1.600E+00,  a0ac= 4.885E-01,  xmns= 0.000E-01,pt2pt0= 9.285E-01,thetad= 1.312E+00,
           xmth= 8.000E-01, athac= 4.140E-01,nishck=-1.000E+00,pthpt0= 9.798E-01,xlipth=-1.000E+00,
  cd2d: xmach0= 1.600E+00, a0iac= 5.185E-01,xmach1= 5.458E-01,pt1pt0= 9.798E-01,   cda= 1.665E-01,
cdwave: xmach0= 1.600E+00, cdwav= 5.652E-02,
 clsuc: xmach0= 1.600E+00, a0iac= 5.185E-01,   cls= 4.035E-02, cdspl= 1.262E-01,thetae= 5.412E+00,
 cdbld: xmach0= 1.600E+00, a0iac= 5.185E-01, bleed= 3.000E-02, cdbld= 2.609E-02,ptblpe= 1.037E+00,
      : xmach0= 1.600E+00, a0iac= 5.185E-01, bleed= 3.000E-02, cdbld= 2.609E-02,
      : xmach0= 1.600E+00, a0iac= 5.185E-01, cdtot= 1.523E-01, cdspl= 1.262E-01, cdref= 5.652E-02,
 cdbyp: xmach0= 1.600E+00, a0iac= 5.185E-01,bypass= 2.875E-01, cdbyp= 1.310E-01,ptbppe= 1.888E+00,
      : xmach0= 1.600E+00, a0iac= 5.185E-01, cdtot= 3.397E-01,pt2pt0= 9.285E-01,
      : xmach0= 1.600E+00,a0enac= 2.010E-01,   w2c= 8.555E+00,    w2= 8.389E+00,
```

```
          : xmachx= 1.600E+00,a0enac= 2.010E-01,w2ceng= 8.555E+00,

    IPAC   2-D Inlet Example Case

    Flight Conditions

              Mach number                 1.600E+00

                 altitude  (ft)           3.209E+04

                                           ambient     total

                 pressure  (lbf/ft**2)    5.706E+02  2.425E+03
              temperature  (R)            4.042E+02  6.112E+02
         dynamic pressure  (lbf/ft**2)    1.023E+03

    Vehicle Effects

                    ML/M0                 1.000E+00
                  PTL/PT0                 1.000E+00
                    AL/A0                 1.000E+00

    Inlet Mass Flow Ratios

                   A0I/AC                 5.185E-01
                 A0SPL/AC                 4.815E-01
                 A0BLD/AC                 3.000E-02
                    A0/AC                 4.885E-01
                 A0BYP/AC                 2.875E-01
                 A0ENG/AC                 2.010E-01

    Inlet Total Pressure Recoveries

                  PT2/PT0                 9.285E-01

                  PTL/PT0                 1.000E+00
                  PT1/PTL                 9.798E-01
                 PTTH/PT1                 1.000E+00
                 PT2/PTTH                 9.476E-01

                  PTx/PTy                 1.000E+00

    Inlet Drag Breakdown

                       AC  (ft**2)        1.000E+00
```

```
                                      CD        D  (lbf)

           spillage                1.262E-01  1.290E+02
              bleed                2.609E-02  2.667E+01
             bypass                1.310E-01  1.339E+02
               cowl                5.652E-02  5.780E+01
              total                3.397E-01  3.474E+02
          reference                5.652E-02  5.780E+01
      power setting                2.832E-01  2.896E+02

Engine Performance Data          uninstalled  installed

         net thrust  (lbf)          0.000E-01 -3.474E+02
                SFC  (lbm/hr/lbf)   0.000E-01 -0.000E-01
                 W2  (lbm/s)        0.000E-01  8.389E+00
       corrected W2  (lbm/s)        8.555E+00  8.555E+00

