TITLE PAGE

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FFFFFFFFFF  LL            OOOOOO    PPPPPPPPP    SSSSSSSS
FF          LL           OO    OO   PP       PP  SS      SS
FF          LL          OO      OO  PP       PP  SS
FF          LL          OO      OO  PP       PP  SS
FFFFFFF     LL          OO      OO  PPPPPPPPP    SSSSSSSS
FF          LL          OO      OO  PP                   SS
FF          LL          OO      OO  PP                   SS
FF          LL           OO    OO   PP           SS      SS
FF          LLLLLLLLLL    OOOOOO    PP            SSSSSSSS
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Flight Optimization System

Release 8.11

User's Guide

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INTRODUCTION

The Flight Optimization System (FLOPS) is a multidisciplinary system of computer programs for conceptual and preliminary design and evaluation of advanced aircraft concepts. It consists of nine primary modules: 1) weights, 2) aerodynamics, 3) engine cycle analysis, 4) propulsion data scaling and interpolation, 5) mission performance, 6) takeoff and landing, 7) noise footprint, 8) cost analysis, and 9) program control.

The weights module uses statistical/empirical equations to predict the weight of each item in a group weight statement. In addition, a more analytical wing weight estimation capability is available for use with more complex wing planforms. Centers of gravity and moments of inertia can also be calculated for multiple fuel conditions.

The aerodynamics module uses a modified version of the EDET (Empirical Drag Estimation Technique, ref. 1) program to provide drag polars for performance calculations. Modifications include smoothing of the drag polars, more accurate Reynolds number calculations, and the inclusion of the Sommer and Short T' method (ref. 2) for skin friction calculations. Alternatively, drag polars may be input and then scaled with variations in wing area and engine (nacelle) size.

The engine cycle analysis module was developed by Karl Geiselhart (ref. 3) and is based on the QNEP program (ref. 4) which is a modified version of NEPCOMP (ref. 5) and its successors. It provides the capability to internally generate an engine deck consisting of thrust and fuel flow data at a variety of Mach-altitude conditions. Engine cycle definition decks are provided for turbojets, turboprops, mixed flow turbofans, separate flow turbofans, and turbine bypass engines. Piston engine and propeller performance data can also be generated.

The propulsion data scaling and interpolation module uses an engine deck that has been input or one that has been generated by the engine cycle analysis module, fills in any missing data, and uses linear or nonlinear scaling laws to scale the engine data to the desired thrust. It then provides any propulsion data requested by the mission performance module or the takeoff and landing module.

The mission performance module uses the calculated weights, aerodynamics, and propulsion system data to calculate performance. Based on energy considerations, optimum climb profiles may be flown to start of cruise conditions. The cruise segments may be flown at the optimum altitude and/or Mach number for maximum range or endurance or to minimize NOx emissions, at the long range cruise Mach number, or at a constant lift coefficient. Descent may be flown at the optimum lift-drag ratio. In addition, acceleration, turn, refueling, payload release, and hold segments may be specified in any reasonable order. Reserve calculations can include flight to an alternate airport and a specified hold segment. For supersonic aircraft, sonic boom overpressures are computed along the aircraft track using the approximate method of reference 6.

The takeoff and landing module computes the all-engine takeoff field length, the balanced field length including one-engine-out takeoff and aborted takeoff, and the landing field length. The approach speed is also calculated, and the second segment climb gradient and the missed approach climb gradient criteria are evaluated. Insofar as possible with the available data, all FAR Part 25 or MIL-STD-1793 requirements are met. The module also has the capability to generate a detailed takeoff and climbout profile for use in calculating noise footprints.

The noise footprint module uses the takeoff and climbout profile generated in the takeoff and landing module to compute noise footprint contour data or noise levels at user specified or FAA locations. It is based on the FOOTPR program (ref. 7). The noise sources include fan inlet and exhaust, jet, flap (for powered lift), core (combustor), turbine and airframe. Noise propagation corrections are available for atmospheric attenuation, ground reflections, extra ground attenuation, and shielding.

The cost analysis module is based on Dr. V. S. Johnson's PhD dissertation (ref. 8) and uses configuration, engine, performance and weights data from other modules. It contains the capability to calculate airframe RDT&E cost (ref. 9), airframe production cost (ref. 10), engine RDT&E and production costs (ref. 11), direct operating cost (ref. 12), and indirect operating cost (ref. 13), and to combine them to produce life cycle cost for subsonic transport aircraft.

Through the program control module, FLOPS may be used to analyze a point design, parametrically vary certain design variables, or optimize a configuration with respect to these design variables (for minimum gross weight, minimum fuel burned, maximum range, minimum cost, or minimum NOx emissions) using nonlinear programming techniques. The Kreisselmeier-Steinhauser (KS) function (ref. 14) or the Fiacco-McCormick penalty function (ref. 15) may be used with the Davidon-Fletcher-Powell (DFP) or the Broyden-Fletcher-Goldfarb-Shano (BFGS) algorithm. The configuration design variables are wing area, wing sweep, wing aspect ratio, wing taper ratio, wing thickness-chord ratio, gross weight, and thrust (size of engine). The performance design variables are cruise Mach number and maximum cruise altitude. The engine cycle design variables are the design point turbine entry temperature, the maximum turbine entry temperature, the fan pressure ratio, the overall pressure ratio, and the bypass ratio for turbofan and turbine bypass engines.

Most of the input data is in Namelist format with default values coded into the program. For new users, it is recommended that these default values be used whenever there is some uncertainty as to the meaning or appropriate value of a given parameter (i.e., "When in doubt, leave it out"). In most cases, this will provide reasonable results.

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13. Stoessel, R. F.: A Proposed Standard Method for Estimating Airline Indirect Operating Expenses. Lockheed-Georgia Co., Marietta, GA, LW70-500R, May 1970.

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INPUT DATA STREAM ORDER

Title Card

Namelist $OPTION

Namelist $WTIN

Namelist $FUSEIN

Namelist $CONFIN

Namelist $AERIN

Namelist $ARIDE

```
               Namelist $COSTIN

               Namelist $ENGDIN

               Namelist $ENGINE or the Engine Deck

               Namelist $NACELL

               Namelist $MISSIN

               Mission Definition Data

               Namelists $PCONIN

               Aerodynamic Data (May include Namelist $RFHIN )

               Namelist $ASCLIN

               Namelist $TOLIN

               Namelist $PROIN

               Namelists $SEGIN

               Namelist $NOISIN

               Namelist $SYNTIN
                                        ----+
               Namelist $RERUN              +
                                            +
               Namelist $MISSIN             +  Repeat
                                            +    as
               Mission Definition Data      +  Desired
                                            +
               Namelists $PCONIN            +
                                        ----+
```

The Title Card, and Namelists $OPTION, $WTIN, $CONFIN, and $AERIN are always required. The other input data are optional depending on the type of analysis being performed.

===

TITLE CARD

(Required)

Columns 1-80   Any alphanumeric title

===

Namelist $OPTION

Program Control, Execution, Analysis and Plot Option Data
(Required)

Name	Description
MPRINT	Master print control = 1, Normal output for all analyses (Default) = 0, Print only 3-5 line summary for each analysis Usually used only for contour plots (IOPT = 4)
IOPT	= 1, Analysis - Analyze input configuration (Default) = 2, Parametric variation - Perform a matrix of analyses varying the design variables as indicated in Namelist $CONFIN = 3, Optimization - Optimize the configuration using the design variables as indicated in Namelist $CONFIN. Namelist $SYNTIN must be included with NDD > 0 in that namelist. = 4, Contour or thumbprint plot - Prepare data for plotting contours of OBJ versus 2 parametrically varying design variables (See Namelist $CONFIN)
IANAL	= 1, Compute weights = 2, Compute weights and aerodynamics = 3, Full analysis including mission performance (Default) = 4, Propulsion system only - Provides the capability to optimize an engine at its design point or to perform a parametric variation using the engine design variables (See Namelist $CONFIN)
INENG	= 1, Engine data is read in or generated even if IANAL = 1 or 2 = 0, Engine data is used only if IANAL = 3 or 4 (Default)
ITAKOF	= 1, Detailed takeoff performance will be calculated (Namelist $TOLIN required) = 0, Otherwise (Default)
ILAND	= 1, Detailed landing performance will be calculated (Namelist $TOLIN required) = 0, Otherwise (Default)
NOPRO	= 1, Detailed takeoff and climb profiles will be generated for noise calculations (Namelists $TOLIN, $PROIN and $SEGIN required) = 0, Otherwise (Default unless NOISE = 1)
NOISE	= 0, No noise data will be generated (Default) = 1, Noise footprint data for takeoff and climbout will be generated (Namelist $NOISIN required) This will set NOPRO = 1 = 2, Noise data will be generated only for the final analysis for an optimization run
ICOST	= 1, Calculate costs (Namelist $COSTIN required) = 0, No costs are calculated (Default)

```
 IFITE      = 0, Use transport weight equations and FAA transport
                 takeoff and landing procedures and requirements
                 (Default)
            = 1, Use fighter/attack weight equations and
                 MIL-STD-1793 takeoff and landing procedures and
                 requirements
            = 2, Use general aviation weight equations -
                 currently incomplete
            = 3, Use blended wing body weight equations and FAA
                 transport takeoff and landing procedures and
                 requirements.  Requires Namelist $FUSEIN to
                 define the fuselage.


-----------------------------------------------------------------
#    Plot File Input Data

Contour or Thumbprint Plot Data File (IOPT = 4)

 CNFILE     Contour or thumbprint plot data file name
            (Default = 'FLPPLOT')


Plot files for XFLOPS Graphical Interface Postprocessor

 IXFL       = 1, Cruise, mission and takeoff and landing plot
                 files will be generated
            = 0, Otherwise (Default)

 MSFILE     Mission summary data file name (Default =
            'MSMPLOT' - this name is used by XFLOPS)

 CRFILE     Cruise schedule summary data file name
            (Default = 'CRUPLOT')
            IFLAG (Namelist $MISSIN) must be greater than 0.
            If IFLAG is greater than 1, separate climb and
            descent profiles may also be plotted by XFLOPS.

 TOFILE     Takeoff and landing aerodynamic and thrust data
            file name (Default = 'TOLPLOT')


Takeoff and Climb Profile File for Noise Calculations

 NPFILE     = 1, Detailed profiles will be output on file NOFILE
                 for use with ANOPP preprocessor
            = 0, Otherwise (Default)

 NOFILE     Takeoff and climb profile data file name
            (Default = 'NPROF')


Drag Polar Plot File

 IPOLP      = 0, No drag polar plots (Default)
            = 1, Prepare data on APFILE (Unit 8) for plotting
                 drag polars at existing (internal) Mach numbers
```

```
             = 2, Drag polar plot data will be at NMACH input
                  Mach numbers

 APFILE      Drag polar plot data file name (Default = 'POLPLOT')

 POLALT      Altitude for drag polar plots (Default = 0.)

 NMACH       Number of input Mach numbers for IPOLP = 2
             (Maximum = 20, Default = 0)

 PMACH(I)    Input Mach numbers for IPOLP = 2, NMACH values
             (Default = 0.)


Engine Performance Data Plot File

 IPLTTH      = 2, Engine data suitable for plotting will be
                  output on file THFILE for the final scaled or
                  optimized engine
             = 1, Engine data suitable for plotting will be
                  output on file THFILE for the initial engine
             = 0, Otherwise (Default)

 THFILE      Engine plot data file name (Default = 'THRPLOT')
             This file is in the same format as the input Engine
             Deck (See EIFILE in Namelist $ENGDIN) and includes
             all sorted and filled engine points.  It can be used
             for input for subsequent runs if it does not exceed
             the size limit.


Design History Plot File

 IPLTHS      = 1, Prepare data on HSFILE (Unit 18) for plotting
                  design history for design variables, objectives,
                  constraints, and other data of interest during
                  an optimization run or parametric variation.
             = 0, Otherwise (Default)

 HSFILE      Design history plot file name (Default = 'HISPLOT')

-----------------------------------------------------------------
#    Excess Power Plot File

 IPLTPS      Number of excess power (Ps) and/or load factor (Nz)
             contour plot data sets to be generated and output on
             PSFILE (Default = 0, Maximum = 10)

 PSFILE      Excess power and load factor plot data file name
             (Default = 'PSPLOT')

 XMAX        Maximum Mach number for plots (Default = 0.9)

 XMIN        Minimum Mach number for plots (Default = 0.3)

 XINC        Mach number increment for plots (Default = 0.2)
```

```
 YMAX       Maximum altitude for plots, ft (Default = 40000.)

 YMIN       Minimum altitude for plots, ft (Default = 0.)

 YINC       Altitude increment for plots, ft (Default = 10000.)

 PLTNZ(I)   < 0., Plot load factor (Nz) contours (Default)
            Otherwise, load factor (Nz) at which excess power
            (Ps) contours will be plotted

 PLTPC(I)   Engine power setting parameter
            < 1., Fraction of maximum available thrust
            = 1., Maximum thrust (Default)
            > 1., Power setting for engine deck
                  (3. would indicate the third highest thrust)

 IPSTDG(I)  Number of store drag schedule (see Namelist $MISSIN)
            to be applied to the Ith plot (Default = 0)


There are three ways to input the weight at which the plot data
are to be generated.  They are listed in the order of precedence.
(Default = Ramp Weight)

 PLTWT(I)   Fixed weight, lb

  -or-

 IPLTSG(I)  Weight at start of mission segment IPLTSG is used

  -or-

 PLTFM(I)   Fuel multiplier or fraction of fuel burned

 PLTWTA(I)  Delta weight, lb

 where      Weight = Ramp Weight - PLTFM(I)*Max Fuel + PLTWTA(I)

=================================================================
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Namelist $WTIN

```
 Geometric, Weight, Balance and Inertia Data
 (Required)

 (All defaults = 0. unless otherwise noted)

 Name       Description

 ULF        Structural ultimate load factor (Default = 3.75)

 DGW        Design gross weight - fraction of GW (see $CONFIN)
            or weight, lb (Default = 1.0)

 VMMO       Maximum operating Mach number
            (Default = VCMN, Namelist $CONFIN)
```

```
 NWREF      The number of the reference weight for percentage
            weight output.  Typical values are:
            39 - Ramp Weight (Default)
            37 - Zero Fuel Weight
            33 - Operating Weight Empty
            26 - Weight Empty

 CGREFL     Reference length for percentage C.G. location
            output, in. (Default = XL*12., fuselage length)

 CGREFX     X - location of start of reference length, in.
            (Default =0.)

 MYWTS      = 0, Weights will be computed (Default)
            = 1, Otherwise (See User-Specified Weights,
                 Namelist $MISSIN)

 HYDPR      Hydraulic system pressure (Default = 3000.)

 WPAINT     Weight of paint for all wetted areas, lb/sq.ft.

 IALTWT     = 1, Alternate weight equations for some components
                 will be used (Special option)
            = 0, Normal FLOPS weight equations will be used

-----------------------------------------------------------------
Special Option for Operating Weight Empty Calculations

 ISPOWE     = 0, Normal FLOPS weight equations will be used
            = 1, Special equation for Operating Weight Empty will
                 be used:

                OWE = SPWTH*THRUST + SPWSW*SW + SPWGW*GW + SPWCON

                 Structures group weights will be scaled to meet
                 the calculated OWE.
            = 2, Use response surface for weights - available
                 only in DOSS version

 SPWTH      Multiplier for thrust/engine in special equation for
            Operating Weight Empty, lb/lb (Default = 2.2344)

                                                 AIRFLOWref
            SPWTH = (PODscalar + dOEWscalar) * ------------
                                                SLSTHRUSTref

 SPWSW      Multiplier for wing area in special equation for
            Operating Weight Empty, lb/ft2 (Default = 9.5)

 SPWGW      Multiplier for gross weight in special equation for
            Operating Weight Empty, lb/lb (Default = .104087)

                    MTOWscalar + OEWgrowth*MTOWgrowth
            SPWGW = -----------------------------------
                             1. + MTOWgrowth
```

```
 SPWCON     Constant weight term in special equation for
            Operating Weight Empty, lb (Default = 38584.)

            SPWCON = OEWuncycled - MTOWscalar*MTOWuncycled
                     - WINGscalar*SWref
                     - (PODscalar + dOEWscalar)*AIRFLOWref

-----------------------------------------------------------------
#    Wing Data

 SPAN       Wing span (optional, see $CONFIN - SW and AR)

 DIH        Wing dihedral (positive) or anhedral (negative)
            angle, deg

 FLAPR      Flap ratio -- ratio of total movable wing surface
            area (flaps, elevators, spoilers, etc.) to wing area
            (Default = .333)

 GLOV       Total glove and bat area beyond theoretical wing,
            sq.ft.

 VARSWP     Fraction of wing variable sweep weight penalty
            = 0., Fixed-geometry wing
            = 1., Full variable-sweep wing

 FCOMP      Decimal fraction of amount of composites used in
            wing structure
            = 0., No composites
            = 1., Maximum use of composites, approximately
                  equivalent to FRWI1=.6, FRWI2=.83, FRWI3=.7
                  (Not necessarily all composite)
            This only applies to the wing.  Use override
            parameters for other components such as FRHT=.75,
            FRVT=.75, FRFU=.82, FRLGN=.85, FRLGM=.85, FRNA=.8

 FAERT      Decimal fraction of amount of aeroelastic
            tailoring used in design of wing
            = 0., No aeroelastic tailoring
            = 1., Maximum aeroelastic tailoring

 FSTRT      Wing strut-bracing factor
            = 0., No wing strut
            = 1., Full benefit from strut bracing

-----------------------------------------------------------------
#    Detailed Wing Data

Optional - Triggered by a positive value of NETAW, wing stations,
chords, t/c`s and sweeps are defined at wing root, break points,
and tip.  For aircraft where the wing weight does not include the
carry-through structure (e.g., F-16, B-70), the first wing
station would be at side-of-body and the appropriate PCTL would
be input.  Used only for wing weight calculation.  Does not
impact aerodynamic calculations.
```

For BWB (Blended Wing-Body) aircraft (IFITE = 3 in Namelist $OPTION), these data are used to define an outboard wing panel to be added to the side of the cabin. ETAW(1) should be 0. FLOPS will change the corresponding chord to the fuselage outboard chord and add one additional wing station at the body centerline. Station data will be renumbered, and values will be adjusted to reflect the presence of the BWB cabin as part of the detailed wing planform. The outboard semispan (OSSPAN in Namelist $FUSEIN) is required.

NETAW	Number of input wing stations (Maximum = 21)
ETAW(I)	Wing station location - fraction of semispan or distance from fuselage centerline, ft. Typically, goes from 0. to 1. Input fixed distances (>1.1) are not scaled with changes in span.
CHD(I)	Chord length - fraction of semispan or actual chord, ft. Actual chord lengths (>5.) are not scaled.
TOC(I)	Thickness - chord ratio
SWL(I)	Sweep of load path, deg. Typically parallel to rear spar tending toward max t/c of airfoil. The Ith value is used between wing stations I and I+1.
ETAE(K)	Engine locations - fraction of semispan or distance from fuselage centerline, ft. Actual distances are not scaled with changes in span. NEW/2 values are input (Default = .3,.6,0.,0., Maximum of 4 values)
PCTL	Fraction of load carried by defined wing (Default = 1.)
ARREF	Reference aspect ratio (Default = AR in $CONFIN)
TCREF	Reference thickness-chord ratio (Default = TCA in $CONFIN)
NSTD	Number of integration stations (Default = 50, Maximum = 100)
PDIST	Pressure distribution indicator (Default = 2.) = 0., Input distribution - see below = 1., Triangular distribution = 2., Elliptical distribution = 3., Rectangular distribution

PDIST is a continuous variable, i.e., a value of 1.5 would be half way between triangular and elliptical. CAUTION - the constants in the wing weight calculations were correlated with existing aircraft assuming an elliptical distribution. Use the default value unless you have a good reason not to.

Input Pressure Distribution (Used only if PDIST = 0.)

```
 NETAP      Number of input points (Maximum = 51)

 ETAP(J)    Fraction of wing semispan

 PVAL(J)    Relative spanwise pressure at ETAP(J)

-----------------------------------------------------------------
#    Tails, Fins, Canards

Horizontal Tail Data

 SHT        Horizontal tail theoretical area, sq ft
            (Overridden by HTVC in Namelist $CONFIN if HTVC > 0.)

 SWPHT      Horizontal tail 25% chord sweep angle, deg
            (Default = SWEEP, Namelist $CONFIN)

 ARHT       Horizontal tail theoretical aspect ratio
            (Default = AR/2, Namelist $CONFIN)

 TRHT       Horizontal tail theoretical taper ratio
            (Default = TR, Namelist $CONFIN)

 TCHT       Thickness-chord ratio for the horizontal tail
            (Default = TCA, Namelist $CONFIN)

 HHT        Decimal fraction of vertical tail span where
            horizontal tail is mounted
            = 0. for body mounted (Default for transports with
                 all engines on the wing and for fighters)
            = 1. for T tail (Default for transports with
                 multiple engines on the fuselage)


Vertical Tail Data

 NVERT      Number of vertical tails (Default = 1)

 SVT        Vertical tail theoretical area (per tail), sq ft
            (Overridden by VTVC in Namelist $CONFIN if VTVC > 0.)

 SWPVT      Vertical tail sweep angle at 25% chord, deg
            (Default = SWPHT)

 ARVT       Vertical tail theoretical aspect ratio
            (Default = ARHT/2)

 TRVT       Vertical tail theoretical taper ratio
            (Default = TRHT)

 TCVT       Thickness-chord ratio for the vertical tail
            (Default = TCHT)


Fin Data (Drag will not be computed internally)

 NFIN       Number of fins
```

```
 SFIN       Vertical fin theoretical area, sq ft

 ARFIN      Vertical fin theoretical aspect ratio

 TRFIN      Vertical fin theoretical taper ratio

 SWPFIN     Vertical fin sweep angle at 25% chord, deg

 TCFIN      Vertical fin thickness - chord ratio


Canard Data (Skin friction drag is computed internally)

 SCAN       Canard theoretical area, sq ft

 SWPCAN     Canard sweep angle at 25% chord, deg

 ARCAN      Canard theoretical aspect ratio

 TRCAN      Canard theoretical taper ratio

 TCCAN      Canard thickness-chord ratio
            (Default = TCHT)

-----------------------------------------------------------------
#    Fuselage Data

Fuselage Data

 NFUSE      Number of fuselages (Default = 1)

 XL         Fuselage total length, ft
            If XL is not input for a passenger transport,
            Namelist $FUSEIN is required, and Flops will
            calculate the fuselage length, width and depth and
            the length of the passenger compartment.

 WF         Maximum fuselage width, ft

 DF         Maximum fuselage depth, ft

 XLP        Length of passenger compartment, ft
            (Default is internally computed)

-----------------------------------------------------------------
#    Landing Gear Data

 XMLG       Length of extended main landing gear oleo, in.
            (Default is computed internally)

 XNLG       Length of extended nose landing gear oleo, in.
            (Default is computed internally)

 WLDG       Design landing weight, lb (if WRATIO is input
            in Namelist $AERIN, WLDG = GW*WRATIO)
            See Namelist $AERIN for WRATIO defaults.
```

```
 MLDWT      =  1, The design landing weight is set to the end of
                  descent weight for the main mission plus DLDWT.
                  Use only if IRW = 1 in Namelist $MISSIN.
            =  0, The design landing weight is determined by WLDG
                  above or WRATIO in Namelist $AERIN. (Default)
            = -1, The initial design landing weight determined by
                  WLDG above or WRATIO in Namelist $AERIN is not
                  scaled with changes in the gross weight.

 DLDWT      Delta landing weight for MLDWT = 1, lb (Default = 0.)

 CARBAS     Carrier based aircraft switch, affects weight of
            flight crew, avionics and nose gear
            = 1., Carrier based
            = 0., Land based (Default)

-----------------------------------------------------------------
#    Propulsion System Data

 NEW        Number of wing mounted engines

 NEF        Number of fuselage mounted engines

 THRSO      Rated thrust of baseline engine as described in
            Engine Deck, lb (Default = THRUST, see $CONFIN)

 WENG       Weight of each baseline engine or bare engine if
            WINL and WNOZ (below) are supplied, lb (Default =
            THRSO/5.5 for transports and THRSO/8 for fighters)
            If WENG > 0. but < 5., it is a scale factor applied
            to internally computed weight

 EEXP       Engine weight scaling parameter (Default = 1.15)
               W(Engine) = WENG*(THRUST/THRSO)**EEXP
            If EEXP is less than 0.3,
               W(Engine) = WENG + (THRUST-THRSO)*EEXP

 WINL       Inlet weight for baseline engine if not included in
            WENG above (Default = 0., Included in WENG)

 EINL       Inlet weight scaling exponent (Default = 1.)
               W(Inlet) = WINL*(THRUST/THRSO)**EINL

 WNOZ       Nozzle weight for baseline engine if not included in
            WENG above (Default = 0., Included in WENG)

 ENOZ       Nozzle weight scaling exponent (Default = 1.)
               W(Nozzle) = WNOZ*(THRUST/THRSO)**ENOZ

 XNAC       Average length of baseline engine nacelles, ft
            Scaled by SQRT(THRUST/THRSO)

 DNAC       Average diameter of baseline engine nacelles, ft
            Scaled by SQRT(THRUST/THRSO)

 WPMISC     Additional miscellaneous propulsion system weight, lb
```

```
             or fraction of engine weight if < 1.
             This is added to the engine control and starter
             weight and may be overridden if WPMSC is input.

-----------------------------------------------------------------
Alternate Propulsion System - The following variables are used
for a second set of engines

 NUMDEK      Number of engine decks to be input (Default = 1,
             Maximum = 2)

 NEALT       Number of engines for alternate propulsion system
             (Default = 0, no alternate propulsion system)

 ALTTHR      Rated thrust per engine for alternate propulsion
             system, lb

 ALTEWT      Weight per engine for alternate propulsion system, lb

 POWWT       System weight for alternate propulsion system, lb

-----------------------------------------------------------------
#    Fuel System Data

 ITYPFL(i)   Fuel type indicator (NUMDEK values, Default = 0,0)
             = 0, Normal, burnable fuel (hydrocarbons)
             = 1, Fuel is not burned (electric, etc.)

 NTANK       Number of fuel tanks (Default = 7)

 FULWMX      Total fuel capacity of wing, lb
             The default is internally calculated from:

                              TCA * SW**2            TR
             FULWMX = FWMAX * ----------- * ( 1 - --------- )
                                  SPAN             (1+TR)**2

             Where the default value of FWMAX is 23.  If FULWMX
             is input < 50, it is interpreted as FWMAX and the
             above equation is used.  This equation is also used
             for scaling when the wing area, t/c, aspect ratio,
             or taper ratio is varied or optimized.

 FULDEN      Fuel density ratio for alternate fuels compared to
             jet fuel (typical density of 6.7 lb/gal), used in the
             calculation of FULWMX (if FULWMX is not input) and in
             the calculation of fuel system weight. (Default = 1.)

-----------------------------------------------------------------
 FULFMX      Total fuel capacity of fuselage (wing "carry-thru"
             structure and/or in fuselage tanks), lb

 IFUFU       = 1, Fuselage fuel capacity is adjusted to meet the
                  required fuel capacity for the primary mission.
                  Use only if IRW = 1 in Namelist $MISSIN, and use
                  with care - some passengers can't swim.
             = 0, Fuselage fuel capacity is fixed. (Default)
```

```
 FULAUX     Auxiliary (external) fuel tank capacity, lb
            (Fighters only)

-----------------------------------------------------------------
Alternate Energy Source
If none of the engines burn fuel, BATWT and POWMAX should be
used instead of the fuel variables.  If all engines burn fuel,
use the fuel variables only.  If there are two sets of engines
and one set burns fuel and the other doesn't, use both these
variables and the fuel variables.

