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ENERGY EFFICIENT ENGINE
FAN COMPONENT DETAILED DESIGN REPORT

Prepared by

J. E. Halle and C. J. Michael

UNITED TECHNOLOGIES CORPORATION
Pratt & Whitney Aircraft
Commercial Products Division

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
NASA-Lewis Research Center
Cleveland, Ohio 44135
Contract NAS3-20646

PRATT & WHITNEY AIRCRAFT GROUP
Commercial Products Division

East Hartford, Connecticut 06108

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To: National Aeronautics and Space Administration
Lewis Research Center
21000 Brookpark Road
Cleveland, Ohio 44135

Attention: Mr. Carl C. Ciepluch, Mail Stop 301-4

Subject: Energy Efficient Engine
Fan Component Detailed Design Report
PWA-5594-183

References: Contract No. NAS3-20646

Enclosures: Twenty copies of the subject report

Gentlemen:

Enclosed are twenty copies of the subject report in accordance with the requirements of the referenced contract.

Sincerely yours,

UNITED TECHNOLOGIES CORPORATION
Pratt & Whitney Aircraft Group
Commercial Products Division

W. B. Gardner

W. B. Gardner
Program Manager

cc: Administrative Contracting Officer (Letter Only)
Air Force Plant Representative Office
Pratt & Whitney Aircraft Group
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UNITED TECHNOLOGIES

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FOREWORD

The Energy Efficient Engine Component Development and Integration Program is being conducted under parallel National Aeronautics and Space Administration contracts to the Pratt & Whitney Aircraft Group, Commercial Products Division and the General Electric Company. The overall project is under the direction of Mr. Carl C. Ciepluch. Mr. John W. Schafer is the NASA Assistant Project Manager for the Pratt & Whitney Aircraft effort under Contract NAS3-20646, and Mr. Frank D. Berkopec is the NASA Project Engineer responsible for the portion of the program described in this report. Mr. William B. Gardner is the Pratt & Whitney Aircraft Program Manager for the Energy Efficient Engine Program. This report was prepared by Mr. C. J. Michael and Mr. J. E. Halle of Pratt & Whitney Aircraft.

SECTION 1.0
SUMMARY

The fan component designed for the Energy Efficient Engine is an advanced high-performance, single-stage system. The design is based on technology advancements in the areas of aerodynamics and structure-mechanics. This advanced technology fan contributes to a greater than 3 percent reduction in overall engine fuel consumption when compared to the base (-12 percent) Pratt & Whitney Aircraft JT9D-7A turbofan engine.

In the design effort, two fan components were designed, both meeting the integrated core/low spool engine efficiency goal of 84.5 percent. The primary configuration, envisioned for a future flight propulsion system, features a shroudless, hollow blade and offers a predicted efficiency of 87.3 percent. In order to ensure that a fan would be available, if the shroudless, hollow design encountered fabrication or other technical problems a more conventional blade was designed for the integrated core/low spool demonstrator engine as a back-up. Although efficiency was penalized slightly by the addition of a part span shroud, the alternate blade configuration has a predicted efficiency of 86.3 percent for the future flight propulsion system. In addition to efficiency, both fan configurations either meet or surpass goals established for surge margin, structural integrity and durability.

The mechanical design of the fan has been accomplished so that the shroudless blade can be interchangeable with the shrouded blade with only minor modifications. The design is based on component modularity to enhance maintenance. The fan rotor consists of an integral disk/hub geometry that is cantilevered from the low-pressure rotor shaft. This disk/hub design produces a substantial reduction in component weight. To enhance performance, blade tip leakage is reduced by using a blade tip trench with an abradable material.

Much of the technology incorporated in the Energy Efficient Engine fan design will have direct application in modern gas-turbine engines.

SECTION 2.0
INTRODUCTION

The objective of the Energy Efficient Engine Program is to develop, evaluate, and demonstrate the technology for achieving lower installed fuel consumption and lower operating costs in future commercial turbofan engines. The National Space and Aeronautics Administration (NASA) has established the minimum goals for reducing thrust specific fuel consumption by 12 percent, direct operating cost by 5 percent, and performance degradation by 50 percent for the Energy Efficient Engine flight propulsion system relative to the JT9D-7A engine. To ensure a high probability of meeting the NASA goals, Pratt & Whitney Aircraft goals are a 15.3 percent reduction in thrust specific fuel consumption and 6.1 percent reduction in direct operating cost. In addition, environmental goals for emissions (Environmental Protection Agency 1981 regulation) and noise (Federal Aviation Regulation 36 (1978)) have been established.

To meet the program objective, the program is organized into four technical tasks. These include:

- Task 1 -- Flight Propulsion System Analysis, Design and Integration
- Task 2 -- Component Analysis, Design, and Development
- Task 3 -- Core Design, Fabrication and Development
- Task 4 -- Integrated Core/Low Spool Design, Fabrication and Test.

A major accomplishment under the Task 2 effort has been the design of the fan component. The fan for the Energy Efficient Engine, as described in this report, is an advanced, high performance single stage configuration. This report presents the details pertaining to the aerodynamic and mechanical design of the fan component.

The following section, Section 3.0, outlines the design goals and predicted performance. Section 4.0 describes the aerodynamic and mechanical design of the fan, and Section 5.0 presents concluding remarks. In addition, detailed tabulations of the aerodynamic performance, and blade geometry at aerodynamic design point conditions are contained in Appendices A, B, and C, respectively. These appendices compare the aerodynamic geometries of both the shrouded and shroudless fan blades. Appendix D contains a glossary of terms used in the report.

SECTION 3.0
DESIGN OVERVIEW

3.1 DESIGN GOALS AND CHALLENGES

The goal of the Energy Efficient Engine Fan Component Design Program was to design a high performance fan component featuring a shroudless, hollow blade. A more conventional shrouded blade was designed for the integrated core/low spool demonstrator engine as a back-up. Performance and durability design goals for the fans with both blade configurations are listed in Table 3.1-I

TABLE 3.1-I
FAN COMPONENT PERFORMANCE AND DURABILITY DESIGN GOALS

	Goal
Efficiency (Shroudless)	87.3*
Efficiency (shrouded)	86.3*
Corrected total airflow, kg/sec (lbm/sec)	622.7 (1372.8)
Corrected rotor speed, rpm	4215
Fan tip speed, m/sec (ft/sec)	456.0 (1496)
Duct pressure ratio	1.74
Surge margin goal (percent)	15
Pressure Ratio	1.74 OD/1.56 ID
Life	20,000 missions/30,000 hours
Foreign Object Resistance	Same as in-service blades

* Efficiency values reflect flight propulsion system goals. The goal efficiency for the integrated core/low spool demonstrator is 84.5 percent.

A number of challenges had to be surmounted to attain these goals. The shrouded blade was subjected to an unusually high loading level because of the ambitious efficiency and pressure ratio goals. To maintain the surge margin at an acceptable level, loadings had to be balanced carefully throughout the flowpath.

The shroudless blade required a very low aspect ratio of 2.5 (compared to 4.0 for shrouded blades) as well as a thick blade (thickness to chord ratio of 0.080 versus 0.060 at 20 percent span when compared to a conventional shrouded blade) to maintain the necessary rigidity to avoid flutter and undesirable resonance characteristics. However, low aspect ratios increase weight and thick blades increase aerodynamic losses both of which are counterproductive to fuel efficiency. As a result, these factors had to be optimized during the design process to provide the most efficient design.

3.2 DESIGN APPROACH

The fan component was designed so that both shrouded and shroudless blades could be interchanged with a minimum of modifications. This allowed the flexibility to incorporate the shroudless blade into the component design, should fabrication technology be refined to the point that the blade manufacture is feasible within existing time and resource constraints.

The design of the Energy Efficient Engine shrouded fan blade was initiated by scaling an existing airfoil design. Aerodynamic, structural and vibrational characteristics unique to the Energy Efficient Engine design requirement were then applied to establish the final blade design. In general, this blade design is similar to current high bypass ratio blade designs except that the fan rotates counterclockwise when viewed from the rear.

The shrouded fan blade is essentially the same as fan blades currently in service in Pratt & Whitney Aircraft high bypass ratio engines. It has an aft part span shroud to reduce aerodynamic losses, relative to a part span shroud located in the middle of the blade chord. Existing analytical techniques and experience were used in designing this blade. In contrast, the shroudless fan blade represents a more difficult challenge since no design system existed for analyzing hollow fan blades. However, an in-house design system did exist for hollow turbine blades. This method was adapted to analyze blade structural response. Also, existing in-house design systems were used to perform aerodynamic analysis.

The fan rotor was designed to meet current commerical criteria. However, the fan component design was not optimized for flight weight, since the fan is not going to be flight tested. This allowed less expensive materials and hardware to be used. Existing parts were used as much as possible in the bearing compartment to reduce costs. For example, existing bearings, seals, and fasteners from current production engines are used. Titanium, the traditional material for fan blades, was selected as the blade material because of the extensive experience. Composites were considered but rejected because of the low resistance to foreign object damage.

3.3 FAN COMPONENT DESIGN FEATURES

The Energy Efficient Engine fan component is a high performance, single stage configuration. A cross sectional view of the fan component is presented in Figure 3.3-1. The fan rotor is supported by two main bearings housed in a common bearing support. The fan overhangs its supports in a cantilevered configuration. The bearing support is attached to the compressor intermediate case.

Table 3.3-I presents a comparison of the fan configurations with the shroudless and shrouded blades. With the shroudless blade design, the rotor contains a total of 24 titanium hollow blades. In this blade design, The outer two-thirds is hollow, with an internal rib structure for added strength. This is somewhat of a complex structure, requiring new manufacturing practices and technology. This new technology was to be developed as part of the Energy Efficient Engine Program but schedule and budget difficulties led to premature termination of this effort.

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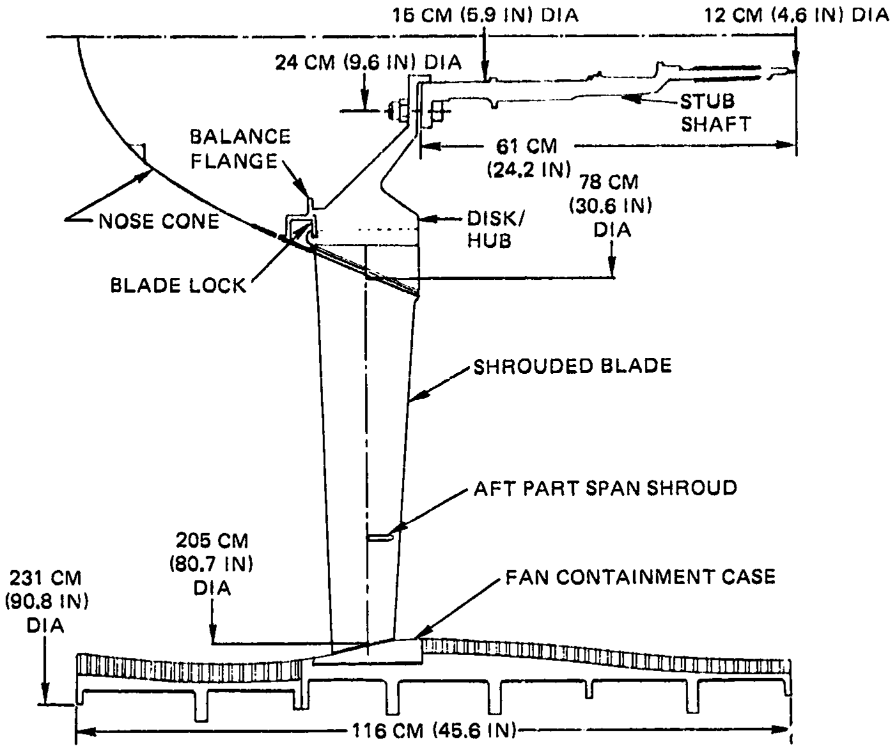

Figure 3.3-1 Fan Component For the Energy Efficient Engine

TABLE 3.3-I
COMPARISON OF SHROUDED AND SHROUDLESS FAN BLADE
DESIGN FEATURES

Parameter	Shrouded Fan	Shroudless Fan
Hub/tip ratio	0.34	0.34
Aspect ratio	4.0	2.5
Taper ratio	1.45	1.46
Number blades	36	24
Bypass ratio	6.51	6.51

The alternate shrouded fan blade rotor consists of 36 titanium fan blades with aft part span shrouds, and uses the same fan exit guide vane configuration as the shroudless fan. As stated previously, this blade is essentially the same as fan blades currently used in Pratt & Whitney Aircraft high bypass ratio engines. The shrouded fan has all the basic features of the shroudless fan, with minor differences in the flowpath.

The fan blade/disk attachment is an existing design. The titanium hub attaches to a steel stubshaft with fifteen 2.50 cm (1.0 in) diameter tie bolts. The stubshaft is splined to its mating low-pressure turbine drive shaft. The rotor has an aluminum nose cone and cap, and a steel blade lock ring. A low cost steel containment case with an acoustic liner is specified for the integrated core/low spool test program.

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3.4 PREDICTED PERFORMANCE

Predicted fan performance is summarized in Table 3.4-I. As indicated, the fan with a shrouded fan blade meets or exceeds all design goals, including the requirement for a integrated core/low spool adiabatic efficiency of 84.5 percent. However, the adiabatic efficiency for the flight propulsion system is 86.3 percent. This is a full percentage point lower that the predicted efficiency of 87.3 for the shroudless blade configuration. Performance maps for both fan configurations are shown in Figures 3.4-1 and 3.4-2.

TABLE 3.4-I
COMPARISON OF SHROUDED AND SHROUDLESS FAN
PERFORMANCE AT AERODYNAMIC DESIGN POINT

Parameter	Design Point	Shrouded Fan	Shroudless Fan
Corrected total engine airflow, kg/sec (lbm/sec)	622.7 (1372.8)	622.7 (1372.8)	622.7 (1372.8)
Corrected rotor speed, rpm	4215	4215	4215
Fan tip speed, m/sec (ft/sec)	456.0 (1496)	456.9 (1499)	456.0 ([illegible])
Corrected flow/unit area, kg/sec-m^2 (lbm/sec-ft^2)	209.9 (43.0)	209.9 (43.0)	209.9 (43.0)
Duct pressure ratio	1.740	1.740	1.740
Fan hub pressure ratio	1.61	1.61	1.61
Duct goal efficiency (percent)	86.3/87.3	86.3	87.3
Surge margin goal (percent)	15	15	15

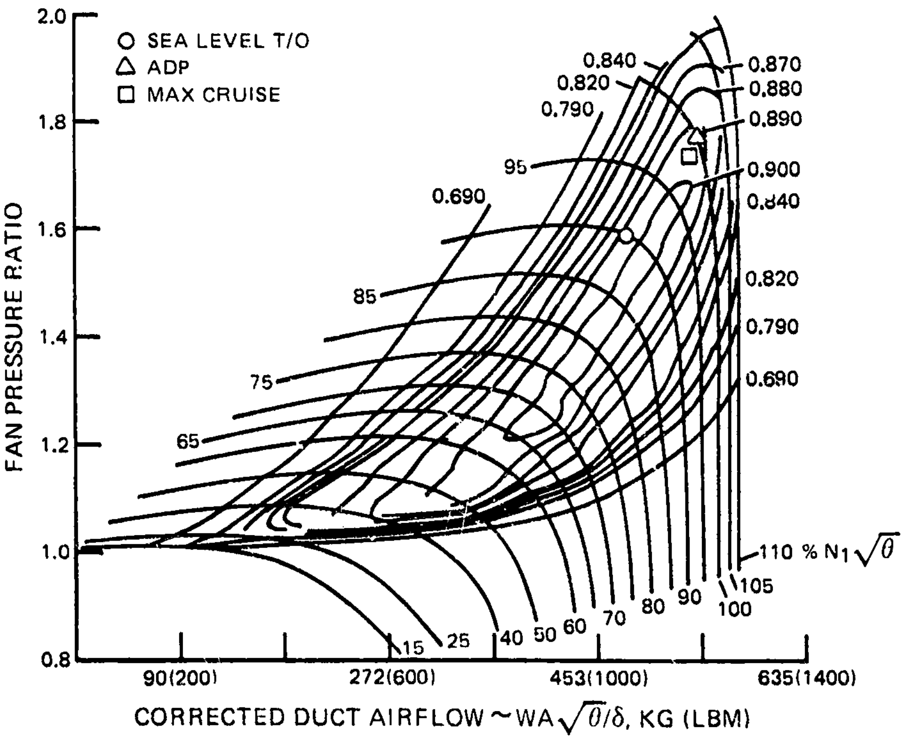

Figure 3.4-1 Performance Map of Shrouded Fan Design

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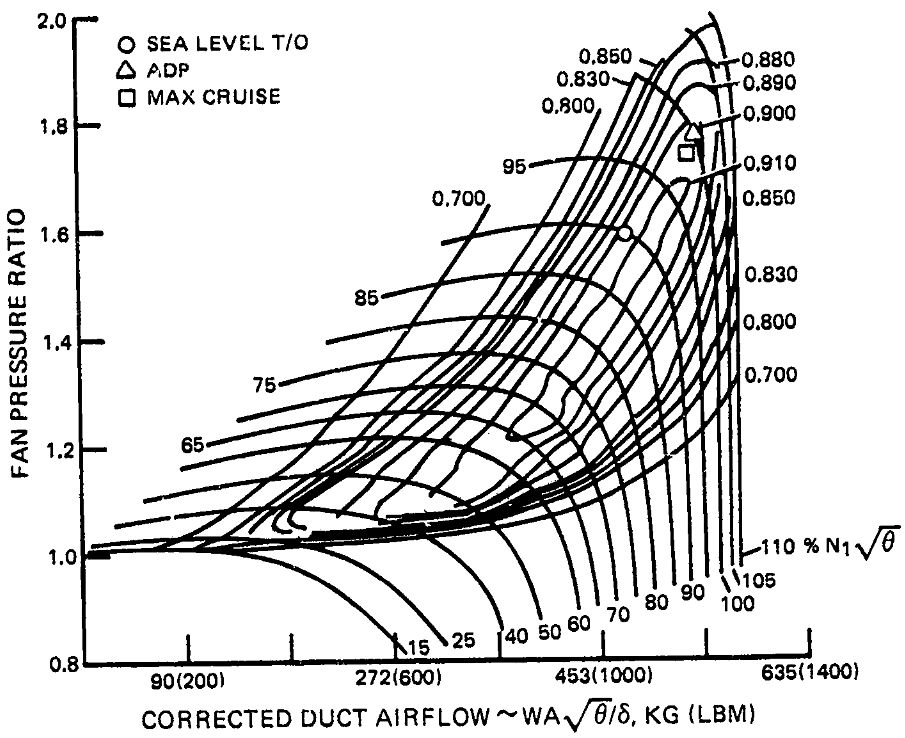

Figure 3.4-2 Performance Map of Shroudless Fan Design

Figure 3.4-3 compares the predicted loading on an operating line 15 percent higher than the design operating line with test data for the NASA 1800 feet/second tip speed fan (Reference 2) at the near surge point. The shroudless fan is predicted to be more lightly loaded than the 1800 feet/second tip speed fan and should readily achieve its 15 percent surge margin goal. The middle of the shrouded fan is predicted to be more highly loaded than 1800 feet/second tip speed fan, but in the range of other Pratt & Whitney Aircraft commercial engine fan blades.

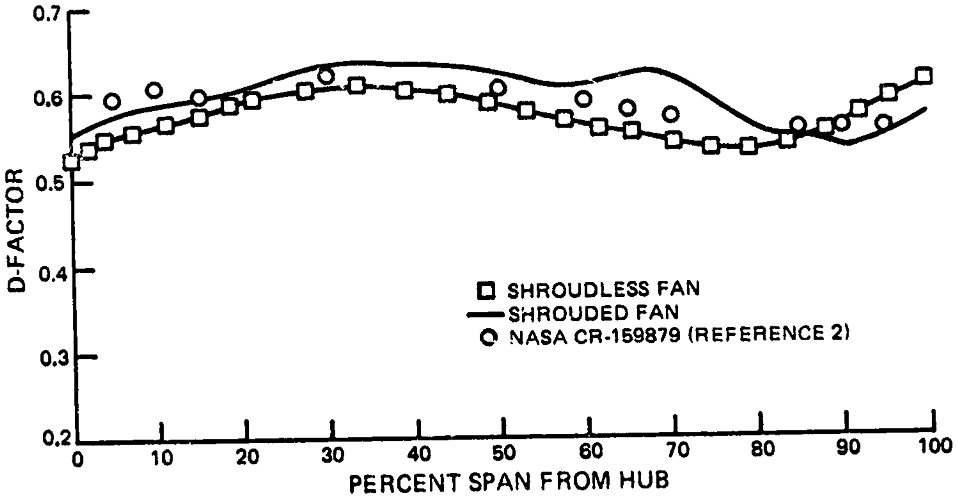

Figure 3.4-3 Comparison of Shroudless and Shrouded Fan Off-Design Loadings

Surge margin requirements were established by a stability audit taken at the major operating points in the flight envelope. For each of these points, the surge margin reduction, resulting from surge line and operating line shifts caused by destabilizing factors, was examined to determine how much initial surge margin was required. The destabilizing factors include such events as engine and control deterioration, inlet distortion, production tolerances, and power transients. The results of the fan stability audit which applies to both shroudless and shrounded fans are presented in Table 3.4-II for the sea level static takeoff point. The results of this audit showed that the design fan surge margin of 15 percent is sufficient to ensure ample surge margin at takeoff, climb, cruise, idle and reverse, as indicated in Table 3.4-III.

TABLE 3.4-II
FAN STABILITY AUDIT RESULTS AT TAKEOFF CONDITIONS
SHROUDLESS AND SHROUDED FANS

SURGE LINE DETERIORATION	Fixed Quanity (%)	Random Quantity (%)
Engine Deterioration	2.3	±1.2
Distortion	3.0	0
Engine Production Tolerances	0	±1.0
OPERATING LINE DEGRADATION		
Engine Production Tolerances	0	±0.5
Control Production Tolerances	0	0
Engine Deterioration	0.5	±0.5
Control Deterioration	0	0
Power Transients	0	0
Sum of Fixed	5.8	
Sum of Random		±1.7
Required Surge Margin (%)	7.5	
Available Surge Margin (%)	16.2	

TABLE 3.4-III
FAN STABILITY AUDIT RESULTS AT MAJOR OPERATING POINTS
SHROUDLESS ADN SHROUDED FANS

		Surge Margin (%)	
Flight Condition	Flow (%)	Required	Available
Aerodynamic Design Point*	100	4.5	15.0
Idle (sea level static)	29.7	1.9	7.4
Takeoff	89.7	7.5	16.2
Reverse	88.9	9.5	16.7

* Representative of maximum climb and cruise operation

SECTION 4.0
AERODYNAMIC AND MECHANICAL DESIGN

4.1 AERODYNAMIC DESIGN

The aerodynamic design point for the Energy Efficient Engine fan component is at a flight altitude of 10,668 m (35,000 ft) and a cruise Mach number of 0.8.

The following sections describe the aerodynamic design of the fan flowpath, blade and exit guide vane designs.

4.1.1 Flowpath

The basic fan flowpath was determined during the design of the shroudless fan blade and fan exit guide vane. Because of the prerequisite for blade interchangeability, the shrouded blade was required to fit into this existing flowpath with no change to the fan exit guide vane or first stage low-pressure compressor stator. A comparison of the flowpaths to accommodate the two blade configurations is presented in Figure 4.1.1-I. A tabulation of flow behavior through the flowpath is given in Appendix A.

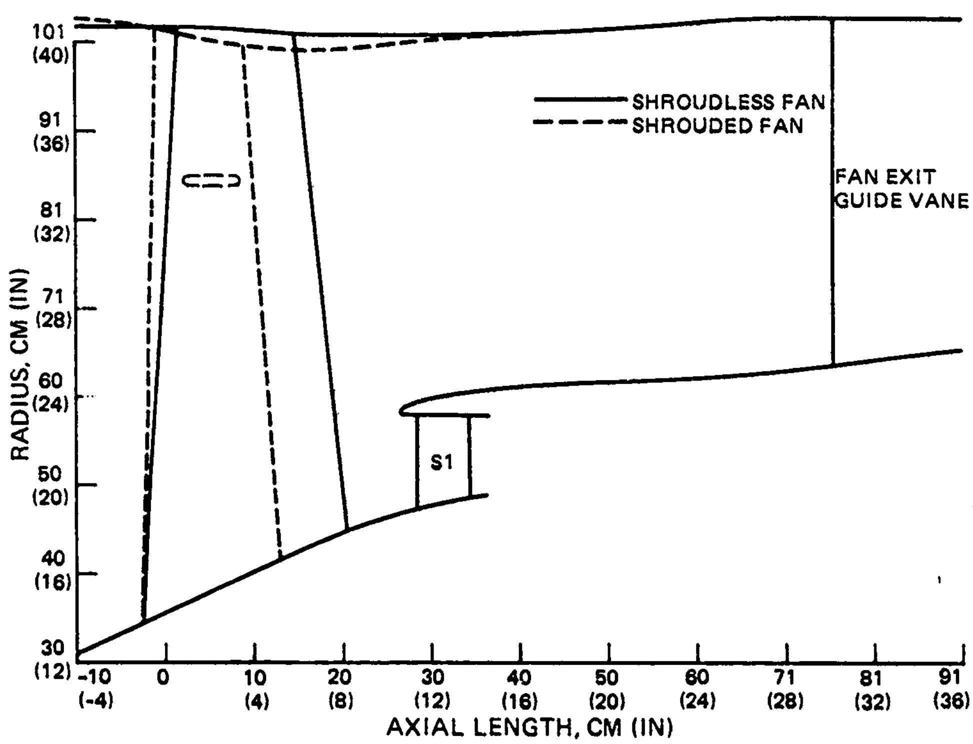

Figure 4.1.1-1 Comparison of Fan Flowpaths with the Shrouded and Shroudless fan Blades.

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The shrouded fan, however, is different from the shroudless fan in a number of ways. The inner flowpath is the same for both configurations, but the outer flowpath of the shrouded fan is recontoured in the vicinity of the blade tip to provide the proper area ratio and reduce tip loading. The radial pressure ratio distribution of the shrouded fan was modified to compensate for the additional aerodynamic loss incurred by the part span shroud, thereby permitting both fan configurations to use the same low-pressure compressor inlet stator and fan duct exit guide vane.

In the tip region, the flowpath for the shrouded fan results from compromises between fan blade tip loadings and wall loadings. Increasing the convergence lowers the blade tip diffusion factor, but raises the diffusion along the outer wall.

Another important difference between the shroudless and shrouded fan flowpaths is caused by the differences in the two blades. The trailing edge of the shrouded blade has a smaller average diameter than the shroudless configuration. This causes the flowpath to be narrower at this location than the shroudless fan flowpath and results in a lower average wheel speed and an increased diffusion factor for the shrouded fan.

Tip trenches, as shown in Figure 4.1.1-2, are used in both the shrouded and shroudless fan components. Tests have shown that this feature reduces blade tip losses relative to a smooth wall for a given clearance. Fan efficiency is improved by an estimated 0.2 percent by tip trenching.

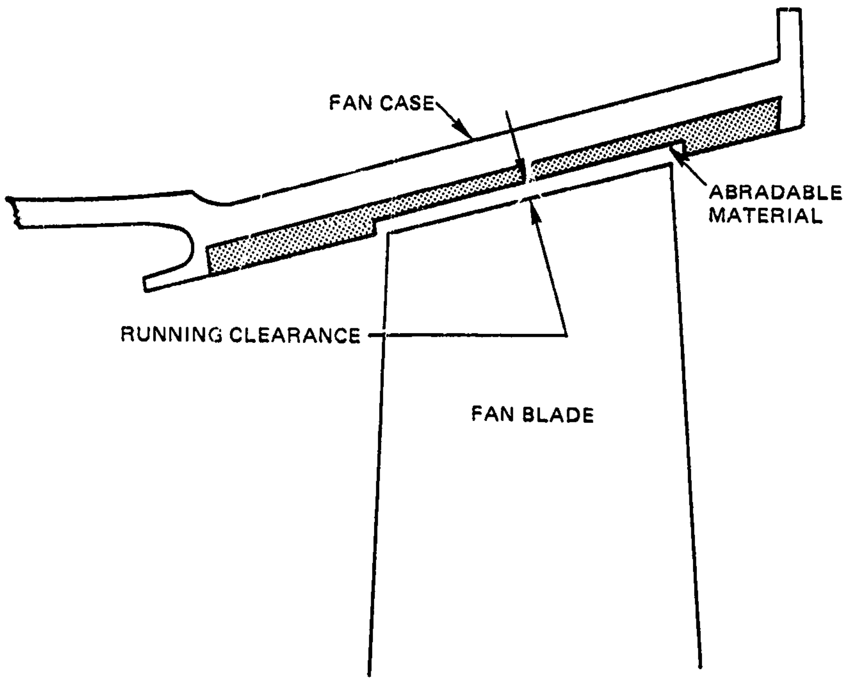

Figure 4.1.1-2 Fan Blade Tip Trench Design for leakage Control

4.1.2 Fan Blades

The fan blades, both the shrouded and shroudless, are a combination of multiple circular arc and design contoured airfoils. The shroudless blade has design contoured airfoil sections in the outer 30 percent of the span, whereas the thinner, shrouded blade has these sections in the outer 50 percent of the span. The remainder of both airfoils is multiple circular arc.

In a multiple circular arc cascade, a desired incidence is satisfied only at one point, designated the a' point. This point is approximately half of the distance between the leading edge and the point of origin of the first "captured" Mach line (the first Mach line that does not extend upstream) on the suction surface. In a design contoured cascade, shown in Figure 4.1.2-1, the entire suction surface from the leading edge to the first captured Mach line (arc no. 1 in Figure 4.1.2-1) is aligned with the flow at the specified incidence, resulting in a smoother expansion around the leading edge and an improved flowfield. Design-contoured airfoil sections are particularly useful where the Mach number is high enough and the airfoil thickness small enough so that the multiple circular arc cascade would have a larger incidence at the leading edge than at the a' point. Multiple circular arc airfoils are used for lower Mach numbers, generally in the 1.0 to 1.2 range.

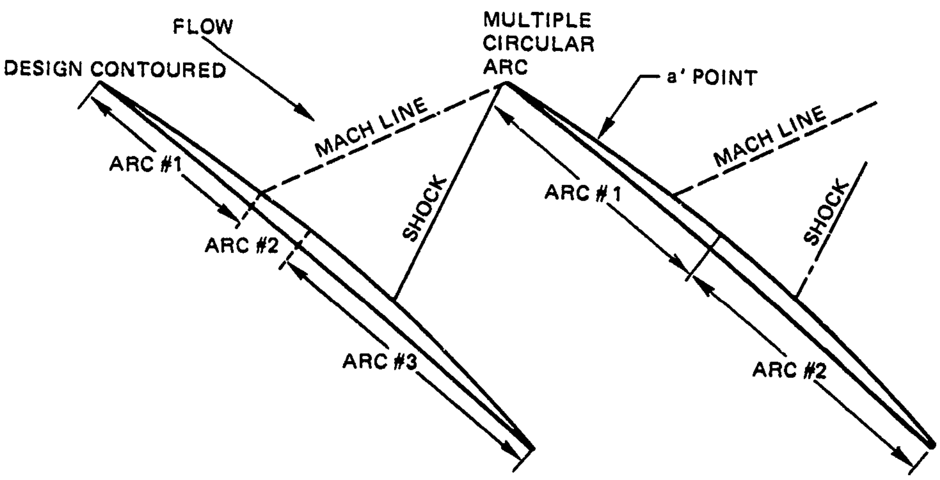

Figure 4.1.2-1 Comparison of Multiple Circular Arc and Design Contoured Airfoil Cascade

The resulting geometries of both shrouded and shroudless blades are shown in Figures 4.1.2-2 through 4.1.2-9. The most noticeable features of the shroudless blade, the long chord and thick airfoil sections, are shown in Figures 4.1.2-5 and 4.1.2-8. The location of maximum thickness is also moved forward to provide greater resistance to damage from bird ingestion. All of these features result from the hollow, shroudless nature of the blade.

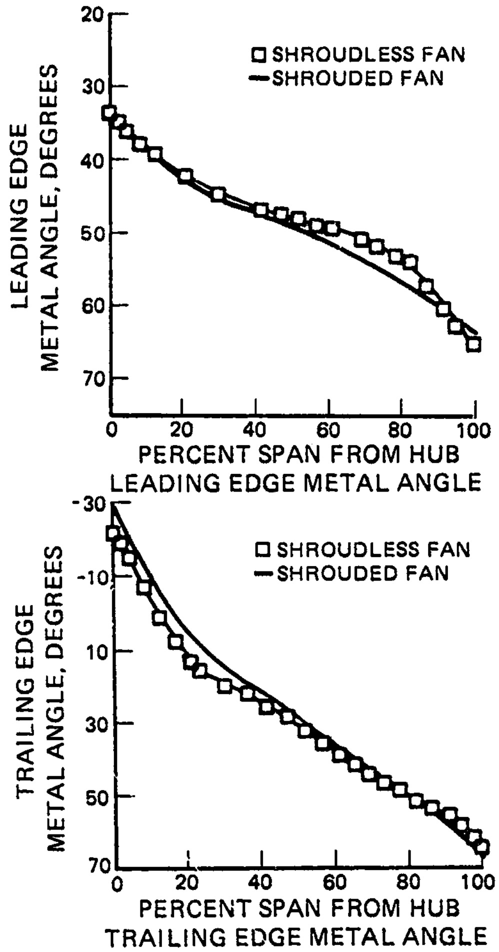

Figure 4.1.2-2 Comparison of Shroudless and Shrouded Fan Angles.

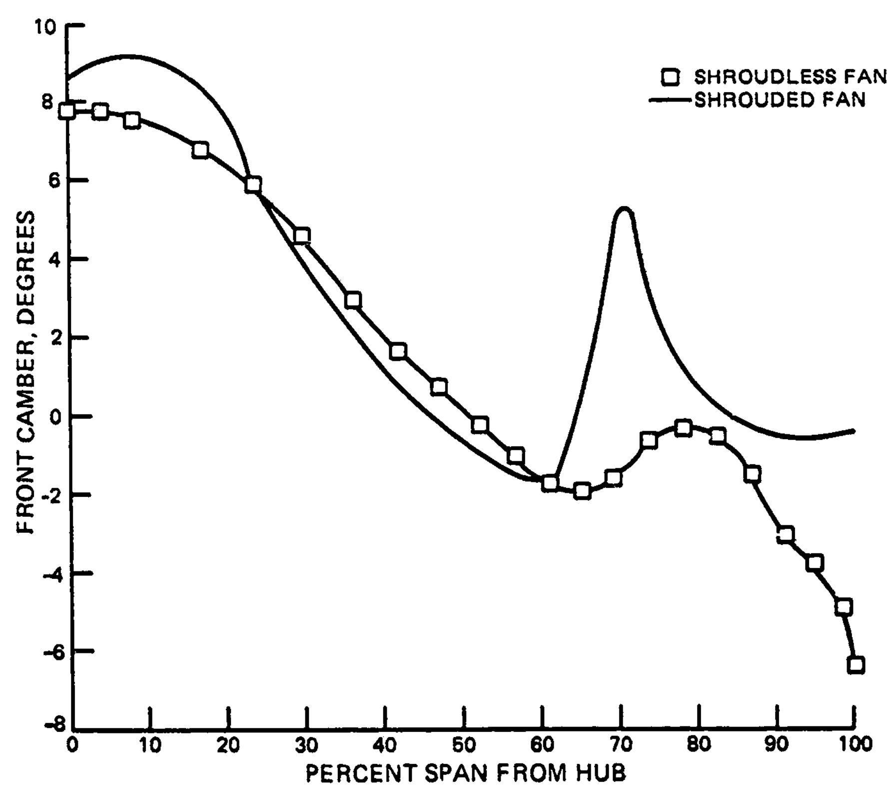

Figure 4.1.2-3 Comparison of Shroudless and Shrouded Fan Front Camber

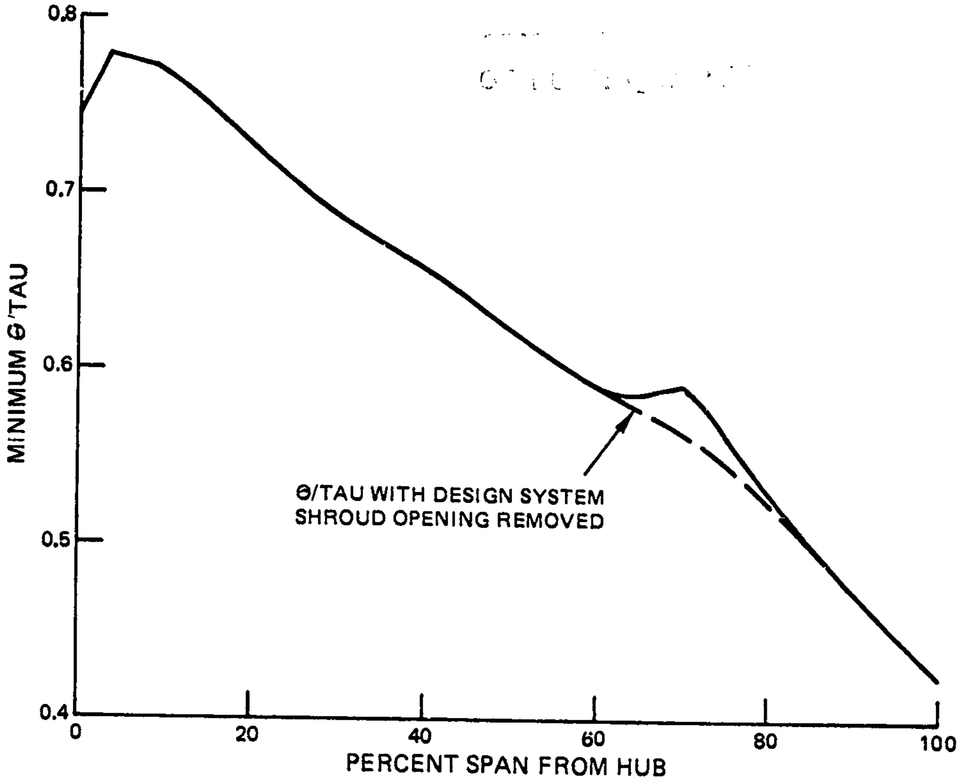

Figure 4.1.2-4 Minimum Channel Width Between Airfoils/Gap Between Airfoils Ratio (Θ/tau) For Shrouded Fan Showing Local Increase to Accomodate Shroud Blockage

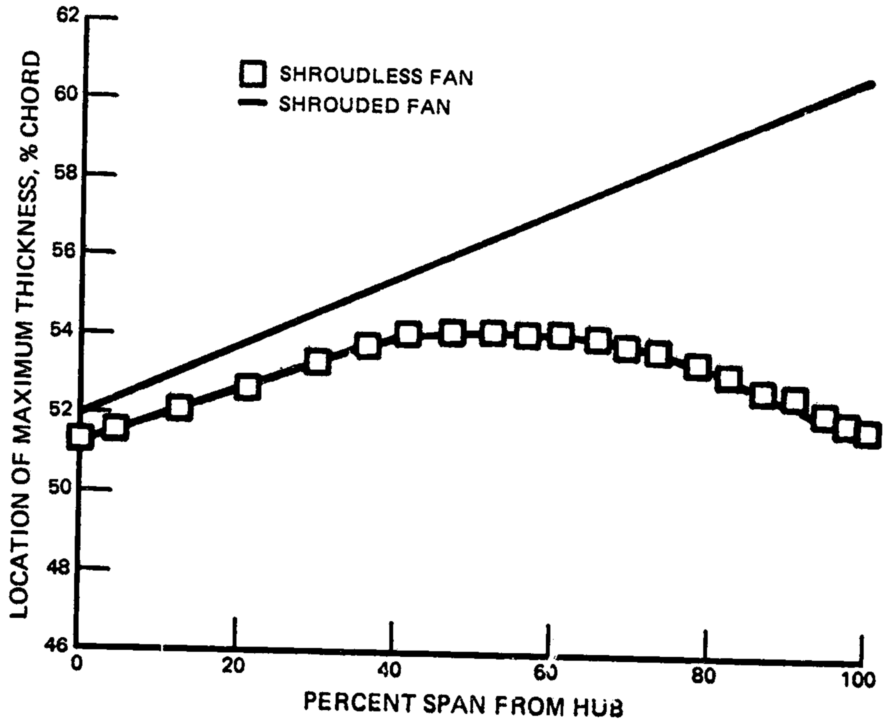

Figure 4.1.2-5 Comparison of Shroudless and Shrouded Fan Location of Maximum Thickness

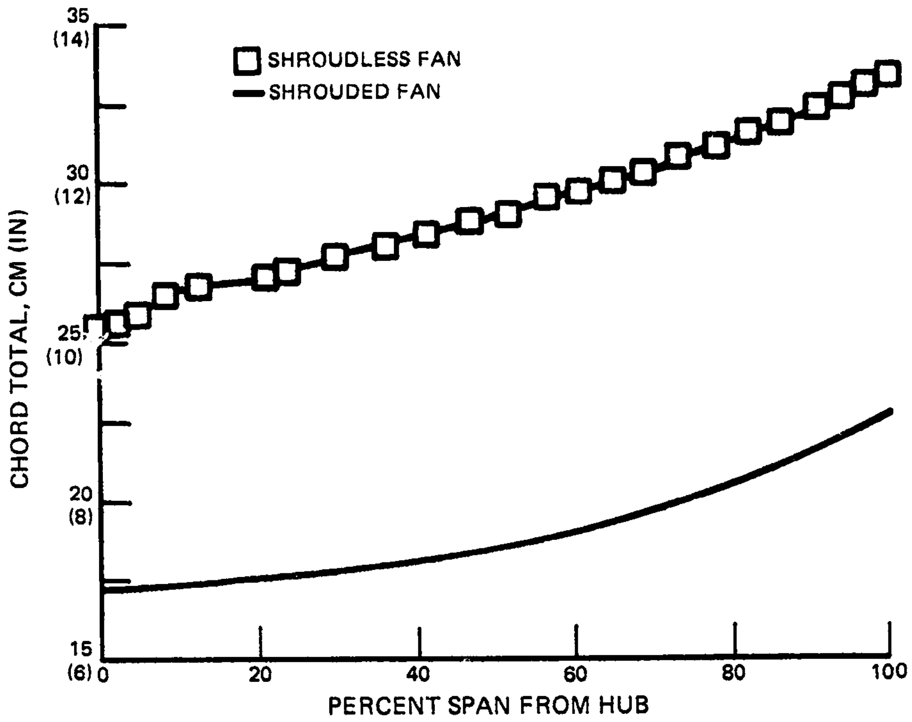

Figure 4.1.2-6 Comparison of Shroudless and Shrouded Fan Chord Total

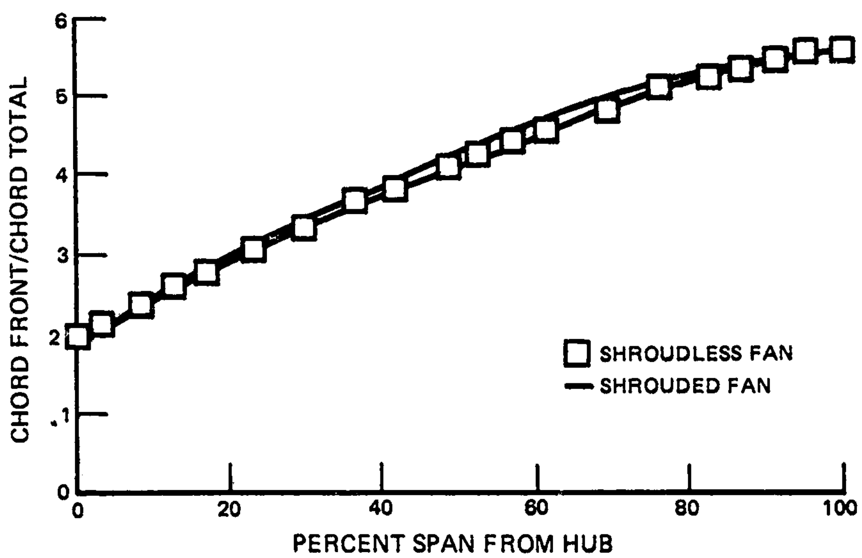

Figure 4.1.2-7 Comparison of Shroudless and Shrouded Fan Chord Front/Chord Total

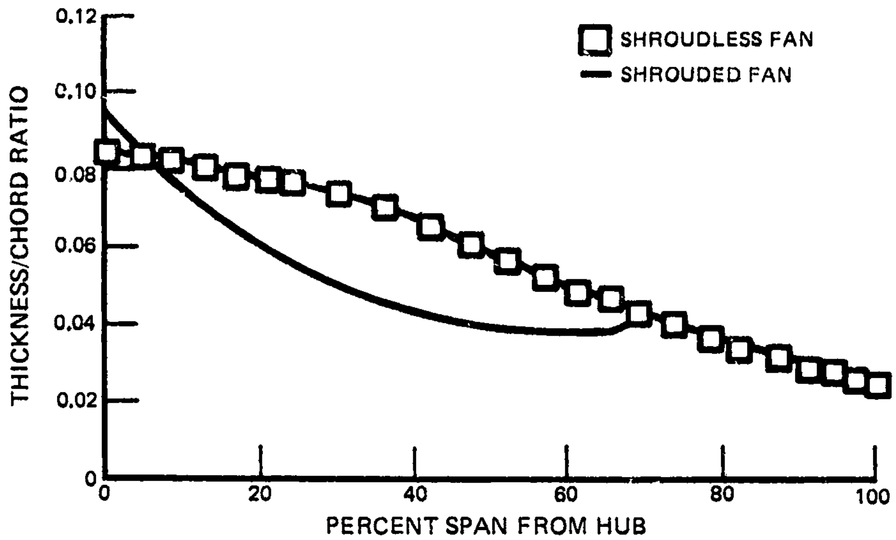

Figure 4.1.2-8 Comparison of Shroudless and Shrouded Fan Thickness/Chord Ratio

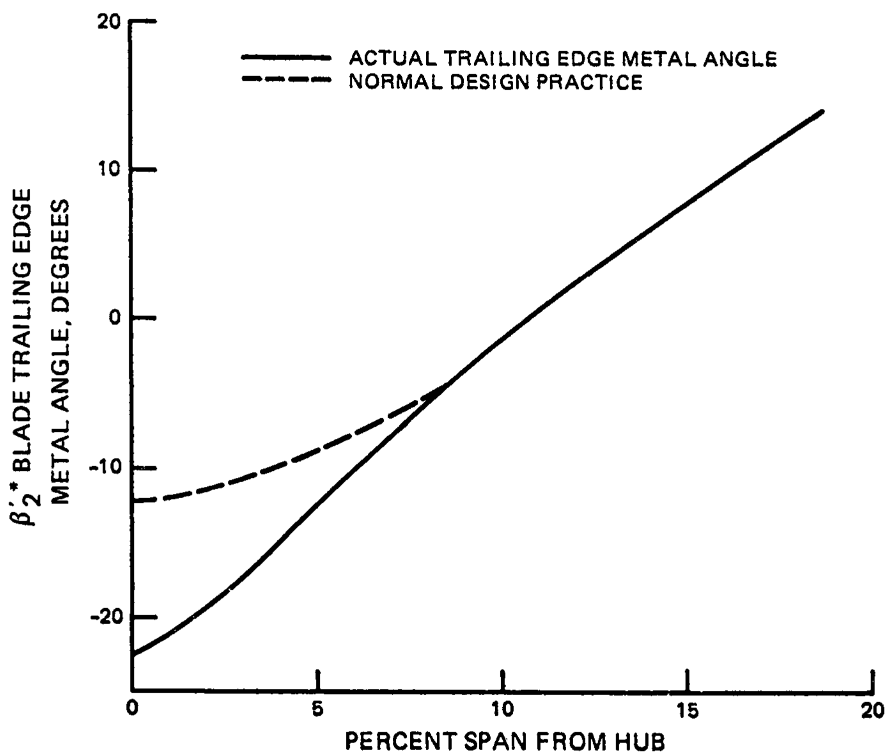

Figure 4.1.2-9 Shroudless Blade Root Overcamber

4.1.2.1 Part Span Shroud

The objective of the aerodynamic design of the part span shroud was to align the shroud with the adjacent streamlines. This is necessary to minimize meridional velocity overspeed and subsequent diffusion along the shroud as well as eliminate any radial lift force in either direction. Shroud parameters are listed in Table 4.1.2-I

TABLE 4.1.2-I
SHROUD PARAMETERS

	Shrouded Fan	Other Recent Designs
Shroud Thickness/Span (%)	1.3	1.1 - 1.3
Shroud Spanwise Location (%)	71.5	68 - 73.5
Shroud Chordwise Location (%)	Aft	Mid - Aft

The shroud was positioned in a rearward location on the blade rather than at the center. This minimizes the incident flow velocity on the shroud and positions the shroud in the region of maximum blade-to-blade distance normal to the flow, reducing losses.

No arbitrary shroud opening was used. The quasi three-dimensional design flow redistribution method automatically created the shroud opening by having the shroud physically present as an integral part of the axisymmetric intrablade calculation, and by a decrease in streamtube height ratio in the blade to blade calculation. The resulting local increase in channel width is reflected by a local increase in front camber (Figure 4.1.2-3). The shroud opening is very similar to that normally used. Figure 4.1.2-4 shows the minimum channel width/gap versus span.

4.1.2.2 Velocity Triangles

A comparison of the shrouded and shroudless blade inlet conditions is presented in Figures 4.1.2-10 through 4.1.2-12. Figure 4.1.2-10 shows the inlet Mach numbers and Figure 4.1.2-11 shows the inlet air angles. Exit air angles are shown in Figure 4.1.2-12. The effect of the shroudless blade tip pressure ratio profile fall off is an adjustment in Mach number and leading edge angle. The lower wheel speed of the shrouded fan causes the decrease in trailing edge angle in the lower half of the span.

