116480

P.37

NASA Technical Memorandum 104112

Advanced Subsonic Transport Approach Noise—The Relative Contribution of Airframe Noise

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June 1992

National Aeronautics and
Space Administration

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(NASA-TM-104112) ADVANCED SUBSONIC TRANSPORT APPROACH NOISE: THE RELATIVE CONTRIBUTION OF AIRFRAME NOISE (NASA) 37 p

N92-34148

Unclas

G3/71 0116480

INTRODUCTION

With current engine technology, airframe noise is a contributing source for large commercial aircraft on approach, but not the major contributor. With the promise of much quieter jet engines with the planned new generation of high-by-pass turbofan engines, airframe noise has become a topic of interest in the advanced subsonic transport research program. Questions being raised include: Will airframe noise be the dominant noise source on approach? How well can it be predicted? Is airframe noise an absolute noise floor to which other noise sources should be reduced, or can airframe noise be reduced? The concerns raised in these questions ultimately are connected to the noise acceptability of the aircraft.

The objective of this paper is to assess the contribution of airframe noise relative to the other aircraft noise sources on approach. The assessment will be made for a current technology large commercial transport aircraft and for an envisioned advanced technology aircraft. NASA's Aircraft Noise Prediction Program (ANOPP) will be used to make total aircraft noise predictions for these two aircraft types. Predicted noise levels and areas of noise contours will be used to determine the relative importance of the contributing approach noise sources. The actual set-up decks used to make the ANOPP runs for the two aircraft types are included in appendixes.

AIRFRAME NOISE

Background

Airframe noise arises from the interactions of unsteady air flow with the aircraft structure exposed to the flow. The unsteadiness of the air flow is a consequence of flight, for instance the turbulent boundary layer of a wing or the impingent of a turbulent wake of an up-stream aircraft component on a down-stream aircraft component. The primary airframe noise sources are usually considered to be trailing edges, landing gear, cavities, flaps, and slats. These sources are not, in general, independent and may interact. The air flow around an aircraft is highly energized and dynamic, making airframe noise a significant and complex aircraft noise source. Airframe noise is expected to contribute the most to overall aircraft noise during approach when the engines are throttled and the aircraft is in a dirty (high lift devices and landing gear deployed) configuration.

Much airframe noise research has been done. Both experimental and theoretical investigations have been extensive, much of the work being performed over a decade ago. Experimental investigations have included full scale flight experiments, complete model and component wind tunnel testing, and free flight glider and model experiments. Theoretical investigations have been concerned with the fundamental physics of individual airframe noise sources. Many excellent summaries of airframe noise research are available (refs. 1-4).

Initially, airframe noise modelling was aimed at whole aircraft Overall Sound Pressure Level (OASPL) prediction which was empirically based with pertinent parameters identified from analytical insight. These methods soon were extended to predict 1/3 octave band spectra. These empirical methods worked reasonably well when applied to the same or similar class of aircraft. Whole aircraft airframe noise prediction was soon surpassed by component noise prediction models in which the airframe noise of particular aircraft components is predicted. One method of component prediction is very similar to the whole aircraft models in that the individual component prediction models are largely empirical; however, much greater use of analytical insight, where available, was used.

Fundamental principle aerodynamic and aeroacoustic models were developed for some airframe noise sources. In particular, models for predicting trailing edge noise are well founded and complete for many flow environments (ref. 4).Another airframe noise component which in principle is well understood is that due to landing gear.

During approach, dominant airframe noise sources other than landing gear are those caused by the deployment of high lift devices, such as flaps and slats. The increase in airframe noise with flap and slat deployment over that of a clean wing is on the order of 10 EPNdB (ref. 1). Flap and slat airframe noise is associated with the physical gaps or slots between slat and wing, or wing and flap, and with the edges of the flaps.

Continued analytical work is needed so that new airframe noise sources can be incorporated in future component prediction schemes either by parametrically correct empirical methods or by first principle methods. First principle methods are preferred over empirical methods; however, it is often difficult to obtain sufficient input to use the first principle methods. This is the case for both trailing edge and landing gear airframe noise prediction for complete aircraft. The air flow around a complete aircraft is in general not known sufficiently to predict either of these two airframe noise sources from analytical expressions. Parametrically correct empirical prediction methods are then the next best methods to predict airframe noise for complete aircraft.

Predicted Total Aircraft Noise

The Fink component method is recommended in reference 1 to make whole aircraft airframe noise predictions, and was used to make the airframe noise predictions in this paper. NASA Langley Research Center's Aircraft Noise Prediction Program, ANOPP, (ref. 5) was used to make the total aircraft noise predictions. The Fink airframe noise method is incorporated in ANOPP. The airframe noise prediction method in ANOPP was validated in reference 6 with a variety of measured data not incorporated into the Fink method. The result of the validation showed that the Fink method agreed within ±2 EPNdB to the measured results.

ANOPP, and programs similar to it, requires detailed information in order to make an aircraft noise prediction. For example, one of the needed categories of information is engine operating parameters, often referred to as the engine operating deck. The engine data are critical to the prediction of the fan, core, turbine, and jet noise. It typically is very difficult to obtain the required engine parameters, particularly for an engine in the current fleet or an engine in development. The required input to make airframe noise predictions is relatively easily obtained from published descriptions (ref. 7). One of the early ANOPP validation studies involved a DC-10 (ref. 8). The ANOPP input parameters listed in reference 8, although somewhat different from the current required input, were used as the basis to make ANOPP predictions for a DC-10 on approach. These predictions were used to verify the numbers being predicted by ANOPP 15 years after the DC-10 validation and to serve as a baseline for comparison to the projected advanced subsonic transport noise predictions. Noise sources included in the total aircraft ANOPP predictions are fan inlet, fan discharge, core, turbine, and jet; along with main landing gear, flap, slat, nose landing gear, wing, horizontal tail, and vertical tail airframe noise sources.

Another important category of input to ANOPP which is difficult to obtain is the amount of suppression to apply to the fan and turbine noise sources. ANOPP does not predict the noise suppression to be applied to the fan and turbine noise sources. Noise suppression is supplied by the user of ANOPP. Noise suppression technology is very competitive sensitive. To make the baseline current technology DC-10 noise predictions with ANOPP, the following values of noise suppression 0, 10, and 10 dB were applied to the fan inlet, fan discharge, and turbine noise sources, respectively. These values of suppression were selected based on available published information (refs. 24-25), engineering insight into known suppression technology, and known behavior of the noise sources of current technology transports on approach. Suppression of fan and turbine noise is achieved by the placement of absorbing material (liners) in and the design of the fan and turbine ducts. The selection process for the noise suppression amounts to a calibration of ANOPP necessitated by a lack of detailed information for current technology engines.

An example of the result of the noise prediction process is given in figure 1 for the baseline DC-10 in the form of an Effective Perceived Noise Level (EPNL) contour plot of the total aircraft noise. The rectangular array of points on the plot represents observer positions used to generate the contours. The actual set-up deck used as input to make the current technology total aircraft noise predictions with ANOPP are given in Appendix A. The ANOPP input parameters are included in this paper to document how ANOPP was used to make the predictions given in this report. The results in Figure 1 and all the results to be given are for an aircraft flying an approach consisting of a 3 degree glideslope. The maximum approach EPNL value is given in the upper right portion of the plot for the approach position. The approach position is the one specified in the FAR 36 (ref. 9) noise certification regulations which is 1.25 miles (2.0 km) from the end of the runway. The 3-degree approach glideslope results in the aircraft passing approximately 120 m above the approach position. In figure 1, the circle symbol underneath the flight track is the location of the approach position. Similar noise contour results were predicted for individual noise sources. All noise predictions were made for a microphone positioned 1.2 m above the ground. The results for the baseline DC-10 ANOPP noise predictions are summarized in Table 1 in the form of approach EPNL values and areas of the 103 EPNL noise contours. In Table 1, results are given for the total aircraft noise, and the noise contributions of fan discharge, fan inlet, turbine, airframe, core, and jet noise sources.

The total aircraft noise approach EPNL value which corresponds to the FAA approach certification position is compatible with published values for a DC-10-40 powered with JT9D-59A engines. The predicted total level of 107 dB is one EPNdB above the largest reported certification level in reference 23 for a DC-10. One decibel is within the accuracy of the predictions which is believed to be on the order of 2 EPNdB. The contributions of each of the predicted noise sources are presented in Table 1 in increasing order of importance. The largest contributor to the total noise on approach is fan noise with airframe noise, on the basis of approach EPNL values, the fourth largest contributor, 10 EPNdB less than fan noise.

The frequency content of the various noise sources is given in figure 2 for the sound emitted when the aircraft was over the approach centerline microphone position. At frequencies less than 600 Hz, airframe and jet noise sources are comparable in level and dominate. Turbine noise dominates in the frequency range of 600 Hz to 1500 Hz. At frequencies greater than 1600 Hz, the turbine and fan discharge noise levels are similar and dominate.

To make total aircraft noise predictions for an advanced subsonic transport, the engines on the baseline DC-10 were replaced with engines having a by-pass-ratio (BPR) of 10 and an additional 5 dB of suppression was applied to both the fan (inlet and discharge) and turbine noise sources. This 'rubber' engine was obtained by using the Navy/NASA Engine Program, NNEP, (ref. 10) to extrapolate the engine deck of a smaller (approximately 40,000 lbs thrust), BPR 6 engine. The authors wish to acknowledge Karl A. Geiselhart of Lockheed Engineering and Sciences Company for setting up and running the Navy/NASA Engine Program (NNEP), and providing ANOPP compatible engine state tables for a 10:1 BPR engine concept. The resulting engine generated 53,000 lbs of thrust at full (100%) throttle. The same airframe and approach flight profile were used in ANOPP to make the noise predictions. A BPR of 10 and an additional 5 dB suppression represent modest assumptions for an advanced subsonic transport. BPRs in the range of 20 and additional fan noise suppression in the range of 10 dB have been discussed as goals for advanced subsonic transports. The additional suppression would be obtained through the use of advanced technology liners which might include bulk absorbers, multi-layered honeycomb reactive liners, and possibly, active noise control.

The noise prediction results for the advanced technology transport are summarized in Table 2 in the form of approach EPNL values and areas of the 103 EPNL noise contours. The ANOPP set-up deck used to make the advanced technology transport noise predictions is given in Appendix B. Results in Table 2 are given for the total aircraft noise, the fan inlet, the fan discharge, the airframe, turbine, and core noise sources. The predicted jet noise was so small that it is not presented in Table 2. The higher BPR engines have resulted in less jet noise and the additional noise suppression is evident in the results. For this realization of an advanced technology transport, the airframe noise is the second largest (tied with fan discharge noise) noise contributor on the basis of approach microphone EPNL levels behind fan inlet noise. The airframe noise is 2 EPNdB less than the largest contributor to the total aircraft noise predicted for the advanced technology transport.

For the advanced technology transport, a large reduction in total noise impact is evident when comparing the size of the noise contours for the current technology (Table 1) and the advanced technology (Table 2) transports. An approximate nine-fold reduction is observed in the area of the total aircraft noise 103 EPNdB noise contour area for the two transports.

The spectra of the various noise sources for the advanced technology transport are given in figure 3 for the noise emitted when the aircraft was above the approach centerline microphone. At frequencies less than 200 Hz, airframe noise is the dominant noise source. From approximately 200 Hz to 800 Hz, airframe and combustor noise are dominant. From 800 Hz to 4 kHz, fan discharge noise is dominant. Above 4 kHz, turbine noise becomes dominant. Jet noise is seen to be very low and not a contributing noise source.

Within the accuracy of the noise predictions, on the order of 2 EPNdB, the contribution of airframe noise in terms of EPNL is comparable to the contribution of fan noise to the total noise of this advanced technology transport. Additional reductions in fan noise alone will ultimately result in airframe noise becoming the dominant noise source on approach. From a noise impact point of view, as measured by the area of the 103 EPNL noise contour, fan inlet noise of the advanced technology transport has an impact over four times that of airframe noise. Further reductions in fan noise need to be done with consideration of airframe noise. However, the higher frequency content of fan noise over that of airframe noise and the larger noise impact (larger contour area) make reductions in fan noise more attractive to further increase the noise acceptability of the next generation of transport aircraft.

The airframe noise predictions were the same for both the baseline and the advanced technology transport due to the fact that the same airframe and approach flight path were used to make the noise predictions. The approach noise levels and the area of the 103 EPNL noise contours are given for the major airframe noise sources in Table 3. A finer grid was used to generate the individual airframe noise source contours. The total airframe noise contour area in Table 3 is slightly different and more accurate than the total airframe noise contour area given previously. On the basis of approach EPNL, main landing gear noise is the largest contributor, followed by trailing edge flap noise and slat edge noise. The approach EPNL levels of these three airframe noise sources are comparable, falling in the range of 85 to 87 EPNdB. On the basis of noise impact, as measured by the area of the 103 EPNL noise contour, main landing gear and trailing edge flap noise are comparable, having a little less than twice the noise impact of leading edge slat noise.

Airframe noise should not be considered an absolute noise floor. Many ideas to reduce airframe noise have been published (ref. 1). Lower approach speeds would lessen airframe noise, but great reductions in landing speed are not likely. A move toward simpler high lift systems with fewer slat and flap segments with thought given to downstream wake impingement would tend to minimize airframe noise. Porous, serrated, swept, sucking, and blowing leading and trailing edges have been proposed to reduce the intensity of the interaction between the unsteady flow and trailing edges. In the case of flap edge noise, the above listed surface changes or an edge plate might be used to reduce the noise. Interactions between airframe noise components have been shown to be either adverse, causing an increase in airframe noise or favorable, causing a decrease in total airframe noise. In a model experiment involving an Advanced Supersonic Transport (ref. 11), the airframe noise with the flaps and main landing gear deployed was greater than the sum of the noise from each component deployed individually. In another model study (ref. 12) the total noise of a wing with a particular combination of deployed slats and flaps was less than the sum of the noise generated separately by each component. These results indicate that the interactions between airframe noise components are complex but once understood should be able to be exploited to yield lower airframe noise aircraft designs. Poor designs can increase airframe noise; good designs can reduce airframe noise. Further systematic research is needed to identify ways to reduce airframe noise.

Summary

Total aircraft noise, including airframe noise, for approach was predicted for a current technology large transport and for an envisioned advanced technology transport. An objective of the research was to assess the relative importance of airframe noise to the other noise sources on approach for the two aircraft types. Airframe noise for the current technology transport was 10 EPNdB less than the more dominant fan and turbine noise sources. The advanced technology transport was modelled as having engines with a BPR of 10 with an additional 5 dB suppression on fan and turbine noise. On approach, the airframe noise for this envisioned aircraft was 2 EPNdB below the largest contributing noise source, the fan inlet. This level difference was within the prediction accuracy; therefore, a conclusion is that airframe noise is comparable in amplitude to fan noise sources on approach for the studied advanced technology transport. The noise impact of fan noise, as measured by noise contour area, was greater by more than a factor of four over airframe noise. Further reduction in fan noise needs to be done with consideration of airframe noise. Airframe noise should not, however, be considered an absolute noise floor. Airframe noise can be reduced by good design practice. Many airframe noise reduction ideas have been identified and need to be validated.

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Table 1. Noise Predictions for Baseline DC-10

Noise Source	EPNL, dB	Contour Area, mi^2 (km^2)
Core	86	—
Jet	91	.003 (.008)
Airframe	92	.003 (.008)
Turbine	100	.064 (.166)
Fan Inlet	101	.134 (.347)
Fan Discharge	102	.108 (.280)
Total	107	.531 (1.375)

Table 2. Noise Predictions for Advanced Technology Transport

Noise Source	EPNL, dB	Contour Area, mi^2 (km^2)
Core	86	—
Turbine	91	.001 (.003)
Airframe	92	.003 (.008)
Fan Discharge	92	.003 (.008)
Fan Inlet	94	.014 (.036)
Total	99	.060 (.155)

Table 3. Airframe Noise Pr

Noise Source	EPNL, dB
Nose Landing Gear	76
Leading Edge Slat	85
Trailing Edge Flap	86
Main Landing Gear	87
Total	92

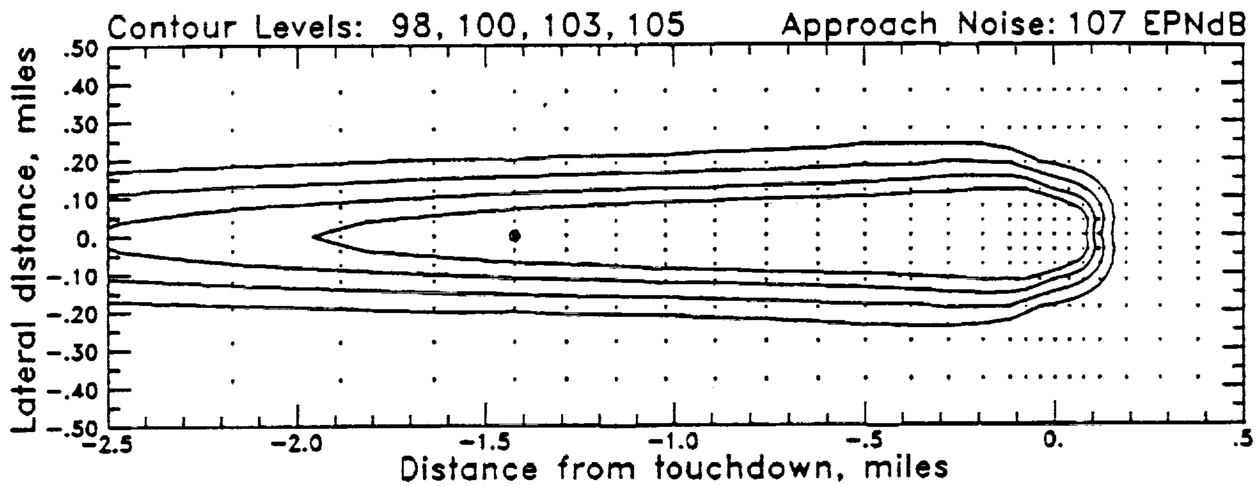

Figure 1. EPNL noise contour for current technology total landing noise.