 BATWT      Storage system weight for alternate energy source, lb

 POWMAX     Storage system capacity for alternate energy source

 MBATWT     = 1, Modify POWMAX and BATWT to meet mission
                 requirements (Default)
            = 0, Otherwise

            Note: This is used only in mixed mode operation with
            IRW = 1 where the free segment is fuel-burning.  For
            single mode operation, IRW controls resizing for both
            fuel burning and non-fuel burning propulsion systems.

 POWRES     Reserve storage system capacity for alternate energy
            source.  Typically used with MBATWT.  When used for
            single mode operation, this is in addition to other
            reserves.

-----------------------------------------------------------------
Special method for scaling wing fuel capacity
This option is triggered by FUSCLA > 0.

      FULWMX = FUELRF + FUSCLA*(SW**1.5 - FSWREF**1.5)
                      + FUSCLB*(SW - FSWREF)

 FUELRF     Fuel capacity at FSWREF, lb

 FSWREF     Reference wing area for FUELRF, ft**2
            (Default = SW in Namelist $CONFIN)

 FUSCLA     Factor A for 1.5 power term

 FUSCLB     Factor B for linear term

-----------------------------------------------------------------
#    Crew and Payload Data

(If not input, optional items will be computed internal to the
 program.)

 NPF        Number of first class passengers

 NPB        Number of business class passengers

 NPT        Number of tourist class passengers
```

NSTU Number of flight attendants (optional)

NGALC Number of galley crew (optional)

NFLCR Number of flight crew (optional)

WPPASS Weight per passenger, lb (Default = 165.)

BPP Weight of baggage per passenger, lb (Default = 35., or 40. if DESRNG in Namelist $CONFIN > 900., or 44. if DESRNG > 2900.)

CARGF Military cargo aircraft floor factor
= 0., Passenger transport (Default)
= 1., Military cargo transport floor

CARGOW Cargo carried in wing, lb (Weight of wing-mounted external stores for fighters)

CARGOF Cargo (other than passenger baggage) carried in fuselage, lb (Fuselage external stores for fighters)

Override Parameters

The following parameters are used to modify or override internally computed weights for various components as follows:

< 0., negative of starting weight which will be modified as appropriate during optimization or parametric variation, lb

= 0., no weight for that component

> 0. but < 5., scale factor applied to internally computed weight

> 5., actual fixed weight for component, lb

(Default = 1. if not otherwise noted)

FRWI Total wing weight - fixed weight overrides FRWI1, FRWI2, FRWI3 below, scale factor is cumulative

FRWI1 First term in wing weight equation - loosely corresponds to bending material weight

FRWI2 Second term in wing weight equation - loosely corresponds to control surfaces, spars and ribs

FRWI3 Third term in wing weight equation - miscellaneous, just because it's there

FRWI4 Fourth term in wing weight equation - aft body for BWB configurations - see IFITE = 3

FRHT Horizontal tail weight

FRVT Vertical tail weight

FRFIN Wing vertical fin weight

FRCAN Canard weight

FRFU Fuselage weight (Note: For BWB fuselages, IFITE=3, the fuselage is assumed to be composite.)

FRLGN Landing gear weight, nose

FRLGM Landing gear weight, main

FRNA Total weight of nacelles and/or air induction system

WTHR Total weight of thrust reversers (Default = 0.)

WPMSC Weight of miscellaneous propulsion systems such as engine controls, starter and wiring

WFSYS Weight of fuel system

FRSC Surface controls weight

WAPU Auxiliary power unit weight

WIN Instrument Group weight

WHYD Hydraulics Group weight

WELEC Electrical Group weight

WAVONC Avionics Group weight

WARM Armament Group weight - includes thermal protection system or armor and fixed weapons (Default = 0.)

WFURN Furnishings Group weight

WAC Air Conditioning Group weight

WAI Transports: Anti-icing Group weight
Fighters: Auxiliary gear

WUF Weight of unusable fuel

WOIL Engine oil weight

WSRV Transports: Passenger service weight
Fighters: Ammunition and nonfixed weapons weight

WCON Transports: Cargo and baggage container weight
Fighters: Miscellaneous operating items weight
If < 0.5, as a fraction of Gross Weight

```
 WAUXT      Auxiliary fuel tank weight (Fighters only)

 WFLCRB     Total weight of flight crew and baggage
            (Defaults:  Transports    - 225.*NFLCR
                        Fighters      - 215.*NFLCR
                        Carrier-based - 180.*NFLCR)

 WSTUAB     Total weight of cabin crew and baggage
            (Default = 155.*NSTU + 200.*NGALC)

-----------------------------------------------------------------
 EWMARG     Empty weight margin (Special Option) - delta weight
            added to Weight Empty.  If abs(EWMARG) < 5., it is
            interpreted as a fraction of calculated Weight Empty.
            May be positive or negative (Default = 0.)

-----------------------------------------------------------------
#    Center of Gravity (C.G.) Data

Used only in C.G. and inertia calculations.  C.G. and inertia
results are not currently used in other FLOPS modules and are,
therefore, not necessary.  All C.G.  dimensions are in inches.

 CGW        Longitudinal C.G. of wing

 CGHT       Longitudinal C.G. of horizontal tail

 CGVT       Longitudinal C.G. of vertical tail

 CGFIN      Longitudinal C.G. of wing vertical fins

 CGCAN      Longitudinal C.G. of canard

 CGF        Longitudinal C.G. of fuselage

 CGLGN      Longitudinal C.G. of nose landing gear

 CGLGM      Longitudinal C.G. of main landing gear

 CGEF       Longitudinal C.G. of two forward mounted engines

 CGEA       Longitudinal C.G. of one or two aft mounted engines

 CGAP       Longitudinal C.G. of auxiliary power unit

 CGAV       Longitudinal C.G. of avionics group (optional)

 CGARM      Longitudinal C.G. of armament group - includes
            thermal protection system or armor and fixed weapons
            (Default = CGF)

 CGCR       Longitudinal C.G. of flight crew

 CGP        Longitudinal C.G. of passengers

 CGCW       Longitudinal C.G. of wing cargo or external stores
```

CGCF	Longitudinal C.G. of fuselage cargo or external stores
CGZWF	Longitudinal C.G. of fuselage fuel
CGFWF	Longitudinal C.G. of wing fuel in full condition
CGPOW	Longitudinal C.G. of system weight for alternate engines
CGALTE	Longitudinal C.G. of alternate engines
CGBAT	Longitudinal C.G. of storage system for alternate energy source

Fighter only:

CGAIS	Longitudinal C.G. of air induction system
CGACON	Longitudinal C.G. of air conditioning system
CGAXG	Longitudinal C.G. of auxiliary gear
CGAXT	Longitudinal C.G. of auxiliary tanks
CGAMMO	Longitudinal C.G. of ammunition and nonfixed weapons
CGMIS	Longitudinal C.G. of miscellaneous operating items

Inertia Data

Used only in inertia and vertical C.G. calculations. Vertical distances are measured from and perpendicular to the bottom of the fuselage.

INRTIA	= 1, Aircraft inertias will be calculated = 0, Otherwise (Default)
ZHT	Vertical C.G. of the horizontal tail (optional)
ZVT	Vertical C.G. of the vertical tail (optional)
ZFIN	Vertical C.G. of the vertical fin (optional)
YFIN	Lateral C.G. of the vertical fin (optional)
ZEF	Vertical C.G. of two forward mounted engines (optional)
YEF	Lateral C.G. of two forward mounted engines (optional, may be input as a fraction of the semispan)
ZEA	Vertical C.G. of one or two aft mounted engines (optional)

```
 YEA        Lateral C.G. of one or two aft mounted engines
            (optional, may be input as a fraction of the
            semispan)

 ZBW        Lowermost point of wing root airfoil section

 ZAP        Vertical C.G. of Auxiliary Power Unit (optional)

 ZRVT       Vertical datum line (Water Line) of vertical tail
            theoretical root chord (optional, if blank assumes
            at maximum height of fuselage)

 YMLG       Lateral C.G. of extended main landing gear

 YFUSE      Lateral C.G. of outboard fuselage if there is
            more than one fuselage

 YVERT      Lateral C.G. of outboard vertical tail if there
            is more than one vertical tail

 SWTFF      Gross fuselage wetted area, sq ft
            (Default = internally computed)

 TCR        Wing root thickness-chord ratio
            (Default = TOC(1) or TCA in $CONFIN)

 TCT        Wing tip thickness-chord ratio
            (Default = TOC(NETAW) or TCA in $CONFIN)

For inertia calculations, all mission fuel is placed in "tanks."

 INCPAY     = 1, Include passengers, passenger baggage, and cargo
                 in the fuselage and contents for inertia
                 calculations.
            = 0, For inertia calculations, all payload
                 (passengers, passenger baggage, and cargo) are
                 placed in "tanks" like the fuel. (Default)

 ITANK      Number of tanks for inertia calculations - fuel
            tanks plus payload tanks (Default = 1, Maximum = 40)

 NFCON      Number of fuel conditions (Default = 1, Maximum = 10)

 TX(I)      x, y and z coordinates of the centroid of the
 TY(I)      Ith tank
 TZ(I)

 TL(I)      Length, width and depth of the Ith tank
 TW(I)      (optional, used only in calculating I0's which
 TD(I)      may be negligible)

 TF(I,J)    Weight of fuel (or payload) in Ith tank for Jth
            fuel condition, lb

=================================================================
```

Namelist $FUSEIN

Fuselage Design Data
(Required if XL = 0. or IFITE = 3 in Namelist $WTIN)

(All defaults = 0. unless otherwise noted)

If XL in Namelist $WTIN above is not input for a passenger transport, Flops will calculate the fuselage length, width and depth and the length of the passenger compartment. Any of the six variables below are used if input. Otherwise, default values are computed internally. These values are also used for blended-wing-body (BWB) transport cabin definition as number of passengers abreast per bay.

Name	Description
FPITCH	Seat pitch for the first class passengers
NFABR	Number of first class passengers abreast
BPITCH	Seat pitch for business class passengers
NBABR	Number of business class passengers abreast
TPITCH	Seat pitch for tourist class passengers
NTABR	Number of tourist class passengers abreast

If the BWB cabin is to be designed, there are two ways to specify the outboard wing panel to be added to the cabin. The first is to specify the shape using the Detailed Wing Data capability in Namelist $WTIN. OSSPAN below is used to specify the semispan of the outboard panel. The root chord is redefined to be equal to the length of the chord at the outboard cabin wall, and another segment is added for the cabin itself. The second is to simply specify the total wing span. FLOPS will add a trapezoidal panel out to the total semispan with the root chord equal to the length of the chord at the outboard cabin wall, and the tip chord equal to TIPCHD below. In either case, the Reference wing area (SW) is recalculated based on the new detailed wing definition.

OSSPAN	Outboard semispan, ft (Default = ETAW(NETAW), required if ETAW(NETAW) is less than or equal to 1.0 and IFITE = 3 and NETAW > 1) This variable is used if a detailed wing outboard panel (See Detailed Wing Data in Namelist $WTIN) is being added to a BWB fuselage.
TIPCHD	Wing tip chord, ft (Default = 0.06*Wing span) This variable is used if the wing outer panel is defined as a trapezoid attached to the BWB cabin.

If the detailed wing definition already includes the cabin planform, neither of these capabilities are used. This option is triggered by an input value of the following variable greater than 1.

NESOB Wing eta station number for outboard side of body. If this variable is greater than 1, the detailed wing definition is assumed to include the cabin. Weight calculations for the outboard wing start at this eta station. (Default = 0, the detailed outboard wing is added to the cabin as indicated above.)

The remaining variables in this namelist are used only for BWB fuselage design (IFITE = 3 in Namelist $WTIN).

ACABIN Fixed area of passenger cabin for blended wing body transports, sq ft (Default is internally computed based on passenger data)

XLW Fixed length of side wall, ft
This is the outboard wall of the passenger cabin and is used to define the outboard wing root chord.

XLWMIN Minimum side wall length, ft
The typical value of 38.5 ft is based on a required maximum depth at the side wall of 8.25 ft divided by a fuselage thickness/chord ratio of 0.15 and 70 percent of the resulting wing root chord of 55 ft.

NBAY Fixed number of bays

NBAYMX Maximum number of bays

BAYW Fixed bay width, ft

BAYWMX Maximum bay width, ft

SWPLE Sweep angle of the leading edge of the passenger cabin, deg (Default = 45 deg)

CRATIO Fixed ratio of the centerline length to the cabin width (XLP/WF)

TCF Fuselage thickness/chord ratio
(Default = TCA, Namelist $CONFIN)

TCSOB Fuselage thickness/chord ratio at side of body
(Default = TCF)

RSPCHD Rear spar percent chord for BWB at fuselage centerline (Default = 70 percent)

RSPSOB Rear spar percent chord for BWB fuselage at side of body (Default = RSPCHD)

With the cabin area (ACABIN) input or computed from passenger data and the leading edge sweep (SWPLE) defined, one more data point is required to define the cabin. The computational hierarchy is as follows:

- XLP is used if it is input in Namelist $WTIN, or, if XL is input and XLP is not, XLP is set to 0.7*XL

- WF is used if it is input in Namelist $WTIN, or, if NBAY and BAYW are input and WF is not, WF is set to NBAY*BAYW

  (If both XLP and WF are specified, this overrides input or computation of ACABIN and defines all dimensions)

- CRATIO is used if it is input

- If none of the above are input, XLW is used. If it is not input, it defaults to XLWMIN (if input) or 38.5 ft

Once the cabin dimensions are defined, the constraints represented by XLWMIN, NBAYMX and BAYWMX are enforced. This may alter some of the input dimensions.

===

Namelist $CONFIN

Configuration Geometric Ratios, Objective Function Definition, and Design Variables
(Required)

(All defaults = 0. unless otherwise noted)

```
Name       Description

DESRNG     Design range, n.mi. (or endurance, min.  See INDR
           in Namelist $MISSIN)  Required - if IRW = 2 in
           Namelist $MISSIN, the range is computed, but a
           reasonable guess must still be input.

WSR        >  0., required wing loading.  Do not set WSR > 0
                  during optimization or if wing area is being
                  varied.
           = -1., interpret SW as wing loading for parametric
                  variation.  Do not use for optimization.

TWR        >  0., required total thrust-weight ratio.  Do not
                  set TWR > 0 during optimization or if thrust
                  is being varied.
           = -1., interpret THRUST as thrust-weight ratio for
                  parametric variation.  Do not use for
                  optimization.

HTVC       Modified horizontal tail volume coefficient.
           * If HTVC > 0., SHT = HTVC * SW * Sqrt(SW/AR) / XL
             (This overrides any input value for SHT)
             SHT will be recalculated if SW or AR are changed
             during optimization or parametric variation.
           * If HTVC = 1., the horizontal tail volume
             coefficient calculated from the input values of
             SHT, SW, AR and XL will be maintained.
           * If HTVC = 1. and SHT = 0. (which is the default), a
```

```
                reasonable value for HTVC will be calculated, and,
                then, SHT will be calculated as above.

 VTVC         Modified vertical tail volume coefficient.
              * If VTVC > 0., SVT = VTVC * SW * Sqrt(SW*AR) / XL
                (This overrides any input value for SVT)
                SVT will be recalculated if SW or AR are changed
                during optimization or parametric variation.
              * If VTVC = 1., the vertical tail volume coefficient
                calculated from the input values of SVT, SW, AR and
                XL will be maintained.
              * If VTVC = 1. and SVT = 0. (which is the default), a
                reasonable value for VTVC will be calculated, and,
                then, SVT will be calculated as above.
              * Note: If NVERT = 0, VTVC is set to 0.

 PGLOV        Fixed ratio of glove area to wing area (GLOV/SW)
              If PGLOV > 0., GLOV will change if SW changes

 FIXSPN       Special Option - Fixed wing span, ft.  If the wing
              area is being varied or optimized, the wing aspect
              ratio will be adjusted to maintain a constant span.
              (Default = not used)

 FIXFUL       Special Option - Fixed mission fuel, lb.  Allows
              specification of mission fuel.  Since this fuel is
              normally a fall out (what's left over after OWE and
              payload are subtracted from the gross weight), this
              option requires iterating on the gross weight until
              the mission fuel = FIXFUL.  Gross weight cannot be
              an active design variable or used in a parametric
              variation, and IRW must be 2 in Namelist $MISSIN.
              (Default = not used)

-----------------------------------------------------------------
#    Objective Function Definition

 OFG          Objective function weighting factor for gross weight

 OFF          Objective function weighting factor for mission fuel
              (Default = 1.)

 OFM          Objective function weighting factor for
              Mach*(L/D), should be negative to maximize

 OFR          Objective function weighting factor for Range,
              should be negative to maximize.

 OFC          Objective function weighting factor for Cost

 OSFC         Objective function weighting factor for Specific Fuel
              Consumption at the engine design point.  Generally
              used only for engine design cases (IANAL = 4).

 OFNOX        Objective function weighting factor for NOx emissions

 OFNF         Objective function weighting factor for flyover noise
```

(used primarily for contour plots)

OFNS   Objective function weighting factor for sideline noise (used primarily for contour plots)

OFNFOM   Objective function weighting factor for noise figure of merit

OAREA   Objective function weighting factor for area of noise footprint (not implemented)

OFH   Objective function weighting factor for hold time for segment NHOLD (See Namelist $MISSIN)

The function that is minimized is

```
       OBJ = OFG*GW + OFF*Fuel + OFM*VCMN*(Lift/Drag) + OFR*Range
             + OFC*Cost + OSFC*SFC + OFNOX*NOx
             + OFNF*(Flyover Noise) + OFNS*(Sideline Noise)
             + OFNFOM*(Noise Figure of Merit)
             + OFH*(Hold Time for Segment NHOLD)
```

Design Variables

Each design variable is actually a five element vector.
For optimization (IOPT = 3), the elements are:

(1) Initial value
(2) Activity status, active if > 0. (Default = 0.)
(3) Lower bound (Default = Initial value / 10.)
(4) Upper bound (Default = Initial value * 10.)
(5) Optimization scale factor. See AUTSCL (Namelist $SYNTIN) for default value. If negative, the inverse of the design variable will be used for optimization.

If the design variable is inactive or if only an analysis is being performed, the design variable may be input as a scalar.

Configuration Design Variables - If IRW = 1 in Namelist $MISSIN, the ramp weight GW is a fallout and cannot be active.

GW   Ramp weight, lb (Required. If IRW = 1, a good initial guess must be input.)

AR   Wing aspect ratio (See below)

THRUST   Maximum rated thrust per engine, lb, or thrust-weight ratio if TWR = -1. (Default = THRSO in Namelist $WTIN if TWR = 0.)

SW   Reference wing area, sq ft, or wing loading (GW/SW) if WSR = -1. (See below)

TR   Taper ratio of the wing (Required)

SWEEP	Quarter-chord sweep angle of the wing, degrees (Required)
TCA	Wing thickness-chord ratio (weighted average) (Required)

The relationship between AR and SW from $CONFIN, and SPAN and GLOV from $WTIN is as follows:

AR = SPAN ** 2 / (SW - GLOV)

Nonzero values for two of AR, SW and SPAN must be input. The other is calculated. If all three are input, GLOV is calculated.

For blended wing-body (BWB) aircraft (IFITE = 3), SW is calculated from the input or calculated detailed wing definition. (The input value of SW is not used.) AR is then calculated as shown above.

Mission Performance Design Variables - Cruise Mach number and altitude optimization is normally handled locally in the mission performance module. For very short missions, however, it may be advantageous to fly below the optimums. In these cases, the following variables may be used. In any case, reasonable values must be input for use by other modules.

VCMN	Cruise Mach number (Required)
CH	Maximum cruise altitude, ft (Required)

Noise Abatement Design Variables - The following three variables are used to meet noise constraints.

VARTH	Thrust derating factor for takeoff noise Fraction of full thrust used in takeoff (Default = 1. Use full thrust)
ROTVEL	Rotation velocity for takeoff noise abatement (default is minimum required to meet takeoff performance constraints)
PLR	Thrust fraction after programmed lapse rate (default thrust is specified in each segment)

Engine Design Variables for IENG (Namelist $ENGINE) < 100. (Defaults are values input in Namelist $ENGINE for TETDES, OPRDES, FPRDES, BPRDES and TTRDES, respectively)

ETIT	Engine design point turbine entry temperature, deg R
EOPR	Overall pressure ratio
EFPR	Fan pressure ratio (Turbofans only)

EBPR   Bypass ratio (Turbofans only)

ETTR   Engine throttle ratio defined as the ratio of the maximum allowable turbine inlet temperature divided by the design point turbine inlet temperature. If ETTR is greater than ETIT, it is assumed to be the maximum allowable turbine inlet temperature.

The following definitions apply if IENG > 100. (Defaults are values input in Namelist $ENGINE for DESHP, DPROP, CLI, AF, PRPSPD and BLANG, respectively)

ETIT   Design power, hp (Default = 180.)

EOPR   Propeller diameter, ft. (Default = 6.375)

EFPR   Integrated design lift coefficient (Default = 0.569)

EBPR   Activity factor (Default = 87.6)

ETTR   Maximum propeller shaft speed, RPM (Default = 2700.)

EBLA   Blade angle for fixed pitch propeller, deg

The engine design variables may be used to overide corresponding variables in $ENGINE, during parametric variation, during an engine only design point optimization (See IANAL = 4 in Namelist $OPTION), or to optimize engine design variables simultaneously with configuration design variables. The use of engine design variables significantly increases run times.

Parametric Variation

For parametric variation or contour or thumbprint plots (IOPT = 2 or 4), the design variable vector elements change definition. Element (2) controls the meaning of the other elements, and Element (5) is not used.

If Element (2) is equal to 0, Element (1) is used as the fixed value for that variable (except for GW if IRW = 1, and SW and/or THRUST if WSR and/or TWR, respectively, are input). Elements (3) and (4) are not used.

If Element (2) is equal to 1, Element (3) is used as the fixed value for that variable, and Element (1) is used only as a reference value, e.g., SW(1) and AR(1) in calculating HTVC if it is input as 1. or THRUST(1) as a default for THRSO. Element (4) is not used.

If Element (2) is 2 or greater, the variable is varied Element (2) times, from Element (3) to Element (4) in equal steps. Element (1) is used only as a reference value.

```
For example,  AR  =  10., 3.,  9.,  13.,
              TCA =  .15, 4., .13,  .10,
              SW  = 900., 1., 1000.,
```

```
              TR  =  .25, 0., .10,  .45,
```

would result in a matrix of 12 analyses with aspect ratios of 9, 11 and 13, thickness-chord ratios of .13, .12, .11 and .10, a fixed wing area of 1000, and a fixed taper ratio of .25. The following reference values would be used for modification of other input data - AR = 10., TCA = .15, and SW = 900.

For contour plotting, only two design variables may be varied with up to 15 values each.

Single Analysis

In pure analysis mode (IOPT = 1), Element (1) is used as the fixed value for each variable. The other elements are not used.

===

Namelist $AERIN

Aerodynamic Input Options and Data for Internal Aerodynamic Calculations and Approximate Takeoff and Landing (Required)

(All defaults = 0. unless otherwise noted)

```
 Name       Description

 MYAERO     Controls type of user-supplied aerodynamic data
            = 0, Drag polars are computed internally (Default)
            = 1, Aerodynamic Data will be read in
            = 2, Scalable Aerodynamic Data will be input
                 (Namelist $ASCLIN required)
            = 3, Special parabolic Aerodynamic Data format
                 (Namelist $RFHIN required)
            = 4, Use aerodynamic response surface - available
                 only in DOSS version

 IWAVE      Controls Wave Drag Data input type
            = 1, Input Wave Drag Data will be formatted
            = 0, Otherwise (Default, no wave drag or it is input
                 in Namelist $ASCLIN)

 FWAVE      Wave drag factor - multiplies input values of wave
            drag from formatted aerodynamic data or Namelist
            $ASCLIN (Default = 1.)

 ITPAER     Aerodynamic data interpolation switch
            = 1, Linear - Use if aerodynamic data is irregular.
                 This is usually indicated by strange climb,
                 descent or cruise profiles.
            = 2, Parabolic (Default)
            = 3, Parabolic interpolation for CL, linear
                 interpolation for Mach number and altitude.
```

```
 IBO        Format indicator for input aerodynamic matrices
            = 1, A new line is started for each Mach number for
                 Cards 4 and for each altitude for Cards 8
            = 0, Data is continuous, 10 to a line (Default)
```

Internally Computed Aerodynamics Input Data

(Note: Internally computed aerodynamics do not use the detailed wing data. The average or reference values input as design variables in Namelist $CONFIN are used exclusively.)

```
 CAM        Maximum camber at 70% semispan, percent of local
            chord

 SBASE      Aircraft base area (total exit cross-section area
            minus inlet capture areas for internally mounted
            engines), sq ft

 AITEK      Airfoil technology parameter.  Limiting values are:
            = 1., Conventional wing (Default)
            = 2., Advanced technology wing

 MODARO     = 1, Data tables in EDET are to be modified,
                 Namelist $ARIDE will be read in
            = 0, Otherwise (Default)

 FCLDES     Fixed design lift coefficient.  If input, overrides
            design CL computed by EDET.

 FMDES      Fixed design Mach number.  If input, overrides
            design Mach number computed by EDET.

 XLLAM      = 0., Turbulent flow assumed
            = 1., Laminar Flow (LF) assumed as indicated below

 TRUW,TRLW  Percent LF wing upper surface, lower surface

 TRUH,TRLH  Percent LF horizontal tail upper surface, lower
            surface

 TRUV,TRLV  Percent LF vertical tail upper surface, lower surface

 TRUB,TRLB  Percent LF fuselage upper surface, lower surface

 TRUN,TRLN  Percent LF nacelle upper surface, lower surface

 TRUC,TRLC  Percent LF canard upper surface, lower surface
```

Special Option: The following parameters can be used to modify the induced drag calculated by EDET for the wing.

```
 MIKE       Switch for span efficiency reduction for extreme
            taper ratios
            = 1, A span efficiency factor (EO) is calculated
                 based on wing taper ratio and aspect ratio.
            = 0, Otherwise (Default, EO = 1.)
```

```
 E           Span efficiency factor for wing (Default = 1.0)
              > 0.3, EO = EO * E (See above)
             <= 0.3, EO = EO + E
```

The following parameters may be used to override internally computed values for wetted areas in the same manner and with the same options described in Namelist $WTIN for the weight override parameters.

```
 SWETW       Wing wetted area

 SWETH       Horizontal tail wetted area

 SWETV       Vertical tail wetted area

 SWETF       Fuselage wetted area

 SWETN       Nacelle wetted area

 SWETC       Canard wetted area
```

Takeoff and Landing Data

```
 WRATIO      Ratio of maximum landing weight to maximum takeoff
             weight (Default = WLDG/GW if WLDG is input, otherwise
             for supersonic aircraft Default = 1. - .00009*DESRNG,
             for subsonic aircraft Default = 1. - .00004*DESRNG)

 VAPPR       Maximum allowable landing approach velocity, kts
             (Default = 150.)

 FLTO        Maximum allowable takeoff field length, ft
             (Default = 12000.)

 FLLDG       Maximum allowable landing field length, ft
             (Default = FLTO)
```

The following parameters are used only for approximate takeoff and landing calculations, or, for CLTOM and CLLDM, as default values for data in Namelist $TOLIN.

```
 CLTOM       Maximum CL in takeoff configuration (Default = 2.)