   reference recovery               9.624E-01


&ipac  xmach0=1.4,figure=0,  &end

forebd: xmachx= 1.400E+00,xmach0= 1.400E+00, xmlm0= 1.000E+00,ptlpt0= 1.000E+00,  ala0= 1.000E+00,
  cd2d: xmach0= 1.400E+00, a0iac= 5.000E-01,xmach1= 6.001E-01,pt1pt0= 9.979E-01,   cda= 1.899E-01,
 ptrcv: xmach0= 1.400E+00,  a0ac= 4.437E-01,  xmns= 0.000E-01,pt2pt0= 9.456E-01,thetad= 1.312E+00,
         xmth= 8.000E-01, athac= 4.140E-01,nishck=-1.000E+00,pthpt0= 9.979E-01,xlipth=-1.000E+00,
  cd2d: xmach0= 1.400E+00, a0iac= 4.662E-01,xmach1= 5.376E-01,pt1pt0= 9.979E-01,   cda= 2.102E-01,
cdwave: xmach0= 1.400E+00, cdwav= 7.750E-02,
 clsuc: xmach0= 1.400E+00, a0iac= 4.662E-01,   cls= 4.214E-02, cdspl= 1.680E-01,thetae= 5.412E+00,
*** error ***  in program segment cdbld    (errflg=2)
 cdbld: xmach0= 1.400E+00, a0iac= 4.662E-01, bleed= 2.250E-02, cdbld= 1.884E-02,ptblpe= 1.001E+00,
      : xmach0= 1.400E+00, a0iac= 4.662E-01, bleed= 2.250E-02, cdbld= 1.884E-02,
      : xmach0= 1.400E+00, a0iac= 4.662E-01, cdtot= 1.869E-01, cdspl= 1.680E-01, cdref= 7.750E-02,
*** error ***  in program segment cdbyp    (errflg=2)
 cdbyp: xmach0= 1.400E+00, a0iac= 4.662E-01,bypass= 2.601E-01, cdbyp= 1.168E-01,ptbppe= 1.553E+00,
      : xmach0= 1.400E+00, a0iac= 4.662E-01, cdtot= 3.812E-01,pt2pt0= 9.456E-01,
      : xmach0= 1.400E+00,a0enac= 1.836E-01,   w2c= 8.601E+00,    w2= 8.565E+00,
      : xmachx= 1.400E+00,a0enac= 1.836E-01,w2ceng= 8.601E+00,

IPAC   2-D Inlet Example Case

Flight Conditions

          Mach number               1.400E+00

            altitude  (ft)          2.611E+04
```

```
                                                ambient     total

               pressure  (lbf/ft**2)           7.481E+02  2.381E+03
            temperature  (R)                   4.256E+02  5.924E+02
       dynamic pressure  (lbf/ft**2)           1.026E+03

  Vehicle Effects

                   ML/M0                       1.000E+00
                 PTL/PT0                       1.000E+00
                   AL/A0                       1.000E+00

  Inlet Mass Flow Ratios

                  A0I/AC                       4.662E-01
                A0SPL/AC                       5.338E-01
                A0BLD/AC                       2.250E-02
                   A0/AC                       4.437E-01
                A0BYP/AC                       2.601E-01
                A0ENG/AC                       1.836E-01

  Inlet Total Pressure Recoveries

                 PT2/PT0                       9.456E-01

                 PTL/PT0                       1.000E+00
                 PT1/PTL                       9.979E-01
                PTTH/PT1                       1.000E+00
                PT2/PTTH                       9.476E-01

                 PTx/PTy                       1.000E+00

  Inlet Drag Breakdown

                      AC  (ft**2)              1.000E+00

                                                  CD      D  (lbf)

                spillage                       1.680E-01  1.725E+02
                   bleed                       1.884E-02  1.934E+01
                  bypass                       1.168E-01  1.199E+02
                    cowl                       7.750E-02  7.955E+01
                   total                       3.812E-01  3.912E+02
               reference                       7.750E-02  7.955E+01
           power setting                       3.037E-01  3.117E+02
```

```
Engine Performance Data                 uninstalled  installed

            net thrust  (lbf)              0.000E-01 -3.912E+02
                   SFC  (lbm/hr/lbf)       0.000E-01 -0.000E-01
                    W2  (lbm/s)            0.000E-01  8.565E+00
          corrected W2  (lbm/s)            8.601E+00  8.601E+00