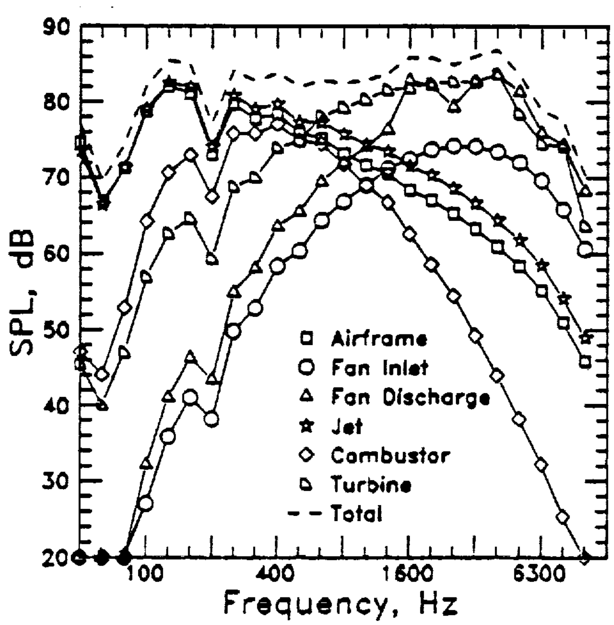

Figure 2. Current technology overhead noise source spectra.

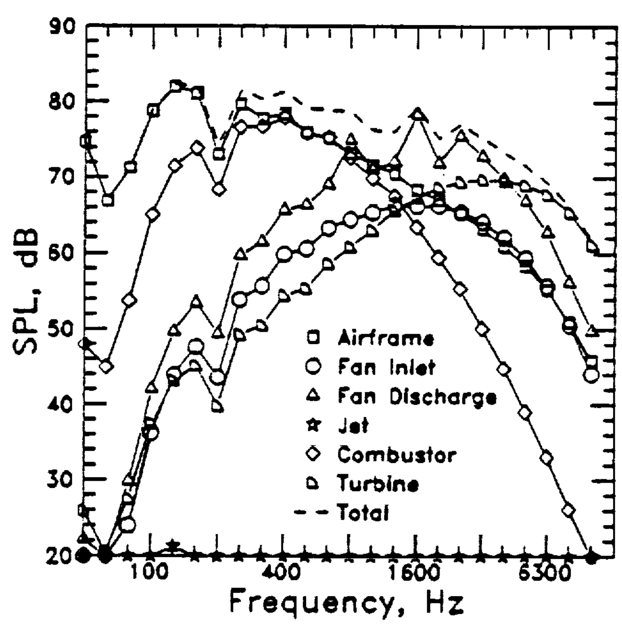

Figure 3. Advanced technology overhead noise source spectra.