 CLLDM       Maximum CL in landing configuration
             (Default = 3. or 1.69 CLAPP if it is input)

 CLAPP       Approach CL

 DRATIO      Takeoff and landing air density ratio
             (Default = 1., sea level standard day)

 ELODSS      Lift-Drag ratio for second segment climb
             (Default is internally computed)
```

```
 ELODMA     Lift-Drag ratio for missed approach climb
            (Default is internally computed)

 THRSS      Thrust per baseline engine for second segment
            climb, lb (Default = THRUST, Namelist $CONFIN)

 THRMA      Thrust per baseline engine for missed approach
            climb, lb (Default = THRSS)

 THROFF     Thrust per baseline engine for takeoff, lb
            (Default = THRSS)
```

===

Namelist $ARIDE

Data for Modification of EDET Aerodynamic Tables
(Used only if MODARO = 1 in Namelist $AERIN)
Note: Not available in the XFlops Graphical User Interface.

The namelist contains replacement data for the aerodynamic data tables in EDET. The data can be modified on an element by element basis, or entire arrays may be replaced. The arrays which can be modified with their maximum dimensions are listed below. See the EDET documentation and listing for definitions and current values.

```
     AR05 (132)
     AR1 (132)
     AR2 (132)
     AR4 (132)
     AR6 (120)
     ARS07 (110)
     ARS08 (110)
     ARS10 (110)
     ARS12 (110)
     ARS14 (110)
     ARS16 (110)
     ARS18 (110)
     ARS20 (110)
     AMDES (36)
     CMDES (32)
     HSMDES (28)
     PCW (112)
     BSUB (90)
     PCAR (170)
     BSUP (105)
     BINT (154)
     BUFT (99)
```

===

Namelist $COSTIN

Cost Calculation Data

(Used only if ICOST = 1 in Namelist $CONFIN)

Name	Default	Description
AC	350.	Airconditioning total pack air flow, lb/min
APUFLW	400.	Auxiliary power unit flow rate, lb/min
APUSHP	170.	Auxiliary power unit shaft horsepower, hp
DEPPER	14.	Depreciation period, years
DEVST	1980.	Development start time, year
DLBUR	2.0	Direct labor burden factor
DYEAR	1986	Desired year for dollar calculations
EPR	20.	Engine pressure ratio at sea level static
FAFMSP	0.1	Spares factor for production airframes
FARE	0.0	Fare, dollars per passenger per statute mile (Triggers calculation of return on investment)
FENGSP	0.3	Spares factor for production engines
FPPFT	0.5	Spares factor for prototype and flight test engines
FUELPR	0.5	Fuel price, dollars per gallon
HYDGPM	150.	Gallon per minute flow of hydraulic pumps
IACOUS	0	Acoustic treatment in nacelle =0, No =1, Yes
IBODY	0	Body type indicator =0, Narrow body =1, Wide body
ICIRC	1	Circuit indicator - fire detection =1, Single circuit =2, Dual circuit
ICOREV	1	Thrust reverser =0, No core reverser =1, Core reverser
ICOSTP	1	Type of cost calculation desired =1, Life cycle cost (LCC) =2, Acquisition cost =3, Direct operating cost (DOC) =4, Indirect operating cost (IOC)

		=5, Operating cost only (DOC + IOC - Depreciation)
IDOM	1	Operation type indicator =1, Domestic =2, International
IMUX	0	Multiplex indicator =0, No multiplex =1, Multiplex
INOZZ	1	Nozzle type indicator =1, Cascade or target type reverser with translating sleeve =2, Simple target type reverser with separate flow exhaust nozzle =3, Simple target type reverser with mixed flow exhaust nozzle =4, Separate flow engine exhaust system without thrust reverser =5, Short duct engine without thrust reverser
IPFLAG	1	Print controller for Cost Module =0, Only print major cost elements =1, Print details
IRAD	1	Indicator to include research and development =0, Ignore R & D costs =1, Include R & D costs distributed over entire program
IRANGE	1	Range indicator =0, Short range =1, Medium range =2, Long range
ISPOOL	0	Auxiliary power unit complexity indicator =0, Single spool, fixed vane APU =1, Double spool, variable vane APU
ITRAN	0	Cargo/baggage transfer operation indicator =0, Through (no transfer) operation =1, Transfer operation
IWIND	0	Windshield type indicator =0, Flat windshield =1, Curved windshield
KVA	200.	KVA rating of full-time generators (100-300)
LF	55.	Passenger load factor, percent
LIFE	14.	Number of years for Life Cycle Cost calculation

NAPU	1	Number of auxiliary power units
NCHAN	1	Number of autopilot channels (1, 2, or 3; 1 most common)
NFLTST	2	Number of flight test aircraft
NGEN	3	Number of inflight operated generators (3 or 4)
NINS	0	Number of inertial navigation systems
NPOD	4	Number of podded engines
NPROTP	2	Number of prototype aircraft
PCTFC	10.	Percent of seats for first class
PLMQT	1984.	Planned MQT (150-hour Model Qualification Test or FAA certification), year
PRORAT	15.	Manufacturers' profit rate, percent
PRPROC	0.	Prior number of engines procured
Q	100.	Airframe production quantities
RESID	2.	Residual value at end of lifetime, percent
ROI	10.	Return on investment, percent (Triggers calculation of required fare)
SFC	0.6	Engine specific fuel consumption, lb/hr/lb
TAXRAT	0.33	Corporate tax rate for ROI calculations
TEMP	1800.	Maximum turbine inlet temperature, degrees F

Mission Performance Data

The following variables have been disconnected from the mission analysis to avoid changes in airframe cost due to performance of alternate missions.

DESMCH	Design Mach number (Default = VCMN, Namelist $CONFIN)
DPRSMX	Maximum dynamic pressure, psf (Default = 460. * DESMCH)
VELOC	Cruise velocity, mph (Default = 660. * DESMCH)

The following variables are used only if no mission analysis is performed

BLOCKF		Block fuel, lb or fraction of aircraft fuel capacity (Default = 0.90 * (FULWMX+FULFMX), Namelist $WTIN)
BLOCKT		Block time, hr (Default = DESRNG/VELOC + 0.65)

Cost Technology Parameters

(1.0 = no change)

Research and Development

FAFRD	1.0	Airframe R&D
FENRD	1.0	Engine R&D

Manufacturing

FMAC	1.0	Air conditioning
FMAI	1.0	Anti-icing
FMAPU	1.0	Auxiliary power unit
FMAV	1.0	Avionics
FMBODY	1.0	Fuselage
FMCOMP	1.0	Composite materials (applied to the wing, tails, fuselage, and nacelles)
FMEL	1.0	Electrical systems
FMENG	1.0	Engine
FMENSY	1.0	Engine systems
FMFCS	1.0	Surface controls
FMFEQ	1.0	Furnishings and equipment
FMFUSY	1.0	Fuel systems
FMGEAR	1.0	Landing gear
FMHYD	1.0	Hydraulic systems
FMINS	1.0	Instruments
FMNAC	1.0	Nacelles
FMPNM	1.0	Pneumatics

FMTAIL	1.0	Tail
FMTRV	1.0	Thrust reversers
FMWING	1.0	Wing

Operating (Maintenance)

FOAC	1.0	Air conditioning
FOAI	1.0	Anti-icing
FOAPU	1.0	Auxiliary power unit
FOAV	1.0	Avionics
FOBODY	1.0	Fuselage
FOCOMP	1.0	Composite materials
FOEL	1.0	Electrical systems
FOFCS	1.0	Flight control system
FOFEQ	1.0	Furnishings and equipment
FOFUSY	1.0	Fuel systems
FOGEAR	1.0	Landing gear
FOHYD	1.0	Hydraulic systems
FOINS	1.0	Instruments
FONAC	1.0	Nacelles
FOPNM	1.0	Pneumatics
FOPROP	1.0	Propulsion system
FOWING	1.0	Wing

Economics

FEACSR	1.0	Aircraft servicing
FECFEE	1.0	Aircraft control fee
FECRW	1.0	Flight crew
FEDEP	1.0	Depreciation
FEFLTA	1.0	Flight attendants

```
 FEINS     1.0       Insurance

 FELABR    1.0       R&D labor rate

 FELDFE    1.0       Landing fee

 FEMAIN    1.0       Maintenance man hours
=================================================================
```

Namelist $ENGDIN

```
 Engine Deck Control, Scaling and Usage Data
 (Required if IANAL = 3 or 4 or INENG = 1 in Namelist $OPTION)

 Name       Description

 NGPRT      = 0, No printout of engine input data
            = 1, Print engine data tables (Default)
            = 2, Also print sorted engine input data

 IGENEN     Switch indicating source of Engine Deck
            =  1, Engine Deck to be generated, requires Namelist
                  $ENGINE and external files TFILE and IFILE (See
                  Namelist $ENGINE)
            =  0, Engine Deck follows Namelist $ENGDIN (Default)
            = -1, Engine Deck is on external file EIFILE
                  (thrust/fuel flow)
            = -2, Engine Deck is on external file EIFILE
                  (horsepower/rpm/fuel flow)  Requires Namelist
                  $ENGINE to calculate propeller performance
            = -3, Use response surfaces for engine performance -
                  available only in DOSS version

 EIFILE(i)  Name of Engine Deck external file(s) (Default =
            'ENGDEK') Used only if IGENEN = -1

 EXTFAC     Slope factor for extrapolating engine fuel flows for
            thrust levels above the maximum for that Mach number
            and altitude (Default = 1.)

 FFFSUB     Fuel flow factor for all subsonic engine points
            (Default = 1.)

 FFFSUP     Fuel flow factor for all supersonic engine points
            (Default = 1.)

 IDLE       > 0, Flight idle data will be internally generated
                 with zero thrust and an extrapolated fuel flow.
                 The fuel flow must be at least FIDMIN times the
                 fuel flow at power setting number IDLE and no
                 more than FIDMAX times the fuel flow at power
                 setting number IDLE.  If NONEG (below) = 0 and
                 negative thrusts exist, an idle power setting
                 is not generated.
            = 0, The lowest input power setting is assumed
```

```
          to be flight idle (Default, but not recommended.
          Results will be more consistent with IDLE > 0)

NONEG      = 1, Points in the Engine Deck with negative thrust
                are ignored.
           = 0, All input or generated points are used (Default)

FIDMIN     Minimum fraction of the fuel flow at power setting
           number IDLE for generated flight idle fuel flows
           (Default = 0.08)

FIDMAX     Maximum fraction of the fuel flow at power setting
           number IDLE for generated flight idle fuel flows
           (Default = 1.00)

IXTRAP     = 1, Prevents improvement in SFC and NOx rate for
                engine data extrapolated beyond altitudes
                provided in input data (Default)
           = 0, Linear extrapolation of both thrust and fuel
                flow data may result in radically improved SFC's

IFILL      = 0, No part power data will be generated
           > 0, Part power cruise data will be filled in for
                Mach-altitude points for which IFILL (or fewer)
                thrust levels have been input (Default = 2)
                For NPCODE > 1, data will be filled in for each
                specified power code that is not input for each
                Mach-altitude point.

MAXCR      Maximum power setting used for cruise (Default = 2)

NOX        = 0, NOx emissions data will not be used (Default)
           = 1, NOx emissions indices are included in the Engine
                Deck or will be generated for IGENEN > 0
           = 2, Engine Deck contains NOx emissions in lb/hr and
                will be converted to indices
           = 3, Engine Deck contains another engine parameter in
                the place of the NOx Emissions Index.  Used for
                printout and plotting only.
           If IGENEN=-2, NOx emissions data are replaced with
           engine shaft speed, rpm.

NPCODE     Number of power codes to be used in thrust and fuel
           flow tables if other than ALL.  NPCODE AND PCODE are
           used to specify a subset of the input power codes.
           If < 2, power codes (PC) in the Engine Deck will be
           ignored and all input data will be used.
           (Default = 0, Maximum = 16)

PCODE(i)   Power codes to be used in sorting the Engine Deck.
           NPCODE values are required corresponding to thrust
           levels in descending order, i.e., climb, maximum
           continuous, part power cruise settings, and flight
           idle.  Actual values are arbitrary (they are just
           used as labels), but only points in the Engine Deck
           with corresponding values for PC will be used.
           (Used if NPCODE > 1)
```

```
 BOOST      > 0., Scale factor for boost engine to be added to
                  baseline engine for takeoff and climb.  Climb
                  thrust of the boost engine in the Engine Deck
                  must be artificially increased by 100,000.
            = 0., No boost engine (Default)

 IGEO       = 0, Engine deck altitudes are geometric (Default)
            = 1, Engine deck altitudes are geopotential and
                 will be converted to geometric altitudes
```

Special Options

The fuel flow will normally be scaled linearly with the engine rated thrust. If nonlinear scaling is desired, the following two variables are available.

```
 DFFAC      Fuel flow scaling constant term (Default = 0.)

 FFFAC      Fuel flow scaling linear term (Default = 0.)
```

The engine fuel flow scale factor for ENGSKAL = THRUST/THRSO is

```
       ENGSKAL*[1. + DFFAC + FFFAC*(1. - ENGSKAL)]
```

The following 2 arrays are input only if the engine deck is being generated internally (IGENEN = 1), and the arrays generated by the cycle analysis module are not acceptable.

```
 EMACH(I)   Array of Mach numbers in descending order at which
            engine data are to be generated (Default computed
            internally, Maximum = 20, Minimum = 2, Do not zero
            fill)

 ALT(J,I)   Arrays of altitudes in descending order, one set for
            each Mach number, at which engine data are to be
            generated (Default computed internally, Maximum = 20
            per Mach number, Minimum = 2 per Mach number, Do not
            zero fill).  Altitudes and numbers of altitudes do
            not have to be consistent between Mach numbers.
```

The following variables are used only if the engine deck is to be read in, if it has the nozzle exit area in columns 71-80, and if scaling the nozzle installation drag using table look-up is desired.

```
 INSDRG     Nozzle installation drag scaling switch
            = 0, No nozzle installation drag scaling (Default)
            = 1, Scale the nozzle installation drag for changes
                 in A10
            = 2, Calculate installation drag based on A10
            = 3, Calculate installation drag for Cd = 0 at
                 A9 = A9REF
```

CDFILE	Name of the file containing the table of drag coefficients (Default = 'ENDRAG') where D/(q*A) is a function of Mach number, nozzle boattail angle and A9/A10 (used only if INSDRG is not zero).
NAB	Table number in CDFILE to be used for afterbody drag (Default = 6969, but I don't know why)
NABREF	Table number in CDFILE to be used for reference afterbody drag (Default = 6969)
A10	Maximum nozzle area, sq. in. (Required if INSDRG > 0)
A10REF	Reference maximum nozzle area, sq. in. (Required if INSDRG > 0)
A9REF	Reference nozzle exit area, sq. in. (Required if INSDRG = 3)
XNOZ	Nozzle length, in. (Required if INSDRG > 0)
XNREF	Reference nozzle length, in. (Required if INSDRG > 0)
RCRV	Nozzle radius of curvature parameter (Triggers special nozzle drag option. Default = not used)

===

ENGINE DECK

Tabular Engine Performance Data
(Required in this position if IGENEN = 0,
and from an external file if IGENEN = -1)

The Engine Deck consists of one entry for each Mach-altitude-thrust combination. From 2 to 20 distinct Mach numbers may be input with 2 to 20 altitudes per Mach number. The number of altitudes per Mach number and the altitudes themselves do not have to be consistent between Mach numbers.

For NPCODE < 2, Power codes are ignored, and up to 16 thrust levels may be input for each Mach-altitude combination. Climb thrust must be input for each Mach-altitude point, and part power cruise data must be input for at least one Mach-altitude point. If IFILL > 0, part power data will be generated for any point for which part power data are not input.

For NPCODE > 1, thrust levels at each Mach-altitude combination are ordered using the power codes input. Only points with power codes corresponding to a PCODE in Namelist $ENGDIN will be used. If not all power code entries are input for a given Mach-altitude combination, the rest will be automatically generated, but a complete set - one point for each power code - must be input for at least one Mach-altitude combination.

If IDLE > 0, flight idle data will be generated for all points. The Engine Deck is order independent, and duplicate entries are ignored. The Engine Deck is terminated with a Mach number greater than 5. There is a limit of 3000 valid entries including duplicates and the terminator.

Card Format: (F5.2, F10.0, F5.0, 3F10.0, 10X, 2F10.0)

Columns	Description
1-5	Mach number
6-15	Altitude, ft
16-20	Power code (used only if NPCODE > 1)
21-30	Gross thrust, lb Shaft power, hp (if IGENEN = -2)
31-40	Ram drag, lb Power extraction, hp (if IGENEN = -2)
41-50	Fuel flow, lb/hr
61-70	NOx Emissions Index, grams/kilogram fuel (or NOx Emissions, lb/hr or other engine parameter selected by user - See NOX, Namelist $ENGDIN, used only if NOX > 0) Engine shaft speed, rpm (if IGENEN = -2)
71-80	Nozzle exit area, sq. in. (Required only if INSDRG = 1 in Namelist $ENGDIN)

The program uses the Net thrust = Gross thrust - Ram drag.
Data appearing in unused columns are ignored.

If IGENEN = -1, this engine deck is read from an external file (See EIFILE in Namelist $ENGDIN). In this case, the first line MAY be a title card, and the terminator card with a Mach number greater than 5. is not required.

==

Namelist $ENGINE

Data for Engine Deck Generation Using the Internal Cycle Analysis Module
(Required if IGENEN = 1 or -2 in Namelist $ENGDIN. Note - Some variables in this Namelist are logical, others are not.)

Name	Description
IENG	Engine cycle definition input file indicator = 0, User defined engine cycle (See IFILE below) = 1, Turbojet (IFILE = 'TURJET', Default)

```
               = 2, Separate flow turbofan, 2 compressor components
                    (IFILE = 'TFNSEP')
               = 3, Mixed flow turbofan, 2 compressor components
                    (IFILE = 'TFNMIX')
               = 4, Turboprop (IFILE = 'TURPRP')
               = 5, Turbine bypass (IFILE = 'TBYPAS')
               = 6, Separate flow turbofan, 3 compressor components
                    (IFILE = 'TFNSP3')
               = 7, Mixed flow turbofan, 3 compressor components
                    (IFILE = 'TFNMX3')
               = 8, 3 Spool separate flow turbofan, 3 compressor
                    components (IFILE = 'TFN3SH')
               = 9, 2 Spool turbojet (IFILE = 'TURJT2')

               = 101, IC engine with input (IGENEN = -2) or
                    generated (IGENEN = 1) performance with detailed
                    propeller performance

IFILE          Name of cycle definition input file.  Used only if
               IENG = 0, but there must be an external file with the
               correct name available (See IENG above, no default).
               To generate your own engine cycle file, see the cycle
               definition manual (Cycle.man) or Reference 4.

TFILE          Name of the file containing component map tables
               (Default = 'ENGTAB').  This is a required file if the
               engine deck is to be generated.

IPRINT         Engine cycle analysis printout control.  Printout is
               on file OFILE (See below).
               =  0, Important warning messages only
               =  1, Normal output (Default, 200 - 1000 lines)
               =  2, Plus component and station data at each full
                     throttle point (2000 - 3500 lines)
               =  3, Plus component and station data at each part
                     power point and engine component tabular data
                     (2500 - 25000 lines, depending on ITHROT below)
               =  4, Plus convergence history (5000 - 35000 lines)

OFILE          Name of engine cycle analysis printout file
               (Default = 'ENGOUT').
               If OFILE = 'OUTPUT', printout will be put on the
               standard output file (Unit 6).  If IPRINT = 0 (See
               above), OFILE is set to 'OUTPUT' automatically.

GENDEK         If .TRUE., engine data will be saved on the file
               designated by EOFILE (below) as an Engine Deck for
               future use (Default = .FALSE.)

EOFILE         Name of output Engine Deck for GENDEK = .TRUE.
               (Default = 'ENGDEK', See EIFILE in Namelist $ENGDIN)

ITHROT         Controls frequency of part power data generation
               = 0, Computed at each Mach-altitude combination
               = 1, Computed only at the maximum altitude for each
                    Mach number (Default)
               = 2, Computed only once, at the maximum altitude for
```

```
                 the maximum Mach number
            Values of 1 or 2 will save over half of the engine
            generation cpu time with little impact on results,
            but IFILL must be > 0 in Namelist $ENGDIN.
```

The following 3 variables control the number of part power throttle settings generated. Since the mission analysis module can only use 16, it is recommended that the engine cycle analysis module be used to generate up to 15 and that IDLE > 0 in Namelist $ENGDIN be used to generate flight idle.

```
 NPAB       Maximum number of afterburning throttle settings for
            each Mach-altitude combination (Default = 0)

 NPDRY      Maximum number of dry (non-afterburning) throttle
            settings ( Default = 15, NPAB + NPDRY .LE. 30 )

 XIDLE      Fraction of maximum dry thrust used as a cutoff for
            part power throttle settings (Default = .05)

 NITMAX     Maximum iterations per point (Default = 50)
```

The next 6 variables define the Mach-altitude array points at which engine performance data is to be computed unless EMACH and ALT are input in Namelist $ENGDIN.

```
 XMMAX      Max Mach number (Default = VCMN, Namelist $CONFIN)

 AMAX       Max altitude, ft (Default = CH, Namelist $CONFIN)

 XMINC      Mach number increment (Default = .2)

 AINC       Altitude increment (Default = 5000.)

 QMIN       Minimum dynamic pressure, psf (Default = 150.)

 QMAX       Maximum dynamic pressure, psf (Default = 1200.)
```

```
#    Noise Data Generation

 NPRINT     Noise data print control.
            = -1, print compressor component operating line on
                  normal output file if IPRINT > 0.
            =  0, no printout (default)
            =  1, print noise data file to file named ANOPP
            =  2, print noise data file to file named FOOTPR

 IVAT       Flag for variable exit area low pressure turbine.
            Used only for estimating LPT exit area when NPRINT=1
            =  0, fixed area (default)
            =  1, variable area

 JET        FOOTPR input data generation control.
            = -1, No noise data will be generated (Default)
            =  0, No jet noise
            =  1, Calculate jet mixing/shock cell noise using the
```

```
                 original Stone/Clark model
           =  2, Calculate jet mixing/shock cell noise using the
                 improved "Kresja" model
           =  3, Calculate jet mixing/shock cell noise using
                 Stone's "ALLJET" model which includes inverted
                 velocity profile jets
           =  4, Calculate jet mixing/shock cell noise using
                 Stone's "JET181" model
           =  5, Calculate jet mixing/shock cell noise using the
                 GE M*S jet noise model
           =  6, Calculate jet noise using methods developed by
                 the SAE A-21 jet noise subcommittee - based on
                 an ANOPP module

 FTMACH    Mach number to calculate FOOTPR input data.
           (Default = 0.)

 FTALT     Altitude to calculate FOOTPR input data.
           (Default = 0. ft.)

-----------------------------------------------------------------
#    Design Point Data

 DESFN     Engine design point net dry thrust, lb
           (Default = THRUST, Namelist $CONFIN)
           Do not use the default for afterburning engines since
           THRUST is the maximum wet thrust rating.  The maximum
           wet (afterburning) thrust for the generated engine is
           transferred back to THRSO for scaling with THRUST.

 XMDES     Engine optimization point Mach number
           (Default = VCMN, Namelist $CONFIN).  XMDES and XADES
           are used for propulsion only analyses (IANAL = 4)
           and do not apply when running program enggen.

 XADES     Engine optimization point altitude, ft (Default = CH,
           Namelist $CONFIN).  If XADES < 0., it is interpreted
           as the negative of the design point dynamic pressure
           (psf), and the altitude is back-calculated with a
           minimum of 0.


(The following 5 variables are overridden if comparable data is
input in Namelist $CONFIN.)

 OPRDES    Overall pressure ratio (Default = 25.0)

 FPRDES    Fan pressure ratio (Default = 1.5, turbofans only)

 BPRDES    Bypass ratio (Turbofans only, Default is computed
           based on OPRDES, FPRDES, TTRDES, XMDES and ALDES).
           If BPRDES < -1, then the bypass ratio is computed
           such that the ratio of the fan to core jet velocities
           equals the absolute value of BPRDES.  For turbine
           bypass engines, BPRDES must be input and is defined
           as the fraction of compressor exit airflow that is
           bypassed around the main burner and the turbine.  If
```

both EBPR and BPRDES are zero, the optimum bypass ratio is computed at the design Mach number and altitude (XMDES, XADES).

TETDES	Engine design point turbine entry temperature, deg R (Default = 2500.)
TTRDES	Engine throttle ratio defined as the ratio of the maximum allowable turbine inlet temperature divided by the design point turbine inlet temperature. If TTRDES is greater than TETDES, it is assumed to be the maximum allowable turbine inlet temperature. (Default = 1.0)

Other Engine Definition Data

HPCPR	Pressure ratio of the high pressure (third) compressor. (Only used if there are three compressor components, Default = 5.)
ABURN	True if there is an afterburner (Default = .FALSE.)
DBURN	True if there is a duct burner (Separate flow turbofans only, Default = .FALSE.) ABURN and DBURN cannot both be true.
EFFAB	Afterburner/duct burner efficiency (Default = .85)
TABMAX	Maximum afterburner/duct burner temperature, deg R (Default = 3500.)
VEN	True if the exhaust nozzle has a variable flow area (Default = .FALSE.) The nozzle flow area is automatically allowed to vary for cases when the afterburner or duct burner is on.
COSTBL	Customer high pressure compressor bleed, lb/sec (Default = 1.)
FANBL	Fan bleed fraction, only used for bypass engines (Default = 0.)
HPEXT	Customer power extraction, hp (Default = 200. or 5. if IENG > 100)
WCOOL	Turbine cooling flow as a fraction of high pressure compressor mass flow. The cooling flow defaults to the value in the engine cycle definition file. If WCOOL is input greater than or equal to zero the default will be overridden. If WCOOL > 1., the turbine cooling flow fraction required to bring the turbine inlet temperature down to WCOOL will be computed.
FHV	Fuel heating value, btu/lb (Default = 18500.)

DTCE — Deviation from standard day temperature in degrees C. The deviation, as used in the cycle analysis module, is DTCE at sea level and varies to zero at ALC (see below). The design point is at standard temperature.

ALC — The altitude at which DTCE (see above) becomes zero. (Default = 10000. ft.)

YEAR — Technology availability date used to estimate compressor polytropic efficiency (Default = 1985.)

BOAT — True to include boattail drag (Default = .FALSE.) Boattail drag uses a simple empirical method based on area ratio (Ae/A10) and Mach number unless tables are included in TFILE and the engine cycle definition file (IFILE) has the correct table reference numbers (see CDAT3 in cycle.man). A10 is either input (see AJMAX) or calculated if nacelle weight and geometry calculations are performed.

AJMAX — Nozzle reference area for boattail drag, sq ft. Used only if BOAT = .TRUE. Default is the largest of
1) 1.1 times the inlet capture area
2) Nozzle exit area at the inlet design point
3) Estimated engine frontal area
4) Estimated nozzle entrance area

or

If nacelle weight and geometry calculations are performed (see NGINWT below) AJMAX is set to the nacelle cross-sectional area at the customer connect.

or

If AJMAX is less than zero, the cruise design point nozzle exit area multiplied by the absolute value of AJMAX is used as the reference.

SPILL — True to include spillage and lip drag in engine performance data (Default = .FALSE.)

The next 5 variables are used only if SPILL = .TRUE.

LIP — Compute inlet cowl lip drag (Default = .FALSE.)

BLMAX — Inlet bleed flow fraction of total flow at the inlet design point (Default = .016 * AMINDS**1.5)

SPLDES — Inlet design spillage fraction (Default = .01)

AMINDS — Inlet design Mach number (Default = XMMAX)

ALINDS — Inlet design altitude, ft (Default = AMAX)

The next 2 variables are used only for turboprops (IENG = 4)

ETAPRP — Maximum propeller efficiency (Default = 0.840). The actual propeller efficiency is based on an internal schedule of efficiency versus Mach number with the maximum efficiency (ETAPRP) occurring at a Mach number of 0.80. To use the Hamilton Standard Method set ETAPRP=1 and input the propeller characteristics as defined under "IC Engine or Propeller Performance". To use table look up for propeller performance, set ETAPRP to the table number (see cycle.man).

SHPOWA — Design point shaft horsepower divided by the design point core airflow, HP/(lb/sec) (Default = 60).

The following six variables control the engine behavioral constraints. (See Namelist $SYNTIN, G(8) to G(12) respectively.) In addition CDTMAX and CDPMAX are used during the cycle analysis as constraints on engine operation at all points in the flight envelope unless LIMCD is input as zero.

CDTMAX — Maximum allowable compressor discharge temperature, deg R (Default = 99999.).

CDPMAX — Maximum allowable compressor discharge pressure, psi (Default = 99999.).

VJMAX — (IENG < 100) Maximum allowable jet velocity, ft/sec
(IENG > 100) Propeller tip speed, ft/sec
(Default = 99999.)

STMIN — Minimum allowable specific thrust, lb/lb/sec (Default = 1.)

ARMAX — Maximum allowable ratio of the bypass area to the core area of a mixed flow turbofan (Default = 99999.)

LIMCD — Switch to use the compressor discharge temperature and pressure limits only for optimization.
- = 0, limits at the cruise design Mach number and altitude used only for optimization
- = 1, limits enforced at all points in the flight envelope (Default)
- = 2, limits the maximum compressor discharge temperature, wherever it may be in the flight envelope (use only for optimization).

Engine Weight Calculation Data

The following variables are used only if the engine weight and dimensions are to be calculated in the cycle analysis module by designing the engine components. The weight calculations in ENGGEN and FLOPS are not suitable for small engines (turboprops) that might have reverse flow combustors, gear boxes, and/or centrifugal flow compressors or turbines.

NGINWT — Switch for engine weight calculations (IENG < 100)
- = 0, none (Default)

```
           = 1 or -1, engine only
           = 2 or -2, engine and inlet
           = 3 or -3, engine, inlet and nacelle
           = 4 or -4, engine, inlet, nacelle and nozzle
Use the negative value to calculate the weight for the initial
design and then scale engine weights and dimensions with
airflow.  Zero or a negative value should always be used during
optimization with engine cycle design variables.
           The following apply if IENG > 100.
           = 0, none (Default)
           = 1, calculate total propulsion system weight
           = 2, propeller weight only
           = 3, propeller, cowl, and mounts
           = 4, propeller, cowl, mounts, and exhaust
           = 5, propeller, cowl, mounts, exhaust, and alternator

IWTPRT     Printout control for engine weight calculations.
           Printout is on file OFILE.
           = 0, No output.
           = 1, Print component weights and dimensions (Default)
           = 2, Print component design details.
           = 3, Plus initial and final optimization data.
           = 4, Print component details at each iteration.