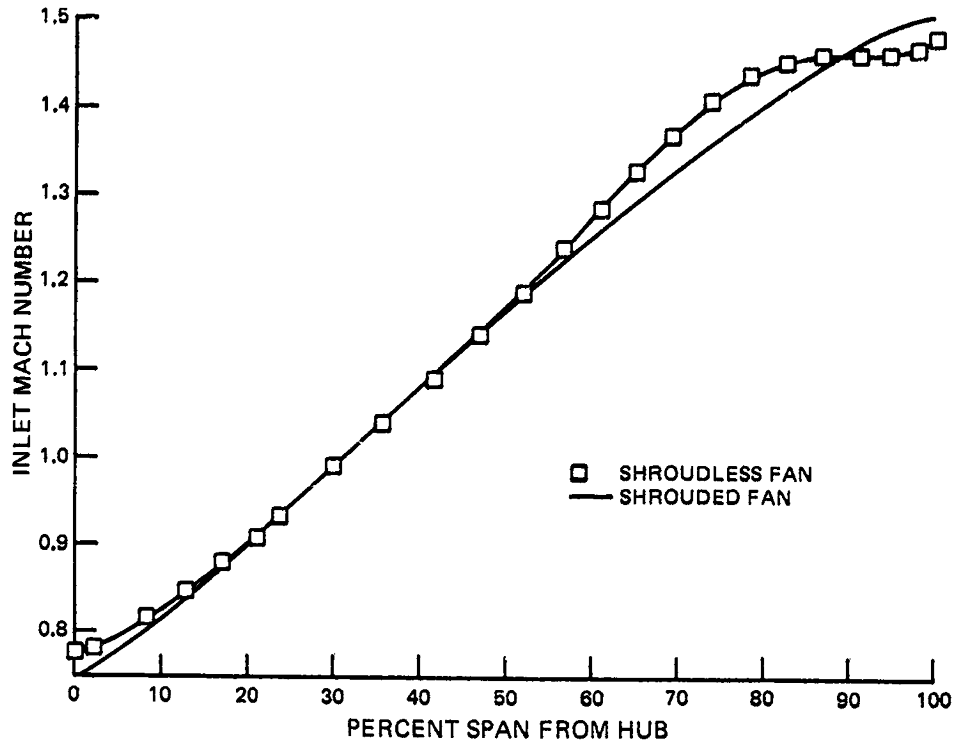

Figure 4.1.2-10 Comparison of Shroudless and Shrouded Fan Inlet Mach Numbers

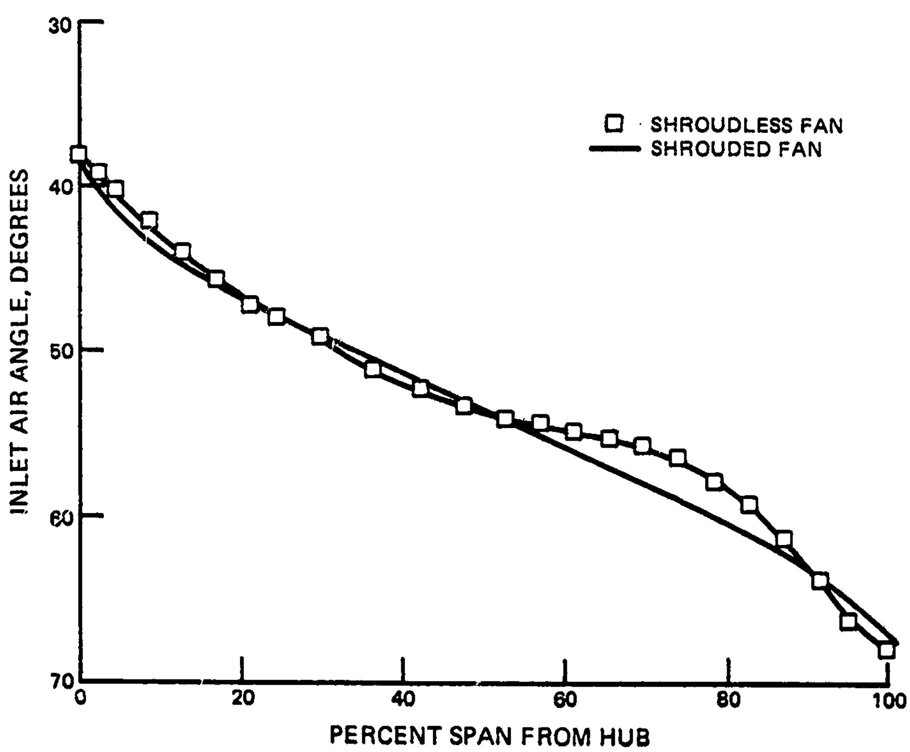

Figure 4.1.2-11 Comparison of Shroudless and Shrouded Fan Inlet Air Angles

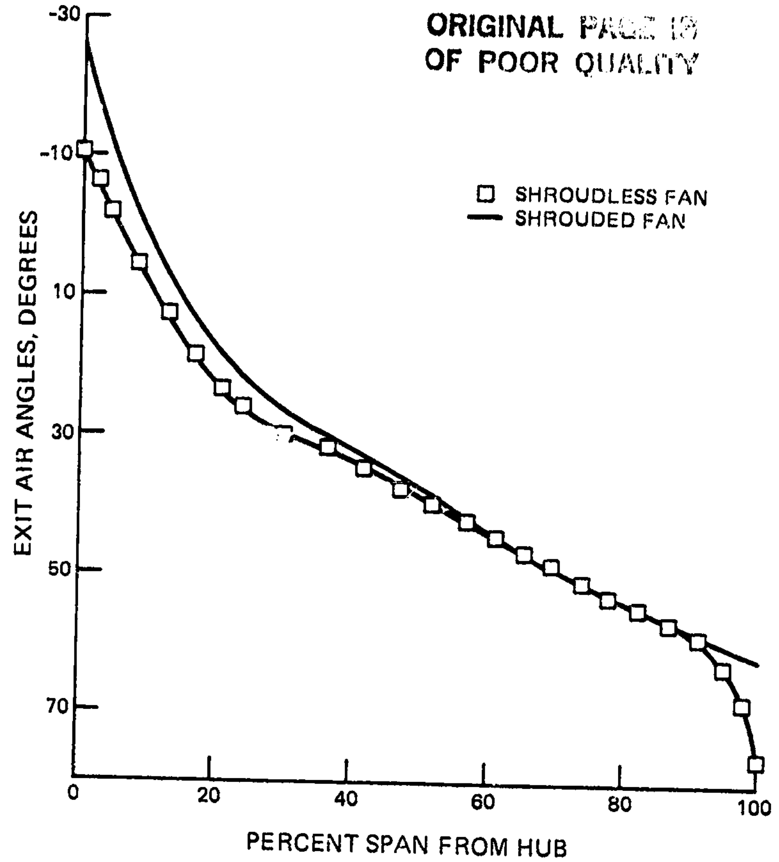

Figure 4.1.2-12 Comparison of Shroudless and Shrouded Fan Exit Air Angles

4.1.2.3 Fan Blade Loading

Figure 4.1.2-13 shows design aerodynamic loadings for both blade configurations. The shroudless design has moderate loading levels everywhere except at the tip, where its low aspect ratio should provide adequate surge margin capability, despite the high aerodynamic loading. The shrouded blade has aerodynamic loads more representative of conventional single-stage, highly loaded fans, except at the root where the loading is high. The high root loading is a result of using the flowpath for the shroudless blade (Figure 4.1.2-14), which has no trailing edge curvature. This curvature would normally pull flow toward the root to maintain radial equilibrium, reducing the local loading. Off-design loadings were also calculated at sea level takeoff (Figure 4.1.2-15) and near surge (Figure 3.4-3). Off-design loading increases were less for the root of the shrouded blade compared to the shroudless blade, so that near the surge point the loading profiles were quite similar.

4.1.2.4 Pressure Ratio and Recovery

Figure 4.1.2-16 shows pressure ratio and recovery profiles for both fans. The shroudless fan pressure profile falls off significantly in the tip region, to satisfy a structural vibration requirement for more blade twist locally at the tip. Reducing the pressure ratio reduces flow at the tip, causing the blades to twist so that the blade stagger decreases. This also redistributes flow to lower loss region of the inner span of the fan blade.

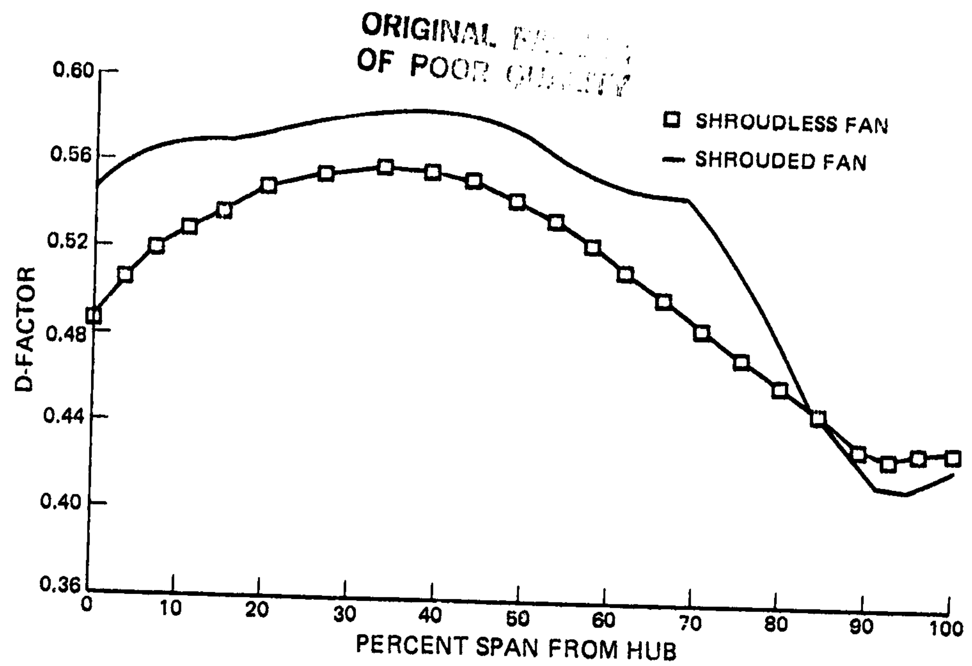

Figure 4.1.2-13 Comparison of Shroudless and Shrouded Fan Design Loadings

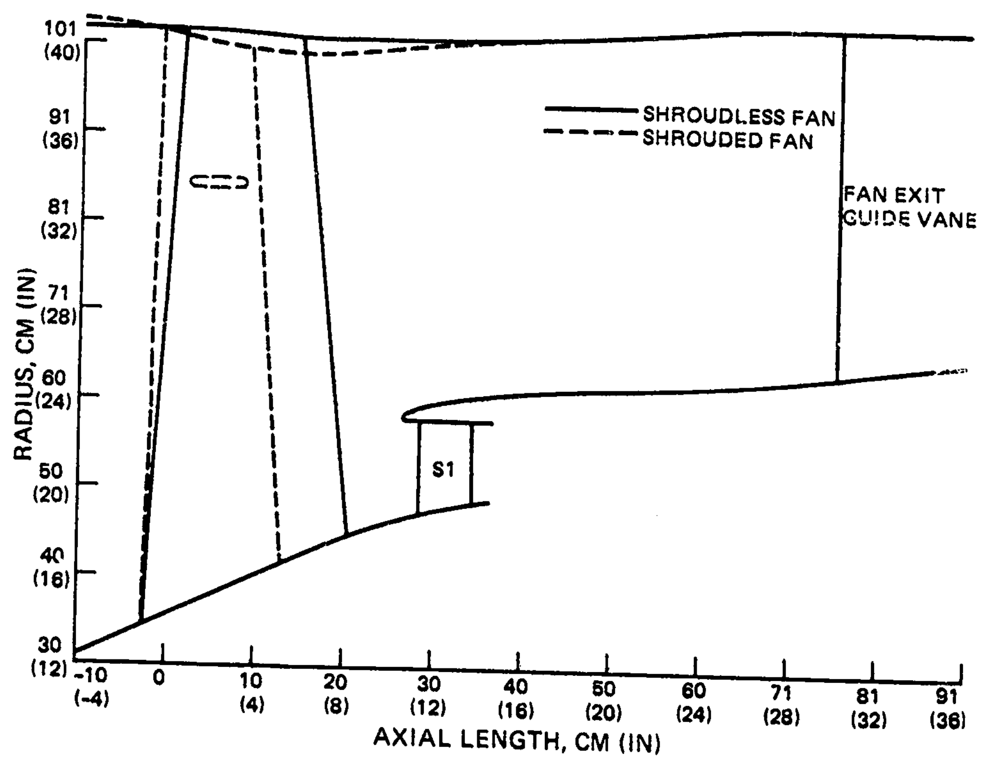

Figure 4.1.2-14 Comparison of Shroudless and Shrouded Fan Flowpaths

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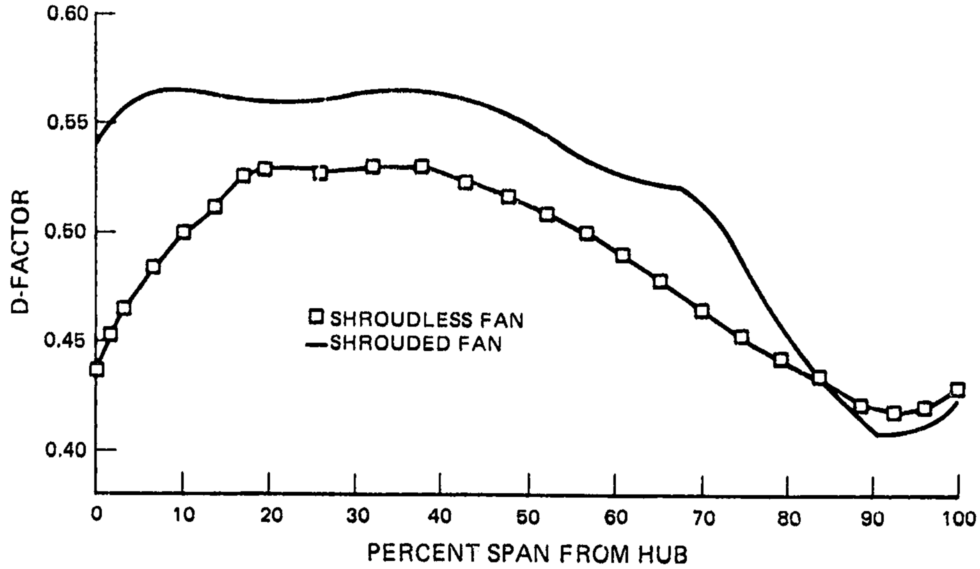

Figure 4.1.2-15 Sea Level and Takeoff Loadings

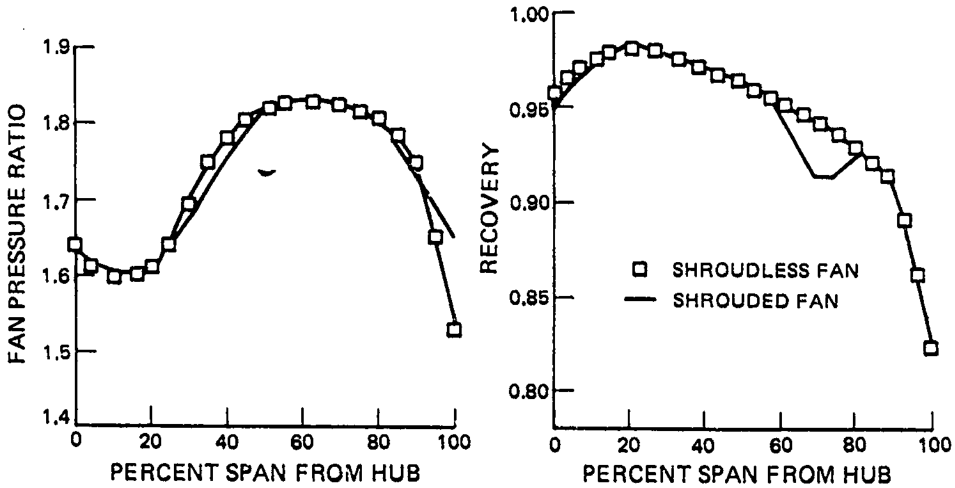

Figure 4.1.2-16 Comparison of Shroudless and Shrouded Fan Pressure Ratio and Recovery Profiles

The shrouded fan design tip pressure ratio was increased to increase the velocity head downstream of the fan, where the tip wall diffuses relative to the shroudless fan flowpath, to reduce the wall loading. The pressure profile of both fans is increased locally at the extreme root to provide a flat radial velocity profile at the exit of the first stator.

Figure 4.1.2-16 also shows the additional pressure loss as a result of the part span shroud. This additional loss causes an approximate 2-degree more stalled incidence at about 60 percent span on the duct exit guide vane, as indicated in Figure 4.1.2-17, which should be well within the low loss range of the vane.

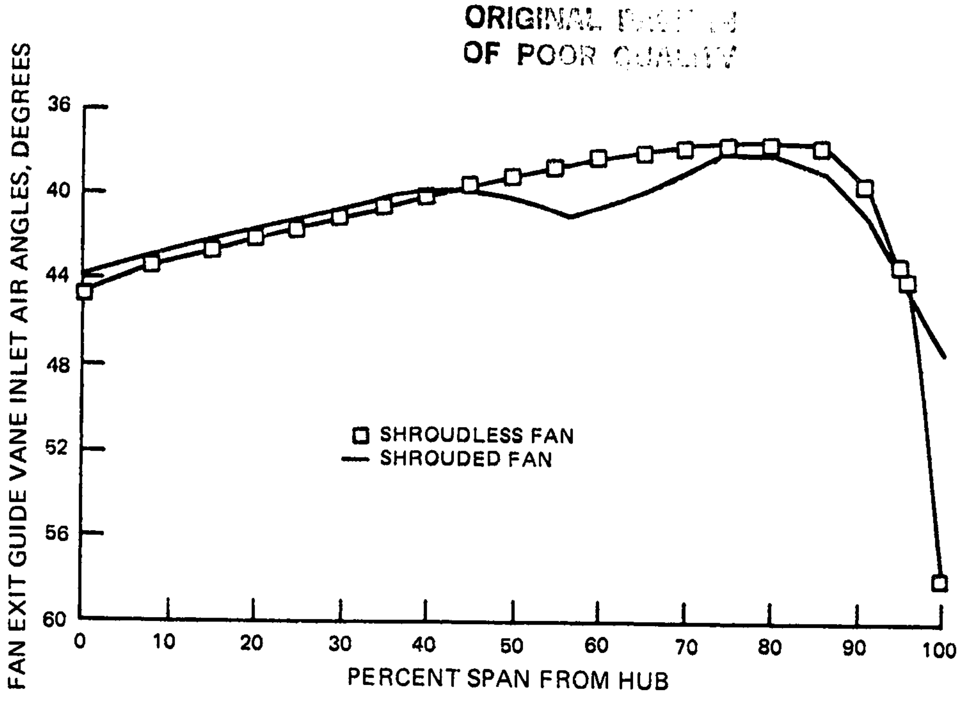

Figure 4.1.2-17 Comparison of Shroudless and Shrouded Fan Exit Guide Vane Inlet Air Angles

4.1.2.5 Incidence, Choke Margin, and Deviation

The shroudless blade was designed with incidence, choke margin, and deviation similar to the design of the quasi three-dimensional NASA 1800 feet/second tip speed fan (Reference 1). As indicated in reference 3, this fan has demonstrated good performance.

The a' incidence is 1 degree and choke margin is 3 percent (Figures 4.1.2-18 through 4.1.2-20). The deviation was established in a manner similar to the NASA 1800 feet/second tip speed fan. In the root region, there was a structural requirement for more blade twist, which was obtained by increasing the assumed deviation (Figure 4.1.2-21). In the tip region, the deviation was allowed to rise to prevent a sharp upward hook in trailing edge metal angle.

The shrouded fan was designed with incidence, choke margin, and delta deviation set like those of recent shrouded fans. Incidence and choke margin for the shrouded fan are shown in Figures 4.1.2-17 through 4.1.2-20. In the root region, the shrouded fan is almost a circular arc, and suction surface incidence was set accordingly. The deviation was again set like the NASA 1800 feet/second tip speed fan, except in the tip region where it was allowed to fall off a bit to keep a smooth blade (Figure 4.1.2-21).

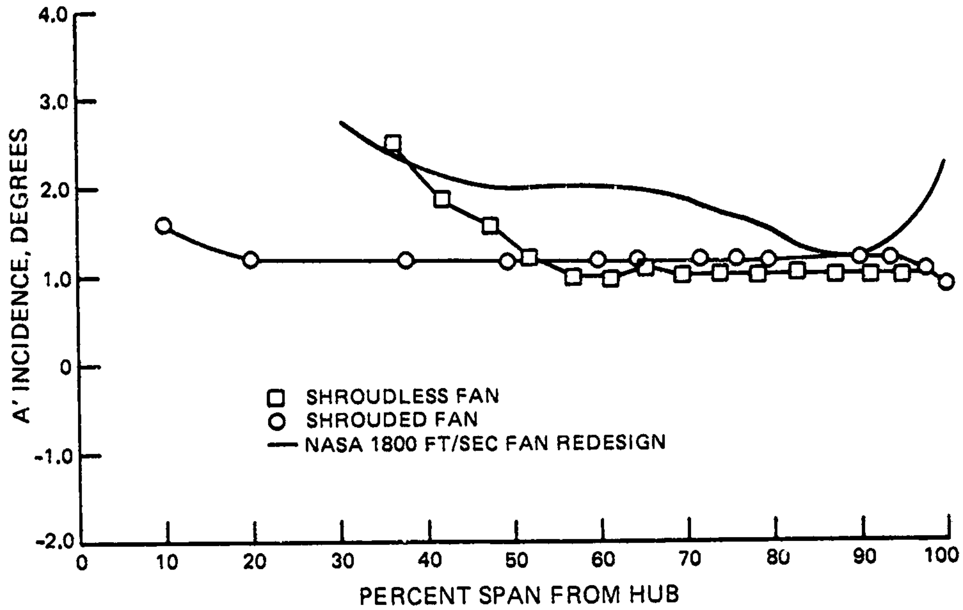

Figure 4.1.2-18 Comparison of Shroudless and Shrouded Fan a' Incidence Versus Span

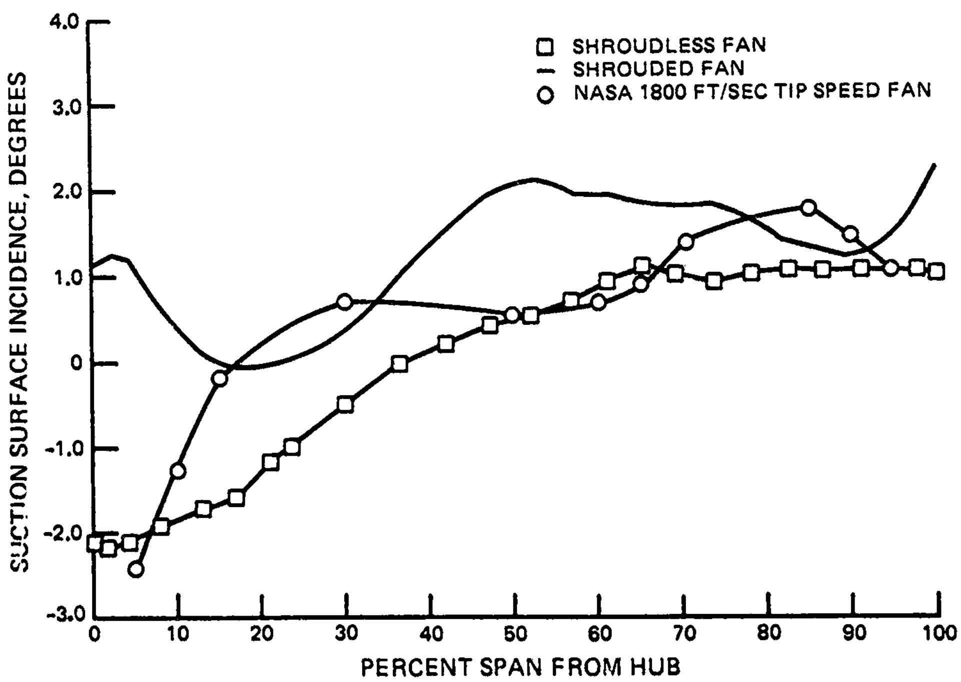

Figure 4.1.2-19 Comparison of Shroudless and Shrouded Fan Suction Surface Incidence Versus Span

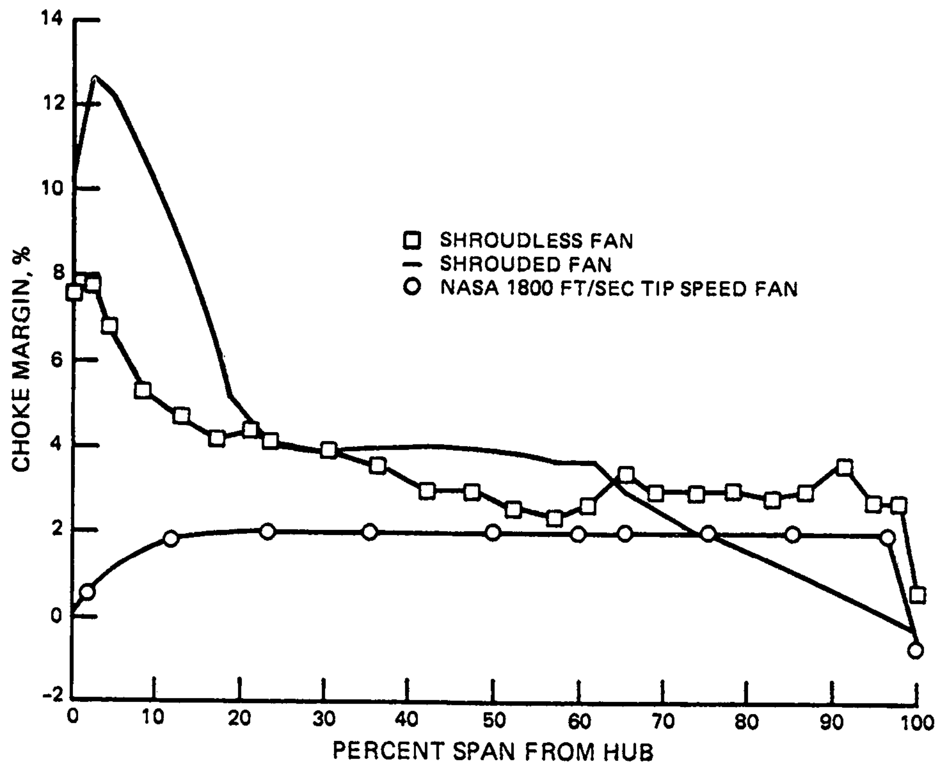

Figure 4.1.2-20 Comparison of Shroudless and Shrouded Fan Choke Margin Versus Span

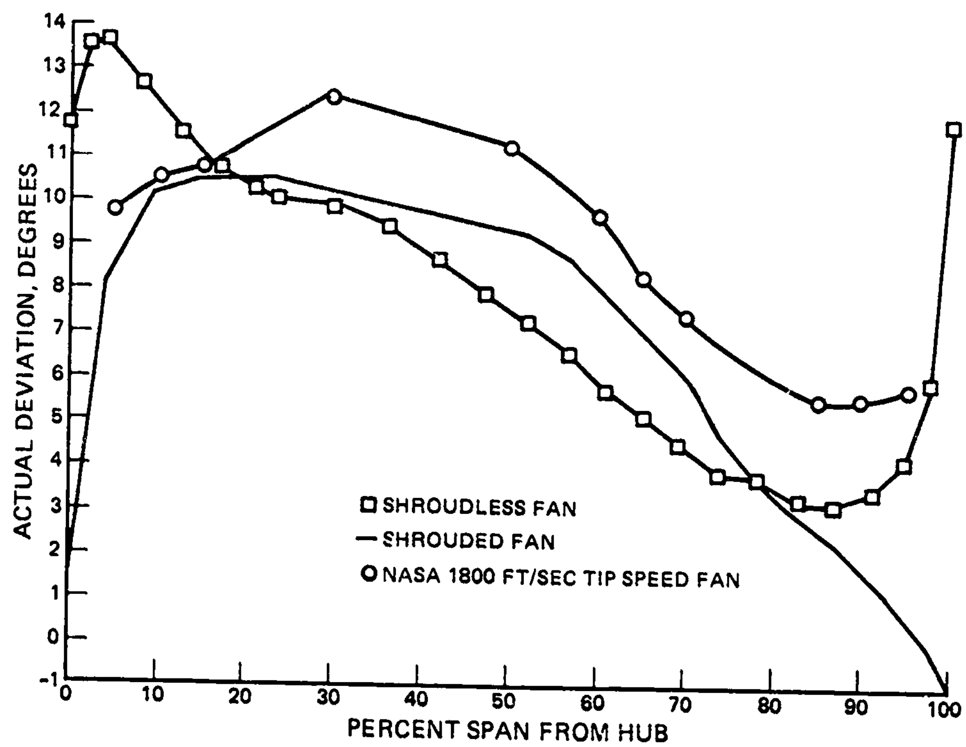

Figure 4.1.2-21 Comparison of Shroudless and Shrouded Fan Deviation

The shroudless fan blade design incorporates features not ordinarily found in conventional high performance fan designs. These include a relatively thick blade (Figure 4.1.2-8) and a local overcamber at the hub trailing edge (Figure 4.1.2-9). These features are incorporated primarily to increase torsional frequency margin, but may decrease performance. A blade-to-blade analysis indicated that the increased thickness decreases efficiency up to 0.2 percent. A comparison of test data from several other thick blades indicates that there is no uncompensated increase in deviation resulting from the increased thickness. The blade hub overcamber may increase the Mach number and loading at the first stator hub, but analyses have shown these parameters will remain within acceptable limits.

The rotor aerodynamic design was performed using a quasi three-dimensional analysis. The analysis consists of an axisymmetric intrablade flowfield calculation, which models the shroud as an isolated splitter, and is coupled with blade-to-blade calculations along conical surfaces (Figure 4.1.2-22). The procedure is iterative with output from one calculation providing input for the other until convergence of a number of physical parameters is achieved.

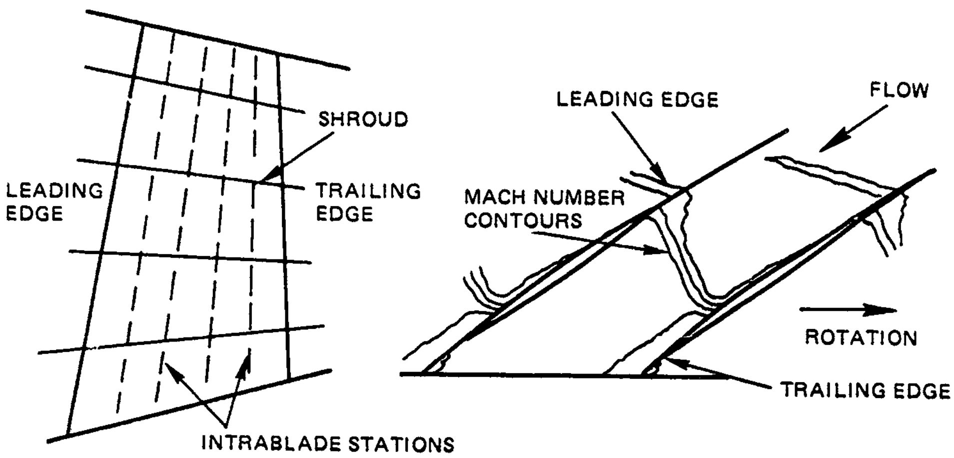

Figure 4.1.2-22 Quasi Three-Dimensional Analysis

The advantages of the quasi three-dimensional design approach include improved shroud modeling, improved modeling of radial flow distribution, and definition of chordwise and radial distributions of work, loss, and blockage. The definition of the intrablade flow field and the resolution of total loss into calculated increments makes this design system a useful tool in producing an efficient fan blade.

A comparison of the fan exit guide vane inlet air angles is shown in Figure 4.1.2-17 and for the first stator in Figure 4.1.2-23. The outer flowpath wall was modified for the shrouded fan by adding convergence across the blade tip, otherwise the flowpath is unchanged (Figure 4.1.2-14).

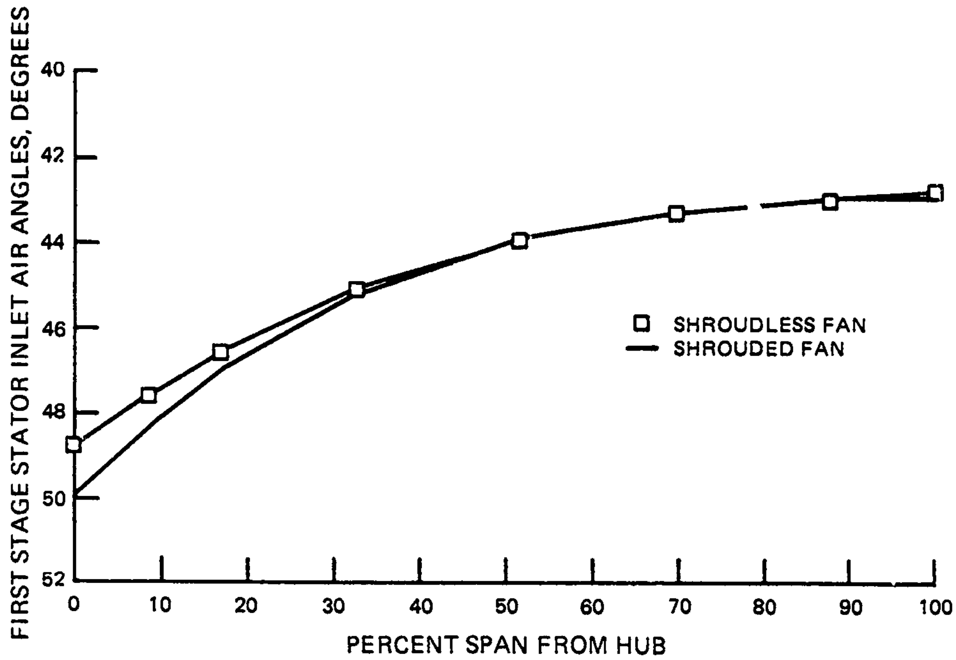

Figure 4.1.2-23 Comparison of Shroudless and Shrouded Fan First Stage Stator Inlet Air Angles

4.1.3 Fan Exit Guide Vane Aerodynamic Design

Because of the strong interaction between the compressor intermediate case and the high-pressure compressor, the design of the intermediate case and integral fan duct exit guide vanes was included in the high-pressure compressor analysis and design effort. However, a review of the aerodynamic design of the fan duct exit guide vane is presented in the following sections because of its inherent applicability to the fan design.

4.1.3.1 Intermediate Case Fan Duct Section Aerodynamics

Flow straightening downstream of the fan discharge was accomplished by designing an intermediate case fan duct section consisting of a vane array that includes ten structural struts and nonstructural exit guide vanes positioned between the struts. The top dead center strut serves as the leading edge fairing for the engine support pylon. The aft section of the bottom strut is faired into a 18.84 cm (4.25 in) thick lower bifurcation of the fan duct.

The aerodynamic design goals for this section included:

- o Complete swirl removal
- o Minimize upstream influence of pylon blockage
- o Separation free airfoils with 15 percent surge margin at design point
- o Sufficient choke margin to pass the part power flow requirement.

The following initial conditions were established prior to proceeding with the analysis that lead to the fan duct section aerodynamic design:

- o Exit Guide Vane Leading Edge Pressure and Temperature Profiles -- These profiles were output from the detailed analysis and design of the shroudless fan blade and are shown in Figure 4.1.3-1.

- o Aerodynamic Flow Blockage -- Inlet flow blockage was established at 2.5 percent of actual flow area.

- o Air Turning Requirements -- Any residual swirl into the fan discharge ducts was totally eliminated by turning fan discharge air back to axial.

- o Chord Length Constraint -- A constant axial chord length over the span of the exit guide vanes was maintained to simplify the integration with the structural struts.

Once these conditions were established, analysis proceeded as described in the following sections.

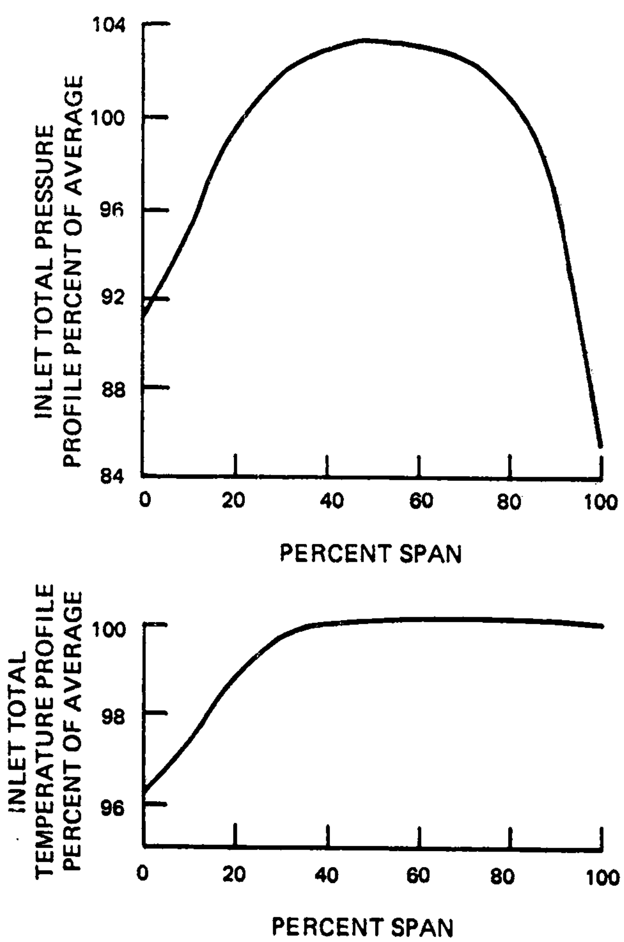

Figure 4.1.3-1 Fan Exit Guide Vane Inlet Pressure and Temperature Profiles

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4.1.3.2 Fan Duct Flowpath

The flowpath was designed to decelerate the air from Mach number 0.67 to 0.49 at the discharge within a constant diameter outer wall annular passage as shown in Figure 4.1.3-2. Sufficient convergence has been provided in the configuration to limit the average diffusion factor to an acceptable level at the aerodynamic design point and to provide smooth transition between the fan outer diameter and splitter nose.

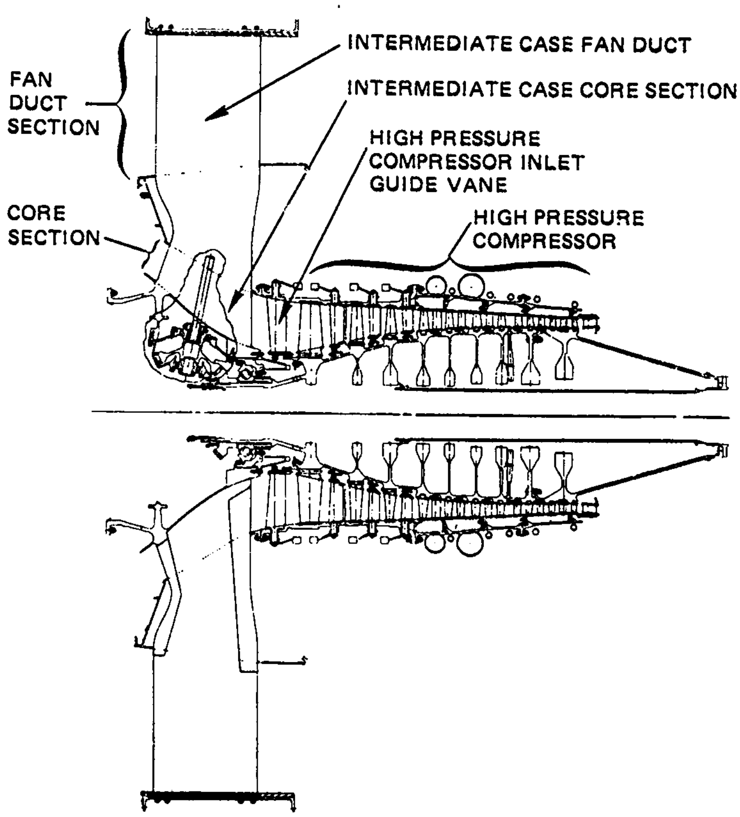

Figure 4.1.3-2 Compressor Intermediate Case and High Pressure Compressor Subsystems and Aerodynamic Design Analysis

4.1.3.3 Exit Guide Vane Airfoil Series Selection

Controlled diffusion airfoils were selected for the exit guide vanes because of their extended incidence range and loading capability relative to conventional series airfoils. Profiles of two adjacent nominal exit guide vanes are shown in Figure 4.1.3-3. Both structural and nonstructural vanes have the same surface contours.

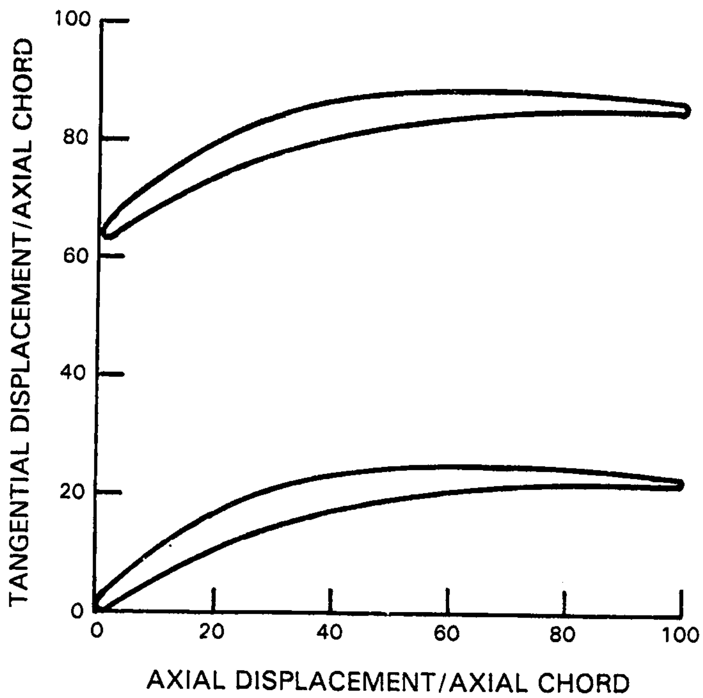

Figure 4.1.3-3 Nominal Intermediate Case Exit Guide Vane Profile

Inlet incidence and chordwise camber distribution were set to provide separation free operation to 15 percent surge margin from the aerodynamic design point. This was accomplished by an analytical procedure that combines a compressible potential flow solution and a boundary layer analysis. A choke margin calculation indicated that operation could be choke-free down to at least 50 percent of maximum cruise power. This is well below nominal aircraft cruise power requirements. Deviation was established from results of controlled diffusion airfoil cascade testing outside the scope of this contract. The spanwise aerodynamic design parameters for the final nominal exit guide vanes are summarized in Figure 4.1.3-4.

4.1.3.4 Pylon Matched Exit Guide Vane Array

The purpose of pylon matching is to arrive at a structural strut and exit guide vane array that will minimize blockage effects and subsequent backpressure distortion on the fan rotor. This task was complicated by the need for the topmost structural strut to provide the leading edge fairing for the engine mount pylon. As such, it is considerably thicker than the other exit guide vanes. The bottom strut fairs into the thicker core access lower bifurcation of the integrated nacelle. The result is a nonuniform blockage around the fan exit flow annulus, and it was necessary therefore, to tailor the array so as to minimize the distortion effects caused by this nonuniformity.

A two-dimensional incompressible potential flow analysis was used to determine the effects of pylon matching on upstream distortion. Groundrules used in the design process included: (1) optimization of upstream pressure distortion, (2) maintenance of a maximum of 10 degree change in exit angle between adjacent vanes, and (3) minimization of construction costs by limiting the number of structural strut part numbers.

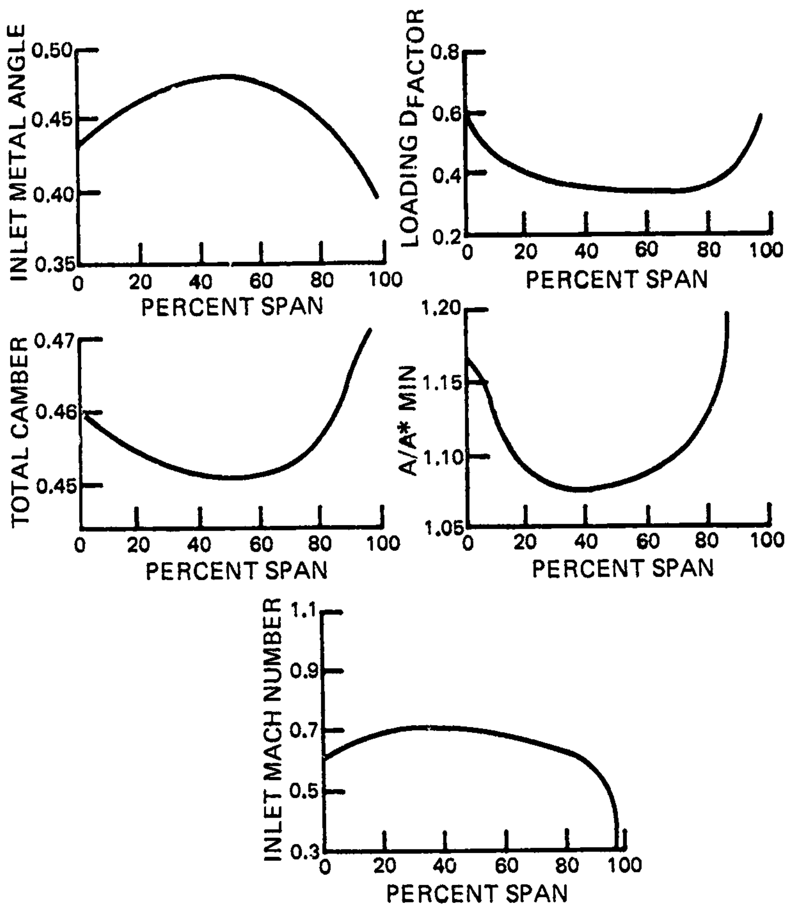

Figure 4.1.3-4 Nominal Fan Exit Guide Vane Aerodynamic Design Parameters

Figure 4.1.3-5 presents a comparison of the calculated back-pressure profile for both a nominal vane cascade and pylon matched vanes. Calculated rotor trailing edge distortion at the 15 percent span exit guide vane diameter, in terms of ΔC_p (maximum-minimum), was reduced from 0.164 to 0.048 by pylon matching. The optimization included the removal of the vane adjacent to the suction side of the pylon to realize a reduction in upstream distortion, and avoid the extreme vane uncamber needed to achieve a reasonable passage area distribution. Achieving this low level of back-pressure distortion required only two structural strut part numbers and seven nonstructural exit guide vane part numbers.

4.1.3.5 Pressure Loss Prediction

A pressure loss map was generated for use in the performance prediction of the exit guide vane row. The predicted loss characteristics, representative of the controlled diffusion airfoils, are shown in Figure 4.1.3-6 in terms of cascade inlet air angle and Mach number.

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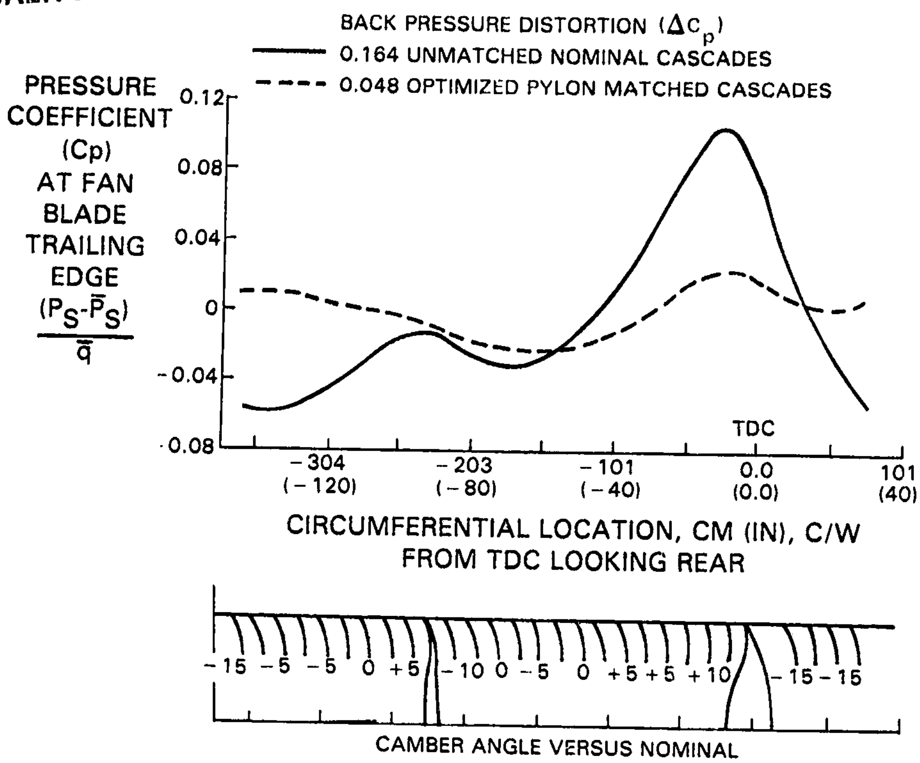

Figure 4.1.3-5 Calculated Back Pressure Distortion with Nominal and Pylon Matched Fan Exit Guide Vanes

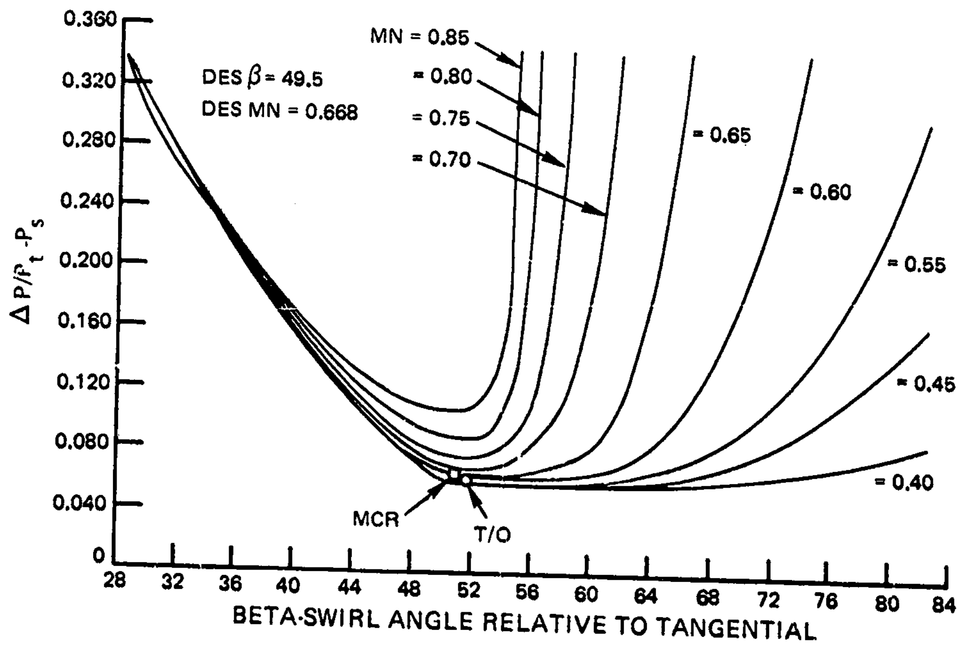

Figure 4.1.3-6 Duct Exit Guide Vane Map

4.2 MECHANICAL DESIGN

The weight of the fan was not optimized for a flight propulsion system. This allowed the use of less expensive materials and hardware. In addition, existing parts were used as much as possible in the bearing compartment to reduce costs. For example, existing bearings, seals, and fasteners from current production engines are used. For a flight system most of these parts would be designed specifically for this application and would result in a weight savings.