Appendix A: Conventional Transport ANOPP Command File

Contained herein is the ANOPP command file used to calculate EPNL values for the approach to landing of a conventionally powered commercial transport. For brevity's sake the majority of observer positions (for the Geometry Module GEO) and suppression factors (for the General Suppression Module GENSUP) were omitted. Except for those omissions the command file is sufficient to reproduce the results presented in this paper.

```
      ANOPP ACCOUNT=.FALSE., JECHO=.TRUE., JLOG=.FALSE., LENGL=12000,
            MAXCARDS=10000, NAETD=100, NAEUD=100, NLPPM=48, NOGO=.FALSE. $
$
      STARTCS $
$
$ LOAD LIBRARYS
$
      LOAD /LIBRARY/ PROCLIB, STNTBL $
$
$==============================================================================
$
$ ATM PARAMETERS
$
      PARAM    DELH = 100.        $ ALTITUDE INCREMENT FOR OUTPUT
      PARAM      H1 = 0.          $ GROUND LEVEL ALTITUDE, FT
      PARAM  IUNITS = 7HENGLISH   $ INPUT UNITS
      PARAM     NHO = 22          $ NUMBER OF ALTITUDE INCREMENTS
      PARAM      P1 = 2116.224    $ ATMOSPHERIC PRESSURE AT GROUND, LBF/SQFT
      PARAM  IPRINT = 2           $ PRINT OUTPUT
$
$ ATM MEMBER ATM(IN)
$
      UPDATE NEWU=ATM, SOURCE=* $
      -ADDR OLDM=*, NEWM=IN, FORMAT=4H3RS$, MNR=22 $
            0.0, 518.670,  70.0 $
          100.0, 518.313,  70.0 $
          200.0, 517.957,  70.0 $
          300.0, 517.600,  70.0 $
          400.0, 517.244,  70.0 $
          500.0, 516.887,  70.0 $
          600.0, 516.530,  70.0 $
          700.0, 516.174,  70.0 $
          800.0, 515.817,  70.0 $
          900.0, 515.461,  70.0 $
         1000.0, 515.104,  70.0 $
         1100.0, 514.747,  70.0 $
         1200.0, 514.391,  70.0 $
         1300.0, 514.034,  70.0 $
         1400.0, 513.678,  70.0 $
         1500.0, 513.321,  70.0 $
         1600.0, 512.965,  70.0 $
         1700.0, 512.608,  70.0 $
         1800.0, 512.251,  70.0 $
         1900.0, 511.895,  70.0 $
         2000.0, 511.538,  70.0 $
         2100.0, 511.182,  70.0 $
      END* $
$
$ EXECUTE ATM, GENERATE ATM(TMOD)
$
      EXECUTE ATM $
$
$==============================================================================
$
$ ABS PARAMETERS
$
      PARAM  IUNITS = 7HENGLISH  $ INPUT UNITS
      PARAM  ABSINT = 5          $ NUMBER OF INTEGRATION STEPS
      PARAM  IPRINT = 2          $ PRINT OUTPUT
      PARAM     SAE = .TRUE.     $ SAE METHOD
$
$ ABS MEMBER SFIELD(FREQ) AND DIRECTIVITY MEMBERS SFIELD(THETA) AND SFIELD(PHI)
$
      UPDATE NEWU=SFIELD, SOURCE=* $
      -ADDR OLDM=*, NEWM=FREQ, FORMAT=4H*RS$, MNR=1 $
          50.0,     63.0,     80.0,    100.0,    125.0,    160.0,    200.0,
         250.0,    315.0,    400.0,    500.0,    630.0,    800.0,   1000.0,
        1250.0,   1600.0,   2000.0,   2500.0,   3150.0,   4000.0,   5000.0,
        6300.0,   8000.0,  10000.0,  12500.0 $
      -ADDR OLDM=*, NEWM=PHI, FORMAT=4H*RS$, MNR=1 $
         0.,   5.,  10.,  15.,  20.,  25.,  30.,  35.,  40.,
        45.,  50.,  55.,  60.,  65.,  70.,  75.,  80.,  85. $
      -ADDR OLDM=*, NEWM=THETA, FORMAT=4H*RS$, MNR=1 $
```

```
       5.,  10.,  15.,  20.,  25.,  30.,  35.,  40.,  45.,  50.,
      55.,  60.,  65.,  70.,  75.,  80.,  85.,  90.,  95., 100.,
     105., 110., 115., 120., 125., 130., 135., 140., 145., 150.,
     155., 160., 165., 170., 175. $
    END* $
$
$ EXECUTE ABS, GENERATE ATM(AAC)
$
    EXECUTE ABS $
$
$============================================================================
$
$ SFO PARAMETERS
$
    PARAM  IUNITS = 7HENGLISH  $ INPUT UNITS
    PARAM     NJO = 0          $ NUMBER OF TIME STEPS COMPLETED
    PARAM  IPRINT = 0          $ PRINT NOTHING
    PARAM    IOUT = 1          $ OUTPUT OPTION
    PARAM       J = 1          $ INITIAL STEP NUMBER
    PARAM   TSTEP = 0.5        $ TIME STEP INTERVAL, SEC
    PARAM      Z1 = 0.         $ ALTITUDE AT BRAKE RELEASE, FT
    PARAM  ENGNAM = 3HEN1      $ ENGINE IDENTIFIER NAME
    PARAM      TT = 0.         $ INITIAL TIME, SEC
    PARAM      VA = 233.       $ AIRCRAFT VELOCITY, FT/SEC
    PARAM      XA = -38162.    $ INITIAL DISTANCE FROM ORIGIN, FT
    PARAM      YA = 0.         $ LATERAL DISTANCE FROM ORIGIN, FT
    PARAM      ZA = 2010.      $ INITIAL ALTITUDE, FT
    PARAM     THW = -3.0       $ INCLINATION OF FLIGHT VECTOR WRT HOR, DEG
    PARAM     PLG = 4HDOWN     $ INITIAL LANDING GEAR POSITION
    PARAM     TLG = 0.         $ LANDING GEAR RETRACTION TIME, SEC
    PARAM      JF = 1000       $ INTEGRATION STEP NUMBER
    PARAM      TF = 200.       $ TIME LIMIT, SEC
    PARAM      XF = 10000.     $ DISTANCE LIMIT, FT
    PARAM      ZF = 10.        $ ALTITUDE LIMIT, FT
    PARAM   ALPHA = 6.5        $ ANGLE-OF-ATTACK, DEG
    PARAM   DELTA = 50.        $ FLAP SETTING, DEG
    PARAM   THROT = .1880      $ POWER SETTING
$
$ EXECUTE SFO, GENERATE FLI(PATH) AND FLI(FLIEN1)
$
    EXECUTE SFO $
$
$============================================================================
$
$ GEO PARAMETERS
$
    PARAM      AW = 3648.      $ WING AREA, SQFT
    PARAM     CTK = .1         $ CHARACTERISTIC TIME CONSTANT, SEC
    PARAM   DELDB = 20.        $ LIMITING NOISE LEVEL DOWN FROM PEAK
    PARAM  MASSAC = 12526.     $ REFERENCE MASS OF AIRCRAFT, SLUG
    PARAM   START = 0.         $ INITIAL FLIGHT TIME TO BE CONSIDERED, SEC
    PARAM    STOP = 9999.      $ FINAL FLIGHT TIME TO BE CONSIDERED, SEC
    PARAM   DTIME = 0.5        $ RECEPTION TIME INCREMENT, SEC
    PARAM   DELTH = 10.        $ MAXIMUM DIRECTIVITY ANGLE LIMIT, DEG
    PARAM  ICOORD = 3          $ BOTH BODY AND WIND AXES OUTPUT
    PARAM  DIRECT = .FALSE.    $ CALCULATION OPTION
    PARAM  IPRINT = 0          $ PRINT NOTHING
    PARAM  IUNITS = 7HENGLISH  $ INPUT UNITS
$
$ GEO MEMBER OBSERV(COORD)
$
    UPDATE NEWU=OBSERV, SOURCE=* $
    -ADDR OLDM=*, NEWM=COORD, FORMAT=4H*RS$, MNR=208 $
     -13200.,     0., 4. $
     -11460.,     0., 4. $
        .
        . total of ( 26 * 8 ) = 208 observer locations
        .
       2640., 2640., 4. $
    END* $
$
$ EXECUTE GEO, GENERATE GEO(BODY) AND GEO(WIND)
$
    EXECUTE GEO  $
```

```
$
$=============================================================================
$
$ SELECTED APM OUTPUT
$
$     AMU            DYNAMIC VISCOSITY
$     CA             SPEED OF SOUND
$     HUMID          HUMIDITY
$     PRES           PRESSURE
$     RHOA           DENSITY
$     TA             TEMPERATURE
$
$ APM PARAMETERS
$
      PARAM  IPRINT = 2            $ PRINT LOCAL ATMOSPHERIC PROPERTIES
      PARAM  IUNITS = 7HENGLISH    $ INPUT UNITS
      PARAM       Z = 2010.        $ ALTITUDE, FT
$
$ EXECUTE APM, GENERATE ATMOSPHERIC PARAMETERS
$
      EXECUTE APM $
$
$=============================================================================
$
$ FNKAFM PARAMETERS
$
      PARAM      AF = 667.         $ FLAP AREA, SQFT
      PARAM      AH = 1090.        $ HORIZONTAL TAIL AREA, SQFT
      PARAM      AV = 605.         $ VERTICAL TAIL AREA, SQFT
      PARAM      AW = 3648.        $ WING AREA, SQFT
      PARAM      BF = 68.          $ FLAP SPAN, FT
      PARAM      BH = 70.9         $ HORIZONTAL TAIL SPAN, FT
      PARAM      BV = 24.          $ VERTICAL TAIL SPAN, FT
      PARAM      BW = 165.         $ WING SPAN, FT
      PARAM  DELTAF = 50.          $ FLAP SETTING, DEG
      PARAM     DMG = 4.33         $ TIRE DIAMETER OF MAIN LANDING GEAR, FT
      PARAM     DNG = 3.33         $ TIRE DIAMETER OF NOSE LANDING GEAR, FT
      PARAM     LMG = 8.31         $ MAIN LANDING GEAR STRUT LENGTH, FT
      PARAM     LNG = 5.96         $ NOSE LANDING GEAR STRUT LENGTH, FT
$     PARAM      CA = 0.           $ VALUE FROM APM
$     PARAM    RHOA = 0.           $ VALUE FROM APM
      PARAM     MUA = AMU          $ VALUE FROM APM
      PARAM      RS = 1.           $ OBSERVER DISTANCE, FT
   EVALUATE      MA = VA / CA      $ FLIGHT MACH NUMBER
$     PARAM   STIME = 0.           $ DEFAULT SOURCE TIME, SEC
      PARAM    NWMG = 4            $ NUMBER OF WHEELS PER MAIN LANDING GEAR
      PARAM    NWNG = 2            $ NUMBER OF WHEELS PER NOSE LANDING GEAR
      PARAM     NMG = 3            $ NUMBER OF MAIN LANDING GEAR
      PARAM     NNG = 1            $ NUMBER OF NOSE LANDING GEAR
      PARAM      NS = 1            $ NUMBER OF SLOTS FOR TRAILING EDGE FLAPS
      PARAM  IPRINT = 0            $ PRINT NOTHING
      PARAM    IOUT = 0            $ NO PRINT
      PARAM  SCRNNN = 001          $ SOURCE PREDICTION NUMBER
      PARAM  DYNCLN = .TRUE.       $ AERODYNAMICALLY CLEAN AIRCRAFT
      PARAM  DELTAW = .TRUE.       $ DELTA WING PLANFORM
      PARAM   LANDG = 4HDOWN       $ LANDING GEAR POSITION
      PARAM  SCRXXX = 3HEN1        $ CODE USED TO FORM MEMBER NAME
      PARAM  IUNITS = 7HENGLISH    $ INPUT UNITS
      PARAM    TEWN = .TRUE.       $ WING TRAILING EDGE NOISE
      PARAM   TEHTN = .TRUE.       $ HORIZONTAL TAIL TRAILING EDGE NOISE
      PARAM   TEVTN = .TRUE.       $ VERTICAL TAIL TRAILING EDGE NOISE
      PARAM    TEFN = .TRUE.       $ TRAILING EDGE FLAP NOISE
      PARAM    LESN = .TRUE.       $ LEADING EDGE SLAT NOISE
      PARAM    MLGN = .TRUE.       $ MAIN LANDING GEAR NOISE
      PARAM    NLGN = .TRUE.       $ NOSE LANDING GEAR NOISE
$
$ EXECUTE FNKAFM, GENERATE FNKAFM(EN1001)
$
      EXECUTE FNKAFM $
$
$=============================================================================
$
$ GECOR PARAMETERS
$
```

```
      PARAM       AE = 46.3          $ ENGINE REFERENCE AREA, SQFT
      PARAM      CEA = 1.0           $ COMBUSTOR ENTRANCE AREA, SQFT
   EVALUATE        A = CEA / AE      $ NORMALIZED ENTRANCE AREA
      PARAM     NENG = 3             $ NUMBER OF ENGINES
      PARAM       RS = 1.            $ OBSERVER DISTANCE, FT
      PARAM    CEMFR = 5.221         $ COMB ENTRANCE MASS FLOWRATE, SLUG/SEC
   EVALUATE     MDOT = CEMFR / ( RHOA * CA * AE ) $ NORMALIZED MASS FLOWRATE
   EVALUATE       MA = VA / CA       $ FLIGHT MACH NUMBER
      PARAM     CETP = 18821.1       $ COMBUSTOR ENTRANCE TOT PRESSURE, LBF/SQFT
   EVALUATE       PI = CETP / PRES   $ NORMALIZED TOTAL PRESSURE
      PARAM     CETT = 1191.6        $ COMBUSTOR ENTRANCE TOTAL TEMP, DEG R
   EVALUATE       TI = CETT / TA     $ NORMALIZED ENTRANCE TEMPERATURE
      PARAM     CXTT = 2126.3        $ COMBUSTOR EXIT TOTAL TEMPERATURE, DEG R
   EVALUATE      TCJ = CXTT / TA     $ NORMALIZED EXIT TEMPERATURE
      PARAM     DTTR = 1310.         $ DESIGN TURBINE TEMP EXTRACTION, DEG R
   EVALUATE   TDDELT = DTTR / TA     $ NORMALIZED TEMPERATURE EXTRACTION
$     PARAM       CA = 0.            $ VALUE FROM APM
$     PARAM     RHOA = 0.            $ VALUE FROM APM
$     PARAM    STIME = 0.            $ DEFAULT SOURCE TIME, SEC
      PARAM   ICAO78 = .FALSE.       $ REGULAR SPECTRAL DISTRIBUTION
      PARAM   SCRXXX = 3HEN1         $ CODE USED TO FORM MEMBER NAME
      PARAM   SCRNNN = 001           $ SOURCE PREDICTION NUMBER
      PARAM     IOUT = 0             $ NO PRINT
      PARAM   IPRINT = 0             $ PRINT NOTHING
      PARAM   IUNITS = 7HENGLISH     $ INPUT UNITS
$
$ EXECUTE GECOR, GENERATE GECOR(EN1001)
$
      EXECUTE GECOR $
$
$======================================================================
$
$ GETUR PARAMETERS
$
      PARAM       AE = 46.3                  $ ENGINE REFERENCE AREA, SQFT
      PARAM     NENG = 3                     $ NUMBER OF ENGINES
      PARAM       RS = 1.                    $ OBSERVER DISTANCE, FT
$     PARAM    STIME = 0.                    $ DEFAULT SOURCE TIME, SEC
      PARAM    TICSA = 1.68                  $ TURBINE INLET X-SECT AREA, SQFT
   EVALUATE     AREA = TICSA / AE            $ NORMALIZED INLET AREA
      PARAM        F = .0140                 $ FUEL TO AIR RATIO
      PARAM       HA = HUMID                 $ ABSOLUTE HUMIDITY FROM APM
      PARAM   NBLADE = 102                   $ NUMBER OF ROTOR BLADES
      PARAM      TRD = 3.9472                $ TURBINE ROTOR DIAMETER, FT
   EVALUATE        D = TRD / SQRT ( AE )     $ NORMALIZED ROTOR DIAMETER
   EVALUATE       MA = VA / CA               $ FLIGHT MACH NUMBER
      PARAM    ROSPD = 39.67                 $ ROTATIONAL SPEED, REV/SEC
   EVALUATE   ROTSPD = ROSPD / ( CA / TRD )  $ NORMALIZED ROTATIONAL SPEED
      PARAM     TETT = 2126.3                $ TURBINE ENTRANCE TOT TEMP, DEG R
   EVALUATE      TTI = TETT / TA             $ NORMALIZED TOTAL TEMPERATURE
      PARAM     TXST = 1390.3                $ TURBINE EXIT STAT TEMP, DEG R
   EVALUATE      TSJ = TXST / TA             $ NORMALIZED STATIC TEMPERATURE
$     PARAM       CA = 0.                    $ VALUE FROM APM
$     PARAM     RHOA = 0.                    $ VALUE FROM APM
      PARAM   SCRXXX = 3HEN1                 $ CODE USED TO FORM MEMBER NAME
      PARAM   SCRNNN = 001                   $ SOURCE PREDICTION NUMBER
      PARAM    BROAD = .TRUE.                $ BROADBAND SPECTRA
      PARAM     PURE = .TRUE.                $ PURE TONE SPECTRA
      PARAM     IOUT = 0                     $ NO PRINT
      PARAM   IPRINT = 0                     $ PRINT NOTHING
      PARAM   IUNITS = 7HENGLISH             $ INPUT UNITS
$
$ EXECUTE GETUR, GENERATE GETUR(EN1001)
$
      EXECUTE GETUR $
$
$======================================================================
$
$ HDNFAN PARAMETERS (DISCHARGE)
$
      PARAM       AE = 46.3                  $ ENGINE REFERENCE AREA, SQFT
      PARAM       RS = 1.                    $ OBSERVER DISTANCE, FT
      PARAM      AAF = 18.7                  $ FAN INLET AREA, SQFT
   EVALUATE     AFAN = AAF / AE              $ NORMALIZED FAN INLET AREA
```

```
      PARAM    DIAFR = 4.89                  $ FAN ROTOR DIAMETER, FT
   EVALUATE     DIAM = DIAFR / SQRT(AE)      $ NORMALIZED FAN ROTOR DIAMETER
      PARAM       MD = 1.36                  $ FAN TIP MACH NUMBER AT DESIGN
      PARAM      RSS = 0.26                  $ ROTOR-STATOR SPACING
      PARAM    MDOTA = 29.71                 $ MASS FLOW RATE, SLUG/SEC
   EVALUATE     MDOT = MDOTA / ( RHOA * CA * AE ) $ NORMALIZED MASS FLOW RATE
   EVALUATE       MA = VA / CA               $ FLIGHT MACH NUMBER
      PARAM      RPS = 39.67                 $ ROTATIONAL SPEED, REV/SEC
   EVALUATE        N = RPS / ( CA / DIAFR )  $ NORMALIZED ROTATIONAL SPEED
      PARAM   DELTAA = 44.                   $ TEMP RISE ACROSS FAN, DEG R
   EVALUATE   DELTAT = DELTAA / TA           $ NORMALIZED TEMP RISE ACROSS FAN
$     PARAM       CA = 0.                    $ VALUE FROM APM
$     PARAM     RHOA = 0.                    $ VALUE FROM APM
      PARAM   NBANDS = 0                     $ 1/3 OCTAVE BANDS FOR FREQ SHIFT
      PARAM     NENG = 3                     $ NUMBER OF ENGINES
      PARAM       NB = 46                    $ NUMBER OF ROTOR BLADES
      PARAM       NV = 96                    $ NUMBER OF STATOR VANES
      PARAM      IGV = 1                     $ INLET GUIDE VANE INDEX
      PARAM      DIS = 1                     $ INLET DISTORTION INDEX
$     PARAM    STIME = 0.                    $ DEFAULT SOURCE TIME, SEC
      PARAM     IOUT = 0                     $ NO PRINT
      PARAM   IPRINT = 0                     $ PRINT NOTHING
      PARAM   SCRNNN = 001                   $ SOURCE PREDICTION NUMBER
      PARAM   SCRXXX = 3HEN1                 $ CODE USED TO FORM MEMBER NAME
      PARAM   IUNITS = 7HENGLISH             $ INPUT UNITS
      PARAM     INRS = .FALSE.               $ INLET ROTOR-STATOR INTERACTION
      PARAM     INCT = .FALSE.               $ COMBINATION TONES
      PARAM    INDIS = .FALSE.               $ INLET DISTORTION TONES
      PARAM     IDBB = .TRUE.                $ DISCHARGE BROADBAND NOISE
      PARAM     IDRS = .TRUE.                $ DISCHARGE ROTOR-STATOR INTERACTION
      PARAM     INBB = .FALSE.               $ INLET BROADBAND NOISE