IWTPLT     PostScript plot control for engine (and nacelle)
           schematics on file PLTFIL (See below, default = 0).
           If the negative value is input, only the final design
           will be plotted.
           = 0, No plot (Default).
           = 1, One correct aspect ratio plot of engine and
                nacelle (one page per design).
           = 2, One correct apsect ratio plot of engine only
                and one of engine and nacelle (two pages per
                design).
           = 3, 1 with full page plot (two pages per design).
           = 4, 2 with full page plot (four pages per design).

PLTFIL     Name of the PostScript plot file (Default = 'ENGPLT')

GRATIO     Ratio of the RPM of the low pressure compressor to
           the rpm of the connected fan (Default = 1).

UTIP1      Tip speed of the first compressor (or fan) in the
           flow.  Default is based on YEAR, engine type, and
           other design considerations.

RH2T1      Hub to tip radius ratio of the first compressor (or
           fan) in the flow.  Default is based on YEAR, engine
           type, and other design considerations.

IGVW       Flag for compressor inlet guide vanes
           = 0, None (default)
           = 1, Fixed
           = 2, Variable
           Use negative 1 or 2 for no IGV on the fan.

TRBRPM     The rotational speed of any free turbine (rev/min).
```

TRBAN2 is used to set the free turbine rotational speed if TRBRPM is not input. TRBRPM overrides TRBAN2. (Default = not used)

TRBAN2 — Maximum allowable AN**2 for turbine components. The input value is the actual maximum divided by 10**10. AN**2 is the flow area in square inches multiplied by the rotational speed squared and has units of in**2*RPM**2. The default is based on year.

TRBSTR — Turbine usable stress lower limit, psi. Normally when component weights are predicted, the usable stress is a function of operating conditions. For turbine components, this can be unusually low because cooling effects are not accounted for. (Default = 15000.)

CMPAN2 — Maximum allowable AN**2 for compressor components. The input value is the actual maximum divided by 10**10. AN**2 is the flow area in square inches multiplied by the rotational speed squared and has units of in**2*RPM**2. The default is based on year.

CMPSTR — Requested compressor usable stress, psi. This forces a change in compressor material when the current (lower temperature) material starts to run out of strength as temperature increases. (Default = 25000.)

VJPNLT — Weight penalty factor for a suppressor to reduce the core jet velocity to 1500 ft/sec (Default = 0.)

WTEBU — Fraction for weight of engine build up unit (pylon, mounting hardware, etc) (Default = 0.2)

WTCON — Fraction for weight of engine controls (Default = 0.05)

IC Engine or Propeller Performance

The next 6 variables are required for IC engine performance modeling (IENG=101, IGENEN=1)

NCYL — Number of cylinders (Default = 4)

DESHP — Baseline engine power, hp (Default = 180.)

ALCRIT — Critical turbocharger altitude, ft. The altitude to which turbocharged IC engines are able to maintain DESHP (Default = 0., no turbocharger)

SFCMAX — Brake specific fuel consumption at maximum power, lb/hr/hp (Default = 0.52)

SFCMIN — Minimum brake specific fuel consumption or SFC, lb/hr/hp (Default = 0.4164)

PWRMIN	Fraction of maximum power where SFCMIN occurs If NRPM > 0 and PWRMIN > 1 then PWRMIN is the rotational speed where SFCMIN occurs (recommend PWRMIN > 1 if SFCMIN is less than about 0.4; Default = 0.65)
ENGSPD	Maximum engine crankshaft speed, RPM (Default = 2700)
PRPSPD	Maximum propeller shaft speed, RPM (Default = 2700)

The next 3 variables are required for IC engine weight prediction

IWC	= 0, Air cooled (Default) = 1, Water cooled
ECID	Engine displacement, cu.in. (Default = 361.)
ECR	Engine compression ratio (Default = 8.5)

The next 10 variables are required for propeller performance modeling and weight prediction (IENG=101, IGENEN=-2)

EHT	Engine envelope height, in (Default = 19.96)
EWID	Engine envelope width, in (Default = 33.37)
ELEN	Engine envelope length, in (Default = 31.83)
NTYP	Propeller type indicator = 1, fixed pitch = 2, variable pitch (Default) = 3, variable pitch, full feathering = 4, variable pitch, full feathering, deicing = 5, variable pitch, full feathering, deicing, w/reverse = 6, ducted fan
AF	Activity factor (Default = 87.6)
CLI	Integrated design lift coefficient (Default = 0.569)
BLANG	Blade angle for fixed pitch propeller, deg
DPROP	Propeller diameter, ft. (Default = 6.375)
NBLADE	Number of blades (Default = 2)
GBLOSS	Gearbox losses, fraction (default = 0.02) If PRPSPD = ENGSPD, there are no losses.

The next 2 variables are needed if propeller performance tables are used (see "Propeller Input Data" in cycle.man)

PLDES	Design point power loading, PL = SHP/D^2
TSDES	Design point power tip speed, ft/s

The next 5 variables may be used to override the default sea
level power curve (IENG=101)

NRPM	Number of points in power curve (Maximum is 15).
ARRPM(I)	Rotational speed, rpm (descending order)
ARPWR(I)	Engine shaft power at ARRPM(I), hp
LFUUN	Fuel input type indicator = 0, Fuel flows are computed from SFCMAX, SFCMIN and PWRMIN (Default) = 1, Brake specific fuel consumption values are input in ARFUL (lb/hr/hp) = 2, Actual fuel flows are input in ARFUL (lb/hr) = 3, Actual fuel flows are input in ARFUL (gal/hr)
ARFUL(I)	Engine fuel requirements at ARRPM(I), (Required only if LFUUN is not equal to zero)

The next 3 variables are weight scale factors

FENG	Scale factor on engine weight (Default = 1.)
FPROP	Scale factor on propeller weight (Default = 1.)
FGBOX	Scale factor on gear box weight (Default = 1.)

===

Namelist $NACELL

Data for Computation of Nacelle Weights
(Required only if NGINWT in Namelist $ENGINE is not equal to 0)

```
                                /
                               /\
                              /  \               RADD - \
                             /  CLANG                   |
                            ______|______________________v_____
                           / _____________________________
   ______________________ /_/                            ^
    ^                     |                              |
    |                     |                              |  E
    |                     |                              |  N  F
    | ____________________|______ ____ ______________    |  G  A
    | ^                   |   __/ T \_____        |      |  I  C
    R | __________________|__/    H      \_____ ANGLE    |  N  E
    | |  ^              __/       R          \__/_       |  E
    | R2 |          ____/         O               \______|
    | |  R1     ____/             A                  ^
    | |  |  ___/                  T                  R3
   _v_v__v_/ _______ _ ______ _ ____ __ _ _______ _ _____v_ _ ___

         |______ X _______|__ X __|__________ X __________|
```

| 1 | 2 | 3 |

Name   Description

Computed values (DO NOT INCLUDE IN INPUT).

R   Inlet capture radius (height for 2-D)

R3   Compressor hub radius (zero for 2-D)

X3   Subsonic Diffuser length based on R2, R3, and ANGLE.

The remaining variables may be input. The default values are based on a Mach number 2.4 axisymmetric translating centerbody inlet and are used only if MIXED (see below) is greater than zero.

X1R   X1 / R (Default = 2.06). If IVAR (see below) = -1, X1R is the cowl length divided by the inlet capture radius.

X2R   X2 / R (Default = 1.58)

R1R   R1 / R (Default = .354)

R2R   R2 / R (Default = .585)

ANGLE   Average angle of the subsonic diffuser portion of the inlet between the throat and the engine face (Default = 10 degrees).

CLANG   Cowl lip angle (Default =0.).

MIXED   Inlet compression type indicator.
= -1, Inlet geometry is based solely on the geometry variables described above (Default).
= 0, Inlet geometry is based in the internal geometry data base for external compression inlets and the given inlet design Mach number.
= 1, Inlet geometry is based in the internal geometry data base for mixed compression inlets and the given inlet design Mach number.

RADD   Distance from the engine compressor tip to the exterior of the nacelle (Default = 3. in). If RADD < 1. the added radial distance is RADD times the compressor tip radius.

XNLOD   Nozzle length / diameter (Default is computed).

XNLD2   Fan nozzle length / height (Default is computed).

INAC   Nacelle type indicator
= 0, None (Default)
= 1, Axisymmetric
= 2, Two-dimensional (use -2 if two or more engines

are to be podded together)
= 3, Two-dimensional inlet / axisymmetric nozzle (use -3 if two or more engines are to be podded together)
= 4, Two-dimensional bifurcated inlet / two-dimensional nozzle (use -4 if two or more engines are to be podded together)
= 5, Two-dimensional bifurcated inlet / axisymmetric nozzle (use -5 if two or more engines are to be podded together)

IVAR — Variable geometry switch used to estimate weight factor WTCB1 described below
=-1, Fixed geometry inlet (no centerbody) (See X1R above.)
= 0, Fixed geometry inlet (with centerbody)
= 1, Translating centerbody (Default)
= 2, Collapsing centerbody
= 3, Translating and collapsing centerbody

NVAR — Variable geometry switch used to estimate weight factor WTNOZ described below
= 0, Fixed geometry nozzle (Default)
= 1, Variable area throat
= 2, Variable area exit
= 3, Variable area throat and exit
= 4, Fixed geometry plug core nozzle and fixed geometry fan nozzle (typical subsonic transport installation)

The following weighting factors are multiplied by the surface area of the applicable inlet section to predict inlet weight. The defaults are based on the internal materials data base and the maximum cruise Mach number.

WTCB1 — Weighting factor for the inlet centerbody up to the throat

WTCB2 — Weighting factor for the inlet centerbody from the throat to the engine face

WTINT — Weighting factor for the internal cowl up to the engine face

WTEXT — Weighting factor for the external nacelle

WTNOZ — Weighting factor for the nozzle

The remaining variable is only used for 2-D nacelles (INAC = 2).

H2W — Inlet height to width ratio for 2-D inlets (Default = 1.0)

==

Namelist $MISSIN

Performance Controls and Factors and Mission Segment Definition
(Required if IANAL = 3 in Namelist $OPTION)

(All defaults = 0. unless otherwise noted)

Name	Description
INDR	= 0, DESRNG (Namelist $CONFIN) is in n.mi. (Default) = 1, Endurance mission - DESRNG is in minutes
FACT	Factor to increase or decrease fuel flows (Default = 1.) Cumulative with FFFSUB and FFFSUP in Namelist $ENGDIN.
FLEAK	Constant delta fuel flow, lb/hr
FCDO	Factor to increase or decrease lift-independent drag coefficients (Default = 1.)
FCDI	Factor to increase or decrease lift-dependent drag coefficients (Default = 1.)
FCDSUB	Factor to increase or decrease all subsonic drag coefficients (Default = 1.) Cumulative with FCDO and FCDI.
FCDSUP	Factor to increase or decrease all supersonic drag coefficients (Default = 1.) Cumulative with FCDO and FCDI.
ISKAL	Special option used to turn off engine scaling = 1, If engine is to be scaled using THRUST/THRSO (Default) = 0, If engine scaling is to be ignored
OWFACT	Factor for increasing or decreasing OWE (Default = 1.)
IFLAG	= 0, Prints mission summary data only (Default) = 1, Plus details of cruise optimization = 2, Plus climb and descent profiles (More complete data is available with MSUMPT = 1) = 3, Plus scaled engine data
MSUMPT	= 1, Detailed mission summary will be calculated and printed = 0, Otherwise (Default)
DTC	Deviation from standard day temperature in degrees C (See also DTCT in Namelist $TOLIN and DTCE in Namelist $ENGINE. These temperature deviations are independent.)
IRW	= 1, Calculates ramp weight with fixed range = 2, Fixed ramp weight, calculates range (Default)

RTOL	Tolerance in range calculation for IRW = 1, n.mi. (Default = .001)
NHOLD	Special option - Time for segment NHOLD (which must be a Hold Segment) is adjusted until the specified range is met for the input ramp weight (Default = 0, Normal operation) Note - IRW must be 1
IATA	= 1, Range is adjusted for ATA Traffic Allowance (Default) = 0, Otherwise
TLWIND	Velocity of tail wind, kts (Default = 0.) (Input negative value for head wind)
NPCON	Number of performance constraints - primarily for fighters. Requires a Namelist $PCONIN for each constraint. (Default = 0, Maximum = 30)
DWT	Gross weight increment for performance tables, lb (Default is internally computed)
OFFDR(I)	Off design range, n.mi. (up to 10 values) Note: This simply performs the defined mission with the sized airplane with a different design range. If more changes are desired or if additional analyses are required (e.g., cost analysis), use Namelist $RERUN. If OFFDR is used with a cost analysis, costs will be computed for the last design range.
IDOQ	= 1, Drag increments are in the form of D/q, ft2 = 0, Drag increments are drag coefficients (Default)

Combat Radius Mission - Iterates until outbound leg and inbound leg are equal. IRW must be equal to 2, and there must be at least two cruise segments. Triggered by NSOUT > 0

NSOUT	Last segment number in outbound leg (Default = 0, radius is not calculated)
NSADJ	Cruise segment in outbound leg to be adjusted for radius calculation (Default = NSOUT) Note: Make sure that the NSADJ Cruise segment is terminated on total rather than segment distance in the Mission Definition Data.
MIRROR	Cruise segment in inbound leg to be set equal to segment NSADJ (Default = 0, only total leg lengths are forced to be equal). This option would be used for a high-low-low-high mission where the dash in and dash out are unknown but must be equal to each other. NSADJ would be the dash in segment number, and MIRROR would be the dash out segment number.

Store Drags (When a variable drag increment is required)

```
 STMA(I,J)  Mach number schedule, up to 20 (I) Mach numbers
            for up to 10 (J) conditions

 CDST(I,J)  Corresponding drag coefficients or D/q's
            (See IDOQ above)

 ISTCL(K)   Store drag condition applied to climb schedule K
            = 0, No store drag for climb schedule K

 ISTCR(K)   Store drag condition applied to cruise schedule K
            = 0, No store drag for cruise schedule K

 ISTDE      Store drag condition applied to descent schedule
            = 0, No store drag for descent schedule
```

Store drags can also be assessed in ACCEL and TURN segments of the mission as covered in the Segment Definition Cards section, in PS and NZ plots (see Namelist $OPTION), and in performance constraints (see Namelist $PCONIN)

User-Specified Weights

```
 Mywts      Weight input switch, overrides value input in
            Namelist $WTIN.  For the XFLOPS Graphical Interface
            it must be mixed case as shown.
            = 0, Weights will be computed
            = 1, The following four parameters will be used
                 in mission analysis

 RAMPWT     Gross weight before taxi out, lb
            (Default = DOWE + PAYLOD + FUEMAX)

 DOWE       Fixed operating weight empty, lb

 PAYLOD     Fixed payload weight, lb

 FUEMAX     Total usable fuel weight, lb
            FUEMAX = RAMPWT - DOWE - PAYLOD
            Required only if RAMPWT is not input
```

Ground Operations and Takeoff and Approach Allowances

```
 TAKOTM     Takeoff time, min

 TAXOTM     Taxi out time, min

 APPRTM     Approach time, min

 APPFFF     Approach fuel flow factor applied to sea level static
            idle fuel flow (Default = 2.)

 TAXITM     Taxi in time, min
```

NDKTO   Engine deck number used for takeoff and taxi for ITTFF > 0 (Default = 1)

ITTFF   > 0, Engine deck power setting for takeoff.
(Usually = 1 if specified)
Taxi fuel flow is sea level static idle.
= 0, Use the following two variables (Default)

TAKOFF   Takeoff fuel flow, lb/hr/engine

TXFUFL   Taxi fuel flow, lb/hr/engine

Fixed Values for Above Allowances - These values override values calculated from the above variables and are not scaled with engine thrust.

FTKOFL   Fixed takeoff fuel, lb

FTXOFL   Fixed taxi out fuel, lb

FTXIFL   Fixed taxi in fuel, lb

FAPRFL   Fixed approach fuel, lb

Turn Segment Limits

XNZ(I)   Maximum turn load factor at the Ith Mach number, g's

XCL(I)   Maximum turn lift coefficient at the Ith Mach number

XMACH(I)   Mach number array corresponding to both XNZ and XCL

If a single value is input for XNZ and/or XCL, the limit is applied to the entire Mach number range. If either is specified at multiple Mach numbers, XMACH must be input.

Climb Schedule Definition

Tabular data for each defined climb schedule are generated. The sequence in which the schedules are flown is defined in the next section. These schedules are building blocks used in mission definition.

NCLIMB   Number of climb schedules to be defined
(Default = 1, Maximum = 10, Include reserve climb)

Note: Separate climb schedules are not required if the only changes are in the minimum or maximum Mach number or altitude. Just make sure all climbs are bracketed.

The following data are subscripted to correspond to the appropriate climb schedule.

CLMMIN(I) Minimum Mach number (Default = .3)

```
 CLMMAX(I)  Maximum Mach number
            (Default = VCMN, Namelist $CONFIN)

 CLAMIN(I)  Minimum altitude, ft

 CLAMAX(I)  Maximum altitude, ft (Default = CH, Namelist $CONFIN)

 NINCL(I)   Number of climb steps (Default = 31 = Maximum)

 FWF(I)     Climb profile optimization function control parameter
            Recommended aircraft in parentheses.
            (Default = -.001)
            =  1., minimum fuel-to-distance profile (Subsonic
                   transports, do NOT use for supersonic
                   transports)
            =  0., minimum time-to-distance profile
                   (Interceptors only)
            1. > FWF > 0., combination of the above
            = -.001, minimum time-to-climb profile (Fighters)
            = -1., minimum fuel-to-climb profile (Supersonic
                   transports, Subsonic transports)
            -1. < FWF < -.001, combination of the above

 NCRCL(I)   Number of the cruise schedule to be used in fuel- or
            time-to-distance profile climb optimization
            comparisons (Default = 1)

 CLDCD(I)   Drag coefficient increment applied to the Ith climb
            schedule.  If coefficient varies with Mach number,
            see ISTCL above.

 IPPCL(I)   Number of power settings to be considered for climb.
            Program will select the most efficient.  Should be
            used only with afterburning engines for minimum fuel
            climb profiles.  (Default = 1, full thrust only)

 MAXCL(I)   Maximum power setting used for climb (Default = 1)

 NDKCL(I)   Engine deck number used for climb (Default = 1)

Input Climb Schedules

 NO(I)      Number of input climb altitudes and speeds
            (Maximum = 20)
            = 0, Climb profile will be optimized (Default)

 ACTAB(J,I) Altitude schedule, ft
            (NO(I) values for the Ith climb schedule)

 KEASVC     = 1, VCTAB is in knots equivalent airspeed (keas)
            = 0, VCTAB is true airspeed or Mach number (Default)

 VCTAB(J,I) Climb speed schedule, kts, keas or Mach number
            (NO(I) values for the Ith climb schedule)

Note:  For NO(I) > 0, if only part of the climb profile is
```

specified, the portion of the profile outside the energy range defined by values of ACTAB and VCTAB will be optimized for the Ith climb schedule. Also, if VCTAB is input in keas during a rerun, KEASVC must be reinput = 1.

The following parameters apply to all climb and descent schedules

```
 IFAACL     = 0, Climb at optimum speed
            = 1, Climb speed limited by the FAA to a maximum of
                 250 knots calibrated airspeed below 10,000 ft
                 (Default)
            = 2, Climb to 250 kcas at 1500 ft and then to SPDLIM
                 (See below) at 10,000 ft

 IFAADE     = 0, Descend at optimum speed
                 (Default if IFAACL = 0)
            = 1, Descent speed limited by the FAA to a maximum of
                 250 knots calibrated airspeed below 10,000 ft
                 (Default if IFAACL > 0)

 NODIVE     = 0, Program will select the optimum altitude
                 for each energy level.  (Default)
            = 1, Minimum rate of climb limit (see DIVLIM below)
                 will be enforced

 DIVLIM     Minimum allowable rate of climb or descent, ft/min
            (Default = 0.)  Enforced only if NODIVE = 1, may be
            negative to allow a shallow dive during climb.

 QLIM       Constant dynamic pressure limit, psf.  Applied at all
            climb and descent points not covered by the variable
            dynamic pressure limit below.  (Default = no limit)

 SPDLIM     Maximum speed at 10,000 ft, used only for IFAACL = 2,
            kts or Mach number (Default is computed from a) the
            variable dynamic pressure limit below, if applicable,
            b) QLIM above, if QLIM > 0., or c) a dynamic pressure
            of 450 psf, in that order)
```

Variable dynamic pressure limit during climb and descent

```
 NQL        Number of altitudes for q limit schedule
            (Default = 0 - QLIM is used, Maximum = 20 )

 QLALT(I)   Altitudes in increasing order, ft
            (QLIM is used outside the altitude range defined)

 VQLM(I)    Corresponding dynamic pressure limits, psf
```

Cruise Schedule Definition

Tabular data for each defined cruise schedule are generated. The sequence in which the schedules are flown is defined in the next section. Cruise schedules are used for either cruise or hold segments and can be used as many times as desired and in any order. They are building blocks used in mission definition.

NCRUSE — Number of cruise schedules to be defined (Default = 1, Maximum = 15, Include reserve cruise)

The following data are subscripted to correspond to the appropriate cruise schedule.

IOC(I) — Cruise option switch
- = 0, optimum altitude and Mach number for specific range
- = 1, fixed Mach number, optimum altitude for specific range (Default)
- = 2, fixed Mach number at input maximum altitude or cruise ceiling
- = 3, fixed altitude, optimum Mach number for specific range
- = 4, fixed altitude, optimum Mach number for endurance (minimum fuel flow)
- = 5, fixed altitude, constant lift coefficient (CRCLMX)
- = 6, fixed Mach number, optimum altitude for endurance
- = 7, optimum Mach number and altitude for endurance
- = 8, maximum Mach number at input fixed altitude
- = 9, maximum Mach number at optimum altitude
- =10, fixed Mach number, constant lift coefficient (CRCLMX)

If the defined or optimized cruise point is unacceptable due to rate of climb ceiling (RCIN below) or minimum or maximum altitude (HPMIN or HPMAX below), the Mach number will be held constant and the altitude will be varied until all constraints are met.

CRMACH(I) — Maximum or fixed Mach number (or velocity, kts) (Default = VCMN, Namelist $CONFIN)

CRALT(I) — Maximum or fixed altitude, ft (Default = CH, Namelist $CONFIN)

CRDCD(I) — Drag coefficient increment

FLRCR(I) — Specific range factor for long range cruise Mach number - used if IOC = 3 (Default = 1., Typical value = .99)

CRMMIN(I) — Minimum Mach number

CRCLMX(I) — Maximum or fixed lift coefficient

HPMIN(I) — Minimum cruise altitude, ft (Default = 1000.) For fixed Mach number cruise schedules, HPMIN can be used to enforce a dynamic pressure (Q) limit.

NDKCR(I) — Engine deck number used for cruise (Default = 1)

If NOX > 0 in Namelist $ENGDIN, cruise profiles may be optimized to minimize NOx emissions instead of just fuel. The following variables control the relative importance of fuel vs. NOx.

```
 FFUEL(I)   Fuel factor in cruise profile optimization
            (Default = 1.)

 FNOX(I)    NOx emissions factor in cruise profile optimization
            (Default = 0.) Since for supersonic engines the NOx
            emissions are on the order of 1 - 3 percent of fuel,
            FNOX should be relatively large (30. - 100.) to get
            comparable weighting.
```

Feathered Engines During Cruise

```
 IFEATH(I)  = 1, Engines may be feathered during cruise to
                 improve performance
            = 0, Otherwise (Default)
            =-1, Engines must be feathered (Engine out condition)

 FEATHF(I)  Fraction of engines remaining after feathering
            (Default = 0.5)

 CDFETH(I)  Drag coefficient increase due to feathered engines.
```

The following parameters apply to all cruise schedules:

```
 DCWT       Weight increment used to compute cruise tables, lb
            (Default = the greater of 1. or DWT/20)

 RCIN       Instantaneous rate of climb for ceiling
            calculation, ft/min (Default = 100.)
```

Special Option - For step cruise mode, the user defines a series of constant altitude cruise schedules at increasing altitudes - for example, at 27000, 31000, 35000 and 39000 feet. The FREE segment is then flown using the cruise schedule with the best specific range at that weight. As the fuel burns off, the optimum altitude increases and the aircraft climbs to the next altitude. The following parameters are used only if the FREE segment is flown in step cruise mode.

```
 ISTPCR     Step cruise switch
            = 1, The FREE segment is flown in step cruise mode
            = 0, Otherwise (Default)

 ICLN       Number of the climb schedule to be used for climbs
            in between constant altitude step cruise segments
            (Default = 1)

 STPMIN     Minimum range for last step cruise segment
            (Default = 300 n.mi.)
```

Special Option - For some low sonic boom configurations, the maximum allowable altitude is a function of aircraft weight. This option is triggered by input of the following arrays which apply to all cruise schedules.