4.2.1 Fan Blade and Attachment

4.2.1.1 Shroudless Blade Mechanical Design

The shroudless fan blade has an aspect ratio of 2.5, integral platforms and is hollow to reduce the mass concentrated near the tip, thereby reducing centrifugal forces. The hollow section comprises three radial ribs and one cross rib. This construction provides adequate stiffness to meet bird strike, flutter, and vibration requirements.

Multiple circular arc airfoil sections were incorporated into the blade during detailed design to minimize shock losses and increase efficiency. A structural analysis of the final blade aerodynamic design resulted in small stagger angle changes relative to the preliminary blade design to provide increased torsional frequency margin on 4E resonance at redline speed. Blade resonance and flutter characteristics are such that stability has been achieved in the first three modes of operation.

Steady stresses at the airfoil root caused by centrifugal and untwist loads are considered acceptable for a glass bead-peened surface to provide adequate low cycle fatigue life. Stresses in the hollow-solid transition region are also acceptable and provide adequate low cycle fatigue life for a stress-relieved surface. Figure 4.2.1-1 shows a description of the blade. Table 4.2.1-I identifies the blade general design parameters.

The selection of three radial ribs and one cross rib as the internal structure of this hollow airfoil was the result of a detailed NASTRAN analysis of several different rib configurations. Many other radial rib and cross rib patterns were evaluated. The selected pattern was the configuration that combined structural integrity with relative ease of manufacture. However, the potential for further refinement of this configuration exists. This refinement would include a parametric analysis of all possible configurations with prime emphasis on minimum weight and ease of manufacture.

4.2.1.1.1 Vibration and Flutter Analysis

The blade resonance and flutter characteristics were established based on the final aerodynamic design. These characteristics are shown in Figures 4.2.1-2 and 4.2.1-3.

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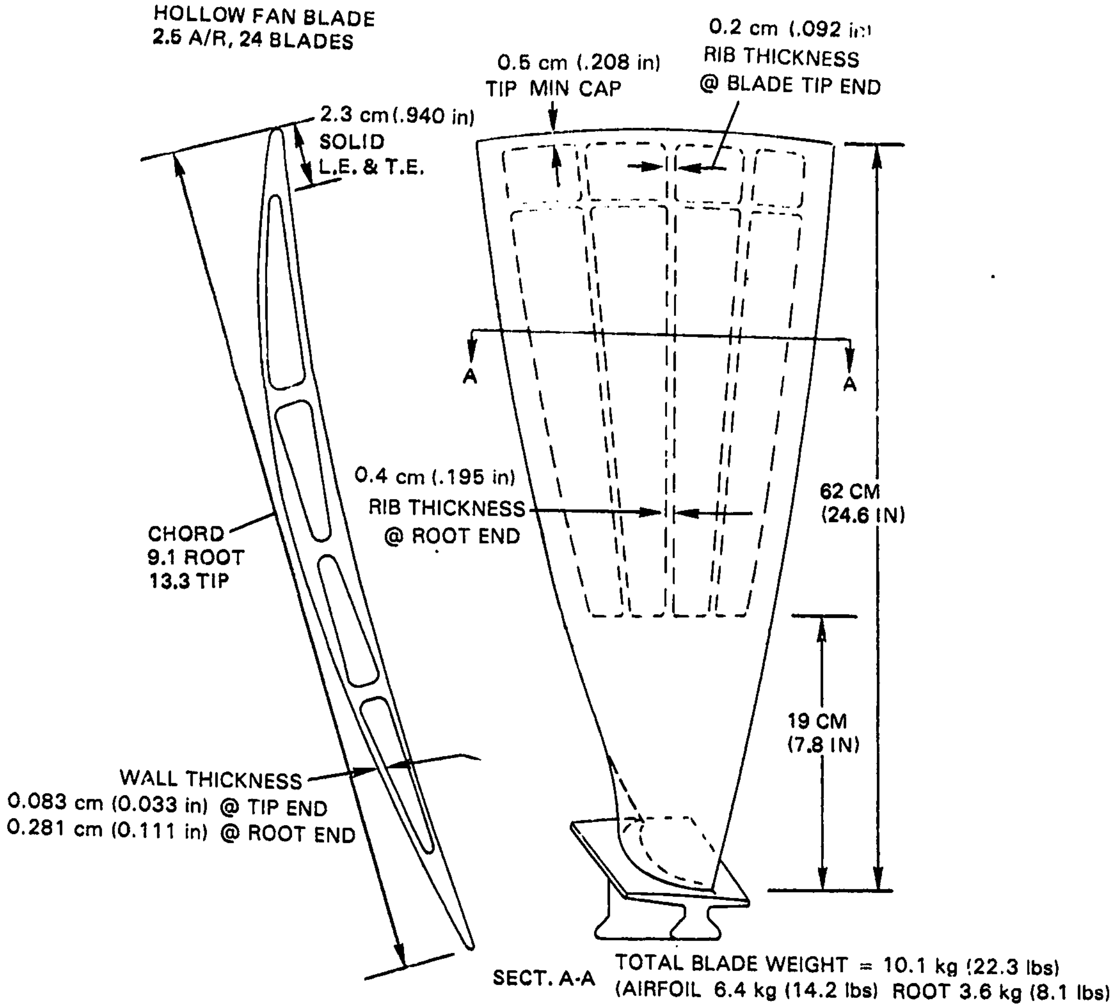

Figure 4.2.1-1 Shroudless Fan Blade Cross-Section

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TABLE 4.2.1-I
SHROUDLESS FAN BLADE GENERAL PARAMETERS

Hub/Tip	0.34 (le)	
	0.393 (Avg.)	
Aspect Ratio (Avg. Span/Root Chord)	2.50	
Span (Avg.) cm (in.)	62	(24.572)
Root Radius (Avg.) cm (in.)	40	(15.918)
Root Chord(in.)	23	(9.093)
Taper Ratio (Avg. Span/Root Chord)	1.46	
Thickness/Chord @ Root	0.0954	
Thickness/Chord @ Tip	0.0252	
αchord @ Root (deg.)	85.82	
αchord @ Tip (deg.)	21.88	
Root Angle (deg.)	24.28	
Tip Angle (deg.)	4.14	
Number of Blades	24	
Material	AMS 4928	
Airfoil Root Fillet Radius cm (in.)	0.88	(0.35)
Redline Rotor Speed (rpm)	4267	
Low Cycle Fatique Rotor Speed (rpm)	3988	
Tip Speed @ Redline Speed m/sec (ft/sec)	461	(1515)
Tip Speed @ ADP m/sec (ft/sec)	422	(1385)
Tip Speed Corrected @ ADP m/sec (ft/sec)	455	(1496)
Torsional Stall Flutter Parameter m/sec (bw_t)	577	(1895 fps)

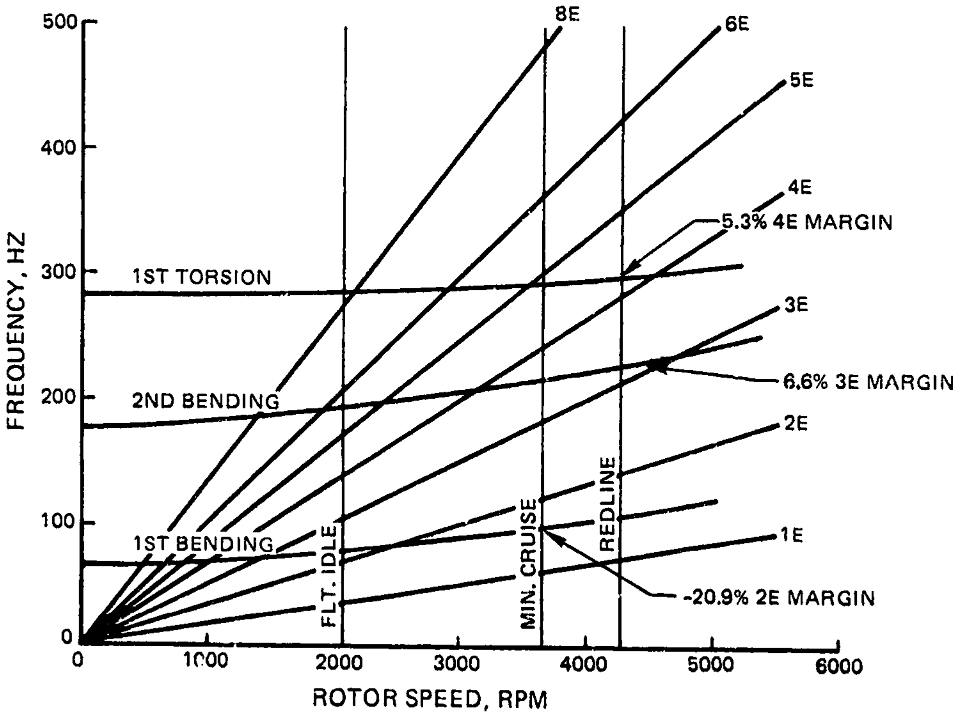

Figure 4.2.1-2 Shroudless Blade Frequency Characteristics

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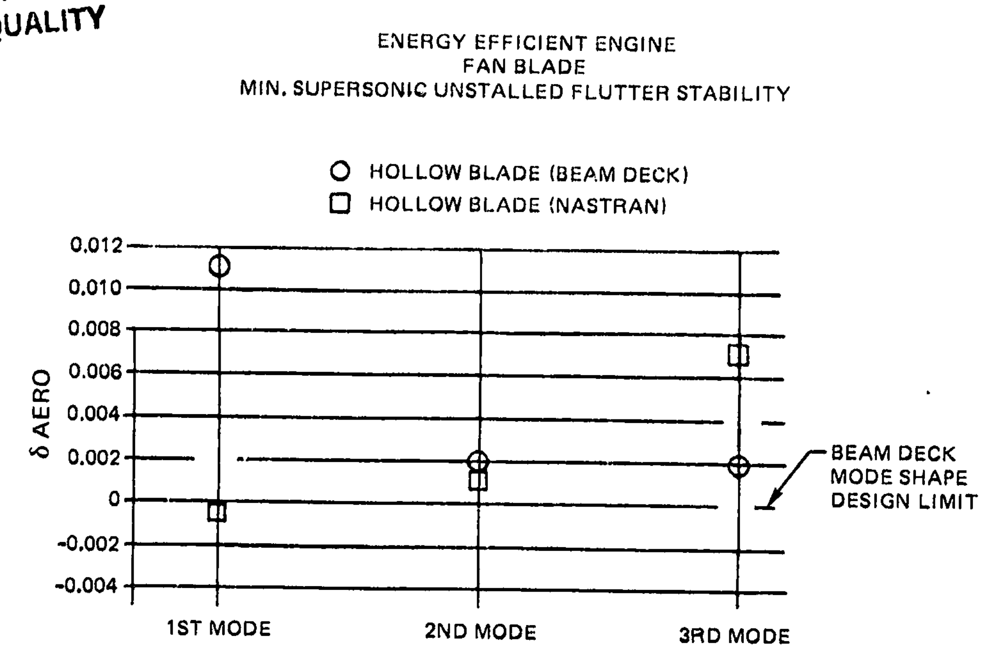

Figure 4.2.1-3 Blade Flutter Characteristics

Frequency calculations were accomplished with both NASTRAN finite element plate analysis and the more standard beam analysis. Although the beam analysis is the standard vibration prediction tool, the application of this technique is questionable for this low aspect ratio hollow blade because of a greater than normal chordwise bending component in the primary modes. Figure 4.2.1-2 shows the NASTRAN results. The beam analysis results afforded a more conservative frequency margin for 4E first torsion and 3E second bending modes (for example, 14.6 and 7.1 percent versus 5.3 and 6.6 percent for NASTRAN method). A -17.6 percent margin for 2E resonance was predicted by the beam method versus -20.9 percent for NASTRAN. The results of both methods are acceptable for experimental engine running. The 5.3 percent margin predicted by NASTRAN for 4E first torsion mode may be lower than actual since recent holographic test data indicate that NASTRAN method calculates torsional frequencies 4 to 8 percent low. If this is correct the margin would be sufficient for flight propulsion system.

The 2E first bending mode resonance is predicted to occur between flight idle and minimum cruise speeds (2400 to 2750 rpm). Acceptance of a 2E resonance within the speed range is a departure from standard Pratt & Whitney Aircraft practice, but is necessary to make a shroudless fan blade feasible. The sensitivity of the 2E resonance stress levels to inlet distortion is of concern and will have to be evaluated through testing before the acceptability of the shroudless concept can be established for a flight propulsion system application.

Diagrams showing platform mode resonances, tip mode resonances, and panel mode resonances are presented in Figure 4.2.1-4. The tip mode was calculated using the same full blade NASTRAN model used to calculate the primary modes. Individual, more detailed NASTRAN models, were used for calculation of platform and panel modes. Panel mode calculations were performed for the two concave surface leading edge panels, which were judged to be representative of all the low frequency panels. No critical platform or tip mode resonances occur within the operating range.

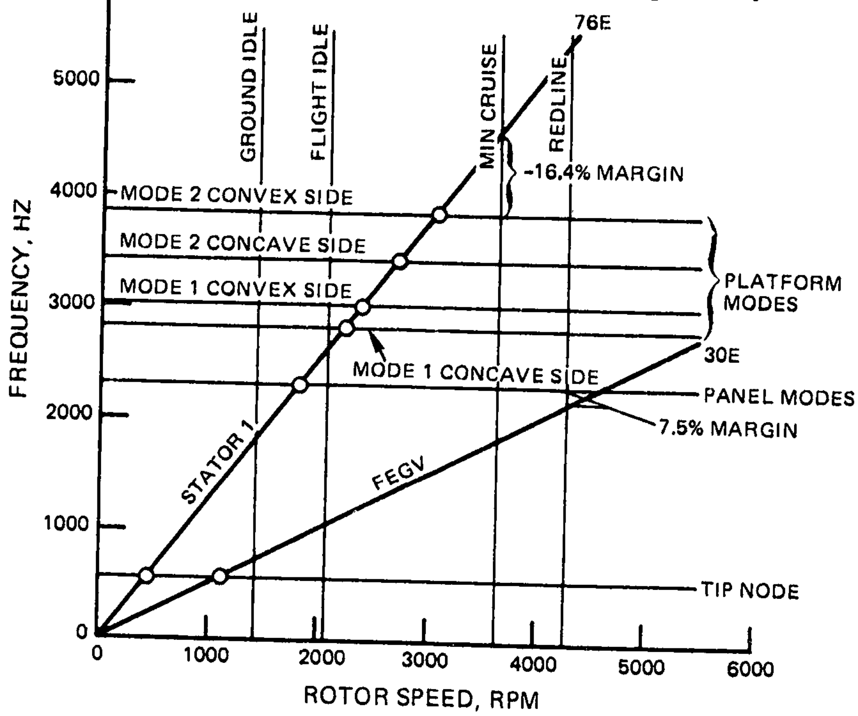

Figure 4.2.1-4 Shroudless Fan Blade Tip Mode, Flatform Mode, and Panel Mode

The blade stability was checked for unstalled supersonic and torsional stall flutter modes. The torsional stall flutter parameter of 1895 feet/second meets the design criteria. The unstalled supersonic flutter parameter was found to be stable in all modes when standard beam analysis mode shapes were used. Calculations were also made using the NASTRAN mode shapes as input to the flutter analysis because of the unavailability of the hollow beam analysis. The minimum log decrements calculated for both of these analysis are shown in Figure 4.2.1-3. The greatest difference between the two analyses is in the first mode, the only mode where NASTRAN mode shapes predict a slight instability. This negative log decrement is not considered a problem because of the limited first mode flutter experience and the lack of correlation with NASTRAN mode shapes. Some risk is associated with the Energy Efficient Engine low aspect ratio design because of the larger than normal chordwise bending component in the primary modes. Since the flutter analyses do not recognize chordwise bending deflections, they would not properly account for any instabilities introduced by this motion.

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4.2.1.1.2 Stress Analysis

The procedure used to calculate the airfoil static stresses was consistent with standard procedure for solid fan blades (NASTRAN plate analysis and fillet concentration curves). The low cycle fatigue allowable stresses were compared to the maximum stress levels calculated at the inner surfaces of the hollow/solid transition region (Figure 4.2.1-5), in addition to the maximum airfoil root stresses (Figure 4.2.1-6). The low cycle fatigue life properties for the inner surfaces were estimated from available specimen data for the nonpeened, stress relieved, forged AMS 4928 titanium. Table 4.2.1-II presents the 30,000 cycle low cycle fatigue life peak concentrated stress levels in the airfoil. These results are well within allowables and indicate the airfoil has a low cycle fatigue life greater than 30,000 cycles at all locations.

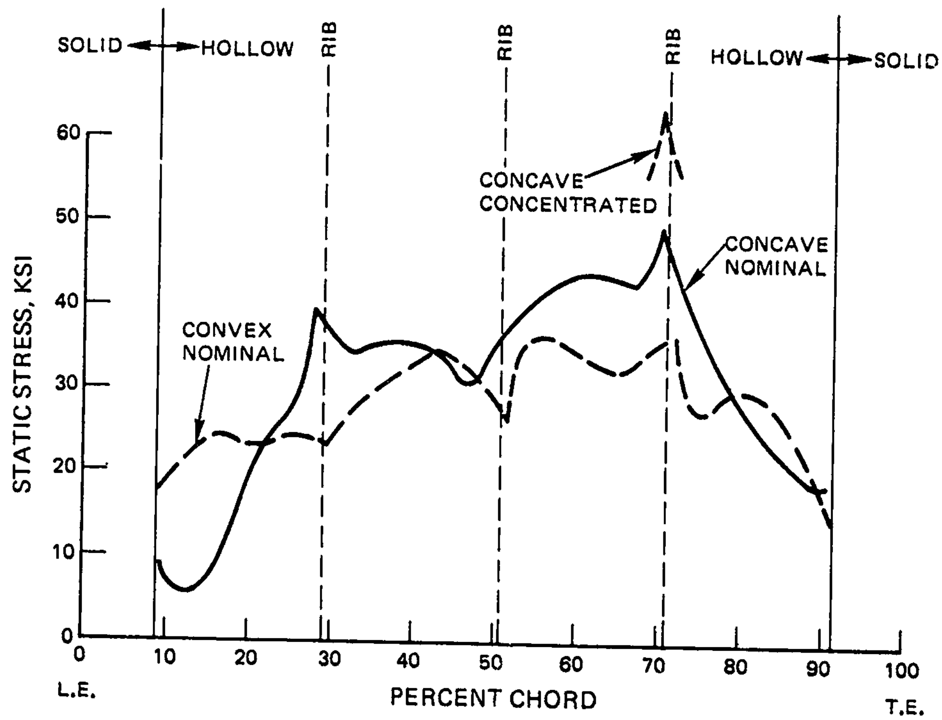

Figure 4.2.1-5 Blade Internal Surface Stresses at Solid to Hollow Transition Region

The standard Pratt and Whitney local leading edge and gross bending modes of bird impact failure were assessed for the Energy Efficient Engine fan blade. Analytical treatment of any other failure modes was not attempted since the test or field experience required for correlation does not exit. The most likely failure mode for the Energv Efficient Engine fan is probably of the local leading edge type because of the hollow feature. The large size and low aspect ratio of the Energy Efficient Engine blade diminishes the possibility of gross bending or torsion failures.

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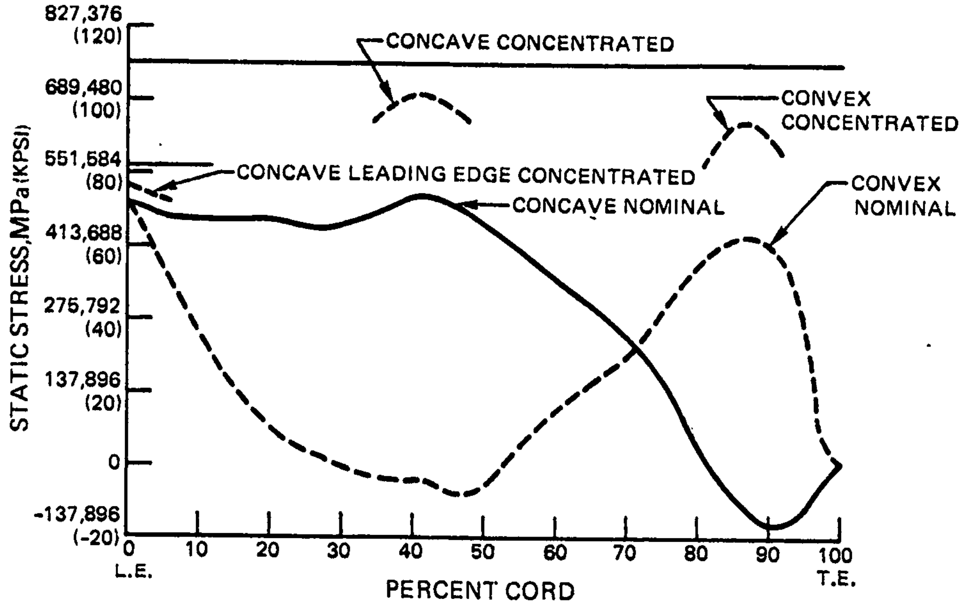

Figure 4.2.1-6 Airfoil Allowabale Root Stresses are for a Low Cycle Fatigure Life of 30,000 Cycles

TABLE 4.2.1-II
AIRFOIL STRESS SUMMARY

Location	Concentrated* Stress MPa (kpsi)
Root Leading Edge Concave Surface	527,452 MPa (76.5 kpsi)
Root 40% Chord Concave Surface	701,890 MPa (101.8 kpsi)
Root 85% Chord Convex Surface	653,627 MPa (94.8 kpsi)
Internal Surface at Solid to Hollow Transition Region 70% Chord, Concave Side	446,783 MPa (64.8 kpsi)

*Include gas bending and tilt stress components

The local leading edge bird ingestion capability was assessed by utilizing the normal solid blade analysis (local shear bird ingestion parameter -- LSBIP) with modifications to account for local inertia and shear area changes due to airfoil hollowness. The results of this analysis are presented in Figure 4.2.1-7. The data indicate that the LSBIP is well below the standard solid blade limit. The Energy Efficient Engine blade, when analyzed as though it were solid, was designed to have a LSBIP of less than 60 percent of the limit to provide capability to accept the reduced strength of the hollow blade.

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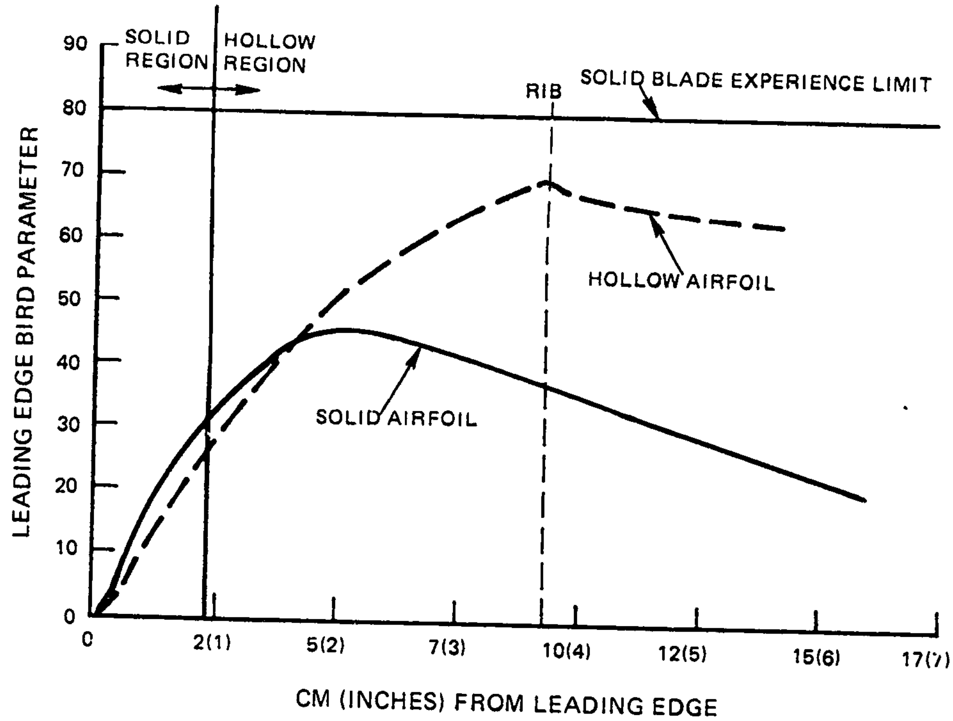

Figure 4.2.1-7 Leading Edge Local Shear Bird Ingestion Parameter

In addition to the LSBIP analysis, the local leading edge capabilities were compared to shrouded blades with NASTRAN analyses. The results of these analyses indicated that the stress rise from the hollowness was approximately offset by the benefit of the absence of a shroud hard point. The results of the gross bending analysis, shown in Figure 4.2.1-8, indicate this parameter is well below the maximum allowable value. The low value of this parameter results from the increased stiffness of the low aspect ratio design.

The dovetail fillet concentrated stress was also analyzed. The calculated dovetail stress concentration for the Energy Efficient Engine attachment is higher than most current designs because the ratio of tooth bending stress to the neck stress is higher than usual. A lower than normal stress level results from a reduced pull hollow airfoil, and neck stiffness requirements for frequency. Although the tooth bending stresses are well within criteria requirements, they are high relative to the neck stress levels, thereby producing the higher than normal stress concentration. The concentrated fillet attachment stresses is 613,637 MPa (89 kpsi).

The standard vibratory stress ratio calculation indicates that the Energy Efficient Engine fan has a stress ratio which is less than the minimum acceptable, but approximately equal to the values of current design fans. Although the low stress ratio could be justified on the basis of fillet radius, the higher than normal contributions of the tooth bending effect to the concentrated fillet stress make comparisons with present fan attachments questionable. Therefore, a revised stress ratio approach was also used to evaluate the design. This analysis not only includes fillet radius effects, but also avoids the questionable tooth bending stress treatment of the present analysis. The results of the analysis indicate the Energy Efficient Engine stress ratio is better than those of current fan designs.

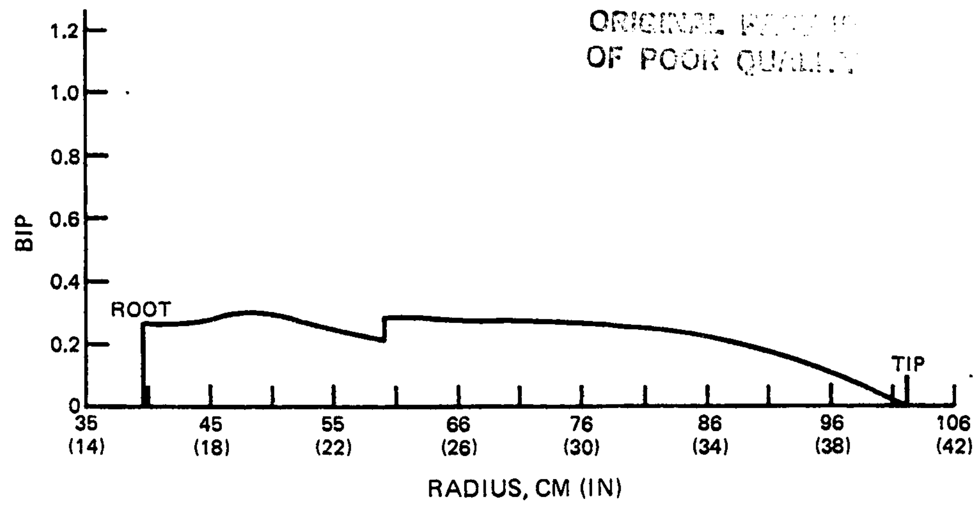

Figure 4.2.1-8 Bending Bird Ingestion Parameter

Blade tilt was determined to be 0.914 cm (0.360 in) tangential and 0.381 cm (0.150 in) axial. Analysis was done using a standard airfoil computer program with hollow section properties developed from the hollow section designs. A residual gas bending moment resulted in a compressive maximum stress of 44,126 MPa (6.4 kpsi) and a reduction of 23,442 MPa (3.4 kpsi) in the foil root maximum stress. Residual bending moment stress components were included in the dovetail fillet life and bearing stress calculations.

Bearing stress of the airfoil attachment was calculated to be 468,846 MPa (68 kpsi), which is acceptable for experimental use.

4.2.1.1.3 Cold Geometry Correction

A NASTRAN uncamber/untwist analysis was performed at the aerodynamic design point to establish the required cold correction to the manufacturing drawing. A larger than normal correction was expected due to the absence of the mid span shroud on this design. However, the NASTRAN results show less geometry effect than expected due to the stiffening effect of the large root section camber and wide chord of the blade design. The analysis results are shown in Figure 4.2.1-9. The maximum effect is at the tip. The analysis showed metal angle change at the leading edge to be 3.4 degree and at the trailing edge 3.2 degree. The net effect on α ch was 2.4 degree opening. Untwist and uncamber are largely from centrifugal rather than gas loads. Average takeoff low-pressure is 0.6 percent above the aerodynamic design point and the geometry effect on this increased speed is negligible. The minimum cruise low-pressure rotor speed is 4.2 percent below the aerodynamic design point and the airflow flow loss there is only 0.4 percent.

4.2.1.2 Shrouded Blade Mechanical Design

The shrouded fan blade is a completely solid, 4.0 aspect ratio design, with a part span shroud to reduce undesirable vibration characteristics. A summary of the fan blade and attachment design is contained in Table 4.2.1-III.

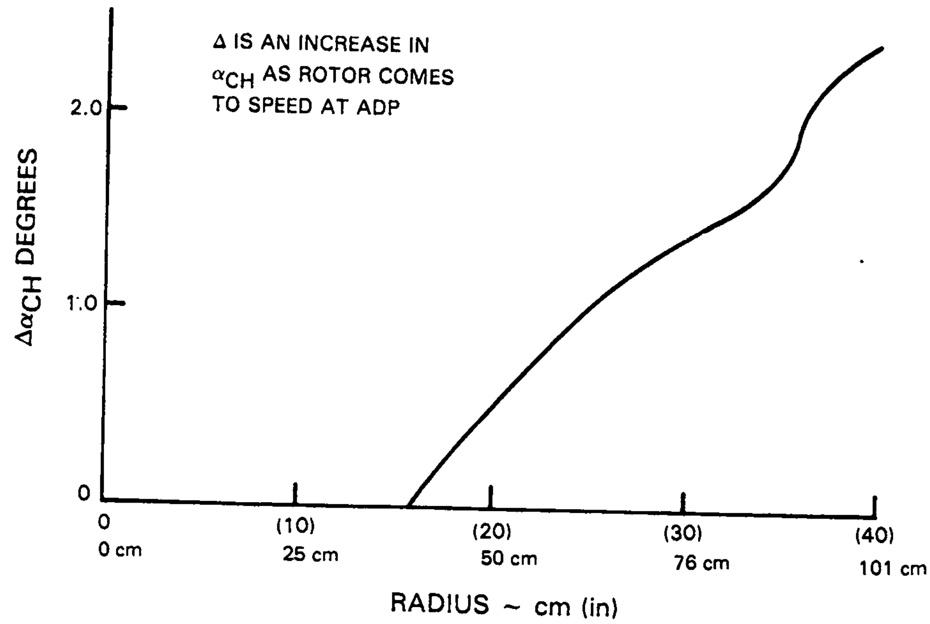

Figure 4.2.1-9 Results of Shroudless Blade Untwist and Uncamber Analysis

TABLE 4.2.1-III
SHROUDED FAN BLADE GENERAL DESIGN PARAMETERS

Aspect Ratio	4.0
Material	AMS 4928
Number of Blades	36
Airfoil Series	Multiple Circular Arc - Design contoured airfoil
Average Root Chord - cm (in)	15 (6.219)
Average Tip Chord - cm (in)	23 (9.059)
Number of Shrouds	1
Shroud Location	71.5% span
Broach Angle	2
Airfoil Length (at stacking line) cm (in)	63.304 (24.923) (hot with 0.254 (0.100) in tip gap)
Z Plane Radius - cm (in)	32 (12.835) (cold)
Maximum Speed (flight propulsion system redline)	4267 RPM
Tip Velocity (flight propulsion system redline) m/sec (ft/sec)	456 m (1499)
Airfoil tilt (at 40.137" R_{cold}) cm(in)	1.016 (0.400) axial
cm(in)	0.584 (0.230) tangential
Average Moment Weight/Blade	4054 oz-in

4.2.1.2.1 Shroud

The shroud was designed in accordance with successful commercial experience, and is similar to current high bypass ratio blade shrouds. Cross-sectional area of the shroud is sized to survive impact and/or vibratory loads that the adjacent airfoil would not. An increased thickness/chord ratio bump and revised shroud geometry was used to alleviate high airfoil bending stress induced by the shroud. Since this stress was anticipated, extra material had been designed into the forging layout to accommodate the increased thickness/chord ratio.

A 65-degree shroud-to-shroud contact angle was selected on the basis of recent test experience with similiar blade designs. To simplify manufacturing, the shroud was defined as a tipped cylinder. Deflection from centrifugal force will cause the shroud to assume a conical ring shape during operation. These deflections were taken from the NASTRAN analysis.

A shroud location of 71.5 percent span was chosen for this fan blade. This location was selected because: (1) a loss of 4E second mode margin and second mode stability occurred when the shroud was moved inboard, (2) a loss of first mode stability occurred when the shroud was moved outboard, and (3) the research and development fan experienced high 3E resonance stresses with the shroud at 73 percent span.

Stress to slip for various second mode nodal diameter patterns was calculated according to the guidelines of the shroud design system. This stress was plotted versus the resonant speed in percent of redline speed. Comparing this plot to past experience shows that only in the 4E resonance would the shroud slip. The 4E second mode resonance was therefore calculated using a pinned shroud while all others were calculated using the normal shroud model.

4.2.1.2.2 Balancing

Bending stresses at the root were designed to be zero for the low cycle fatigue limiting condition (3879 rpm, sea level takeoff gas loads). To achieve this condition, an initial cold tilt of 0.749 cm (0.295 in) axial and 0.297 cm (0.117 in) tangential was was analytically imposed in the direction of the gas load. These values were determined using a computer program. Stresses were determined acceptable at the aerodynamic design point with no gas loads. The blade remained in tension, with centrifugal stress greater than bending stress, so buckling was not a concern. Final cold tilt was then established as 1.016 cm (0.400 in) axial and 0.584 cm (0.230 in) tangential when untwist-uncamber effects were added. A NASTRAN program which accounts for shroud untwist caused by shroud to shroud growth gap was used to obtain untwist-uncamber. Although originally not incorporated, the shroud untwist effect is an additional 0.35-degree. The tilt under hot conditions at the aerodynamic design point (3902 rpm, scaled down gas loads) is 0.563 cm (0.222 in) axial and 0.119 cm (0.047 in) tangential.

The blade is also balanced about the root by an 0.203 cm (0.080 in) offset (stacking line to blade root centerline). This not only accounts for the centrifugal load of the blade and shroud and gas loads, but also for the platform and neck pulls, yielding zero moment about the Z-plane.

4.2.1.2.3 Vibration Characteristics

The shrouded fan blade was analyzed for natural frequencies and resonance crossings using a beam vibration analysis. This analysis includes the effects of the shroud, disk, and dovetail attachment in its calculation of the natural frequencies. Figure 4.2.1-10 shows the resonance diagram for the shrouded blade.

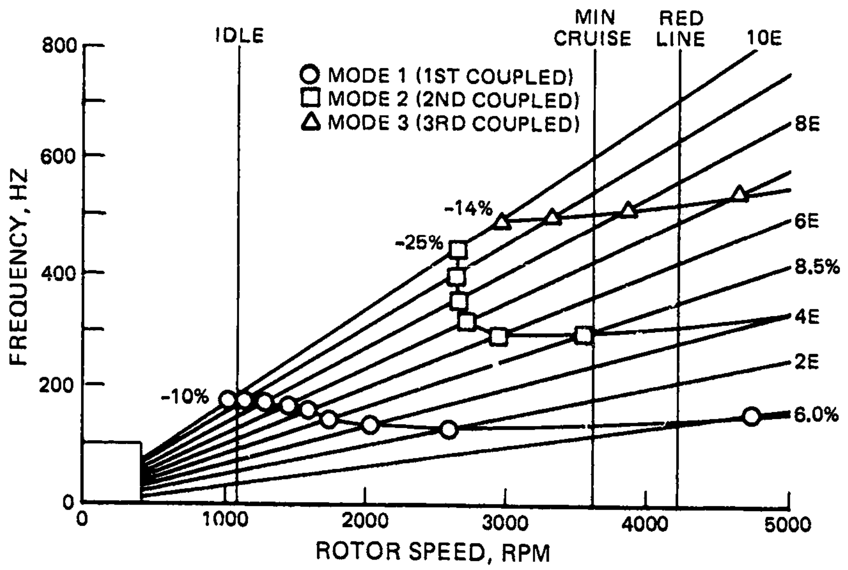

Figure 4.2.1-10 Resonance Diagram for Shrouded Fan Blade

All critical engine harmonic orders were out of the normal engine operating range. The critical harmonic orders were: second (2E), third (3E), fourth (4E), and tenth (10E, the intermediate case strut order). These harmonic orders were avoided in the first three modes of vibration.

An increase in the disk rim depth was needed to achieve the needed first mode 2E margin. The 3E and 4E resonances in the first mode occur between the idle and minimum cruise speeds. Final frequency margins are shown on the resonance diagram (Figure 4.2.1-10). The intermediate case strut order (10E) occurs safely below idle for the first mode and between idle and minimum cruise speed for the second and third modes.

Chordwise bending modes near the tip of the airfoil are calculated using a free-free beam analysis of the outer 15 percent span of the airfoil. Critical resonances must have either positive redline or negative minimum cruise speed frequency margin.

The resonances that had to be avoided were the intermediate case strut order (10E), its first harmonic (20E) and the exit guide vane order (30E). Calculation of the first two tip modes revealed that adequate margins exist for all the critical resonances (Table 4.2.1-IV) and no design changes were required.

TABLE 4.2.1-IV
ENERGY EFFICIENT ENGINE SOLID FAN BLADE
TIP MODE FREQUENCY MARGINS

	10E	20E	30E
First Tip Mode (%)	54 Min. Cruise	-9.6 at Min. Cruise	-40 at Min. Cruise
Second Tip Mode (%)	236 at Redline	68 at Redline	12 at Redline

4.2.1.2.4 Flutter Analysis

The final airfoil design was analyzed for supersonic unstalled flutter and stall flutter. The supersonic unstalled flutter prediction system uses the airfoil vibratory mode shapes and frequencies from the beam vibration analysis, along with the blades aerodynamics at various operating points to predict the airfoil's aerodynamic damping. Stall flutter is predicted based on the airfoils reduced velocity, tip twist to flap ratio, and experience.

Supersonic unstalled flutter is predicted based on sea level takeoff aerodynamic conditions. This was the only set of conditions considered because it is the only critical operating point the integrated core/low spool engine will encounter. Also, the prediction system shows no unstable vibratory modes in the first three natural frequencies. Based on this, flutter is not expected. A comparison of first mode reduced velocities and twist to flap ratios to previous experience shows that the Energy Efficient Engine shrouded fan lies well within the stable region, therefore, stall flutter is not expected. Figures 4.2.1-11 and 4.2.1-12 show the flutter prediction results.

4.2.1.2.5 Bird Ingestion

Although the integrated core/low spool demonstrator has not been scheduled to undergo bird ingestion testing, the fan blade was analyzed to demonstrate that it has the resistance to bird strikes. Both bird ingestion parameters, bending and local shear, were calculated according to the requirements of the structural and dynamic design criteria. This blade satisfies the design criteria for both bird ingestion parameters as shown in Figures 4.2.1-13 and 4.2.1-14.

4.2.1.2.6 Steady Stresses

An analysis of airfoil steady stresses summarize in Table 4.2.1-V showed that root and under shroud stresses were within the limits of the low cycle fatigue requirement as shown in Table 4.2.1-V. The maximum radial undershroud stress is 730,848 MPa (106 kpsi) on the convex surface at 85 percent chord. Figures 4.2.1-15 and 4.2.1-16 show the concentrated stress profiles for undershroud and airfoil root, respectively. The maximum trailing edge radial stress peak is 482,636 MPa (70 kpsi), occurring just below the shroud.

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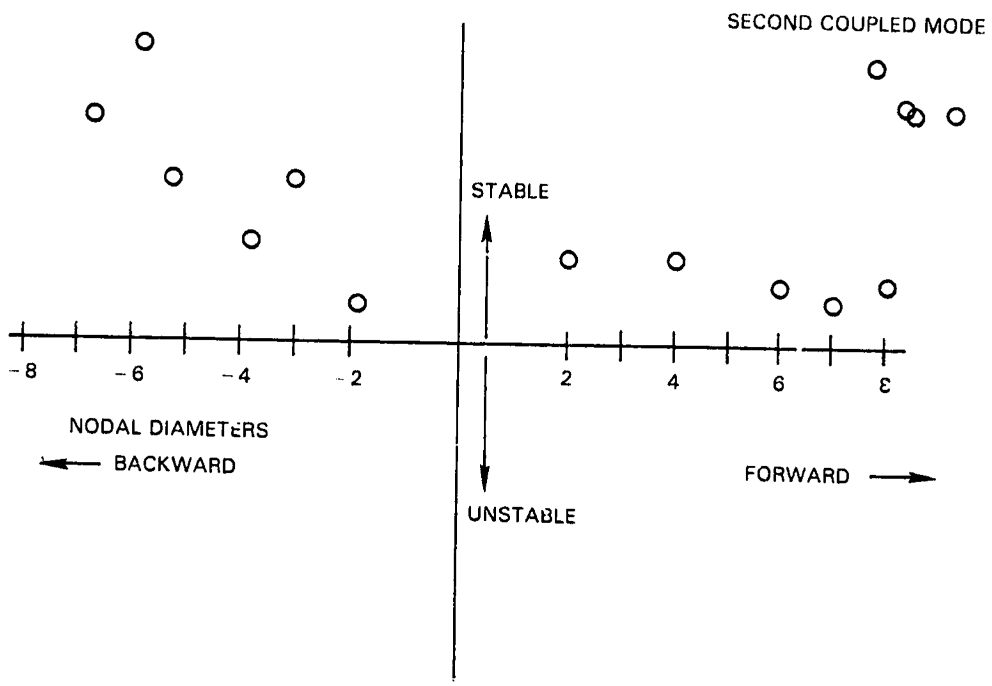

Figure 4.2.1-11 Energy Efficient Engine Shrouded Fan Stable in Supersonic Unstalled Flutter

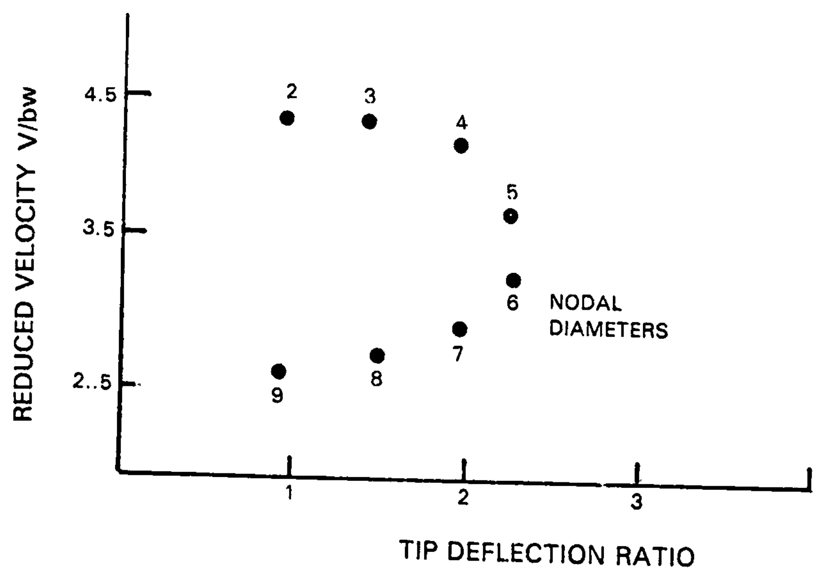

Figure 4.2.1-12 Energy Efficient Engine Shrouded Fan Stall Flutter

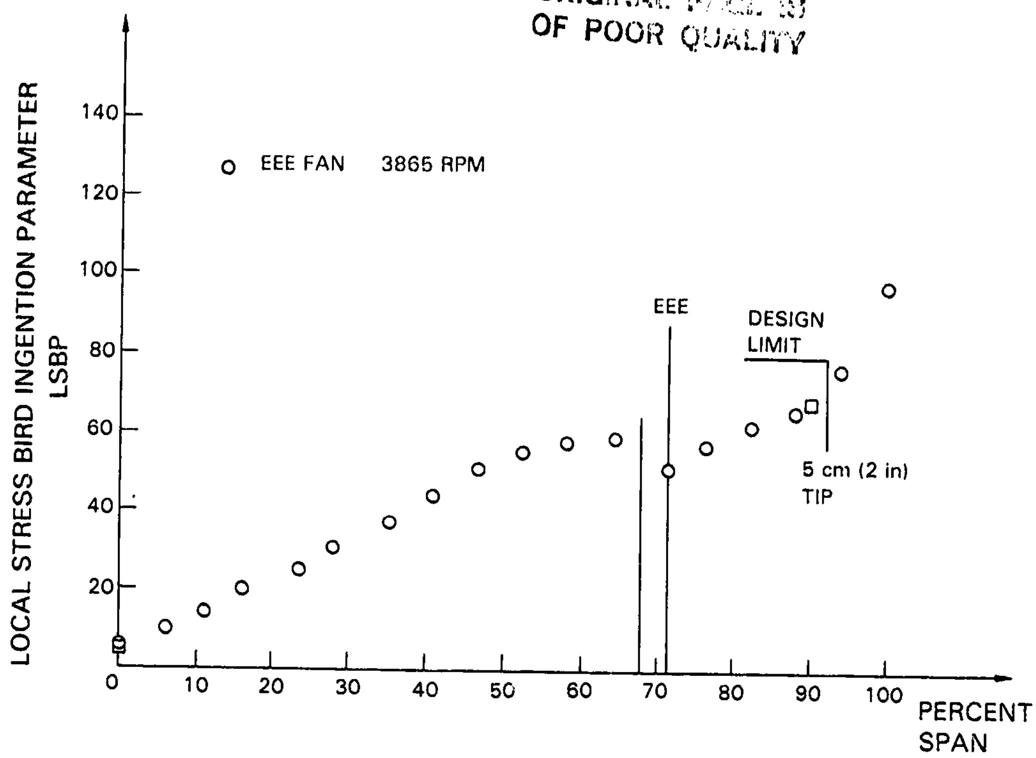

Figure 4.2.1-13 Energy Efficient Engine Shrouded Fan Blade Local Stress Bind Ingestion Parameter

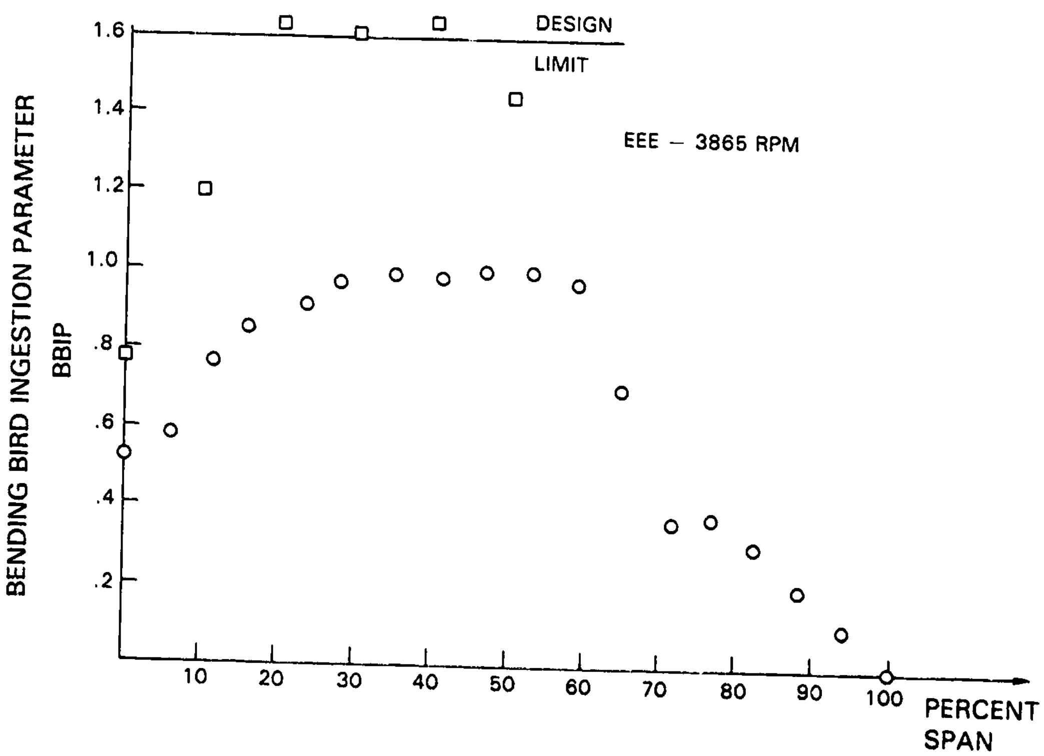

Figure 4.2.1-14 Energy Efficient Engine Shrouded Fan Blade Bending Bird Ingestion Parameter

TABLE 4.2.1-V
SHROUDED FAN BLADE
LOW CYCLE FATIGUE LIFE SUMMARY

Location	Concentrated Stress MPa (kpsi)	Resultant Low Cycle Fatigue Stage Life (cycles)
Airfoil root 30% chord convex	503,320 (73)	10^5
Undershroud 85% chord convex	730,848 (106)	58,000
Undershroud 40% chord concave	620,532 (90)	10^5

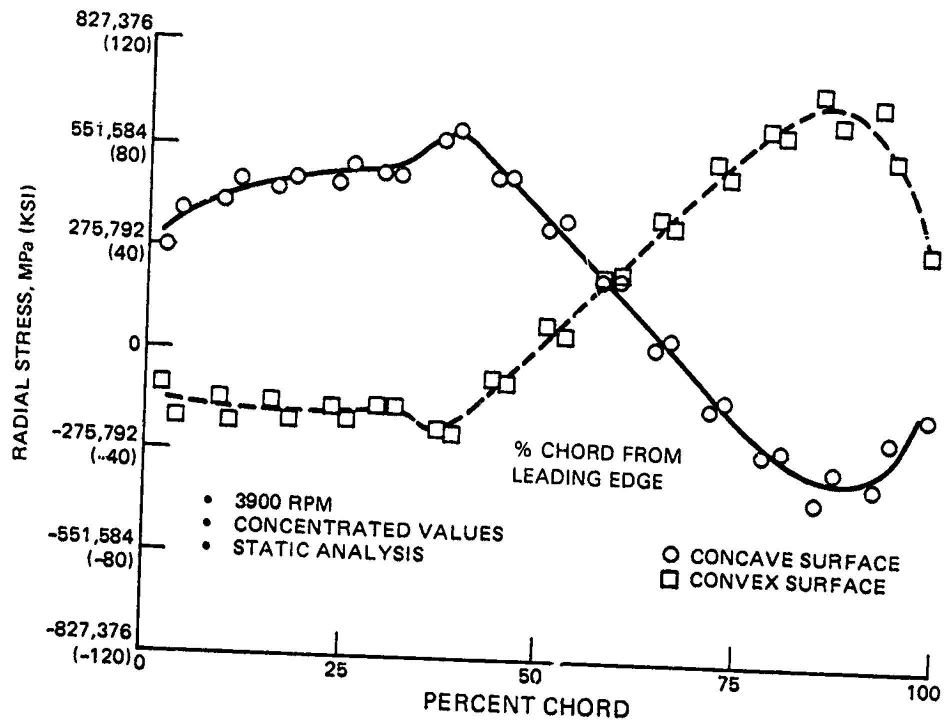

Figure 4.2.1-15 Undershroud Concentrated Stress Profiles for the Shrouded Fan

4.2.1.2.7 Cold Geometry Correction

The NASTRAN uncamber/untwist analysis generated coordinates reflecting the uncamber and untwist from the aerodynamic design point. This output was used to correct the cold geometry file, using an automated technique. The untwist and uncamber versus span plot from the NASTRAN analysis is shown in Figure 4.2.1-17.