$
$ EXECUTE HDNFAN, GENERATE HDNFND(EN1001)
$
      EXECUTE HDNFAN HDNFAN=HDNFND $
$
$==============================================================================
$
$ HDNFAN PARAMETERS (INLET)
$
      PARAM       AE = 46.3                  $ ENGINE REFERENCE AREA, SQFT
      PARAM       RS = 1.                    $ OBSERVER DISTANCE, FT
      PARAM      AAF = 46.3                  $ FAN INLET AREA, SQFT
   EVALUATE     AFAN = AAF / AE              $ NORMALIZED FAN INLET AREA
      PARAM    DIAFR = 7.68                  $ FAN ROTOR DIAMETER, FT
   EVALUATE     DIAM = DIAFR / SQRT(AE)      $ NORMALIZED FAN ROTOR DIAMETER
      PARAM       MD = 1.36                  $ FAN TIP MACH NUMBER AT DESIGN
      PARAM      RSS = 0.26                  $ ROTOR-STATOR SPACING
      PARAM    MDOTA = 34.94                 $ MASS FLOW RATE, SLUG/SEC
   EVALUATE     MDOT = MDOTA / ( RHOA * CA * AE ) $ NORMALIZED MASS FLOW RATE
   EVALUATE       MA = VA / CA               $ FLIGHT MACH NUMBER
      PARAM      RPS = 39.67                 $ ROTATIONAL SPEED, REV/SEC
   EVALUATE        N = RPS / ( CA / DIAFR )  $ NORMALIZED ROTATIONAL SPEED
      PARAM   DELTAA = 44.                   $ TEMP RISE ACROSS FAN, DEG R
   EVALUATE   DELTAT = DELTAA / TA           $ NORMALIZED TEMP RISE ACROSS FAN
$     PARAM       CA = 0.                    $ VALUE FROM APM
$     PARAM     RHOA = 0.                    $ VALUE FROM APM
      PARAM   NBANDS = 0                     $ 1/3 OCTAVE BANDS FOR FREQ SHIFT
      PARAM     NENG = 3                     $ NUMBER OF ENGINES
      PARAM       NB = 46                    $ NUMBER OF ROTOR BLADES
      PARAM       NV = 96                    $ NUMBER OF STATOR VANES
      PARAM      IGV = 1                     $ INLET GUIDE VANE INDEX
      PARAM      DIS = 1                     $ INLET DISTORTION INDEX
$     PARAM    STIME = 0.                    $ DEFAULT SOURCE TIME, SEC
      PARAM     IOUT = 0                     $ NO PRINT
      PARAM   IPRINT = 0                     $ PRINT NOTHING
      PARAM   SCRNNN = 001                   $ SOURCE PREDICTION NUMBER
      PARAM   SCRXXX = 3HEN1                 $ CODE USED TO FORM MEMBER NAME
      PARAM   IUNITS = 7HENGLISH             $ INPUT UNITS
      PARAM     INRS = .FALSE.               $ INLET ROTOR-STATOR INTERACTION
      PARAM     INCT = .TRUE.                $ COMBINATION TONES
      PARAM    INDIS = .FALSE.               $ INLET DISTORTION TONES
      PARAM     IDBB = .FALSE.               $ DISCHARGE BROADBAND NOISE
      PARAM     IDRS = .FALSE.               $ DISCHARGE ROTOR-STATOR INTERACTION
```

```
     PARAM    INBB = .TRUE.                $ INLET BROADBAND NOISE
$
$ EXECUTE HDNFAN, GENERATE HDNFNI(EN1001)
$
     EXECUTE HDNFAN HDNFAN=HDNFNI $
$
$==============================================================================
$
$ STNJET PARAMETERS
$
$    PARAM       CA = 0.                   $ VALUE FROM APM
$    PARAM     RHOA = 0.                   $ VALUE FROM APM
  EVALUATE       MA = VA / CA              $ FLIGHT MACH NUMBER
     PARAM       RS = 1.                   $ OBSERVER DISTANCE, FT
     PARAM       AE = 46.3                 $ ENGINE REFERENCE AREA, SQFT
     PARAM     FEJA = 6.27                 $ FULLY EXPANDED JET AREA, SQFT
  EVALUATE       A1 = FEJA / AE            $ NORMALIZED FULLY EXPANDED JET AREA
     PARAM    ETANG = 0.                   $ ENGINE TILT ANGLE, DEG
  EVALUATE    DELTA = ALPHA + ETANG        $ ANGLE BETWEEN FLIGHT AND ENGINE, DEG
     PARAM     PSED = 2.82                 $ PRIMARY STREAM EQUIV DIAMETER, FT
  EVALUATE      DE1 = PSED / SQRT(AE)      $ NORMALIZED EQUIV DIAMETER
     PARAM     PSHD = 2.82                 $ PRIMARY STREAM HYDR DIAMETER, FT
  EVALUATE      DH1 = PSHD / SQRT(AE)      $ NORMALIZED HYDR DIAMETER
     PARAM     PSJV = 870.4                $ PRIMARY STREAM JET VELOCITY, FT/SEC
  EVALUATE       V1 = PSJV / CA            $ NORMALIZED JET VELOCITY
     PARAM     PSJD = .000962              $ PRIMARY STREAM JET DENSITY, SLUG/CUFT
  EVALUATE     RHO1 = PSJD / RHOA          $ NORMALIZED JET DENSITY
     PARAM     PSTT = 1340.                $ PRIMARY STREAM TOTAL TEMP, DEG R
  EVALUATE       T1 = PSTT / TA            $ NORMALIZED TOTAL TEMPERATURE
     PARAM       M1 = 0.5027               $ PRIMARY STREAM MACH NUMBER
     PARAM    SFEJA = 19.32                $ SECONDARY FULLY EXP JET AREA, SQFT
  EVALUATE       A2 = SFEJA / AE           $ NORMALIZED FULLY EXPANDED JET AREA
     PARAM     SSJV = 695.0                $ SECONDARY STREAM JET VELOCITY, FT/SEC
  EVALUATE       V2 = SSJV / CA            $ NORMALIZED JET VELOCITY
     PARAM     SSJD = .002317              $ SECONDARY STREAM JET DENS, SLUG/CUFT
  EVALUATE     RHO2 = SSJD / RHOA          $ NORMALIZED JET DENSITY
     PARAM     SSTT = 568.1                $ SECONDARY STREAM TOTAL TEMP, DEG R
  EVALUATE       T2 = SSTT / TA            $ NORMALIZED TOTAL TEMPERATURE
     PARAM       M2 = 0.6235               $ SECONDARY STREAM MACH NUMBER
$    PARAM    STIME = 0.                   $ DEFAULT SOURCE TIME, SEC
     PARAM     NENG = 3                    $ NUMBER OF ENGINES
     PARAM   SCRNNN = 001                  $ SOURCE PREDICTION NUMBER
     PARAM   SCRXXX = 3HEN1                $ CODE USED TO FORM MEMBER NAME
     PARAM   IUNITS = 7HENGLISH            $ INPUT UNITS
     PARAM     PLUG = .TRUE.               $ PLUG
     PARAM   CIRCLE = .TRUE.               $ COAXIAL NOZZLE
     PARAM    SUPER = .FALSE.              $ NO PRIMARY STREAM SHOCK NOISE
     PARAM     IOUT = 0                    $ NO PRINT
     PARAM   IPRINT = 0                    $ PRINT NOTHING
$
$ EXECUTE STNJET, GENERATE STNJET(EN1001)
$
     EXECUTE STNJET $
$
$==============================================================================
$
$ GENSUP TABLE SUPPREST(FACTOR), 10 DB SUPPRESSION
$
  TABLE SUPPREST(FACTOR ) 1 SOURCE=* $
   INT= 1 2
   IND1= RS 25 2 2
          50.0,     63.0,     80.0,    100.0,    125.0,    160.0,    200.0,
         250.0,    315.0,    400.0,    500.0,    630.0,    800.0,   1000.0,
        1250.0,   1600.0,   2000.0,   2500.0,   3150.0,   4000.0,   5000.0,
        6300.0,   8000.0,  10000.0,  12500.0
   IND2= RS 35 2 2
         5.,  10.,  15.,  20.,  25.,  30.,  35.,  40.,  45.,  50.,
        55.,  60.,  65.,  70.,  75.,  80.,  85.,  90.,  95., 100.,
       105., 110., 115., 120., 125., 130., 135., 140., 145., 150.,
       155., 160., 165., 170., 175.
   IND3= RS 18 2 2
         0.,   5.,  10.,  15.,  20.,  25.,  30.,  35.,  40.,
        45.,  50.,  55.,  60.,  65.,  70.,  75.,  80.,  85.
   DEP= RS
```

```
     .1, .1, .1, .1, .1, .1, .1, .1, .1, .1, .1, .1, .1, .1, .1, .1, .1, .1,
     .1, .1, .1, .1, .1, .1, .1, .1, .1, .1, .1, .1, .1, .1, .1, .1, .1, .1,
      .
      . total of ( 25 * 35 * 18 ) = 15750 suppression values
      .
     .1, .1, .1, .1, .1, .1, .1, .1, .1, .1, .1, .1, .1, .1, .1, .1, .1, .1
    END* $
$
$--------------------------------------------------------------------------
$
$ GENSUP PARAMETERS
$
      PARAM  SCRXXX = 3HEN1       $ CODE USED TO FORM MEMBER NAME
      PARAM  SCRNNN = 001         $ SOURCE PREDICTION NUMBER
      PARAM  IPRINT = 0           $ PRINT NOTHING
$     PARAM    RHOA = 0.          $ VALUE FROM APM
$     PARAM      CA = 0.          $ VALUE FROM APM
      PARAM    IOUT = 0           $ NO PRINT
      PARAM  IUNITS = 7HENGLISH   $ INPUT UNITS
$
$ APPLY 10 DB SUPPRESSION TO TURBINE NOISE, GENERATE GETURS(EN1001)
$
      EXECUTE GENSUP NOISE=GETUR  SUPPRESS=SUPPREST $
$
$ APPLY 10 DB SUPPRESSION TO FAN DISCHARGE NOISE, GENERATE HDNFNDS(EN1001)
$
      EXECUTE GENSUP NOISE=HDNFND SUPPRESS=SUPPREST $
$
$==========================================================================
$
$ PRO PARAMETERS COMMON TO ALL
$
      PARAM  IPRINT = 0           $ PRINT NOTHING
      PARAM    IOUT = 1           $ DB OUTPUT
$     PARAM   SIGMA = 485.        $ DEFAULT GROUND FLOW RESIST, SLUG/SEC-CUFT
      PARAM  IUNITS = 7HENGLISH   $ INPUT UNITS
      PARAM   NBAND = 1           $ NUMBER OF SUBBANDS PER 1/3 OCTAVE
      PARAM      RS = 1.          $ OBSERVER DISTANCE, FT
      PARAM SURFACE = 4HSOFT      $ SURFACE TYPE OPTION
$     PARAM     COH = .01         $ DEFAULT INCOHERENCE COEFFICIENT
      PARAM  ABSORP = .TRUE.      $ ATMOSPHERIC ABSORPTION OPTION
      PARAM  GROUND = .TRUE.      $ GROUND EFFECTS OPTION
      PARAM PROTIME = 3HEN1       $ CODE USED TO FORM MEMBER NAME
$
$ PRO PARAMETER FOR AIRFRAME, EXECUTE PRO
$
      PARAM PROSUM1 = 6HFNKAFM                         $ NAME OF NOISE UNIT
      EXECUTE PRO PROSUM=PROSUM1, GEOM=WIND, PRO=PRO1 $ GENERATE PRO1(PRES)
$
$ PRO PARAMETER FOR CORE, EXECUTE PRO
$
      PARAM PROSUM2 = 5HGECOR                          $ NAME OF NOISE UNIT
      EXECUTE PRO PROSUM=PROSUM2, GEOM=BODY, PRO=PRO2 $ GENERATE PRO2(PRES)
$
$ PRO PARAMETER FOR TURBINE, EXECUTE PRO
$
      PARAM PROSUM3 = 5HGETUR                          $ NAME OF NOISE UNIT
      EXECUTE PRO PROSUM=PROSUM3, GEOM=BODY, PRO=PRO3 $ GENERATE PRO3(PRES)
$
$ PRO PARAMETER FOR FAN DISCHARGE, EXECUTE PRO
$
      PARAM PROSUM4 = 6HHDNFND                         $ NAME OF NOISE UNIT
      EXECUTE PRO PROSUM=PROSUM4, GEOM=BODY, PRO=PRO4 $ GENERATE PRO4(PRES)
$
$ PRO PARAMETER FOR FAN INLET, EXECUTE PRO
$
      PARAM PROSUM5 = 6HHDNFNI                         $ NAME OF NOISE UNIT
      EXECUTE PRO PROSUM=PROSUM5, GEOM=BODY, PRO=PRO5 $ GENERATE PRO5(PRES)
$
$ PRO PARAMETER FOR JET, EXECUTE PRO
$
      PARAM PROSUM6 = 6HSTNJET                         $ NAME OF NOISE UNIT
      EXECUTE PRO PROSUM=PROSUM6, GEOM=BODY, PRO=PRO6 $ GENERATE PRO6(PRES)
$
```

```
$ PRO PARAMETER FOR SUPPRESSED TURBINE, EXECUTE PRO
$
     PARAM PROSUM7 = 6HGETURS                       $ NAME OF NOISE UNIT
     EXECUTE PRO PROSUM=PROSUM7, GEOM=BODY, PRO=PRO7 $ GENERATE PRO7(PRES)
$
$ PRO PARAMETER FOR SUPPRESSED FAN DISCHARGE, EXECUTE PRO
$
     PARAM PROSUM8 = 7HHDNFNDS                      $ NAME OF NOISE UNIT
     EXECUTE PRO PROSUM=PROSUM8, GEOM=BODY, PRO=PRO8 $ GENERATE PRO8(PRES)
$
$==========================================================================
$
$ LEV PARAMETERS COMMON TO ALL
$
     PARAM    IAWT = .FALSE.     $ A-WEIGHTED LEVEL OPTION
     PARAM    IDWT = .FALSE.     $ D-WEIGHTED LEVEL OPTION
     PARAM   IOSPL = .FALSE.     $ OASPL OPTION
     PARAM    IOUT = 1           $ DB OUTPUT
     PARAM    IPNL = .FALSE.     $ PNL OPTION
     PARAM   IPNLT = .TRUE.      $ PNLT OPTION
     PARAM    NAWT = .FALSE.     $ NO NARROW BAND DATA
     PARAM    NDWT = .FALSE.     $ NO NARROW BAND DATA
     PARAM   NOSPL = .FALSE.     $ NO NARROW BAND DATA
$
$ EFF PARAMETERS COMMON TO ALL
$
     PARAM   DTIME = .5          $ RECEPTION TIME INCREMENT, SEC
$
$ CNT PARAMETERS COMMON TO ALL
$
     PARAM    ISYM = .FALSE.     $ NON-SYMMETRICAL OUTPUT
     PARAM    IOPT = 1           $ EPNL PLOT OUTPUT
$
$ PRINT PARAMETERS COMMON TO ALL MODULES
$
     PARAM  IPRINT = 0           $ PRINT NOTHING
$
$ LEV AND CNT PARAMETERS FOR AIRFRAME, EXECUTE LEV, EFF, AND CNT
$
     PARAM  MEMSUM = 6HPRO1   , 6HPRES    $ LEV UNIT NAME AND MEMBER NAME
     PARAM FILNAME = 8HFRAMCBPR           $ CNT FILE NAME
     EXECUTE LEV                          $ GENERATE LEV(PNLT)
     EXECUTE EFF                          $ GENERATE EFF(EPNL)
     EXECUTE CNT                          $ GENERATE DATA FILE FRAMCBPR.OUT
$
$ LEV AND CNT PARAMETERS FOR CORE, EXECUTE LEV, EFF, AND CNT
$
     PARAM  MEMSUM = 6HPRO2   , 6HPRES    $ LEV UNIT NAME AND MEMBER NAME
     PARAM FILNAME = 8HCORECBPR           $ CNT FILE NAME
     EXECUTE LEV                          $ GENERATE LEV(PNLT)
     EXECUTE EFF                          $ GENERATE EFF(EPNL)
     EXECUTE CNT                          $ GENERATE DATA FILE CORECBPR.OUT
$
$ LEV AND CNT PARAMETERS FOR TURBINE, EXECUTE LEV, EFF, AND CNT
$
     PARAM  MEMSUM = 6HPRO3   , 6HPRES    $ LEV UNIT NAME AND MEMBER NAME
     PARAM FILNAME = 8HTURBCBPR           $ CNT FILE NAME
     EXECUTE LEV                          $ GENERATE LEV(PNLT)
     EXECUTE EFF                          $ GENERATE EFF(EPNL)
     EXECUTE CNT                          $ GENERATE DATA FILE TURBCBPR.OUT
$
$ LEV AND CNT PARAMETERS FOR FAN DISCHARGE, EXECUTE LEV, EFF, AND CNT
$
     PARAM  MEMSUM = 6HPRO4   , 6HPRES    $ LEV UNIT NAME AND MEMBER NAME
     PARAM FILNAME = 8HFANDCBPR           $ CNT FILE NAME
     EXECUTE LEV                          $ GENERATE LEV(PNLT)
     EXECUTE EFF                          $ GENERATE EFF(EPNL)
     EXECUTE CNT                          $ GENERATE DATA FILE FANDCBPR.OUT
$
$ LEV AND CNT PARAMETERS FOR FAN INLET, EXECUTE LEV, EFF, AND CNT
$
     PARAM  MEMSUM = 6HPRO5   , 6HPRES    $ LEV UNIT NAME AND MEMBER NAME
     PARAM FILNAME = 8HFANICBPR           $ CNT FILE NAME
     EXECUTE LEV                          $ GENERATE LEV(PNLT)
```

```
     EXECUTE EFF                              $ GENERATE EFF(EPNL)
     EXECUTE CNT                              $ GENERATE DATA FILE FANICBPR.OUT
$
$ LEV AND CNT PARAMETERS FOR JET, EXECUTE LEV, EFF, AND CNT
$
     PARAM  MEMSUM = 6HPRO6   , 6HPRES    $ LEV UNIT NAME AND MEMBER NAME
     PARAM FILNAME = 8HJETNCBPR           $ CNT FILE NAME
     EXECUTE LEV                              $ GENERATE LEV(PNLT)
     EXECUTE EFF                              $ GENERATE EFF(EPNL)
     EXECUTE CNT                              $ GENERATE DATA FILE JETNCBPR.OUT
$
$ LEV AND CNT PARAMETERS FOR SUPPRESSED TURBINE, EXECUTE LEV, EFF, AND CNT
$
     PARAM  MEMSUM = 6HPRO7   , 6HPRES    $ LEV UNIT NAME AND MEMBER NAME
     PARAM FILNAME = 8HTURSCBPR           $ CNT FILE NAME
     EXECUTE LEV                              $ GENERATE LEV(PNLT)
     EXECUTE EFF                              $ GENERATE EFF(EPNL)
     EXECUTE CNT                              $ GENERATE DATA FILE TURSCBPR.OUT
$
$ LEV AND CNT PARAMETERS FOR SUPPRESSED FAN DISCHARGE, EXECUTE LEV, EFF, AND CNT
$
     PARAM  MEMSUM = 6HPRO8   , 6HPRES    $ LEV UNIT NAME AND MEMBER NAME
     PARAM FILNAME = 8HFADSCBPR           $ CNT FILE NAME
     EXECUTE LEV                              $ GENERATE LEV(PNLT)
     EXECUTE EFF                              $ GENERATE EFF(EPNL)
     EXECUTE CNT                              $ GENERATE DATA FILE FADSCBPR.OUT
$
$ LEV AND CNT PARAMETERS FOR AIRFRAME AND ENGINE, EXECUTE LEV, EFF, AND CNT
$
     PARAM  MEMSUM = 6HPRO1   , 6HPRES    , 6HPRO2   , 6HPRES   ,
                     6HPRO3   , 6HPRES    , 6HPRO4   , 6HPRES   ,
                     6HPRO5   , 6HPRES    , 6HPRO6   , 6HPRES
                                          $ LEV UNIT NAMES AND MEMBER NAMES
     PARAM FILNAME = 8HLOUDCBPR           $ CNT FILE NAME
     EXECUTE LEV                              $ GENERATE LEV(PNLT)
     EXECUTE EFF                              $ GENERATE EFF(EPNL)
     EXECUTE CNT                              $ GENERATE DATA FILE LOUDCBPR.OUT
$
$ LEV AND CNT PARAMETERS FOR AIRFRAME & ENGINE WITH SUPPRESSED FAN AND TURBINE,
$ EXECUTE LEV, EFF, AND CNT
$
     PARAM  MEMSUM = 6HPRO1   , 6HPRES    , 6HPRO2   , 6HPRES   ,
                     6HPRO5   , 6HPRES    , 6HPRO6   , 6HPRES   ,
                     6HPRO7   , 6HPRES    , 6HPRO8   , 6HPRES
                                          $ LEV UNIT NAMES AND MEMBER NAMES
     PARAM FILNAME = 8HHUSHCBPR           $ CNT FILE NAME
     EXECUTE LEV                              $ GENERATE LEV(PNLT)
     EXECUTE EFF                              $ GENERATE EFF(EPNL)
     EXECUTE CNT                              $ GENERATE DATA FILE HUSHCBPR.OUT
$
$=========================================================================
$
$ FINEM RESPICE
$
     ENDCS $
```