```
 WTBM(J)    Array of weights, lb (Maximum = 50, Minimum = 2, must
            be in ascending order) Since linear interpolation/
            extrapolation is used, data should cover the entire
            expected weight range. (Default = not used)

 ALTBM(J)   Corresponding array of maximum altitudes, ft
```

Descent Schedule Definition

(IFAACL and QLIM apply here as well as in climb)

```
 IVS        Descent option switch
            = 0, no descent time, distance or fuel
            = 1, descent at optimum lift-drag ratio (Default)
            = 2, descent at constant lift coefficient

 DECL       Descent lift coefficient for IVS = 2 (Default = .8)

 DEMMIN     Minimum Mach number (Default = .3)

 DEMMAX     Max Mach number (Default = VCMN, Namelist $CONFIN)

 DEAMIN     Minimum altitude, ft

 DEAMAX     Max altitude, ft (Default = CH, Namelist $CONFIN)

 NINDE      Number of descent steps (Default = 31 = Maximum)

 DEDCD      Drag coefficient increment applied to descent

 RDLIM      Limiting or constant rate of descent, ft/min
            Must be negative (Default = -99999)

 NDKDE      Engine deck number used for descent (Default = 1)
```

Input Descent Schedule

```
 NS         Number of input descent altitudes and speeds
            (Maximum = 20)

 ADTAB(J)   Descent altitude schedule, ft (NS values)

 KEASVD     = 1, VDTAB is in knots equivalent airspeed (keas)
            = 0, VDTAB is true airspeed or Mach number (Default)

 VDTAB(J)   Descent speed schedule, kts, keas or Mach number
            (NS values)
```

Note: For NS > 0, if only part of the descent profile is specified, the portion of the profile outside the energy range defined by values of ADTAB and VDTAB will be optimized for the

```
descent schedule.  Also, if VDTAB is input in keas during a
rerun, KEASVD must be reinput = 1.

-----------------------------------------------------------------
#    Reserve Segment Definition

 IRS        Reserve fuel calculation switch
            = 1, Reserves at calculated reserve fuel for trip to
                 alternate airport plus RESRFU and/or RESTRP
            = 2, Reserves at constant values (RESRFU and/or
                 RESTRP) only (Default)
            = 3, Special Option - Reserve fuel is what is left
                 over after primary mission has been flown

 RESRFU     > 1., Fixed reserve fuel, lb
            < 1., Reserve fuel as a fraction of total usable fuel
                  weight

 RESTRP     Reserve fuel as a fraction of total trip fuel weight

 RESRPW     > 1., Fixed reserve alternate energy
            < 1., Reserve alternate energy as a fraction of
                  POWMAX

 RPWTRP     Reserve alternate energy as a fraction of total trip
            alternate energy used

 TIMMAP     Missed approach time, min

 ALTRAN     Range to alternate airport, n.mi.
            (Default = 0, no reserve mission)

 NCLRES     Climb schedule number used in reserve mission
            (Default = 1)

 NCRRES     Cruise schedule number used in reserve mission
            (Default = 1)

 SREMCH     Start reserve Mach number (Default = CLMMIN (NCLRES))

 EREMCH     End reserve Mach number (Default = DEMMIN)

 SREALT     Start reserve altitude (Default = CLAMIN(NCLRES))

 EREALT     End reserve altitude (Default = DEAMIN)

 HOLDTM     Reserve holding time, min

 NCRHOL     Cruise schedule number for hold (Default = NCRRES)

 IHOPOS     Hold position switch
            = 0, Hold occurs between main mission descent and
                 missed approach
            = 1, Hold occurs at end of reserve cruise (Default)
            = 2, Hold occurs at end of reserve descent

 ICRON      = 0, Climb-cruise-descend to alternate airport
```

```
            = 1, Climb-cruise-beam down to alternate airport
            = 2, Cruise only to alternate airport
```

If a second reserve hold segment or a reserve hold segment based on flight time is desired, the following variables may be used to define a hold segment between main mission descent and missed approach.

```
 THOLD      > 1., Reserve holding time, min
            < 1., Fraction of flight time to be used as reserve
                  holding time.  (Effective only if IRW = 1)
            = 0., This option is ignored (Default)

 NCRTH      Cruise schedule number for THOLD (Default = 1)
```

===

MISSION DEFINITION DATA

Main Mission Flight Sequence Definition
(Required if IANAL = 3 in Namelist $OPTION)

Climb, cruise, and descent schedules were defined in Namelist $MISSIN along with a complete definition of the reserve mission. These schedules are now combined with other segments to define the main mission. The segments available are defined below. They can be sequenced in almost any logical order. The deck must start with a START card and end with an END card. The first segment will usually be a CLIMB and the last will be a DESCENT. If the first segment is not CLIMB, a starting Mach number and altitude should be input on the START card. If the last segment is not DESCENT, an ending Mach number and altitude should be input on the END card.

It is no longer necessary for all CLIMB segments to be followed by a CRUISE or HOLD segment, and DESCENT segments to be preceded by a CRUISE or HOLD segment. If the segment following a CLIMB or preceding a DESCENT does not have a specified Mach number and altitude, data from the "free" segment (see below) will be used. Continuity in Mach number, altitude and energy is maintained wherever possible.

There is a "recharge" capability available for non-fuel burning propulsion systems, for example, solar panels to recharge the battery for an electric propulsion system. The recharge rate can be entered in columns 71-80 of any segment definition card.

Segment Definition Cards (Maximum of 40)

```
 Columns    Contents

  1-4       STAR (Start mission)
 11-20      Starting Mach number (Default = CLMMIN for first
              climb segment)
 21-30      Starting altitude, ft (Default = CLAMIN for first
```

climb segment)

1-4	CLIM (Climb)
9-10	Climb schedule number (Default = 1)
11-30	Not used
31-40	Starting Mach number (Default = ending Mach number for previous segment or START card)
41-50	Starting altitude, ft (Required if starting Mach number is specified)
71-80	Recharge rate for non-fuel burning propulsion system

1-4	CRUI (Cruise)
8	Cruise segment termination criterion = 0, cruise terminates on distance (Default) = 1, cruise terminates on fuel burned - This would be used to terminate cruise when external fuel is exhausted in order to drop the external tank.
9-10	Cruise schedule number (Default = 1)
11-20	Total distance (or fuel burned) at the end of this cruise segment, n.mi. Required for all but the "free" cruise segment (see notes below)
21-30	Distance (or fuel burned) for this segment only. If input, overrides data input in columns 11-20.
71-80	Recharge rate for non-fuel burning propulsion system

1-4	REFU (Refuel)
11-20	Fuel added, lb (If the maximum usable fuel, FUEMAX, would be exceeded, fuel is just topped off)
21-30	Time required, min
31-40	Mach number (Default = ending Mach number for previous segment)
41-50	Altitude, ft (Default = ending altitude for previous segment)
71-80	Recharge rate for non-fuel burning propulsion system

1-4	RELE (Release)
11-20	Weight of payload released, lb
31-40	Mach number (Default = ending Mach number for previous segment)
41-50	Altitude, ft (Default = ending altitude for previous segment)

1-4	ACCE (Accelerate)
6	Engine deck number for this segment
7-8	Number of store drag condition to be applied to this segment
10	Acceleration power setting (Default = 1, max power)
11-20	Ending Mach number
21-30	Not used
31-40	Starting Mach number (Default = ending Mach number for previous segment) If this is input, distance is not included in mission range.
41-50	Altitude, ft (Default = ending altitude for previous segment)
51-60	Drag coefficient increment
61-70	Weight specified for point performance. If this is input, distance is not included in mission range.

71-80	Recharge rate for non-fuel burning propulsion system

1-4	TURN (Sustained turn solution is for instantaneous condition, i.e., weight at start of turn. For long turns, use multiple turns.)
6	Engine deck number for this segment
7-8	Number of store drag condition to be applied to this segment
10	Power setting for max G turn (Default is specified G turn)
11-20	Turn arc, deg
21-30	Turn acceleration, G's (Not used if power setting is specified. If used, must be > 1.0)
31-40	Starting Mach number (Default = ending Mach number for previous segment)
41-50	Altitude, ft (Default = ending altitude for previous segment)
51-60	Drag coefficient increment
61-70	Weight specified for point performance
71-80	Recharge rate for non-fuel burning propulsion system

1-4	COMB (Combat - Specify a time at a power setting. No distance credit or acceleration/deceleration.)
6	Engine deck number for this segment
10	Power setting
11-20	Time, minutes
31-40	Mach number (Default = ending Mach number for previous segment)
41-50	Altitude, ft (Default = ending altitude for previous segment)
71-80	Recharge rate for non-fuel burning propulsion system

1-4	HOLD (Hold - Specify a time using a cruise schedule. No distance credit.)
9-10	Cruise schedule number (Default = 1)
11-20	Holding time, min
71-80	Recharge rate for non-fuel burning propulsion system

1-4	DESC (Descent)
71-80	Recharge rate for non-fuel burning propulsion system
	Military (instantaneous) descents are not defined as segments except for the final descent. In these cases, flight path continuity is not maintained. Each segment is started at its own altitude without regard to the previous segment.

1-3	END (End mission)
11-20	Ending Mach number (Default = DEMMIN)
21-30	Ending altitude (Default = DEAMIN)

Notes on the "free" segment. FLOPS flies missions from both ends meeting in the middle at the "free" CRUISE segment. It starts with the ramp weight, subtracts taxi out and takeoff allowances, and then climbs, cruises, etc. until the start of the free segment is reached. It then goes to the other end of the mission and starts with the zero fuel weight, adds the reserve fuel, and then descends, cruises, etc. in reverse until the back end of the free segment is reached. The difference in fuel between the start and end of the free segment is then used to determine the free segment cruise distance. The free segment is usually the highest energy (altitude or Mach number) segment and should not have a defined distance. CRUISE segments after the free segment must have a negative distance indicated, the distance from the end of the mission to the start of that segment. CLIMB segments may not follow the free segment, and DESCENT segments may not precede the free segment.

===

Namelist $PCONIN

Performance Constraint Definition

This namelist is input NPCON (see Namelist $MISSIN) times, once for each fighter performance constraint to be defined. Currently, there are 13 types of constraint which may be defined. Each type of constraint may be used multiple times, but the total must be no more than thirty.

Name	Description
CONALT	Altitude at which constraint is to be evaluated, ft (Default = value from preceding constraint)
CONMCH	Velocity at which constraint is to be evaluated, kts If less than or equal to 5., assumed to be Mach number (Default = value from preceding constraint)
CONNZ	Load factor (Nz) at which constraint is to be evaluated, G's (Default = value from preceding constraint or 1.)
CONPC	Engine power setting parameter < 1., Fraction of maximum available thrust = 1., Maximum thrust at this Mach number and altitude > 1., Power setting for engine deck (3. would indicate the third highest thrust) (Default = value from preceding constraint or 1.)
NEO	Number of engines operating (Default = all)
ICSTDG	Number of store drag schedule (see Namelist $MISSIN) to be applied to this constraint (Default = value from preceding constraint or 0)
NDKCON	Number of engine deck to be used for this constraint (Default = value from preceding constraint or 1)

There are three ways to input the weight at which the constraint is to be evaluated. They are listed in the order of precedence.

```
(Default = value from preceding constraint)

 CONWT       Fixed weight, lb

  -or-

 ICONSG      Weight at start of mission segment ICONSG is used

  -or-

 CONFM       Fuel multiplier or fraction of fuel burned

 CONWTA      Delta weight

 where       Weight = RAMPWT - CONFM * FUEMAX + CONWTA


The type of constraint is indicated by ICONTP, and the limiting
or target value for the performance indicator being constrained
is CONLIM.  In some cases, an additional parameter (CONAUX) is
required.  These variables are explained below.
(Defaults = values from preceding constraint)

 ICONTP      CONLIM Definition

    5        Minimum acceptable climb rate, ft/min

    6        Maximum acceptable Time-to-Climb, min
             (CONAUX = Mission segment number, not including START
             if positive, cumulative time to end of segment CONAUX
              - does not include TAXI and TAKEOFF times -
             if negative, time for segment -CONAUX only.)

    7        Maximum acceptable Time-to-Distance, min
             (CONAUX = Mission segment number, see above)

    8        Minimum acceptable sustained load factor (Nz), G's
             (no loss of energy)

    9        Minimum acceptable instantaneous load factor
             (Nz), G's (CONAUX = Maximum lift coefficient, CLmax)

   10        Minimum acceptable turn rate, deg/sec

   11        Maximum acceptable turn radius, ft

   12        Minimum acceptable excess energy (Ps), ft/sec
             (Changed from ft/min 6/5/97)

   13        Minimum acceptable climb ceiling, ft
             (CONAUX = limiting rate of climb, ft/min)

   16        Maximum acceptable acceleration or deceleration time
             from CONMCH to CONAUX, minutes
             (CONAUX = ending velocity, knots or Mach number.
             If CONAUX = 0., CONLIM = minimum acceptable
             acceleration, ft/sec/sec)
```

17 Minimum acceptable maximum speed, kts or Mach number

20 Minimum acceptable energy bleed rate at the maximum instantaneous load factor, ft/min (usually negative) (CONAUX = Maximum lift coefficient, CLmax)

30 Minimum acceptable thrust margin, lb

A more complete description of these constraints may be found in the Constraint Description section of the User's Guide.

===

AERODYNAMIC DATA

User Supplied Aerodynamic Drag Polar Data
(Input only if MYAERO > 0 in Namelist $AERIN. If MYAERO = 3, Namelist $RFHIN is input instead of Cards 1 through 4 in that position to define the lift dependent drag.)

Card 1: Format (I3, I4)

NMD - Number of Mach numbers in lift dependent drag polars
(Must be at least 3)
NCD - Number of CL's in lift dependent drag polars
(Must be at least 3)

Limit: (NMD+1)*(NCD+1) must be less than or equal to 500

Card(s) 2: Format (10F8.1)

MD(I), I = 1, NMD - Mach numbers in increasing order

Card(s) 3: Format (10F8.1)

CL(J), J = 1, NCD - CL's in increasing order

Card(s) 4: Format (10F8.1)

[CD (J, I), J = 1, NCD], I = 1, NMD
Lift dependent drag coefficients - Start a new line for each Mach number only if IBO = 1 in Namelist $AERIN

Card 5: Format (I3, I4)

NAP - Number of altitudes for lift independent drag
(Must be at least 3)
NMP - Number of Mach numbers for lift independent drag
(Must be at least 5)

Limit: (NAP+1)*(NMP+1) must be less than or equal to 400

Card(s) 6: Format (10F8.1)

AP(I), I = 1, NAP - Altitudes in increasing order

Card(s) 7: Format (10F8.1)

  MP(J), J = 1, NMP - Mach numbers in increasing order

Card(s) 8: Format (10F8.1) Input only if MYAERO = 1 or 3.

  [CDP (J,I), J = 1, NMP], I = 1, NAP
     Lift independent drag coefficients - Start a new line for
     each altitude only if IBO = 1 in Namelist $AERIN

Card(s) 9: Format (10F8.1) Input only if IWAVE = 1 in
            Namelist $AERIN

  CDWAV (J), J = 1, NMP
     Wave drag coefficients (added to CDP if MYAERO = 1)

===

Namelist $ASCLIN

Scaling Data for Lift Independent Drag
(Input only if MYAERO = 2. All defaults = 0. unless otherwise
noted)

Name	Description
SREF	Wing area on which aerodynamic input is based, ft2 (Default = SW, Namelist $CONFIN) If different from SW, aerodynamics will be scaled.
TREF	Engine thrust corresponding to nacelle size used in generating aerodynamic input data, lb (Default = THRUST, Namelist $CONFIN) If different from THRUST, aerodynamic data will be modified.
AWETT(I)*	Total wetted area/SREF
AWETW(I)*	Wing wetted area/SREF
AWETN	Nacelle wetted area/SREF
ELTOT	Total configuration length, ft (Default = fuselage length)
ELW(I)*	Total length of exposed wing, ft
VOLTOT	Total configuration volume, ft3
VOLW(I)*	Total volume of exposed wing, ft3
FORM(I)*	Subsonic form factor for total configuration
EQL(I)*	Equivalent friction length for total baseline configuration, ft. If EQL is omitted, skin friction drag is computed from component data

CDWAV	Wave drag coefficients (NMP values)
DCDNAC	Delta wave drag coefficients, nacelles on - nacelles off (NMP values)

*For variable geometry aircraft, up to NMP values may be input. The arrays are filled with the last value input.

===

Namelist $RFHIN

Aerodynamic Data for Parabolic Drag Polars
(Input in place of Cards 1 through 4 if MYAERO = 3.
All defaults = 0. unless otherwise noted)

Name	Description
MMACH	Number of Mach numbers (Default = Minimum = 2, Maximum = 30)
TMACH(I)	MMACH Mach numbers in increasing order
CDMIN(I)	Minimum drag for each of MMACH Mach numbers
CK(I)	Drag-due-to-lift factors for each Mach number
CLB(I)	Lift coefficients corresponding to each CDMIN(I)
C1SW(I)	Coefficient for wing area term for each Mach number. May be a drag coefficient or D/Q depending on the values of REFAS, REFBS and EXPS.
REFAS	Wing area reference value (Default = 1.)
REFBS	Wing area base value (Default = 0.)
EXPS	Wing area term exponent (Default = 1.)
C1TH(I)	Coefficient for thrust term for each Mach number. May be a drag coefficient or D/Q depending on the values of REFAT, REFBT and EXPT.
REFAT	Thrust reference value (Default = 1.)
REFBT	Thrust base value (Default = 0.)
EXPT	Thrust term exponent (Default = 1.)

The lift dependent drag coefficient for the Ith Mach number is computed from:

```
CD = CDMIN(I) + CK(I) * [CL - CLB(I)] ** 2
     + C1SW(I) * (SW/REFAS - REFBS) ** EXPS
     + C1TH(I) * (THRUST/REFAT - REFBT) ** EXPT
```

where SW and THRUST are the current values for the wing area and for the thrust per engine, and CL is the lift coefficient.

==

Namelist $TOLIN

Detailed Takeoff and Landing Data
(Used only if ITAKOF, ILAND and/or NOPRO = 1 in Namelist $OPTION)

Name	Description
APA	Airport Altitude, ft (Default = 0.)
DTCT	Delta temperature from standard day, deg C (Default = 0., This parameter is independent from the DTC in Namelist $MISSIN and DTCE in Namelist $ENGINE.)
SWREF	Wing area on which takeoff and landing drag polars are based, sq ft (Default = SW, Namelist $CONFIN) If different from SW, polars will be scaled.
ARRET	Wing aspect ratio on which takeoff and landing drag polars are based (Default = AR, Namelist $CONFIN) If different from AR, polars will be modified.
WHGT	Wing height above ground, ft (Default = 8.)
ALPRUN	Angle of attack on ground, deg (Default = 0.)
TINC	Thrust incidence on ground, deg (Default = 0.)
ROLLMU	Coefficient of rolling friction (Default = .025)
BRAKMU	Coefficient of friction, brakes on (Default = .3)
CDGEAR	Landing gear drag coefficient (Default = 0.)
CDEOUT	Delta drag coefficient due to engine out condition. Includes effect of stopped or windmilling engine and the trim drag associated with compensating for asymmetric thrust. (Default = 0.)
CLSPOL	Spoiler delta lift coefficient (Should be negative, Default = 0., no spoiler)
CDSPOL	Spoiler delta drag coefficient (Default = 0.)
INCGEF	Ground effects switch = 1, Include ground effects as appropriate (Default) = 0, Do not include ground effects
ARGEF	Aspect ratio factor for ground effects (Default=1.)

```
 ITIME      = 1, Detailed takeoff and landing profiles will be
                 printed
            = 0, Otherwise (Default)

-----------------------------------------------------------------
Thrust Reverser

 INTHRV     = -1, Use takeoff thrust (Default)
            =  0, Input thrust values will be used
            =  1, Input values will be scaled
            >  1, Scaled engine deck for the (INTHRV-1)th
                  power setting will be used

 RVFACT     Fraction of thrust reversed - net  (Default = 0.,
            no reverse thrust.  Real values should be negative)

 VELRV(I)   Velocities for reverse thrust, ft/sec (10 values,
            Default = 0., 50., ..., 450.)

 THRRV(I)   Thrust values, lb (10 values)

 TIRVRS     Time after touchdown to reverse thrust, sec
            (Default = 5.)

 REVCUT     Cutoff velocity for thrust reverser, kts
            (Default = -1000 = no cutoff)

 CLREV      Change in lift coefficient due to thrust reverser
            (Default = 0.)

 CDREV      Change in drag coefficient due to thrust reverser
            (Default = 0.)

-----------------------------------------------------------------
Integration Intervals  (Default values will provide a precision
of +/-.25 ft)

 DELVTO     Velocity step during ground run, ft/sec
            (Default = 4.)

 DELTRO     Time step during rotation, sec (Default = .2)

 DELTCL     Time step during climbout, sec (Default = .2)

 DELHAP     Altitude step during approach, ft (Default = 10.)

 DELDFL     Distance step during flare, ft (Default = 10.)

 DELTRN     Time step during runout, sec (Default = .25)

-----------------------------------------------------------------
#    Takeoff Data

 cltom      Maximum CL for takeoff (Default, see $AERIN)
            Must be lower case for XFLOPS Graphical Interface

 CDMTO      Minimum CD for takeoff, typically, this is the drag
```

```
           coefficient at zero lift (Default = 0.)

FCDMTO     Fraction of CDMTO due to wing (Default = .3)

ALMXTO     Maximum angle of attack during takeoff, deg
           (Default = 25.)

OBSTO      Takeoff obstacle height, ft
           (Defaults, Transport = 35., Fighter = 50.)

The following 3 variables are required for detailed takeoff.
They are not generated internally.

ALPTO(I)   Alpha's for takeoff polar, deg
           (at least 2 values required, maximum of 30)

CLTO(I)    CL's for takeoff polar
           (one value for each ALPTO)

CDTO(I)    CD's for takeoff polar
           (one value for each ALPTO)

INTHTO     = 0, Input thrust values will be used (Default)
           = 1, The input values will be scaled
           > 1, Scaled engine data deck for the (INTHTO-1)th
                power setting will be used

VELTO(I)   Velocities for takeoff thrust, ft/sec
           (10 values, Default = 0., 50., 100., ..., 450.)

THRTO(I)   Thrust values, lb (10 values, Default is INTHTO = 2)

ALPROT     Maximum angle of attack during rotation phase of
           takeoff, deg (Default = ALMXTO)

VROTAT     Minimum rotation start speed, knots or fraction
           of Vstall (Default = 1.05 Vstall)

VANGL      Rotation rate, deg/sec (Default = 2.)

THFACT     Thrust multiplier for input or extracted thrust
           data (Default = 1.)

FTOCL      Factor for takeoff lift (Default = 1.)
           Also applied to drag polars input in $PROIN

FTOCD      Factor for takeoff drag (Default = 1.)
           Also applied to drag polars input in $PROIN

IGOBS      Gear retraction switch
           = 0, Start landing gear retraction TDELG seconds
                after liftoff (Default)
           = 1, Start landing gear retraction TDELG seconds
                after obstacle height is reached

TDELG      Time delay after liftoff/obstacle before start of
           landing gear retraction, sec (Default = 0.)
```

```
 TIGEAR     Time required to retract landing gear, sec
            Landing gear drag is reduced using a cosine function.
            (Default = 2.)

 IBAL       = 1, Balanced field length will be computed using
                 pre-1998 FAA rules (Default)
            = 2, Balanced field length will be computed using
                 post-1998 FAA rules
            = 0, Otherwise

 ER5KT      Delta velocity for early rotation, kts (Default = 5.)
            See FAR Part 25.107(e)(3)

 ITXOUT     Subtract taxi out fuel switch
            = 1, Use (Ramp Weight - Taxi Out Fuel) for
                 takeoff field length calculations.
            = 0, Use Ramp Weight for takeoff field length
                 calculations (Default)


Aborted Takeoff

 PILOTT     Actual pilot reaction time from engine failure to
            brake application, sec (Default = 1.).  Spoilers,
            brakes, and thrust reversal are assumed to become
            effective and engine cutback occurs at PILOTT + 2
            seconds after engine failure.

 TISPA, TIBRA, and TIRVA are not currently used.

 ISPOL      = 0, Spoilers are not used during aborted takeoff
            = 1, Spoilers used during aborted takeoff (Default)

 IREV       = 0, No thrust reversal during aborted takeoff
            = 1, Thrust reversal during aborted takeoff only
                 if all engines are operational (Default)
            = 2, Thrust reversal during aborted takeoff for
                 both all-engines-operational and one-engine-
                 out cases

-----------------------------------------------------------------
#    Landing Data

 clldm      Maximum CL for landing (Default, see $AERIN)
            Must be lower case for XFLOPS Graphical Interface

 CDMLD      Minimum CD for landing (Default = 0.)

 FCDMLD     Fraction of CDMLD due to wing (Default = FCDMTO)

 ALMXLD     Maximum angle of attack during landing, deg
            (Default = 25.)

 OBSLD      Landing obstacle height, ft (Default = 50.)

The following 3 variables are required for detailed landing.
```

They are not generated internally.

```
ALPLD(I)   Alpha's for landing polar, deg
           (at least 2 values required, maximum of 30)

CLLD(I)    CL's for landing polar
           (one value for each ALPLD)

CDLD(I)    CD's for landing polar
           (one value for each ALPLD)

INTHLD     = 0, Input thrust values will be used (Default)
           = 1, The input values will be scaled
           > 1, Scaled engine data deck will be used

VELLD(I)   Velocities for landing (idle) thrust, ft/sec
           (10 values, Default = 0., 50., 100., ..., 450.)

THRLD(I)   Thrust values, lb (10 values, Default = 10*0.)

THDRY      Maximum dry thrust at missed appproach for
           fighters, lb. (Default = takeoff thrust)

APRHGT     Height above ground for start of approach, ft
           (Default = 100.)

APRANG     Approach flight path angle, deg (Default = -3.)

DVAPP      Delta approach velocity, kts (Default = 0.)
           Vapp = 1.3 * Vstall + DVAPP

FLDCL      Factor for landing lift (Default = 1.)

FLDCD      Factor for landing drag (Default = 1.)

TDSINK     Sink rate at touchdown, ft/sec
           (Default = 0., must be positive if input)

VANGLD     Flare rate, deg/sec (Default = VANGL)

NOFLAR     No flare during landing switch
           = 1, There is no flare during approach, sink rate
                at touchdown is the approach sink rate with
                ground effects.
           = 0, Normal landing with flare (Default)

TISPOL     Time after touchdown to spoiler actuation, sec
           (Default = 2.)

TICUT      Time after touchdown to cut back of engines to zero
           thrust, sec (Default = 3.)

TIBRAK     Time after touchdown to brake application, sec
           (Default = 4.)

ACCLIM     Deceleration limit, ft/sec2 (Default = 16.)
```

```
 MAGRUP     Missed approach landing gear switch
            = 1, Landing gear is up during missed approach
                 No landing gear drag (Default for fighters)
            = 0, Landing gear is down during missed approach
                 CDGEAR is included in drag
                 (Default for transports)

=================================================================
```

Namelist $PROIN

Input Data for Detailed Takeoff and Climb Profile for Noise Calculations
(Used only if NOPRO = 1 in Namelist $OPTION.)

Up to 10 drag polars may be input for different flap deflections. The defaults for the first polar are ALPTO, CLTO and CDTO from Namelist $TOLIN. The polar to be used for a particular segment is selected in the $SEGIN Namelists.

```
 NPOL       Number of drag polars to be printed out (Default = 1)

 ALPRO(I,N) Alpha's for Nth drag polar, deg
            Must be the same number of Alpha's as in ALPTO in
               Namelist $TOLIN

 CLPRO(I,N) CL's for Nth drag polar
            FTOCL from Namelist $TOLIN is applied

 CDPRO(I,N) CD's for Nth drag polar
            FTOCD from Namelist $TOLIN is applied

 DFLAP(N)   Flap deflection corresponding to Nth drag polar.
            Used only for output (Default = N)

 NTIME      = 1, Detailed takeoff and climb profiles for noise
                 will be printed
            = 0, Otherwise (Default)

 IPCMAX     Maximum engine power code (Default = 1, This variable
            could be used, for example, to limit takeoff and
            climb to dry power settings on an afterburning
            engine.)

 KEAS       = 1, VFIX and VSTOP in Namelist $SEGIN below are in
                 knots equivalent airspeed (keas)
            = 0, VFIX and VSTOP are true airspeed (Default)

 TXF        Fuel used in taxiing out to runway, lb
            (Default is computed in mission analysis)

 ALPMIN     Minimum angle of attack during climb segment
            (Default = 0.)