   reference recovery                      9.782E-01


&ipac
 xmach0=1.2,figure=0,
 theta=5,5.0,2.0,
 xmth=0.550,
 bypass=0.0,
&end

forebd: xmachx= 1.200E+00,xmach0= 1.200E+00, xmlm0= 1.000E+00,ptlpt0= 1.000E+00,  ala0= 1.000E+00,
*** error ***  in program segment cd2d     (errflg=2)
  cd2d: xmach0= 1.200E+00, a0iac= 5.000E-01,xmach1=-1.000E+00,pt1pt0= 9.928E-01,   cda= 2.102E-01,
 ptrcv: xmach0= 1.200E+00,  a0ac= 1.708E-01,  xmns= 0.000E-01,pt2pt0= 9.538E-01,thetad= 2.204E+00,
          xmth= 5.500E-01, athac= 2.096E-01,nishck=-1.000E+00,pthpt0= 9.928E-01,xlipth=-1.000E+00,
  cd2d: xmach0= 1.200E+00, a0iac= 1.858E-01,xmach1= 2.614E-01,pt1pt0= 9.928E-01,   cda= 7.740E-01,
cdwave: xmach0= 1.200E+00, cdwav= 1.251E-01,
 clsuc: xmach0= 1.200E+00, a0iac= 1.858E-01,   cls= 1.180E-01, cdspl= 6.560E-01,thetae= 5.412E+00,
*** error ***  in program segment cdbld    (errflg=2)
 cdbld: xmach0= 1.200E+00, a0iac= 1.858E-01, bleed= 1.500E-02, cdbld= 1.131E-02,ptblpe= 1.001E+00,
      : xmach0= 1.200E+00, a0iac= 1.858E-01, bleed= 1.500E-02, cdbld= 1.131E-02,
      : xmach0= 1.200E+00, a0iac= 1.858E-01, cdtot= 6.673E-01, cdspl= 6.560E-01, cdref= 1.251E-01,
      : xmach0= 1.200E+00,a0enac= 1.708E-01,   w2c= 8.585E+00,    w2= 8.975E+00,
      : xmachx= 1.200E+00,a0enac= 1.708E-01,w2ceng= 8.601E+00,

IPAC   2-D Inlet Example Case

Flight Conditions

          Mach number                      1.200E+00

            altitude  (ft)                 1.906E+04

                                            ambient     total

            pressure  (lbf/ft**2)          1.012E+03  2.453E+03
         temperature  (R)                  4.507E+02  5.805E+02
    dynamic pressure  (lbf/ft**2)          1.020E+03
```

```
Vehicle Effects

               ML/M0                 1.000E+00
             PTL/PT0                 1.000E+00
               AL/A0                 1.000E+00

Inlet Mass Flow Ratios

              A0I/AC                 1.858E-01
            A0SPL/AC                 8.142E-01
            A0BLD/AC                 1.500E-02
               A0/AC                 1.708E-01
            A0BYP/AC                 0.000E-01
            A0ENG/AC                 1.708E-01

Inlet Total Pressure Recoveries

             PT2/PT0                 9.538E-01

             PTL/PT0                 1.000E+00
             PT1/PTL                 9.928E-01
            PTTH/PT1                 1.000E+00
            PT2/PTTH                 9.608E-01

             PTx/PTy                 1.000E+00

Inlet Drag Breakdown

                  AC  (ft**2)        1.000E+00

                                        CD        D  (lbf)

            spillage                 6.560E-01  6.689E+02
               bleed                 1.131E-02  1.153E+01
              bypass                 0.000E-01  0.000E-01
                cowl                 1.251E-01  1.275E+02
               total                 7.924E-01  8.079E+02
           reference                 1.251E-01  1.275E+02
       power setting                 6.673E-01  6.804E+02