Appendix B: Advanced Transport ANOPP Command File

Contained herein is the ANOPP command file used to calculate EPNL values for the approach to landing of a commercial transport powered by a 10:1 by-pass ratio turbofan engine. For brevity's sake the majority of observer positions (for the Geometry Module GEO) and suppression factors (for the General Suppression Module GENSUP) were omitted. Except for those omissions the command file is sufficient to reproduce the results presented in this paper.

```
      ANOPP ACCOUNT=.FALSE., JECHO=.TRUE., JLOG=.FALSE., LENGL=12000,
            MAXCARDS=10000, NAETD=100, NAEUD=100, NLPPM=48, NOGO=.FALSE. $
$
      STARTCS $
$
$ LOAD LIBRARYS
$
      LOAD /LIBRARY/ PROCLIB, STNTBL $
$
$=======================================================================
$
$ ATM PARAMETERS
$
      PARAM    DELH = 100.        $ ALTITUDE INCREMENT FOR OUTPUT
      PARAM      H1 = 0.          $ GROUND LEVEL ALTITUDE, FT
      PARAM  IUNITS = 7HENGLISH   $ INPUT UNITS
      PARAM     NHO = 22          $ NUMBER OF ALTITUDE INCREMENTS
      PARAM      P1 = 2116.224    $ ATMOSPHERIC PRESSURE AT GROUND, LBF/SQFT
      PARAM  IPRINT = 2           $ PRINT OUTPUT
$
$ ATM MEMBER ATM(IN)
$
      UPDATE NEWU=ATM, SOURCE=* $
      -ADDR OLDM=*, NEWM=IN, FORMAT=4H3RS$, MNR=22 $
            0.0, 518.670,  70.0 $
          100.0, 518.313,  70.0 $
          200.0, 517.957,  70.0 $
          300.0, 517.600,  70.0 $
          400.0, 517.244,  70.0 $
          500.0, 516.887,  70.0 $
          600.0, 516.530,  70.0 $
          700.0, 516.174,  70.0 $
          800.0, 515.817,  70.0 $
          900.0, 515.461,  70.0 $
         1000.0, 515.104,  70.0 $
         1100.0, 514.747,  70.0 $
         1200.0, 514.391,  70.0 $
         1300.0, 514.034,  70.0 $
         1400.0, 513.678,  70.0 $
         1500.0, 513.321,  70.0 $
         1600.0, 512.965,  70.0 $
         1700.0, 512.608,  70.0 $
         1800.0, 512.251,  70.0 $
         1900.0, 511.895,  70.0 $
         2000.0, 511.538,  70.0 $
         2100.0, 511.182,  70.0 $
      END* $
$
$ EXECUTE ATM, GENERATE ATM(TMOD)
$
      EXECUTE ATM $
$
$=======================================================================
$
$ ABS PARAMETERS
$
      PARAM  IUNITS = 7HENGLISH   $ INPUT UNITS
      PARAM  ABSINT = 5           $ NUMBER OF INTEGRATION STEPS
      PARAM  IPRINT = 2           $ PRINT OUTPUT
      PARAM     SAE = .TRUE.      $ SAE METHOD
$
$ ABS MEMBER SFIELD(FREQ) AND DIRECTIVITY MEMBERS SFIELD(THETA) AND SFIELD(PHI)
$
      UPDATE NEWU=SFIELD, SOURCE=* $
      -ADDR OLDM=*, NEWM=FREQ, FORMAT=4H*RS$, MNR=1 $
          50.0,     63.0,     80.0,    100.0,    125.0,    160.0,    200.0,
         250.0,    315.0,    400.0,    500.0,    630.0,    800.0,   1000.0,
        1250.0,   1600.0,   2000.0,   2500.0,   3150.0,   4000.0,   5000.0,
        6300.0,   8000.0,  10000.0,  12500.0 $
      -ADDR OLDM=*, NEWM=PHI, FORMAT=4H*RS$, MNR=1 $
         0.,    5.,   10.,   15.,   20.,   25.,   30.,   35.,   40.,
        45.,   50.,   55.,   60.,   65.,   70.,   75.,   80.,   85. $
      -ADDR OLDM=*, NEWM=THETA, FORMAT=4H*RS$, MNR=1 $
```

```
          5.,  10.,  15.,  20.,  25.,  30.,  35.,  40.,  45.,  50.,
         55.,  60.,  65.,  70.,  75.,  80.,  85.,  90.,  95., 100.,
        105., 110., 115., 120., 125., 130., 135., 140., 145., 150.,
        155., 160., 165., 170., 175. $
        END* $
$
$ EXECUTE ABS, GENERATE ATM(AAC)
$
        EXECUTE ABS $
$
$==========================================================================
$
$ SFO PARAMETERS
$
        PARAM  IUNITS = 7HENGLISH  $ INPUT UNITS
        PARAM     NJO = 0          $ NUMBER OF TIME STEPS COMPLETED
        PARAM  IPRINT = 0          $ PRINT NOTHING
        PARAM    IOUT = 1          $ OUTPUT OPTION
        PARAM       J = 1          $ INITIAL STEP NUMBER
        PARAM   TSTEP = 0.5        $ TIME STEP INTERVAL ,SEC
        PARAM      Z1 = 0.         $ ALTITUDE AT BRAKE RELEASE, FT
        PARAM  ENGNAM = 3HEN1      $ ENGINE IDENTIFIER NAME
        PARAM      TT = 0.         $ INITIAL TIME, SEC
        PARAM      VA = 233.       $ AIRCRAFT VELOCITY, FT/SEC
        PARAM      XA = -38162.    $ INITIAL DISTANCE FROM ORIGIN, FT
        PARAM      YA = 0.         $ LATERAL DISTANCE FROM ORIGIN, FT
        PARAM      ZA = 2010.      $ INITIAL ALTITUDE, FT
        PARAM     THW = -3.0       $ INCLINATION OF FLIGHT VECTOR WRT HOR, DEG
        PARAM     PLG = 4HDOWN     $ INITIAL LANDING GEAR POSITION
        PARAM     TLG = 0.         $ LANDING GEAR RETRACTION TIME, SEC
        PARAM      JF = 1000       $ INTEGRATION STEP NUMBER
        PARAM      TF = 200.       $ TIME LIMIT, SEC
        PARAM      XF = 10000.     $ DISTANCE LIMIT, FT
        PARAM      ZF = 10.        $ ALTITUDE LIMIT, FT
        PARAM   ALPHA = 6.5        $ ANGLE-OF-ATTACK, DEG
        PARAM   DELTA = 50.        $ FLAP SETTING, DEG
        PARAM   THROT = .2445      $ POWER SETTING
$
$ EXECUTE SFO, GENERATE FLI(PATH) AND FLI(FLIEN1)
$
        EXECUTE SFO $
$
$==========================================================================
$
$ GEO PARAMETERS
$
        PARAM      AW = 3648.      $ WING AREA, SQFT
        PARAM     CTK = .1         $ CHARACTERISTIC TIME CONSTANT, SEC
        PARAM   DELDB = 20.        $ LIMITING NOISE LEVEL DOWN FROM PEAK
        PARAM  MASSAC = 12526.     $ REFERENCE MASS OF AIRCRAFT, SLUG
        PARAM   START = 0.         $ INITIAL FLIGHT TIME TO BE CONSIDERED, SEC
        PARAM    STOP = 9999.      $ FINAL FLIGHT TIME TO BE CONSIDERED, SEC
        PARAM   DTIME = 0.5        $ RECEPTION TIME INCREMENT, SEC
        PARAM   DELTH = 10.        $ MAXIMUM DIRECTIVITY ANGLE LIMIT, DEG
        PARAM  ICOORD = 3          $ BOTH BODY AND WIND AXES OUTPUT
        PARAM  DIRECT = .FALSE.    $ CALCULATION OPTION
        PARAM  IPRINT = 0          $ PRINT NOTHING
        PARAM  IUNITS = 7HENGLISH  $ INPUT UNITS
$
$ GEO MEMBER OBSERV(COORD)
$
        UPDATE NEWU=OBSERV, SOURCE=* $
        -ADDR OLDM=*, NEWM=COORD, FORMAT=4H*RS$, MNR=208 $
         -13200.,     0., 4. $
         -11460.,     0., 4. $
             .
             . total of ( 26 * 8 ) = 208 observer locations
             .
           2640., 2640., 4. $
        END* $
$
$ EXECUTE GEO, GENERATE GEO(BODY) AND GEO(WIND)
$
        EXECUTE GEO  $
```

```
$
$=========================================================================
$
$ SELECTED APM OUTPUT
$
$     CA             SPEED OF SOUND
$     RHOA           DENSITY
$     TA             TEMPERATURE
$
$ APM PARAMETERS
$
      PARAM   IPRINT = 2          $ PRINT LOCAL ATMOSPHERIC PROPERTIES
      PARAM   IUNITS = 7HENGLISH  $ INPUT UNITS
      PARAM        Z = 2010.      $ ALTITUDE, FT
$
$ EXECUTE APM, GENERATE ATMOSPHERIC PARAMETERS
$
      EXECUTE APM $
$
$=========================================================================
$
$ ENGINE STATE TABLES
$
   TABLE ENG   (FAN1     ) 1 SOURCE=* $
        INT=        0 1
        IND1= RS  10 2 2
          1.0, 0.9, 0.8, 0.7, 0.6, 0.5, 0.4, 0.3, 0.2, 0.1
        IND2= RS   7 2 0
          0.0, 0.1, 0.2, 0.3, 0.4, 0.5, 0.6
        IND3= 0    6 0 0
        DEP= RS
          1.0, 1.0, 1.0, 1.0, 1.0, 1.0, 1.0, 1.0, 1.0, 1.0,
          1.0, 1.0, 1.0, 1.0, 1.0, 1.0, 1.0, 1.0, 1.0, 1.0,
          1.0, 1.0, 1.0, 1.0, 1.0, 1.0, 1.0, 1.0, 1.0, 1.0,
          1.0, 1.0, 1.0, 1.0, 1.0, 1.0, 1.0, 1.0, 1.0, 1.0,
          1.0, 1.0, 1.0, 1.0, 1.0, 1.0, 1.0, 1.0, 1.0, 1.0,
          1.0, 1.0, 1.0, 1.0, 1.0, 1.0, 1.0, 1.0, 1.0, 1.0,
          1.0, 1.0, 1.0, 1.0, 1.0, 1.0, 1.0, 1.0, 1.0, 1.0,
          0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0,
          0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0,
          0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0,
          0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0,
          0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0,
          0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0,
          0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0,
          0.2680, 0.2548, 0.2407, 0.2254, 0.2090, 0.1912, 0.1714,
          0.1489, 0.1222, 0.0872, 0.2706, 0.2583, 0.2452, 0.2311,
          0.2159, 0.1994, 0.1811, 0.1604, 0.1359, 0.1114, 0.2780,
          0.2667, 0.2546, 0.2415, 0.2274, 0.2122, 0.1955, 0.1767,
          0.1546, 0.1326, 0.2901, 0.2796, 0.2684, 0.2564, 0.2435,
          0.2295, 0.2144, 0.1974, 0.1779, 0.1585, 0.3064, 0.2968,
          0.2865, 0.2754, 0.2636, 0.2509, 0.2371, 0.2220, 0.2050,
          0.1879, 0.3267, 0.3178, 0.3083, 0.2981, 0.2873, 0.2757,
          0.2633, 0.2499, 0.2349, 0.2200, 0.3506, 0.3424, 0.3336,
          0.3243, 0.3143, 0.3038, 0.2925, 0.2804, 0.2672, 0.2540,
          1.0000, 1.0000, 1.0000, 1.0000, 1.0000, 1.0000, 1.0000,
          1.0000, 1.0000, 1.0000, 1.0070, 1.0070, 1.0070, 1.0070,
          1.0070, 1.0070, 1.0070, 1.0070, 1.0070, 1.0070, 1.0283,
          1.0283, 1.0283, 1.0283, 1.0283, 1.0283, 1.0283, 1.0283,
          1.0283, 1.0283, 1.0646, 1.0646, 1.0646, 1.0646, 1.0646,
          1.0646, 1.0646, 1.0646, 1.0646, 1.0646, 1.1168, 1.1168,
          1.1168, 1.1168, 1.1168, 1.1168, 1.1168, 1.1168, 1.1168,
          1.1168, 1.1867, 1.1867, 1.1867, 1.1867, 1.1867, 1.1867,
          1.1867, 1.1867, 1.1867, 1.1867, 1.2762, 1.2762, 1.2762,
          1.2762, 1.2762, 1.2762, 1.2762, 1.2762, 1.2762, 1.2762,
          1.0000, 1.0000, 1.0000, 1.0000, 1.0000, 1.0000, 1.0000,
          1.0000, 1.0000, 1.0000, 1.0020, 1.0020, 1.0020, 1.0020,
          1.0020, 1.0020, 1.0020, 1.0020, 1.0020, 1.0020, 1.0080,
          1.0080, 1.0080, 1.0080, 1.0080, 1.0080, 1.0080, 1.0080,
          1.0080, 1.0080, 1.0180, 1.0180, 1.0180, 1.0180, 1.0180,
          1.0180, 1.0180, 1.0180, 1.0180, 1.0180, 1.0320, 1.0320,
          1.0320, 1.0320, 1.0320, 1.0320, 1.0320, 1.0320, 1.0320,
          1.0320, 1.0500, 1.0500, 1.0500, 1.0500, 1.0500, 1.0500,
          1.0500, 1.0500, 1.0500, 1.0500, 1.0720, 1.0720, 1.0720,
```

```
      1.0720, 1.0720, 1.0720, 1.0720, 1.0720, 1.0720, 1.0720,
      0.4892, 0.4676, 0.4446, 0.4206, 0.3953, 0.3683, 0.3381,
      0.3040, 0.2643, 0.2183, 0.4888, 0.4686, 0.4470, 0.4242,
      0.4002, 0.3745, 0.3457, 0.3127, 0.2733, 0.2339, 0.4880,
      0.4686, 0.4477, 0.4256, 0.4023, 0.3770, 0.3487, 0.3156,
      0.2756, 0.2356, 0.4870, 0.4682, 0.4479, 0.4263, 0.4033,
      0.3784, 0.3504, 0.3179, 0.2788, 0.2396, 0.4866, 0.4683,
      0.4485, 0.4275, 0.4050, 0.3806, 0.3535, 0.3224, 0.2858,
      0.2493, 0.4871, 0.4693, 0.4501, 0.4299, 0.4083, 0.3848,
      0.3589, 0.3299, 0.2967, 0.2635, 0.4890, 0.4718, 0.4534,
      0.4340, 0.4134, 0.3912, 0.3669, 0.3402, 0.3107, 0.2813
    END* $
$
  TABLE ENG  (FAN2     ) 1 SOURCE=* $
    INT=        0 1
    IND1= RS   10 2 2
      1.0, 0.9, 0.8, 0.7, 0.6, 0.5, 0.4, 0.3, 0.2, 0.1
    IND2= RS    7 2 0
      0.0, 0.1, 0.2, 0.3, 0.4, 0.5, 0.6
    IND3= 0     6 0 0
    DEP= RS
      1.5217, 1.5217, 1.5217, 1.5217, 1.5217, 1.5217, 1.5217,
      1.5217, 1.5217, 1.5217, 1.5217, 1.5217, 1.5217, 1.5217,
      1.5217, 1.5217, 1.5217, 1.5217, 1.5217, 1.5217, 1.5217,
      1.5217, 1.5217, 1.5217, 1.5217, 1.5217, 1.5217, 1.5217,
      1.5217, 1.5217, 1.5217, 1.5217, 1.5217, 1.5217, 1.5217,
      1.5217, 1.5217, 1.5217, 1.5217, 1.5217, 1.5217, 1.5217,
      1.5217, 1.5217, 1.5217, 1.5217, 1.5217, 1.5217, 1.5217,
      1.5217, 1.5217, 1.5217, 1.5217, 1.5217, 1.5217, 1.5217,
      1.5217, 1.5217, 1.5217, 1.5217, 1.5217, 1.5217, 1.5217,
      1.5217, 1.5217, 1.5217, 1.5217, 1.5217, 1.5217, 1.5217,
      0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0,
      0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0,
      0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0,
      0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0,
      0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0,
      0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0,
      0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0,
      0.2680, 0.2548, 0.2407, 0.2254, 0.2090, 0.1912, 0.1714,
      0.1489, 0.1222, 0.0872, 0.2706, 0.2583, 0.2452, 0.2311,
      0.2159, 0.1994, 0.1811, 0.1604, 0.1359, 0.1114, 0.2780,
      0.2667, 0.2546, 0.2415, 0.2274, 0.2122, 0.1955, 0.1767,
      0.1546, 0.1326, 0.2901, 0.2796, 0.2684, 0.2564, 0.2435,
      0.2295, 0.2144, 0.1974, 0.1779, 0.1585, 0.3064, 0.2968,
      0.2865, 0.2754, 0.2636, 0.2509, 0.2371, 0.2220, 0.2050,
      0.1879, 0.3267, 0.3178, 0.3083, 0.2981, 0.2873, 0.2757,
      0.2633, 0.2499, 0.2349, 0.2200, 0.3506, 0.3424, 0.3336,
      0.3243, 0.3143, 0.3038, 0.2925, 0.2804, 0.2672, 0.2540,
      1.3933, 1.3542, 1.3155, 1.2770, 1.2387, 1.2011, 1.1637,
      1.1267, 1.0899, 1.0537, 1.4015, 1.3648, 1.3281, 1.2915,
      1.2549, 1.2184, 1.1820, 1.1453, 1.1082, 1.0710, 1.4268,
      1.3914, 1.3560, 1.3203, 1.2843, 1.2483, 1.2121, 1.1752,
      1.1373, 1.0994, 1.4697, 1.4351, 1.4001, 1.3647, 1.3288,
      1.2926, 1.2561, 1.2187, 1.1799, 1.1412, 1.5323, 1.4977,
      1.4627, 1.4271, 1.3909, 1.3540, 1.3168, 1.2787, 1.2391,
      1.1994, 1.6174, 1.5823, 1.5468, 1.5105, 1.4735, 1.4356,
      1.3972, 1.3581, 1.3174, 1.2768, 1.7290, 1.6930, 1.6564,
      1.6190, 1.5806, 1.5414, 1.5013, 1.4605, 1.4185, 1.3765,
      1.1172, 1.1064, 1.0956, 1.0852, 1.0749, 1.0647, 1.0544,
      1.0439, 1.0333, 1.0232, 1.1188, 1.1086, 1.0985, 1.0885,
      1.0786, 1.0688, 1.0587, 1.0482, 1.0372, 1.0263, 1.1239,
      1.1141, 1.1043, 1.0946, 1.0849, 1.0751, 1.0650, 1.0544,
      1.0430, 1.0317, 1.1326, 1.1231, 1.1136, 1.1040, 1.0944,
      1.0847, 1.0746, 1.0641, 1.0529, 1.0417, 1.1454, 1.1362,
      1.1269, 1.1175, 1.1081, 1.0984, 1.0886, 1.0784, 1.0677,
      1.0570, 1.1627, 1.1537, 1.1446, 1.1355, 1.1263, 1.1169,
      1.1073, 1.0976, 1.0875, 1.0775, 1.1848, 1.1760, 1.1672,
      1.1584, 1.1494, 1.1403, 1.1311, 1.1218, 1.1124, 1.1030,
      0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0,
      0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0,
      0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0,
      0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0,
      0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0,
      0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0,
```

```
        0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0
      END* $
$
   TABLE ENG   (CORE1    ) 1 SOURCE=* $
      INT=         0 1
      IND1= RS   10 2 2
        1.0, 0.9, 0.8, 0.7, 0.6, 0.5, 0.4, 0.3, 0.2, 0.1
      IND2= RS    7 2 0
        0.0, 0.1, 0.2, 0.3, 0.4, 0.5, 0.6
      IND3= 0     6 0 0
      DEP= RS
        0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0,
        0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0,
        0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0,
        0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0,
        0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0,
        0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0,
        0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0,
        0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0,
        0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0,
        0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0,
        0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0,
        0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0,
        0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0,
        0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0,
        0.02046, 0.01957, 0.01854, 0.01738, 0.01620, 0.01498, 0.01349,
        0.01195, 0.01050, 0.00906, 0.02053, 0.01970, 0.01873, 0.01763,
        0.01649, 0.01536, 0.01395, 0.01242, 0.01091, 0.00940, 0.02077,
        0.01995, 0.01901, 0.01794, 0.01681, 0.01571, 0.01436, 0.01282,
        0.01124, 0.00967, 0.02117, 0.02036, 0.01942, 0.01835, 0.01723,
        0.01613, 0.01484, 0.01330, 0.01169, 0.01008, 0.02178, 0.02096,
        0.02001, 0.01894, 0.01782, 0.01671, 0.01548, 0.01397, 0.01236,
        0.01075, 0.02263, 0.02179, 0.02083, 0.01975, 0.01864, 0.01753,
        0.01634, 0.01490, 0.01331, 0.01172, 0.02376, 0.02290, 0.02193,
        0.02085, 0.01974, 0.01864, 0.01746, 0.01611, 0.01456, 0.01301,
        39.024, 36.412, 33.674, 30.828, 28.006, 25.008, 21.665,
        18.362, 15.271, 12.258, 39.169, 36.708, 34.122, 31.416,
        28.706, 25.905, 22.677, 19.364, 16.140, 12.917, 39.622,
        37.240, 34.721, 32.079, 29.412, 26.703, 23.545, 20.184,
        16.810, 13.435, 40.410, 38.052, 35.549, 32.924, 30.268,
        27.600, 24.526, 21.130, 17.662, 14.193, 41.591, 39.229,
        36.714, 34.083, 31.425, 28.778, 25.818, 22.425, 18.927,
        15.430, 43.246, 40.857, 38.317, 35.666, 32.999, 30.349,
        27.519, 24.205, 20.727, 17.249, 45.469, 43.043, 40.468,
        37.783, 35.087, 32.414, 29.660, 26.536, 23.073, 19.609,
        3.2701, 3.1934, 3.1200, 3.0490, 2.9689, 2.8409, 2.6828,
        2.5116, 2.3304, 2.1226, 3.2705, 3.1985, 3.1291, 3.0610,
        2.9906, 2.8798, 2.7297, 2.5642, 2.3821, 2.1999, 3.2724,
        3.2036, 3.1370, 3.0718, 3.0056, 2.9086, 2.7650, 2.6017,
        2.4159, 2.2302, 3.2763, 3.2102, 3.1456, 3.0826, 3.0183,
        2.9346, 2.8008, 2.6395, 2.4547, 2.2699, 3.2834, 3.2201,
        3.1568, 3.0953, 3.0321, 2.9603, 2.8438, 2.6874, 2.5100,
        2.3326, 3.2946, 3.2344, 3.1724, 3.1120, 3.0509, 2.9842,
        2.8932, 2.7494, 2.5846, 2.4198, 3.3106, 3.2536, 3.1943,
        3.1344, 3.0734, 3.0094, 2.9378, 2.8241, 2.6709, 2.5176,
        0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0,
        0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0,
        0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0,
        0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0,
        0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0,
        0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0,
        0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0
      END* $
$
   TABLE ENG   (CORE2    ) 1 SOURCE=* $
      INT=         0 1
      IND1= RS   10 2 2
        1.0, 0.9, 0.8, 0.7, 0.6, 0.5, 0.4, 0.3, 0.2, 0.1
      IND2= RS    7 2 0
        0.0, 0.1, 0.2, 0.3, 0.4, 0.5, 0.6
      IND3= 0     6 0 0
      DEP= RS
        0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0,
        0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0,
```

```
        0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0,
        0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0,
        0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0,
        0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0,
        0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0,
        0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0,
        0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0,
        0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0,
        0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0,
        0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0,
        0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0,
        0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0,
        0.02095, 0.02000, 0.01892, 0.01770, 0.01647, 0.01520, 0.01366,
        0.01209, 0.01059, 0.00912, 0.02102, 0.02014, 0.01911, 0.01797,
        0.01678, 0.01560, 0.01414, 0.01257, 0.01102, 0.00946, 0.02126,
        0.02040, 0.01940, 0.01828, 0.01711, 0.01596, 0.01456, 0.01298,
        0.01136, 0.00974, 0.02168, 0.02081, 0.01982, 0.01871, 0.01754,
        0.01639, 0.01505, 0.01347, 0.01181, 0.01016, 0.02230, 0.02142,
        0.02042, 0.01931, 0.01815, 0.01699, 0.01571, 0.01416, 0.01250,
        0.01084, 0.02317, 0.02227, 0.02126, 0.02014, 0.01898, 0.01783,
        0.01659, 0.01510, 0.01346, 0.01183, 0.02433, 0.02341, 0.02239,
        0.02126, 0.02010, 0.01895, 0.01773, 0.01633, 0.01474, 0.01314,
        38.243, 35.684, 33.001, 30.211, 27.446, 24.508, 21.231,
        17.994, 14.966, 12.012, 38.386, 35.973, 33.439, 30.788,
        28.132, 25.387, 22.223, 18.976, 15.818, 12.659, 38.830,
        36.495, 34.027, 31.437, 28.824, 26.169, 23.074, 19.781,
        16.474, 13.167, 39.602, 37.291, 34.838, 32.265, 29.663,
        27.048, 24.035, 20.707, 17.308, 13.910, 40.759, 38.444,
        35.980, 33.401, 30.796, 28.203, 25.301, 21.977, 18.549,
        15.121, 42.381, 40.039, 37.550, 34.953, 32.339, 29.742,
        26.969, 23.721, 20.313, 16.904, 44.560, 42.182, 39.658,
        37.027, 34.385, 31.766, 29.067, 26.005, 22.611, 19.217,
        5.9479, 5.6776, 5.4282, 5.1991, 4.9515, 4.6215, 4.2753,
        3.9042, 3.4957, 3.0083, 5.9479, 5.6944, 5.4585, 5.2390,
        5.0165, 4.7153, 4.3763, 4.0222, 3.6177, 3.2131, 5.9479,
        5.7085, 5.4840, 5.2745, 5.0643, 4.7886, 4.4539, 4.1054,
        3.6961, 3.2867, 5.9479, 5.7204, 5.5060, 5.3052, 5.1018,
        4.8521, 4.5282, 4.1806, 3.7744, 3.3683, 5.9479, 5.7322,
        5.5258, 5.3321, 5.1332, 4.9080, 4.6095, 4.2646, 3.8765,
        3.4884, 5.9479, 5.7440, 5.5453, 5.3574, 5.1647, 4.9520,
        4.6955, 4.3664, 4.0079, 3.6495, 5.9479, 5.7554, 5.5661,
        5.3820, 5.1921, 4.9879, 4.7661, 4.4850, 4.1455, 3.8060,
        0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0,
        0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0,
        0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0,
        0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0,
        0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0,
        0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0,
        0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0
      END* $
$
   TABLE ENG  (TURBINE1) 1 SOURCE=* $
      INT=       0 1
      IND1= RS  10 2 2
        1.0, 0.9, 0.8, 0.7, 0.6, 0.5, 0.4, 0.3, 0.2, 0.1
      IND2= RS   7 2 0
        0.0, 0.1, 0.2, 0.3, 0.4, 0.5, 0.6
      IND3= 0    6 0 0
      DEP= RS
        0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0,
        0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0,