 GAMLIM     Minimum flight path angle during fixed angle of
            attack segments, deg. (Default = 0.)
```

```
Special Option: Generate data files necessary for transporting
        FLOPS takeoff and climb profile data to the FAA
        Integrated Noise Model (INM) program
        Reference: FAA-AEE-95-01, INM Version 5.0 User's Guide

 INM        = 1, Generate data files for INM
            = 0, Otherwise (Default)

 IATR       = 1, Automatic Thrust Restoration indicator switch
                 on (has no effect on takeoff and climb profile)
            = 0, Otherwise (Default)

 FZF        Maneuver Speed Factor (Default = 1.25)

 THCLMB     Climb Throttle Setting (Default = -1.)

 FLAPID(N)  Six character label for each of the NPOL input drag
            polars, for example, 'gearup'

=================================================================


# Namelist $SEGIN

 Data Defining Each Segment in the Detailed Climb Profile
 (Required for each noise profile segment if NOPRO = 1 in
 Namelist $OPTION)

 KEY        Key word specifying reason for end of segment (A4)
            'ROTATE' - Segment ends at start of rotation
            'LIFTOFF' - Segment ends at liftoff
            'OBSTACLE' - Segment ends at obstacle height
            'CHANGE' - Segment ends to change parameters
                 (Default)
            'CUTBACK' - No distance segment to define required
                 thrust setting (ENGSCL) for following segment
            'LAST' - Final segment, end of profile calculations

            'FLYOVER' - Special option: A constant speed (VFIX),
                 constant altitude (HMIN) flight profile is
                 flown for TSTOP seconds.  ENGSCL will be used
                 if specified.  Otherwise, the required thrust
                 will be computed.

 NFLAP      Number of drag polar to be used
            (Default = value from previous segment or 1)

 IFIX       Constraints for climb segments after 'OBSTACLE'
            = 1, Fixed thrust and constant velocity
            = 2, Fixed thrust and constant flight path angle
            = 3, Fixed thrust and fixed angle of attack
            = 4, Fixed velocity and constant flight path angle
            = 5, Fixed thrust and fixed cabin floor angle (angle
                 of attack plus flight path angle)
            = 6, Fixed velocity and fixed angle of attack
            (Default = value from previous segment or 1)
```

ENGSCL Engine setting as a fraction of thrust at IPCMAX (Default = value from previous segment or 1.)

AFIX Fixed angle of attack for IFIX = 3 or 6, deg (Default = final value from previous segment)

GFIX Fixed flight path angle for IFIX = 2 or 4 or fixed cabin floor angle for IFIX = 5, deg (Default = final value from previous segment)

VFIX Fixed velocity for IFIX = 1, 4 or 6, kts (Default = final value from previous segment)

HSTOP Segment termination altitude, ft (Default = value from following segment or OBSTO from Namelist $TOLIN for the 'OBSTACLE' segment)

DSTOP Segment termination distance, ft (Default = value from following segment)

TSTOP Segment termination time, sec (Default = value from following segment)

VSTOP Segment termination velocity, kts (Default = value from following segment or rotation speed from detailed takeoff analysis for 'ROTATE' segment)

HMIN Minimum altitude for segment termination, ft Overrides 'STOP' variables above

SPRATE Thrust reduction rate during segments where the power setting is reduced, can be used for Programmed Lapse Rate (PLR) takeoffs. (Default = value from previous segment or 0.1 = 10 percent/second, i.e., a cutback from 90 to 60 percent thrust would require 3 seconds)
= 0., Cutback is instantaneous

IPLR Programmed Lapse Rate switch for this segment
= 0, Do not use PLR (Default)
= 1, Thrust factor is reduced to PLR (Namelist $CONFIN) using SPRATE above
= 2, Thrust factor is reduced to PLR while landing gear is retracted (See TDELG and TIGEAR, Namelist $TOLIN)

NOYCAL Noise calculation switch - available only for simplified noise calculations in DOSS version
= 0, Do not calculate noise (Default)
= 1, Calculate noise at the end of this segment

DELT Time step for post 'OBSTACLE' segments, sec. (Default = 1.)

GRDAEO Flight path angle for 'CUTBACK' with all engines operating, deg (Default = 2.29061 deg or 4 percent)

```
 GRDOEO     Flight path angle for 'CUTBACK' with one engine
            out, deg (Default = 0.)

Notes - ROTATE, LIFTOFF and LAST segments are required.  An
        OBSTACLE segment is not required but must follow LIFTOFF
        if it is present.  CHANGE segments may occur before
        ROTATE or between OBSTACLE (or LIFTOFF) and LAST.
        CUTBACK segments may occur between OBSTACLE (or LIFTOFF)
        and LAST.  A large change in profile (e.g., during
        CUTBACK) may cause porpoising.  Smaller time steps,
        thrust reduction rate, or rotation rate may help this.

Special Option: If the segment after the OBSTACLE is a constant
        velocity segment, a small value of VFIX (less than 50.)
        causes that segment to be flown at the maximum of the
        OBSTACLE velocity and VFIX + V2 where V2 is the obstacle
        velocity for one engine out from the takeoff field length
        calculations.

=================================================================
```

Namelist $NOISIN

```
 Data for Noise Calculations
 (Used only if NOISE = 1 in Namelist $AERIN.  All defaults = 0.
  unless otherwise noted)

Noise regulation control

 IEPN       = 0, Stage III (default)
            = 1, Stage III - Delta dB (see below)
            = 2, Find the X-coordinate where the maximum EPNL
                 occurs.  NOB, XO and YO must be input.  YO
                 should be constant.  IEPN=2 is usually used
                 to get a sideline (YO) noise for GA aircraft.

 DEPNT      Increment below Stage III for takeoff (see IEPN)

 DEPNS      Increment below Stage III for sideline (see IEPN)
            If IEPN=2, DEPNS is the upper limit for sideline noise

 DEPNL      Increment below Stage III for landing (see IEPN)

 ITRADE     = 1, Trade 2 db between sideline and flyover noise
            = 0, Otherwise (default)

Noise sources to be included.

 Name       Description

 IJET       = 0, No jet noise (Default)
            = 1, Calculate jet mixing/shock cell noise using the
                 original Stone/Clark model
            = 2, Calculate jet mixing/shock cell noise using the
                 improved "Kresja" model
            = 3, Calculate jet mixing/shock cell noise using
```

```
                 Stone's "ALLJET" model which includes inverted
                 velocity profile jets
            = 4, Calculate jet mixing/shock cell noise using
                 Stone's "JET181" model
            = 5, Calculate jet mixing/shock cell noise using the
                 GE M*S jet noise model
            = 6, Calculate jet noise using methods developed by
                 the SAE A-21 jet noise subcommittee - based on
                 an ANOPP module

 IFAN       = 0, Do not calculate fan noise (Default)
            = 1, Calculate fan or compressor noise
            = 2, Compute fan noise using simplified Gliebe model

 ICORE      = 1, Calculate burner noise
            = 0, No burner noise (Default)

 ITURB      = 1, Calculate turbine noise
            = 0, No turbine noise (Default)

 IPROP      = 0, No propeller noise (Default)
            = 1, Calculate propeller noise using old SAE Method
            = 2, Calculate propeller noise using Gutin's Method

 IFLAP      = 1, Calculate flap noise and jet/flap impingement
                 noise
            = 0, No flap noise (Default)

 IAIRF      = 1, Calculate airframe noise
            = 0, No airframe noise (Default)

 IGEAR      = 1, Approximate gear box noise using crude method
            = 0, No gear box noise (Default)

-----------------------------------------------------------------
#    Noise Propagation Corrections

 ISUPP      = 1, Apply suppression spectra to each source for
                 which they are supplied
            = 0, No suppression (Default)

 IDOP       = 1, Apply doppler frequency and intensity correction
                 to total noise
            = 0, No correction (Default)

 IGND       = 0, No ground reflection - free field (Default)
            = 1, Perfect ground reflection (+3.01 dB)
            = 2, Calculate ground reflection based on TMX 56033
                 by T. W. Putnam of DFRC

 IATM       = 0, No atmospheric attenuation correction (Default)
            = 1, Correct total noise for atmospheric attenuation
                 using ARP 866
            = 2, Correct total noise for atmospheric attenuation
                 using Bass & Shields

 IEGA       = 1, Apply extra ground attenuation to total noise
```

```
            = 0, No extra ground attenuation (Default)

 ISHLD      = 1, Calculate shielding of fan, jet, core, turbine,
                 and propeller sources
            = 0, No shielding (Default)

 DELDB      Number of dB down from the peak noise level to cut
            off printing of noise time histories  (Default = 20.)

 HENG       Height of engine above the ground during taxi, ft

 FILBW      Fraction of filter bandwidth with a gain of 1.
            (Default = 1.)

 TDI        Reception time increment, sec (Default = 1.)

 RH         Ambient relative humidity, percent (Default = 70.)

-----------------------------------------------------------------
#    Observer Locations

If no observers are input, noise levels at the FAR 36 observer
points will be calculated automatically.  The x-axis is parallel
to the runway.

 NOB        Number of input observers (Maximum = 400)

 XO(I)      X-coordinate of each observer, ft

 YO(I)      Y-coordinate of each observer, ft

 ZO         Height of all observers above the ground, ft

 NDPRT      = 1, Print observer noise histories (Default)
            = 0, Otherwise

 IFOOT      = 1, Print noise levels of input observers in contour
                 format to file 'NSPLOT' for subsequent plotting
                 of the noise footprint
            = 0, No noise footprint plot file (Default)

 IGEOM      = 1, Print geometric relations of aircraft/observer
                 at each time point
            = 0, No print (Default)

 THRN       Thrust of baseline engine, lb.  Geometry data and
            engine parameter arrays will be scaled accordingly
            (Default = THRSO, Namelist $WTIN)

 ICORR      = 1, Apply corrections to engine parameters to
                 correct for ambient conditions
            = 0, Otherwise (Default)

 TCORXP     Exponent for core temperature correction in engine
            parameter arrays  (Default = 1.)

-----------------------------------------------------------------
```

Engine Noise Parameters

Variables are input as a function of percent net thrust with NPARAM values for each.

NPARAM	Number of power settings (Default = Minimum = 2, Maximum = 20)
AEPP(I)	Throttle settings as a fraction of net thrust.
AVC(I)	Core/primary exhaust jet velocity (ideally expanded velocity; exclude friction and expansion alterations) ft/sec. Used for IJET=1,2,3,4,6
AVF(I)	Fan/secondary exhaust jet velocity (ideally expanded velocity; exclude friction and expansion alterations) ft/sec. Used for IJET=1,2,3,4
ATC(I)	Core/primary jet exhaust total temperature, deg R Used for IJET=1,2,3,4,6
ATF(I)	Fan/secondary jet exhaust total temperature, deg R Used for IJET=1,2,3,4
AAC(I)	Core jet nozzle exhaust area, sq ft. For IJET=1,2,6, AAC represents exit area; for IJET=3,4, AAC represents throat area.
AAF(I)	Fan jet nozzle exhaust area, sq ft. For IJET=1 or IJET=2, AAF represents exit area; for IJET=3,4, AAF represents throat area.
ADJ(I)	Core outer diameter, ft; at the equivalent throat if the nozzle is C-D. Used only for IJET=3,4
ADJ2(I)	Fan outer diameter, ft; at the equivalent throat if the nozzle is C-D. Used only for IJET=3,4
AHJ(I)	Core annulus height, ft; at the equivalent throat if the nozzle is C-D. Used only for IJET=3,4
AHJ2(I)	Fan annulus height, ft; at the equivalent throat if the nozzle is C-D. Used only for IJET=3,4
AFUEL(I)	Fuel flow, lb/sec. Used if ICORE, ITURB=1; and IJET=1,2 and only if calculating GAMMAC and GASRC.
ATIPM(I)	Fan first-stage relative tip Mach number. These are approximated if not input. Used if IFAN=1
ATIPM2(I)	Fan second-stage relative tip Mach number. These are approximated if not input. Used if IFAN=1
AWAFAN(I)	Total engine airflow, lb/sec. Used if IFAN=1
ADELT(I)	Fan temperature rise, deg R. Used if IFAN=1

```
AFPR(I)     Fan pressure ratio.  This is not needed if ADELT is
            input.  Otherwise, values for ADELT will be
            calculated using AFANEF and AFANF2 values.

AFANEF(I)   Fan first-stage efficiency.  These are required if
            AFPR is supplied rather than ADELT.

AFANF2(I)   Fan second-stage efficiency.  These are required if
            AFPR is supplied rather than ADELT.

ARPM(I)     Fan or turbine speed, RPM.  Used if IFAN, ITURB=1

AWCORE(I)   Burner and turbine airflow, lb/sec.  Used if ICORE or
            ITURB=1 and IJET=1,2 and only if calculating GAMMAC
            and GASRC.

AP3(I)      Burner inlet pressure, psf.  Used if ICORE=1

AT3(I)      Burner inlet temperature, deg R.  Used if ICORE=1

AT4(I)      Burner exit static temperature, deg R.  These are
            approximated from the fuel/air ratio if not input.
            Used if ICORE=1

ATURTS(I)   Turbine last stage rotor relative tip speed, ft/sec.
            These are approximated if not input.
            Used if ITURB=1

ATCTUR(I)   Turbine exit temperature, deg R.  These are assumed
            the same as ATC if not supplied.  Used if ITURB=1

AEPWR(I)    Some propeller parameter.  Power?  Used if IPROP=1

ATHRST(I)   Some propeller parameter.  Thrust?  Used if IPROP=1

AMSP9(I)    Nozzle pressure ratio: entance total to ambient
            static.  Used for M*S code jet predictions, IJET=5

AMSTT3(I)   Nozzle exit total temperature, deg R.
            Used for M*S code jet predictions, IJET=5

AMSA9(I)    Nozzle exit area, sq ft.
            Used for M*S code jet predictions, IJET=5

AMSA7(I)    Nozzle ejector chute area ratio.
            Used for M*S code jet predictions, IJET=5

AMSAA8(I)   Inner nozzle flow area, sq ft.
            Used for M*S code jet predictions, IJET=5

AMSTT4(I)   Inner nozzle exit total temperature, deg R.
            Used for M*S code jet predictions, IJET=5

AMSP4(I)    Inner nozzle pressure ratio: entrance total to
            ambient static.  Used for M*S code jet predictions,
            IJET=5
```

```
 AMSTT5(I)  Outer nozzle exit total temperature, deg R.
            Used for M*S code jet predictions, IJET=5

 AMSP5(I)   Outer nozzle pressure ratio: entrance total to
            ambient static.  Used for M*S code jet predictions,
            IJET=5

-----------------------------------------------------------------
#    Jet Noise Input Data

(Required if IJET > 0)

 INOZ       = 1, Coaxial nozzle
            = 0, Simple circular nozzle (Default)
            Used for IJET=1,2

 IPLUG      = 1, Plug nozzle on primary
            = 0, Otherwise (Default)
            Used for IJET=1,2

 ISLOT      = 1, Slot nozzle on primary
            = 0, Otherwise (Default)
            Used for IJET=1,2

 IAZ        = 1, Azimuthal correction for nozzle geometry is used
            = 0, Otherwise (Default)

 DBAZ       Noise reduction due to nozzle geometry in dB
            at phi = 75 degrees, used only if IAZ = 1

 EJDOP      Exponent on source motion (Doppler) amplification on
            shock noise only (Default = 1.)  Used for IJET=1,2

 ZMDC       Core (primary) jet design Mach number (Default = 1.)
            Used for application of non-ideally expanded shock
            noise.  Used for IJET=1,2

 GAMMAC     Core (primary) jet exhaust gamma
            Used for IJET=1,2,6  (Default = 1.4)

 GASRC      Core exhaust gas constant, ft-lb/lbm-R
            Used for IJET=1,2  (Default = 53.35 ft-lb/lbm-R)

 ANNHT      Core nozzle annulus height, ft
            Used for IJET=1,2

 ZMDF       Fan (secondary) jet design Mach number (Default = 1.)
            Used for application of non-ideally expanded shock
            noise.  Used for IJET=1,2

 GAMMAP     Fan (secondary) jet exhaust gamma
            Used for IJET=1,2  (Default = GAMMAF)

 GASRF      Fan exhaust gas constant, ft-lb/lbm-R
            Used for IJET=1,2  (Default = 53.35 ft-lb/lbm-R)

 ANNHTF     Fan nozzle annulus height, ft
```

```
            Used for IJET=1,2

 DHC        Core nozzle hydraulic diameter, ft
            Used for IJET=3,4

 DHF        Fan nozzle hydraulic diameter, ft
            Used for IJET=3,4

 ZL2        Axial distance from the outer exit plane to the exit
            plane of the inner nozzle, ft.  Used for IJET=3,4

 IFWD       = 1, Forward velocity effects on source
            = 0, Otherwise (Default)
            Used for IJET=1,2,3,4,5

 ISHOCK     = 1, Calculate shock noise (Default)
            = 0, Otherwise
            Used for IJET=1,2,3,4,5

 ZJSUPP(I)  Jet suppression spectrum.  Used for IJET=1,2,3,4,5

-----------------------------------------------------------------
Special M*S Jet Noise Input Data - Required if IJET = 5

 IY9        = 1, Convergent, conical nozzle (Default)
            = 2, Single flow, multitube nozzle
            = 3, Single flow, multichute/spoke nozzle
            = 4, Dual flow, convergent conical nozzle
            = 5, Dual flow, multitube suppressors on outer stream
            = 6, Dual flow, multichute/spoke suppressor on outer
                 stream

 N          For IY9=2,5:  Number of tubes
            For IY9=3,6:  Number of elements

 RP         For IY9=2,3,5,6:  Centerbody plug radius, ft

 B9         For IY9=2,5:  Tube centerline cant angle, deg
            For IY9=3,6:  Chute/spoke exit cant angle, deg

 DT         For IY9=2,5:  Tube diameter, in

 Z5         For IY9=2,5:  Number of rows of tubes, counting
                          center tube (if present) as zero

 S1J        For IY9=2,5:  Tube centerline spacing to tube
                          diameter ratio

 A6         For IY9=2,3,5,6:  Ratio of ejector inlet area to
                              nozzle (total or annulus) area
                              (input zero for no ejector)

 ZL9        For IY9=2,3,5,6:  Ratio of ejector length to
                              suppressor nozzle equivalent
                              diameter

 A(1)       For IY9=2,3,5,6:  Ejector treatment faceplate
```

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                            thickness, in
 A(2)       For IY9=2,3,5,6:  Ejector treatment hole diameter, in
 A(3)       For IY9=2,3,5,6:  Ejector treatment cavity depth, in
 A(4)       For IY9=2,3,5,6:  Ejector treatment open area ratio

 RR(I)      For IY9=2,3,5,6:  Ejector treatment specific
                              resistance, Rayls (59 values
                              required)

 RX(I)      For IY9=2,3,5,6:  Ejector treatment specific
                              reactance, Rayls (59 values
                              required)

 R4         For IY9=3,6:  Outer circumferential flow dimension,
                          in.

 R6         For IY9=3,6:  Inner circumferential flow dimension,
                          in.

 SS         For IY9=3,6:  Outer circumferential element
                          dimension, in.

 DN         For IY9=5,6:  Nozzle outer diameter, ft

 AA, NFLT, HTR, NST   Unknown variables

-----------------------------------------------------------------
#    Fan Noise Data

(Required if IFAN > 0)

 IGV         = 1, Inlet guide vanes
             = 0, Otherwise (Default)

 IFD         = 1, Inlet flow distortion during ground run
             = 0, Otherwise (Default)

 IEXH        = 0, Fan inlet only
             = 1, Fan exhaust only
             = 2, Include both inlet and exhaust (Default)

 NFH          Number of harmonics to be considered in
              blade-passing tone (Default = 10)

NSTG        Number of fan stages (Default = 1)

SUPPIN(I)   Fan inlet suppression spectrum, dB

SUPPEX(I)   Fan exhaust suppression spectrum, dB

METHTIP     Method for calculation of relative tip Mach number
            = 1, Duplication of ANOPP method (Default)
            = 2, Bruce Clark's method
            = 3, Use input array ATIPM above

ICOMB       = 1, If relative tip Mach number is supersonic,
                 include combination tones (Default)
```

```
           = 0, Otherwise

DECMPT     Decrement to apply to combination tones, dB

GAMMAF     Gamma of fan air (Default = 1.4)
           May have been input with jet noise data

First Stage Variables

NBL        Number of fan blades

NVAN       Number of stator vanes

FANDIA     Fan diameter, ft

FANHUB     Fan hub diameter, ft

TIPMD      Design relative tip Mach number

RSS        Rotor-stator spacing in percent (Default = 100.)

EFDOP      Exponent on source motion (Doppler) amplification
           on fan noise (Default = 4.)

FANEFF     Constant first stage fan efficiency, < 1.0.
           (Default = 0.88) Overridden by AFANEF(I).

Second Stage Variables - Required if NSTG > 1

NBL2       Number of fan blades for second stage (Default = NBL)

NVAN2      Number of stator vanes for second stage
           (Default = NVAN)

FAND2      Fan diameter for second stage, ft (Default = FANDIA)

TIPMD2     Design relative tip Mach number for second stage
           (Default = TIPMD)

RSS2       Rotor-stator spacing in percent for second stage
           (Default = RSS)

EFDOP2     Exponent on source motion (Doppler) amplification
           on second stage fan noise (Default = EFDOP)

FANEF2     Constant second stage fan efficiency, < 1.0.
           (Default = 0.88) Overridden by AFANF2(I).

TRAT       Ratio of second stage temperature rise (DELT2) to
           that of first stage.  Either TRAT or PRAT is used to
           calculate DELT2.  (Default = use PRAT)

PRAT       Ratio of second stage fan pressure ratio to that of
           first stage (Default = 1.)

-----------------------------------------------------------------
#    Core Noise Data
```

```
(Required if ICORE > 0)

CSUPP(I)   Core suppression spectrum, dB

GAMMA      Specific heat ratio;  required if using AP3 rather
           than AT3 (Default = 1.4)

IMOD       = 1, Use modified core level prediction (DTEMD)
           = 0, Otherwise (Default)

DTEMD      Design turbine temperature drop, T4des - TCTURdes,
           deg R

ECDOP      Exponent on source motion (Doppler) amplification
           on core noise (Default = 2.)

-----------------------------------------------------------------
#    Turbine Noise Data

(Required if ITURB > 0)

TSUPP(I)   Turbine suppression spectrum, dB

TBNDIA     Diameter of last-stage turbine, ft

GEAR       Gear ratio:  turbine RPM/fan RPM (Default = 1.)

CS         Stator chord to rotor spacing ratio, percent
           (Usually > 100%)

NBLR       Number of last stage rotor blades

ITYPTB     = 1, Turbofans (core ahead of fan exit, e.g., JT8D)
           = 0, Turbojets or fans with coplanar exits (Default)

ETDOP      Exponent on source motion (Doppler) amplification
           on turbine noise (Default = 4.)

-----------------------------------------------------------------
#    Propeller Noise Data

(Required if IPROP > 0)

NB         Number of blades per propeller

BLDIA      Diameter of propeller, ft

BLAREA     Total blade area for one side of propeller, sq ft

GEARP      Ratio of propeller rpm / engine rpm (Default = 1.)

EPDOP      Exponent on source motion (Doppler) amplification
           on propeller noise (Default = 1.)

BLTH       Blade thickness at 70% span, ft
```

BLCH   Blade chord at 70% span, ft

BLATTK   Blade angle of attack at 70% span, deg

DHARM   Rate of decrease in harmonic level beyond tenth,
           dB/harmonic (Default = .5)

NPH   Number of harmonics of BDF desired (Default = 10)

IVOR   = 1, Calculate vortex noise component (Default)
           = 0, Otherwise

IROT   = 1, Calculate rotational noise component (Default)
           = 0, Otherwise

IPDir   = 1, Apply Boeing directivity correction
           = 0, Otherwise (Default)

PSUPP(I)   Propeller noise suppression spectrum, dB

\#   Shielding Effects Data

(Required if ISHLD > 0)

IUOTW   =1, Over-the-wing engine location
           =0, Under-the-wing engine location (Default)

SFUSE   Maximum fuselage shielding, dB (Default = 10.)

SWIDE   Degrees of arc where fuselage shielding is greater
           than SFUSE/e (e=2.718...) (Default = 60.)

SWING   Maximum wing shielding for over-the-wing engine, dB
           (Default = 10.)

SMX   Angle in flyover plane of maximum over-the-wing
           shielding, deg. (Default = 90.)

CFUSE   Characteristic fuselage dimension (such as diameter),
           ft (Default = 10.)

CWING   Characteristic wing dimension (such as chord), ft
           (Default = 10.)

\#   Flap Noise Data

(Required if IFLAP > 0)

IUOTW   Engine location (If not input in shielding data)

ILNOZ   = 2, Coaxial nozzle - mixed flow
           = 1, Coaxial nozzle - separate flow
           = 0, Simple circular nozzle (Default)

INSENS   = 1, Configuration with noise levels insensitive to

```
                 flap angle
            = 0, Otherwise (Default)

AC1         Core (primary) nozzle area, sq ft

AF1         Fan (secondary) nozzle area, sq ft

BPR         Bypass ratio, for mixed flow coaxial nozzle

WINGD       Ratio of wing chord to total nozzle diameter, used
            for large BPR designs when WINGD < 3.  (Default = 3.)

FLSUPP(I)   Flap noise suppression spectrum, dB

ELDOP       Exponent on source motion (Doppler) amplification
            on flap noise (Default = 4.)

-----------------------------------------------------------------
#    Airframe Noise Data

(Required if IAIRF > 0)

IFL         = 1, Include slotted flap noise
            = 0, Otherwise (Default)

NF          Number of trailing edge flap slots for IFL = 1
            (Default = 2, Maximum = 3)

PFCHD       Average chord for slotted flap, ft or fraction of
            wing chord.  Used only if IFL = 1 (Default = .25)

ITYPW       = 1, Conventional wing (Default)
            = 2, Delta wing

ICLEAN      = 1, Aerodynamically clean aircraft (as a sailplane)
            = 0, Conventional aircraft (Default)

IWING       = 1, Include wing and horiz. and vert. tail noise
            = 0, Otherwise (Default)

ISLAT       = 1, Include slatted leading edge noise
            = 0, Otherwise (Default)

ILG         = 1, Include nose and main landing gear noise
            = 0, Otherwise (Default)

NG(1)       Number of nose gear trucks (Default = 1)
NG(2)       Number of main gear trucks (Default = 2)

NW(1)       Number of wheels per nose gear truck (Default = 2)
NW(2)       Number of wheels per main gear truck (Default = 2)

DW(1)       Diameter of nose gear tires, ft (Default = 3.)
DW(2)       Diameter of main gear tires, ft (Default = 3.)

CG(1)       Ratio of nose strut length to DW(1) (Default = 3.)
CG(2)       Ratio of main strut length to DW(2) (Default = 3.)
```

```
----------------------------------------------------------------
#    Ground Reflection Effects Data

(Required if IGND = 2)

ITONE      = 1, 1/3-octave bands exceeding adjacent bands by
                3 dB or more are approximated as tones
           = 0, Otherwise (Default)

NHT        Number of heights to be used to approximate a
           distributed source by multiple sources
           (Default = 1, Maximum = 10)

DK         Heights of multiple sources from source center, ft
           (Default = NHT*0.)

RGND(I)    Real part of complex specific ground impedance,
           24 values
           (Default = Delaney and Bazley impedance function from
            ANOPP Theoretical Manual for grass-covered ground.)

XGND(I)    Imaginary part of complex specific ground impedance,
           24 values
           (Default = Delaney and Bazley impedance function from
            ANOPP Theoretical Manual for grass-covered ground.)

Note: QABS, the ground reflectivity, and FSHIFT, the phase shift
     of the reflected signal, previously input, are now
     calculated based on Putnam, TM X-56033.

================================================================


# Namelist $SYNTIN

Optimization Control and Constraint Limits
(Required only for IOPT = 3 in Namelist $OPTION.)

The optimization uses the Sequence of Unconstrained Minimizations
Technique (SUMT) with a Fiacco-McCormick (FM) penalty function
(with optional quadratic extension) or the Kreisselmeier-
Steinhauser function (KS) to transform the constrained problem to
an unconstrained problem.  The constraints are of the form:

  G = value/(upper limit) - 1., or 1. - value/(lower limit)

where the constraint is satisfied if G is less than zero.  The
compatibility constraints are upper and lower limits on each
active design variable.  In addition to the fighter performance
constraints defined in Namelist $PCONIN, there are several other
behavioral constraints:

  (1)  Lower limit on range (not used if IRW = 1)
  (2)  Upper limit on approach speed
  (3)  Upper limit on takeoff field length
  (4)  Upper limit on landing field length
```

(5) Lower limit on missed approach climb gradient thrust (0.)
(6) Lower limit on second segment climb gradient thrust (0.)
(7) Lower limit on excess fuel capacity
(8) Upper limit on compressor discharge temperature
(9) Upper limit on compressor discharge pressure
(10) Upper limit on jet velocity
(11) Lower limit on specific thrust
(12) Upper limit on bypass/core area ratio for mixed flow turbofans
(13) Upper limit on flyover noise (Internally computed)
(14) Upper limit on sideline noise (Internally computed)
(15) Upper limit on combined flyover and sideline noise (2 db may be traded between flyover and sideline noise but the sum must be less than the constraint sum)
(16) Upper limit on NOx emissions
(17) Lower limit on potential rate of climb during climb segments
(18) Lower limit on actual rate of climb during climb segments (Note: This constraint is only for thumbprint plotting. Do not use it in optimization. Use NODIVE and DIVLIM in Namelist $MISSIN instead.)
(19) Lower limit on thrust margin, (Thrust-Drag)/Drag, during climb segments

The following variables are the constraint limits described above. Except for EXFCAP, GNOX, ROCLIM, DHDTLM, and TMGLIM they may be input in other Namelists. They are repeated here only for convenience. Values input in this Namelist override previously input values. For the XFLOPS Graphical Interface, they must be mixed or lower case exactly as shown. For a more complete description of these constraints, see the Constraint Description section.