Engine Performance Data            uninstalled  installed

          net thrust  (lbf)          0.000E-01 -8.079E+02
                 SFC  (lbm/hr/lbf)   0.000E-01 -0.000E-01
                  W2  (lbm/s)        0.000E-01  8.975E+00
```

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          corrected W2   (lbm/s)        8.601E+00  8.585E+00

    reference recovery                  9.915E-01


&ipac  xmach0=1.0,figure=0,  &end

forebd: xmachx= 1.000E+00,xmach0= 1.000E+00, xmlm0= 1.000E+00,ptlpt0= 1.000E+00,  ala0= 1.000E+00,
 ptrcv: xmach0= 1.000E+00,  a0ac= 1.670E-01,  xmns= 0.000E-01,pt2pt0= 9.608E-01,thetad= 2.204E+00,
          xmth= 5.500E-01, athac= 2.096E-01,nishck=-1.000E+00,pthpt0= 1.000E+00,xlipth=-1.000E+00,
  cd2d: xmach0= 1.000E+00, a0iac= 1.745E-01,xmach1= 2.503E-01,pt1pt0= 1.000E+00,   cda= 5.619E-01,
 clsuc: xmach0= 1.000E+00, a0iac= 1.745E-01,   cls= 8.218E-02, cdspl= 4.797E-01,thetae= 5.412E+00,
*** error ***  in program segment cdbld    (errflg=2)
 cdbld: xmach0= 1.000E+00, a0iac= 1.745E-01, bleed= 7.500E-03, cdbld= 4.803E-03,ptblpe= 1.001E+00,
      : xmach0= 1.000E+00, a0iac= 1.745E-01, bleed= 7.500E-03, cdbld= 4.803E-03,
      : xmach0= 1.000E+00, a0iac= 1.745E-01, cdtot= 4.845E-01, cdspl= 4.797E-01, cdref= 0.000E-01,
      : xmach0= 1.000E+00,a0enac= 1.670E-01,   w2c= 8.585E+00,    w2= 1.002E+01,
      : xmachx= 1.000E+00,a0enac= 1.670E-01,w2ceng= 8.601E+00,

IPAC   2-D Inlet Example Case

Flight Conditions

          Mach number                   1.000E+00

             altitude  (ft)             1.040E+04

                                         ambient     total

             pressure  (lbf/ft**2)      1.433E+03  2.712E+03
          temperature  (R)              4.816E+02  5.779E+02
     dynamic pressure  (lbf/ft**2)      1.003E+03

Vehicle Effects

                ML/M0                   1.000E+00
              PTL/PT0                   1.000E+00
                AL/A0                   1.000E+00

Inlet Mass Flow Ratios

               A0I/AC                   1.745E-01
             A0SPL/AC                   8.255E-01
             A0BLD/AC                   7.500E-03
                A0/AC                   1.670E-01
             A0BYP/AC                   0.000E-01
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                AOENG/AC                   1.670E-01

 Inlet Total Pressure Recoveries

                PT2/PT0                    9.608E-01

                PTL/PT0                    1.000E+00
                PT1/PTL                    1.000E+00
               PTTH/PT1                    1.000E+00
               PT2/PTTH                    9.608E-01

                PTx/PTy                    1.000E+00

 Inlet Drag Breakdown

                     AC  (ft**2)           1.000E+00

                                             CD        D  (lbf)

               spillage                    4.797E-01  4.811E+02
                  bleed                    4.803E-03  4.818E+00
                 bypass                    0.000E-01  0.000E-01
                   cowl                    0.000E-01  0.000E-01
                  total                    4.845E-01  4.859E+02
              reference                    0.000E-01  0.000E-01
          power setting                    4.845E-01  4.859E+02

 Engine Performance Data                 uninstalled  installed

             net thrust  (lbf)             0.000E-01 -4.859E+02
                    SFC  (lbm/hr/lbf)      0.000E-01 -0.000E-01
                     W2  (lbm/s)           0.000E-01  1.002E+01
           corrected W2  (lbm/s)           8.601E+00  8.585E+00

    reference recovery                     1.000E+00


 &ipac  xmach0=0.8,figure=0,  &end

 forebd: xmachx= 8.000E-01,xmach0= 8.000E-01, xmlm0= 1.000E+00,ptlpt0= 1.000E+00,  ala0= 1.000E+00,
  ptrcv: xmach0= 8.000E-01,  a0ac= 1.734E-01,  xmns= 0.000E-01,pt2pt0= 9.608E-01,thetad= 2.204E+00,
           xmth= 5.500E-01, athac= 2.096E-01,nishck=-1.000E+00,pthpt0= 1.000E+00,xlipth=-1.000E+00,