        0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0,
        0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0,
        0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0,
        0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0,
        0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0,
        0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0,
        0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0,
        0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0,
        0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0,
        0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0,
        0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0,
        0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0,
        0.02676, 0.02508, 0.02330, 0.02146, 0.01964, 0.01785, 0.01601,
```

```
        0.01422, 0.01246, 0.01074, 0.02686, 0.02527, 0.02360, 0.02184,
        0.02009, 0.01836, 0.01657, 0.01477, 0.01296, 0.01115, 0.02716,
        0.02563, 0.02400, 0.02228, 0.02055, 0.01885, 0.01706, 0.01524,
        0.01336, 0.01149, 0.02769, 0.02617, 0.02455, 0.02284, 0.02112,
        0.01943, 0.01764, 0.01580, 0.01390, 0.01200, 0.02848, 0.02696,
        0.02533, 0.02362, 0.02190, 0.02021, 0.01844, 0.01659, 0.01470,
        0.01281, 0.02959, 0.02805, 0.02641, 0.02468, 0.02295, 0.02126,
        0.01952, 0.01769, 0.01582, 0.01396, 0.03107, 0.02951, 0.02785,
        0.02610, 0.02436, 0.02265, 0.02092, 0.01913, 0.01729, 0.01545,
        7.7782, 7.0084, 6.2274, 5.4556, 4.7438, 4.1559, 3.6012,
        3.0587, 2.5336, 2.0307, 7.8124, 7.0876, 6.3484, 5.6121,
        4.9054, 4.3153, 3.7658, 3.2245, 2.6819, 2.1394, 7.9186,
        7.2204, 6.5022, 5.7793, 5.0746, 4.4632, 3.9077, 3.3580,
        2.7939, 2.2297, 8.1036, 7.4161, 6.7065, 5.9873, 5.2808,
        4.6363, 4.0689, 3.5109, 2.9355, 2.3601, 8.3815, 7.6937,
        6.9883, 6.2692, 5.5590, 4.8784, 4.2838, 3.7195, 3.1450,
        2.5705, 8.7733, 8.0763, 7.3691, 6.6479, 5.9286, 5.2291,
        4.5791, 4.0058, 3.4393, 2.8728, 9.3047, 8.5909, 7.8701,
        7.1448, 6.4205, 5.7052, 5.0017, 4.3838, 3.8164, 3.2490,
        3.8798, 3.7004, 3.5292, 3.3662, 3.1905, 2.9725, 2.7385,
        2.4854, 2.2109, 1.8910, 3.8804, 3.7123, 3.5509, 3.3958,
        3.2352, 3.0345, 2.8073, 2.5654, 2.2923, 2.0193, 3.8822,
        3.7236, 3.5701, 3.4222, 3.2699, 3.0827, 2.8598, 2.6218,
        2.3446, 2.0673, 3.8854, 3.7347, 3.5882, 3.4466, 3.2995,
        3.1251, 2.9097, 2.6731, 2.3972, 2.1213, 3.8902, 3.7469,
        3.6066, 3.4705, 3.3277, 3.1653, 2.9642, 2.7306, 2.4662,
        2.2019, 3.8969, 3.7609, 3.6264, 3.4953, 3.3573, 3.2032,
        3.0226, 2.8001, 2.5557, 2.3113, 3.9059, 3.7768, 3.6484,
        3.5213, 3.3872, 3.2398, 3.0771, 2.8810, 2.6499, 2.4188,
        0.6192, 0.5920, 0.5629, 0.5324, 0.5005, 0.4662, 0.4280,
        0.3848, 0.3346, 0.2763, 0.6188, 0.5932, 0.5658, 0.5370,
        0.5066, 0.4740, 0.4377, 0.3958, 0.3460, 0.2961, 0.6177,
        0.5932, 0.5668, 0.5388, 0.5093, 0.4773, 0.4414, 0.3995,
        0.3489, 0.2982, 0.6166, 0.5927, 0.5670, 0.5397, 0.5106,
        0.4790, 0.4436, 0.4024, 0.3529, 0.3033, 0.6160, 0.5928,
        0.5677, 0.5411, 0.5128, 0.4818, 0.4475, 0.4081, 0.3618,
        0.3156, 0.6166, 0.5941, 0.5699, 0.5442, 0.5168, 0.4871,
        0.4543, 0.4176, 0.3756, 0.3336, 0.6191, 0.5973, 0.5740,
        0.5494, 0.5233, 0.4952, 0.4644, 0.4307, 0.3934, 0.3561
      END* $
$
   TABLE ENG  (TURBINE2) 1 SOURCE=* $
      INT=        0 1
      IND1= RS  10 2 2
        1.0, 0.9, 0.8, 0.7, 0.6, 0.5, 0.4, 0.3, 0.2, 0.1
      IND2= RS    7 2 0
        0.0, 0.1, 0.2, 0.3, 0.4, 0.5, 0.6
      IND3= 0     6 0 0
      DEP= RS
        0.03133, 0.03133, 0.03133, 0.03133, 0.03133, 0.03133, 0.03133,
        0.03133, 0.03133, 0.03133, 0.03133, 0.03133, 0.03133, 0.03133,
        0.03133, 0.03133, 0.03133, 0.03133, 0.03133, 0.03133, 0.03133,
        0.03133, 0.03133, 0.03133, 0.03133, 0.03133, 0.03133, 0.03133,
        0.03133, 0.03133, 0.03133, 0.03133, 0.03133, 0.03133, 0.03133,
        0.03133, 0.03133, 0.03133, 0.03133, 0.03133, 0.03133, 0.03133,
        0.03133, 0.03133, 0.03133, 0.03133, 0.03133, 0.03133, 0.03133,
        0.03133, 0.03133, 0.03133, 0.03133, 0.03133, 0.03133, 0.03133,
        0.03133, 0.03133, 0.03133, 0.03133, 0.03133, 0.03133, 0.03133,
        0.03133, 0.03133, 0.03133, 0.03133, 0.03133, 0.03133, 0.03133,
        0.0140, 0.0140, 0.0140, 0.0140, 0.0140, 0.0140, 0.0140,
        0.0140, 0.0140, 0.0140, 0.0140, 0.0140, 0.0140, 0.0140,
        0.0140, 0.0140, 0.0140, 0.0140, 0.0140, 0.0140, 0.0140,
        0.0140, 0.0140, 0.0140, 0.0140, 0.0140, 0.0140, 0.0140,
        0.0140, 0.0140, 0.0140, 0.0140, 0.0140, 0.0140, 0.0140,
        0.0140, 0.0140, 0.0140, 0.0140, 0.0140, 0.0140, 0.0140,
        0.0140, 0.0140, 0.0140, 0.0140, 0.0140, 0.0140, 0.0140,
        0.0140, 0.0140, 0.0140, 0.0140, 0.0140, 0.0140, 0.0140,
        0.0140, 0.0140, 0.0140, 0.0140, 0.0140, 0.0140, 0.0140,
        0.0140, 0.0140, 0.0140, 0.0140, 0.0140, 0.0140, 0.0140,
        0.02676, 0.02508, 0.02330, 0.02146, 0.01964, 0.01785, 0.01601,
        0.01422, 0.01246, 0.01074, 0.02685, 0.02527, 0.02360, 0.02184,
        0.02009, 0.01836, 0.01657, 0.01477, 0.01296, 0.01115, 0.02716,
        0.02563, 0.02400, 0.02228, 0.02055, 0.01885, 0.01706, 0.01524,
        0.01336, 0.01149, 0.02769, 0.02617, 0.02455, 0.02284, 0.02112,
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      0.01943, 0.01764, 0.01580, 0.01390, 0.01200, 0.02848, 0.02696,
      0.02533, 0.02362, 0.02190, 0.02021, 0.01844, 0.01659, 0.01470,
      0.01281, 0.02959, 0.02805, 0.02641, 0.02468, 0.02295, 0.02126,
      0.01952, 0.01769, 0.01582, 0.01396, 0.03108, 0.02951, 0.02785,
      0.02610, 0.02436, 0.02265, 0.02092, 0.01913, 0.01729, 0.01545,
      1.1290, 1.1095, 1.0917, 1.0757, 1.0615, 1.0484, 1.0369,
      1.0273, 1.0196, 1.0133, 1.1298, 1.1114, 1.0943, 1.0787,
      1.0649, 1.0519, 1.0401, 1.0301, 1.0216, 1.0131, 1.1326,
      1.1145, 1.0976, 1.0821, 1.0682, 1.0553, 1.0430, 1.0324,
      1.0232, 1.0140, 1.1374, 1.1193, 1.1022, 1.0864, 1.0722,
      1.0591, 1.0464, 1.0351, 1.0253, 1.0154, 1.1449, 1.1262,
      1.1086, 1.0923, 1.0775, 1.0642, 1.0510, 1.0390, 1.0286,
      1.0181, 1.1555, 1.1361, 1.1176, 1.1005, 1.0850, 1.0710,
      1.0576, 1.0448, 1.0337, 1.0225, 1.1706, 1.1499, 1.1302,
      1.1119, 1.0952, 1.0802, 1.0663, 1.0531, 1.0407, 1.0284,
      2.5328, 2.4508, 2.3806, 2.3219, 2.2552, 2.1497, 2.0384,
      1.9210, 1.7972, 1.6349, 2.5311, 2.4542, 2.3874, 2.3304,
      2.2732, 2.1799, 2.0685, 1.9573, 1.8335, 1.7097, 2.5260,
      2.4535, 2.3900, 2.3358, 2.2829, 2.2006, 2.0897, 1.9803,
      1.8517, 1.7231, 2.5174, 2.4488, 2.3883, 2.3367, 2.2858,
      2.2144, 2.1084, 1.9964, 1.8652, 1.7340, 2.5054, 2.4406,
      2.3822, 2.3322, 2.2820, 2.2205, 2.1261, 2.0107, 1.8830,
      1.7553, 2.4896, 2.4286, 2.3721, 2.3229, 2.2736, 2.2162,
      2.1400, 2.0282, 1.9104, 1.7926, 2.4706, 2.4127, 2.3585,
      2.3091, 2.2588, 2.2033, 2.1409, 2.0504, 1.9333, 1.8162,
      0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0,
      0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0,
      0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0,
      0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0,
      0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0,
      0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0,
      0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0
    END* $
$
  TABLE ENG  (PRIM  ) 1 SOURCE=* $
    INT=       0 1
    IND1= RS  10 2 2
      1.0, 0.9, 0.8, 0.7, 0.6, 0.5, 0.4, 0.3, 0.2, 0.1
    IND2= RS   7 2 0
      0.0, 0.1, 0.2, 0.3, 0.4, 0.5, 0.6
    IND3= 0    6 0 0
    DEP= RS
      0.08522, 0.08522, 0.08522, 0.08522, 0.08522, 0.08522, 0.08522,
      0.08522, 0.08522, 0.08522, 0.08522, 0.08522, 0.08522, 0.08522,
      0.08522, 0.08522, 0.08522, 0.08522, 0.08522, 0.08522, 0.08522,
      0.08522, 0.08522, 0.08522, 0.08522, 0.08522, 0.08522, 0.08522,
      0.08522, 0.08522, 0.08522, 0.08522, 0.08522, 0.08522, 0.08522,
      0.08522, 0.08522, 0.08522, 0.08522, 0.08522, 0.08522, 0.08522,
      0.08522, 0.08522, 0.08522, 0.08522, 0.08522, 0.08522, 0.08522,
      0.08522, 0.08522, 0.08522, 0.08522, 0.08522, 0.08522, 0.08522,
      0.08522, 0.08522, 0.08522, 0.08522, 0.08522, 0.08522, 0.08522,
      0.08522, 0.08522, 0.08522, 0.08522, 0.08522, 0.08522, 0.08522,
      0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0,
      0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0,
      0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0,
      0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0,
      0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0,
      0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0,
      0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0,
      0.02676, 0.02508, 0.02330, 0.02146, 0.01964, 0.01785, 0.01601,
      0.01422, 0.01246, 0.01074, 0.02685, 0.02527, 0.02360, 0.02184,
      0.02009, 0.01836, 0.01657, 0.01477, 0.01296, 0.01115, 0.02716,
      0.02563, 0.02400, 0.02228, 0.02055, 0.01885, 0.01706, 0.01524,
      0.01336, 0.01149, 0.02769, 0.02617, 0.02455, 0.02284, 0.02112,
      0.01943, 0.01764, 0.01580, 0.01390, 0.01200, 0.02848, 0.02696,
      0.02533, 0.02362, 0.02190, 0.02021, 0.01844, 0.01659, 0.01470,
      0.01281, 0.02959, 0.02805, 0.02641, 0.02468, 0.02295, 0.02126,
      0.01952, 0.01769, 0.01582, 0.01396, 0.03108, 0.02951, 0.02785,
      0.02610, 0.02436, 0.02265, 0.02092, 0.01913, 0.01729, 0.01545,
      1.1290, 1.1095, 1.0917, 1.0757, 1.0615, 1.0484, 1.0369,
      1.0273, 1.0196, 1.0133, 1.1298, 1.1114, 1.0943, 1.0787,
      1.0649, 1.0519, 1.0401, 1.0301, 1.0216, 1.0131, 1.1326,
      1.1145, 1.0976, 1.0821, 1.0682, 1.0553, 1.0430, 1.0324,
      1.0232, 1.0140, 1.1374, 1.1193, 1.1022, 1.0864, 1.0722,
```

```
        1.0591, 1.0464, 1.0351, 1.0253, 1.0154, 1.1449, 1.1262,
        1.1086, 1.0923, 1.0775, 1.0642, 1.0510, 1.0390, 1.0286,
        1.0181, 1.1555, 1.1361, 1.1176, 1.1005, 1.0850, 1.0710,
        1.0576, 1.0448, 1.0337, 1.0225, 1.1706, 1.1499, 1.1302,
        1.1119, 1.0952, 1.0802, 1.0663, 1.0531, 1.0407, 1.0284,
        2.5328, 2.4508, 2.3806, 2.3219, 2.2552, 2.1497, 2.0384,
        1.9210, 1.7972, 1.6349, 2.5311, 2.4542, 2.3874, 2.3304,
        2.2732, 2.1799, 2.0685, 1.9573, 1.8335, 1.7097, 2.5260,
        2.4535, 2.3900, 2.3358, 2.2829, 2.2006, 2.0897, 1.9803,
        1.8517, 1.7231, 2.5174, 2.4488, 2.3883, 2.3367, 2.2858,
        2.2144, 2.1084, 1.9964, 1.8652, 1.7340, 2.5054, 2.4406,
        2.3822, 2.3322, 2.2820, 2.2205, 2.1261, 2.0107, 1.8830,
        1.7553, 2.4896, 2.4286, 2.3721, 2.3229, 2.2736, 2.2162,
        2.1400, 2.0282, 1.9104, 1.7926, 2.4706, 2.4127, 2.3585,
        2.3091, 2.2588, 2.2033, 2.1409, 2.0504, 1.9333, 1.8162,
        0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0,
        0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0,
        0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0,
        0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0,
        0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0,
        0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0,
        0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0
      END* $
$
   TABLE ENG  (SEC      ) 1 SOURCE=* $
      INT=        0 1
      IND1= RS  10 2 2
        1.0, 0.9, 0.8, 0.7, 0.6, 0.5, 0.4, 0.3, 0.2, 0.1
      IND2= RS   7 2 0
        0.0, 0.1, 0.2, 0.3, 0.4, 0.5, 0.6
      IND3= 0     6 0 0
      DEP= RS
        0.3060, 0.3060, 0.3060, 0.3060, 0.3060, 0.3060, 0.3060,
        0.3060, 0.3060, 0.3060, 0.3060, 0.3060, 0.3060, 0.3060,
        0.3060, 0.3060, 0.3060, 0.3060, 0.3060, 0.3060, 0.3060,
        0.3060, 0.3060, 0.3060, 0.3060, 0.3060, 0.3060, 0.3060,
        0.3060, 0.3060, 0.3060, 0.3060, 0.3060, 0.3060, 0.3060,
        0.3060, 0.3060, 0.3060, 0.3060, 0.3060, 0.3060, 0.3060,
        0.3060, 0.3060, 0.3060, 0.3060, 0.3060, 0.3060, 0.3060,
        0.3060, 0.3060, 0.3060, 0.3060, 0.3060, 0.3060, 0.3060,
        0.3060, 0.3060, 0.3060, 0.3060, 0.3060, 0.3060, 0.3060,
        0.3060, 0.3060, 0.3060, 0.3060, 0.3060, 0.3060, 0.3060,
        0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0,
        0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0,
        0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0,
        0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0,
        0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0,
        0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0,
        0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0,
        0.2416, 0.2301, 0.2176, 0.2042, 0.1895, 0.1734, 0.1555,
        0.1347, 0.1097, 0.0764, 0.2441, 0.2334, 0.2219, 0.2095,
        0.1959, 0.1811, 0.1646, 0.1457, 0.1229, 0.1002, 0.2512,
        0.2414, 0.2309, 0.2195, 0.2071, 0.1935, 0.1786, 0.1615,
        0.1413, 0.1211, 0.2628, 0.2538, 0.2442, 0.2338, 0.2225,
        0.2102, 0.1968, 0.1816, 0.1640, 0.1464, 0.2784, 0.2702,
        0.2614, 0.2520, 0.2419, 0.2308, 0.2188, 0.2055, 0.1903,
        0.1751, 0.2975, 0.2901, 0.2822, 0.2737, 0.2646, 0.2547,
        0.2440, 0.2323, 0.2191, 0.2060, 0.3200, 0.3133, 0.3061,
        0.2985, 0.2902, 0.2813, 0.2717, 0.2614, 0.2500, 0.2386,
        1.3655, 1.3273, 1.2893, 1.2515, 1.2141, 1.1772, 1.1406,
        1.1043, 1.0683, 1.0327, 1.3736, 1.3376, 1.3017, 1.2658,
        1.2299, 1.1942, 1.1585, 1.1225, 1.0861, 1.0497, 1.3984,
        1.3637, 1.3290, 1.2940, 1.2588, 1.2234, 1.1880, 1.1518,
        1.1146, 1.0775, 1.4405, 1.4065, 1.3722, 1.3375, 1.3024,
        1.2669, 1.2311, 1.1944, 1.1565, 1.1185, 1.5018, 1.4679,
        1.4336, 1.3987, 1.3632, 1.3271, 1.2906, 1.2532, 1.2144,
        1.1756, 1.5852, 1.5509, 1.5160, 1.4805, 1.4441, 1.4071,
        1.3694, 1.3311, 1.2912, 1.2514, 1.6945, 1.6593, 1.6234,
        1.5867, 1.5492, 1.5107, 1.4714, 1.4314, 1.3902, 1.3491,
        1.1172, 1.1064, 1.0956, 1.0852, 1.0749, 1.0647, 1.0544,
        1.0439, 1.0333, 1.0232, 1.1188, 1.1086, 1.0985, 1.0885,
        1.0786, 1.0688, 1.0587, 1.0482, 1.0372, 1.0263, 1.1239,
        1.1141, 1.1043, 1.0946, 1.0849, 1.0751, 1.0650, 1.0544,
        1.0430, 1.0317, 1.1326, 1.1231, 1.1136, 1.1040, 1.0944,
```

```
        1.0847, 1.0746, 1.0641, 1.0529, 1.0417, 1.1454, 1.1362,
        1.1269, 1.1175, 1.1081, 1.0984, 1.0886, 1.0784, 1.0677,
        1.0570, 1.1627, 1.1537, 1.1446, 1.1355, 1.1263, 1.1169,
        1.1073, 1.0976, 1.0875, 1.0775, 1.1848, 1.1760, 1.1672,
        1.1584, 1.1494, 1.1403, 1.1311, 1.1218, 1.1124, 1.1030,
        0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0,
        0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0,
        0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0,
        0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0,
        0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0,
        0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0,
        0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0
      END* $
$
$=======================================================================
$
$ TFNKAFM PARAMETERS
$
     PARAM      AF = 667.         $ FLAP AREA, SQFT
     PARAM      AH = 1090.        $ HORIZONTAL TAIL AREA, SQFT
     PARAM      AV = 605.         $ VERTICAL TAIL AREA, SQFT
     PARAM      AW = 3648.        $ WING AREA, SQFT
     PARAM      BF = 68.          $ FLAP SPAN, FT
     PARAM      BH = 70.9         $ HORIZONTAL TAIL SPAN, FT
     PARAM      BV = 24.          $ VERTICAL TAIL SPAN, FT
     PARAM      BW = 165.         $ WING SPAN, FT
     PARAM     DMG = 4.33         $ TIRE DIAMETER OF MAIN LANDING GEAR, FT
     PARAM     DNG = 3.33         $ TIRE DIAMETER OF NOSE LANDING GEAR, FT
     PARAM     LMG = 8.31         $ MAIN LANDING GEAR STRUT LENGTH, FT
     PARAM     LNG = 5.96         $ NOSE LANDING GEAR STRUT LENGTH, FT
     PARAM      RS = 1.           $ OBSERVER DISTANCE, FT
     PARAM    NWMG = 4            $ NUMBER OF WHEELS PER MAIN LANDING GEAR
     PARAM    NWNG = 2            $ NUMBER OF WHEELS PER NOSE LANDING GEAR
     PARAM     NMG = 3            $ NUMBER OF MAIN LANDING GEAR
     PARAM     NNG = 1            $ NUMBER OF NOSE LANDING GEAR
     PARAM      NS = 1            $ NUMBER OF SLOTS FOR TRAILING EDGE FLAPS
     PARAM  PREPRT = 2            $ PRINT FOR PREAFM MODULE
     PARAM    IOUT = 0            $ NO PRINT
     PARAM  IPRINT = 0            $ PRINT NOTHING
     PARAM  SCRXXX = 3HEN1        $ CODE USED TO FORM MEMBER NAME
     PARAM  DYNCLN = .TRUE.       $ AERODYNAMICALLY CLEAN AIRCRAFT
     PARAM  DELTAW = .TRUE.       $ DELTA WING PLANFORM
     PARAM  IUNITS = 7HENGLISH    $ INPUT UNITS
     PARAM    TEWN = .TRUE.       $ WING TRAILING EDGE NOISE
     PARAM   TEHTN = .TRUE.       $ HORIZONTAL TAIL TRAILING EDGE NOISE
     PARAM   TEVTN = .TRUE.       $ VERTICAL TAIL TRAILING EDGE NOISE
     PARAM    TEFN = .TRUE.       $ TRAILING EDGE FLAP NOISE
     PARAM    LESN = .TRUE.       $ LEADING EDGE SLAT NOISE
     PARAM    MLGN = .TRUE.       $ MAIN LANDING GEAR NOISE
     PARAM    NLGN = .TRUE.       $ NOSE LANDING GEAR NOISE
     PARAM   LANDG = 4HDOWN       $ LANDING GEAR POSITION
$
$ EXECUTE TFNKAFM, GENERATE FNKAFM(EN1001)
$
     CALL PROCLIB(TFNKAFM) $
$
$=======================================================================
$
$ TGECOR PARAMETERS
$
     PARAM      AE = 115.911      $ ENGINE REFERENCE AREA, SQFT
     PARAM     CEA = 11.5911      $ COMBUSTOR ENTRANCE AREA, SQFT
  EVALUATE       A = CEA / AE     $ NORMALIZED ENTRANCE AREA
     PARAM  PREPRT = 2            $ PRINT FOR PRECOR MODULE
     PARAM  IUNITS = 7HENGLISH    $ INPUT UNITS
     PARAM   ITYPE = 1            $ LINEAR INTERPOLATION
     PARAM      RS = 1.           $ OBSERVER DISTANCE, FT
     PARAM    NENG = 3            $ NUMBER OF ENGINES
     PARAM  SCRXXX = 3HEN1        $ CODE USED TO FORM MEMBER NAME
     PARAM    IOUT = 0            $ NO PRINT
     PARAM  IPRINT = 0            $ PRINT NOTHING
     PARAM    DTTR = 1310.        $ DESIGN TURBINE TEMPERATURE EXTRACTION, DEG R
  EVALUATE  TDDELT = DTTR / TA    $ NORMALIZED TEMPERATURE EXTRACTION
$
```

```
$ EXECUTE TGECOR, GENERATE GECOR(EN1001)
$
     CALL PROCLIB(TGECOR) $
$
$=========================================================================
$
$ TGETUR PARAMETERS
$
     PARAM      AE = 115.911              $ ENGINE REFERENCE AREA, SQFT
     PARAM    NENG = 3                    $ NUMBER OF ENGINES
     PARAM      RS = 1.                   $ OBSERVER DISTANCE, FT
     PARAM   TICSA = 1.477                $ TURBINE INLET X-SECTIONAL AREA, SQFT
  EVALUATE    AREA = TICSA / AE           $ NORMALIZED INLET AREA
     PARAM  NBLADE = 102                  $ NUMBER OF ROTOR BLADES
     PARAM     TRD = 3.78                 $ TURBINE ROTOR DIAMETER, FT
  EVALUATE       D = TRD / SQRT( AE )     $ NORMALIZED ROTOR DIAMETER
     PARAM  SCRXXX = 3HEN1                $ CODE USED TO FORM MEMBER NAME
     PARAM   BROAD = .TRUE.               $ BROADBAND SPECTRA
     PARAM    PURE = .TRUE.               $ PURE TONE SPECTRA
     PARAM    IOUT = 0                    $ NO PRINT
     PARAM  IPRINT = 0                    $ PRINT NOTHING
     PARAM  IUNITS = 7HENGLISH            $ INPUT UNITS
     PARAM   ITYPE = 1                    $ LINEAR INTERPOLATION
     PARAM  IRATIO = 8HCONSTANT           $ SPECIFIC HEAT OPTION
     PARAM  PREPRT = 2                    $ PRINT FOR PRETUR MODULE
$
$ EXECUTE TGETUR, GENERATE GETUR(EN1001)
$
     CALL PROCLIB(TGETUR) $
$
$=========================================================================
$
$ THDNFAN PARAMETERS (DISCHARGE)
$
     PARAM  PREPRT = 2                    $ PRINT FOR PREFAN MODULE
     PARAM  IUNITS = 7HENGLISH            $ INPUT UNITS
     PARAM   ITYPE = 1                    $ LINEAR INTERPOLATION
     PARAM      AE = 115.911              $ ENGINE REFERENCE AREA, SQFT
     PARAM      RS = 1.                   $ OBSERVER DISTANCE, FT
     PARAM     AAF = 115.911              $ FAN INLET AREA, SQFT
  EVALUATE    AFAN = AAF / AE             $ NORMALIZED FAN INLET AREA
     PARAM   DIAFR = 12.148               $ FAN ROTOR DIAMETER, FT
  EVALUATE    DIAM = DIAFR / SQRT(AE)     $ NORMALIZED FAN ROTOR DIAMETER
     PARAM      MD = 1.50                 $ FAN TIP MACH NUMBER AT DESIGN
     PARAM     RSS = 0.26                 $ ROTOR-STATOR SPACING
     PARAM  NBANDS = 0                    $ 1/3 OCTAVE BANDS FOR FREQ SHIFT
     PARAM    NENG = 3                    $ NUMBER OF ENGINES
     PARAM      NB = 36                   $ NUMBER OF ROTOR BLADES
     PARAM      NV = 76                   $ NUMBER OF STATOR VANES
     PARAM     IGV = 1                    $ INLET GUIDE VANE INDEX
     PARAM     DIS = 1                    $ INLET DISTORTION INDEX
     PARAM    IOUT = 0                    $ NO PRINT
     PARAM  IPRINT = 0                    $ PRINT NOTHING
     PARAM  SCRXXX = 3HEN1                $ CODE USED TO FORM MEMBER NAME
     PARAM    INRS = .FALSE.              $ INLET ROTOR-STATOR INTERACTION TONES
     PARAM    INCT = .FALSE.              $ COMBINATION TONES
     PARAM   INDIS = .FALSE.              $ INLET DISTORTION TONES
     PARAM    INBB = .FALSE.              $ INLET BROADBAND NOISE
     PARAM    IDRS = .TRUE.               $ DISCHARGE ROTOR-STATOR INTERACTION
     PARAM    IDBB = .TRUE.               $ DISCHARGE BROADBAND NOISE
$
$ EXECUTE THDNFAN, GENERATE HDNFND(EN1001)
$
     CALL PROCLIB(THDNFAN) HDNFAN=HDNFND $
$
$=========================================================================
$
$ THDNFAN PARAMETERS (INLET)
$
     PARAM  PREPRT = 2                    $ PRINT FOR PREFAN MODULE
     PARAM  IUNITS = 7HENGLISH            $ INPUT UNITS
     PARAM   ITYPE = 1                    $ LINEAR INTERPOLATION
     PARAM      AE = 115.911              $ ENGINE REFERENCE AREA, SQFT
     PARAM      RS = 1.                   $ OBSERVER DISTANCE, FT
```