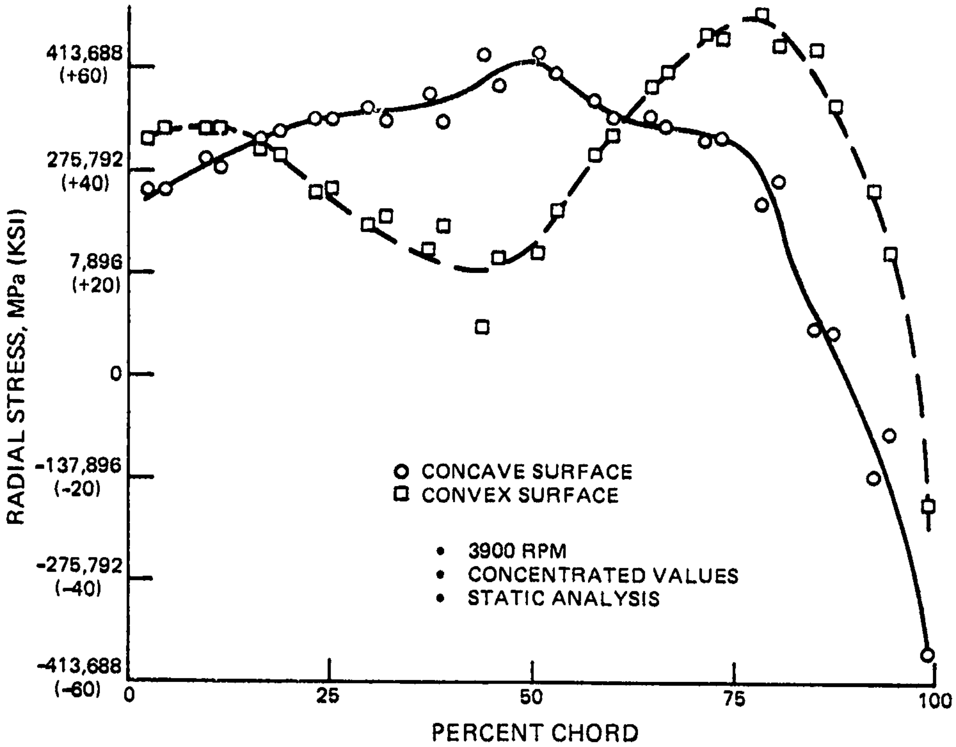

Figure 4.2.1-16 Airfoil Root Stresses for the Shrouded Fan

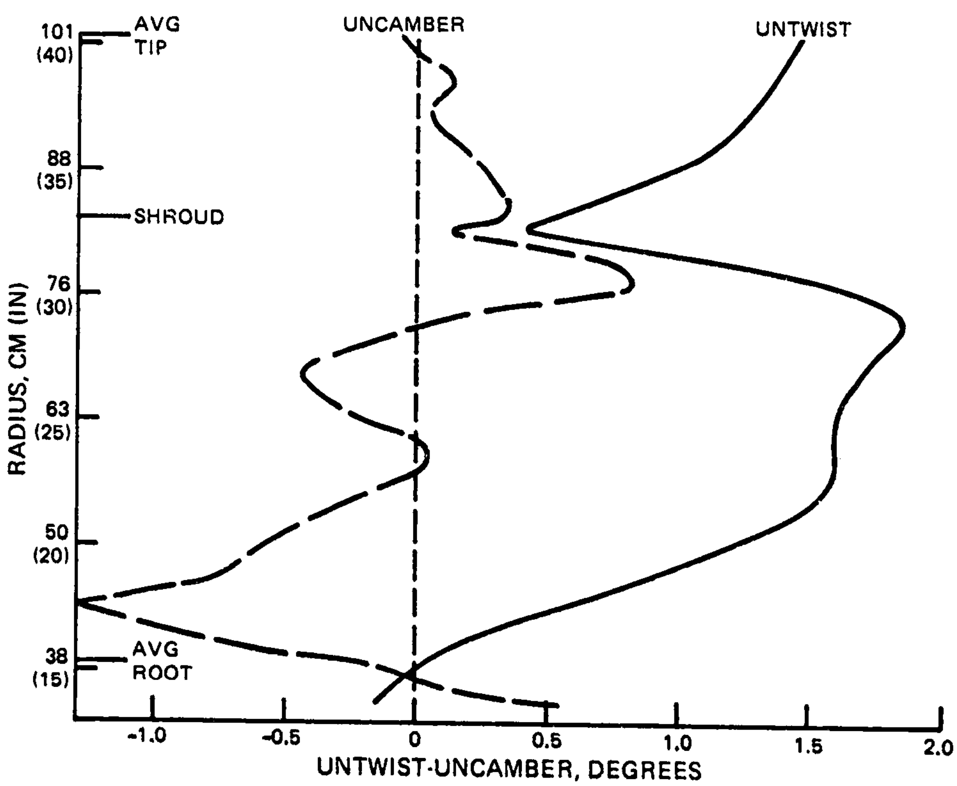

Figure 4.2.1-17 Uncamber and Untwist for the Shrouded Fan

4.2.1.2.8 Multiple Blade Loss

Multiple blade loss was checked by calculating the Fit/Fa ratio and comparing it to failure criteria. The Fit/Fa ratio compares the energy of the released blade to the energy the following blade can absorb. The results of the analysis are presented in Figure 4.2.1-18. The vertical axis shows where the following blade is struck by the released blade in percent span from the root. The horizontal axis is a ratio of the energy in the released blade to the energy the following blade can absorb before failing. This figure shows the design curve. A data point to the right of the curve indicates a multiple blade failure, while a point to the left indicates a single blade failure. For the fan blade, only the energy ratio was calculated since it was found to lie to the left of the design curve for any contact point on the following blade.

4.2.1.2.9 Root

Blade attachment requirements were established based on the size and weight of the airfoil. Using these requirements, an existing broach design was selected. The use of this existing design will result in a substantial cost savings in component design, tool design, and fabrication.

Blade attachment stresses were calculated using this existing broach design and were found to be well within design limits. The broach profile and a summary of these stresses is shown in Figure 4.2.1-19.

A snap ring is used to retain the blades. This design can withstand 10 percent of the blade pull load or approximately 4,989 kg (11,000 lbs). In addition, a maximum platform curling stress of 52,400 MPa (7600 kpsi) was calculated which is within allowable limits.

4.2.2 Fan Disk and Hub

Besides the blade, the fan rotor design consists of a hub, blade lock, blade lock retainer, and tiebolts to attach the hub to the stubshaft.

4.2.2.1 Fan Hub

Fan hubs were designed for both shrouded and shroudless blades since interchangeability with the nose cone and stubshaft was required. AMS 4928 titanium was selected for each since it has the best strength and weight characteristics. Both hubs were sized to keep the coupled blade/disk vibratory mode out of the operating range.

The burst margin and stress values for the hubs were calculated using an available computer program, based on the integrated core/low spool redline speed of 3902 rpm. Low cycle fatigue lives were calculated based on stress from zero to sea level take-off speed (3883 rpm). The results of these analyses are tabulated in Tables 4.2.2-I and 4.2.2-II.

The rotor assembly was analyzed using shell techniques. This analysis was used to position the disk on the nose cone to minimize rolling of the disk rim. The results of this analysis are presented in Figure 4.2.2-1.

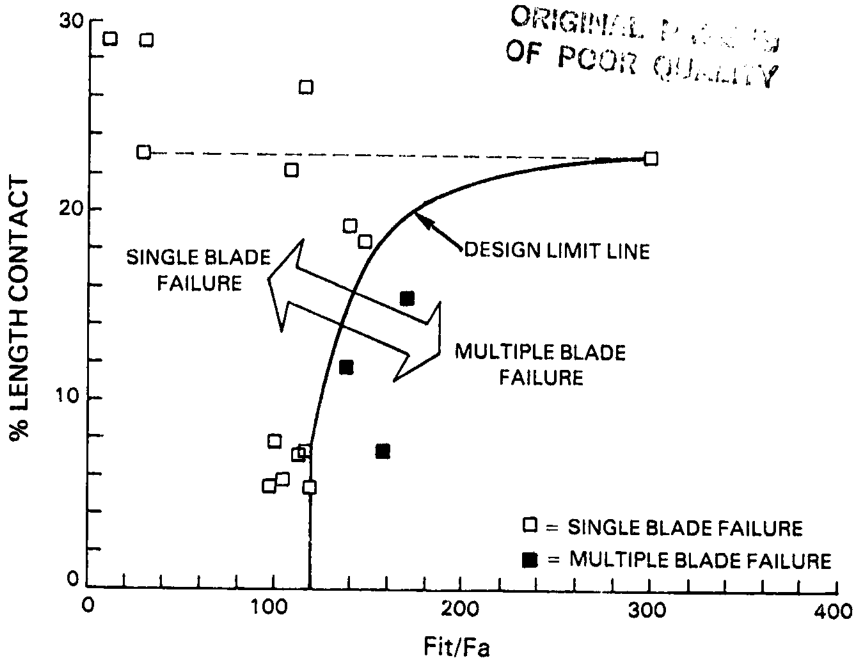

Figure 4.2.1-18 Multiple Blade Loss Criteria for the Shrouded Fan The calculated value lies to the safe side of the parameter curve, so multiple blade loss is not expected

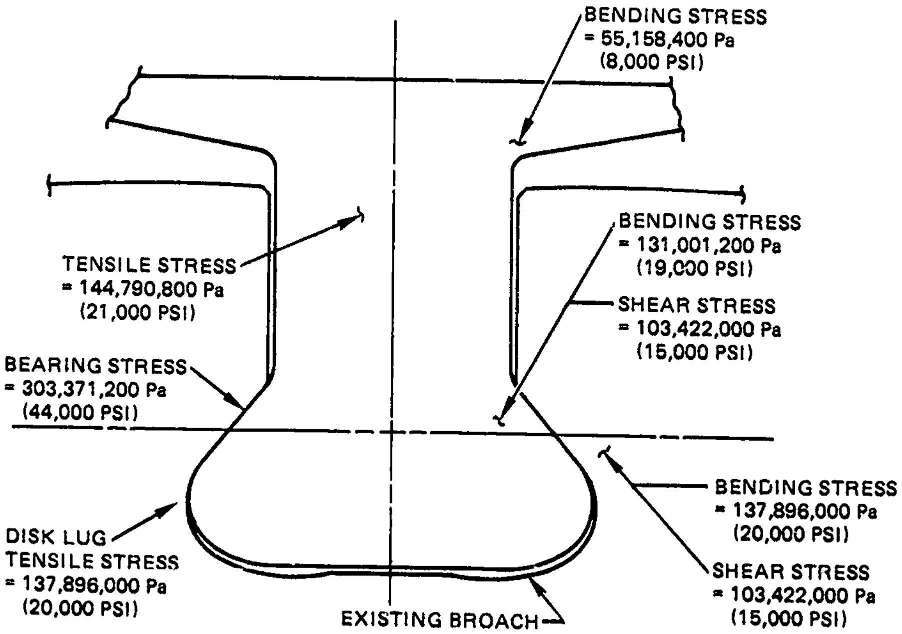

Figure 4.2.1-19 Blade Attachment Stresses

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TABLE 4.2.2-I
COMPONENTS OF DISK RIM PULL

	Solid Blade*			Hollow Blade*		
	Weight kg (lbs)	Radius cm (in.)	Pull kg (lbs)	Weight kg (lbs)	Radius cm (in.)	Pull kg (lbs)
Foil	3 kg (7.050)	67 cm (26.745)	36,956 kg (81475)	6 kg (14.21)	63 cm (24.901)	69,353 kg (152899)
Shroud & Fillet	0.305 kg (0.673)	83 cm (33.035)	4,357 kg (9607)	-	-	.
Platform & Fillet	0.214 kg (0.473)	38 cm (15.350)	1,422 kg (3137)	0.42 kg (0.94)	40 cm (15.80)	2,911 kg (6418)
Neck	0.613 kg (1.352)	36 cm (14.543)	3,853 kg (8496)	2 kg (5.15)	37 cm (14.80)	1,331 kg (2935)
Blade Dovetail	0.552 kg (1.219)	32 cm (12.840)	3,067 kg (6763)	0.90 kg (2.00)	33 cm (13.10)	5,135 kg (11321)
Disk Lug	0.514 kg (1.134)	32 cm (12.859)	2,858 kg (6302)	1 kg (2.88)	33 cm (13.10)	7,394 kg (16302)
Snap Ring	0.049 kg (0.109)	31 cm (12.450)	532 kg (1174)	0.049 kg (0.109)	31 cm (12.450)	532 kg (1174)
Total Disk Rim Pull			4210380			5305183

* Pull is calculated at 3902 RPM

$$\text{Pull} = mrw^2 = (wt/386.4) \times r \times \left(\frac{3902 \times 2\pi}{60}\right)^2$$

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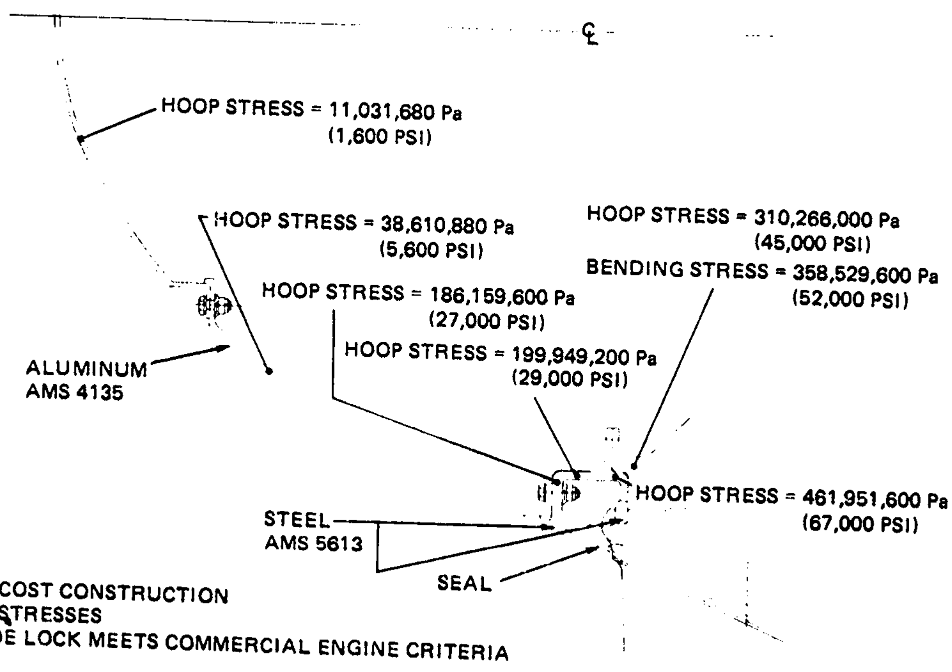
TABLE 4.2.2-II
DISK STRESS AND LIFE SUMMARY

	Shrouded Blade	Shroudless Blade
Average Tangential Stress MPa (kpsi)	339,224 (49.2)	266,139 (38.6)
Burst Margin	1.495	1.687
Rim		
Tangential Stress MPa (kpsi)	305,439 (44.3)	199,949 (29)
Radial Stress MPa (kpsi)	56,537 (8.2)	48,263 (7)
Low Cycle Fatigue Life, Cycles	10^5	10^5
Bolt Circle - Inner		
Tangential Stress MPa (kpsi)	151,685 (22)	273,034 (39.6)
Radial Stress MPa (kpsi)	8,273 (1.2)	284,755 (41.3)
Low Cycle Fatigue Life, Cycles	10^5	10000
Bolt Circle - Outer		
Tangential Stress MPa (kpsi)	89,632 (13.0)	312,334 (45.3)
Radial Stress MPa (kpsi)	200,638 (29.1)	327,503 (47.5)
Low Cycle Fatigue Life, Cycles	10^5	8000
SNAP - Concentrated Stress MPa (kpsi)	187,538 (27.2)	425,409 (61.7)
Low Cycle Fatigue Life, Cycles	10^5	10^5
Hub - Bending Stress MPa (kpsi)	389,556 (56.5)	456,435 (66.2)
Low Cycle Fatigue Life, Cycles	10^5	10^5



- LOW COST CONSTRUCTION
- LOW STRESSES
- BLADE LOCK MEETS COMMERCIAL ENGINE CRITERIA

Figure 4.2.2-1 Shrouded Fan Nose Cone Assembly

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4.2.2.2 Bolted Joint

The fan hub, low-pressure compressor rotor, and stub shaft are bolted together with fifteen 2.50 cm (1.0 in) diameter steel (AMS 5617) bolts. The configuration of the joint was influenced by the use of an existing number 1 bearing design. This bearing was used for cost considerations. Although this bearing is acceptable for ground tests, it does not meet minimum life requirements for the flight engine. A larger diameter flight engine bearing will necessitate a redesign of the joint area.

The bolted joint was analyzed using a two dimensional finite element program. The snap joint was found to have a life greater than 10^5 cycles on both hubs. The bolt circle life on the shrouded blade hub is also greater than 10^5 cycles. However, it is only 8,000 cycles on the shroudless blade bolt circle, but would be adequate for experimental use. Additional design work would be required to increase this life for a flight engine application.

The bolted joint was sized for fan blade loss load of 329960 cm - kN (292,000 in-lbf) at the limiting 3902 rpm condition. A bolt torque of 9040 cm - kN (800 in-lbf) will be used to load the bolts to 80 percent of their yield strength. The bolt low cycle fatigue life meets design requirements.

A summary of fan rotor materials is shown in Figure 4.2.2-2.

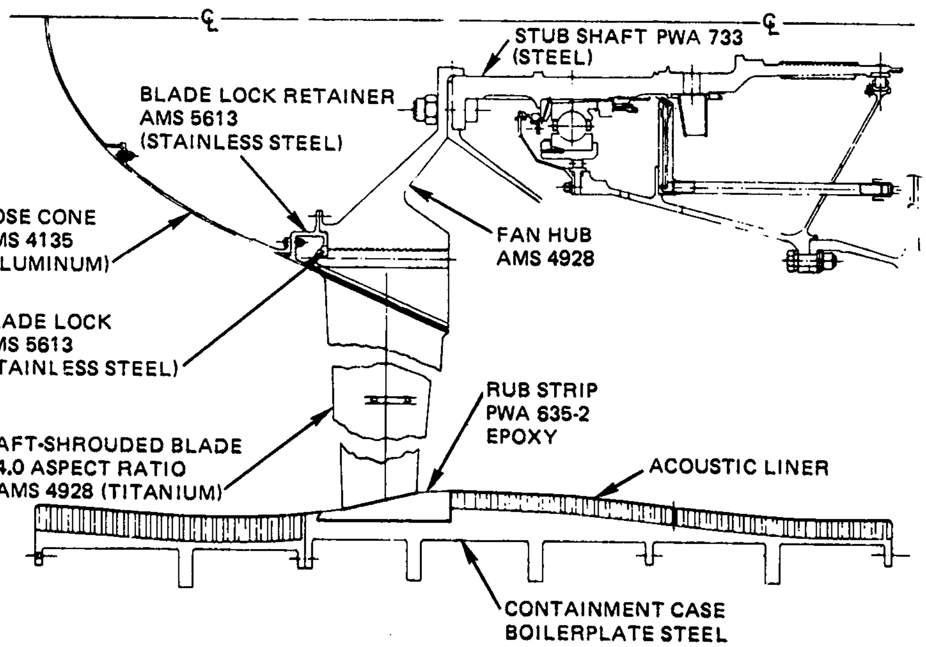

Figure 4.2.2-2 Shrouded Fan Rotor Assembly Materials

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4.2.3 Nose Cone

The nose cone and end cap are copies of a JT9D design, and are machined from AMS 4135 aluminum. This material was selected for the integrated core/low spool because of cost considerations. Fiberglass would be specified for a flight weight engine. The outer contour of the nose cone is an elliptical body of revolution which blends into a cone at the blade root.

The nose cone incorporates a blade retention ring that locks the blades into the rotor so there is no axial movement. The nose cone also serves to brace the fan disk against loads imposed on it by the blades. These loads tend to make the disk edges "roll", or curl towards the front of the engine. The nose cone is compressed by this curling motion, acting as a support to limit the curling motion.

4.2.4 Stubshaft and Bearing Compartment

The stubshaft, bearing compartment, and bearing support were designed in conjunction with both the fan and low-pressure compressor component to ensure that the combination load requirement was satisfied. Maximum use was made of existing designs.

4.2.4.1 Stubshaft

The stubshaft was designed to satisfy the fan blade loss moment load of 29.73 x 10^6 (2.631 x 10^6 in-lbf) at the centerline of the number one bearing and to accommodate a 7708543.6 cm (682,172 in-lbf) torque load. In addition, an axial load requirement of 19,800 kN (45,000 lbf) forward and 30,800 kN (70,000 lbf) rearward of the number 1 bearing was incorporated.

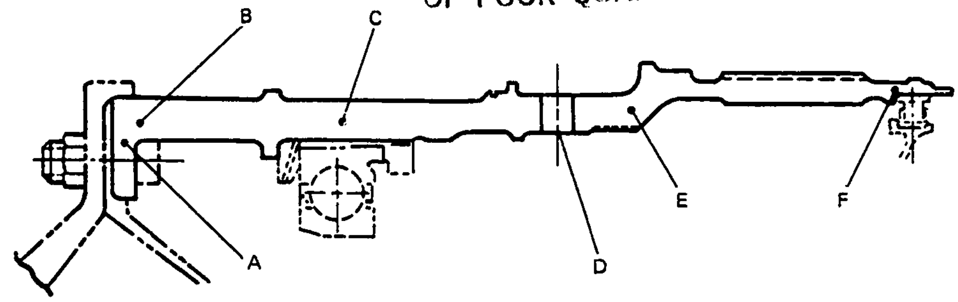
Both AMS 4928 titanium and PWA 733 steel were considered for materials. Steel was selected for both the integrated core/low spool and flight propulsion system because of cost considerations. The favorable weight of the titanium is not attractive for the flight propulsion system even on a total cost basis. The steel shaft weighs 67 kg (148.4 lbs.).

The shaft has 15 flange holes forward to accommodate the fan/low-pressure compressor rotor tie bolts. These holes are indexed to the 10 de-oiler holes to facilitate balancing of the shaft.

Figure 4.2.4-1 shows the location and values of maximum stress in the stubshaft. Low cycle fatigue life was evaluated at three locations on shaft. All three locations, which include the front flange, the deoiler hole location, and the spline, were found to have lives greater than 20,000 cycles.

4.2.4.2 De-Oiler

The de-oiler is mounted on the stubshaft and is designed to separate oil from breather air for all main engine bearing compartments. The deoiler air passes through the center of the low pressure turbine shaft and exits at the rear end of the mixer via a center tube. The de-oiler type was chosen to minimize pressure drop while not using more than 0.118 percent total engine airflow. The maximum oil loss goal was established at 0.3 liter per hour (0.1 gallon per hour).



LOCATION	STRESS	0.2% YIELD STRESS	% OF MATERIAL IN PLASTIC RANGE
A	834,270 MPa (121 kpsi)	820,481 MPa (119 kpsi)	1%
B	806,691 MPa (117 kpsi)	820,481 MPa (119 kpsi)	NONE
C	503,320 MPa (73 kpsi)	820,481 MPa (119 kpsi)	NONE
D	482,636 MPa (70 kpsi)	820,481 MPa (119 kpsi)	NONE
E	393,003 MPa (57 kpsi)	820,481 MPa (119 kpsi)	NONE
F	379,214 MPa (55 kpsi)	820,481 MPa (119 kpsi)	NONE

Figure 4.2.4-1 Location and Values of Maximum Stress in the Stubshaft

The de-oiler, shown in Figure 4.2.4-2, is a brazed assembly consisting of 80 radial vanes and two side plates. AMS 5062 steel is used for all parts because of its low cost and excellent weldability. The forward side plate was canted aft as a precaution to trap the vanes in the event of braze failure during service. This design is similar to the gear box de-oilers used in current engine models.

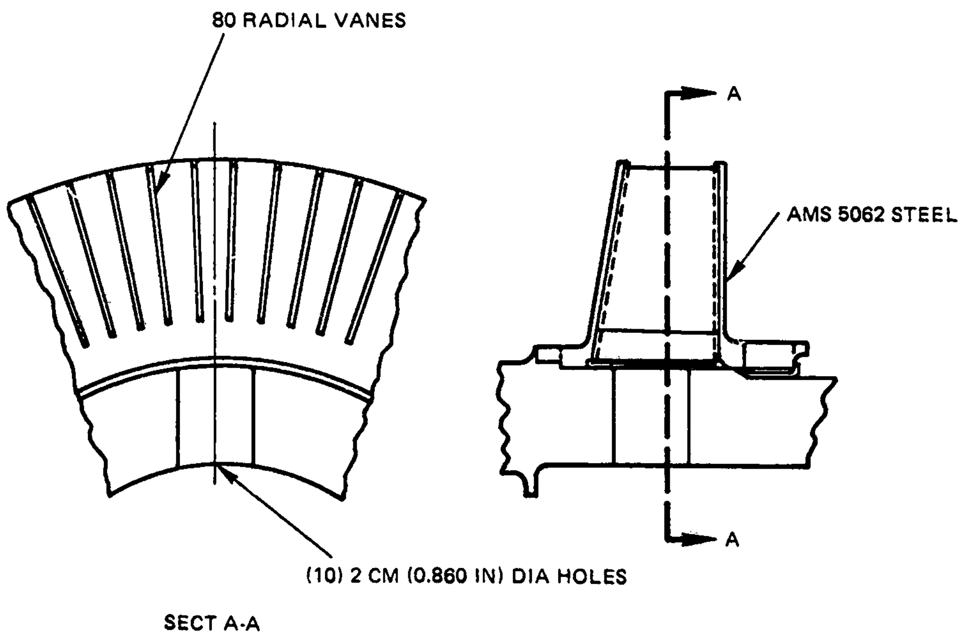


Figure 4.2.4-2 Shrouded Fan Deoiler Assembly

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4.2.4.3 Bearings

The number 1 and number 2 bearings are existing designs to eliminate the cost of a bearing development program. Pertinent design characteristics of the bearings are contined in Table 4.2.4-I.

Both designs are adequate for the integrated core/low spool program, but do not meet flight propulsion system life requirements. To meet the flight propulsion system life requirements, the diameter of the number 1 bearing would have to be increased to 269 mm inner and 385 mm outer diameter from the present 210 and 350 mm diameters. The number 2 bearing outer diameter also requires an increase from its present 180 mm to 190 mm.

TABLE 4.2.4-I
BEARING CHARACTERISTICS

	No. 1	No. 2
Type	Unflanged Ball Split Inner Race	Unflanged Roller Double Shouldered Outer Race Outer Land Riding
Size	210 x 350 x 55.9 mm	130 x 180 x 21.9 mm
Material		
Rolling Element	PWA 793	PWA 723
Rings	PWA 793	PWA 723
Cage	AMS 4616	AMS 6414
No. of Rolling Elements	20	26
Rolling Element Size cm (in)	3 (1.5625) dia	1 (0.5512) dia x 1 (0.5512) Lg
Internal Radial Clearance cm (in)	0.033 (0.0133) - 0.368 (0.145)	0.009 (0.0036) - 0.013 (0.0052)
Tolerance Class	ABEC #7	RBEC #5
DN Value Max	0.819×10^6	0.507×10^6
Cooling Scheme	Axial Scoop Under Race	Jet

4.2.4.4 Number 1 Bearing Seal

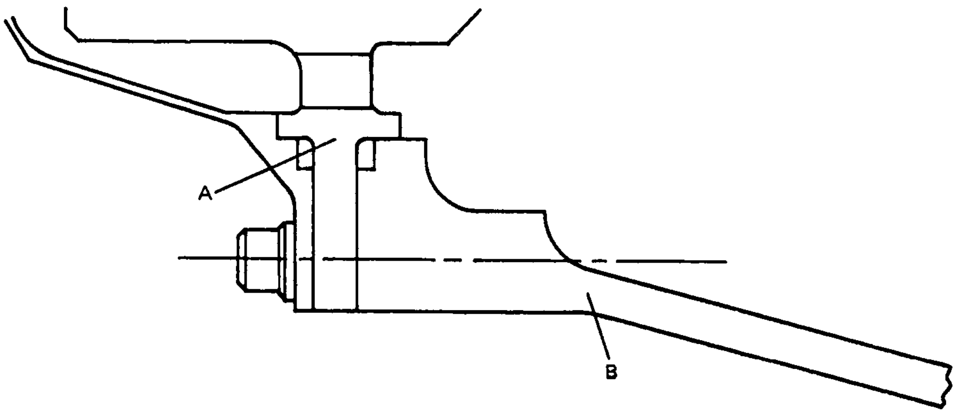
An existing bearing seal design was selected for cost considerations. It is an internally pressurized carbon face, spring guided seal design. This seal meets all requirements except for the minimum pressure differential. The differential requirement of 6,894 Pa (1 psi) may not be met because of the low pressure build up in the low-pressure compressor at idle and due to the pressure drop across the de-oiler at this condition. No backup air seal is used as a result of its ineffectiveness at low speeds. Testing in integrated core/low spool will determine if the seal will leak at idle. The operating characteristics are described in Table 4.2.4-II.

TABLE 4.2.4-II
BEARING SEAL DESIGN

Parameter	Predicted Performance
Maximum Rubbing Speed m/sec (ft/sec)	53 (174)
Maximum Air Temperature C (F)	125 C (257°F)
Pressure Differential	
Maximum pa (psi)	137,896 (20 psi)
Minimum pa (psi)	possibly less than 6,894 (1psi)

4.2.4.5 Number 1 Bearing Housing

The bearing housing is an existing design that meets the integrated core/low spool fan blade loss moment of 11.58 x 10^6 kN (2.631 x 10^6 lbf) at the number 1 bearing location, and oil drainage flow rate requirements of 9 kg/min (21 lbm/min). The housing material is AMS 4928 titanium. Representative stresses are shown in Figure 4.2.4-3.



LOCATION	STRESS
A	542,620 Pa (78.7 kpsi)
B	35,852 (5.2 kpsi)

Figure 4.2.4-3 Number 1 and 2 Bearing Housing Front Flange Representative Stresses Under Fan Blade Loss Condition

4.2.4.6 Numbers 1 and 2 Bearing Support

The combined bearing support was designed to meet the fan blade loss stress requirement of 11.58 x 10^6 kN (2.631 x 10^6 lbf) at the number 1 bearing location. To reduce costs both front and rear flange were designed using existing bolts. Representative rear flange stresses during the fan blade loss condition are shown in Figure 4.2.4-4. The support is a steel AMS 5504/5513 weldment.

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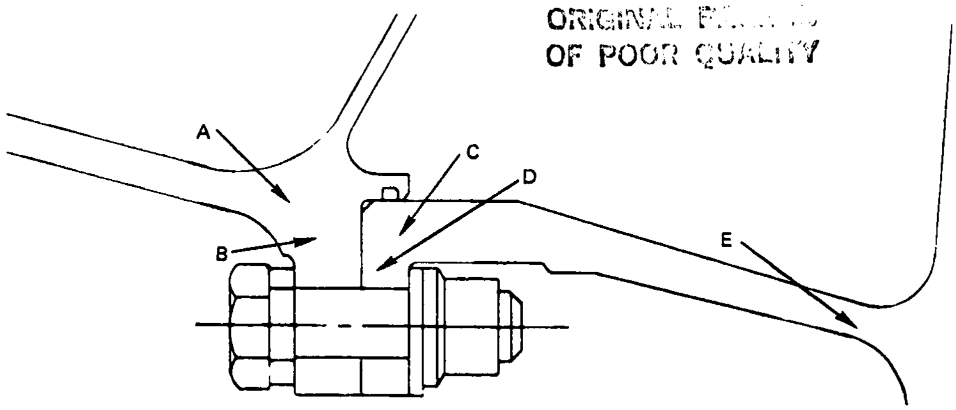

LOCATION	STRESSES	
	INTEGRATED CORE/LOW SPOOL LOADS	E^3 LOADS
A	419,203 MPa (60.8 kpsi)	432,993 MPa (62.8 kpsi)
B	786,696 MPa (114.1 kpsi)	748,085 MPa (108.5 kpsi)
C	276,481 MPa (40.1 kpsi)	501,251 MPa (72.7 kpsi)
D	517,799 MPa (75.1 kpsi)	941,140 MPa (136.5 kpsi)
E	894,945 MPa (129.8 kpsi)	276,481 MPa (40.1 kpsi)

Figure 4.2.4-4 Number 1 and 2 Bearing Housing Rear Flange Representative Stresses Under Fan Blade Loss Condition

4.2.4.7 Oil System

The oil supply system for the number 1 bearing and seal delivers 8 kg/min (18 lbm/min) of oil through a single oil jet to an axial scoop attached to the bearing retaining nut. The oil is supplied to the bearing and seal via slots and grooves in the stubshaft nuts and spaces. The oil drains to the intermediate case bottom strut through drain holes in the bearing housing and bearing support.

Oil for the number 2 bearing is supplied by an oil jet in the intermediate case towershaft/number 3 bearing oil system.

4.2.5 Fan Containment Case

The integrated core/low spool fan containment case was designed to be inexpensive, while meeting acoustic, containment, and structural requirements. Since the case is for experimental use only, it does not meet weight limitations for a flight application. It was designed for use with the shrouded fan, but can be modified for shroudless fan use if required.

The case assembly consists of two rings machined from forgings. AMS 5062 low carbon steel was selected for its low cost. Acoustic liners are constructed of aluminum honeycomb which is bonded to the steel case. Perforated aluminum sheet is bonded to the honeycomb which in turn, is covered with a bonded stainless steel mesh. The design is shown in Figure 4.2.4-5.

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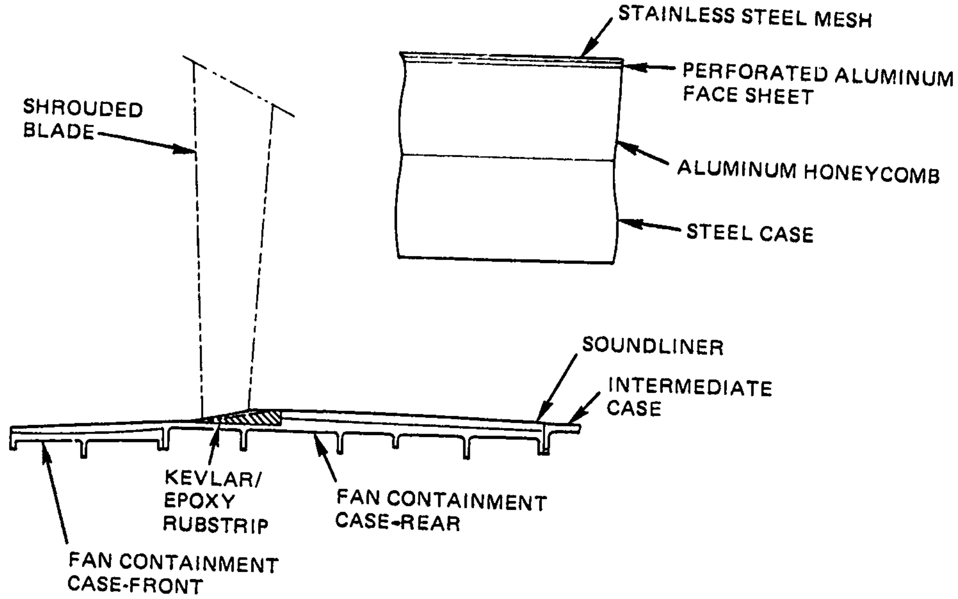

Figure 4.2.4-5 Integrated Core/Low Spool Fan Case Baseline Design

The blade tip rubstrip consists of 25 abradable chopped Kevlar/epoxy segments (PWA 635-2) bonded to the case. These segments will be trenched or a groove machined in below the flowpath after installation in the case.

The case was analyzed for containment, coincidence, blade passing resonance, natural frequency, buckling, and bending. Containment was provided ahead of and behind the fan blade as well as in the blade plane. The minimum required case thickness to contain the fan blade depends on several factors, such as the dynamic shear strength of the case, the fan blade geometry, and redline speed. Both the solid shrouded blade and hollow shroudless blade were analyzed for containment at the flight propulsion system redline speed of 4267 rpm. The minimum required case thickness calculated for an in-plane impact was found to be 0.85 inch for the shrouded blade and 2.54 cm (1.00 in) for the shroudless blade. The case was designed to satisfy the required in-plane aft thickness and forward thickness for both blades.

The integrated core/low spool fan case natural frequencies for nodal diameters 2 through 12 were determined using a shell analysis. The assembly analyzed consisted of the two piece fan case as shown in Figure 4.2.4-5. The design included 3 cm (1.33 in) thick honeycomb in front of the fan blade and 2.2 cm (0.9 in) thick honeycomb aft of the fan blade, bonded onto the case. The mass of the acoustic honeycomb and the rubstrip under the fan blade was taken into account in the model, but not their structural stiffness. The aft end of the case was pinned, allowing no deflection in the radial and axial direction. Full compatibility was assumed at the flange connecting the forward containment case to the rest of the fan case.

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Two criterion were used in determining which of the case natural frequencies could contribute to coincidence: (1) the area under the blade must display at least 25 percent of the maximum displacement of the model and (2) the maximum kinetic energy must occur in the area under the blade. Analyses were conducted for two case geometries, a "baseline" configuration without coincidence rings and a "stiffened" case using straight sided stiffening rings, as shown in Figure 4.2.4-6.

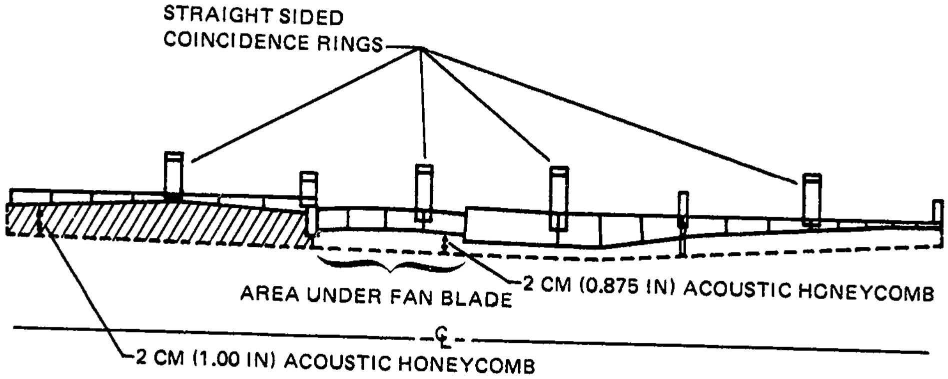


Figure 4.2.4-6 Integrated Core/Low Spool Fan Case "Stiffened" Design

For the integrated core/low spool engine, the gearbox is mounted on the fan case. Integral with the case are two rings where the gearbox can be bolted onto the case. The presence of the gearbox poses a limitation on the location of coincidence rings.

The case frequencies were combined with the blade and disk natural frequencies, as shown in Figures 4.2.4-7 and 4.2.4-8, to obtain a coincidence diagram. A frequency margin was calculated at integrated core/low spool redline speed of 3902 rpm for each nodal diameter. The limiting frequency margins are at a relatively low nodal diameter = 4. The baseline model (with no coincidence rings) resulted in a fan case coincidence frequency margin of +5 percent for the shroudless blade and +62 percent for the solid blade.

To attain an adequate frequency margin for the shroudless blade design, the fan case was stiffened with four coincidence rings, as in Figure 4.2.4-6. This increased the fan case coincidence frequency margin to +21 percent for the shroudless blade and +93 percent for the solid blade.

Although the case coincidence frequency margin for the shroudless blade is somewhat less than the design requirement, it is greater than other Pratt & Whitney Aircraft successful designs and is considered to be adequate. Flight experience with current engine models has demonstrated successful fan case operation with coincidence margins below those in the integrated core/low spool fan case design.

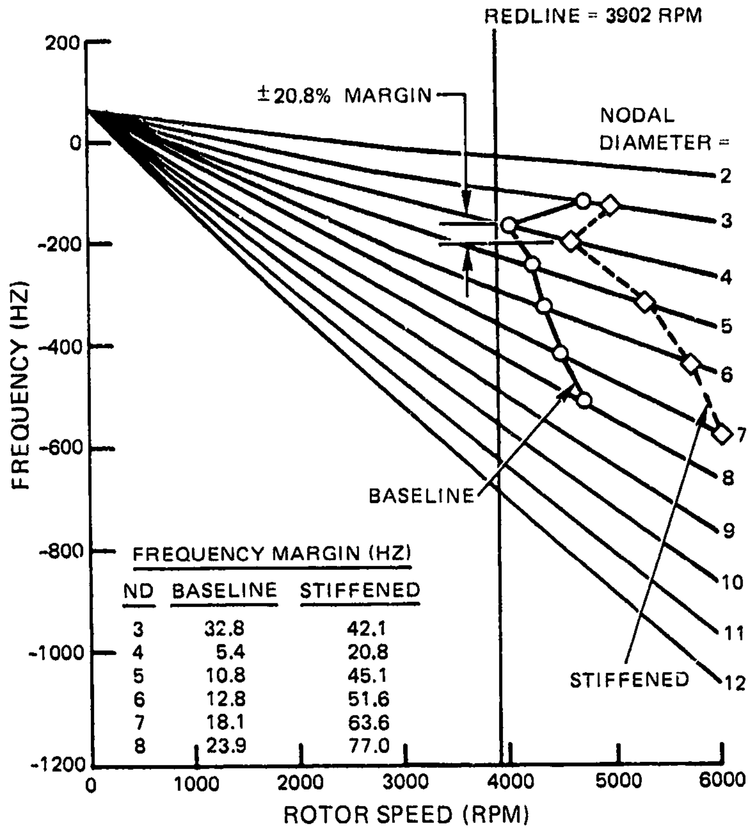


Figure 4.2.4-7 Shroudless Fan Case Coincidence Diagram

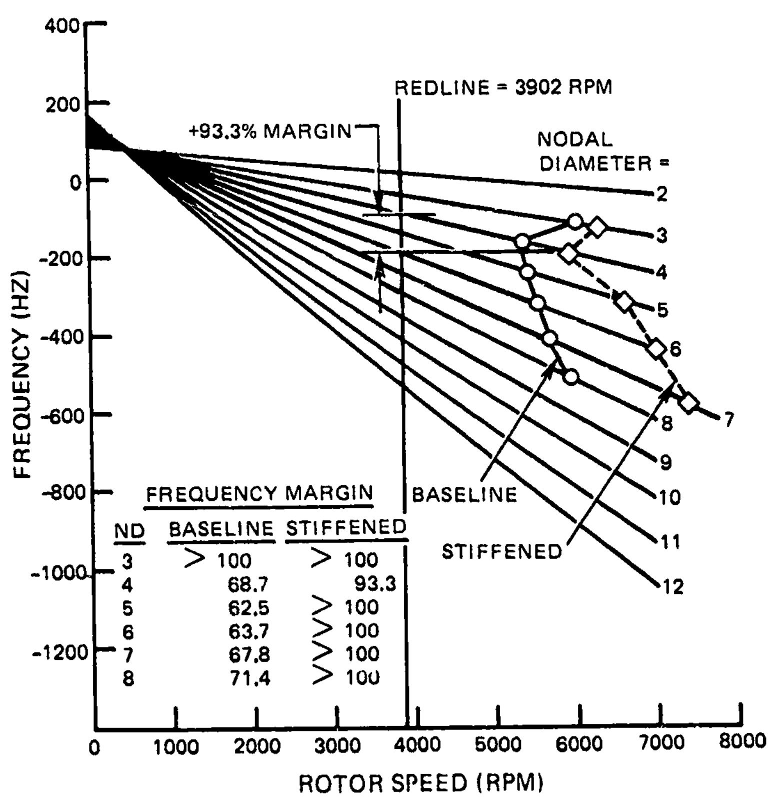


Figure 4.2.4-8 Shrouded Fan Case Coincidence Diagram Case

Analysis for fan case resonance due to blade passing involved using an analytical model and evaluating the natural frequencies at nodal diameters 24 and 36, the number of blades for the shroudless and shrouded fan, respectively. The unstiffened case natural frequencies for nodal diameters 24 and 36 are shown in Figure 4.2.4-9. There is greater than 100 percent case frequency margin on blade pass frequencies for the baseline fan case with no coincidence rings. The addition of the coincidence or stiffening rings will serve to increase the fan case natural frequencies and the frequency margins.

The case meets buckling and bending requirements at 3902 rpm redline speed with a blade loss moment of 4305300 cm - kN (381,000 in-lbf) at the blade area. Maximum temperature in this area is 30 C (86°F) forward of the blade and 68 C (156°F) aft of the blade.