   cd2d: xmach0= 8.000E-01, a0iac= 1.734E-01,xmach1= 2.331E-01,pt1pt0= 1.000E+00,   cda= 4.913E-01,
  clsuc: xmach0= 8.000E-01, a0iac= 1.734E-01,   cls= 9.522E-02, cdspl= 3.961E-01,thetae= 5.412E+00,
 *** error ***  in program segment cdbld    (errflg=2)
  cdbld: xmach0= 8.000E-01, a0iac= 1.734E-01, bleed= 2.310E-09, cdbld= 1.109E-09,ptblpe= 1.001E+00,
```

```
      : xmach0= 8.000E-01, a0iac= 1.734E-01, bleed= 2.310E-09, cdbld= 1.109E-09,
      : xmach0= 8.000E-01, a0iac= 1.734E-01, cdtot= 3.961E-01, cdspl= 3.961E-01, cdref= 0.000E-01,
      : xmach0= 8.000E-01,a0enac= 1.734E-01,   w2c= 8.585E+00,    w2= 1.184E+01,
      : xmachx= 8.000E-01,a0enac= 1.734E-01,w2ceng= 8.601E+00,

IPAC   2-D Inlet Example Case

Flight Conditions

          Mach number                  8.000E-01

            altitude  (ft)             0.000E-01

                                        ambient     total

            pressure  (lbf/ft**2)      2.116E+03  3.226E+03
         temperature  (R)              5.187E+02  5.851E+02
    dynamic pressure  (lbf/ft**2)      9.481E+02

Vehicle Effects

               ML/M0                   1.000E+00
             PTL/PT0                   1.000E+00
               AL/A0                   1.000E+00

Inlet Mass Flow Ratios

              A0I/AC                   1.734E-01
            A0SPL/AC                   8.266E-01
            A0BLD/AC                   2.310E-09
               A0/AC                   1.734E-01
            A0BYP/AC                   0.000E-01
            A0ENG/AC                   1.734E-01

Inlet Total Pressure Recoveries

             PT2/PT0                   9.608E-01

             PTL/PT0                   1.000E+00
             PT1/PTL                   1.000E+00
            PTTH/PT1                   1.000E+00
            PT2/PTTH                   9.608E-01

             PTx/PTy                   1.000E+00

Inlet Drag Breakdown
```

```
                AC  (ft**2)       1.000E+00

                                     CD       D  (lbf)

          spillage                3.961E-01  3.755E+02
             bleed                1.109E-09  1.052E-06
            bypass                0.000E-01  0.000E-01
              cowl                0.000E-01  0.000E-01
             total                3.961E-01  3.755E+02
         reference                0.000E-01  0.000E-01
     power setting                3.961E-01  3.755E+02

Engine Performance Data         uninstalled  installed

        net thrust  (lbf)         0.000E-01 -3.755E+02
               SFC  (lbm/hr/lbf)  0.000E-01 -0.000E-01
                W2  (lbm/s)       0.000E-01  1.184E+01
      corrected W2  (lbm/s)       8.601E+00  8.585E+00

   reference recovery             1.000E+00


&ipac  xmach0=0.6,figure=0,  &end

forebd: xmachx= 6.000E-01,xmach0= 6.000E-01, xmlm0= 1.000E+00,ptlpt0= 1.000E+00,  ala0= 1.000E+00,
 ptrcv: xmach0= 6.000E-01,  a0ac= 1.984E-01,  xmns= 0.000E-01,pt2pt0= 9.608E-01,thetad= 2.204E+00,
          xmth= 5.500E-01, athac= 2.096E-01,nishck=-1.000E+00,pthpt0= 1.000E+00,xlipth=-1.000E+00,
  cd2d: xmach0= 6.000E-01, a0iac= 1.984E-01,xmach1= 2.331E-01,pt1pt0= 1.000E+00,   cda= 3.932E-01,
 clsuc: xmach0= 6.000E-01, a0iac= 1.984E-01,   cls= 7.733E-02, cdspl= 3.159E-01,thetae= 5.412E+00,
      : xmach0= 6.000E-01, a0iac= 1.984E-01, cdtot= 3.159E-01, cdspl= 3.159E-01, cdref= 0.000E-01,
      : xmach0= 6.000E-01,a0enac= 1.984E-01,   w2c= 8.585E+00,    w2= 1.017E+01,
      : xmachx= 6.000E-01,a0enac= 1.984E-01,w2ceng= 8.601E+00,

IPAC   2-D Inlet Example Case

Flight Conditions

         Mach number              6.000E-01

            altitude  (ft)        0.000E-01

                                   ambient     total

            pressure  (lbf/ft**2)  2.116E+03  2.699E+03
         temperature  (R)          5.187E+02  5.560E+02
```

```
      dynamic pressure   (lbf/ft**2)    5.333E+02

  Vehicle Effects

                   ML/MO                1.000E+00
                  PTL/PTO               1.000E+00
                   AL/AO                1.000E+00

  Inlet Mass Flow Ratios