Name	Description
Desrng	Design range, n.mi. (or endurance, min.) See INDR in Namelist $MISSIN. (No default, Namelist $CONFIN)
vappr	Maximum allowable landing approach velocity, kts (Default = 150., Namelist $AERIN)
flto	Maximum allowable takeoff field length, ft (Default = 12000., Namelist $AERIN)
flldg	Maximum allowable landing field length, ft (Default = FLTO, Namelist $AERIN)
EXFCAP	Minimum allowable excess fuel capacity (Default = 0.)
cdtmax	Maximum allowable compressor discharge temperature, deg R (Default = 99999., Namelist $ENGINE)
cdpmax	Maximum allowable compressor discharge pressure, psi (Default = 99999., Namelist $ENGINE)
vjmax	Maximum allowable jet velocity, ft/sec (Default = 99999., Namelist $ENGINE)

stmin	Minimum allowable specific thrust, lb/lb/sec (Default = 1., Namelist $ENGINE)
armax	Maximum allowable ratio of the bypass area to the core area of a mixed flow turbofan. (Default = 99999., Namelist $ENGINE)
GNOX	Maximum allowable NOx emissions, lb (Default = not constrained, no other references)
ROCLIM	Minimum allowable potential rate of climb during climb segments (Default = 100.)
DHDTLM	Minimum allowable actual rate of climb during climb segments (Default = 100.)
TMGLIM	Minimum allowable thrust margin, (Thrust-Drag)/Drag, during climb segments (Default = 0.1)

The following variables define the optimization problem.

Name	Description
IG(I)	= 1, Ith behavioral constraint is used in optimization (Default for first 7 constraints) = 0, Otherwise (Default for remaining constraints)
IBFGS	= 0, Davidon-Fletcher-Powell (DFP) Algorithm = 1, Broyden-Fletcher-Goldfarb-Shano (BFGS) Algorithm (Default) = 2, Conjugate Gradient (Polak-Ribiere) Algorithm = 3, Steepest Descent Algorithm = 4, Univariate Search Algorithm (The above options use the FM penalty function) = 5, Kreisselmeier-Steinhauser function with DFP Algorithm
ITFINE	= 1, sets IRW = 1 for final analysis = 0, otherwise (Default)

The Fiacco-McCormick penalty function, used if IBFGS is less than 5, is of the form:

F = OBJ - RK (summation)[1./G(J)]

where OBJ was described in Namelist $CONFIN and G(J) is the value of the Jth constraint.

The optimization is performed as a series of minimizations of F (called drawdowns) with the value of the penalty function factor RK successively lowered so that the constraints have less and less effect on F. A drawdown consists of several finite difference gradient calculations and corresponding one-dimensional searches. The nonlinear programming algorithm modifies the gradient to determine the direction for the one-dimensional search.

Optimization Control

The following parameters in this Namelist, along with the scaling factors in the design variable input, control the convergence speed and accuracy of the optimization process and are used only with the Fiacco-McCormick penalty function. Experimentation is recommended.

NDD	Number of drawdowns (Defaults to analysis only - no optimization is performed. Suggested value = 3 or 4)
RK	Initial value of RK (Default internally computed)
FDD	RK multiplier for successive drawdowns (Default = .2)
NLIN	Maximum number of gradients per drawdown (Default = number of active design variables times 2)
NSTEP	Maximum number of steps per one-dimensional minimization (Default = 20)
EF	Limits one-dimensional minimization step size to EF times previous step (Default = 3.)
EPS	Fraction of initial design variable value used as a finite difference delta (Default = .001)
AMULT	The initial step in a one-dimensional search is controlled by the design variable value times EPS times AMULT (Default = 10.)
DEP	One-dimensional search convergence criterion on step size as a fraction of move distance (Default = .001)
ACCUX	One-dimensional search convergence criterion on step size as a fraction of initial design variable value (Default = .0003)
GLM	Value of G at which constraint switches to quadratic extended form, a value of .002 is recommended (Default = 0., no quadratic extension)
GFACT(I)	Scaling factor for Ith behavioral constraint (Default = 1.)
AUTSCL	Design variable scale factor exponent (Default = 1.00). Scale factors for design variables default to VALUE ** AUTSCL
ICENT	= 0, Forward differences will be used in gradient calculations (Default) = 1, central differences will be used

The KS function, used if IBFGS = 5, is documented in reference 14 (See the Introduction). The following variables are used only with this function.

RHOMIN — Starting value for RHO, a scalar multiplying factor used in the KS function. (Default is computed internally)

RHOMAX — Maximum value for RHO (Default = 300.)

RHODEL — RHO increment (Default is computed internally)

ITMAX — Maximum number of iterations (Default = 30)

JPRNT — KS module print control (Default = 2)
= 0, No output from the KS module
= 999, Maximum output (See reference 11)

RDFUN — If the relative change in the KS function is less than RDFUN for three consecutive iterations, optimization is terminated. (Default = .01)

ADFUN — If the absolute change in the KS function is less than ADFUN for three consecutive iterations, optimization is terminated. (Default = .001)

===

Namelist $RERUN

Data to Reanalyze a Sized or Optimized Configuration for an Alternate Mission

This namelist, followed by a new Namelist $MISSIN and new Mission Definition Data, can be used to reanalyze the final configuration of a sizing or optimization run for an alternate mission. As many alternate missions as desired may be analyzed with Namelists $RERUN and $MISSIN and Mission Definition Data input for each. Default values are those previously input or those previously computed. For the XFLOPS Graphical Interface, all variables in this Namelist must be lower case.

Name	Description
desrng	Alternate mission design range, n.mi.
mywts	= 0, New weights will be computed = 1, Weights calculated previously during sizing or optimization or the weights input below will be used in the alternate mission analysis

If mywts = 1, the following four parameters (if input) override the previously calculated values

Name	Description
rampwt	Gross weight before taxi out, lb

```
dowe       Operating weight empty, lb

paylod     Payload weight, lb

fuemax     Total usable fuel weight, lb

Note - If PAYLOD and/or DOWE are changed, FUEMAX is automatically
       adjusted to maintain RAMPWT.  If a constant FUEMAX is
       desired with a modified PAYLOD or DOWE or if FUEMAX is
       changed, input RAMPWT = 0., and RAMPWT will be set to
       DOWE + PAYLOD + FUEMAX.  If IRW = 1, the fuel and
       corresponding ramp weight will be determined to fly the
       mission that is input.

The following variable can be used to keep the landing weight
constant during reruns.

mldwt      = -1, The landing weight determined previously is not
                 scaled with changes in the gross weight.

The following variables can be used to turn off options not
desired for the alternate mission analysis.  Options not
previously used cannot be activated.  The only valid input for
these variables is zero.

itakof     = 0,  Turn off detailed takeoff performance
                 calculations

iland      = 0,  Turn off detailed landing performance
                 calculations

nopro      = 0,  Turn off detailed takeoff and climb profile
                 generation for noise calculations

noise      = 0,  Turn off noise calculations

icost      = 0,  Turn off cost calculations

wsr        = 0., Wing area remains constant

twr        = 0., Engine thrust remains constant

Each Namelist $RERUN must be followed by a Namelist $MISSIN and a
full set of Mission Definition Data.  Most variables in Namelist
$MISSIN default to previous values and are not required if they
do not change.

=================================================================
```

TROUBLESHOOTING

Flops is a large, complex program that has evolved over a 15 year period with many options and many variables. Consequently, there are many combinations of options that have never been run and may not work. Please report all problems encountered. Most problems, however, can be corrected by the user. A concerted effort is being made to make Flops as user-friendly as possible, detecting errors and printing informative error messages. In addition, this section describes many of the most common problems and how to fix them.

Flops Input Errors

Input errors for Flops consist of the usual misspelling of variables in namelists, omitted commas, too many values in arrays, data in the wrong columns, etc. Always check the input data echo printed by Flops to ensure that Flops correctly interpreted the input data. The error message:

```
ERROR READING NAMELIST xxx FROM UNIT y
```

indicates that the FORTRAN namelist input routines could not find or would not accept the data. If it could not find the namelist, the problem could be a misspelling of the namelist name, use of the wrong symbol (some compilers accept only $'s for namelist names, some only &'s, and some both), not having the $ or & in column 2, or a missing $END for the previous namelist. If the problem is the data in the namelist, it could be a misspelled variable, a variable that is not currently valid for this namelist, an invalid number (usually caused by a missing comma), or a missing $END. The XFlops namelist parser will identify the string that is causing the problem if the input deck is read by XFlops.

If the aerodynamic data is being input as formatted matrices, each matrix should be input continuously, 10 values to a line, until all values are input. If the data is created starting a new line for each Mach number for lift dependent drag and for each altitude for lift independent drag, the option IBO=1 (Namelist $AERIN) may allow it to be read properly.

Input Engine Decks require at least two Mach numbers, at least two altitudes for each Mach number, and at least one complete set of part power data. There are maximums of 20 distinct Mach numbers, 20 altitudes for each Mach number, and 16 power settings for each Mach number/altitude combination (15 if flight idle is to be generated internally). An informative error message will usually be printed if any Engine Deck requirements are violated.

Weight Analysis Problems

Usually, the only fatal error in the weight analysis is indicated by the error message:

```
NO WEIGHT AVAILABLE FOR FUEL
```

This means that the calculated zero fuel weight is greater than the gross weight. This can be caused by a gross underestimation of the gross weight or miscalculation of one or more weight elements. Check the "MASS AND BALANCE SUMMARY" to see if any of the component weights are out of line. Results in the example cases can be used to see what a reasonable group weight summary looks like. If this problem occurs during an optimization or sizing run, the code probably just took too large a step and recovered on its own. If it did not recover, changing the starting point may work. Always check the "OUTPUT FROM THE WEIGHTS MODULE" to ensure that the calculated and scaled values make sense.

The message:

    * * * INSUFFICIENT FUEL CAPACITY * * *

indicates that the fuel on board (the specified gross weight minus the calculated zero fuel weight) is greater than the specified or calculated fuel tank volume. Since the fuel system weight depends on the capacity, if this is still true for the final design, the fuel system weight will be underestimated. FULWMX, FULFMX and/or FULAUX should be adjusted to provide sufficient capacity. On the other hand, if the fuel capacity is much greater than that required, the design will be penalized by excessive fuel system weight.

Mission Analysis Problems

The majority of problems that occur in mission analysis are engine related, but, occasionally, aerodynamics and weights will contribute. The error message:

    * FAILURE FOR CRUISE CONDITION n

usually indicates that either the thrust/weight ratio or the lift/drag ratio for the configuration is too low. Check the "SUMMARY DATA FOR CRUISE SCHEDULE n" (IFLAG in Namelist $MISSIN must be greater than 0). If the lift/drag ratio is low and the aerodynamics are being generated internally, check the "DESIGN MACH NUMBER" and the "DESIGN CL" in the aerodynamic output. If it is trying to fly above the design (critical or drag divergence) Mach number, more wing sweep, a lower thickness/chord ratio, or a lower Mach number may be necessary. If it is trying to fly above the design Cl, more wing area may be necessary. If the aerodynamic data is input and is not very smooth, setting ITPAER to 1 in Namelist $AERIN may solve the problem by using linear interpolation for aerodynamics instead of curve fitting a biquadratic surface to the data. Otherwise, either more thrust is required, or a lower starting gross weight should be used for a sizing run. The aerodynamic and propulsion data may be plotted using the XFlops Graphical User Interface.

The error message:

    * FAILURE FOR CLIMB SEGMENT n

indicates that the rate of climb is less than or equal to zero at some point in the climb profile (RCI in the "CLIMB PROFILE DATA FOR SEGMENT n" table following this error message - IFLAG in

Namelist $MISSIN must be greater than 1). This usually occurs at one of two points: at the start of climb or while accelerating through Mach 1. If the problem is at the start of climb, the low speed may be requiring a high lift coefficient resulting in a low lift/drag ratio. If the Cl is off the aerodynamic tables, setting ITPAER to 1 in Namelist $AERIN may solve the problem by using linear extrapolation, but the best solution is to include high Cl's in the tables. Also, increasing the start-of-climb Mach number may be a feasible solution. If the problem occurs at Mach 1, allowing the aircraft to dive through Mach 1 (See NODIVE and DIVLIM in Namelist $MISSIN) may solve the problem or it may be necessary to increase the thrust. If the problem occurs elsewhere, it is probably due to incomplete or bad aerodynamic or propulsion data. The aerodynamic and propulsion data may be plotted using the XFlops Graphical User Interface.

The error message:

```
     * FAILURE FOR DESCENT SEGMENT n
```

indicates that the rate of climb is greater than or equal to zero at some point in the descent profile (RCI in the "DESCENT PROFILE DATA FOR SEGMENT n" table following this error message - IFLAG in Namelist $MISSIN must be greater than 1). This is usually caused by excessive thrust at flight idle conditions. Setting IDLE to 1 or 2 and NONEG to 1 normally provides the best results. If the drag is negative, fix the aerodynamics or set ITPAER to 1 to prevent an inappropriate interpolation or extrapolation.

If Flops thinks that it has successfully flown the mission but the results make no sense, the problem is probably in the Mission Definition Data. There must be no climbs after the "free" cruise segment and no descents before the free segment. If there is a military "beam down" descent before the free segment, omit it. Each cruise segment before the free segment should have a positive distance specified from the start of the mission, and each cruise segment after the free segment should have a negative distance specified from the end of the mission. The distance for the free cruise segment is what's left over and should not be specified. Climb segments must be followed by a cruise or hold segment to specify when to stop climbing. If the next segment is not a cruise or hold, a dummy hold segment (zero hold time) may be inserted to terminate the climb. Similarly, descent segments must be preceded by a cruise or hold segment.

Takeoff and Landing Problems

The detailed takeoff and landing analyses are very tricky numerically. The error message:

```
     * * *  FAILED TAKEOFF * * *
```

usually indicates that there is not enough thrust to take off. Sometimes in borderline cases, reducing the Integration Intervals DELVTO, DELTRO and DELTCL in Namelist $TOLIN will provide more consistent results. Similarly, the error message:

* * * FAILED SECOND SEGMENT CLIMB CRITERION * * *

indicates a thrust deficiency. Flops will increase the rotation speed in an attempt to meet the criterion, but if it cannot find a rotation speed that will meet the criterion, it reverts to the rotation speed it started with. This will cause a discontinuity in the constraint surface causing problems in optimization and contour plots. If the aerodynamic or thrust data is poorly behaved, increasing VROTAT in Namelist $TOLIN may provide better results. In either case, the real problem may be not enough lift or too much drag. Takeoff aerodynamic and thrust data may be plotted using the XFlops Graphical User Interface.

Similarly, during landing calculations, the error message:

* * * FAILED MISSED APPROACH CLIMB CRITERION * * *

indicates a thrust deficiency. Flops will increase the approach speed in an attempt to meet the criterion, but if it cannot find an approach speed that will meet the criterion, it reverts to the approach speed it started with. This will cause a discontinuity in the constraint surface causing problems in optimization and contour plots. If the aerodynamic or thrust data is poorly behaved, increasing CLLDM or CLAPP in Namelist $AERIN or clldm in Namelist $TOLIN will increase the approach speed and may provide better results. The real problem, however, may be not enough lift or too much drag. Landing aerodynamic and thrust data may be plotted using the XFlops Graphical User Interface.

The error messages:

ITERATION OF CONSTANT VELOCITY ANGLE OF ATTACK IS INCOMPLETE

UNABLE TO ITERATE ON FLARE NORMAL ACCELERATION - PROGRAM CONTINUE

ITERATION OF TOUCHDOWN ALTITUDE IS INCOMPLETE - PROGRAM CONTINUE

are indicators of numerical problems during approach and flare. Usually, these problems may be fixed by reducing the Iteration Interval DELDFL (and possibly DELHAP) in Namelist $TOLIN. These problems may also be caused by poor landing polars, or insufficient lift may be available due to a low angle of attack (ALMXLD in Namelist $TOLIN).

Inconsistent Results

On occasion, attempting to repeat an analysis from a different starting point will result in different answers. This may occur, for example, in trying to analyze the optimum point from a contour plot. There are six common causes for this problem: 1) fuel capacity/fuel system weight, 2) horizontal and vertical tail volume coefficients are set to 1., 3) a fixed glove area (GLOV), 4) input aerodynamics, 5) design thrust for generated engines, and 6) detailed wing input data.

If the actual fuel capacity is input as FULWMX in Namelist $WTIN, it is scaled with changes in aspect ratio (or span), wing area, taper ratio, and thickness-chord ratio. Therefore, a different starting point will scale differently. In the input echo, FWMAX (the scaling constant) is printed just below the input value of FULWMX. If this value is input for FULWMX on subsequent runs, the fuel system capacity and weight will be consistent.

Similarly, if HTVC and/or VTVC (horizontal and vertical tail volume coefficients) are set to 1., the horizontal and/or vertical tail areas will be scaled based on the aspect ratio and wing area of the initial or reference design for that run. Calculated values for HTVC and VTVC are printed in the input echo and should be used for subsequent runs.

Also, if a glove area (GLOV) is input, it will remain constant - affecting the wing aspect ratio in a nonlinear manner. If PGLOV (the ratio of glove area to wing area) is used instead, the wing shape will remain consistent.

If Namelist $ASCLIN is used, variables SREF and TREF should be used to specify the wing area and thrust on which the aerodynamic data are based. Similarly, variables SWREF and ARRET are available in Namelist $TOLIN to specify the wing area and aspect ratio on which the takeoff and landing polars are based. If these variables are not used, Flops assumes that the initial values are the reference values of these variables and will not scale the aerodynamic data consistently.

If the engine deck is being generated by the Flops Engine Cycle Analysis module, DESFN in Namelist $ENGINE should be specified to ensure consistent engine data. An engine generated at 50,000 lb thrust and scaled to 40,000 lb is not the same as an engine generated at 40,000 lb thrust. If DESFN is not specified, the engine is generated at the current thrust. Alternatively, if GENDEK in Namelist $ENGINE is set to .TRUE., an engine deck will be generated on the file specified by EOFILE and can be used on subsequent runs with the appropriate values of THRSO and WENG in Namelist $WTIN to guarantee consistency.

If the detailed wing definition is used (NETAW > 1 in Namelist $WTIN), data should be input in nondimensional form and values for ARREF and TCREF should be supplied so that the geometric data will be scaled consistently.

XFlops Input Troubleshooting

The XFlops Graphical User Interface has its own data base and namelist parser. It is case sensitive and does not allow duplicate variable names. Consequently, there are several restrictions on Flops input files used as input to XFlops.

1. Namelist $OPTION must be input when running Flops from XFlops. The Option Card, which was used in previous releases and is

still acceptable in batch mode, will not work with XFlops.

2. "$" must be used instead of "&" to precede Namelist names.

3. Each data item must end in a comma even if it is at the end of the line or if it is followed by the $END.

4. Input of the form n*x.xx is not allowed. You must specify each element of an array individually, separated by commas, For example, "FWF=3*-.1," must become "FWF=-.1,-.1,-.1,".

5. Variables must appear in only the Namelist shown for them in the User's Guide. For example, ITAKOF, ILAND, NOISE, NOPRO and NPFILE can only be input in Namelist $OPTION for XFlops. In batch mode, the first four may also be input in Namelist $AERIN, and NPFILE may also be input in Namelist $PROIN.

6. For variables for which multiple namelist input capability is important, lower case versions of the variable have been created. Therefore, everything must be upper case except:

```
 The Title Card
 "Mywts" in $MISSIN ("MYWTS" in $WTIN)
 "cltom" and "clldm" in $TOLIN ("CLTOM" and "CLLDM" in $AERIN)
 All variables in $RERUN which are all lower case
```

7. When inputting arrays, subscripts are not usually a good idea. FWF(1)=1.0, FWF(2)=-.001, FWF(3)=-1.0, will not work because XFlops sees this as duplicate variable names. FWF=1.0,-.001,-1.0, will work.

8. For two dimensional matrices, you must fill one row before starting the next. For example, a matrix with dimensions 20 by 3 using only 4 by 2 elements would normally be input as:

```
STMA(1,1)=0.3,0.5,0.7,0.8,
STMA(1,2)=0.3,0.4,0.6,0.8,
```

   In XFlops it must be input as:

```
STMA=0.3,0.5,0.7,0.8,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,
     0.3,0.4,0.6,0.8,
```

   with 16 0's to fill out the first row to its dimension of 20. If you are unsure of the dimensions of the array, click on the input field and press F1 for a complete report.

Violation of these restrictions will result in segmentation faults, bus errors, and bad data warnings. Bad data warnings are accompanied by a string which includes the offending variable and surrounding numerical data as well as an indication of its location.

===

CONSTRAINT DESCRIPTIONS

This section provides additional information on the constraints available in Flops. This may include how the constraint is calculated, where the limiting value is input, and what to do if the constraint is violated.

Mission Constraints

These constraints may be applied to any type of aircraft and generally are concerned with overall mission performance.

Range

The computed range must be greater than or equal to DESRNG (Namelist $CONFIN). If IRW = 1 in Namelist $MISSIN, Flops will iterate on the gross weight until the range flown is equal to this Design Range. If IRW = 2, the gross weight is fixed and the range is calculated. If the range is too low, the gross weight can usually be increased until the design range is met. Any design variable, however, can impact the range, but there are usually trade offs involved. For example, increasing the aspect ratio may improve the aerodynamic efficiency, but it will also increase the structural weight.

If the range flown is zero, an error has occurred. Look at the last block of output to determine the problem. If it is an input error, fix it and rerun. If an execution error occurs, see the troubleshooting section above.

Fuel Capacity

The fuel capacity constraint requires that the total capacity of wing, fuselage, and (for fighters) auxiliary fuel tanks (input in Namelist $WTIN) be sufficient for the fuel on board plus a required excess capacity. The constraint value indicated is the fuel capacity minus the fuel on board and should always be greater than or equal to EXFCAP (Namelist $SYNTIN).

If this constraint is violated, increasing the wing area, increasing the thickness/chord ratio, decreasing the aspect ratio, or (to a lesser extent) decreasing the taper ratio will all increase the wing fuel capacity. Alternatively, fuselage tanks can be added or enlarged if the fuselage volume is available.

If the wing fuel capacity is internally calculated, the following equation is used:

```
                   (t/c)*(Wing Area)**2          Taper
  FULWMX = FWMAX * -------------------- * ( 1 - ------------ )
                        Wing Span               (1+Taper)**2
```

The default value for FWMAX is 23.0 which is about average for subsonic transports. If FULWMX is input, Flops calculates and prints FWMAX. For simple wings, FWMAX may be as high as 28, or, for aircraft where fuel capacity is not a problem, it may be very low.

NOx Emissions

The calculated oxides of nitrogen (NOx) emissions must be less than GNOX (Namelist $SYNTIN). This is used primarily for supersonic transports where NOx emissions are a concern. The input or generated engine deck must have emissions index data.

A reduction in burner temperature (ETTR and/or ETIT) and a reduction in compressor discharge temperature (EOPR or CDTMAX) will generally reduce NOx emissions indices (EI's). This will also generally reduce engine overall efficiency and therefore increase fuel burn and overall NOx emissions. It may not be possible to satisfy this constraint with current combustor technology (EI relations in the cycle analysis module). If the engine cycle analysis module is not being used to generate EI's, try to minimize the fuel burned or vary the cruise Mach number and altitude to reduce emissions.

Minimum Rate of Climb

Flops calculates the instantaneous potential rate of climb (excess power) at each point of the climb profile. The minimum of these values must be greater than ROCLIM (Namelist $SYNTIN).

If this constraint is violated, the thrust is usually increased. If the climb profile is being optimized, this parameter is being maximized (FWF = -.001) or is at least a major component of the objective, and more thrust (or less drag) is required. If the climb profile is specified or restricted (q limit, etc.), it may be possible to meet this constraint by easing the restrictions.

Minimum Climb Thrust Margin

Flops calculates the thrust required (= drag) for level flight and the thrust available at each point of the climb profile and computes the thrust margin from (Thrust - Drag)/Drag. The minimum of these values must be greater than TMGLIM (Namelist $SYNTIN).

If this constraint is violated, the thrust is usually increased. If the climb profile is being optimized, this parameter is a major component of the objective, and more thrust (or less drag) is required. If the climb profile is specified or restricted (q limit, etc.), it may be possible to meet this constraint by easing the restrictions.

Takeoff and Landing Constraints

These constraints may be active for any analysis. If the detailed takeoff and landing module is not used, approximate values are computed based on data input in Namelist $AERIN.

Approach Velocity

The computed approach velocity must be less than or equal to VAPPR (Namelist $AERIN). The approach velocity depends on the wing area, landing weight, and maximum landing lift coefficient. If this constraint is violated, the wing area is usually increased until the approach speed is down to the desired value. The exception occurs when the missed approach climb gradient thrust margin is zero. This usually means that Flops has increased the approach speed to meet the thrust margin constraint. The solution to this is usually increasing the thrust.

Takeoff Field Length

The computed takeoff field length must be less than or equal to FLTO (Namelist $AERIN). The takeoff field length is heavily influenced by both the wing area and the thrust. If this constraint is violated, look at the other constraints to determine how to fix it. If the missed approach and/or second segment climb gradient thrust constraints are violated or close, increase the thrust. If the approach velocity and/or landing field length constraints are violated or close, increase the wing area.

Landing Field Length

The computed landing field length must be less than or equal to FLLDG (Namelist $AERIN). The landing field length is determined primarily by the approach velocity, which, in turn, is governed by the wing area. If this constraint is violated, increase the wing area unless the missed approach climb gradient thrust margin is zero. In this case, the thrust must be increased to decrease the approach velocity.