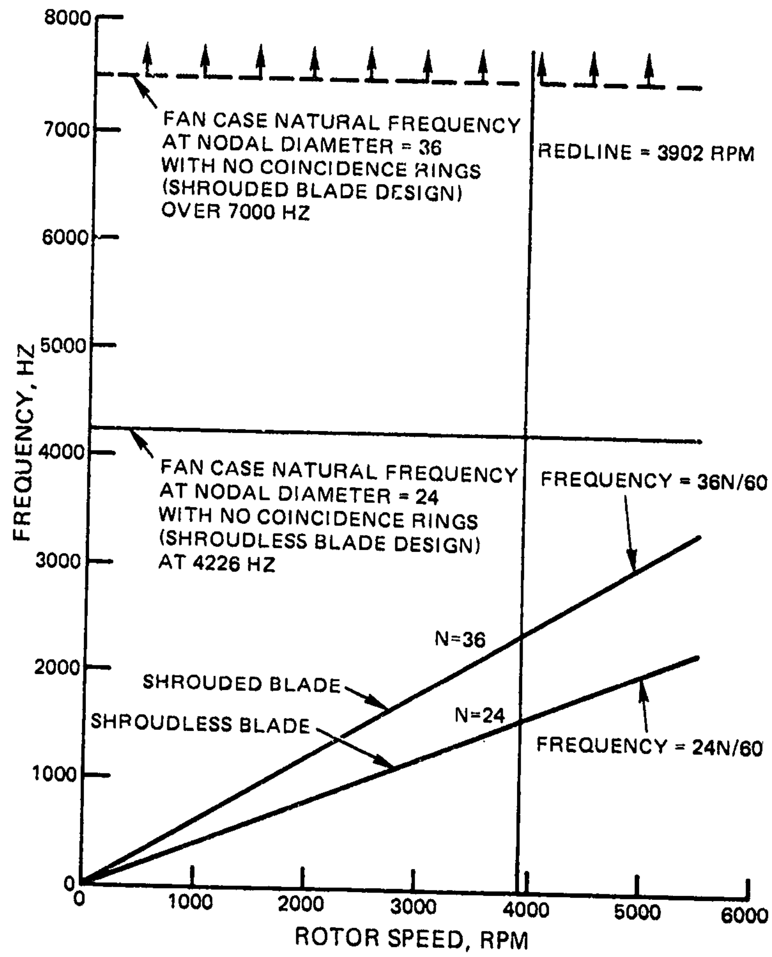


Figure 4.2.4-9 Comparison of Shrouded and Shroudless Fan Blade Passing Resonance

4.2.6 Blade Tip Gap

The blade radial tip clearance status is shown in Table 4.2.6-I. Factors that affect clearances are listed in Table 4.2.6-II, and Table 4.2.6-III identifies factors that are permitted to rub in.

The cold gaps are established to position the blade tip line-on-line with the theoretical flowpath at the aerodynamic design point. The mating rub strip has a shallow trench installed to allow for normal operating excursions, rotor whirl, maneuver, and cowl loading. The blade tip clearance was established, assuming 50 percent cowl load sharing. Tolerances will be permitted to rub in. The tip clearance values shown are to the bottom of this trench.

TABLE 4.2.6-I
BLADE TIP CLEARANCES

Condition	Clearance cm (in.)
Aerodynamic design point	0.139 (0.055)
Sea level take-off-Transient	0.088 (0.035)
Sea level take-off-Steady State	0.152 (0.060)
Cold	0.317 (0.125)

TABLE 4.2.6-II
FACTORS AFFECTING TIP CLEARANCE

Factor	Required increase in Tip Clearance cm (in.)
Rotor Whirl	0.005 (0.002)
Maneuver (sea level take-off)	0.045 (0.018)
Pinch	0.050 (0.020)
Cowl Load	0.038 (0.015)
Total	0.139 (0.055)

TABLE 4.2.6-III
CLEARANCES THAT WILL RUB IN

Factor	Clearance cm (in.)
Tolerances	0.025 (0.010)
Case Ovalization	0.000 (0)
Total	0.025 (0.010)

4.2.7 Component Weight Summary

A weight analysis was performed for the integrated core/low spool for both fan configurations. A summary of the component weight by major subassembly as designed is presented in Table 4.2.7-I. These weights do not reflect future Flight Propulsion System values. Flight component weight will be presented in the Propulsion System Final Design and Analysis Update in 1984.

TABLE 4.2.7-I
WEIGHT SUMMARY

	Shroudless kgs(lbs)	Shrouded kgs(lbs)
Blades	242 (535.2)	175 (387.6)
Fan Hub	184 (405.8)	117 (258.3)
Stubshaft	64 (141.7)	64 (141.7)
De-oiler	1 (3.9)	1 (3.9)
Nose Cone/Attachment Hardware	29 (65.8)	29 (65.8)
Fan Containment Case (Front and Rear)	1,637 (3610.5)	1,711 (3774.2)
Totals	2,160 (4762.9)	2,100 (4631.5)

SECTION 5.0
CONCLUDING REMARKS

The fan component designed for the Energy Efficient Engine capitalizes on the technology advancements in aerodynamics and structure-mechanics to provide a high-performance system. On the basis of results from design analyses, the fan meets or exceeds performance, durability and structural integrity goals.

The design analyses corroborate the perfomance superiority of a hollow, shroudless blade concept. However, considerable development is required in manufacturing technology to produce a viable component. This technology may be available for a far term flight propulsion system.

Overall, the technology incorporated in the Energy Efficient Engine fan will have wide application. Much of this technology is applicable to next generation gas-turbine engines as well as advanced derivatives of current commercial engines.

REFERENCES

1. Norton, J. M., Tari, U., and Weber, R.M.: "Rotor Redesign for a Highly Loaded 1800 ft/sec Tip Speed Fan - I. Aerodynamic and Mechanical Design," NASA CR-159596, PWA-5523-42, 1979.

2. Bolt, C. R., Lee, D., and McDonald, P. W.: "Rotor Redesign for a Highly Loaded 1800 ft/sec Tip Speed Fan - II. Final Performance Report," NASA-5523-92, PWA-5523-92, 1980.

Appendix A
Aerodynamic Summary

SL	V_1 M/S	V_2 M/S	V_{m1} M/S	V_{m2} M/S	$V_{\theta 1}$ M/S	$V_{\theta 2}$ M/S	U_1 M/S	U_2 M/S	V'_1 M/S	V'_2 M/S	$V_{\theta}'_1$ M/S	$V_{\theta}'_2$ M/S	$\rho_1 V_{m1}$ KG/M²-S	$\rho_2 V_{m2}$ KG/M²-S	ϵ_1 RAD	ϵ_2 RAD	PO/PO INLET
1	193.7	303.1	193.7	152.8	0.0	261.8	154.8	186.5	247.9	170.3	-154.8	75.3	200.67	182.30	0.4237	0.4239	1.6396
2	191.4	283.3	191.4	160.3	0.0	233.5	167.8	198.0	254.5	164.2	-167.8	35.5	199.08	198.89	0.4164	0.4063	1.6146
3	192.5	267.7	192.5	164.0	0.0	211.6	182.9	210.6	265.6	164.0	-182.9	1.0	199.90	209.95	0.3969	0.3749	1.6017
4	196.1	257.2	196.1	165.4	0.0	197.0	197.8	222.6	278.5	167.4	-197.8	-25.7	202.30	216.89	0.3618	0.3361	1.6006
5	200.8	250.2	200.8	165.1	0.0	188.0	211.7	234.0	291.8	171.4	-211.7	-46.1	205.36	220.78	0.3202	0.3062	1.6089
6	213.4	246.1	213.4	165.1	0.0	182.5	247.7	264.4	327.0	184.3	-247.7	-81.9	213.01	230.02	0.2328	0.2380	1.6779
7	226.4	249.2	226.4	171.2	0.0	181.0	313.1	319.9	386.4	220.5	-313.1	-138.9	219.99	251.98	0.1166	0.1070	1.8223
8	229.5	243.9	229.5	170.2	0.0	174.6	340.4	343.3	410.5	239.7	-340.4	-168.7	221.48	253.23	0.0670	0.0665	1.8310
9	229.3	239.5	229.3	168.2	0.0	170.5	371.4	370.9	436.4	261.6	-371.4	-200.4	221.38	249.90	0.0197	-0.0460	1.8273
10	222.1	228.4	222.1	176.5	0.0	145.0	414.4	408.5	470.2	317.1	-414.4	-263.5	217.78	261.20	-0.0633	-0.1147	1.7680
11	217.1	223.0	217.1	173.8	0.0	139.8	426.2	418.8	478.3	328.8	-426.2	-279.1	215.09	255.31	-0.0672	-0.1341	1.7357
12	211.0	219.3	211.0	170.5	0.0	137.9	437.9	429.2	486.1	337.5	-437.9	-291.3	211.60	246.80	-0.0775	-0.1556	1.7024
13	192.9	220.3	192.9	168.4	0.0	142.0	456.9	446.3	496.0	347.8	-456.9	-304.3	200.11	233.35	-0.1504	-0.1435	1.6482

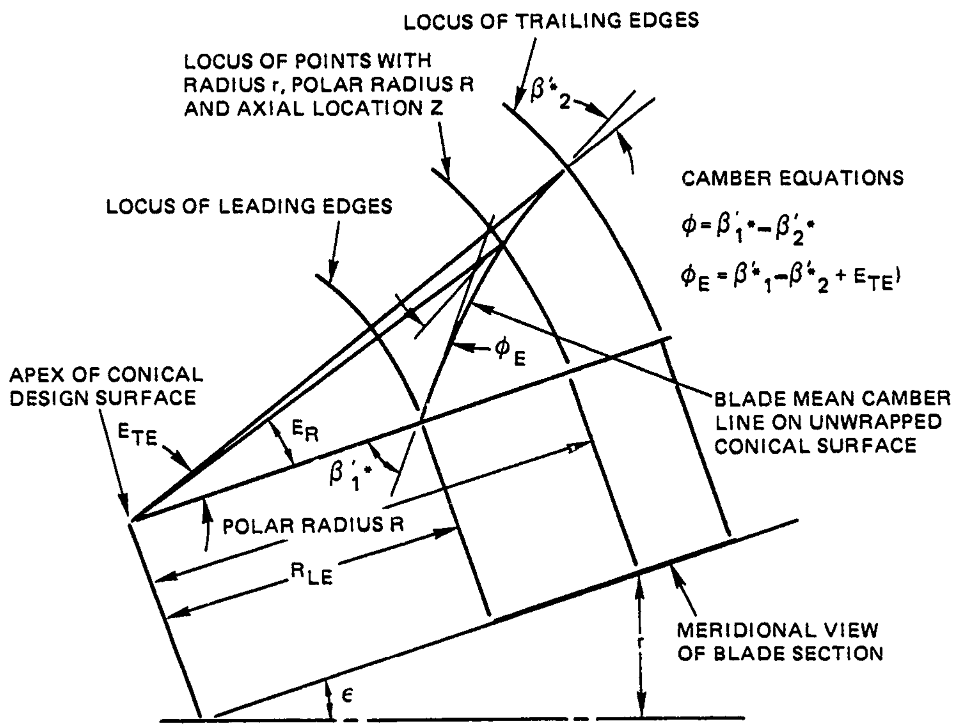
SL	V_1 FT/S	V_2 FT/S	V_{m1} FT/S	V_{m2} FT/S	$V_{\theta 1}$ FT/S	$V_{\theta 2}$ FT/S	U_1 FT/S	U^2 FT/S	V'_1 FT/S	V'_2 FT/S	$V_{\theta}'_1$ FT/S	$V_{\theta}'_2$ FT/S	$\rho_1 V_{m1}$ LBM/FT²-S	$\rho_2 V_{m2}$ LBM/FT²-S	ϵ_1 DEG	ϵ_2 DEG	TE SPAN PERCENT
1	635.4	994.6	635.4	501.3	0.0	859.0	507.7	612.0	813.4	558.9	-507.7	247.1	41.10	37.34	24.276	24.286	0.0000
2	627.8	929.4	627.8	526.0	0.0	766.2	550.6	649.8	835.1	538.8	-550.6	116.4	40.77	40.73	23.858	23.393	0.0444
3	631.7	878.4	631.7	538.1	0.0	694.3	600.2	691.0	871.4	538.1	-600.2	3.3	40.94	43.00	22.739	21.479	0.0927
4	643.4	843.9	643.4	542.7	0.0	646.2	648.9	730.5	913.8	549.2	-648.9	-84.3	41.43	44.42	20.727	19.255	0.1390
5	658.8	820.9	658.8	541.7	0.0	616.7	694.6	767.9	957.4	562.4	-694.6	-151.1	42.06	45.22	18.349	17.542	0.1829
6	700.2	807.5	700.2	541.8	0.0	598.7	812.7	867.5	1072.7	604.8	-812.7	-268.8	43.63	47.11	13.337	13.639	0.2997
7	743.0	817.5	743.0	561.7	0.0	594.0	1027.3	1049.7	1267.8	723.4	-1027.3	-455.8	45.06	51.61	6.678	6.131	0.5136
8	752.9	800.1	752.9	558.6	0.0	572.9	1116.7	1126.3	1346.8	786.3	-1116.7	-553.4	45.36	51.86	3.839	3.810	0.6034
9	752.2	785.9	752.2	551.9	0.0	559.5	1218.5	1217.1	1432.0	858.5	-1218.5	-657.5	45.34	51.18	1.131	-2.636	0.7099
10	728.8	749.5	728.8	579.1	0.0	475.8	1359.6	1340.3	1542.6	1040.5	-1359.6	-864.4	44.00	53.50	-3.626	-6.570	0.8544
11	712.4	731.7	712.4	570.2	0.0	458.6	1398.4	1374.2	1569.4	1078.7	-1398.4	-915.7	44.05	52.29	-3.853	-7.685	0.8942
12	692.2	719.4	692.2	559.2	0.0	452.5	1436.8	1408.3	1594.8	1107.4	-1436.8	-955.8	43.34	50.55	-4.441	-8.915	0.9342
13	632.8	722.7	632.8	552.4	0.0	466.0	1499.2	1464.4	1627.3	1141.1	-1499.2	-998.4	40.98	47.79	-8.619	-8.220	1.0000

SL	β_1 DEG	β_2 DEG	β'_1 DEG	β'_2 DEG	M_1	M_2	M'_1	M_2	i_{ss} DEG	i_m DEG	δ^* DEG	$\beta'_1-\beta'_2$ DEG	D	$\bar{\omega}$ TOTAL	$\bar{\omega}\cos\beta'_2/2\sigma$ TOTAL	PO2/PO1	η_a TOTAL percent	η_p TOTAL percent
1	0.0	59.7	38.63	-26.24	0.5884	0.8864	0.7532	0.4981	0.82	6.71	1.47	64.86	0.5353	0.1693	0.0292	1.6396	89.95	90.62
2	0.0	55.6	41.41	-12.51	0.5809	0.8233	0.7726	0.4775	1.26	6.40	8.26	53.92	0.5585	0.1272	0.0255	1.6146	91.80	92.34
3	0.0	52.2	43.80	0.35	0.5847	0.7752	0.8066	0.4748	0.75	5.28	10.18	44.15	0.5696	0.0906	0.0199	1.6017	93.57	93.93
4	0.0	49.9	45.43	8.80	0.5963	0.7422	0.8469	0.4830	0.23	4.33	10.45	36.63	0.5735	0.0652	0.0150	1.6006	94.95	95.28
5	0.0	48.6	46.56	15.54	0.6116	0.7196	0.8888	0.4931	0.05	3.83	10.53	31.02	0.5787	0.0511	0.0121	1.6089	95.76	96.04
6	0.0	47.8	49.12	26.31	0.6532	0.7019	1.0008	0.5257	0.28	3.49	10.11	22.82	0.5961	0.0483	0.0120	1.6779	95.61	95.92
7	0.0	46.6	54.13	39.03	0.6969	0.7006	1.1892	0.6199	2.03	4.44	9.25	15.10	0.5852	0.0661	0.0169	1.8223	93.47	93.99
8	0.0	45.8	56.04	44.76	0.7071	0.6821	1.2649	0.6704	2.01	4.36	7.77	11.28	0.5642	0.0853	0.0210	1.8310	91.09	91.81
9	0.0	45.4	58.32	50.02	0.7064	0.6655	1.3448	0.7269	1.80	4.70	5.52	8.29	0.5424	0.1287	0.0300	1.8273	86.00	87.13
10	0.0	39.4	61.69	56.17	0.6823	0.6361	1.4443	0.8830	1.12	3.28	2.19	5.32	0.4415	0.1091	0.0230	1.7680	86.38	87.42
11	0.0	38.7	62.80	58.03	0.6656	0.6205	1.4663	0.9147	0.98	3.02	1.56	4.77	0.4233	0.1212	0.0245	1.7357	84.36	85.52
12	0.0	38.9	63.98	59.57	0.6451	0.6086	1.4864	0.9369	1.10	2.88	0.75	4.41	0.4136	0.1505	0.0293	1.7024	80.26	81.68
13	0.0	39.7	66.81	60.66	0.5857	0.6078	1.5064	0.9596	2.11	3.31	-1.50	6.15	0.4085	0.2307	0.0438	1.6482	70.08	72.09

WC1/A1, kg/s-m² (lbm/s-ft²)	203.77 (42.78)	TO/TO INLET	1.1951
PO/PO INLET	1.7496	η_{AD} INLET, percent	88.81
η_p INLET, percent	89.65	TO2/TO1	1.1951
PO2/PO1	1.7496	η_{AD} ROTOR, percent	88.81
η_p ROTOR, percent	89.65		

APPENDIX B
GEOMETRY SUMMARY

KEY TO TERMINOLOGY



Geometry Summary

SHROUDLESS FAN, 24 BLADES

S.I. UNITS : METERS (M) AND RADIANS (RAD)

D_1 (M)	D_2 (M)	Percent Span LE	C (M)	Cf (M)	LER (MM)	TER (MM)	β_1^* (RAD)	β_2^* (RAD)	ϕ_E (RAD)	ϕ_{EF} (RAD)	ϵ (RAD)	A/C	σ
0.702[illegible]	0.9146	0.0	0.2595	0.0519	1.0338	1.1938	0.5850	-0.3907	0.9443	0.1350	0.4238	0.5060	2.4516
0.7321	0.9364	2.2	0.2610	0.0547	1.0312	1.1887	0.6093	-0.3436	0.9139	0.1350	0.4074	0.5069	2.3901
0.7607	0.9572	4.3	0.2627	0.0579	1.0287	1.1811	0.6280	-0.2719	0.8531	0.1350	0.3916	0.5074	2.3370
0.8149	0.9967	8.2	0.2660	0.0637	1.0236	1.0668	0.6581	-0.1273	0.7266	0.1315	0.3638	0.5079	2.2437
0.9352	1.0849	17.0	0.2729	0.0760	1.0160	0.9881	0.7156	0.1375	0.5087	0.1175	0.3076	0.5082	2.0544
0.9884	1.1259	21.0	0.2759	0.0817	1.0084	0.9830	0.7372	0.2270	0.4406	0.1103	0.2862	0.5087	1.9940
1.0246	1.1543	23.6	0.2773	0.0854	1.0008	0.9754	0.7505	0.2766	0.4051	0.1020	0.2723	0.5111	1.9432
1.1119	1.2245	30.0	0.2819	0.0944	0.9855	0.9423	0.7761	0.3448	0.3679	0.0795	0.2414	0.5251	1.8433
1.1960	1.2923	36.2	0.2858	0.1032	0.9576	0.9017	0.7962	0.3846	0.3551	0.0513	0.2109	0.5455	1.7544
1.2734	1.3549	41.9	0.2895	0.1113	0.9144	0.8560	0.8133	0.4414	0.3223	0.0283	0.1812	0.5622	1.6827
1.3451	1.4124	47.1	0.2929	0.1187	0.8636	0.8052	0.8290	0.5039	0.2825	0.0125	0.1530	0.5766	1.6223
1.4122	1.4668	52.0	0.2964	0.1258	0.8077	0.7595	0.8426	0.5644	0.2424	-0.0042	0.1270	0.5922	1.5731
1.4752	1.5186	56.7	0.2999	0.1323	0.7544	0.7163	0.8528	0.6215	0.2020	-0.0183	0.1029	0.6076	1.5305
1.5349	1.5682	61.0	0.3031	0.1386	0.7036	0.6782	0.8604	0.6784	0.1590	-0.0313	0.0808	0.6250	1.4925
1.5915	1.6160	65.2	0.3063	0.1443	0.6604	0.6426	0.8690	0.7271	0.1248	-0.0337	0.0602	0.6376	1.4588
1.6459	1.6623	69.2	0.3094	0.1499	0.6248	0.6121	0.8827	0.7709	0.1002	-0.0282	0.0408	0.6448	1.4290
1.7086	1.7158	73.8	0.3133	0.1558	0.5867	0.5817	0.9055	0.8167	0.0836	-0.0111	0.0183	0.6432	1.3978
1.7692	1.7631	78.2	0.3173	0.1616	0.5461	0.5410	0.9289	0.8518	0.0816	-0.0057	-0.0159	0.6453	1.3727
1.8286	1.8179	82.6	0.3211	0.1675	0.5359	0.5105	0.9597	0.8914	0.0765	-0.0104	-0.0287	0.6599	1.3452
1.8874	1.8675	86.9	0.3249	0.1732	0.5334	0.4801	1.0008	0.9299	0.0875	-0.0272	-0.0569	0.6877	1.3219
1.9464	1.9177	91.2	0.3290	0.1790	0.5334	0.4572	1.0502	0.9708	0.1059	-0.0539	-0.0894	0.7157	1.3007
1.9960	1.9627	94.9	0.3330	0.1835	0.5334	0.4343	1.0934	1.0245	0.1030	-0.0679	-0.1132	0.7380	1.2853
2.0365	2.0042	97.8	0.3361	0.1872	0.5334	0.4140	1.1224	1.0786	0.0795	-0.0796	-0.1178	0.7655	1.2710
2.0661	2.0472	100.0	0.3383	0.1890	0.5334	0.4013	1.1359	1.1247	0.0331	-0.1138	-0.0723	0.8128	1.2566

U.S. CUSTOMARY UNITS : INCHES (IN) AND DEGREES (DEG)

D_1 (IN)	D_2 (IN)	Percent Span TE	C (IN)	Cf (IN)	LER (IN)	TER (IN)	β_1^* (DEG)	β_2^* (DEG)	ϕ_E (DEG)	ϕ_{EF} (DEG)	$\bar{\epsilon}$ (DEG)	T/C MAX	LOC TMAX Percent C
27.67	36.01	0.0	10.217	2.042	0.0407	0.0470	33.58	-22.39	54.13	7.74	24.28	0.0851	51.3385
28.82	36.87	1.9	10.277	2.154	0.0406	0.0468	34.91	-19.69	52.36	7.74	23.34	0.0847	51.4566
29.95	37.69	3.8	10.344	2.278	0.0405	0.0465	35.98	-15.58	48.88	7.74	22.44	0.0841	51.5685
32.08	39.24	7.2	10.474	2.508	0.0403	0.0420	37.71	-7.29	41.63	7.53	20.85	0.0828	51.8434
36.82	42.71	15.0	10.745	2.994	0.0400	0.0389	41.00	7.88	29.15	6.73	17.63	0.0799	52.4380
38.91	44.33	18.7	10.863	3.217	0.0397	0.0387	42.24	13.01	25.25	6.32	16.40	0.0783	52.7221
40.34	45.45	21.2	10.939	3.363	0.0394	0.0384	43.00	15.85	23.21	5.85	15.64	0.0773	52.9129
43.77	48.21	27.4	11.097	3.717	0.0388	0.0371	44.47	19.76	21.08	4.55	13.83	0.0743	53.3771
47.09	50.90	33.4	11.251	4.063	0.0377	0.0355	45.62	22.04	20.35	2.95	12.08	0.0706	53.7981
50.13	53.34	38.9	11.396	4.382	0.0360	0.0337	46.60	25.29	18.47	1.65	10.38	0.0661	54.0588
52.96	55.61	44.0	11.531	4.675	0.0340	0.0317	47.50	28.87	16.19	0.72	8.77	0.0616	54.1509
55.60	57.75	48.8	11.670	4.954	0.0318	0.0299	48.28	32.34	13.89	-0.24	7.28	0.0572	54.1782
58.08	59.79	53.3	11.806	5.208	0.0297	0.0282	48.86	35.61	11.57	-1.05	5.90	0.0531	54.1758
60.43	61.74	57.7	11.934	5.455	0.0277	0.0267	49.30	38.87	9.11	-1.79	4.63	0.0496	54.1519
62.66	63.62	61.9	12.057	5.682	0.0260	0.0253	49.79	41.66	7.15	-1.93	3.45	0.0463	54.0670
64.80	65.44	66.0	12.181	5.900	0.0246	0.0241	50.58	44.17	5.74	-1.62	2.34	0.0433	53.9441
67.27	67.55	70.7	12.335	6.132	0.0231	0.0229	51.88	46.79	4.79	-0.63	1.05	0.0402	53.7758
69.65	69.41	74.9	12.493	6.363	0.0215	0.0213	53.22	48.81	4.67	-0.33	-0.91	0.0369	53.5344
71.99	71.57	79.8	12.640	6.596	0.0211	0.0201	54.99	51.07	4.38	-0.60	-1.65	0.0342	53.2740
74.31	73.52	84.1	12.790	6.819	0.0210	0.0189	57.34	53.28	5.02	-1.56	-3.26	0.0318	52.9402
76.63	75.50	88.6	12.951	7.045	0.0210	0.0180	60.17	55.62	6.07	-3.09	-5.12	0.0295	52.5640
78.58	77.27	92.5	13.111	7.226	0.0210	0.0171	62.65	58.70	5.90	-3.89	-6.49	0.0276	52.2811
80.18	78.91	96.2	13.233	7.371	0.0210	0.0163	64.31	61.80	4.55	-4.56	-6.75	0.0262	52.0538
81.34	80.60	100.0	13.319	7.443	0.0210	0.0158	65.08	64.44	1.90	-6.52	-4.14	0.0252	51.9146

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Geometry Summary

SHROUDED FAN, 36 BLADES

S.I. UNITS : METERS (M) AND RADIANS (RAD)

D_1 (M)	D_2 (M)	Percent Span LE	C (M)	Cf (M)	LER (MM)	TER (MM)	β_1^* (RAD)	β_2^* (RAD)	ϕ_E (RAD)	ϕ_{EF} (RAD)	τ (RAD)	A/C	σ
0.7030	0.8470	0.0	0.1755	0.03310	.5461	0.4648	0.5585	-0.4739	1.0277	0.1484	0.4237	0.5041	2.5947
0.7331	0.8742	2.2	0.1761	0.0352	0.5461	0.4648	0.5856	-0.4256	0.9939	0.1544	0.4143	0.5044	2.5113
0.7623	0.8994	4.3	0.1764	0.0371	0.5461	0.4648	0.6127	-0.3372	0.9459	0.1584	0.4035	0.5045	2.4331
0.8307	0.9560	9.3	0.1774	0.0418	0.5461	0.4648	0.6737	-0.1786	0.8149	0.1604	0.3741	0.5049	2.2758
0.8976	1.0102	14.2	0.1784	0.0464	0.5461	0.4648	0.7133	-0.0249	0.6939	0.1540	0.3437	0.5059	2.1435
0.9605	1.0616	18.8	0.1794	0.0507	0.5461	0.4648	0.7463	0.0900	0.6101	0.1414	0.3157	0.5087	2.0325
1.0279	1.1179	23.8	0.1806	0.0553	0.5461	0.4648	0.7698	0.1840	0.5391	0.1009	0.2891	0.5220	1.9294
1.1231	1.1985	30.7	0.1824	0.0619	0.5436	0.4648	0.7967	0.2832	0.4702	0.0646	0.2510	0.5394	1.8008
1.2054	1.2690	36.8	0.1842	0.0675	0.5309	0.4521	0.8125	0.3477	0.4200	0.0365	0.2165	0.5561	1.7062
1.2813	1.3336	42.3	0.1862	0.0727	0.5156	0.4343	0.8282	0.4014	0.3941	0.0112	0.1825	0.5727	1.6315
1.3522	1.3936	47.5	0.1882	0.0775	0.5004	0.4191	0.8482	0.4589	0.3622	-0.0019	0.1483	0.5898	1.5736
1.4188	1.4500	52.4	0.1903	0.0821	0.4953	0.4140	0.8673	0.5200	0.3262	-0.0158	0.1145	0.6084	1.5200
1.4821	1.5038	57.0	0.1925	0.0864	0.4928	0.4115	0.8857	0.5827	0.2877	-0.0268	0.0818	0.6266	1.4775
1.5423	1.5556	61.4	0.1950	0.0905	0.4928	0.4115	0.9020	0.6456	0.2467	-0.0277	0.0512	0.6376	1.4426
1.6000	1.6063	65.6	0.1978	0.0945	0.4928	0.4115	0.9174	0.6997	0.2132	0.0104	0.0239	0.6156	1.4134
1.6557	1.6580	69.7	0.2003	0.0983	0.4928	0.4115	0.9280	0.7535	0.1729	0.0826	0.0083	0.4695	1.3852
1.6829	1.6804	71.7	0.2020	0.1001	0.4928	0.4115	0.9358	0.7761	0.1614	0.0890	-0.0094	0.4500	1.3767
1.7097	1.7038	73.6	0.2035	0.1020	0.4928	0.4115	0.9436	0.7992	0.1487	0.0555	-0.0228	0.5199	1.3665
1.7674	1.7549	77.9	0.2071	0.1059	0.4928	0.4115	0.9709	0.8489	0.1315	0.0213	-0.0507	0.6154	1.3475
1.8233	1.8036	82.0	0.2109	0.1097	0.4928	0.4115	0.9954	0.8953	0.1160	0.0120	-0.0830	0.6531	1.3326
1.8780	1.8511	86.0	0.2148	0.1135	0.4928	0.4115	1.0195	0.9422	0.1001	-0.0074	-0.1172	0.6755	1.3193
1.9315	1.8982	89.9	0.2187	0.1171	0.4928	0.4115	1.0433	0.9859	0.0869	-0.0095	-0.1501	0.6901	1.3089
1.9841	1.9455	93.7	0.2231	0.1207	0.4928	0.4115	1.0664	1.0270	0.0749	-0.0079	-0.1795	0.7074	1.3012
2.0317	1.9890	97.2	0.2272	0.1240	0.4928	0.4115	1.0885	1.0611	0.0680	-0.0068	-0.2042	0.7294	1.2950
2.0699	2.0235	100.0	0.2303	0.1266	0.4928	0.4115	1.1085	1.0856	0.0684	-0.0080	-0.2280	0.7479	1.2893

U.S. CUSTOMARY UNITS : INCHES (IN) AND DEGREES (DEG)

D_1 (IN)	D_2 (IN)	Percent Span TE	C (IN)	Cf (IN)	LER (IN)	TER (IN)	β_1^* (DEG)	β_2^* (DEG)	ϕ_E (DEG)	ϕ_{EF} (DEG)	τ (DEG)	T/C MAX	LOC TMAX Percent C
27.68	33.35	0.0	6.909	1.303	0.0215	0.0183	32.00	-27.30	58.88	8.50	24.28	0.0950	52.0024
28.86	34.42	2.3	6.935	1.384	0.0215	0.0183	33.55	-24.38	56.95	8.85	23.74	0.0898	52.1992
30.01	35.41	4.4	6.945	1.462	0.0215	0.0183	35.11	-20.46	54.19	9.07	23.12	0.0845	52.5376
32.70	37.64	9.3	6.985	1.647	0.0215	0.0183	38.60	-10.24	46.69	9.19	21.43	0.0749	52.8340
35.34	39.77	13.9	7.025	1.827	0.0215	0.0183	41.15	-1.43	40.04	8.82	19.69	0.0676	53.2715
37.81	41.80	18.2	7.061	1.997	0.0215	0.0183	42.76	5.16	34.96	8.10	18.09	0.0619	53.6847
40.47	44.01	23.0	7.111	2.179	0.0215	0.0183	44.11	10.54	30.89	5.78	16.56	0.0566	54.1273
44.22	47.19	29.9	7.182	2.436	0.0214	0.0183	45.65	16.23	26.94	3.70	14.38	0.0509	54.7416
47.46	49.96	35.9	7.253	2.658	0.0209	0.0178	46.55	19.92	24.44	2.09	12.41	0.0469	55.2535
50.45	52.51	41.4	7.330	2.862	0.0203	0.0171	47.45	23.00	22.58	0.64	10.46	0.0439	55.7550
53.24	54.86	46.5	7.410	3.053	0.0197	0.0165	48.60	26.29	20.75	-0.11	8.50	0.0413	56.2077
55.86	57.09	51.3	7.491	3.233	0.0195	0.0163	49.69	29.79	18.69	-0.90	6.56	0.0393	56.6339
58.35	59.20	55.8	7.579	3.403	0.0194	0.0162	50.74	33.38	16.49	-1.54	4.69	0.0382	57.0339
60.72	61.25	60.2	7.677	3.564	0.0194	0.0162	51.68	36.99	14.14	-1.59	2.93	0.0375	57.4273
62.99	63.24	64.5	7.786	3.720	0.0194	0.0162	52.56	40.09	12.22	0.60	1.37	0.0385	57.8018
65.18	65.28	68.9	7.885	3.869	0.0194	0.0162	53.17	43.17	9.91	4.73	0.50	0.0434	58.1349
66.25	66.16	70.8	7.954	3.943	0.0194	0.0162	53.62	44.47	9.25	5.10	-0.54	0.0440	58.3407
67.31	67.08	72.8	8.013	4.015	0.0194	0.0162	54.07	45.79	8.52	3.18	-1.30	0.0432	58.5096
69.58	69.09	77.2	8.154	4.170	0.0194	0.0162	55.63	48.64	7.54	1.22	-2.90	0.0378	58.8614
71.79	71.01	81.3	8.304	4.320	0.0194	0.0162	57.03	51.30	6.65	0.69	-4.75	0.0354	59.2397
73.94	72.88	85.3	8.455	4.467	0.0194	0.0162	58.41	53.99	5.73	-0.42	-6.72	0.0334	59.5912
76.04	74.73	89.4	8.611	4.611	0.0194	0.0162	59.78	56.49	4.98	-0.54	-8.60	0.0315	59.9389
78.11	76.59	93.4	8.784	4.753	0.0194	0.0162	61.10	58.34	4.29	-0.45	-10.28	0.0284	60.2833
79.99	78.31	97.1	8.944	4.881	0.0194	0.0162	62.37	60.80	3.90	-0.39	-11.70	0.0250	60.5964
81.49	79.67	100.0	9.067	4.936	0.0194	0.0162	63.51	62.20	3.92	-0.46	-13.06	0.0218	60.8495

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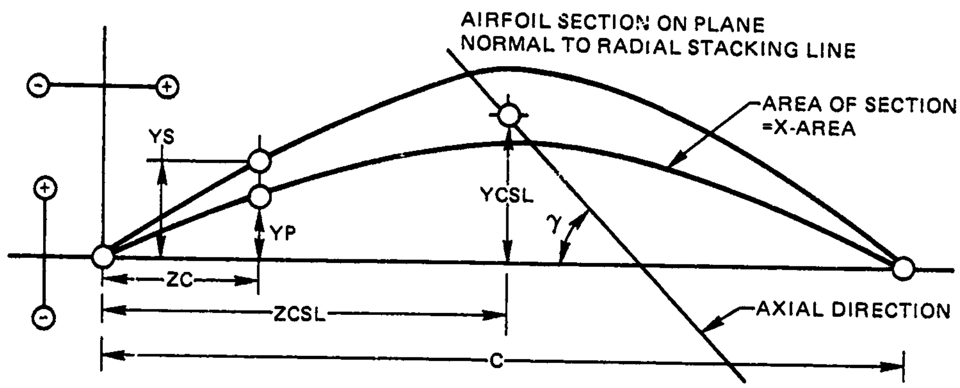
APPENDIX C
FAN BLADE COORDINATES
(under load at the aerodynamic design point)

KEY TO TERMINOLOGY



Appendix C
Fan Blade Coordinates
(under load at the aerodynamic design point)

Shroudless Fan

METERS			INCHES		
ZC	YP	YS	ZC	YP	YS
0.0	-0.0011	0.0014	0.0	-0.0433	0.0552
0.0073	0.0045	0.0100	0.2858	0.1753	0.3945
0.0145	0.0097	0.0180	0.5717	0.3824	0.7079
0.0218	0.0146	0.0253	0.8575	0.5756	0.9956
0.0290	0.0192	0.0320	1.1433	0.7553	1.2594
0.0363	0.0234	0.0381	1.4291	0.9217	1.4996
0.0436	0.0273	0.0436	1.7149	1.0745	1.7151
0.0508	0.0308	0.0484	2.0008	1.2127	1.9046
0.0581	0.0340	0.0526	2.2866	1.3366	2.0708
0.0653	0.0367	0.0563	2.5724	1.4464	2.2151
0.0726	0.0392	0.0594	2.8582	1.5423	2.3384
0.0799	0.0413	0.0620	3.1440	1.6240	2.4418
0.0871	0.0430	0.0642	3.4299	1.6916	2.5258
0.0944	0.0443	0.0658	3.7157	1.7447	2.5901
0.1016	0.0453	0.0669	4.0015	1.7835	2.6353
0.1089	0.0459	0.0676	4.2873	1.8079	2.6612
0.1162	0.0462	0.0678	4.5732	1.8171	2.6676
0.1234	0.0460	0.0674	4.8590	1.8111	2.6545
0.1307	0.0455	0.0666	5.1448	1.7896	2.6215
0.1379	0.0445	0.0652	5.4306	1.7526	2.5678
0.1452	0.0432	0.0633	5.7164	1.6995	2.4931
0.1525	0.0414	0.0609	6.0023	1.6297	2.3968
0.1597	0.0392	0.0579	6.2881	1.5429	2.2782
0.1670	0.0365	0.0543	6.5739	1.4388	2.1366
0.1742	0.0335	0.0501	6.8597	1.3172	1.9710
0.1815	0.0299	0.0452	7.1456	1.1778	1.7806
0.1888	0.0259	0.0397	7.4314	1.0194	1.5649
0.1960	0.0214	0.0336	7.7172	0.8422	1.3233
0.2033	0.0164	0.0268	8.0030	0.6458	1.0552
0.2105	0.0109	0.0193	8.2888	0.4303	0.7595
0.2178	0.0050	0.0111	8.5747	0.1959	0.4351
0.2251	-0.0015	0.0021	8.8605	-0.0588	0.0809

Radius, m (in.)	=	0.3498	(13.7713)
Chord, m (in.)	=	0.2251	(8.8605)
ZCSL, m (in.)	=	0.1104	(4.3450)
YCSL, m (in.)	=	0.0455	(1.7910)
Leading edge radius, m (in.)	=	0.000996	(0.0392)
Trailing edge radius, m (in.)	=	0.001311	(0.0516)
X-area, m^2 ($in.^2$)	=	0.003619	(5.6092)
Gamma, deg. (rad.)	=	-6.27	(-0.1094)

Fan Blade Coordinates (under load at the aerodynamic design point)

METERS			INCHES		
ZC	YP	YS	ZC	YP	YS
0.0	-0.0011	0.0013	0.0	-0.0422	0.0529
0.0073	0.0042	0.0095	0.2882	0.1653	0.3745
0.0146	0.0092	0.0171	0.5764	0.3625	0.6729
0.0220	0.0139	0.0241	0.8646	0.5463	0.9473
0.0293	0.0182	0.0305	1.1528	0.7171	1.1996
0.0366	0.0222	0.0363	1.4410	0.8752	1.4310
0.0439	0.0259	0.0417	1.7291	1.0216	1.6425
0.0512	0.0294	0.0465	2.0173	1.1563	1.8314
0.0586	0.0325	0.0508	2.3055	1.2782	1.9987
0.0659	0.0352	0.0545	2.5937	1.3869	2.1450
0.0732	0.0377	0.0577	2.8819	1.4828	2.2715
0.0805	0.0398	0.0604	3.1701	1.5656	2.3790
0.0878	0.0415	0.0627	3.4583	1.6353	2.4678
0.0952	0.0430	0.0645	3.7465	1.6915	2.5382
0.1025	0.0440	0.0658	4.0346	1.7341	2.5903
0.1098	0.0448	0.0666	4.3228	1.7629	2.6238
0.1171	0.0452	0.0670	4.6110	1.7776	2.6386
0.1244	0.0451	0.0669	4.8992	1.7774	2.6342
0.1318	0.0448	0.0663	5.1874	1.7622	2.6103
0.1391	0.0440	0.0652	5.4756	1.7317	2.5662
0.1464	0.0428	0.0635	5.7638	1.6853	2.5010
0.1537	0.0412	0.0613	6.0520	1.6223	2.4139
0.1610	0.0392	0.0585	6.3402	1.5421	2.3041
0.1684	0.0367	0.0551	6.6284	1.4440	2.1704
0.1757	0.0337	0.0511	6.9165	1.3277	2.0113
0.1830	0.0303	0.0464	7.2047	1.1927	1.8257
0.1903	0.0264	0.0410	7.4929	1.0375	1.6123
0.1976	0.0219	0.0348	7.7811	0.8619	1.3696
0.2050	0.0169	0.0279	8.0693	0.6652	1.0968
0.2123	0.0114	0.0201	8.3575	0.4471	0.7915
0.2196	0.0053	0.0115	8.6457	0.2073	0.4518
0.2269	-0.0014	0.0019	8.9339	-0.0558	0.0760

Radius, m (in.)	=	0.3693	(14.5402)
Chord, m (in.)	=	0.2269	(8.9339)
ZCSL, m (in.)	=	0.1136	(4.4717)
YCSL, m (in.)	=	0.0444	(1.7493)
Leading edge radius, m (in.)	=	0.000991	(0.0390)
Trailing edge radius, m (in.)	=	0.001219	(0.0480)
X-area, m^2 ($in.^2$)	=	0.003680	(5.7038)
Gamma, deg. (rad.)	=	-2.76	(-0.0482)

Fan Blade Coordinates (under load at the aerodynamic design point)

METERS			INCHES		
ZC	YP	YS	ZC	YP	YS
0.0	-0.0010	0.0013	0.0	-0.0412	0.0506
0.0074	0.0039	0.0090	0.2907	0.1532	0.3525
0.0148	0.0086	0.0162	0.5814	0.3395	0.6364
0.0222	0.0131	0.0229	0.8721	0.5154	0.9005
0.0295	0.0173	0.0291	1.1628	0.6807	1.1460
0.0369	0.0212	0.0349	1.4534	0.8360	1.3745
0.0443	0.0249	0.0403	1.7441	0.9810	1.5857
0.0517	0.0283	0.0451	2.0348	1.1139	1.7747
0.0591	0.0313	0.0493	2.3255	1.2335	1.9416
0.0665	0.0340	0.0530	2.6162	1.3398	2.0872
0.0738	0.0364	0.0562	2.9069	1.4329	2.2133
0.0812	0.0385	0.0590	3.1976	1.5139	2.3211
0.0886	0.0402	0.0613	3.4882	1.5838	2.4123
0.0960	0.0417	0.0631	3.7789	1.6412	2.4862
0.1034	0.0428	0.0646	4.0696	1.6856	2.5422
0.1108	0.0436	0.0655	4.3603	1.7170	2.5807
0.1181	0.0441	0.0661	4.6510	1.7350	2.6011
0.1255	0.0442	0.0661	4.9417	1.7389	2.6031
0.1329	0.0439	0.0657	5.2324	1.7283	2.5862
0.1403	0.0433	0.0648	5.5231	1.7028	2.5495
0.1477	0.0422	0.0633	5.8137	1.6617	2.4921
0.1551	0.0408	0.0613	6.1044	1.6043	2.4130
0.1624	0.0389	0.0587	6.3951	1.5299	2.3111
0.1698	0.0365	0.0555	6.6858	1.4374	2.1850
0.1772	0.0337	0.0516	6.9765	1.3264	2.0329
0.1846	0.0304	0.0471	7.2672	1.1962	1.8531
0.1920	0.0265	0.0418	7.5579	1.0450	1.6437
0.1994	0.0222	0.0356	7.8485	0.8722	1.4026
0.2067	0.0172	0.0287	8.1392	0.6769	1.1231
0.2141	0.0116	0.0208	8.4299	0.4583	0.8169
0.2215	0.0055	0.0118	8.7206	0.2155	0.4659
0.2289	-0.0014	0.0018	9.0113	-0.0534	0.0721

Radius, m (in.)	=	0.3860	(15.1969)
Chord, m (in.)	=	0.2289	(9.0113)
ZCSL, m (in.)	=	0.1163	(4.5803)
YCSL, m (in.)	=	0.0433	(1.7064)
Leading edge radius, m (in.)	=	0.000986	(0.0388)
Trailing edge radius, m (in.)	=	0.001151	(0.0453)
X-area, m^2 ($in.^2$)	=	0.003729	(5.7796)
Gamma, deg. (rad.)	=	0.33	(0.0057)

Fan Blade Coordinates (under load at the aerodynamic design point)

METERS			INCHES		
ZC	YP	YS	ZC	YP	YS
0.0	-0.0010	0.0012	0.0	-0.0402	0.0485
0.0075	0.0036	0.0084	0.2939	0.1405	0.3300
0.0149	0.0080	0.0151	0.5877	0.3141	0.5959
0.0224	0.0122	0.0215	0.8816	0.4786	0.8452
0.0299	0.0161	0.0274	1.1755	0.6340	1.0785
0.0373	0.0198	0.0329	1.4693	0.7805	1.2971
0.0448	0.0233	0.0381	1.7632	0.9181	1.5017
0.0522	0.0266	0.0429	2.0571	1.0464	1.6890
0.0597	0.0296	0.0472	2.3509	1.1649	1.8577
0.0672	0.0323	0.0510	2.6448	1.2723	2.0071
0.0746	0.0348	0.0543	2.9387	1.3686	2.1385
0.0821	0.0369	0.0572	3.2325	1.4532	2.2519
0.0896	0.0388	0.0596	3.5264	1.5257	2.3478
0.0970	0.0402	0.0616	3.8202	1.5844	2.4250
0.1045	0.0414	0.0631	4.1141	1.6299	2.4843
0.1120	0.0422	0.0642	4.4080	1.6623	2.5260
0.1194	0.0427	0.0648	4.7018	1.6818	2.5500
0.1269	0.0429	0.0650	4.9957	1.6889	2.5571
0.1344	0.0427	0.0647	5.2896	1.6823	2.5461
0.1418	0.0422	0.0639	5.5834	1.6613	2.5161
0.1493	0.0413	0.0626	5.8773	1.6252	2.4661
0.1567	0.0400	0.0608	6.1712	1.5735	2.3948
0.1642	0.0382	0.0584	6.4650	1.5049	2.3011
0.1717	0.0360	0.0555	6.7589	1.4187	2.1832
0.1791	0.0334	0.0518	7.0528	1.3138	2.0392
0.1866	0.0302	0.0474	7.3466	1.1893	1.8668
0.1941	0.0265	0.0423	7.6405	1.0436	1.6636
0.2015	0.0222	0.0362	7.9344	0.8754	1.4267
0.2090	0.0174	0.0293	8.2282	0.6835	1.1535
0.2165	0.0119	0.0213	8.5221	0.4666	0.8395
0.2239	0.0057	0.0122	8.8160	0.2231	0.4800
0.2314	-0.0013	0.0017	9.1098	-0.0505	0.0680

Radius, m (in.)	=	0.4030	(15.8650)
Chord, m (in.)	=	0.2314	(9.1098)
ZCSL, m (in.)	=	0.1192	(4.6924)
YCSL, m (in.)	=	0.0420	(1.6533)
Leading edge radius, m (in.)	=	0.000986	(0.0388)
Trailing edge radius, m (in.)	=	0.001079	(0.0425)
X-area, m^2 ($in.^2$)	=	0.003771	(5.8453)
Gamma, deg. (rad.)	=	3.49	(0.0609)

Fan Blade Coordinates (under load at the aerodynamic design point)

METERS			INCHES		
ZC	YP	YS	ZC	YP	YS
0.0	-0.0010	0.0012	0.0	-0.0397	0.0471
0.0075	0.0034	0.0080	0.2969	0.1319	0.3151
0.0151	0.0076	0.0145	0.5937	0.2975	0.5694
0.0226	0.0116	0.0205	0.8906	0.4554	0.8091
0.0302	0.0154	0.0263	1.1875	0.6046	1.0335
0.0377	0.0189	0.0316	1.4843	0.7431	1.2424
0.0452	0.0222	0.0365	1.7812	0.8731	1.4388
0.0528	0.0253	0.0412	2.0781	0.9948	1.6204
0.0603	0.0281	0.0454	2.3749	1.1079	1.7858
0.0679	0.0308	0.0491	2.6718	1.2117	1.9342
0.0754	0.0332	0.0525	2.9687	1.3059	2.0657
0.0829	0.0353	0.0554	3.2655	1.3900	2.1804
0.0905	0.0372	0.0579	3.5624	1.4633	2.2787
0.0980	0.0387	0.0599	3.8593	1.5251	2.3601
0.1056	0.0400	0.0616	4.1561	1.5746	2.4247
0.1131	0.0409	0.0628	4.4530	1.6117	2.4721
0.1206	0.0415	0.0635	4.7499	1.6353	2.5020
0.1282	0.0418	0.0638	5.0467	1.6448	2.5135
0.1357	0.0417	0.0637	5.3436	1.6403	2.5063
0.1433	0.0412	0.0630	5.6405	1.6216	2.4802
0.1508	0.0404	0.0618	5.9373	1.5891	2.4350
0.1583	0.0391	0.0602	6.2342	1.5412	2.3696
0.1659	0.0375	0.0580	6.5311	1.4770	2.2819
0.1734	0.0354	0.0551	6.8279	1.3955	2.1703
0.1810	0.0329	0.0516	7.1248	1.2955	2.0328
0.1885	0.0299	0.0474	7.4217	1.1758	1.8669
0.1961	0.0263	0.0424	7.7185	1.0349	1.6696
0.2036	0.0221	0.0365	8.0154	0.8711	1.4375
0.2111	0.0173	0.0296	8.3123	0.6829	1.1670
0.2187	0.0119	0.0217	8.6091	0.4686	0.8528
0.2262	0.0057	0.0124	8.9060	0.2258	0.4886
0.2338	-0.0012	0.0017	9.2029	-0.0490	0.0656

Radius, m (in.)	=	0.4165	(16.3994)
Chord, m (in.)	=	0.2338	(9.2029)
ZCSL, m (in.)	=	0.1215	(4.7834)
YCSL, m (in.)	=	0.0408	(1.6075)
Leading edge radius, m (in.)	=	0.000983	(0.0387)
Trailing edge radius, m (in.)	=	0.001046	(0.0412)
X-area, m^2 ($in.^2$)	=	0.003802	(5.8927)
Gamma, deg. (rad.)	=	6.10	(0.1064)