                   AOI/AC               1.984E-01
                 AOSPL/AC               8.016E-01
                 AOBLD/AC               0.000E-01
                    AO/AC               1.984E-01
                 AOBYP/AC               0.000E-01
                 AOENG/AC               1.984E-01

  Inlet Total Pressure Recoveries

                  PT2/PTO               9.608E-01

                  PTL/PTO               1.000E+00
                  PT1/PTL               1.000E+00
                 PTTH/PT1               1.000E+00
                 PT2/PTTH               9.608E-01

                  PTx/PTy               1.000E+00

  Inlet Drag Breakdown

                      AC   (ft**2)      1.000E+00

                                           CD       D  (lbf)

                 spillage               3.159E-01  1.685E+02
                    bleed               0.000E-01  0.000E-01
                   bypass               0.000E-01  0.000E-01
                     cowl               0.000E-01  0.000E-01
                    total               3.159E-01  1.685E+02
                reference               0.000E-01  0.000E-01
            power setting               3.159E-01  1.685E+02

  Engine Performance Data             uninstalled  installed

               net thrust  (lbf)        0.000E-01 -1.685E+02
                      SFC  (lbm/hr/lbf) 0.000E-01 -0.000E-01
```

```
                W2  (lbm/s)         0.000E-01  1.017E+01
      corrected W2  (lbm/s)         8.601E+00  8.585E+00

   reference recovery               1.000E+00


&ipac  xmach0=0.4,figure=0,  &end

forebd: xmachx= 4.000E-01,xmach0= 4.000E-01, xmlm0= 1.000E+00,ptlpt0= 1.000E+00,  ala0= 1.000E+00,
 ptrcv: xmach0= 4.000E-01,  a0ac= 2.655E-01,  xmns= 0.000E-01,pt2pt0= 9.608E-01,thetad= 2.204E+00,
          xmth= 5.500E-01, athac= 2.096E-01,nishck=-1.000E+00,pthpt0= 1.000E+00,xlipth=-1.000E+00,
  cd2d: xmach0= 4.000E-01, a0iac= 2.655E-01,xmach1= 2.331E-01,pt1pt0= 1.000E+00,   cda= 2.407E-01,
 clsuc: xmach0= 4.000E-01, a0iac= 2.655E-01,   cls= 4.936E-02, cdspl= 1.914E-01,thetae= 5.412E+00,
      : xmach0= 4.000E-01, a0iac= 2.655E-01, cdtot= 1.914E-01, cdspl= 1.914E-01, cdref= 0.000E-01,
      : xmach0= 4.000E-01,a0enac= 2.655E-01,   w2c= 8.585E+00,    w2= 9.069E+00,
      : xmachx= 4.000E-01,a0enac= 2.655E-01,w2ceng= 8.601E+00,

IPAC   2-D Inlet Example Case

Flight Conditions

         Mach number                4.000E-01

            altitude  (ft)          0.000E-01

                                     ambient     total

            pressure  (lbf/ft**2)   2.116E+03  2.363E+03
         temperature  (R)           5.187E+02  5.353E+02
    dynamic pressure  (lbf/ft**2)   2.370E+02

Vehicle Effects

               ML/M0                1.000E+00
             PTL/PT0                1.000E+00
               AL/A0                1.000E+00

Inlet Mass Flow Ratios

              A0I/AC                2.655E-01
            A0SPL/AC                7.345E-01
            A0BLD/AC                0.000E-01
               A0/AC                2.655E-01
            A0BYP/AC                0.000E-01
            A0ENG/AC                2.655E-01
```

```
Inlet Total Pressure Recoveries

               PT2/PT0                 9.608E-01

               PTL/PT0                 1.000E+00
               PT1/PTL                 1.000E+00
              PTTH/PT1                 1.000E+00
              PT2/PTTH                 9.608E-01

               PTx/PTy                 1.000E+00

Inlet Drag Breakdown

                    AC  (ft**2)        1.000E+00

                                          CD       D  (lbf)

              spillage                 1.914E-01  4.536E+01
                 bleed                 0.000E-01  0.000E-01
                bypass                 0.000E-01  0.000E-01
                  cowl                 0.000E-01  0.000E-01
                 total                 1.914E-01  4.536E+01
             reference                 0.000E-01  0.000E-01
         power setting                 1.914E-01  4.536E+01