Missed Approach Climb Gradient

The FAA requires that if an engine fails during approach for landing, the remaining engines must be able to maintain a specified climb gradient in the approach configuration. This climb gradient is a function of the number of engines: 2.1 percent for 2 engines, 2.4 percent for 3 engines, and 2.7 percent for 4 engines. The required climb gradient for multiengine fighters is 2.5 percent.

Flops calculates the thrust required to maintain this gradient and subtracts it from the thrust available. The resulting thrust margin must be greater than or equal to zero. If the margin is initially less than zero, Flops will automatically increase the approach velocity to see if that will satisfy the constraint. If possible, Flops will iterate until the thrust margin is zero. This will increase the landing field length and may violate the approach velocity constraint.

If this constraint is violated or if satisfying this constraint causes the approach velocity or landing field length constraints to be violated, the thrust is usually increased. Improving the lift/drag ratio in the approach configuration or reducing the landing weight will also help.

Second Segment Climb Gradient

The FAA requires that if an engine fails during second segment climb - after the obstacle has been cleared during takeoff, the remaining engines must be able to maintain a specified climb gradient in the takeoff configuration. This climb gradient is a function of the number of engines: 2.4 percent for 2 engines, 2.7 percent for 3 engines, and 3.0 percent for 4 engines. The required climb gradient for multiengine fighters is 2.5 percent.

Flops calculates the thrust required to maintain this gradient and subtracts it from the thrust available. The resulting thrust margin must be greater than or equal to zero. If the margin is initially less than zero, Flops will automatically increase the rotation velocity to see if that will satisfy the constraint. If possible, Flops will iterate until the thrust margin is zero. This will increase the takeoff field length.

If this constraint is violated or if satisfying this constraint causes the takeoff field length constraint to be violated, the thrust is usually increased. Improving the lift/drag ratio in the takeoff configuration will also help.

Noise Constraints

These constraints are active only if the noise module is used to calculate sideline and flyover noise. The values and limits are both calculated internally.

Flyover Noise

The flyover noise is measured along the runway centerline, 6500 meters (21325 feet) from brake release. The noise limit is based on FAR 36 Stage III requirements which depend on number of engines and aircraft gross weight. This limit is increased by 2 dB to account for being able to trade 2 dB between flyover noise and sideline noise.

If this constraint is violated, add acoustic treatment for suppression, reduce the jet velocity (see jet velocity constraint), and/or reduce the fan tip speed (UTIP1).

Sideline Noise

The sideline noise is measured parallel to and 450 meters (1476 feet) from the runway centerline. Noise is calculated at 500 foot increments and the worst point is used. The noise limit is based on FAR 36 Stage III requirements which depend on number of engines and aircraft gross weight. This limit is increased by 2 dB to account for being able to trade 2 dB between flyover noise and sideline noise.

If this constraint is violated, add acoustic treatment for suppression, reduce the jet velocity (see jet velocity constraint), and/or reduce the fan tip speed (UTIP1).

Combined Noise

This constraint ensures that the trade of 2 dB between flyover noise and sideline noise is conducted honestly. It limits the sum of the flyover noise and sideline noise to be less than or equal to the sum of the FAR 3Stage III limits for flyover noise and sideline noise.

If this constraint is violated, add acoustic treatment for suppression, reduce the jet velocity (see jet velocity constraint), and/or reduce the fan tip speed (UTIP1).

Engine Performance Constraints

These constraints are active only if the engine deck is being generated internally and an engine variable is active. They were developed to keep the engine within reasonable operating limits.

Compressor Discharge Temperature

The compressor discharge temperature (CDT) limit (CDTMAX, Namelist $ENGINE) is enforced at the design cruise Mach number and altitude (XMDES and XADES defined in namelist $ENGINE). If this constraint is violated, decreasing the overall pressure ratio or decreasing the throttle ratio (T4_max/T4_design), will reduce the CDT. The throttle ratio is decreased by reducing ETTR or, for a fixed T4_max (ETTR > ETIT), the throttle ratio is effectively reduced by increasing T4_design (ETIT). Note, however, that increasing T4_design will likely increase the takeoff jet velocity and noise. If LIMCD=1 in namelist $ENGINE, then the limit is enforced internal to the cycle analysis module, and this constraint should not be active.

T4 is the burner temperature.
ETIT is the design burner temperature.
ETTR is the throttle ratio or the maximum allowable T4 if
    ETTR > ETIT.

Compressor Discharge Pressure

The compressor discharge pressure (CDP) limit (CDPMAX, Namelist $ENGINE) is enforced at the design cruise Mach number and altitude (XMDES and XADES defined in namelist $ENGINE). If this constraint is violated, decreasing the overall pressure ratio or decreasing the throttle ratio (T4_max/T4_design), will reduce the

CDP. The throttle ratio is decreased by reducing ETTR or, for a fixed T4_max (ETTR > ETIT), the throttle ratio is effectively reduced by increasing T4_design (ETIT). Note, however, that increasing T4_design will likely increase the takeoff jet velocity and noise. If LIMCD=1 in namelist $ENGINE, then the limit is enforced internal to the cycle analysis module, and this constraint should not be active.

T4 is the burner temperature.
ETIT is the design burner temperature.
ETTR is the throttle ratio or the maximum allowable T4 if
      ETTR > ETIT.

Maximum Engine Jet Velocity

The jet velocity limit (VJMAX, Namelist $ENGINE) is enforced at sea level static. It is primarily intended as a way of limiting takeoff noise without actually calculating the noise levels. If this constraint is violated, the takeoff jet velocity can be reduced by reducing the design burner temperature at takeoff if ETTR > ETIT, increasing the throttle ratio if ETTR < ETIT (this effectively reduces T4_design), or increasing the bypass ratio. Increasing the design burner temperature will probably increase the compressor discharge temperature and increase the takeoff field length.

T4 is the burner temperature.
ETIT is the design burner temperature.
ETTR is the throttle ratio or the maximum allowable T4 if
      ETTR > ETIT.

Minimum Specific Thrust

The specific thrust limit (STMIN, Namelist $ENGINE) is enforced at sea level static conditions. It is defined as thrust/airflow. Turbojets, turbine bypass engines, and low bypass ratio flow turbofans generally have a higher specific thrust than turboprops and high bypass ratio turbofans. The higher specific thrust engines usually have higher specific fuel consumption and are more common on high speed / high performance fighters, while the lower specific thrust engines are common on subsonic transports. The specific thrust can be increased by increasing the design burner temperature, by reducing the bypass ratio, and/or by increasing the overall pressure ratio.

Maximum Bypass/Core Area Ratio

This limit (ARMAX, Namelist $ENGINE) is enforced at sea level static conditions. It is generally not necessary to use this constraint. It would only be used for mixed and separate flow turbofans and only if the area ratio became unrealistic. This would be caused by an unrealistic combination of fan pressure ratio, bypass ratio, overall pressure ratio, and/or design burner temperature. This will generate poor specific fuel consumption and a poor performing aircraft so that minimization of the objective function should solve any problems.

Performance Constraints

Although these constraints can be used for other types of aircraft, they were designed for fighter missions to guarantee a level of maneuverability and performance. Each constraint, including flight conditions and limits, is defined in a separate Namelist $PCONIN. The number of performance constraints is defined by NPCON in Namelist $MISSIN.

Minimum Climb Rate

The instantaneous rate of climb is calculated from:

(Thrust - Drag) * Velocity / Weight

where the drag is that for level flight. The constraint is evaluated at the input Mach number, altitude and weight, and the value must be greater than an input limit. If it is violated, it may be possible to decrease drag but usually the thrust is increased.

Maximum Time To Climb

The time to climb is calculated from the start of the mission to the end of the specified segment. The value must be less than an input limit. FWF in Namelist $MISSIN should be set to -.001 to minimize this value. If the constraint is violated, it may be possible to decrease drag, but usually the thrust is increased.

Maximum Time To Distance

The time to distance is calculated from the start of the mission to the end of the specified segment. The value must be less than an input limit. FWF in Namelist $MISSIN should be set to 0. to minimize this value. If the constraint is violated, it may be possible to decrease drag, but usually the thrust is increased.

Minimum Sustained Load Factor

The lift coefficient is calculated for which the drag is equal to the available thrust at the input Mach number, altitude and weight. The corresponding load factor (Nz) must be greater than an input limit. If the constraint is violated, it may be possible to decrease drag, but usually the thrust or wing area is increased.

Minimum Instantaneous Load Factor

The load factor (Nz) corresponding to an input maximum lift coefficient is calculated at the input Mach number, altitude and weight. This value must be greater than an input limit. If this constraint is violated, it may be possible to increase the maximum lift coefficient or decrease the weight at which the constraint is evaluated, but usually the wing area is increased. The calculated value for the load factor is limited to Turn Segment Limits if they are input in Namelist $MISSIN.

Minimum Turn Rate

The lift coefficient is calculated for which the drag is equal to the available thrust at the input Mach number, altitude and weight. The corresponding load factor and turn rate are computed, and the turn rate must be greater than an input limit. If the constraint is violated, it may be possible to decrease drag, but usually the thrust or wing area is increased.

Minimum Turn Radius

The lift coefficient is calculated for which the drag is equal to the available thrust at the input Mach number, altitude and weight. The corresponding load factor and turn radius are computed, and the turn radius must be greater than an input limit. If the constraint is violated, it may be possible to decrease drag, but usually the thrust or wing area is increased.

Minimum Excess Energy

The excess specific energy is calculated from:

$$(\text{Thrust} - \text{Drag}) * \text{Velocity} / \text{Weight}$$

where the drag is that for level flight. The constraint is evaluated at the input Mach number, altitude and weight, and the value must be greater than an input limit. If it is violated, it may be possible to decrease drag but usually the thrust is increased.

Minimum Climb Ceiling

The climb ceiling is the altitude at which the rate of climb is equal to a minimum acceptable input value at the input Mach number and weight. This altitude must be greater than an input limit. If the constraint is violated, it may be possible to decrease drag, but usually the thrust or wing area is increased.

Minimum Acceleration/Deceleration Time

The time required to accelerate or decelerate from the starting to the ending speed is calculated for the weight, altitude and engine thrust level input. The calculated time must be less than an input limit. If an acceleration constraint is violated, it may be possible to decrease drag but usually the thrust is increased. If a deceleration constraint is violated, drag is usually added using control surfaces.

If no ending speed is specified, the instantaneous acceleration rate at the starting speed is calculated. The calculated rate must be greater than an input limit. If this constraint is violated, it may be possible to decrease drag but usually the thrust is increased.

Minimum Top Speed

The Mach number is calculated for which the available thrust is equal to the drag at the altitude and weight input. This speed must be greater than an input limit. If the constraint is violated, it may be possible to decrease drag, but usually the thrust is increased.

Minimum Energy Bleed

The drag corresponding to an input maximum lift coefficient is calculated at the input Mach number, altitude and weight. The specific energy bleed rate (usually negative) is calculated from:

(Thrust - Drag) * Velocity / Weight

This rate must be greater than an input limit. If the constraint is violated, it may be possible to decrease drag, but usually the thrust is increased.

Minimum Thrust Margin

The drag corresponding to the input load factor (Nz) is calculated at the input weight, Mach number and altitude and subtracted from the available thrust. This net thrust must be greater than an input limit. If the constraint is violated, it may be possible to decrease drag, but usually the thrust is increased.

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FILE USAGE

```
 Unit  3 = Primary engine cycle input file (See Namelist $ENGINE)
           For IENG = 0, User defined - IFILE, Namelist $ENGINE
           For IENG = 1, Named 'TURJET'
           For IENG = 2, Named 'TFNSEP'
           For IENG = 3, Named 'TFNMIX'
           For IENG = 4, Named 'TURPRP'
           For IENG = 5, Named 'TBYPAS'
```

```
           For IENG = 6, Named 'TFNSP3'
           For IENG = 7, Named 'TFNMX3'
           For IENG = 8, Named 'TFN3SH'
           For IENG = 9, Named 'TURJT2'

Unit  4 = Optional engine cycle analysis output file - OFILE,
          Namelist $ENGINE (Default name = 'ENGOUT')

Unit  5 = Standard input file, named 'FLOPSIN' on some computers

Unit  6 = Standard output file, 'FLOPOUT' on some computers

Unit  7 = Optional output file for contour plot data - CNFILE,
          Namelist $OPTION (Default name = 'FLPPLOT')

Unit  8 = Optional output file for aerodynamic drag polar plot
          data - APFILE, Namelist $OPTION (Default name =
          'POLPLOT')

Unit  9 = Optional output file for takeoff and climbout data to
          be used in noise calculations - NOFILE, Namelist
          $OPTION (Default name = 'NPROF')

Unit 10 = Optional engine cycle analysis debug file, 'DEBUG'

Unit 11 = Optional external engine deck (Default = 'ENGDEK')
          If being input - EIFILE, Namelist $ENGDIN
          If being generated - EOFILE, Namelist $ENGINE

Unit 12 = Engine component map tabular data file - TFILE,
          Namelist $ENGINE (Default name = 'ENGTAB')

Unit 13 = Optional output data for noise prediction

Unit 14 = Optional engine / nacelle PostScript Plot file -
          PLTFIL, Namelist $ENGINE (Default name = 'ENGPLT')

Unit 15 = Temporary scratch file used in generating Unit 14

Unit 16 = Optional output file for excess power (Ps) and load
          factor (Nz) contour plot data - PSFILE, Namelist
          $OPTION (Default name = 'PSPLOT')

Unit 17 = Optional output file containing a sorted, filled and
          scaled engine deck suitable for plotting - THFILE,
          Namelist $ENGDIN (Default name = 'THRPLOT')

Unit 18 = Optional output file containing a time history of
          changes to design variables and the resulting values
          of objectives and constraints during optimization -
          HSFILE, Namelist $OPTION (Default name = 'HISPLOT')

Unit 19 = Optional output file containing mission summary data
          for use with the XFLOPS Graphical Interface - MSFILE,
          Namelist $OPTION (Default name = 'MSMPLOT')

Unit 20 = Optional output file containing cruise schedule data
```

for use with the XFLOPS Graphical Interface - CRFILE,
Namelist $OPTION (Default name = 'CRUPLOT')

Unit 21 = Optional output file containing fuselage design data
for use with the XFLOPS Graphical Interface
(Name = 'FUSEDATA')

Unit 22 = Optional output file containing takeoff and landing
aerodynamic and thrust data for use with the XFLOPS
Graphical Interface - TOFILE, Namelist $OPTION
(Default name = 'TOLPLOT')

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DEVELOPMENT HISTORY

The primary addition for Release 8.1 is a step climb capability based on the one developed at Georgia Tech.
In addition, batteries can be recharged during any segment for electric power, fuel tanks can be topped off during refueling, and climb termination or start of descent can occur at segments other than Cruise and Hold.

Release 8.0 represents a major increase in capability. Energy sources other than hydrocarbon fuels may now be used instead of or in addition to fuels that are burned. Combined with the dual engine deck capability, it is now possible to perform a mission flying to an area using jet engines, performing a reconnaissance under electric power, and flying back out using the jets.

The primary feature added in Release 7.70 is the capability to input 2 engine decks and to select which deck to use for each mission segment. Nitrous oxide (NOx) calculations were also added for all segments not previously covered.

In Release 7.60, the performance module was rewritten to allow more schedules for more complicated missions. Currently, dimensions are set for 10 climb schedules and 15 cruise schedules.

The primary addition for Release 7.50 is a capability to size both horizontal and vertical tails for transport and fighter aircraft based on geometric and mission data. Other improvements included a delta approach velocity variable, a fixed landing weight capability, and allowing up to 10 store drag conditions 10.

Release 7.40 includes the capability to change the fuel density and various improvements to the BWB (blended wing body) analysis and design capability. Aerodynamic efficiency factors were redefined, and the takeoff analysis was updated with new capabilities to match flight test data.

For Release 7.30, input variables for fixed takeoff, taxi out, taxi in, and approach fuel allowances were added. This release also features full implementation of a revised BWB (blended wing body) capability, including wing geometry and aerodynamics.

Release 7.20 represents a complete overhaul of the inertia calculations and output. In addition, cabin sizing and weight calculations were added for a BWB (blended wing body) aircraft.

Release 7.10 includes the capability to terminate a cruise segment based on fuel burned instead of distance and the capability to input a climb schedule in KEAS (knots equivalent airspeed). The propeller model was expanded to allow fixed pitch props with fuel consumption array inputs. The engine weight calculations were extended to 3-spool engine cycles and engine cycles with free turbines.

Release 7.0 features the addition of two predefined engine definition input files - a three spool separate flow turbofan with three compressor components and a two spool turbojet. Modifications were made to the data preparation for the FAA integrated noise model program. The turbine analysis was modified so that the year of technology availability affects efficiency, and fuel flow input options were added for internal combustion engines. The inflation calculations based on the Consumer Price Index was updated. Standard distribution packages for the PC were developed.

For Release 6.1, the clean up and standardization of the FLOPS Fortran code was completed. A method of specifying double precision acceptable across platforms and compilers was implemented. Modifications to weights, aerodynamics and takeoff and landing were made to account for large numbers of engines (distributed propulsion). A ducted fan capability and several minor modifications were implemented in the cycle analysis module. More flexibility was added to the input of drag polars in takeoff and landing. Based on user input, minor changes and corrections were made to input, output, and limits.

For Release 6.0, FLOPS was modified to adhere to ANSI syntax standards to provide improved portability to new systems, particularly PC's. In addition, many minor corrections and enhancements have been made to improve code versatility, precision, consistency and performance. KSOPT was reinstated as a choice for optimization. A combat segment, time at a specified power setting, was added to the Mission Definition options. A fixed velocity and angle of attack segment option was added to the takeoff profile for noise. The capability to write files necessary for transporting FLOPS data to the FAA Integrated Noise Model (INM) program was added. Flyover was added to the noise profile capability. Fuel leak and paint weight options were added. Gutin's Method for propeller noise was implemented. A fixed fuel mission capability and a gear box noise option were added.

FLOPS Release 5.9 features new analysis, optimization and engine cycle analysis capabilities. An approximate method for calculating sonic boom overpressures has been added. They can be plotted along the flight path using the XFLOPS interface. Optimization variables were added for rotation speed, an engine derate parameter, and the cutback for a Programmed Lapse Rate (PLR) segment to improve design with noise constraints. A cycle definition file was added for a mixed flow turbofan with three compressor components. The capability to calculate engine performance for intermittent combustion (piston or rotary) engines and for propellers has also been added to the cycle analysis module. Corrections and improvements have also been made to the noise calculation module.

Major modifications to the engine weight calculations were made for FLOPS Release 5.8. In addition, a propfan error was corrected and more flexibility was added to the weights calculations. In the Mission Performance Module, a specified distance cruise segment and an approach segment were added as well as the capability to force equal dash in - dash out legs for military radius missions. A descent rate limit was added allowing constant glide slope descents. In the Takeoff and Landing Module, options were added for gear up during missed approach and subtracting taxi out fuel before takeoff. Military critical field length calculations were corrected, and delta Cl and Cd and cutoff velocity were added for thrust reversers.

FLOPS Release 5.7 features a number of corrections and improvements in the cycle analysis module in the areas of engine weights and engine noise data and in the FOOTPR noise module. Calculations for fan noise, ground reflection effects, and effective perceived noise level were improved, and several minor corrections were made to bring the results in line with those from ANOPP. Also, the FLOPS example problem suite has been revised, and corrections were made to avoid warnings from other FORTRAN compilers (VAX, AIX).

In FLOPS Release 5.6, the cycle analysis module and the FOOTPR noise module were integrated. The FAR Stage III noise regulations or Stage III - delta dB can be used as constraints during optimization and on contour plots. A suboptimization capability was added to the cycle analysis module to allow for limited variable geometry cycles. Now one can vary nozzle throat area or inlet guide vane angle to minimize specific fuel consumption and/or maximize thrust. Also, a fuselage design module has been added which calculates fuselage dimensions based on the number of passengers if the fuselage length is not input. More flexibility has been added for FAA mandated climb profiles below 10,000 feet.

FLOPS Release 5.5 changes the fighter weight statement to conform with MIL-STD-1374. It also adds a specified dive limit for optimized climbs and the capability to enforce a dynamic pressure limit in cruise by specifying a minimum altitude for each cruise condition. Modifications were made to eliminate compiler warnings and errors for a wide range of FORTRAN compilers, to improve convergence in several iterative processes, and to provide better data for the XFLOPS Graphical User Interface.

FLOPS Release 5.4 provides the capability to print a detailed mission summary sequentially from takeoff to landing and to generate an XFLOPS plot file with these data. An engine data file containing all sorted, filled and scaled engine performance data can also be generated for use with XFLOPS plotting or as an input engine deck for subsequent runs. In addition, a plot file containing a history of the changes in design variables, constraints, objectives, and other data of interest may be generated for optimization runs or parametric variations.

FLOPS Release 5.3 implements a new, improved cycle analysis module including a new capability to estimate propulsion system weight and dimensions based on component design. Also, a constraint has been added to limit the first compressor surge margin, iteration tolerances have been tightened, compressor design point adiabatic efficiency is based on maximum efficiency in the tables instead of being estimated, generation of part power data is biased toward higher thrust levels, and engine schematic plot data can be generated.

FLOPS Release 5.2 adds a sixth jet noise prediction option, based on the ANOPP SAE single jet data, to the noise footprint module. Also, noise calculations are now available in the stand-alone takeoff and landing program. A constraint has been added for the minimum rate of climb during climb segments, and output files are produced for postprocessing by the XFLOPS Graphical Interface. Wing area and engine size effects have been added to the special parabolic drag polar input. This change necessitates modifications to any old input files containing Namelist $RFHIN. A variable dynamic pressure limit has also been added.

FLOPS Release 5.1 includes the capability to scale nozzle boattail drag data using a table look-up. In addition, new options have been added to climb, cruise, reserve calculations, engine idle calculations, passenger and baggage weights, and takeoff and climbout for noise calculations as well as new aerodynamic technology factors. To prevent duplicate input variable names, the names of a few variables were changed in Namelists $COSTIN, $TOLIN and $NOISIN.

FLOPS Release 5.0 adds the Noise Footprint module. Also, the Option Card has been replaced with an $OPTION namelist (old decks should still work), and the capability to generate output plot files has been expanded. In addition, new options have been added for flight to the alternate airport during the reserve mission. Military requirements (MIL-STD-1793) have been added to the takeoff and landing module, and a constant floor angle (alpha + gamma) segment capability has been added to the climb profile for noise.

FLOPS Release 4.7 includes additional traps and kick outs for input errors and impossible missions, increased fuel weighting in descent optimization, CL and Nz limits in turns, more transonic Mach numbers for internally generated supersonic aerodynamics, and some minor changes to the climb profile for noise. Also, since it didn't work better than the original optimizer, the capability to optimize using the Kreisselmeier-Steinhauser function has been removed.

The modifications for FLOPS Release 4.6 are designed to make the analysis more precise and consistent for optimization. The tolerances for climb, cruise and descent schedule optimization have been tightened, a fuel flow term has been added to the descent optimization function, and the standard atmosphere subroutine ATMO has been converted to double precision. In addition, a third possible reserve hold position has been defined, I/O unit numbers are now variables, error and end kick outs have been added to all read statements, and minor improvements have been made to the climb profile for noise calculations capability.

FLOPS Release 4.5 adds a set of performance constraints for fighter aircraft including climb rate, time-to-climb, time-to-distance, sustained and instantaneous load factors, turn rate and radius, excess energy, ceiling, acceleration, max velocity, energy bleed rate, and thrust margin. In addition, there have been several changes to the climb profile for noise calculations capability. These include changing the part power engine setting from a power code basis to a percentage thrust basis and smoothing out transitions from one segment to another.

FLOPS Release 4.4 adds the following capabilities: a sixth cruise schedule, a second reserve hold segment as a percentage of flight time, analysis of a sized or optimized design for alternate missions, engine weight calculation for turbine bypass engines, skin friction drag calculations by component for MYAERO = 2, and gradual throttling back for climb profiles for noise calculations. In addition, there have been a number of minor corrections, improvements and output modifications primarily in the engine cycle analysis and takeoff and landing modules.

FLOPS Release 4.3 adds the capability to use oxides of nitrogen (NOx) emissions in the preliminary design cycle. NOx emissions may be calculated and used in determining the optimum cruise profile, and/or be constrained or optimized in a configuration optimization. The engine cycle analysis module has been upgraded to provide the required emissions index, and an engine definition deck for a turbine bypass engine is included with this release.

FLOPS Release 4.2 is primarily a modification of the engine deck cycle analysis module. In addition to the constraint on the first compressor corrected flow, constraints have been added on the compressor discharge temperature and pressure and on the overall pressure ratio. Also, the engine design variables have changed, and the spelling of some variables in the engine cycle analysis has changed.

FLOPS Release 4.1 adds the capability to optimize using the Kreisselmeier-Steinhauser function and to use linear interpolation on the aerodynamic tables. Also, a few minor corrections and changes to formats have been made.

FLOPS Release 4.0 adds a new capability to internally generate an engine deck and to use engine parameters as design variables as part of the aircraft synthesis or to optimize the engine cycle. There was also a correction to the detailed wing weight estimation capability to include the shift in aeroelastic penalty with sweep angle for high aspect ratio wings.

FLOPS Release 3.5 adds a new capability to generate takeoff and climb profiles for takeoff noise studies. Also, if the vehicle has insufficient power to climb during the main mission analysis, the analysis is kicked out with zero range.

FLOPS Release 3.4 includes a new takeoff and landing module which follows all FAR Part 25 rules for takeoff to the 35-foot obstacle. In addition, the approximate takeoff and landing equations were modified to correspond to the new module and some corrections have been made to the cost module.

FLOPS Release 3.3 includes smoothed aerodynamic drag tables for internal aerodynamic computation.

FLOPS Release 3.2 includes new approximate takeoff, landing, second segment climb and missed approach climb equations and some minor cleanup to avoid potential problems and smooth convergence.

FLOPS Release 3.1 includes an extensive overhaul of the subsonic transport cost analysis module, improvements in some output formats, changes in the way auxiliary fuel tanks are handled for fighters, and corrections to systems centers-of-gravity if horizontal and/or vertical tails are missing.

FLOPS Release 3.0 represents both an increase in capability and major changes in the programming philosophy. Vicki Johnson's cost calculation module has been added along with the capability to include costs in the objective function for optimization. A new wing weight estimation capability has been installed that depends on more detailed knowledge of the wing geometry. In the mission calculations, combat radius can now be calculated, and multiple descents are allowed.

The code has been cleaned up with comment statements added. The transport and fighter weights modules have been revised to reflect newer aircraft and combined so that selection is made through input instead of loading the proper module. For portability, the code has been converted to FORTRAN 77 with the Namelist extension. This User`s Guide is available as an ASCII text file and can be accessed interactively or printed.

The following is a list of variables whose names have been changed since Release 3.0.

Old	New	Namelist
BPR	BPRDES	$ENGINE
FPR	FPRDES	$ENGINE
OPR	OPRDES	$ENGINE
INOZ	INOZZ	$COSTIN

ARREF	ARRET	$TOLIN
DTC	DTCT	$TOLIN
IFLAP	NFLAP	$TOLIN
NO	NOB	$NOISIN
NS	NHT	$NOISIN
TD	TDI	$NOISIN

In addition, some variables are no longer used in FLOPS.

CONDEN	EALT	EMAC	F	FNOSHP	IDTLNK
IPCODE	PEFFMN	SHPDES	SHPMAX	TETMAX	

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UNDOCUMENTED OPTIONS

MFPR, FPRICE(10)	Namelist $COSTIN
TRPSYR	Namelist $COSTIN
DEBUG	Namelist $ENGINE
DVD(6)	Namelist $CONFIN
NGINWT > 9	Namelist $ENGINE
AFIX = GAMMA rate for IFIX = 4	Namelist $SEGIN