Fan Blade Coordinates (under load at the aerodynamic design point)

METERS			INCHES		
ZC	YP	YS	ZC	YP	YS
0.0	-0.0010	0.0012	0.0	-0.0392	0.0459
0.0076	0.0031	0.0076	0.3000	0.1211	0.2990
0.0152	0.0070	0.0137	0.5999	0.2760	0.5398
0.0229	0.0108	0.0195	0.8999	0.4236	0.7672
0.0305	0.0143	0.0249	1.1998	0.5641	0.9817
0.0381	0.0177	0.0301	1.4998	0.6972	1.1838
0.0457	0.0209	0.0349	1.7997	0.8230	1.3746
0.0533	0.0239	0.0394	2.0997	0.9414	1.5528
0.0610	0.0267	0.0436	2.3996	1.0520	1.7171
0.0686	0.0293	0.0473	2.6996	1.1520	1.8636
0.0762	0.0316	0.0506	2.9995	1.2429	1.9934
0.0838	0.0337	0.0535	3.2995	1.3248	2.1075
0.0914	0.0355	0.0560	3.5994	1.3972	2.2063
0.0990	0.0371	0.0582	3.8994	1.4594	2.2894
0.1067	0.0384	0.0599	4.1993	1.5109	2.3569
0.1143	0.0394	0.0612	4.4993	1.5509	2.4080
0.1219	0.0401	0.0620	4.7992	1.5786	2.4425
0.1295	0.0405	0.0625	5.0992	1.5931	2.4597
0.1371	0.0405	0.0624	5.3992	1.5936	2.4586
0.1448	0.0401	0.0619	5.6991	1.5790	2.4383
0.1524	0.0393	0.0609	5.9991	1.5482	2.3974
0.1600	0.0382	0.0593	6.2990	1.5022	2.3346
0.1676	0.0366	0.0572	6.5990	1.4407	2.2506
0.1752	0.0346	0.0545	6.89[illegible]	1.3638	2.1440
0.1829	0.0323	0.0512	7.1[illegible]	1.2698	2.0140
0.1905	0.0293	0.0471	7.49[illegible]	1.1549	1.8546
0.1981	0.0259	0.0422	7.7988	1.0188	1.6633
0.2057	0.0218	0.0365	8.0987	0.8599	1.4367
0.2133	0.0172	0.0297	8.3987	0.6761	1.1704
0.2209	0.0118	0.0218	8.6986	0.4654	0.8583
0.2286	0.0057	0.0125	8.9986	0.2252	0.4927
0.2362	-0.0012	0.0016	9.2985	-0.0480	0.0642

Radius, m (in.)	=	0.4286	(16.8753)
Chord, m (in.)	=	0.2362	(9.2986)
ZCSL, m (in.)	=	0.1235	(4.8641)
YCSL, m (in.)	=	0.0396	(1.5588)
Leading edge radius, m (in.)	=	0.000988	(0.0389)
Trailing edge radius, m (in.)	=	0.001031	(0.0406)
X-area, m^2 ($in.^2$)	=	0.003828	(5.9341)
Gamma, deg. (rad.)	=	8.39	(0.1465)

Fan Blade Coordinates (under load at the aerodynamic design point)

METERS			INCHES		
ZC	YP	YS	ZC	YP	YS
0.0	-0.0010	0.0011	0.0	-0.0381	0.0434
0.0078	0.0025	0.0067	0.3087	0.0977	0.2653
0.0157	0.0058	0.0121	0.6175	0.2291	0.4777
0.0235	0.0090	0.0172	0.9263	0.3545	0.6790
0.0314	0.0120	0.0221	1.2350	0.4739	0.8696
0.0392	0.0149	0.0267	1.5438	0.5872	1.0497
0.0471	0.0176	0.0310	1.8525	0.6943	1.2198
0.0549	0.0202	0.0350	2.1613	0.7950	1.3797
0.0627	0.0226	0.0389	2.4700	0.8892	1.5295
0.0706	0.0248	0.0423	2.7788	0.9770	1.6669
0.0784	0.0269	0.0455	3.0875	1.0584	1.7904
0.0863	0.0288	0.0483	3.3963	1.1334	1.9007
0.0941	0.0305	0.0507	3.7050	1.2014	1.9975
0.1020	0.0321	0.0529	4.0138	1.2620	2.0810
0.1098	0.0334	0.0546	4.3225	1.3147	2.1510
0.1176	0.0345	0.0561	4.6313	1.3591	2.2072
0.1255	0.0354	0.0571	4.9401	1.3945	2.2496
0.1333	0.0361	0.0578	5.2488	1.4203	2.2774
0.1412	0.0365	0.0582	5.5576	1.4357	2.2901
0.1490	0.0365	0.0581	5.8663	1.4368	2.2870
0.1568	0.0362	0.0575	6.1751	1.4241	2.2637
0.1647	0.0355	0.0564	6.4838	1.3971	2.2211
0.1725	0.0344	0.0548	6.7926	1.3543	2.1577
0.1804	0.0329	0.0526	7.1013	1.2938	2.0710
0.1882	0.0308	0.0497	7.4101	1.2134	1.9584
0.1961	0.0282	0.0461	7.7188	1.1103	1.8158
0.2039	0.0250	0.0416	8.0276	0.9833	1.6383
0.2117	0.0211	0.0361	8.3363	0.8295	1.4223
0.2196	0.0164	0.0294	8.6451	0.6439	1.1580
0.2274	0.0110	0.0214	8.9538	0.4346	0.8416
0.2353	0.0052	0.0122	9.2626	0.2045	0.4795
0.2431	-0.0012	0.0016	9.5714	-0.0470	0.0622

Radius, m (in.)	=	0.4572	(18.0016)
Chord, m (in.)	=	0.2431	(9.5714)
ZCSL, m (in.)	=	0.1282	(5.0467)
YCSL, m (in.)	=	0.0360	(1.4166)
Leading edge radius, m (in.)	=	0.000996	(0.0392)
Trailing edge radius, m (in.)	=	0.001067	(0.0420)
X-area, m^2 (in.^{2})	=	0.003889	(6.0278)
Gamma, deg. (rad.)	=	13.65	(0.2383)

Fan Blade Coordinates (under load at the aerodynamic design point)

METERS			INCHES		
ZC	YP	YS	ZC	YP	YS
0.0	-0.0009	0.0011	0.0	-0.0374	0.0417
0.0081	0.0020	0.0061	0.3171	0.0791	0.2401
0.0161	0.0049	0.0109	0.6343	0.1914	0.4303
0.0242	0.0076	0.0155	0.9514	0.2983	0.6105
0.0322	0.0102	0.0198	1.2685	0.3997	0.7812
0.0403	0.0126	0.0239	1.5857	0.4955	0.9424
0.0483	0.0149	0.0278	1.9028	0.5858	1.0944
0.0564	0.0170	0.0314	2.2199	0.6708	1.2379
0.0644	0.0191	0.0349	2.5370	0.7502	1.3730
0.0725	0.0209	0.0380	2.8542	0.8238	1.4976
0.0806	0.0227	0.0409	3.1713	0.8920	1.6101
0.0886	0.0243	0.0434	3.4884	0.9547	1.7105
0.0967	0.0257	0.0457	3.8056	1.0118	1.7984
0.1047	0.0270	0.0476	4.1227	1.0628	1.8742
0.1128	0.0281	0.0492	4.4398	1.1073	1.9376
0.1208	0.0291	0.0505	4.7570	1.1450	1.9884
0.1289	0.0299	0.0515	5.0741	1.1753	2.0266
0.1369	0.0304	0.0521	5.3912	1.1978	2.0515
0.1450	0.0308	0.0524	5.7084	1.2117	2.0628
0.1530	0.0309	0.0523	6.0255	1.2165	2.0597
0.1611	0.0308	0.0519	6.3426	1.2113	2.0414
0.1692	0.0304	0.0510	6.6597	1.1951	2.0069
0.1772	0.0296	0.0497	6.9769	1.1668	1.9548
0.1853	0.0286	0.0478	7.2940	1.1252	1.8833
0.1933	0.0271	0.0455	7.6111	1.0687	1.7905
0.2014	0.0253	0.0425	7.9283	0.9954	1.6734
0.2094	0.0228	0.0388	8.2454	0.8989	1.5285
0.2175	0.0197	0.0342	8.5625	0.7774	1.3457
0.2255	0.0160	0.0285	8.8797	0.6280	1.1204
0.2336	0.0113	0.0214	9.1968	0.4455	0.8431
0.2417	0.0057	0.0127	9.5139	0.2225	0.4982
0.2497	-0.0012	0.0016	9.8310	-0.0487	0.0631

Radius, m (in.)	=	0.4787	(18.8463)
Chord, m (in.)	=	0.2497	(9.8310)
ZCSL, m (in.)	=	0.1316	(5.1798)
YCSL, m (in.)	=	0.0315	(1.2414)
Leading edge radius, m (in.)	=	0.000998	(0.0393)
Trailing edge radius, m (in.)	=	0.001067	(0.0420)
X-area, m^2 ($in.^2$)	=	0.003916	(6.0694)
Gamma, deg. (rad.)	=	17.91	(0.3125)

Fan Blade Coordinates (under load at the aerodynamic design point)

METERS			INCHES		
ZC	YP	YS	ZC	YP	YS
0.0	-0.0009	0.0010	0.0	-0.0365	0.0399
0.0083	0.0014	0.0053	0.3271	0.0555	0.2092
0.0166	0.0037	0.0095	0.6542	0.1442	0.3724
0.0249	0.0058	0.0134	0.9812	0.2287	0.5272
0.0332	0.0078	0.0171	1.3083	0.3087	0.6740
0.0415	0.0098	0.0206	1.6354	0.3842	0.8127
0.0498	0.0115	0.0240	1.9624	0.4544	0.9430
0.0582	0.0132	0.0270	2.2895	0.5191	1.0648
0.0665	0.0147	0.0299	2.6166	0.5784	1.1789
0.0748	0.0161	0.0326	2.9437	0.6321	1.2842
0.0831	0.0173	0.0350	3.2707	0.6810	1.3795
0.0914	0.0184	0.0372	3.5978	0.7253	1.4640
0.0997	0.0194	0.0390	3.9249	0.7650	1.5371
0.1080	0.0203	0.0406	4.2519	0.7999	1.5990
0.1163	0.0211	0.0419	4.5790	0.8297	1.6497
0.1246	0.0217	0.0429	4.9061	0.8541	1.6890
0.1329	0.0222	0.0436	5.2332	0.8728	1.7168
0.1412	0.0225	0.0440	5.5602	0.8856	1.7326
0.1495	0.0227	0.0441	5.8873	0.8919	1.7363
0.1578	0.0226	0.0439	6.2144	0.8912	1.7273
0.1662	0.0224	0.0433	6.5414	0.8828	1.7048
0.1745	0.0220	0.0424	6.8685	0.8661	1.6682
0.1828	0.0213	0.0411	7.1956	0.8403	1.6164
0.1911	0.0204	0.0393	7.5227	0.8045	1.5482
0.1994	0.0192	0.0371	7.8497	0.7577	1.4617
0.2077	0.0177	0.0344	8.1768	0.6984	1.3552
0.2160	0.0159	0.0311	8.5039	0.6252	1.2257
0.2243	0.0136	0.0272	8.8310	0.5358	1.0698
0.2326	0.0109	0.0224	9.1580	0.4281	0.8827
0.2409	0.0076	0.0167	9.4851	0.2987	0.6576
0.2492	0.0036	0.0098	9.8122	0.1436	0.3851
0.2575	-0.0011	0.0013	10.1392	-0.0419	0.0515

Radius, m (in.)	=	0.5039	(19.8380)
Chord, m (in.)	=	0.2575	(10.1393)
ZCSL, m (in.)	=	0.1354	(5.3318)
YCSL, m (in.)	=	0.0248	(0.9749)
Leading edge radius, m (in.)	=	0.000998	(0.0393)
Trailing edge radius, m (in.)	=	0.001069	(0.0421)
X-area, m^2 ($in.^2$)	=	0.003926	(6.0854)
Gamma, deg. (rad.)	=	23.28	(0.4063)

Fan Blade Coordinates (under load at the aerodynamic design point)

METERS			INCHES		
ZC	YP	YS	ZC	YP	YS
0.0	-0.0009	0.0010	0.0	-0.0359	0.0386
0.0085	0.0009	0.0047	0.3347	0.0359	0.1852
0.0170	0.0027	0.0083	0.6695	0.1047	0.3265
0.0255	0.0043	0.0117	1.0042	0.1698	0.4605
0.0340	0.0059	0.0149	1.3390	0.2312	0.5875
0.0425	0.0073	0.0180	1.6737	0.2886	0.7073
0.0510	0.0087	0.0208	2.0084	0.3419	0.8199
0.0595	0.0099	0.0235	2.3432	0.3909	0.9254
0.0680	0.0111	0.0260	2.6779	0.4353	1.0239
0.0765	0.0121	0.0283	3.0127	0.4760	1.1152
0.0850	0.0130	0.0305	3.3474	0.5129	1.1990
0.0935	0.0139	0.0323	3.6821	0.5457	1.2733
0.1020	0.0146	0.0340	4.0169	0.5747	1.3368
0.1105	0.0152	0.0353	4.3516	0.5998	1.3898
0.1190	0.0158	0.0364	4.6864	0.6207	1.4324
0.1275	0.0162	0.0372	5.0211	0.6374	1.4643
0.1360	0.0165	0.0377	5.3558	0.6493	1.4857
0.1445	0.0167	0.0380	5.6906	0.6561	1.4959
0.1530	0.0167	0.0380	6.0253	0.6578	1.4948
0.1615	0.0166	0.0376	6.3601	0.6540	1.4822
0.1700	0.0164	0.0370	6.6948	0.6445	1.4574
0.1786	0.0160	0.0361	7.0295	0.6287	1.4202
0.1871	0.0154	0.0348	7.3643	0.6062	1.3698
0.1956	0.0146	0.0331	7.6990	0.5765	1.3051
0.2041	0.0137	0.0311	8.0338	0.5389	1.2251
0.2126	0.0125	0.0287	8.3685	0.4926	1.1284
0.2211	0.0111	0.0257	8.7032	0.4367	1.0132
0.2296	0.0094	0.0223	9.0380	0.3699	0.8771
0.2381	0.0074	0.0182	9.3727	0.2909	0.7173
0.2466	0.0050	0.0134	9.7075	0.1979	0.5295
0.2551	0.0023	0.0078	10.0422	0.0889	0.3080
0.2636	-0.0010	0.0011	10.3770	-0.0384	0.0451

Radius, m (in.)	=	0.5276	(20.7702)
Chord, m (in.)	=	0.2636	(10.3769)
ZCSL, m (in.)	=	0.1381	(5.4352)
YCSL, m (in.)	=	0.0197	(0.7742)
Leading edge radius, m (in.)	=	0.000993	(0.0391)
Trailing edge radius, m (in.)	=	0.001067	(0.0420)
X-area, m^2 ($in.^2$)	=	0.003932	(6.0951)
Gamma, deg. (rad.)	=	27.24	(0.4755)

Fan Blade Coordinates (under load at the aerodynamic design point)

METERS			INCHES		
ZC	YP	YS	ZC	YP	YS
0.0	-0.0009	0.0010	0.0	-0.0355	0.0378
0.0086	0.0007	0.0044	0.3397	0.0262	0.1730
0.0173	0.0022	0.0077	0.6793	0.0852	0.3031
0.0259	0.0036	0.0108	1.0190	0.1410	0.4266
0.0345	0.0049	0.0138	1.3586	0.1935	0.5438
0.0431	0.0062	0.0166	1.6983	0.2426	0.6544
0.0518	0.0073	0.0193	2.0380	0.2879	0.7583
0.0604	0.0084	0.0217	2.3776	0.3295	0.8557
0.0690	0.0093	0.0240	2.7173	0.3671	0.9465
0.0776	0.0102	0.0262	3.0569	0.4004	1.0305
0.0863	0.0109	0.0281	3.3966	0.4296	1.1076
0.0949	0.0116	0.0299	3.7363	0.4549	1.1753
0.1035	0.0121	0.0313	4.0759	0.4765	1.2326
0.1122	0.0126	0.0325	4.4156	0.4945	1.2796
0.1208	0.0129	0.0334	4.7552	0.5089	1.3166
0.1294	0.0132	0.0341	5.0949	0.5198	1.3434
0.1380	0.0134	0.0345	5.4346	0.5272	1.3601
0.1467	0.0135	0.0347	5.7742	0.5310	1.3665
0.1553	0.0135	0.0346	6.1139	0.5305	1.3626
0.1639	0.0134	0.0342	6.4535	0.5256	1.3482
0.1725	0.0131	0.0336	6.7932	0.5160	1.3225
0.1812	0.0127	0.0326	7.1329	0.5013	1.2851
0.1898	0.0122	0.0314	7.4725	0.4811	1.2357
0.1984	0.0116	0.0298	7.8122	0.4551	1.1733
0.2071	0.0107	0.0279	8.1518	0.4227	1.0971
0.2157	0.0097	0.0256	8.4915	0.3837	1.0061
0.2243	0.0086	0.0228	8.8312	0.3372	0.8991
0.2329	0.0072	0.0197	9.1708	0.2826	0.7743
0.2416	0.0056	0.0160	9.5105	0.2191	0.6295
0.2502	0.0037	0.0117	9.8501	0.1455	0.4619
0.2588	0.0015	0.0068	10.1898	0.0606	0.2677
0.2674	-0.0009	0.0011	10.5295	-0.0368	0.0421

Radius, m (in.)	=	0.5438	(21.4090)
Chord, m (in.)	=	0.2674	(10.5295)
ZCSL, m (in.)	=	0.1397	(5.4981)
YCSL, m (in.)	=	0.0169	(0.6644)
Leading edge radius, m (in.)	=	0.000988	(0.0389)
Trailing edge radius, m (in.)	=	0.001057	(0.0416)
X-area, m^2 ($in.^2$)	=	0.003936	(6.1012)
Gamma, deg. (rad.)	=	29.52	(0.5153)

Fan Blade Coordinates (under load at the aerodynamic design point)

METERS			INCHES		
ZC	YP	YS	ZC	YP	YS
0.0	-0.0009	0.0009	0.0	-0.0349	0.0368
0.0088	0.0004	0.0041	0.3450	0.0161	0.1600
0.0175	0.0016	0.0071	0.6901	0.0649	0.2784
0.0263	0.0028	0.0099	1.0351	0.1110	0.3910
0.0351	0.0039	0.0126	1.3802	0.1543	0.4977
0.0438	0.0049	0.0152	1.7252	0.1946	0.5986
0.0526	0.0059	0.0176	2.0703	0.2318	0.6933
0.0613	0.0068	0.0199	2.4153	0.2666	0.7828
0.0701	0.0076	0.0220	2.7604	0.2979	0.8664
0.0789	0.0083	0.0240	3.1054	0.3257	0.9439
0.0876	0.0089	0.0258	3.4505	0.3498	1.0157
0.0964	0.0094	0.0274	3.7955	0.3703	1.0788
0.1052	0.0098	0.0288	4.1406	0.3870	1.1321
0.1139	0.0102	0.0298	4.4856	0.4002	1.1751
0.1227	0.0104	0.0307	4.8307	0.4098	1.2081
0.1315	0.0106	0.0313	5.1757	0.4160	1.2310
0.1402	0.0106	0.0316	5.5208	0.4187	1.2438
0.1490	0.0106	0.0317	5.8658	0.4180	1.2465
0.1578	0.0105	0.0315	6.2109	0.4137	1.2391
0.1665	0.0103	0.0310	6.5559	0.4060	1.2214
0.1753	0.0100	0.0303	6.9010	0.3946	1.1934
0.1840	0.0096	0.0293	7.2460	0.3797	1.1546
0.1928	0.0092	0.0281	7.5911	0.3610	1.1051
0.2016	0.0086	0.0265	7.9361	0.3384	1.0442
0.2103	0.0079	0.0247	8.2811	0.3119	0.9716
0.2191	0.0071	0.0225	8.6262	0.2814	0.8868
0.2279	0.0062	0.0200	8.9712	0.2450	0.7892
0.2366	0.0051	0.0172	9.3163	0.2024	0.6772
0.2454	0.0039	0.0139	9.6614	0.1537	0.5474
0.2542	0.0025	0.0101	10.0064	0.0983	0.3995
0.2629	0.0009	0.0059	10.3514	0.0354	0.2312
0.2717	-0.0009	0.0010	10.6965	-0.0355	0.0398

Radius, m (in.)	=	0.5635	(22.1860)
Chord, m (in.)	=	0.2717	(10.6965)
ZCSL, m (in.)	=	0.1415	(5.5715)
YCSL, m (in.)	=	0.0142	(0.5571)
Leading edge radius, m (in.)	=	0.000973	(0.0383)
Trailing edge radius, m (in.)	=	0.001041	(0.0410)
X-area, m^2 ($in.^2$)	=	0.003929	(6.0898)
Gamma, deg. (rad.)	=	31.87	(0.5562)

Fan Blade Coordinates (under load at the aerodynamic design point)

METERS			INCHES		
ZC	YP	YS	ZC	YP	YS
0.0	-0.0009	0.0009	0.0	-0.0342	0.0360
0.0089	0.0003	0.0038	0.3496	0.0100	0.1513
0.0178	0.0013	0.0067	0.6992	0.0525	0.2621
0.0266	0.0024	0.0093	1.0488	0.0931	0.3679
0.0355	0.0033	0.0119	1.3984	0.1314	0.4685
0.0444	0.0043	0.0143	1.7480	0.1673	0.5639
0.0533	0.0051	0.0166	2.0976	0.2009	0.6540
0.0622	0.0059	0.0188	2.4472	0.2316	0.7386
0.0710	0.0066	0.0208	2.7968	0.2595	0.8178
0.0799	0.0072	0.0226	3.1464	0.2845	0.8914
0.0888	0.0078	0.0244	3.4960	0.3063	0.9601
0.0977	0.0082	0.0259	3.8456	0.3248	1.0211
0.1066	0.0086	0.0273	4.1952	0.3394	1.0730
0.1154	0.0089	0.0283	4.5448	0.3502	1.1145
0.1243	0.0091	0.0291	4.8944	0.3573	1.1455
0.1332	0.0092	0.0296	5.2439	0.3608	1.1662
0.1421	0.0092	0.0299	5.5935	0.3613	1.1769
0.1510	0.0091	0.0299	5.9431	0.3590	1.1775
0.1598	0.0090	0.0297	6.2927	0.3533	1.1687
0.1687	0.0087	0.0292	6.6423	0.3443	1.1501
0.1776	0.0084	0.0285	6.9919	0.3319	1.1212
0.1865	0.0080	0.0275	7.3415	0.3162	1.0820
0.1954	0.0075	0.0262	7.6911	0.2972	1.0322
0.2042	0.0070	0.0247	8.0407	0.2749	0.9715
0.2131	0.0063	0.0229	8.3903	0.2491	0.8997
0.2220	0.0056	0.0207	8.7399	0.2199	0.8163
0.2309	0.0048	0.0183	9.0895	0.1870	0.7209
0.2398	0.0038	0.0156	9.4391	0.1506	0.6128
0.2486	0.0028	0.0125	9.7887	0.1104	0.4913
0.2575	0.0017	0.0090	10.1383	0.0663	0.3555
0.2664	0.0005	0.0052	10.4879	0.0181	0.2045
0.2753	-0.0009	0.0010	10.8375	-0.0340	0.0375

Radius, m (in.)	=	0.5833	(22.9635)
Chord, m (in.)	=	0.2753	(10.8375)
ZCSL, m (in.)	=	0.1432	(5.6372)
YCSL, m (in.)	=	0.0125	(0.4923)
Leading edge radius, m (in.)	=	0.000958	(0.0377)
Trailing edge radius, m (in.)	=	0.001006	(0.0396)
X-area, m^2 ($in.^2$)	=	0.003916	(6.0700)
Gamma, deg. (rad.)	=	33.70	(0.5881)

Fan Blade Coordinates (under load at the aerodynamic design point)

METERS			INCHES		
ZC	YP	YS	ZC	YP	YS
0.0	-0.0009	0.0009	0.0	-0.0340	0.0351
0.0090	0.0001	0.0037	0.3532	0.0059	0.1449
0.0179	0.0011	0.0064	0.7064	0.0446	0.2507
0.0269	0.0021	0.0089	1.0596	0.0818	0.3520
0.0359	0.0030	0.0114	1.4128	0.1173	0.4487
0.0449	0.0038	0.0137	1.7660	0.1508	0.5406
0.0538	0.0046	0.0159	2.1192	0.1824	0.6276
0.0628	0.0054	0.0180	2.4724	0.2117	0.7097
0.0718	0.0061	0.0200	2.8256	0.2387	0.7869
0.0807	0.0067	0.0218	3.1788	0.2634	0.8591
0.0897	0.0073	0.0235	3.5321	0.2857	0.9271
0.0987	0.0078	0.0251	3.8853	0.3052	0.9883
0.1077	0.0082	0.0265	4.2385	0.3212	1.0416
0.1166	0.0085	0.0275	4.5917	0.3333	1.0845
0.1256	0.0087	0.0284	4.9449	0.3414	1.1168
0.1346	0.0088	0.0289	5.2981	0.3458	1.1386
0.1435	0.0088	0.0292	5.6513	0.3464	1.1502
0.1525	0.0087	0.0292	6.0045	0.3434	1.1514
0.1615	0.0086	0.0290	6.3577	0.3369	1.1423
0.1705	0.0083	0.0285	6.7109	0.3270	1.1231
0.1794	0.0080	0.0278	7.0641	0.3138	1.0935
0.1884	0.0076	0.0268	7.4173	0.2974	1.0536
0.1974	0.0071	0.0255	7.7705	0.2779	1.0033
0.2063	0.0065	0.0239	8.1237	0.2555	0.9425
0.2153	0.0059	0.0221	8.4769	0.2303	0.8709
0.2243	0.0051	0.0200	8.8301	0.2025	0.7886
0.2333	0.0044	0.0177	9.1833	0.1716	0.6953
0.2422	0.0035	0.0150	9.5365	0.1371	0.5907
0.2512	0.0025	0.0120	9.8897	0.0994	0.4729
0.2602	0.0015	0.0087	10.2429	0.0584	0.3416
0.2691	0.0004	0.0050	10.5961	0.0140	0.1962
0.2781	-0.0008	0.0009	10.9494	-0.0333	0.0365

Radius, m (in.)	=	0.6005	(23.6400)
Chord, m (in.)	=	0.2781	(10.9493)
ZCSL, m (in.)	=	0.1445	(5.6907)
YCSL, m (in.)	=	0.0117	(0.4596)
Leading edge radius, m (in.)	=	0.000945	(0.0372)
Trailing edge radius, m (in.)	=	0.000986	(0.0388)
X-area, m^2 ($in.^2$)	=	0.003893	(6.0348)
Gamma, deg. (rad.)	=	35.03	(0.6113)

Fan Blade Coordinates (under load at the aerodynamic design point)

METERS			INCHES		
ZC	YP	YS	ZC	YP	YS
0.0	-0.0009	0.0009	0.0	-0.0335	0.0344
0.0091	0.0000	0.0035	0.3570	0.0016	0.1377
0.0181	0.0009	0.0060	0.7140	0.0359	0.2378
0.0272	0.0018	0.0085	1.0710	0.0692	0.3339
0.0363	0.0026	0.0108	1.4280	0.1015	0.4261
0.0453	0.0034	0.0131	1.7850	0.1327	0.5141
0.0544	0.0041	0.0152	2.1420	0.1627	0.5979
0.0635	0.0049	0.0172	2.4990	0.1911	0.6775
0.0725	0.0055	0.0191	2.8560	0.2179	0.7528
0.0816	0.0062	0.0209	3.2130	0.2430	0.8238
0.0907	0.0068	0.0226	3.5700	0.2666	0.8910
0.0997	0.0073	0.0242	3.9270	0.2881	0.9527
0.1088	0.0078	0.0256	4.2840	0.3070	1.0085
0.1179	0.0082	0.0268	4.6410	0.3220	1.0541
0.1269	0.0085	0.0277	4.9980	0.3330	1.0891
0.1360	0.0086	0.0283	5.3550	0.3400	1.1136
0.1451	0.0087	0.0286	5.7120	0.3429	1.1278
0.1542	0.0087	0.0287	6.0690	0.3421	1.1315
0.1632	0.0086	0.0286	6.4260	0.3374	1.1247
0.1723	0.0084	0.0281	6.7830	0.3290	1.1076
0.1814	0.0081	0.0274	7.1400	0.3170	1.0800
0.1904	0.0077	0.0265	7.4970	0.3014	1.0418
0.1995	0.0072	0.0252	7.8540	0.2824	0.9930
0.2086	0.0066	0.0237	8.2110	0.2600	0.9334
0.2176	0.0059	0.0219	8.5680	0.2342	0.8626
0.2267	0.0052	0.0198	8.9250	0.2052	0.7807
0.2358	0.0044	0.0175	9.2820	0.1730	0.6873
0.2448	0.0035	0.0148	9.6390	0.1377	0.5820
0.2539	0.0025	0.0118	9.9960	0.0994	0.4645
0.2630	0.0015	0.0085	10.3530	0.0582	0.3343
0.2720	0.0004	0.0049	10.7100	0.0141	0.1913
0.2811	-0.0008	0.0009	11.0670	-0.0323	0.0352

Radius, m (in.)	=	0.6214	(24.4655)
Chord, m (in.)	=	0.2811	(11.0670)
ZCSL, m (in.)	=	0.1460	(5.7487)
YCSL, m (in.)	=	0.0111	(0.4361)
Leading edge radius, m (in.)	=	0.000927	(0.0365)
Trailing edge radius, m (in.)	=	0.000950	(0.0374)
X-area, m^2 ($in.^2$)	=	0.003846	(5.9609)
Gamma, deg. (rad.)	=	36.44	(0.6360)

Fan Blade Coordinates (under load at the aerodynamic design point)

METERS			INCHES		
ZC	YP	YS	ZC	YP	YS
0.0	-0.0008	0.0008	0.0	-0.0321	0.0329
0.0092	-0.0001	0.0032	0.3619	-0.0046	0.1266
0.0184	0.0006	0.0055	0.7237	0.0228	0.2177
0.0276	0.0013	0.0078	1.0856	0.0498	0.3055
0.0368	0.0019	0.0099	1.4474	0.0765	0.3898
0.0460	0.0026	0.0120	1.8093	0.1028	0.4707
0.0551	0.0033	0.0139	2.1712	0.1285	0.5481
0.0643	0.0039	0.0158	2.5330	0.1535	0.6220
0.0735	0.0045	0.0176	2.8949	0.1778	0.6922
0.0827	0.0051	0.0193	3.2568	0.2013	0.7589
0.0919	0.0057	0.0209	3.6186	0.2241	0.8221
0.1011	0.0062	0.0224	3.9805	0.2460	0.8819
0.1103	0.0068	0.0238	4.3423	0.2669	0.9376
0.1195	0.0072	0.0250	4.7042	0.2849	0.9848
0.1287	0.0076	0.0260	5.0661	0.2992	1.0224
0.1379	0.0079	0.0267	5.4279	0.3096	1.0497
0.1471	0.0080	0.0271	5.7898	0.3161	1.0669
0.1563	0.0081	0.0273	6.1517	0.3187	1.0739
0.1654	0.0081	0.0272	6.5135	0.3174	1.0707
0.1746	0.0079	0.0269	6.8754	0.3124	1.0574
0.1838	0.0077	0.0263	7.2372	0.3037	1.0337
0.1930	0.0074	0.0254	7.5991	0.2912	0.9996
0.2022	0.0070	0.0243	7.9609	0.2750	0.9551
0.2114	0.0065	0.0229	8.3228	0.2552	0.8998
0.2206	0.0059	0.0212	8.6847	0.2317	0.8336
0.2298	0.0052	0.0192	9.0465	0.2047	0.7562
0.2390	0.0044	0.0169	9.4084	0.1741	0.6673
0.2482	0.0036	0.0144	9.7703	0.1399	0.5664
0.2574	0.0026	0.0115	10.1321	0.1022	0.4531
0.2665	0.0016	0.0083	10.4940	0.0611	0.3270
0.2757	0.0004	0.0048	10.8559	0.0164	0.1873
0.2849	-0.0008	0.0009	11.2177	-0.0313	0.0339

Radius, m (in.)	=	0.6518	(25.6600)
Chord, m (in.)	=	0.2849	(11.2177)
ZCSL, m (in.)	=	0.1477	(5.8137)
YCSL, m (in.)	=	0.0098	(0.3842)
Leading edge radius, m (in.)	=	0.000889	(0.0350)
Trailing edge radius, m (in.)	=	0.000914	(0.0360)
X-area, m^2 ($in.^2$)	=	0.003737	(5.7923)
Gamma, deg. (rad.)	=	38.53	(0.6725)

Fan Blade Coordinates (under load at the aerodynamic design point)

METERS			INCHES		
ZC	YP	YS	ZC	YP	YS
0.0	-0.0007	0.0007	0.0	-0.0292	0.0294
0.0094	-0.0004	0.0026	0.3712	-0.0174	0.1039
0.0189	-0.0001	0.0045	0.7424	-0.0049	0.1764
0.0283	0.0002	0.0063	1.1137	0.0085	0.2467
0.0377	0.0006	0.0080	1.4849	0.0229	0.3149
0.0471	0.0010	0.0097	1.8561	0.0381	0.3807
0.0566	0.0014	0.0113	2.2273	0.0539	0.4440
0.0660	0.0018	0.0128	2.5985	0.0702	0.5049
0.0754	0.0022	0.0143	2.9697	0.0871	0.5632
0.0849	0.0027	0.0157	3.3410	0.1044	0.6189
0.0943	0.0031	0.0171	3.7122	0.1220	0.6719
0.1037	0.0036	0.0184	4.0834	0.1402	0.7228
0.1131	0.0040	0.0196	4.4546	0.1587	0.7706
0.1226	0.0045	0.0207	4.8258	0.1772	0.8152
0.1320	0.0049	0.0217	5.1971	0.1939	0.8531
0.1414	0.0053	0.0224	5.5683	0.2071	0.8816
0.1509	0.0055	0.0229	5.9395	0.2169	0.9009
0.1603	0.0057	0.0231	6.3107	0.2232	0.9108
0.1697	0.0057	0.0231	6.6819	0.2261	0.9113
0.1791	0.0057	0.0229	7.0531	0.2256	0.9026
0.1886	0.0056	0.0225	7.4244	0.2217	0.8845
0.1980	0.0055	0.0218	7.7956	0.2146	0.8570
0.2074	0.0052	0.0208	8.1668	0.2042	0.8200
0.2169	0.0048	0.0196	8.5380	0.1906	0.7735
0.2263	0.0044	0.0182	8.9092	0.1738	0.7172
0.2357	0.0039	0.0165	9.2804	0.1539	0.6510
0.2452	0.0033	0.0146	9.6517	0.1310	0.5746
0.2546	0.0027	0.0124	10.0229	0.1049	0.4880
0.2640	0.0019	0.0099	10.3941	0.0759	0.3906
0.2734	0.0011	0.0072	10.7653	0.0438	0.2821
0.2829	0.0002	0.0041	11.1365	0.0089	0.1622
0.2923	-0.0007	0.0008	11.5078	-0.0286	0.0309

Radius, m (in.)	=	0.7033	(27.6900)
Chord, m (in.)	=	0.2923	(11.5078)
ZCSL, m (in.)	=	0.1504	(5.9194)
YCSL, m (in.)	=	0.0064	(0.2522)
Leading edge radius, m (in.)	=	0.000803	(0.0316)
Trailing edge radius, m (in.)	=	0.000831	(0.0327)
X-area, m^2 ($in.^2$)	=	0.003496	(5.4188)
Gamma, deg. (rad.)	=	42.40	(0.7401)

Fan Blade Coordinates (under load at the aerodynamic design point)

METERS			INCHES		
ZC	YP	YS	ZC	YP	YS
0.0	-0.0007	0.0007	0.0	-0.0263	0.0262
0.0097	-0.0008	0.0020	0.3807	-0.0312	0.0795
0.0193	-0.0009	0.0034	0.7614	-0.0346	0.1320
0.0290	-0.0009	0.0047	1.1420	-0.0360	0.1832
0.0387	-0.0009	0.0059	1.5227	-0.0357	0.2331
0.0483	-0.0009	0.0072	1.9034	-0.0336	0.2817
0.0580	-0.0008	0.0084	2.2841	-0.0298	0.3288
0.0677	-0.0006	0.0095	2.6648	-0.0244	0.3745
0.0774	-0.0004	0.0106	3.0455	-0.0173	0.4187
0.0870	-0.0002	0.0117	3.4262	-0.0086	0.4614
0.0967	0.0000	0.0128	3.8069	0.0016	0.5025
0.1064	0.0003	0.0138	4.1875	0.0133	0.5420
0.1160	0.0007	0.0147	4.5682	0.0267	0.5801
0.1257	0.0011	0.0157	4.9489	0.0419	0.6171
0.1354	0.0015	0.0165	5.3296	0.0576	0.6505
0.1450	0.0018	0.0172	5.7103	0.0724	0.6784
0.1547	0.0021	0.0177	6.0910	0.0846	0.6985
0.1644	0.0024	0.0180	6.4717	0.0940	0.7104
0.1740	0.0026	0.0181	6.8523	0.1007	0.7141
0.1837	0.0027	0.0180	7.2330	0.1048	0.7099
0.1934	0.0027	0.0177	7.6137	0.1064	0.6975
0.2031	0.0027	0.0172	7.9944	0.1054	0.6772
0.2127	0.0026	0.0165	8.3751	0.1019	0.6489
0.2224	0.0024	0.0156	8.7558	0.0961	0.6125
0.2321	0.0022	0.0144	9.1364	0.0879	0.5681
0.2417	0.0020	0.0131	9.5171	0.0775	0.5156
0.2514	0.0017	0.0116	9.8978	0.0650	0.4549
0.2611	0.0013	0.0098	10.2785	0.0505	0.3861
0.2707	0.0009	0.0078	10.6592	0.0340	0.3090
0.2804	0.0004	0.0057	11.0399	0.0156	0.2234
0.2901	-0.0001	0.0033	11.4206	-0.0045	0.1294
0.2998	-0.0007	0.0007	11.8012	-0.0259	0.0271

Radius, m (in.)	=	0.7549	(29.7200)
Chord, m (in.)	=	0.2998	(11.8012)
ZCSL, m (in.)	=	0.1526	(6.0065)
YCSL, m (in.)	=	0.0024	(0.0960)
Leading edge radius, m (in.)	=	0.000719	(0.0283)
Trailing edge radius, m (in.)	=	0.000737	(0.0290)
X-area, m^2 ($in.^2$)	=	0.003219	(4.9898)
Gamma, deg. (rad.)	=	45.99	(0.8026)

Fan Blade Coordinates (under load at the aerodynamic design point)

METERS			INCHES		
ZC	YP	YS	ZC	YP	YS
0.0	-0.0006	0.0006	0.0	-0.0236	0.0233
0.0099	-0.0010	0.0016	0.3895	-0.0392	0.0621
0.0198	-0.0013	0.0025	0.7790	-0.0531	0.0998
0.0297	-0.0017	0.0035	1.1685	-0.0653	0.1362
0.0396	-0.0019	0.0044	1.5580	-0.0758	0.1714
0.0495	-0.0021	0.0052	1.9475	-0.0843	0.2054
0.0594	-0.0023	0.0061	2.3370	-0.0908	0.2384
0.0693	-0.0024	0.0069	2.7266	-0.0954	0.2703
0.0791	-0.0025	0.0076	3.1160	-0.0980	0.3010
0.0890	-0.0025	0.0084	3.5056	-0.0986	0.3307
0.0989	-0.0025	0.0091	3.8951	-0.0971	0.3592
0.1088	-0.0024	0.0098	4.2846	-0.0936	0.3867
0.1187	-0.0022	0.0105	4.6741	-0.0881	0.4131
0.1286	-0.0020	0.0111	5.0636	-0.0804	0.4384
0.1385	-0.0018	0.0118	5.4531	-0.0701	0.4635
0.1484	-0.0015	0.0123	5.8426	-0.0586	0.4858
0.1583	-0.0012	0.0128	6.2321	-0.0476	0.5030
0.1682	-0.0010	0.0131	6.6216	-0.0378	0.5142
0.1781	-0.0007	0.0132	7.0111	-0.0294	0.5190
0.1880	-0.0006	0.0131	7.4006	-0.0225	0.5175
0.1979	-0.0004	0.0129	7.7901	-0.0169	0.5096
0.2078	-0.0003	0.0126	8.1796	-0.0126	0.4955
0.2177	-0.0002	0.0121	8.5691	-0.0095	0.4752
0.2275	-0.0002	0.0114	8.9587	-0.0076	0.4488
0.2374	-0.0002	0.0106	9.3482	-0.0068	0.4162
0.2473	-0.0002	0.0096	9.7377	-0.0070	0.3777
0.2572	-0.0002	0.0085	10.1272	-0.0082	0.3331
0.2671	-0.0003	0.0072	10.5167	-0.0101	0.2827
0.2770	-0.0003	0.0058	10.9062	-0.0127	0.2264
0.2869	-0.0004	0.0042	11.2957	-0.0159	0.1643
0.2968	-0.0005	0.0025	11.6852	-0.0196	0.0966
0.3067	-0.0006	0.0006	12.0747	-0.0232	0.0237

Radius, m (in.)	=	0.8062	(31.7400)
Chord, m (in.)	=	0.3067	(12.0747)
ZCSL, m (in.)	=	0.1544	(6.0790)
YCSL, m (in.)	=	-0.0013	(-0.0524)
Leading edge radius, m (in.)	=	0.000640	(0.0252)
Trailing edge radius, m (in.)	=	0.000648	(0.0255)
X-area, m^2 ($in.^2$)	=	0.002954	(4.5794)
Gamma, deg. (rad.)	=	48.81	(0.8519)

Fan Blade Coordinates (under load at the aerodynamic design point)

METERS			INCHES		
ZC	YP	YS	ZC	YP	YS
0.0	-0.0005	0.0006	0.0	-0.0198	0.0228
0.0101	-0.0009	0.0014	0.3990	-0.0364	0.0565
0.0203	-0.0013	0.0023	0.7980	-0.0518	0.0888
0.0304	-0.0017	0.0030	1.1970	-0.0658	0.1194
0.0405	-0.0020	0.0038	1.5960	-0.0785	0.1485
0.0507	-0.0023	0.0045	1.9950	-0.0903	0.1754
0.0608	-0.0026	0.0051	2.3940	-0.1013	0.2002
0.0709	-0.0028	0.0057	2.7930	-0.1118	0.2226
0.0811	-0.0031	0.0062	3.1920	-0.1207	0.2435
0.0912	-0.0032	0.0067	3.5910	-0.1279	0.2630
0.1013	-0.0034	0.0071	3.9900	-0.1336	0.2812
0.1115	-0.0035	0.0076	4.3890	-0.1375	0.2981
0.1216	-0.0035	0.0080	4.7880	-0.1394	0.3138
0.1317	-0.0035	0.0083	5.1870	-0.1396	0.3282
0.1419	-0.0035	0.0087	5.5860	-0.1377	0.3417
0.1520	-0.0034	0.0090	5.9850	-0.1336	0.3541
0.1622	-0.0033	0.0092	6.3840	-0.1285	0.3640
0.1723	-0.0031	0.0094	6.7830	-0.1231	0.3701
0.1824	-0.0030	0.0094	7.1820	-0.1178	0.3716
0.1926	-0.0029	0.0094	7.5810	-0.1125	0.3687
0.2027	-0.0027	0.0092	7.9800	-0.1071	0.3614
0.2128	-0.0026	0.0089	8.3790	-0.1015	0.3498
0.2230	-0.0024	0.0085	8.7780	-0.0957	0.3339
0.2331	-0.0023	0.0080	9.1770	-0.0897	0.3140
0.2432	-0.0021	0.0074	9.5759	-0.0833	0.2900
0.2534	-0.0019	0.0067	9.9749	-0.0765	0.2622
0.2635	-0.0018	0.0059	10.3740	-0.0691	0.2307
0.2736	-0.0015	0.0050	10.7730	-0.0609	0.1956
0.2838	-0.0013	0.0040	11.1719	-0.0521	0.1571
0.2939	-0.0011	0.0029	11.5709	-0.0423	0.1153
0.3040	-0.0008	0.0018	11.9699	-0.0313	0.0705
0.3142	-0.0005	0.0006	12.3689	-0.0189	0.0233

Radius, m (in.)	=	0.8575	(33.7600)
Chord, m (in.)	=	0.3142	(12.3689)
ZCSL, m (in.)	=	0.1566	(6.1646)
YCSL, m (in.)	=	-0.0040	(-0.1562)
Leading edge radius, m (in.)	=	0.000577	(0.0227)
Trailing edge radius, m (in.)	=	0.000577	(0.0227)
X-area, m^2 ($in.^2$)	=	0.002714	(4.2068)
Gamma, deg. (rad.)	=	51.30	(0.8954)

Fan Blade Coordinates (under load at the aerodynamic design point)

METERS			INCHES		
ZC	YP	YS	ZC	YP	YS
0.0	-0.0005	0.0006	0.0	-0.0193	0.0221
0.0102	-0.0009	0.0014	0.4035	-0.0352	0.0542
0.0205	-0.0013	0.0021	0.8070	-0.0501	0.0846
0.0307	-0.0016	0.0029	1.2106	-0.0637	0.1133
0.0410	-0.0019	0.0036	1.6141	-0.0762	0.1402
0.0512	-0.0022	0.0042	2.0176	-0.0879	0.1649
0.0615	-0.0025	0.0048	2.4212	-0.0991	0.1872
0.0717	-0.0028	0.0053	2.8247	-0.1102	0.2068
0.0820	-0.0030	0.0057	3.2282	-0.1200	0.2248
0.0922	-0.0033	0.0061	3.6317	-0.1281	0.2413
0.1025	-0.0034	0.0065	4.0352	-0.1349	0.2565
0.1127	-0.0036	0.0069	4.4388	-0.1400	0.2704
0.1230	-0.0036	0.0072	4.8423	-0.1433	0.2832
0.1332	-0.0037	0.0075	5.2458	-0.1447	0.2947
0.1435	-0.0037	0.0078	5.6494	-0.1442	0.3052
0.1537	-0.0036	0.0080	6.0529	-0.1417	0.3144
0.1640	-0.0035	0.0082	6.4564	-0.1376	0.3224
0.1742	-0.0034	0.0083	6.8599	-0.1329	0.3272
0.1845	-0.0033	0.0083	7.2634	-0.1281	0.3280
0.1947	-0.0031	0.0082	7.6670	-0.1233	0.3248
0.2050	-0.0030	0.0081	8.0705	-0.1183	0.3177
0.2152	-0.0029	0.0078	8.4740	-0.1130	0.3067
0.2255	-0.0027	0.0074	8.8776	-0.1074	0.2922
0.2357	-0.0026	0.0070	9.2811	-0.1013	0.2741
0.2460	-0.0024	0.0064	9.6846	-0.0945	0.2526
0.2562	-0.0022	0.0058	10.0881	-0.0871	0.2278
0.2665	-0.0020	0.0051	10.4917	-0.0788	0.2000
0.2767	-0.0018	0.0043	10.8952	-0.0694	0.1694
0.2870	-0.0015	0.0035	11.2987	-0.0589	0.1361
0.2972	-0.0012	0.0025	11.7022	-0.0470	0.1003
0.3075	-0.0008	0.0016	12.1058	-0.0334	0.0621
0.3177	-0.0005	0.0006	12.5093	-0.0182	0.0220

Radius, m (in.)	=	0.8831	(34.7658)
Chord, m (in.)	=	0.3177	(12.5093)
ZCSL, m (in.)	=	0.1575	(6.2005)
YCSL, m (in.)	=	-0.0047	(-0.1849)
Leading edge radius, m (in.)	=	0.000559	(0.0220)
Trailing edge radius, m (in.)	=	0.000546	(0.0215)
X-area, m^2 ($in.^2$)	=	0.002574	(3.9897)
Gamma, deg. (rad.)	=	52.85	(0.9225)

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Fan Blade Coordinates (under load at the aerodynamic design point)

METERS			INCHES		
ZC	YP	YS	ZC	YP	YS
0.0	-0.0005	0.0006	0.0	-0.0195	0.0219
0.0104	-0.0009	0.0013	0.4082	-0.0343	0.0531
0.0207	-0.0012	0.0021	0.8164	-0.0486	0.0823
0.0311	-0.0016	0.0028	1.2246	-0.0619	0.1095
0.0415	-0.0019	0.0034	1.6327	-0.0745	0.1344
0.0518	-0.0022	0.0040	2.0409	-0.0868	0.1568
0.0622	-0.0025	0.0045	2.4491	-0.0991	0.1761
0.0726	-0.0028	0.0049	2.8573	-0.1119	0.1923
0.0829	-0.0031	0.0052	3.2655	-0.1240	0.2063
0.0933	-0.0034	0.0056	3.6736	-0.1348	0.2186
0.1037	-0.0037	0.0058	4.0818	-0.1442	0.2294
0.1140	-0.0039	0.0061	4.4900	-0.1521	0.2388
0.1244	-0.0040	0.0063	4.8982	-0.1582	0.2471
0.1348	-0.0041	0.0065	5.3064	-0.1625	0.2542
0.1451	-0.0042	0.0066	5.7146	-0.1649	0.2604
0.1555	-0.0042	0.0067	6.1227	-0.1653	0.2656
0.1659	-0.0041	0.0069	6.5309	-0.1634	0.2706
0.1763	-0.0041	0.0069	6.9391	-0.1605	0.2731
0.1866	-0.0040	0.0069	7.3473	-0.1572	0.2723
0.1970	-0.0039	0.0068	7.7555	-0.1532	0.2682
0.2074	-0.0038	0.0066	8.1636	-0.1487	0.2609
0.2177	-0.0036	0.0064	8.5718	-0.1435	0.2506
0.2281	-0.0035	0.0060	8.9800	-0.1375	0.2374
0.2385	-0.0033	0.0056	9.3882	-0.1306	0.2214
0.2488	-0.0031	0.0052	9.7964	-0.1224	0.2030
0.2592	-0.0029	0.0046	10.2046	-0.1128	0.1824
0.2696	-0.0026	0.0041	10.6127	-0.1016	0.1596
0.2799	-0.0023	0.0034	11.0209	-0.0888	0.1350
0.2903	-0.0019	0.0028	11.4291	-0.0740	0.1087
0.3007	-0.0015	0.0021	11.8373	-0.0573	0.0810
0.3110	-0.0010	0.0013	12.2455	-0.0387	0.0513
0.3214	-0.0004	0.0005	12.6537	-0.0176	0.0211