Engine Performance Data              uninstalled  installed

            net thrust  (lbf)          0.000E-01 -4.536E+01
                   SFC  (lbm/hr/lbf)   0.000E-01 -0.000E-01
                    W2  (lbm/s)        0.000E-01  9.069E+00
          corrected W2  (lbm/s)        8.601E+00  8.585E+00

   reference recovery                  1.000E+00


&ipac  xmach0=0.2,figure=0,  &end

forebd: xmachx= 2.000E-01,xmach0= 2.000E-01, xmlm0= 1.000E+00,ptlpt0= 1.000E+00,  ala0= 1.000E+00,
 ptrcv: xmach0= 2.000E-01,  a0ac= 4.945E-01,  xmns= 0.000E-01,pt2pt0= 9.601E-01,thetad= 2.204E+00,
          xmth= 5.500E-01, athac= 2.096E-01,nishck=-1.000E+00,pthpt0= 9.993E-01,xlipth=-1.000E+00,
  cd2d: xmach0= 2.000E-01, a0iac= 4.945E-01,xmach1= 2.329E-01,pt1pt0= 1.000E+00,   cda= 0.000E-01,
      : xmach0= 2.000E-01, a0iac= 4.945E-01, cdtot= 0.000E-01, cdspl= 0.000E-01, cdref= 0.000E-01,
      : xmach0= 2.000E-01,a0enac= 4.945E-01,   w2c= 8.585E+00,    w2= 8.445E+00,
      : xmachx= 2.000E-01,a0enac= 4.945E-01,w2ceng= 8.601E+00,

IPAC   2-D Inlet Example Case
```

```
Flight Conditions

          Mach number                    2.000E-01

             altitude  (ft)              0.000E-01

                                          ambient      total

             pressure  (lbf/ft**2)       2.116E+03  2.176E+03
          temperature  (R)               5.187E+02  5.228E+02
     dynamic pressure  (lbf/ft**2)       5.925E+01

Vehicle Effects

                ML/M0                    1.000E+00
              PTL/PT0                    1.000E+00
                AL/A0                    1.000E+00

Inlet Mass Flow Ratios

               A0I/AC                    4.945E-01
             A0SPL/AC                    5.055E-01
             A0BLD/AC                    0.000E-01
                A0/AC                    4.945E-01
             A0BYP/AC                    0.000E-01
             A0ENG/AC                    4.945E-01

Inlet Total Pressure Recoveries

              PT2/PT0                    9.601E-01

              PTL/PT0                    1.000E+00
              PT1/PTL                    1.000E+00
             PTTH/PT1                    9.993E-01
             PT2/PTTH                    9.608E-01

              PTx/PTy                    1.000E+00

Inlet Drag Breakdown

                   AC  (ft**2)           1.000E+00

                                            CD        D  (lbf)

             spillage                    0.000E-01  0.000E-01
```

```
                bleed                         0.000E-01  0.000E-01
               bypass                         0.000E-01  0.000E-01
                 cowl                         0.000E-01  0.000E-01
                total                         0.000E-01  0.000E-01
            reference                         0.000E-01  0.000E-01
        power setting                         0.000E-01  0.000E-01

Engine Performance Data                     uninstalled  installed

           net thrust  (lbf)                  0.000E-01  0.000E-01
                  SFC  (lbm/hr/lbf)           0.000E-01  0.000E-01
                   W2  (lbm/s)                0.000E-01  8.445E+00
         corrected W2  (lbm/s)                8.601E+00  8.585E+00

   reference recovery                         1.000E+00


&ipac  xmach0=0.01,figure=0, &end

forebd: xmachx= 1.000E-02,xmach0= 1.000E-02, xmlm0= 1.000E+00,ptlpt0= 1.000E+00,  ala0= 1.000E+00,
 ptrcv: xmach0= 1.000E-02,  a0ac= 9.355E+00,  xmns= 0.000E-01,pt2pt0= 9.300E-01,thetad= 2.204E+00,
          xmth= 5.500E-01, athac= 2.096E-01,nishck=-1.000E+00,pthpt0= 9.680E-01,xlipth=-1.000E+00,
      : xmach0= 1.000E-02, a0iac= 9.355E+00,   cda= 0.000E-01,
      : xmach0= 1.000E-02, a0iac= 9.355E+00, cdtot= 0.000E-01, cdspl= 0.000E-01, cdref= 0.000E-01,
      : xmach0= 1.000E-02,a0enac= 9.355E+00,   w2c= 8.585E+00,    w2= 7.988E+00,
      : xmachx= 1.000E-02,a0enac= 9.355E+00,w2ceng= 8.601E+00,

IPAC   2-D Inlet Example Case

Flight Conditions

          Mach number                         1.000E-02