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      PARAM      AAF = 115.911            $ FAN INLET AREA, SQFT
   EVALUATE     AFAN = AAF / AE           $ NORMALIZED FAN INLET AREA
      PARAM    DIAFR = 12.148             $ FAN ROTOR DIAMETER, FT
   EVALUATE     DIAM = DIAFR / SQRT(AE)   $ NORMALIZED FAN ROTOR DIAMETER
      PARAM       MD = 1.50               $ FAN TIP MACH NUMBER AT DESIGN
      PARAM      RSS = 0.26               $ ROTOR-STATOR SPACING
      PARAM   NBANDS = 0                  $ 1/3 OCTAVE BANDS FOR FREQ SHIFT
      PARAM     NENG = 3                  $ NUMBER OF ENGINES
      PARAM       NB = 36                 $ NUMBER OF ROTOR BLADES
      PARAM       NV = 76                 $ NUMBER OF STATOR VANES
      PARAM      IGV = 1                  $ INLET GUIDE VANE INDEX
      PARAM      DIS = 1                  $ INLET DISTORTION INDEX
      PARAM     IOUT = 0                  $ NO PRINT
      PARAM   IPRINT = 0                  $ PRINT NOTHING
      PARAM   SCRXXX = 3HEN1              $ CODE USED TO FORM MEMBER NAME
      PARAM     INRS = .FALSE.            $ INLET ROTOR-STATOR INTERACTION TONES
      PARAM     INCT = .TRUE.             $ COMBINATION TONES
      PARAM    INDIS = .FALSE.            $ INLET DISTORTION TONES
      PARAM     INBB = .TRUE.             $ INLET BROADBAND NOISE
      PARAM     IDRS = .FALSE.            $ DISCHARGE ROTOR-STATOR INTERACTION
      PARAM     IDBB = .FALSE.            $ DISCHARGE BROADBAND NOISE
$
$ EXECUTE THDNFAN, GENERATE HDNFNI(EN1001)
$
      CALL PROCLIB(THDNFAN) HDNFAN=HDNFNI $
$
$=========================================================================
$
$ TSTNJET PARAMETERS
$
      PARAM       AE = 115.911         $ ENGINE REFERENCE AREA, SQFT
      PARAM    APLUG = 0.              $ PRIMARY NOZZLE PLUG AREA, SQFT
   EVALUATE       AP = APLUG / AE      $ NORMALIZED NOZZLE PLUG AREA
      PARAM   IRATIO = 8HCONSTANT      $ SPECIFIC HEAT OPTION
      PARAM    ITYPE = 1               $ LINEAR INTERPOLATION
      PARAM   IUNITS = 7HENGLISH       $ INPUT UNITS
      PARAM   PREPRT = 2               $ PRINT FOR PREJET MODULE
      PARAM       RS = 1.              $ OBSERVER DISTANCE, FT
      PARAM    ETANG = 0.              $ ENGINE TILT ANGLE, DEG
   EVALUATE    DELTA = ALPHA + ETANG   $ ANGLE BETWEEN FLIGHT AND ENGINE, DEG
      PARAM     NENG = 3               $ NUMBER OF ENGINES
      PARAM   SCRXXX = 3HEN1           $ CODE USED TO FORM MEMBER NAME
      PARAM     IOUT = 0               $ NO PRINT
      PARAM   IPRINT = 0               $ PRINT NOTHING
      PARAM     PLUG = .TRUE.          $ PLUG
      PARAM   CIRCLE = .TRUE.          $ COAXIAL NOZZLE
      PARAM    SUPER = .FALSE.         $ NO PRIMARY STREAM SHOCK NOISE
$
$ EXECUTE TSTNJET, GENERATE STNJET(EN1001)
$
      CALL PROCLIB(TSTNJET) $
$
$=========================================================================
$
$ GENSUP TABLE SUPPRES5(FACTOR), 5 DB SUPPRESSION
$
   TABLE SUPPRES5(FACTOR ) 1 SOURCE=* $
    INT= 1 2
    IND1= RS 25 2 2
          50.0,     63.0,     80.0,    100.0,    125.0,    160.0,    200.0,
         250.0,    315.0,    400.0,    500.0,    630.0,    800.0,   1000.0,
        1250.0,   1600.0,   2000.0,   2500.0,   3150.0,   4000.0,   5000.0,
        6300.0,   8000.0,  10000.0,  12500.0
    IND2= RS 35 2 2
          5.,  10.,  15.,  20.,  25.,  30.,  35.,  40.,  45.,  50.,
         55.,  60.,  65.,  70.,  75.,  80.,  85.,  90.,  95., 100.,
        105., 110., 115., 120., 125., 130., 135., 140., 145., 150.,
        155., 160., 165., 170., 175.
    IND3= RS 18 2 2
          0.,   5.,  10.,  15.,  20.,  25.,  30.,  35.,  40.,
         45.,  50.,  55.,  60.,  65.,  70.,  75.,  80.,  85.
    DEP= RS
     0.316228, 0.316228, 0.316228, 0.316228, 0.316228, 0.316228, 0.316228,
     0.316228, 0.316228, 0.316228, 0.316228, 0.316228, 0.316228, 0.316228,
```