Radius, m (in.)	=	0.9091	(35.7900)
Chord, m (in.)	=	0.3214	(12.6537)
ZCSL, m (in.)	=	0.1582	(6.2267)
YCSL, m (in.)	=	-0.0056	(-0.2207)
Leading edge radius, m (in.)	=	0.000556	(0.0219)
Trailing edge radius, m (in.)	=	0.000523	(0.0206)
X-area, m^2 ($in.^2$)	=	0.002467	(3.8231)
Gamma, deg. (rad.)	=	55.11	(0.9618)

Fan Blade Coordinates (under load at the aerodynamic design point)

METERS			INCHES		
ZC	YP	YS	ZC	YP	YS
0.0	-0.0005	0.0006	0.0	-0.0199	0.0218
0.0107	-0.0012	0.0009	0.4198	-0.0459	0.0369
0.0213	-0.0018	0.0013	0.8396	-0.0722	0.0496
0.0320	-0.0025	0.0015	1.2594	-0.0981	0.0598
0.0427	-0.0031	0.0017	1.6792	-0.1235	0.0677
0.0533	-0.0038	0.0019	2.0990	-0.1485	0.0733
0.0640	-0.0044	0.0019	2.5188	-0.1728	0.0768
0.0746	-0.0050	0.0020	2.9385	-0.1964	0.0783
0.0853	-0.0056	0.0020	3.3583	-0.2191	0.0780
0.0960	-0.0061	0.0019	3.7781	-0.2403	0.0760
0.1066	-0.0066	0.0019	4.1979	-0.2601	0.0732
0.1173	-0.0070	0.0018	4.6177	-0.2761	0.0712
0.1280	-0.0073	0.0018	5.0375	-0.2878	0.0709
0.1386	-0.0075	0.0019	5.4573	-0.2946	0.0729
0.1493	-0.0075	0.0020	5.8771	-0.2960	0.0772
0.1599	-0.0074	0.0022	6.2969	-0.2921	0.0851
0.1706	-0.0071	0.0024	6.7167	-0.2806	0.0964
0.1813	-0.0067	0.0028	7.1365	-0.2655	0.1092
0.1919	-0.0063	0.0031	7.5563	-0.2486	0.1218
0.2026	-0.0059	0.0033	7.9761	-0.2319	0.1303
0.2133	-0.0055	0.0034	8.3958	-0.2158	0.1352
0.2239	-0.0051	0.0035	8.8156	-0.2001	0.1367
0.2346	-0.0047	0.0034	9.2354	-0.1845	0.1349
0.2452	-0.0043	0.0033	9.6552	-0.1687	0.1302
0.2559	-0.0039	0.0031	10.0750	-0.1525	0.1230
0.2666	-0.0035	0.0029	10.4948	-0.1360	0.1132
0.2772	-0.0030	0.0026	10.9146	-0.1188	0.1012
0.2879	-0.0026	0.0022	11.3344	-0.1006	0.0874
0.2986	-0.0021	0.0018	11.7542	-0.0813	0.0717
0.3092	-0.0015	0.0014	12.1740	-0.0607	0.0547
0.3199	-0.0010	0.0009	12.5938	-0.0388	0.0362
0.3305	-0.0004	0.0005	13.0136	-0.0147	0.0179

Radius, m (in.)	=	0.9688	(38.1400)
Chord, m (in.)	=	0.3305	(13.0136)
ZCSL, m (in.)	=	0.1590	(6.2604)
YCSL, m (in.)	=	-0.0082	(-0.3245)
Leading edge radius, m (in.)	=	0.000556	(0.0219)
Trailing edge radius, m (in.)	=	0.000434	(0.0171)
X-area, m^2 ($in.^2$)	=	0.002217	(3.4362)
Gamma, deg. (rad.)	=	62.76	(1.0954)

Fan Blade Coordinates (under load at the aerodynamic design point)

METERS			INCHES		
ZC	YP	YS	ZC	YP	YS
0.0	-0.0005	0.0006	0.0	-0.0199	0.0217
0.0107	-0.0012	0.0008	0.4231	-0.0491	0.0314
0.0215	-0.0020	0.0010	0.8462	-0.0785	0.0388
0.0322	-0.0027	0.0011	1.2694	-0.1075	0.0437
0.0430	-0.0035	0.0012	1.6925	-0.1359	0.0466
0.0537	-0.0042	0.0012	2.1156	-0.1636	0.0477
0.0645	-0.0048	0.0012	2.5387	-0.1906	0.0471
0.0752	-0.0055	0.0011	2.9618	-0.2167	0.0448
0.0860	-0.0061	0.0010	3.3849	-0.2416	0.0411
0.0967	-0.0067	0.0009	3.8081	-0.2654	0.0360
0.1075	-0.0073	0.0007	4.2312	-0.2875	0.0295
0.1182	-0.0078	0.0006	4.6543	-0.3075	0.0229
0.1290	-0.0082	0.0005	5.0774	-0.3234	0.0180
0.1397	-0.0085	0.0004	5.5006	-0.3328	0.0167
0.1505	-0.0085	0.0005	5.9237	-0.3355	0.0195
0.1612	-0.0084	0.0007	6.3468	-0.3310	0.0277
0.1720	-0.0081	0.0010	6.7699	-0.3175	0.0410
0.1827	-0.0076	0.0015	7.1930	-0.2978	0.0577
0.1934	-0.0070	0.0019	7.6161	-0.2755	0.0764
0.2042	-0.0064	0.0023	8.0393	-0.2531	0.0910
0.2149	-0.0059	0.0026	8.4624	-0.2320	0.1014
0.2257	-0.0054	0.0027	8.8855	-0.2118	0.1081
0.2364	-0.0049	0.0028	9.3086	-0.1923	0.1112
0.2472	-0.0044	0.0028	9.7317	-0.1731	0.1111
0.2579	-0.0039	0.0027	10.1549	-0.1541	0.1078
0.2687	-0.0034	0.0026	10.5780	-0.1352	0.1017
0.2794	-0.0030	0.0024	11.0011	-0.1162	0.0931
0.2902	-0.0025	0.0021	11.4242	-0.0969	0.0820
0.3009	-0.0020	0.0017	11.8473	-0.0771	0.0686
0.3117	-0.0014	0.0014	12.2704	-0.0569	0.0532
0.3224	-0.0009	0.0009	12.6936	-0.0361	0.0353
0.3332	-0.0004	0.0004	13.1167	-0.0141	0.0169

Radius, m (in.)	=	0.9896	(38.9618)
Chord, m (in.)	=	0.3332	(13.1167)
ZCSL, m (in.)	=	0.1598	(6.2901)
YCSL, m (in.)	=	-0.0089	(-0.3519)
Leading edge radius, m (in.)	=	0.000554	(0.0218)
Trailing edge radius, m (in.)	=	0.000414	(0.0163)
X-area, m^2 ($in.^2$)	=	0.002127	(3.2963)
Gamma, deg. (rad.)	=	65.20	(1.1380)

Fan Blade Coordinates (under load at the aerodynamic design point)

METERS			INCHES		
ZC	YP	YS	ZC	YP	YS
0.0	-0.0005	0.0005	0.0	-0.0198	0.0215
0.0109	-0.0013	0.0006	0.4281	-0.0529	0.0232
0.0217	-0.0022	0.0006	0.8561	-0.0859	0.0231
0.0326	-0.0030	0.0005	1.2842	-0.1185	0.0214
0.0435	-0.0038	0.0005	1.7123	-0.1505	0.0180
0.0544	-0.0046	0.0003	2.1404	-0.1820	0.0130
0.0652	-0.0054	0.0002	2.5685	-0.2125	0.0067
0.0761	-0.0061	-0.0000	2.9965	-0.2416	-0.0004
0.0870	-0.0068	-0.0002	3.4246	-0.2688	-0.0081
0.0979	-0.0075	-0.0004	3.8527	-0.2943	-0.0163
0.1087	-0.0081	-0.0006	4.2808	-0.3178	-0.0248
0.1196	-0.0086	-0.0009	4.7088	-0.3405	-0.0343
0.1305	-0.0091	-0.0011	5.1369	-0.3602	-0.0439
0.1414	-0.0095	-0.0013	5.5650	-0.3747	-0.0508
0.1522	-0.0097	-0.0013	5.9931	-0.3815	-0.0519
0.1631	-0.0096	-0.0011	6.4211	-0.3788	-0.0452
0.1740	-0.0093	-0.0008	6.8492	-0.3651	-0.0309
0.1848	-0.0087	-0.0003	7.2773	-0.3417	-0.0101
0.1957	-0.0080	0.0004	7.7054	-0.3142	0.0152
0.2066	-0.0072	0.0010	8.1334	-0.2853	0.0377
0.2175	-0.0066	0.0014	8.5615	-0.2582	0.0560
0.2283	-0.0059	0.0018	8.9896	-0.2325	0.0699
0.2392	-0.0053	0.0020	9.4177	-0.2082	0.0798
0.2501	-0.0047	0.0022	9.8457	-0.1848	0.0859
0.2610	-0.0041	0.0022	10.2738	-0.1623	0.0884
0.2718	-0.0036	0.0022	10.7019	-0.1406	0.0875
0.2827	-0.0030	0.0021	11.1300	-0.1196	0.0834
0.2936	-0.0025	0.0019	11.5581	-0.0990	0.0761
0.3044	-0.0020	0.0017	11.9861	-0.0786	0.0660
0.3153	-0.0015	0.0014	12.4142	-0.0582	0.0532
0.3262	-0.0010	0.0010	12.8423	-0.0380	0.0382
0.3371	-0.0004	0.0005	13.2704	-0.0173	0.0202

Radius, m (in.)	=	1.0281	(40.4750)
Chord, m (in.)	=	0.3371	(13.2704)
ZCSL, m (in.)	=	0.1624	(6.3956)
YCSL, m (in.)	=	-0.0099	(-0.3900)
Leading edge radius, m (in.)	=	0.000546	(0.0215)
Trailing edge radius, m (in.)	=	0.000498	(0.0196)
X-area, m^2 ($in.^2$)	=	0.002022	(3.1341)
Gamma, deg. (rad.)	=	68.13	(1.1891)

Fan Blade Coordinates (under load at the aerodynamic design point)

Shrouded Fan

METERS			INCHES		
ZC	YP	YS	ZC	YP	YS
0.0	-0.0006	0.0007	0.0	-0.0219	0.0272
0.0051	0.0029	0.0060	0.1999	0.1147	0.2381
0.0102	0.0061	0.0111	0.3997	0.2407	0.4359
0.0152	0.0090	0.0158	0.5996	0.3546	0.6209
0.0203	0.0116	0.0202	0.7995	0.4567	0.7939
0.0254	0.0139	0.0242	0.9994	0.5477	0.9534
0.0305	0.0160	0.0278	1.1993	0.6289	1.0963
0.0355	0.0178	0.0310	1.3991	0.7014	1.2223
0.0406	0.0194	0.0338	1.5990	0.7655	1.3325
0.0457	0.0209	0.0363	1.7989	0.8215	1.4283
0.0508	0.0221	0.0384	1.9988	0.8692	1.5101
0.0558	0.0231	0.0401	2.1986	0.9089	1.5786
0.0609	0.0239	0.0415	2.3985	0.9406	1.6341
0.0660	0.0245	0.0426	2.5984	0.9643	1.6769
0.0711	0.0249	0.0434	2.7983	0.9801	1.7072
0.0762	0.0251	0.0438	2.9981	0.9878	1.7249
0.0812	0.0251	0.0439	3.1980	0.9875	1.7301
0.0863	0.0249	0.0438	3.3979	0.9792	1.7226
0.0914	0.0245	0.0432	3.5978	0.9627	1.7023
0.0965	0.0238	0.0424	3.7977	0.9381	1.6688
0.1015	0.0230	0.0412	3.9975	0.9053	1.6218
0.1066	0.0219	0.0396	4.1974	0.8641	1.5610
0.1117	0.0207	0.0377	4.3973	0.8145	1.4858
0.1168	0.0192	0.0354	4.5972	0.7565	1.3956
0.1218	0.0175	0.0328	4.7970	0.6899	1.2899
0.1269	0.0156	0.0297	4.9969	0.6145	1.1680
0.1320	0.0135	0.0261	5.1968	0.5304	1.0287
0.1371	0.0111	0.0221	5.3967	0.4373	0.8716
0.1422	0.0085	0.0177	5.5965	0.3353	0.6952
0.1472	0.0057	0.0127	5.7964	0.2241	0.4988
0.1523	0.0026	0.0071	5.9963	0.1036	0.2799
0.1574	-0.0007	0.0009	6.1962	-0.0268	0.0368

Radius, m (in.)	=	0.3508	(13.8100)
Chord, m (in.)	=	0.1574	(6.1962)
ZCSL, m (in.)	=	0.0809	(3.1834)
YCSL, m (in.)	=	0.0277	(1.0923)
Leading edge radius, m (in.)	=	0.000523	(0.0206)
Trailing edge radius, m (in.)	=	0.000686	(0.0270)
X-area, m^2 ($in.^2$)	=	0.002106	(3.2640)
Gamma, deg. (rad.)	=	-5.11	(-0.0892)

Fan Blade Coordinates (under load at the aerodynamic design point)

METERS			INCHES		
ZC	YP	YS	ZC	YP	YS
0.0	-0.0006	0.0007	0.0	-0.0219	0.0266
0.0051	0.0029	0.0058	0.2003	0.1133	0.2280
0.0102	0.0060	0.0106	0.4007	0.2372	0.4155
0.0153	0.0089	0.0150	0.6010	0.3489	0.5901
0.0204	0.0114	0.0191	0.8014	0.4491	0.7531
0.0254	0.0137	0.0230	1.0017	0.5383	0.9044
0.0305	0.0157	0.0265	1.2021	0.6175	1.0418
0.0356	0.0175	0.0295	1.4024	0.6879	1.1632
0.0407	0.0191	0.0323	1.6028	0.7512	1.2718
0.0458	0.0205	0.0347	1.8031	0.8068	1.3667
0.0509	0.0217	0.0368	2.0035	0.8547	1.4484
0.0560	0.0227	0.0385	2.2038	0.8948	1.5177
0.0611	0.0236	0.0400	2.4042	0.9272	1.5746
0.0662	0.0242	0.0411	2.6045	0.9519	1.6194
0.0712	0.0246	0.0420	2.8049	0.9689	1.6524
0.0763	0.0248	0.0425	3.0052	0.9780	1.6732
0.0814	0.0249	0.0427	3.2056	0.9793	1.6821
0.0865	0.0247	0.0426	3.4059	0.9725	1.6787
0.0916	0.0243	0.0422	3.6062	0.9580	1.6629
0.0967	0.0238	0.0415	3.8066	0.9353	1.6342
0.1018	0.0230	0.0404	4.0069	0.9043	1.5923
0.1069	0.0220	0.0390	4.2073	0.8650	1.5368
0.1120	0.0208	0.0373	4.4076	0.8171	1.4669
0.1170	0.0193	0.0351	4.6080	0.7607	1.3820
0.1221	0.0177	0.0325	4.8083	0.6955	1.2813
0.1272	0.0158	0.0296	5.0087	0.6212	1.1637
0.1323	0.0137	0.0261	5.2090	0.5379	1.0284
0.1374	0.0113	0.0222	5.4094	0.4452	0.8741
0.1425	0.0087	0.0178	5.6097	0.3430	0.6992
0.1476	0.0059	0.0128	5.8101	0.2311	0.5022
0.1527	0.0028	0.0071	6.0104	0.1093	0.2803
0.1578	-0.0006	0.0008	6.2108	-0.0230	0.0317

Radius, m (in.)	=	0.3683	(14.5000)
Chord, m (in.)	=	0.1578	(6.2108)
ZCSL, m (in.)	=	0.0823	(3.2404)
YCSL, m (in.)	=	0.0270	(1.0630)
Leading edge radius, m (in.)	=	0.000518	(0.0204)
Trailing edge radius, m (in.)	=	0.000587	(0.0231)
X-area, m^2 ($in.^2$)	=	0.001998	(3.0974)
Gamma, deg. (rad.)	=	-2.01	(-0.0350)

Fan Blade Coordinates (under load at the aerodynamic design point)

METERS			INCHES		
ZC	YP	YS	ZC	YP	YS
0.0	-0.0006	0.0007	0.0	-0.0220	0.0261
0.0051	0.0028	0.0055	0.2006	0.1112	0.2169
0.0102	0.0060	0.0101	0.4012	0.2353	0.3968
0.0153	0.0089	0.0144	0.6018	0.3489	0.5654
0.0204	0.0114	0.0183	0.8023	0.4499	0.7208
0.0255	0.0137	0.0220	1.0029	0.5396	0.8656
0.0306	0.0157	0.0254	1.2035	0.6196	0.9993
0.0357	0.0175	0.0284	1.4041	0.6906	1.1191
0.0408	0.0191	0.0311	1.6047	0.7535	1.2254
0.0459	0.0205	0.0335	1.8053	0.8082	1.3183
0.0509	0.0217	0.0355	2.0058	0.8549	1.3984
0.0560	0.0227	0.0372	2.2064	0.8939	1.4661
0.0611	0.0235	0.0387	2.4070	0.9253	1.5219
0.0662	0.0241	0.0398	2.6076	0.9491	1.5662
0.0713	0.0245	0.0406	2.8082	0.9654	1.5990
0.0764	0.0247	0.0412	3.0088	0.9743	1.6206
0.0815	0.0248	0.0414	3.2093	0.9758	1.6310
0.0866	0.0246	0.0414	3.4099	0.9698	1.6300
0.0917	0.0243	0.0411	3.6105	0.9560	1.6173
0.0968	0.0237	0.0404	3.8111	0.9342	1.5924
0.1019	0.0230	0.0395	4.0117	0.9044	1.5547
0.1070	0.0220	0.0382	4.2123	0.8664	1.5039
0.1121	0.0208	0.0366	4.4129	0.8198	1.4390
0.1172	0.0194	0.0345	4.6134	0.7646	1.3594
0.1223	0.0178	0.0321	4.8140	0.7005	1.2641
0.1274	0.0159	0.0293	5.0146	0.6273	1.1518
0.1325	0.0138	0.0259	5.2152	0.5447	1.0214
0.1376	0.0115	0.0221	5.4158	0.4523	0.8712
0.1427	0.0089	0.0178	5.6164	0.3500	0.6991
0.1478	0.0060	0.0128	5.8169	0.2375	0.5032
0.1528	0.0029	0.0071	6.0175	0.1143	0.2799
0.1579	-0.0005	0.0007	6.2181	-0.0197	0.0271

Radius, m (in.)	=	0.3881	(15.2790)
Chord, m (in.)	=	0.1579	(6.2181)
ZCSL, m (in.)	=	0.0835	(3.2858)
YCSL, m (in.)	=	0.0263	(1.0355)
Leading edge radius, m (in.)	=	0.000518	(0.0204)
Trailing edge radius, m (in.)	=	0.000500	(0.0197)
X-area, m^2 ($in.^2$)	=	0.001870	(2.8987)
Gamma, deg. (rad.)	=	1.76	(0.0306)

Fan Blade Coordinates (under load at the aerodynamic design point)

METERS			INCHES		
ZC	YP	YS	ZC	YP	YS
0.0	-0.0006	0.0007	0.0	-0.0219	0.0256
0.0051	0.0027	0.0052	0.2011	0.1048	0.2044
0.0102	0.0057	0.0095	0.4021	0.2233	0.3738
0.0153	0.0084	0.0135	0.6032	0.3322	0.5327
0.0204	0.0110	0.0173	0.8043	0.4317	0.6818
0.0255	0.0133	0.0209	1.0054	0.5220	0.8220
0.0306	0.0153	0.0242	1.2064	0.6033	0.9528
0.0358	0.0172	0.0272	1.4075	0.6762	1.0717
0.0409	0.0188	0.0299	1.6086	0.7413	1.1781
0.0460	0.0203	0.0323	1.8097	0.7990	1.2717
0.0511	0.0216	0.0344	2.0107	0.8486	1.3533
0.0562	0.0226	0.0361	2.2118	0.8892	1.4220
0.0613	0.0234	0.0376	2.4129	0.9220	1.4789
0.0664	0.0241	0.0387	2.6139	0.9470	1.5247
0.0715	0.0245	0.0396	2.8150	0.9640	1.5590
0.0766	0.0247	0.0402	3.0161	0.9730	1.5820
0.0817	0.0247	0.0405	3.2172	0.9739	1.5935
0.0868	0.0246	0.0405	3.4182	0.9675	1.5935
0.0919	0.0242	0.0402	3.6193	0.9534	1.5819
0.0970	0.0237	0.0396	3.8204	0.9316	1.5584
0.1021	0.0229	0.0387	4.0214	0.9021	1.5227
0.1073	0.0220	0.0375	4.2225	0.8648	1.4745
0.1124	0.0208	0.0359	4.4236	0.8199	1.4133
0.1175	0.0194	0.0340	4.6247	0.7657	1.3376
0.1226	0.0178	0.0316	4.8257	0.7023	1.2459
0.1277	0.0160	0.0289	5.0268	0.6298	1.1375
0.1328	0.0139	0.0257	5.2279	0.5477	1.0109
0.1379	0.0116	0.0220	5.4290	0.4557	0.8642
0.1430	0.0090	0.0177	5.6300	0.3535	0.6952
0.1481	0.0061	0.0127	5.8311	0.2407	0.5014
0.1532	0.0030	0.0071	6.0322	0.1168	0.2786
0.1583	-0.0005	0.0006	6.2332	-0.0181	0.0248

Radius, m (in.)	=	0.4022	(15.8340)
Chord, m (in.)	=	0.1583	(6.2332)
ZCSL, m (in.)	=	0.0843	(3.3192)
YCSL, m (in.)	=	0.0258	(1.0161)
Leading edge radius, m (in.)	=	0.000521	(0.0205)
Trailing edge radius, m (in.)	=	0.000457	(0.0180)
X-area, m^2 ($in.^2$)	=	0.001775	(2.7511)
Gamma, deg. (rad.)	=	4.52	(0.0789)

Fan Blade Coordinates (under load at the aerodynamic design point)

METERS			INCHES		
ZC	YP	YS	ZC	YP	YS
0.0	-0.0006	0.0006	0.0	-0.0218	0.0251
0.0051	0.0025	0.0049	0.2019	0.0997	0.1943
0.0103	0.0054	0.0090	0.4038	0.2126	0.3540
0.0154	0.0080	0.0128	0.6057	0.3169	0.5043
0.0205	0.0105	0.0164	0.8076	0.4126	0.6456
0.0256	0.0127	0.0198	1.0095	0.5000	0.7787
0.0308	0.0147	0.0230	1.2114	0.5791	0.9038
0.0359	0.0165	0.0259	1.4134	0.6503	1.0188
0.0410	0.0181	0.0285	1.6153	0.7141	1.1226
0.0462	0.0196	0.0309	1.8172	0.7711	1.2147
0.0513	0.0209	0.0329	2.0191	0.8212	1.2957
0.0564	0.0220	0.0347	2.2210	0.8644	1.3656
0.0615	0.0229	0.0362	2.4229	0.9004	1.4246
0.0667	0.0236	0.0374	2.6248	0.9291	1.4727
0.0718	0.0241	0.0383	2.8267	0.9502	1.5098
0.0769	0.0245	0.0390	3.0286	0.9636	1.5360
0.0821	0.0246	0.0394	3.2305	0.9688	1.5508
0.0872	0.0245	0.0395	3.4324	0.9651	1.5539
0.0923	0.0242	0.0392	3.6343	0.9530	1.5452
0.0974	0.0237	0.0387	3.8363	0.9323	1.5244
0.1026	0.0229	0.0379	4.0382	0.9029	1.4910
0.1077	0.0220	0.0367	4.2401	0.8644	1.4445
0.1128	0.0207	0.0352	4.4420	0.8169	1.3839
0.1180	0.0193	0.0333	4.6439	0.7616	1.3092
0.1231	0.0177	0.0310	4.8458	0.6978	1.2196
0.1282	0.0159	0.0283	5.0477	0.6253	1.1140
0.1333	0.0138	0.0252	5.2496	0.5441	0.9911
0.1385	0.0115	0.0216	5.4515	0.4541	0.8492
0.1436	0.0090	0.0174	5.6534	0.3544	0.6862
0.1487	0.0061	0.0126	5.8553	0.2421	0.4962
0.1539	0.0030	0.0070	6.0572	0.1181	0.2760
0.1590	-0.0004	0.0006	6.2591	-0.0171	0.0235

Radius, m (in.)	=	0.4155	(16.3580)
Chord, m (in.)	=	0.1590	(6.2591)
ZCSL, m (in.)	=	0.0852	(3.3536)
YCSL, m (in.)	=	0.0252	(0.9938)
Leading edge radius, m (in.)	=	0.000521	(0.0205)
Trailing edge radius, m (in.)	=	0.000432	(0.0170)
X-area, m^2 ($in.^2$)	=	0.001688	(2.6158)
Gamma, deg. (rad.)	=	7.10	(0.1240)

Fan Blade Coordinates (under load at the aerodynamic design point)

METERS			INCHES		
ZC	YP	YS	ZC	YP	YS
0.0	-0.0005	0.0006	0.0	-0.0210	0.0235
0.0052	0.0021	0.0042	0.2053	0.0816	0.1668
0.0104	0.0045	0.0077	0.4107	0.1790	0.3036
0.0156	0.0069	0.0110	0.6160	0.2698	0.4332
0.0209	0.0090	0.0141	0.8213	0.3541	0.5559
0.0261	0.0110	0.0171	1.0267	0.4319	0.6719
0.0313	0.0128	0.0199	1.2320	0.5031	0.7815
0.0365	0.0144	0.0225	1.4373	0.5677	0.8841
0.0417	0.0159	0.0249	1.6427	0.6259	0.9792
0.0469	0.0172	0.0271	1.8480	0.6786	1.0651
0.0522	0.0184	0.0290	2.0533	0.7258	1.1414
0.0574	0.0195	0.0307	2.2587	0.7675	1.2083
0.0626	0.0204	0.0322	2.4640	0.8036	1.2661
0.0678	0.0212	0.0334	2.6693	0.8339	1.3144
0.0730	0.0218	0.0344	2.8747	0.8582	1.3536
0.0782	0.0223	0.0351	3.0800	0.8764	1.3833
0.0834	0.0226	0.0356	3.2853	0.8882	1.4035
0.0887	0.0227	0.0359	3.4907	0.8926	1.4137
0.0939	0.0226	0.0359	3.6960	0.8896	1.4131
0.0991	0.0223	0.0356	3.9014	0.8792	1.4017
0.1043	0.0219	0.0350	4.1067	0.8611	1.3792
0.1095	0.0212	0.0342	4.3120	0.8348	1.3448
0.1147	0.0203	0.0330	4.5174	0.7998	1.2978
0.1200	0.0192	0.0314	4.7227	0.7556	1.2370
0.1252	0.0178	0.0295	4.9280	0.7016	1.1613
0.1304	0.0162	0.0272	5.1334	0.6370	1.0690
0.1356	0.0142	0.0243	5.3387	0.5610	0.9584
0.1408	0.0120	0.0210	5.5440	0.4727	0.8268
0.1460	0.0094	0.0170	5.7494	0.3710	0.6712
0.1512	0.0065	0.0124	5.9547	0.2545	0.4875
0.1565	0.0032	0.0069	6.1600	0.1243	0.2715
0.1617	-0.0004	0.0006	6.3654	-0.0175	0.0230

Radius, m (in.)	=	0.4463	(17.5710)
Chord, m (in.)	=	0.1617	(6.3654)
ZCSL, m (in.)	=	0.0875	(3.4435)
YCSL, m (in.)	=	0.0231	(0.9081)
Leading edge radius, m (in.)	=	0.000521	(0.0205)
Trailing edge radius, m (in.)	=	0.000427	(0.0168)
X-area, m^2 (in.^{2})	=	0.001514	(2.3464)
Gamma, deg. (rad.)	=	13.16	(0.2297)

Fan Blade Coordinates (under load at the aerodynamic design point)

METERS			INCHES		
ZC	YP	YS	ZC	YP	YS
0.0	-0.0005	0.0006	0.0	-0.0208	0.0227
0.0054	0.0016	0.0036	0.2110	0.0630	0.1410
0.0107	0.0036	0.0065	0.4220	0.1427	0.2548
0.0161	0.0055	0.0092	0.6330	0.2169	0.3626
0.0214	0.0073	0.0118	0.8440	0.2857	0.4647
0.0268	0.0089	0.0143	1.0551	0.3491	0.5611
0.0322	0.0103	0.0166	1.2661	0.4069	0.6519
0.0375	0.0117	0.0187	1.4771	0.4590	0.7370
0.0429	0.0128	0.0207	1.6881	0.5056	0.8168
0.0482	0.0139	0.0226	1.8991	0.5469	0.8894
0.0536	0.0148	0.0242	2.1101	0.5833	0.9539
0.0590	0.0156	0.0257	2.3211	0.6151	1.0102
0.0643	0.0163	0.0269	2.5321	0.6423	1.0584
0.0697	0.0169	0.0279	2.7431	0.6649	1.0985
0.0750	0.0173	0.0287	2.9542	0.6827	1.1307
0.0804	0.0177	0.0293	3.1652	0.6956	1.1547
0.0858	0.0179	0.0297	3.3762	0.7037	1.1705
0.0911	0.0180	0.0299	3.5872	0.7067	1.1780
0.0965	0.0179	0.0299	3.7982	0.7043	1.1769
0.1018	0.0177	0.0296	4.0092	0.6960	1.1668
0.1072	0.0173	0.0291	4.2202	0.6816	1.1472
0.1126	0.0168	0.0284	4.4312	0.6608	1.1175
0.1179	0.0161	0.0274	4.6423	0.6333	1.0773
0.1233	0.0152	0.0261	4.8533	0.5985	1.0257
0.1286	0.0141	0.0244	5.0643	0.5561	0.9618
0.1340	0.0128	0.0225	5.2753	0.5054	0.8844
0.1394	0.0113	0.0201	5.4863	0.4458	0.7922
0.1447	0.0096	0.0174	5.6973	0.3765	0.6833
0.1501	0.0075	0.0141	5.9083	0.2967	0.5554
0.1554	0.0052	0.0103	6.1193	0.2052	0.4054
0.1608	0.0026	0.0058	6.3303	0.1009	0.2295
0.1662	-0.0004	0.0006	6.5414	-0.0177	0.0220

Radius, m (in.)	=	0.4764	(18.7560)
Chord, m (in.)	=	0.1661	(6.5413)
ZCSL, m (in.)	=	0.0899	(3.5394)
YCSL, m (in.)	=	0.0186	(0.7331)
Leading edge radius, m (in.)	=	0.000533	(0.0210)
Trailing edge radius, m (in.)	=	0.000455	(0.0179)
X-area, m^2 ($in.^2$)	=	0.001387	(2.1492)
Gamma, deg. (rad.)	=	19.43	(0.3391)

Fan Blade Coordinates (under load at the aerodynamic design point)

METERS			INCHES		
ZC	YP	YS	ZC	YP	YS
0.0	-0.0005	0.0006	0.0	-0.0203	0.0217
0.0055	0.0012	0.0031	0.2158	0.0484	0.1217
0.0110	0.0029	0.0055	0.4316	0.1143	0.2182
0.0164	0.0045	0.0079	0.6474	0.1765	0.3105
0.0219	0.0060	0.0101	0.8632	0.2348	0.3986
0.0274	0.0073	0.0123	1.0790	0.2892	0.4825
0.0329	0.0086	0.0143	1.2949	0.3394	0.5620
0.0384	0.0098	0.0162	1.5107	0.3853	0.6371
0.0439	0.0108	0.0180	1.7265	0.4267	0.7080
0.0493	0.0118	0.0196	1.9423	0.4635	0.7734
0.0548	0.0126	0.0211	2.1581	0.4957	0.8322
0.0603	0.0133	0.0224	2.3739	0.5232	0.8834
0.0658	0.0139	0.0235	2.5897	0.5461	0.9264
0.0713	0.0143	0.0244	2.8055	0.5643	0.9614
0.0767	0.0147	0.0251	3.0213	0.5777	0.9887
0.0822	0.0149	0.0256	3.2371	0.5864	1.0080
0.0877	0.0150	0.0259	3.4529	0.5903	1.0194
0.0932	0.0150	0.0260	3.6687	0.5894	1.0227
0.0987	0.0148	0.0259	3.8846	0.5838	1.0181
0.1041	0.0146	0.0255	4.1004	0.5733	1.0054
0.1096	0.0142	0.0250	4.3162	0.5577	0.9843
0.1151	0.0136	0.0242	4.5320	0.5371	0.9544
0.1206	0.0130	0.0233	4.7478	0.5111	0.9155
0.1261	0.0122	0.0220	4.9636	0.4795	0.8669
0.1316	0.0112	0.0205	5.1794	0.4421	0.8082
0.1370	0.0101	0.0188	5.3952	0.3985	0.7385
0.1425	0.0089	0.0167	5.6110	0.3485	0.6570
0.1480	0.0074	0.0143	5.8268	0.2914	0.5626
0.1535	0.0058	0.0115	6.0426	0.2269	0.4537
0.1590	0.0039	0.0083	6.2584	0.1544	0.3287
0.1644	0.0019	0.0047	6.4742	0.0730	0.1852
0.1699	-0.0004	0.0005	6.6901	-0.0175	0.0207

Radius, m (in.)	=	0.5050	(19.8800)
Chord, m (in.)	=	0.1699	(6.6901)
ZCSL, m (in.)	=	0.0918	(3.6161)
YCSL, m (in.)	=	0.0156	(0.6149)
Leading edge radius, m (in.)	=	0.000528	(0.0208)
Trailing edge radius, m (in.)	=	0.000475	(0.0187)
X-area, m^2 ($in.^2$)	=	0.001289	(1.9981)
Gamma, deg. (rad.)	=	24.78	(0.4324)

Fan Blade Coordinates (under load at the aerodynamic design point)

METERS			INCHES		
ZC	YP	YS	ZC	YP	YS
0.0	-0.0005	0.0005	0.0	-0.0205	0.0215
0.0056	0.0009	0.0026	0.2202	0.0338	0.1040
0.0112	0.0022	0.0047	0.4403	0.0861	0.1843
0.0168	0.0035	0.0066	0.6605	0.1360	0.2616
0.0224	0.0047	0.0085	0.8806	0.1831	0.3358
0.0280	0.0058	0.0103	1.1008	0.2276	0.4070
0.0336	0.0068	0.0121	1.3209	0.2692	0.4750
0.0391	0.0078	0.0137	1.5411	0.3078	0.5399
0.0447	0.0087	0.0153	1.7613	0.3434	0.6018
0.0503	0.0095	0.0168	1.9814	0.3759	0.6598
0.0559	0.0103	0.0181	2.2016	0.4050	0.7141
0.0615	0.0109	0.0194	2.4217	0.4303	0.7618
0.0671	0.0115	0.0204	2.6419	0.4514	0.8022
0.0727	0.0119	0.0212	2.8620	0.4683	0.8352
0.0783	0.0122	0.0219	3.0822	0.4811	0.[illegible]9
0.0839	0.0124	0.0223	3.3024	0.4897	0[illegible]4
0.0895	0.0125	0.0226	3.5225	0.4940	0.8906
0.0951	0.0125	0.0227	3.7427	0.4941	0.8944
0.1007	0.0124	0.0226	3.9628	0.4898	0.8907
0.1062	0.0122	0.0223	4.1830	0.4810	0.8794
0.1118	0.0119	0.0218	4.4031	0.4676	0.8602
0.1174	0.0114	0.0212	4.6233	0.4497	0.8330
0.1230	0.0108	0.0203	4.8435	0.4270	0.7975
0.1286	0.0101	0.0191	5.0636	0.3994	0.7533
0.1342	0.0093	0.0178	5.2838	0.3668	0.7001
0.1398	0.0084	0.0162	5.5039	0.3291	0.6374
0.1454	0.0073	0.0143	5.7241	0.2860	0.5646
0.1510	0.0060	0.0122	5.9443	0.2374	0.4811
0.1566	0.0046	0.0098	6.1644	0.1830	0.3859
0.1622	0.0031	0.0071	6.3846	0.1225	0.2781
0.1678	0.0014	0.0040	6.6047	0.0557	0.1564
0.1734	-0.0004	0.0005	6.8249	-0.0174	0.0198

Radius, m (in.)	=	0.5358	(21.0960)
Chord, m (in.)	=	0.1734	(6.8249)
ZCSL, m (in.)	=	0.0935	(3.6826)
YCSL, m (in.)	=	0.0130	(0.5116)
Leading edge radius, m (in.)	=	0.000538	(0.0212)
Trailing edge radius, m (in.)	=	0.000480	(0.0189)
X-area, m^2 ($in.^2$)	=	0.001208	(1.8725)
Gamma, deg. (rad.)	=	29.24	(0.5102)

Fan Blade Coordinates (under load at the aerodynamic design point)

METERS			INCHES		
ZC	YP	YS	ZC	YP	YS
0.0	-0.0005	0.0005	0.0	-0.0201	0.0207
0.0057	0.0005	0.0022	0.2256	0.0197	0.0863
0.0115	0.0015	0.0038	0.4511	0.0584	0.1503
0.0172	0.0024	0.0054	0.6767	0.0956	0.2123
0.0229	0.0033	0.0069	0.9023	0.1314	0.2723
0.0286	0.0042	0.0084	1.1278	0.1656	0.3303
0.0344	0.0050	0.0098	1.3534	0.1982	0.3863
0.0401	0.0058	0.0112	1.5790	0.2291	0.4401
0.0458	0.0066	0.0125	1.8045	0.2583	0.4918
0.0516	0.0073	0.0138	2.0301	0.2858	0.5414
0.0573	0.0079	0.0150	2.2557	0.3114	0.5893
0.0630	0.0085	0.0161	2.4812	0.3347	0.6330
0.0688	0.0090	0.0170	2.7068	0.3547	0.6711
0.0745	0.0094	0.0178	2.9324	0.3708	0.7025
0.0802	0.0097	0.0185	3.1579	0.3831	0.7269
0.0859	0.0099	0.0189	3.3835	0.3917	0.7445
0.0917	0.0101	0.0192	3.6091	0.3964	0.7553
0.0974	0.0101	0.0193	3.8346	0.3972	0.7593
0.1031	0.0100	0.0192	4.0602	0.3943	0.7565
0.1089	0.0098	0.0190	4.2858	0.3873	0.7468
0.1146	0.0096	0.0185	4.5113	0.3765	0.7300
0.1203	0.0092	0.0179	4.7369	0.3617	0.7060
0.1260	0.0087	0.0171	4.9625	0.3429	0.6747
0.1318	0.0081	0.0162	5.1880	0.3200	0.6360
0.1375	0.0074	0.0150	5.4136	0.2930	0.5896
0.1432	0.0067	0.0136	5.6392	0.2618	0.5351
0.1490	0.0058	0.0120	5.8647	0.2264	0.4724
0.1547	0.0047	0.0102	6.0903	0.1867	0.4010
0.1604	0.0036	0.0081	6.3159	0.1425	0.3205
0.1662	0.0024	0.0059	6.5414	0.0938	0.2304
0.1719	0.0010	0.0033	6.7670	0.0405	0.1300
0.1776	-0.0004	0.0005	6.9926	-0.0173	0.0190

Radius, m (in.)	=	0.5798	(22.8280)
Chord, m (in.)	=	0.1776	(6.9926)
ZCSL, m (in.)	=	0.0956	(3.7654)
YCSL, m (in.)	=	0.0102	(0.4010)
Leading edge radius, m (in.)	=	0.000533	(0.0210)
Trailing edge radius, m (in.)	=	0.000478	(0.0188)
X-area, m^2 ($in.^2$)	=	0.001115	(1.7280)
Gamma, deg. (rad.)	=	33.94	(0.5923)

Fan Blade Coordinates (under load at the aerodynamic design point)

METERS			INCHES		
ZC	YP	YS	ZC	YP	YS
0.0	-0.0005	0.0005	0.0	-0.0198	0.0199
0.0058	0.0003	0.0019	0.2301	0.0118	0.0758
0.0117	0.0011	0.0033	0.4601	0.0428	0.1307
0.0175	0.0019	0.0047	0.6901	0.0731	0.1843
0.0234	0.0026	0.0060	0.9202	0.1028	0.2366
0.0292	0.0033	0.0073	1.1502	0.1317	0.2875
0.0351	0.0041	0.0086	1.3803	0.1597	0.3369
0.0409	0.0047	0.0098	1.6103	0.1869	0.3849
0.0467	0.0054	0.0110	1.8404	0.2131	0.4314
0.0526	0.0061	0.0121	2.0704	0.2382	0.4765
0.0584	0.0067	0.0132	2.3005	0.2624	0.5201
0.0643	0.0073	0.0143	2.5305	0.2855	0.5618
0.0701	0.0078	0.0152	2.7605	0.3064	0.6003
0.0760	0.0082	0.0161	2.9906	0.3242	0.6325
0.0818	0.0086	0.0167	3.2206	0.3379	0.6579
0.0876	0.0088	0.0172	3.4507	0.3477	0.6765
0.0935	0.0090	0.0175	3.6807	0.3537	0.6885
0.0993	0.0090	0.0176	3.9108	0.3560	0.6936
0.1052	0.0090	0.0176	4.1408	0.3546	0.6922
0.1110	0.0089	0.0174	4.3709	0.3493	0.6842
0.1169	0.0086	0.0170	4.6009	0.3401	0.6693
0.1227	0.0083	0.0164	4.8309	0.3272	0.6475
0.1285	0.0079	0.0157	5.0610	0.3104	0.6189
0.1344	0.0074	0.0148	5.2910	0.2898	0.5831
0.1402	0.0067	0.0137	5.5211	0.2653	0.5401
0.1461	0.0060	0.0124	5.7511	0.2370	0.4898
0.1519	0.0052	0.0110	5.9812	0.2047	0.4318
0.1578	0.0043	0.0093	6.2112	0.1684	0.3660
0.1636	0.0033	0.0074	6.4413	0.1282	0.2921
0.1695	0.0021	0.0053	6.6713	0.0839	0.2098
0.1753	0.0009	0.0030	6.9014	0.0355	0.1185
0.1811	-0.0004	0.0005	7.1314	-0.0167	0.0183

Radius, m (in.)	=	0.6181	(24.3360)
Chord, m (in.)	=	0.1811	(7.1314)
ZCSL, m (in.)	=	0.0975	(3.8405)
YCSL, m (in.)	=	0.0087	(0.3425)
Leading edge radius, m (in.)	=	0.000521	(0.0205)
Trailing edge radius, m (in.)	=	0.000462	(0.0182)
X-area, m^2 ($in.^2$)	=	0.001059	(1.6421)
Gamma, deg. (rad.)	=	37.01	(0.6460)

Fan Blade Coordinates (under load at the aerodynamic design point)

METERS			INCHES		
ZC	YP	YS	ZC	YP	YS
0.0	-0.0005	0.0005	0.0	-0.0186	0.0200
0.0059	0.0002	0.0017	0.2337	0.0067	0.0683
0.0119	0.0008	0.0029	0.4673	0.0317	0.1160
0.0178	0.0014	0.0041	0.7010	0.0565	0.1630
0.0237	0.0021	0.0053	0.9346	0.0814	0.2091
0.0297	0.0027	0.0065	1.1683	0.1061	0.2545
0.0356	0.0033	0.0076	1.4019	0.1306	0.2990
0.0415	0.0039	0.0087	1.6356	0.1548	0.3426
0.0475	0.0045	0.0098	1.8692	0.1787	0.3852
0.0534	0.0051	0.0108	2.1029	0.2020	0.4269
0.0593	0.0057	0.0119	2.3365	0.2253	0.4676
0.0653	0.0063	0.0129	2.5702	0.2482	0.5080
0.0712	0.0069	0.0139	2.8038	0.2705	0.5467
0.0772	0.0074	0.0148	3.0375	0.2910	0.5810
0.0831	0.0078	0.0155	3.2711	0.3076	0.6093
0.0890	0.0081	0.0160	3.5048	0.3202	0.6307
0.0950	0.0084	0.0164	3.7385	0.3289	0.6453
0.1009	0.0085	0.0166	3.9721	0.3335	0.6531
0.1068	0.0085	0.0166	4.2058	0.3342	0.6541
0.1128	0.0084	0.0165	4.4394	0.3310	0.6482
0.1187	0.0082	0.0161	4.6731	0.3239	0.6356
0.1246	0.0079	0.0156	4.9067	0.3128	0.6161
0.1306	0.0076	0.0150	5.1404	0.2978	0.5897
0.1365	0.0071	0.0141	5.3740	0.2788	0.5563
0.1424	0.0065	0.0131	5.6077	0.2559	0.5158
0.1484	0.0058	0.0119	5.8413	0.2290	0.4680
0.1543	0.0050	0.0105	6.0750	0.1980	0.4128
0.1602	0.0041	0.0089	6.3086	0.1631	0.3500
0.1662	0.0032	0.0071	6.5423	0.1242	0.2792
0.1721	0.0021	0.0051	6.7759	0.0813	0.2004
0.1780	0.0009	0.0029	7.0096	0.0343	0.1131
0.1840	-0.0004	0.0004	7.2432	-0.0164	0.0174

Radius, m (in.)	=	0.6533	(25.7220)
Chord, m (in.)	=	0.1840	(7.2432)
ZCSL, m (in.)	=	0.0991	(3.9034)
YCSL, m (in.)	=	0.0077	(0.3020)
Leading edge radius, m (in.)	=	0.000508	(0.0200)
Trailing edge radius, m (in.)	=	0.000447	(0.0176)
X-area, m^2 ($in.^2$)	=	0.001018	(1.5778)
Gamma, deg. (rad.)	=	39.57	(0.6907)

Fan Blade Coordinates (under load at the aerodynamic design point)

METERS			INCHES		
ZC	YP	YS	ZC	YP	YS
0.0	-0.0005	0.0005	0.0	-0.0177	0.0199
0.0060	0.0000	0.0015	0.2372	0.0010	0.0609
0.0121	0.0005	0.0026	0.4744	0.0197	0.1013
0.0181	0.0010	0.0036	0.7117	0.0384	0.1410
0.0241	0.0014	0.0046	0.9489	0.0570	0.1798
0.0301	0.0019	0.0055	1.1861	0.0757	0.2179
0.0362	0.0024	0.0065	1.4233	0.0944	0.2554
0.0422	0.0029	0.0074	1.6606	0.1131	0.2922
0.0482	0.0033	0.0083	1.8978	0.1317	0.3284
0.0542	0.0038	0.0092	2.1350	0.1508	0.3641
0.0603	0.0043	0.0102	2.3722	0.1705	0.3999
0.0663	0.0048	0.0111	2.6094	0.1908	0.4357
0.0723	0.0054	0.0120	2.8467	0.2116	0.4713
0.0783	0.0059	0.0128	3.0839	0.2322	0.5058
0.0844	0.0064	0.0136	3.3211	0.2501	0.5357
0.0904	0.0067	0.0142	3.5583	0.2641	0.5590
0.0964	0.0070	0.0146	3.7956	0.2745	0.5756
0.1024	0.0071	0.0149	4.0328	0.2814	0.5858
0.1085	0.0072	0.0150	4.2700	0.2847	0.5894
0.1145	0.0072	0.0149	4.5072	0.2844	0.5866
0.1205	0.0071	0.0147	4.7444	0.2804	0.5773
0.1265	0.0069	0.0143	4.9817	0.2729	0.5613
0.1326	0.0066	0.0137	5.2189	0.2618	0.5388
0.1386	0.0063	0.0129	5.4561	0.2469	0.5096
0.1446	0.0058	0.0120	5.6933	0.2283	0.4735
0.1506	0.0052	0.0109	5.9305	0.2059	0.4306
0.1567	0.0046	0.0097	6.1678	0.1796	0.3807
0.1627	0.0038	0.0082	6.4050	0.1492	0.3234
0.1687	0.0029	0.0066	6.6422	0.1148	0.2588
0.1747	0.0019	0.0047	6.8794	0.0760	0.1865
0.1808	0.0008	0.0027	7.1167	0.0329	0.1062
0.1868	-0.0004	0.0005	7.3539	-0.0144	0.0182

Radius, m (in.)	=	0.6862	(27.0140)
Chord, m (in.)	=	0.1868	(7.3539)
ZCSL, m (in.)	=	0.1005	(3.9582)
YCSL, m (in.)	=	0.0062	(0.2426)
Leading edge radius, m (in.)	=	0.000495	(0.0195)
Trailing edge radius, m (in.)	=	0.000429	(0.0169)
X-area, m^2 ($in.^2$)	=	0.000980	(1.5185)
Gamma, deg. (rad.)	=	42.06	(0.7340)

Fan Blade Coordinates (under load at the aerodynamic design point)