             altitude  (ft)                   0.000E-01

                                                ambient     total

             pressure  (lbf/ft**2)            2.116E+03  2.116E+03
          temperature  (R)                    5.187E+02  5.187E+02
     dynamic pressure  (lbf/ft**2)            1.481E-01

Vehicle Effects

                ML/M0                         1.000E+00
              PTL/PT0                         1.000E+00
                AL/A0                         1.000E+00
```

```
Inlet Mass Flow Ratios

              A0I/AC                 9.355E+00
            A0SPL/AC                -8.355E+00
            A0BLD/AC                 0.000E-01
               A0/AC                 9.355E+00
            A0BYP/AC                 0.000E-01
            A0ENG/AC                 9.355E+00

Inlet Total Pressure Recoveries

             PT2/PT0                 9.300E-01

             PTL/PT0                 1.000E+00
             PT1/PTL                 1.000E+00
            PTTH/PT1                 9.680E-01
            PT2/PTTH                 9.608E-01

             PTx/PTy                 1.000E+00

Inlet Drag Breakdown

                  AC  (ft**2)        1.000E+00

                                        CD       D  (lbf)

            spillage                 0.000E-01  0.000E-01
               bleed                 0.000E-01  0.000E-01
              bypass                 0.000E-01  0.000E-01
                cowl                 0.000E-01  0.000E-01
               total                 0.000E-01  0.000E-01
           reference                 0.000E-01  0.000E-01
       power setting                 0.000E-01  0.000E-01

Engine Performance Data             uninstalled  installed

          net thrust  (lbf)          0.000E-01  0.000E-01
                 SFC  (lbm/hr/lbf)   0.000E-01  0.000E-01
                  W2  (lbm/s)        0.000E-01  7.988E+00
        corrected W2  (lbm/s)        8.601E+00  8.585E+00

  reference recovery                 1.000E+00
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REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. AGENCY USE ONLY *(Leave blank)*

2. REPORT DATE
July 1997

3. REPORT TYPE AND DATES COVERED
Final Contractor Report

4. TITLE AND SUBTITLE
IPAC - Inlet Performance Analysis Code

5. FUNDING NUMBERS
WU–522–41–43
C–NAS3–27186

6. AUTHOR(S)
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7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
NYMA, Inc.
2001 Aerospace Parkway
Brook Park, Ohio 44142

8. PERFORMING ORGANIZATION REPORT NUMBER
E–10800

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)
National Aeronautics and Space Administration
Lewis Research Center
Cleveland, Ohio 44135–3191

10. SPONSORING/MONITORING AGENCY REPORT NUMBER
NASA CR–204130

11. SUPPLEMENTARY NOTES
Project Manager, Paul F. Senick, Propulsion Systems Analysis Office, NASA Lewis Research Center, organization code 2400, (216) 433–7024.

12a. DISTRIBUTION/AVAILABILITY STATEMENT
Unclassified - Unlimited
Subject Category 07

This publication is available from the NASA Center for AeroSpace Information, (301) 621–0390.

12b. DISTRIBUTION CODE

13. ABSTRACT ***(Maximum 200 words)***

A series of analyses have been developed which permit the calculation of the performance of common inlet designs. The methods presented are useful for determining the inlet weight flows, total pressure recovery, and aerodynamic drag coefficients for given inlet geometric designs. Limited geometric input data is required to use this inlet performance prediction methodology. The analyses presented here may also be used to perform inlet preliminary design studies. The calculated inlet performance parameters may be used in subsequent engine cycle analyses or installed engine performance calculations for existing uninstalled engine data.

14. SUBJECT TERMS
Total pressure recovery; Inlet aerodynamic drags

15. NUMBER OF PAGES
168

16. PRICE CODE
A09

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
Unclassified	Unclassified	Unclassified	