```
      .
      . total of ( 25 * 35 * 18 ) = 15750 suppression values
      .
     0.316228, 0.316228, 0.316228, 0.316228, 0.316228, 0.316228, 0.316228
    END* $
$
$------------------------------------------------------------------------------
$
$ GENSUP TABLE SUPPRESF(FACTOR), 15 DB SUPPRESSION
$
   TABLE SUPPRESF(FACTOR ) 1 SOURCE=* $
    INT= 1 2
    IND1= RS 25 2 2
          50.0,     63.0,     80.0,    100.0,    125.0,    160.0,    200.0,
         250.0,    315.0,    400.0,    500.0,    630.0,    800.0,   1000.0,
        1250.0,   1600.0,   2000.0,   2500.0,   3150.0,   4000.0,   5000.0,
        6300.0,   8000.0, 10000.0, 12500.0
    IND2= RS 35 2 2
         5.,  10.,  15.,  20.,  25.,  30.,  35.,  40.,  45.,  50.,
        55.,  60.,  65.,  70.,  75.,  80.,  85.,  90.,  95., 100.,
       105., 110., 115., 120., 125., 130., 135., 140., 145., 150.,
       155., 160., 165., 170., 175.
    IND3= RS 18 2 2
         0.,   5.,  10.,  15.,  20.,  25.,  30.,  35.,  40.,
        45.,  50.,  55.,  60.,  65.,  70.,  75.,  80.,  85.
    DEP= RS
     0.031623, 0.031623, 0.031623, 0.031623, 0.031623, 0.031623, 0.031623,
     0.031623, 0.031623, 0.031623, 0.031623, 0.031623, 0.031623, 0.031623,
      .
      . total of ( 25 * 35 * 18 ) = 15750 suppression values
      .
     0.031623, 0.031623, 0.031623, 0.031623, 0.031623, 0.031623, 0.031623
    END* $
$
$------------------------------------------------------------------------------
$
$ GENSUP PARAMETERS
$
      PARAM  SCRXXX = 3HEN1      $ CODE USED TO FORM MEMBER NAME
      PARAM  IPRINT = 0          $ PRINT NOTHING
$     PARAM    RHOA = 0.         $ VALUE FROM APM
$     PARAM      CA = 0.         $ VALUE FROM APM
      PARAM    IOUT = 0          $ NO PRINT
      PARAM  IUNITS = 7HENGLISH  $ INPUT UNITS
$
$ APPLY 15 DB SUPPRESSION TO TURBINE NOISE, GENERATE GETURS(EN1001)
$
      PARAM      MAX = SCRNNN                     $
      PARAM        I = 1                          $
       LAB1  CONTINUE                             $
      PARAM  SCRNNN = I                           $
    EXECUTE  GENSUP NOISE=GETUR  SUPPRESS=SUPPRESF $
         IF  (I .EQ. MAX)  GOTO  LAB2             $
   EVALUATE        I = I + 1                      $
       GOTO  LAB1                                 $
       LAB2  CONTINUE                             $
$
$ APPLY 15 DB SUPPRESSION TO FAN DISCHARGE NOISE, GENERATE HDNFNDS(EN1001)
$
      PARAM      MAX = SCRNNN                     $
      PARAM        I = 1                          $
       LAB3  CONTINUE                             $
      PARAM  SCRNNN = I                           $
    EXECUTE  GENSUP NOISE=HDNFND SUPPRESS=SUPPRESF $
         IF  (I .EQ. MAX)  GOTO  LAB4             $
   EVALUATE        I = I + 1                      $
       GOTO  LAB3                                 $
       LAB4  CONTINUE                             $
$
$ APPLY 5 DB SUPPRESSION TO FAN INLET NOISE, GENERATE HDNFNIS(EN1001)
$
      PARAM      MAX = SCRNNN                     $
      PARAM        I = 1                          $
       LAB5  CONTINUE                             $
```

```
      PARAM   SCRNNN = I                             $
    EXECUTE   GENSUP NOISE=HDNFNI SUPPRESS=SUPPRESS5 $
         IF   (I .EQ. MAX)  GOTO  LAB6               $
   EVALUATE       I = I + 1                          $
       GOTO   LAB5                                   $
       LAB6   CONTINUE                               $
$
$===============================================================================
$
$ PRO PARAMETERS COMMON TO ALL
$
      PARAM  IPRINT = 0          $ PRINT NOTHING
      PARAM    IOUT = 1          $ DB OUTPUT
$     PARAM   SIGMA = 485.       $ DEFAULT GROUND FLOW RESIST, SLUG/SEC-CUFT
      PARAM  IUNITS = 7HENGLISH  $ INPUT UNITS
      PARAM   NBAND = 1          $ NUMBER OF SUBBANDS PER 1/3 OCTAVE
      PARAM      RS = 1.         $ OBSERVER DISTANCE, FT
      PARAM SURFACE = 4HSOFT     $ SURFACE TYPE OPTION
$     PARAM     COH = .01        $ DEFAULT INCOHERENCE COEFFICIENT
      PARAM  ABSORP = .TRUE.     $ ATMOSPHERIC ABSORPTION OPTION
      PARAM  GROUND = .TRUE.     $ GROUND EFFECTS OPTION
      PARAM PROTIME = 3HEN1      $ CODE USED TO FORM MEMBER NAME
$
$ PRO PARAMETER FOR AIRFRAME, EXECUTE PRO
$
      PARAM PROSUM1 = 6HFNKAFM                      $ NAME OF NOISE UNIT
      EXECUTE PRO PROSUM=PROSUM1, GEOM=WIND, PRO=PRO1 $ GENERATE PRO1(PRES)
$
$ PRO PARAMETER FOR CORE, EXECUTE PRO
$
      PARAM PROSUM2 = 5HGECOR                       $ NAME OF NOISE UNIT
      EXECUTE PRO PROSUM=PROSUM2, GEOM=BODY, PRO=PRO2 $ GENERATE PRO2(PRES)
$
$ PRO PARAMETER FOR TURBINE, EXECUTE PRO
$
      PARAM PROSUM3 = 5HGETUR                       $ NAME OF NOISE UNIT
      EXECUTE PRO PROSUM=PROSUM3, GEOM=BODY, PRO=PRO3 $ GENERATE PRO3(PRES)
$
$ PRO PARAMETER FOR FAN DISCHARGE, EXECUTE PRO
$
      PARAM PROSUM4 = 6HHDNFND                      $ NAME OF NOISE UNIT
      EXECUTE PRO PROSUM=PROSUM4, GEOM=BODY, PRO=PRO4 $ GENERATE PRO4(PRES)
$
$ PRO PARAMETER FOR FAN INLET, EXECUTE PRO
$
      PARAM PROSUM5 = 6HHDNFNI                      $ NAME OF NOISE UNIT
      EXECUTE PRO PROSUM=PROSUM5, GEOM=BODY, PRO=PRO5 $ GENERATE PRO5(PRES)
$
$ PRO PARAMETER FOR JET, EXECUTE PRO
$
      PARAM PROSUM6 = 6HSTNJET                      $ NAME OF NOISE UNIT
      EXECUTE PRO PROSUM=PROSUM6, GEOM=BODY, PRO=PRO6 $ GENERATE PRO6(PRES)
$
$ PRO PARAMETER FOR SUPPRESSED TURBINE, EXECUTE PRO
$
      PARAM PROSUM7 = 6HGETURS                      $ NAME OF NOISE UNIT
      EXECUTE PRO PROSUM=PROSUM7, GEOM=BODY, PRO=PRO7 $ GENERATE PRO7(PRES)
$
$ PRO PARAMETER FOR SUPPRESSED FAN DISCHARGE, EXECUTE PRO
$
      PARAM PROSUM8 = 7HHDNFNDS                     $ NAME OF NOISE UNIT
      EXECUTE PRO PROSUM=PROSUM8, GEOM=BODY, PRO=PRO8 $ GENERATE PRO8(PRES)
$
$ PRO PARAMETER FOR SUPPRESSED FAN INLET, EXECUTE PRO
$
      PARAM PROSUM9 = 7HHDNFNIS                     $ NAME OF NOISE UNIT
      EXECUTE PRO PROSUM=PROSUM9, GEOM=BODY, PRO=PRO9 $ GENERATE PRO9(PRES)
$
$===============================================================================
$
$ LEV PARAMETERS COMMON TO ALL
$
      PARAM    IAWT = .FALSE.    $ A-WEIGHTED LEVEL OPTION
      PARAM    IDWT = .FALSE.    $ D-WEIGHTED LEVEL OPTION
```

```
     PARAM   IOSPL = .FALSE.     $ OASPL OPTION
     PARAM    IOUT = 1           $ DB OUTPUT
     PARAM    IPNL = .FALSE.     $ PNL OPTION
     PARAM   IPNLT = .TRUE.      $ PNLT OPTION
     PARAM    NAWT = .FALSE.     $ NO NARROW BAND DATA
     PARAM    NDWT = .FALSE.     $ NO NARROW BAND DATA
     PARAM   NOSPL = .FALSE.     $ NO NARROW BAND DATA
$
$ EFF PARAMETERS COMMON TO ALL
$
     PARAM   DTIME = .5          $ RECEPTION TIME INCREMENT, SEC
$
$ CNT PARAMETERS COMMON TO ALL
$
     PARAM    ISYM = .FALSE.     $ NON-SYMMETRICAL OUTPUT
     PARAM    IOPT = 1           $ EPNL PLOT
$
$ PRINT PARAMETER COMMON TO ALL MODULES
$
     PARAM  IPRINT = 0           $ PRINT NOTHING
$
$ LEV AND CNT PARAMETERS FOR AIRFRAME, EXECUTE LEV, EFF, AND CNT
$
     PARAM  MEMSUM = 6HPRO1   , 6HPRES   $ LEV UNIT NAME AND MEMBER NAME
     PARAM FILNAME = 8HFRAMHBPR          $ CNT FILE NAME
     EXECUTE LEV                         $ GENERATE LEV(PNLT)
     EXECUTE EFF                         $ GENERATE EFF(EPNL)
     EXECUTE CNT                         $ GENERATE DATA FILE FRAMHBPR.OUT
$
$ LEV AND CNT PARAMETERS FOR CORE, EXECUTE LEV, EFF, AND CNT
$
     PARAM  MEMSUM = 6HPRO2   , 6HPRES   $ LEV UNIT NAME AND MEMBER NAME
     PARAM FILNAME = 8HCOREHBPR          $ CNT FILE NAME
     EXECUTE LEV                         $ GENERATE LEV(PNLT)
     EXECUTE EFF                         $ GENERATE EFF(EPNL)
     EXECUTE CNT                         $ GENERATE DATA FILE COREHBPR.OUT
$
$ LEV AND CNT PARAMETERS FOR TURBINE, EXECUTE LEV, EFF, AND CNT
$
     PARAM  MEMSUM = 6HPRO3   , 6HPRES   $ LEV UNIT NAME AND MEMBER NAME
     PARAM FILNAME = 8HTURBHBPR          $ CNT FILE NAME
     EXECUTE LEV                         $ GENERATE LEV(PNLT)
     EXECUTE EFF                         $ GENERATE EFF(EPNL)
     EXECUTE CNT                         $ GENERATE DATA FILE TURBHBPR.OUT
$
$ LEV AND CNT PARAMETERS FOR FAN DISCHARGE, EXECUTE LEV, EFF, AND CNT
$
     PARAM  MEMSUM = 6HPRO4   , 6HPRES   $ LEV UNIT NAME AND MEMBER NAME
     PARAM FILNAME = 8HFANDHBPR          $ CNT FILE NAME
     EXECUTE LEV                         $ GENERATE LEV(PNLT)
     EXECUTE EFF                         $ GENERATE EFF(EPNL)
     EXECUTE CNT                         $ GENERATE DATA FILE FANDHBPR.OUT
$
$ LEV AND CNT PARAMETERS FOR FAN INLET, EXECUTE LEV, EFF, AND CNT
$
     PARAM  MEMSUM = 6HPRO5   , 6HPRES   $ LEV UNIT NAME AND MEMBER NAME
     PARAM FILNAME = 8HFANIHBPR          $ CNT FILE NAME
     EXECUTE LEV                         $ GENERATE LEV(PNLT)
     EXECUTE EFF                         $ GENERATE EFF(EPNL)
     EXECUTE CNT                         $ GENERATE DATA FILE FANIHBPR.OUT
$
$ LEV AND CNT PARAMETERS FOR JET, EXECUTE LEV, EFF, AND CNT
$
     PARAM  MEMSUM = 6HPRO6   , 6HPRES   $ LEV UNIT NAME AND MEMBER NAME
     PARAM FILNAME = 8HJETNHBPR          $ CNT FILE NAME
     EXECUTE LEV                         $ GENERATE LEV(PNLT)
     EXECUTE EFF                         $ GENERATE EFF(EPNL)
     EXECUTE CNT                         $ GENERATE DATA FILE JETNHBPR.OUT
$
$ LEV AND CNT PARAMETERS FOR SUPPRESSED TURBINE, EXECUTE LEV, EFF, AND CNT
$
     PARAM  MEMSUM = 6HPRO7   , 6HPRES   $ LEV UNIT NAME AND MEMBER NAME
     PARAM FILNAME = 8HTURSHBPR          $ CNT FILE NAME
     EXECUTE LEV                         $ GENERATE LEV(PNLT)
```

```
     EXECUTE EFF                          $ GENERATE EFF(EPNL)
     EXECUTE CNT                          $ GENERATE DATA FILE TURSHBPR.OUT
$
$ LEV AND CNT PARAMETERS FOR SUPPRESSED FAN DISCHARGE, EXECUTE LEV, EFF, AND CNT
$
     PARAM  MEMSUM = 6HPRO8  , 6HPRES     $ LEV UNIT NAME AND MEMBER NAME
     PARAM FILNAME = 8HFADSHBPR           $ CNT FILE NAME
     EXECUTE LEV                          $ GENERATE LEV(PNLT)
     EXECUTE EFF                          $ GENERATE EFF(EPNL)
     EXECUTE CNT                          $ GENERATE DATA FILE FADSHBPR.OUT
$
$ LEV AND CNT PARAMETERS FOR SUPPRESSED FAN INLET, EXECUTE LEV, EFF, AND CNT
$
     PARAM  MEMSUM = 6HPRO9  , 6HPRES     $ LEV UNIT NAME AND MEMBER NAME
     PARAM FILNAME = 8HFAISHBPR           $ CNT FILE NAME
     EXECUTE LEV                          $ GENERATE LEV(PNLT)
     EXECUTE EFF                          $ GENERATE EFF(EPNL)
     EXECUTE CNT                          $ GENERATE DATA FILE FAISHBPR.OUT
$
$ LEV AND CNT PARAMETERS FOR AIRFRAME AND ENGINE, EXECUTE LEV, EFF, AND CNT
$
     PARAM  MEMSUM = 6HPRO1  , 6HPRES   , 6HPRO2  , 6HPRES  ,
                     6HPRO3  , 6HPRES   , 6HPRO4  , 6HPRES  ,
                     6HPRO5  , 6HPRES   , 6HPRO6  , 6HPRES
                                          $ LEV UNIT NAMES AND MEMBER NAMES
     PARAM FILNAME = 8HLOUDHBPR           $ CNT FILE NAME
     EXECUTE LEV                          $ GENERATE LEV(PNLT)
     EXECUTE EFF                          $ GENERATE EFF(EPNL)
     EXECUTE CNT                          $ GENERATE DATA FILE LOUDHBPR.OUT
$
$ LEV AND CNT PARAMETERS FOR AIRFRAME & ENGINE WITH SUPPRESSED FAN AND TURBINE,
$ EXECUTE LEV, EFF, AND CNT
$
     PARAM  MEMSUM = 6HPRO1  , 6HPRES   , 6HPRO2  , 6HPRES  ,
                     6HPRO6  , 6HPRES   , 6HPRO7  , 6HPRES  ,
                     6HPRO8  , 6HPRES   , 6HPRO9  , 6HPRES
                                          $ LEV UNIT NAMES AND MEMBER NAMES
     PARAM FILNAME = 8HHUSHHBPR           $ CNT FILE NAME
     EXECUTE LEV                          $ GENERATE LEV(PNLT)
     EXECUTE EFF                          $ GENERATE EFF(EPNL)
     EXECUTE CNT                          $ GENERATE DATA FILE HUSHHBPR.OUT
$
$==============================================================================
$
$ FINEM RESPICE
$
     ENDCS $
```

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. AGENCY USE ONLY *(Leave blank)*	2. REPORT DATE	3. REPORT TYPE AND DATES COVERED
	June 1992	Technical Memorandum

4. TITLE AND SUBTITLE
Advanced Subsonic Transport Approach Noise-
The Relative Contribution of Airframe Noise

5. FUNDING NUMBERS
WU 537-03-21-04

6. AUTHOR(S)
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7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
NASA Langley Research Center
Hampton, VA 23665-5225

8. PERFORMING ORGANIZATION REPORT NUMBER

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)
National Aeronautics and Space Administration
Washington, DC 20546-0001

10. SPONSORING/MONITORING AGENCY REPORT NUMBER
NASA TM-104112

11. SUPPLEMENTARY NOTES
Willshire: Langley Research Center, Hampton, VA; Garber: Lockheed Engineering & Sciences Company, Hampton, VA.

12a. DISTRIBUTION/AVAILABILITY STATEMENT
Unclassified-Unlimited

Subject Category 71

12b. DISTRIBUTION CODE

13. ABSTRACT *(Maximum 200 words)* With current engine technology, airframe noise is not a major contributor to the overall noise from a large commercial aircraft during landing approach. Much quieter engines are likely due to the advent of much higher bypass turbofans. This has led to a concern that airframe noise may become a major factor during approach. This study was performed to assess the effect of propulsion noise reduction on perceived noise levels on the ground. NASA's Aircraft Noise Prediction Program (ANOPP) was used to make noise predictions for a current large commercial transport aircraft and for a candidate advanced technology aircraft. Individual predictions of various propulsion and airframe noise components were made for each case. Predicted noise contour areas as well as noise levels predicted for the FAA prescribed measuring point were used to determine the relative importance of source components. The reduction in propulsion noise predicted for the advanced technology aircraft caused airframe noise to be the second largest contributor to landing approach noise after the fan inlet component. These predictions indicate that further reductions in propulsion noise beyond those identified in this paper would not significantly reduce landing noise without a corresponding reduction in airframe noise.

14. SUBJECT TERMS
Aircraft noise; Aeroacoustics; Airframe noise

15. NUMBER OF PAGES
36

16. PRICE CODE
A03

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

NSN 7540-01-280-5500

Standard Form 298 (Rev. 2-89)
Prescribed by ANSI Std. Z39-18
298-102