METERS			INCHES		
ZC	YP	YS	ZC	YP	YS
0.0	-0.0004	0.0005	0.0	-0.0177	0.0196
0.0061	-0.0001	0.0014	0.2408	-0.0038	0.0555
0.0122	0.0003	0.0023	0.4815	0.0101	0.0906
0.0183	0.0006	0.0032	0.7223	0.0239	0.1247
0.0245	0.0009	0.0040	0.9630	0.0374	0.1578
0.0306	0.0013	0.0048	1.2038	0.0508	0.1899
0.0367	0.0016	0.0056	1.4446	0.0642	0.2212
0.0428	0.0020	0.0064	1.6853	0.0774	0.2517
0.0489	0.0023	0.0072	1.9261	0.0909	0.2818
0.0550	0.0027	0.0079	2.1669	0.1054	0.3120
0.0612	0.0031	0.0087	2.4076	0.1211	0.3428
0.0673	0.0035	0.0095	2.6484	0.1382	0.3741
0.0734	0.0040	0.0103	2.8891	0.1565	0.4063
0.0795	0.0045	0.0112	3.1299	0.1766	0.4392
0.0856	0.0050	0.0119	3.3707	0.1954	0.4695
0.0917	0.0054	0.0126	3.6114	0.2112	0.4944
0.0978	0.0057	0.0130	3.8522	0.2235	0.5130
0.1040	0.0059	0.0133	4.0929	0.2323	0.5253
0.1101	0.0060	0.0135	4.3337	0.2376	0.5312
0.1162	0.0061	0.0135	4.5745	0.2395	0.5308
0.1223	0.0060	0.0133	4.8152	0.2380	0.5241
0.1284	0.0059	0.0130	5.0560	0.2331	0.5110
0.1345	0.0057	0.0125	5.2967	0.2247	0.4916
0.1407	0.0054	0.0118	5.5375	0.2129	0.4659
0.1468	0.0050	0.0110	5.7783	0.1976	0.4336
0.1529	0.0045	0.0100	6.0190	0.1787	0.3948
0.1590	0.0040	0.0089	6.2598	0.1562	0.3494
0.1651	0.0033	0.0075	6.5006	0.1300	0.2972
0.1712	0.0025	0.0060	6.7413	0.1000	0.2381
0.1773	0.0017	0.0044	6.9821	0.0660	0.1718
0.1835	0.0007	0.0025	7.2228	0.0280	0.0984
0.1896	-0.0004	0.0005	7.4636	-0.0138	0.0177

Radius, m (in.)	=	0.7170	(28.2300)
Chord, m (in.)	=	0.1896	(7.4636)
ZCSL, m (in.)	=	0.1019	(4.0136)
YCSL, m (in.)	=	0.0047	(0.1870)
Leading edge radius, m (in.)	=	0.000493	(0.0194)
Trailing edge radius, m (in.)	=	0.000419	(0.0165)
X-area, m^2 (in.^{2})	=	0.000959	(1.4870)
Gamma, deg. (rad.)	=	44.34	(0.7739)

Fan Blade Coordinates (under load at the aerodynamic design point)

METERS			INCHES		
ZC	YP	YS	ZC	YP	YS
0.0	-0.0004	0.0005	0.0	-0.0177	0.0196
0.0062	-0.0002	0.0013	0.2442	-0.0093	0.0497
0.0124	-0.0000	0.0020	0.4883	-0.0011	0.0788
0.0186	0.0002	0.0027	0.7325	0.0071	0.1071
0.0248	0.0004	0.0034	0.9767	0.0151	0.1345
0.0310	0.0006	0.0041	1.2209	0.0232	0.1609
0.0372	0.0008	0.0047	1.4650	0.0311	0.1865
0.0434	0.0010	0.0054	1.7092	0.0387	0.2109
0.0496	0.0012	0.0060	1.9534	0.0470	0.2353
0.0558	0.0014	0.0066	2.1976	0.0566	0.2602
0.0620	0.0017	0.0073	2.4417	0.0681	0.2861
0.0682	0.0021	0.0080	2.6859	0.0814	0.3132
0.0744	0.0024	0.0087	2.9301	0.0964	0.3415
0.0806	0.0029	0.0094	3.1743	0.1145	0.3715
0.0868	0.0034	0.0102	3.4184	0.1325	0.4011
0.0930	0.0038	0.0109	3.6626	0.1497	0.4274
0.0992	0.0042	0.0114	3.9068	0.1636	0.4478
0.1054	0.0044	0.0117	4.1510	0.1742	0.4622
0.1116	0.0046	0.0119	4.3951	0.1816	0.4703
0.1178	0.0047	0.0120	4.6393	0.1859	0.4725
0.1240	0.0048	0.0119	4.8835	0.1870	0.4686
0.1302	0.0047	0.0116	5.1277	0.1851	0.4586
0.1364	0.0046	0.0112	5.3718	0.1799	0.4426
0.1426	0.0044	0.0107	5.6160	0.1715	0.4205
0.1488	0.0041	0.0100	5.8602	0.1600	0.3923
0.1551	0.0037	0.0091	6.1044	0.1453	0.3580
0.1613	0.0032	0.0081	6.3485	0.1273	0.3173
0.1675	0.0027	0.0069	6.5927	0.1060	0.2703
0.1737	0.0021	0.0055	6.8369	0.0813	0.2170
0.1799	0.0013	0.0040	7.0810	0.0531	0.1570
0.1861	0.0005	0.0023	7.3252	0.0212	0.0905
0.1923	-0.0004	0.0004	7.5694	-0.0138	0.0175

Radius, m (in.)	=	0.7464	(29.3850)
Chord, m (in.)	=	0.1923	(7.5694)
ZCSL, m (in.)	=	0.1034	(4.0706)
YCSL, m (in.)	=	0.0033	(0.1280)
Leading edge radius, m (in.)	=	0.000493	(0.0194)
Trailing edge radius, m (in.)	=	0.000417	(0.0164)
X-area, m^2 ($in.^2$)	=	0.000957	(1.4840)
Gamma, deg. (rad.)	=	46.55	(0.8125)

Fan Blade Coordinates (under load at the aerodynamic design point)

METERS			INCHES		
ZC	YP	YS	ZC	YP	YS
0.0	-0.0004	0.0005	0.0	-0.0176	0.0195
0.0063	-0.0004	0.0011	0.2476	-0.0139	0.0449
0.0126	-0.0003	0.0018	0.4953	-0.0105	0.0694
0.0189	-0.0002	0.0024	0.7429	-0.0071	0.0931
0.0252	-0.0001	0.0029	0.9905	-0.0037	0.1159
0.0314	-0.0000	0.0035	1.2382	-0.0002	0.1378
0.0377	0.0001	0.0040	1.4858	0.0033	0.1588
0.0440	0.0002	0.0045	1.7334	0.0061	0.1786
0.0503	0.0003	0.0050	1.9811	0.0100	0.1984
0.0566	0.0004	0.0056	2.2287	0.0152	0.2186
0.0629	0.0006	0.0061	2.4763	0.0221	0.2399
0.0692	0.0008	0.0067	2.7240	0.0309	0.2623
0.0755	0.0011	0.0073	2.9716	0.0418	0.2858
0.0818	0.0014	0.0079	3.2193	0.0552	0.3107
0.0881	0.0018	0.0086	3.4669	0.0698	0.3367
0.0943	0.0022	0.0092	3.7145	0.0855	0.3615
0.1006	0.0025	0.0097	3.9622	0.0989	0.3816
0.1069	0.0028	0.0101	4.2098	0.1098	0.3964
0.1132	0.0030	0.0103	4.4574	0.1181	0.4055
0.1195	0.0031	0.0104	4.7051	0.1237	0.4091
0.1258	0.0032	0.0103	4.9527	0.1268	0.4072
0.1321	0.0032	0.0102	5.2003	0.1273	0.3998
0.1384	0.0032	0.0098	5.4480	0.1252	0.3869
0.1447	0.0031	0.0094	5.6956	0.1205	0.3684
0.1510	0.0029	0.0087	5.9432	0.1131	0.3444
0.1572	0.0026	0.0080	6.1909	0.1032	0.3148
0.1635	0.0023	0.0071	6.4385	0.0905	0.2795
0.1698	0.0019	0.0061	6.6862	0.0752	0.2385
0.1761	0.0015	0.0049	6.9338	0.0571	0.1919
0.1824	0.0009	0.0035	7.1814	0.0363	0.1394
0.1887	0.0003	0.0021	7.4291	0.0127	0.0812
0.1950	-0.0003	0.0004	7.6767	-0.0135	0.0172

Radius, m (in.)	=	0.7745	(30.4910)
Chord, m (in.)	=	0.1950	(7.6767)
ZCSL, m (in.)	=	0.1048	(4.1256)
YCSL, m (in.)	=	0.0017	(0.0688)
Leading edge radius, m (in.)	=	0.000490	(0.0193)
Trailing edge radius, m (in.)	=	0.000411	(0.0162)
X-area, m^2 ($in.^2$)	=	0.000968	(1.4997)
Gamma, deg. (rad.)	=	48.28	(0.8426)

Fan Blade Coordinates (under load at the aerodynamic design point)

METERS			INCHES		
ZC	YP	YS	ZC	YP	YS
0.0	-0.0004	0.0005	0.0	-0.0176	0.0197
0.0064	-0.0004	0.0011	0.2513	-0.0160	0.0452
0.0128	-0.0004	0.0018	0.5027	-0.0142	0.0699
0.0192	-0.0003	0.0024	0.7540	-0.0120	0.0938
0.0255	-0.0002	0.0030	1.0053	-0.0095	0.1170
0.0319	-0.0002	0.0035	1.2566	-0.0067	0.1394
0.0383	-0.0001	0.0041	1.5079	-0.0036	0.1611
0.0447	-0.0000	0.0046	1.7593	-0.0003	0.1817
0.0511	0.0001	0.0051	2.0106	0.0030	0.2014
0.0575	0.0002	0.0056	2.2619	0.0065	0.2204
0.0638	0.0003	0.0061	2.5132	0.0106	0.2392
0.0702	0.0004	0.0065	2.7646	0.0155	0.2577
0.0766	0.0005	0.0070	3.0159	0.0214	0.2762
0.0830	0.0007	0.0075	3.2672	0.0283	0.2947
0.0894	0.0009	0.0080	3.5185	0.0359	0.3137
0.0958	0.0011	0.0084	3.7698	0.0445	0.3318
0.1021	0.0013	0.0088	4.0212	0.0522	0.3467
0.1085	0.0015	0.0091	4.2725	0.0586	0.3575
0.1149	0.0016	0.0092	4.5238	0.0637	0.3637
0.1213	0.0017	0.0093	4.7751	0.0673	0.3654
0.1277	0.0018	0.0092	5.0265	0.0693	0.3624
0.1341	0.0018	0.0090	5.2778	0.0699	0.3547
0.1404	0.0018	0.0087	5.5291	0.0689	0.3424
0.1468	0.0017	0.0083	5.7804	0.0664	0.3253
0.1532	0.0016	0.0077	6.0317	0.0624	0.3034
0.1596	0.0014	0.0070	6.2831	0.0564	0.2768
0.1660	0.0012	0.0062	6.5344	0.0487	0.2454
0.1724	0.0010	0.0053	6.7857	0.0393	0.2091
0.1787	0.0007	0.0043	7.0370	0.0283	0.1682
0.1851	0.0004	0.0031	7.2884	0.0157	0.1224
0.1915	0.0000	0.0018	7.5397	0.0018	0.0718
0.1979	-0.0003	0.0004	7.7910	-0.0133	0.0169

Radius, m (in.)	=	0.8016	(31.5580)
Chord, m (in.)	=	0.1979	(7.7910)
ZCSL, m (in.)	=	0.1063	(4.1858)
YCSL, m (in.)	=	0.0008	(0.0303)
Leading edge radius, m (in.)	=	0.000495	(0.0195)
Trailing edge radius, m (in.)	=	0.000409	(0.0161)
X-area, m^2 ($in.^2$)	=	0.001026	(1.5904)
Gamma, deg. (rad.)	=	48.74	(0.8507)

Fan Blade Coordinates (under load at the aerodynamic design point)

METERS			INCHES		
ZC	YP	YS	ZC	YP	YS
0.0	-0.0004	0.0005	0.0	-0.0173	0.0197
0.0065	-0.0003	0.0013	0.2548	-0.0118	0.0525
0.0129	-0.0002	0.0021	0.5097	-0.0061	0.0846
0.0194	0.0000	0.0029	0.7645	0.0001	0.1158
0.0259	0.0002	0.0037	1.0193	0.0068	0.1462
0.0324	0.0004	0.0045	1.2741	0.0138	0.1758
0.0388	0.0005	0.0052	1.5290	0.0211	0.2046
0.0453	0.0007	0.0059	1.7838	0.0291	0.2329
0.0518	0.0009	0.0066	2.0386	0.0364	0.2592
0.0583	0.0011	0.0072	2.2935	0.0422	0.2831
0.0647	0.0012	0.0077	2.5483	0.0461	0.3037
0.0712	0.0012	0.0082	2.8031	0.0478	0.3213
0.0777	0.0012	0.0085	3.0579	0.0476	0.3357
0.0841	0.0012	0.0088	3.3128	0.0455	0.3471
0.0906	0.0010	0.0090	3.5676	0.0413	0.3555
0.0971	0.0009	0.0092	3.8224	0.0352	0.3608
0.1036	0.0007	0.0092	4.0772	0.0285	0.3630
0.1100	0.0006	0.0092	4.3321	0.0220	0.3622
0.1165	0.0004	0.0091	4.5869	0.0159	0.3581
0.1230	0.0003	0.0089	4.8417	0.0104	0.3509
0.1295	0.0001	0.0086	5.0966	0.0055	0.3404
0.1359	0.0000	0.0083	5.3514	0.0009	0.3268
0.1424	-0.0001	0.0079	5.6062	-0.0032	0.3099
0.1489	-0.0002	0.0074	5.8610	-0.0067	0.2898
0.1553	-0.0003	0.0068	6.1159	-0.0098	0.2665
0.1618	-0.0003	0.0061	6.3707	-0.0125	0.2401
0.1683	-0.0004	0.0053	6.6255	-0.0145	0.2105
0.1748	-0.0004	0.0045	6.8804	-0.0159	0.1777
0.1812	-0.0004	0.0036	7.1352	-0.0166	0.1419
0.1877	-0.0004	0.0026	7.3900	-0.0165	0.1031
0.1942	-0.0004	0.0016	7.6448	-0.0153	0.0613
0.2007	-0.0003	0.0004	7.8997	-0.0130	0.0168

Radius, m (in.)	=	0.8284	(32.6150)
Chord, m (in.)	=	0.2007	(7.8997)
ZCSL, m (in.)	=	0.1084	(4.2679)
YCSL, m (in.)	=	0.0004	(0.0176)
Leading edge radius, m (in.)	=	0.000495	(0.0195)
Trailing edge radius, m (in.)	=	0.000411	(0.0162)
X-area, m^2 ($in.^2$)	=	0.001177	(1.8236)
Gamma, deg. (rad.)	=	48.78	(0.8513)

Fan Blade Coordinates (under load at the aerodynamic design point)

METERS			INCHES		
ZC	YP	YS	ZC	YP	YS
0.0	-0.0004	0.0005	0.0	-0.0173	0.0198
0.0065	-0.0003	0.0013	0.2569	-0.0123	0.0528
0.0131	-0.0002	0.0022	0.5138	-0.0069	0.0852
0.0196	-0.0000	0.0030	0.7707	-0.0012	0.1166
0.0261	0.0001	0.0037	1.0275	0.0050	0.1472
0.0326	0.0003	0.0045	1.2844	0.0114	0.1768
0.0391	0.0005	0.0052	1.5413	0.0181	0.2055
0.0457	0.0006	0.0059	1.7982	0.0252	0.2335
0.0522	0.0008	0.0066	2.0551	0.0317	0.2595
0.0587	0.0009	0.0072	2.3120	0.0366	0.2830
0.0652	0.0010	0.0077	2.5689	0.0393	0.3029
0.0718	0.0010	0.0081	2.8258	0.0396	0.3192
0.0783	0.0010	0.0084	3.0827	0.0375	0.3320
0.0848	0.0008	0.0087	3.3395	0.0332	0.3411
0.0913	0.0007	0.0088	3.5964	0.0263	0.3469
0.0979	0.0004	0.0089	3.8533	0.0170	0.3492
0.1044	0.0002	0.0089	4.1102	0.0068	0.3484
0.1109	-0.0001	0.0088	4.3671	-0.0030	0.3446
0.1174	-0.0003	0.0086	4.6240	-0.0120	0.3380
0.1240	-0.0005	0.0083	4.8809	-0.0198	0.3287
0.1305	-0.0007	0.0080	5.1377	-0.0264	0.3167
0.1370	-0.0008	0.0077	5.3946	-0.0320	0.3021
0.1435	-0.0009	0.0072	5.6515	-0.0363	0.2849
0.1501	-0.0010	0.0067	5.9084	-0.0393	0.2651
0.1566	-0.0010	0.0062	6.1653	-0.0409	0.2428
0.1631	-0.0010	0.0055	6.4222	-0.0413	0.2180
0.1696	-0.0010	0.0048	6.6791	-0.0402	0.1907
0.1762	-0.0010	0.0041	6.9360	-0.0377	0.1608
0.1827	-0.0009	0.0033	7.1929	-0.0338	0.1285
0.1892	-0.0007	0.0024	7.4497	-0.0285	0.0937
0.1957	-0.0005	0.0014	7.7066	-0.0215	0.0564
0.2023	-0.0003	0.0004	7.9635	-0.0130	0.0168

Radius, m (in.)	=	0.8403	(33.1030)
Chord, m (in.)	=	0.2023	(7.9635)
ZCSL, m (in.)	=	0.1093	(4.3032)
YCSL, m (in.)	=	-0.0001	(-0.0037)
Leading edge radius, m (in.)	=	0.000495	(0.0195)
Trailing edge radius, m (in.)	=	0.000414	(0.0163)
X-area, m^2 ($in.^2$)	=	0.001213	(1.8804)
Gamma, deg. (rad.)	=	49.74	(0.8681)

Fan Blade Coordinates (under load at the aerodynamic design point)

METERS			INCHES		
ZC	YP	YS	ZC	YP	YS
0.0	-0.0004	0.0005	0.0	-0.0175	0.0198
0.0066	-0.0004	0.0012	0.2588	-0.0165	0.0481
0.0131	-0.0004	0.0019	0.5177	-0.0153	0.0756
0.0197	-0.0004	0.0026	0.7765	-0.0139	0.1021
0.0263	-0.0003	0.0032	1.0353	-0.0124	0.1277
0.0329	-0.0003	0.0039	1.2941	-0.0107	0.1524
0.0394	-0.0002	0.0045	1.5529	-0.0088	0.1761
0.0460	-0.0002	0.0051	1.8118	-0.0068	0.1988
0.0526	-0.0001	0.0056	2.0706	-0.0050	0.2202
0.0592	-0.0001	0.0061	2.3294	-0.0037	0.2398
0.0657	-0.0001	0.0065	2.5882	-0.0036	0.2571
0.0723	-0.0001	0.0069	2.8470	-0.0044	0.2721
0.0789	-0.0002	0.0072	3.1059	-0.0063	0.2848
0.0855	-0.0002	0.0075	3.3647	-0.0093	0.2953
0.0920	-0.0003	0.0077	3.6235	-0.0134	0.3036
0.0986	-0.0005	0.0079	3.8823	-0.0184	0.3098
0.1052	-0.0006	0.0080	4.1412	-0.0239	0.3135
0.1118	-0.0007	0.0080	4.4000	-0.0292	0.3143
0.1183	-0.0009	0.0079	4.6588	-0.0336	0.3120
0.1249	-0.0009	0.0078	4.9176	-0.0374	0.3065
0.1315	-0.0010	0.0076	5.1765	-0.0404	0.2980
0.1381	-0.0011	0.0073	5.4353	-0.0425	0.2866
0.1446	-0.0011	0.0069	5.6941	-0.0438	0.2722
0.1512	-0.0011	0.0065	5.9529	-0.0441	0.2549
0.1578	-0.0011	0.0060	6.2118	-0.0436	0.2348
0.1644	-0.0011	0.0054	6.4706	-0.0421	0.2118
0.1709	-0.0010	0.0047	6.7294	-0.0397	0.1861
0.1775	-0.0009	0.0040	6.9882	-0.0364	0.1576
0.1841	-0.0008	0.0032	7.2471	-0.0322	0.1265
0.1906	-0.0007	0.0024	7.5059	-0.0269	0.0926
0.1972	-0.0005	0.0014	7.7647	-0.0206	0.0558
0.2038	-0.0003	0.0004	8.0235	-0.0133	0.0170

Radius, m (in.)	=	0.8534	(33.5970)
Chord, m (in.)	=	0.2038	(8.0235)
ZCSL, m (in.)	=	0.1100	(4.3304)
YCSL, m (in.)	=	-0.0009	(-0.0340)
Leading edge radius, m (in.)	=	0.000498	(0.0196)
Trailing edge radius, m (in.)	=	0.000419	(0.0165)
X-area, m^2 ($in.^2$)	=	0.001205	(1.8675)
Gamma, deg. (rad.)	=	51.18	(0.8932)

Fan Blade Coordinates (under load at the aerodynamic design point)

METERS			INCHES		
ZC	YP	YS	ZC	YP	YS
0.0	-0.0005	0.0005	0.0	-0.0177	0.0197
0.0067	-0.0005	0.0010	0.2633	-0.0207	0.0409
0.0134	-0.0006	0.0016	0.5267	-0.0237	0.0612
0.0201	-0.0007	0.0020	0.7900	-0.0266	0.0805
0.0268	-0.0008	0.0025	1.0534	-0.0296	0.0986
0.0334	-0.0008	0.0029	1.3167	-0.0327	0.1158
0.0401	-0.0009	0.0033	1.5800	-0.0357	0.1318
0.0468	-0.0010	0.0037	1.8434	-0.0389	0.1466
0.0535	-0.0011	0.0041	2.1067	-0.0421	0.1605
0.0602	-0.0011	0.0044	2.3701	-0.0451	0.1734
0.0669	-0.0012	0.0047	2.6334	-0.0477	0.1856
0.0736	-0.0013	0.0050	2.8967	-0.0493	0.1970
0.0803	-0.0013	0.0053	3.1601	-0.0519	0.2077
0.0870	-0.0014	0.0055	3.4234	-0.0534	0.2178
0.0936	-0.0014	0.0058	3.6868	-0.0544	0.2274
0.1003	-0.0014	0.0060	3.9501	-0.0548	0.2364
0.1070	-0.0014	0.0062	4.2135	-0.0547	0.2446
0.1137	-0.0014	0.0064	4.4768	-0.0545	0.2505
0.1204	-0.0014	0.0064	4.7401	-0.0541	0.2533
0.1271	-0.0014	0.0064	5.0035	-0.0534	0.2529
0.1338	-0.0013	0.0063	5.2668	-0.0524	0.2494
0.1405	-0.0013	0.0062	5.5302	-0.0511	0.2428
0.1472	-0.0013	0.0059	5.7935	-0.0495	0.2331
0.1538	-0.0012	0.0056	6.0568	-0.0475	0.2205
0.1605	-0.0011	0.0052	6.3202	-0.0451	0.2049
0.1672	-0.0011	0.0047	6.5835	-0.0422	0.1863
0.1739	-0.0010	0.0042	6.8469	-0.0388	0.1650
0.1806	-0.0009	0.0036	7.1102	-0.0349	0.1408
0.1873	-0.0008	0.0029	7.3735	-0.0306	0.1138
0.1940	-0.0007	0.0021	7.6369	-0.0256	0.0841
0.2007	-0.0005	0.0013	7.9002	-0.0199	0.0515
0.2074	-0.0003	0.0004	8.1636	-0.0134	0.0168

Radius, m (in.)	=	0.8805	(34.6650)
Chord, m (in.)	=	0.2074	(8.1636)
ZCSL, m (in.)	=	0.1117	(4.3988)
YCSL, m (in.)	=	-0.0021	(-0.0837)
Leading edge radius, m (in.)	=	0.000498	(0.0196)
Trailing edge radius, m (in.)	=	0.000414	(0.0163)
X-area, m^2 ($in.^2$)	=	0.001101	(1.7061)
Gamma, deg. (rad.)	=	53.84	(0.9397)

Fan Blade Coordinates (under load at the aerodynamic design point)

METERS			INCHES		
ZC	YP	YS	ZC	YP	YS
0.0	-0.0005	0.0005	0.0	-0.0178	0.0197
0.0068	-0.0006	0.0009	0.2680	-0.0246	0.0358
0.0136	-0.0008	0.0013	0.5360	-0.0315	0.0510
0.0204	-0.0010	0.0017	0.8039	-0.0384	0.0652
0.0272	-0.0012	0.0020	1.0719	-0.0453	0.0785
0.0340	-0.0013	0.0023	1.3399	-0.0523	0.0907
0.0408	-0.0015	0.0026	1.6078	-0.0594	0.1015
0.0476	-0.0017	0.0028	1.8758	-0.0670	0.1108
0.0545	-0.0018	0.0031	2.1438	-0.0719	0.1216
0.0613	-0.0019	0.0034	2.4118	-0.0751	0.1335
0.0681	-0.0020	0.0036	2.6797	-0.0797	0.1429
0.0749	-0.0021	0.0038	2.9477	-0.0840	0.1515
0.0817	-0.0022	0.0041	3.2157	-0.0873	0.1602
0.0885	-0.0023	0.0043	3.4837	-0.0893	0.1689
0.0953	-0.0023	0.0045	3.7516	-0.0901	0.1783
0.1021	-0.0023	0.0048	4.0196	-0.0893	0.1876
0.1089	-0.0023	0.0050	4.2876	-0.0891	0.1955
0.1157	-0.0022	0.0051	4.5555	-0.0880	0.2022
0.1225	-0.0022	0.0053	4.8235	-0.0855	0.2072
0.1293	-0.0021	0.0053	5.0915	-0.0825	0.2094
0.1361	-0.0020	0.0053	5.3595	-0.0793	0.2086
0.1429	-0.0019	0.0052	5.6274	-0.0757	0.2047
0.1497	-0.0018	0.0050	5.8954	-0.0719	0.1980
0.1566	-0.0017	0.0048	6.1634	-0.0676	0.1884
0.1634	-0.0016	0.0045	6.4314	-0.0629	0.1760
0.1702	-0.0015	0.0041	6.6993	-0.0577	0.1608
0.1770	-0.0013	0.0036	6.9673	-0.0520	0.1431
0.1838	-0.0012	0.0031	7.2353	-0.0457	0.1226
0.1906	-0.0010	0.0025	7.5033	-0.0388	0.0997
0.1974	-0.0008	0.0019	7.7712	-0.0312	0.0742
0.2042	-0.0006	0.0012	8.0392	-0.0228	0.0463
0.2110	-0.0003	0.0004	8.3072	-0.0134	0.0166

Radius, m (in.)	=	0.9066	(35.6930)
Chord, m (in.)	=	0.2110	(8.3072)
ZCSL, m (in.)	=	0.1136	(4.4710)
YCSL, m (in.)	=	-0.0032	(-0.1278)
Leading edge radius, m (in.)	=	0.000498	(0.0196)
Trailing edge radius, m (in.)	=	0.000411	(0.0162)
X-area, m^2 ($in.^2$)	=	0.001071	(1.6594)
Gamma, deg. (rad.)	=	56.15	(0.9801)

Fan Blade Coordinates (under load at the aerodynamic design point)

METERS			INCHES		
ZC	YP	YS	ZC	YP	YS
0.0	-0.0005	0.0005	0.0	-0.0179	0.0197
0.0069	-0.0007	0.0008	0.2728	-0.0278	0.0317
0.0139	-0.0010	0.0011	0.5455	-0.0377	0.0430
0.0208	-0.0012	0.0014	0.8183	-0.0474	0.0535
0.0277	-0.0014	0.0016	1.0911	-0.0567	0.0632
0.0346	-0.0017	0.0018	1.3638	-0.0660	0.0720
0.0416	-0.0019	0.0020	1.6366	-0.0753	0.0798
0.0485	-0.0021	0.0022	1.9094	-0.0846	0.0868
0.0554	-0.0024	0.0024	2.1822	-0.0936	0.0930
0.0624	-0.0026	0.0025	2.4549	-0.1017	0.0989
0.0693	-0.0028	0.0027	2.7277	-0.1089	0.1049
0.0762	-0.0029	0.0028	3.0005	-0.1147	0.1113
0.0831	-0.0030	0.0030	3.2732	-0.1190	0.1182
0.0901	-0.0031	0.0032	3.5460	-0.1217	0.1258
0.0970	-0.0031	0.0034	3.8188	-0.1226	0.1341
0.1039	-0.0031	0.0036	4.0915	-0.1217	0.1430
0.1109	-0.0030	0.0039	4.3643	-0.1191	0.1532
0.1178	-0.0029	0.0041	4.6371	-0.1154	0.1623
0.1247	-0.0028	0.0043	4.9099	-0.1113	0.1691
0.1316	-0.0027	0.0044	5.1826	-0.1069	0.1730
0.1386	-0.0026	0.0044	5.4554	-0.1022	0.1741
0.1455	-0.0025	0.0044	5.7282	-0.0971	0.1723
0.1524	-0.0023	0.0043	6.0009	-0.0916	0.1678
0.1594	-0.0022	0.0041	6.2737	-0.0857	0.1606
0.1663	-0.0020	0.0038	6.5465	-0.0792	0.1508
0.1732	-0.0018	0.0035	6.8192	-0.0721	0.1385
0.1801	-0.0016	0.0031	7.0920	-0.0643	0.1237
0.1871	-0.0014	0.0027	7.3648	-0.0558	0.1065
0.1940	-0.0012	0.0022	7.6376	-0.0466	0.0871
0.2009	-0.0009	0.0017	7.9103	-0.0365	0.0655
0.2079	-0.0006	0.0011	8.1831	-0.0255	0.0418
0.2148	-0.0003	0.0004	8.4558	-0.0134	0.0164

Radius, m (in.)	=	0.9320	(36.6940)
Chord, m (in.)	=	0.2148	(8.4559)
ZCSL, m (in.)	=	0.1154	(4.5441)
YCSL, m (in.)	=	-0.0042	(-0.1669)
Leading edge radius, m (in.)	=	0.000498	(0.0196)
Trailing edge radius, m (in.)	=	0.000404	(0.0159)
X-area, m^2 ($in.^2$)	=	0.001048	(1.6243)
Gamma, deg. (rad.)	=	58.27	(1.0170)

Fan Blade Coordinates (under load at the aerodynamic design point)

METERS			INCHES		
ZC	YP	YS	ZC	YP	YS
0.0	-0.0005	0.0005	0.0	-0.0180	0.0195
0.0071	-0.0008	0.0007	0.2777	-0.0297	0.0288
0.0141	-0.0010	0.0010	0.5553	-0.0413	0.0374
0.0212	-0.0013	0.0012	0.8330	-0.0526	0.0453
0.0282	-0.0016	0.0013	1.1106	-0.0635	0.0526
0.0353	-0.0019	0.0015	1.3883	-0.0741	0.0592
0.0423	-0.0021	0.0017	1.6659	-0.0845	0.0650
0.0494	-0.0024	0.0018	1.9436	-0.0950	0.0699
0.0564	-0.0027	0.0019	2.2212	-0.1054	0.0738
0.0635	-0.0029	0.0020	2.4989	-0.1154	0.0773
0.0705	-0.0032	0.0020	2.7766	-0.1243	0.0807
0.0776	-0.0033	0.0022	3.0542	-0.1317	0.0847
0.0846	-0.0035	0.0023	3.3319	-0.1373	0.0897
0.0917	-0.0036	0.0024	3.6095	-0.1409	0.0956
0.0987	-0.0036	0.0026	3.8872	-0.1425	0.1025
0.1058	-0.0036	0.0028	4.1648	-0.1420	0.1103
0.1128	-0.0035	0.0030	4.4425	-0.1395	0.1199
0.1199	-0.0034	0.0033	4.7201	-0.1356	0.1290
0.1269	-0.0033	0.0035	4.9978	-0.1310	0.1362
0.1340	-0.0032	0.0036	5.2755	-0.1259	0.1408
0.1410	-0.0031	0.0036	5.5531	-0.1203	0.1427
0.1481	-0.0029	0.0036	5.8308	-0.1143	0.1421
0.1552	-0.0027	0.0035	6.1084	-0.1076	0.1390
0.1622	-0.0026	0.0034	6.3861	-0.1004	0.1335
0.1693	-0.0024	0.0032	6.6637	-0.0926	0.1256
0.1763	-0.0021	0.0029	6.9414	-0.0840	0.1156
0.1834	-0.0019	0.0026	7.2191	-0.0746	0.1035
0.1904	-0.0016	0.0023	7.4967	-0.0643	0.0894
0.1975	-0.0014	0.0019	7.7744	-0.0532	0.0735
0.2045	-0.0010	0.0014	8.0520	-0.0411	0.0559
0.2116	-0.0007	0.0009	8.3297	-0.0279	0.0365
0.2186	-0.0003	0.0004	8.6073	-0.0135	0.0163

Radius, m (in.)	=	0.9571	(37.6800)
Chord, m (in.)	=	0.2186	(8.6073)
ZCSL, m (in.)	=	0.1171	(4.6107)
YCSL, m (in.)	=	-0.0051	(-0.1989)
Leading edge radius, m (in.)	=	0.000495	(0.0195)
Trailing edge radius, m (in.)	=	0.000404	(0.0159)
X-area, m^2 ($in.^2$)	=	0.001019	(1.5798)
Gamma, deg. (rad.)	=	60.12	(1.0493)

Fan Blade Coordinates (under load at the aerodynamic design point)

METERS			INCHES		
ZC	YP	YS	ZC	YP	YS
0.0	-0.0005	0.0005	0.0	-0.0181	0.0195
0.0072	-0.0008	0.0007	0.2835	-0.0303	0.0262
0.0144	-0.0011	0.0008	0.5670	-0.0424	0.0324
0.0216	-0.0014	0.0010	0.8505	-0.0543	0.0378
0.0288	-0.0017	0.0011	1.1341	-0.0661	0.0426
0.0360	-0.0020	0.0012	1.4176	-0.0778	0.0466
0.0432	-0.0023	0.0013	1.7011	-0.0894	0.0498
0.0504	-0.0026	0.0013	1.9846	-0.1008	0.0522
0.0576	-0.0029	0.0014	2.2681	-0.1125	0.0534
0.0648	-0.0032	0.0014	2.5516	-0.1244	0.0537
0.0720	-0.0034	0.0014	2.8351	-0.1351	0.0539
0.0792	-0.0037	0.0014	3.1186	-0.1442	0.0551
0.0864	-0.0038	0.0015	3.4021	-0.1515	0.0573
0.0936	-0.0040	0.0015	3.6856	-0.1563	0.0608
0.1008	-0.0040	0.0017	3.9692	-0.1589	0.0657
0.1080	-0.0040	0.0018	4.2527	-0.1592	0.0718
0.1152	-0.0040	0.0020	4.5362	-0.1571	0.0802
0.1224	-0.0039	0.0022	4.8197	-0.1533	0.0885
0.1296	-0.0038	0.0024	5.1032	-0.1484	0.0957
0.1368	-0.0036	0.0026	5.3867	-0.1430	0.1007
0.1440	-0.0035	0.0026	5.6702	-0.1369	0.1034
0.1512	-0.0033	0.0026	5.9537	-0.1302	0.1039
0.1584	-0.0031	0.0026	6.2373	-0.1227	0.1024
0.1656	-0.0029	0.0025	6.5208	-0.1144	0.0989
0.1728	-0.0027	0.0024	6.8043	-0.1054	0.0936
0.1800	-0.0024	0.0022	7.0878	-0.0955	0.0865
0.1872	-0.0021	0.0020	7.3713	-0.0845	0.0779
0.1944	-0.0018	0.0017	7.6548	-0.0725	0.0679
0.2016	-0.0015	0.0014	7.9383	-0.0595	0.0565
0.2088	-0.0012	0.0011	8.2218	-0.0454	0.0440
0.2160	-0.0008	0.0008	8.5053	-0.0301	0.0304
0.2232	-0.0003	0.0004	8.7888	-0.0136	0.0162

Radius, m (in.)	=	0.9819	(38.6570)
Chord, m (in.)	=	0.2232	(8.7889)
ZCSL, m (in.)	=	0.1190	(4.6852)
YCSL, m (in.)	=	-0.0059	(-0.2312)
Leading edge radius, m (in.)	=	0.000493	(0.0194)
Trailing edge radius, m (in.)	=	0.000399	(0.0157)
X-area, m^2 ($in.^2$)	=	0.000957	(1.4832)
Gamma, deg. (rad.)	=	61.74	(1.0776)

Fan Blade Coordinates (under load at the aerodynamic design point)

METERS			INCHES		
ZC	YP	YS	ZC	YP	YS
0.0	-0.0005	0.0005	0.0	-0.0182	0.0194
0.0073	-0.0008	0.0006	0.2888	-0.0307	0.0237
0.0147	-0.0011	0.0007	0.5775	-0.0435	0.0273
0.0220	-0.0014	0.0008	0.8663	-0.0563	0.0299
0.0293	-0.0018	0.0008	1.1550	-0.0692	0.0316
0.0367	-0.0021	0.0008	1.4438	-0.0821	0.0324
0.0440	-0.0024	0.0008	1.7325	-0.0951	0.0323
0.0513	-0.0028	0.0008	2.0213	-0.1083	0.0313
0.0587	-0.0031	0.0007	2.3101	-0.1218	0.0291
0.0660	-0.0034	0.0007	2.5988	-0.1356	0.0258
0.0733	-0.0038	0.0006	2.8876	-0.1491	0.0221
0.0807	-0.0041	0.0005	3.1763	-0.1606	0.0194
0.0880	-0.0043	0.0005	3.4651	-0.1695	0.0184
0.0953	-0.0045	0.0005	3.7539	-0.1762	0.0190
0.1027	-0.0046	0.0005	4.0426	-0.1801	0.0215
0.1100	-0.0046	0.0007	4.3314	-0.1810	0.0258
0.1174	-0.0046	0.0008	4.6201	-0.1792	0.0327
0.1247	-0.0044	0.0010	4.9089	-0.1751	0.0404
0.1320	-0.0043	0.0012	5.1976	-0.1694	0.0478
0.1394	-0.0041	0.0014	5.4864	-0.1629	0.0535
0.1467	-0.0039	0.0015	5.7752	-0.1555	0.0575
0.1540	-0.0037	0.0015	6.0639	-0.1473	0.0598
0.1614	-0.0035	0.0015	6.3527	-0.1383	0.0606
0.1687	-0.0033	0.0015	6.6414	-0.1283	0.0598
0.1760	-0.0030	0.0015	6.9302	-0.1175	0.0578
0.1834	-0.0027	0.0014	7.2190	-0.1057	0.0545
0.1907	-0.0024	0.0013	7.5077	-0.0929	0.0501
0.1980	-0.0020	0.0011	7.7965	-0.0791	0.0447
0.2054	-0.0016	0.0010	8.0852	-0.0644	0.0385
0.2127	-0.0012	0.0008	8.3740	-0.0486	0.0315
0.2200	-0.0008	0.0006	8.6628	-0.0318	0.0237
0.2274	-0.0004	0.0004	8.9515	-0.0140	0.0160

Radius, m (in.) = 1.0045 (39.5490)
Chord, m (in.) = 0.2274 (8.9515)
ZCSL, m (in.) = 0.1203 (4.7367)
YCSL, m (in.) = -0.0068 (-0.2664)
Leading edge radius, m (in.) = 0.000493 (0.0194)
Trailing edge radius, m (in.) = 0.000399 (0.0157)
X-area, m^2 ($in.^2$) = 0.000875 (1.3562)
Gamma, deg. (rad.) = 63.26 (1.1041)

Fan Blade Coordinates (under load at the aerodynamic design point)

METERS			INCHES		
ZC	YP	YS	ZC	YP	YS
0.0	-0.0005	0.0005	0.0	-0.0184	0.0195
0.0074	-0.0008	0.0006	0.2923	-0.0304	0.0219
0.0148	-0.0011	0.0006	0.5846	-0.0429	0.0234
0.0223	-0.0014	0.0006	0.8770	-0.0560	0.0238
0.0297	-0.0018	0.0006	1.1693	-0.0691	0.0232
0.0371	-0.0021	0.0005	1.4616	-0.0824	0.0217
0.0445	-0.0024	0.0005	1.7539	-0.0959	0.0191
0.0520	-0.0028	0.0004	2.0463	-0.1097	0.0157
0.0594	-0.0032	0.0003	2.3386	-0.1244	0.0108
0.0668	-0.0035	0.0001	2.6309	-0.1395	0.0050
0.0742	-0.0039	-0.0000	2.9232	-0.1543	-0.0015
0.0817	-0.0042	-0.0002	3.2155	-0.1670	-0.0071
0.0891	-0.0045	-0.0003	3.5079	-0.1769	-0.0108
0.0965	-0.0047	-0.0003	3.8002	-0.1844	-0.0122
0.1039	-0.0048	-0.0003	4.0925	-0.1884	-0.0113
0.1114	-0.0048	-0.0002	4.3848	-0.1890	-0.0075
0.1188	-0.0047	-0.0000	4.6772	-0.1866	-0.0009
0.1262	-0.0046	0.0002	4.9695	-0.1812	0.0074
0.1336	-0.0044	0.0004	5.2618	-0.1736	0.0166
0.1411	-0.0042	0.0006	5.5541	-0.1652	0.0242
0.1485	-0.0040	0.0008	5.8464	-0.1563	0.0302
0.1559	-0.0037	0.0009	6.1388	-0.1466	0.0347
0.1633	-0.0035	0.0010	6.4311	-0.1364	0.0378
0.1708	-0.0032	0.0010	6.7234	-0.1255	0.0395
0.1782	-0.0029	0.0010	7.0157	-0.1140	0.0399
0.1856	-0.0026	0.0010	7.3081	-0.1018	0.0392
0.1930	-0.0023	0.0009	7.6004	-0.0888	0.0374
0.2005	-0.0019	0.0009	7.8927	-0.0751	0.0346
0.2079	-0.0015	0.0008	8.1850	-0.0609	0.0309
0.2153	-0.0012	0.0007	8.4774	-0.0459	0.0264
0.2227	-0.0008	0.0005	8.7697	-0.0301	0.0212
0.2302	-0.0003	0.0004	9.0620	-0.0136	0.0151

Radius, m (in.)	=	1.0226	(40.2600)
Chord, m (in.)	=	0.2302	(9.0620)
ZCSL, m (in.)	=	0.1211	(4.7686)
YCSL, m (in.)	=	-0.0073	(-0.2870)
Leading edge radius, m (in.)	=	0.000493	(0.0194)
Trailing edge radius, m (in.)	=	0.000378	(0.0149)
X-area, m^2 (in.^{2})	=	0.000786	(1.2186)
Gamma, deg. (rad.)	=	64.48	(1.1254)

Fan Blade Coordinates (under load at the aerodynamic design point)

METERS			INCHES		
ZC	YP	YS	ZC	YP	YS
0.0	-0.0005	0.0005	0.0	-0.0184	0.0195
0.0075	-0.0008	0.0005	0.2934	-0.0298	0.0211
0.0149	-0.0011	0.0006	0.5869	-0.0422	0.0219
0.0224	-0.0014	0.0005	0.8804	-0.0551	0.0216
0.0298	-0.0017	0.0005	1.1738	-0.0680	0.0203
0.0373	-0.0021	0.0005	1.4673	-0.0812	0.0181
0.0447	-0.0024	0.0004	1.7607	-0.0947	0.0148
0.0522	-0.0028	0.0003	2.0542	-0.1085	0.0106
0.0596	-0.0031	0.0001	2.3476	-0.1235	0.0050
0.0671	-0.0035	-0.0000	2.6411	-0.1389	-0.0016
0.0745	-0.0039	-0.0002	2.9345	-0.1540	-0.0090
0.0820	-0.0042	-0.0004	3.2280	-0.1670	-0.0155
0.0894	-0.0045	-0.0005	3.5214	-0.1773	-0.0199
0.0969	-0.0047	-0.0006	3.8149	-0.1849	-0.0219
0.1044	-0.0048	-0.0005	4.1083	-0.1891	-0.0212
0.1118	-0.0048	-0.0004	4.4018	-0.1897	-0.0175
0.1193	-0.0048	-0.0003	4.6952	-0.1871	-0.0109
0.1267	-0.0046	-0.0001	4.9887	-0.1814	-0.0023
0.1342	-0.0044	0.0002	5.2822	-0.1733	0.0074
0.1416	-0.0042	0.0004	5.5756	-0.1646	0.0155
0.1491	-0.0039	0.0006	5.8691	-0.1553	0.0221
0.1565	-0.0037	0.0007	6.1625	-0.1453	0.0272
0.1640	-0.0034	0.0008	6.4560	-0.1349	0.0308
0.1714	-0.0031	0.0008	6.7494	-0.1239	0.0332
0.1789	-0.0029	0.0009	7.0429	-0.1123	0.0343
0.1863	-0.0025	0.0009	7.3363	-0.1001	0.0343
0.1938	-0.0022	0.0008	7.6298	-0.0871	0.0332
0.2013	-0.0019	0.0008	7.9232	-0.0736	0.0311
0.2087	-0.0015	0.0007	8.2167	-0.0595	0.0282
0.2162	-0.0011	0.0006	8.5101	-0.0448	0.0245
0.2236	-0.0007	0.0005	8.8036	-0.0294	0.0201
0.2311	-0.0003	0.0004	9.0970	-0.0133	0.0147

Radius, m (in.)	=	1.0295	(40.5300)
Chord, m (in.)	=	0.2311	(9.0970)
ZCSL, m (in.)	=	0.1214	(4.7778)
YCSL, m (in.)	=	-0.0074	(-0.2923)
Leading edge radius, m (in.)	=	0.000493	(0.0194)
Trailing edge radius, m (in.)	=	0.000368	(0.0145)
X-area, m^2 ($in.^2$)	=	0.000751	(1.1648)
Gamma, deg. (rad.)	=	64.94	(1.1333)

APPENDIX D

GLOSSARY OF TERMS

Symbol	Definition
A	Area
A	Flow area
a'	Incidence angle, degrees
a'	Point mid way between leading edge and point of origin of first captured mach line on the suction surface
A*	Sonic flow area
A/C	Ratio of maximum camber location from leading edge to chord length
ADP	Aerodynamic design point
A/R	Aspect ratio
B	Absolute air angle
b	One half airfoil chord at 75 percent span
BIP	Bird ingestion parameter
C	Aerodynamic chord, i.e. along flow surface
C/W	Clockwise
D	Diameter
D-factor	Diffusion factor
DN	Diameter x low-pressure rotor speed
E	Excitations per revolution of rotor
E_{TE}	Angle on conical of trailing edge
FEGV	Fan exit guide vane
F_{IT}/F_a	Blade loss energy ratio
FT/S	Feet per second

APPENDIX D (Cont'd.)

Symbol	Definition
Hz	Hertz (cycles per second)
ID	Inner diameter - (core engine)
i_m	Incidence angle between inlet air direction and line tangent to blade mean camber line at leading edge, degrees
i_{s_s}	Incidence angle between inlet air direction and line tangent to blade suction surface at leading edge, degrees
LBM/FT^2-S	Pounds per square foot - second
L.E.	Leading Edge
LOC	Location
M	Mass
M/S	Meters per second
N	Number of blades in rotor
N_1	Low rotor speed (RPM)
ND	Nodal diameter
OD	Outer diameter - (fan duct)
PO/PO_{inlet}	Total pressure ratio
Ps	Local static pressure
$\bar{P}s$	Average static pressure
P_T	Total pressure
q	Dynamic pressure
R_{LE}	Polar radius to leading edge
R_{cold}	Cold radius

Symbol	Definition
r	radius
SL	Streamline number
T	Temperature
T/C	Ratio of max thickness to chord length
TDC	Top dead center
T.E.	Trailing edge
TMAX	Maximum airfoil thickness
T/O	Takeoff
TO/TO_{inlet}	Total temperature ratio
U	Rotor tangential speed
V	Relative inlet air velocity at 75 percent span
W	Engine airflow
$\bar{W}$	Total pressure loss coefficient, mass average defect in relative total pressure divided by difference between inlet stagnation and static pressures
WC1	Airflow corrected to station 1
YCSL	Vertical distance to airfoil stacking line from chord line
YP	Airfoil coordinate of pressure surface normal to chord line
YS	Airfoil coordinate of suction surface normal to chord line
Z Plane	Reference plane on airfoil root at center of dovetail contact point
ZC	Airfoil coordinate parallel to chord line
ZCSL	Horizontal distance to airfoil stacking line from leading edge along chord line
αCH	Alpha chord - airfoil stagger angle measured relative to the tangential direction.
$\beta_2'^*$	Blade trailing edge metal angle, degrees
$\beta_1'^*$	Blade leading edge metal angle, degrees

APPENDIX D (Cont'd.)

Symbol	Definition
γ	Blade chord angle, angle between chord and axial direction
δ	Pressure correction factor, $\frac{\text{Pressure (psia)}}{14.7}$
ΔC_p	ΔPressure coefficient, $(C_{P\ max} - C_{P\ min})$
ΔP_T	Pressure differential $(P_{Tin} - P_{Tout})$
ϵ	Angle between tangent to streamline projected on meridional plane and axial direction
$\bar{\epsilon}$	$\bar{\epsilon}$, cone angle = $\tan^{-1} \frac{(r_{TE} - r_{LE})}{(Z_{TE} - Z_{LE})}$
ηa	Adiabatic efficiency
ηad	Adiabatic efficiency
ηp	Polytropic efficiency
Θ	Temperature correction factor, $\frac{T_{amb}(^oF)}{519}$
ϕE	Camber angle, difference between blade angles at leading and trailing edges on the unwrapped conical surface
ϕEF	Difference between blade angle at LE and transition point; front camber
θ/TAU	Ratio of channel width between airfoils to gap between airfoils angle on conical of trailing edge
ρ	Air density
σ	Solidity
ω	Flutter frequency in radius per second
ω	Angular velocity

APPENDIX D (Cont'd.)

Symbol	Definition
	Superscripts
'	Relative to rotor
*	Designates blade metal angle Degrees of arc or temperature
	Subscripts
1	Station into rotor along leading edge
2	Station out of rotor along trailing edge
m	Meridional direction (r-z plane)
f	Front
θ	Tangential