LOCAL FLOW MANAGEMENT/PROFILE DESCENT ALGORITHM

FUEL-EFFICIENT, TIME CONTROLLED PROFILES FOR THE NASA TSRV AIRPLANE

J. L. Groce, K. H. Izumi, C. H. Markham, R. W. Schwab, J. L. Thompson

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1.0 SUMMARY

This document describes a Local Flow Management/Profile Descent (LFM/PD) algorithm designed for NASA's Transport System Research Vehicle (TSRV) program. The algorithm provides fuel-efficient altitude and airspeed profiles consistent with ATC restrictions in a time-based metering environment over a fixed ground track. The model design constraints include accommodation of both published profile descent procedures and unpublished profile descents, incorporation of fuel efficiency as a flight profile criterion, operation within the performance capabilities of the Boeing 737-100 airplane with JT8D-7 engines, and conformity to standard air traffic navigation and control procedures. Holding and path stretching capabilities are included for long delay situations.
2.0 INTRODUCTION

On November 15, 1976, the FAA issued the Local Flow Traffic Management National Order, 7110.71. The purpose was to establish "a local-flow traffic management program designed to enhance safety, conserve aviation fuel and reduce the impact of aircraft noise on the local communities." The order directed Air Traffic Divisions, Air Route Traffic Control Centers, and Air Traffic Terminal Facilities to review and revise procedures to:

"1) Reduce flying time at altitudes below 10,000 feet above airport elevation (AAE) by:

   (a) Minimizing the use of speed of less than 210 knots.
   (b) Eliminating holding and excessive vectoring.
   (c) Designing the shortest practical route from the metering fix to the runway.

"2) Provide for maximum use of profile descents from cruising altitude/level to the approach gate. As a minimum, provide for profile descents during all periods of operation from at least 10,000 feet AAE and preclude routine level flight below this altitude except as required for:

   (a) Simultaneous 'turn-ons' to parallel runways.
   (b) Stabilization for glide slope or final approach course interception.
   (c) Speed adjustments.

"3) Avoid requiring abnormal high descent rates close in to the airport. Aircraft shall be given a distance for descent which is sufficient to permit a stabilized final approach with interception below the glide slope as defined in Chapter 4, Section 9, of Handbook 7110.65.

"4) Enable departures to climb unrestricted to the extent possible and ensure maximum compatibility with new or revised arrival procedures. Routine altitude restrictions below 5,000 feet above ground level should be avoided."

The order, in addition, established a metering program to develop procedures "to monitor the arrival flow to determine when the number of aircraft approaches system capacity. Traffic shall then be metered so as not to exceed this capacity. When delays are imposed, the priority of landing shall be based on the calculated time of arrival (CTA) for each aircraft. CTAs shall be calculated based on the estimated time of arrival at the metering fix plus the estimated flying time to the runway. These times shall then be adjusted to resolve simultaneous demands at the airport and to establish the time that an arrival aircraft will be required to cross the metering fix.

"a) Each facility shall, as required, establish operating positions which will be responsible for monitoring and metering the flow of traffic to and from affected airports. Establishment of these positions shall be subject to regional review and approval.

"b) Procedures shall insure that the metering position be supplied with information on all conditions which affect the terminal acceptance rate. This information is not limited to changes in runway, airport conditions or weather but also includes demands placed on the IFR runways by VFR, tower en route and internally generated IFR traffic landing at the impacted or a satellite airport. Metering techniques, therefore, shall insure that all aircraft operating within the system receive equitable distribution of delays."
"c) Delay absorbing techniques (holding, speed control, and vectoring) shall be used to provide time intervals between succeeding arrival aircraft which will allow for only the most expeditious routes to be flown from the metering fix to the runway at optimum system speeds. Holding should be accomplished at or above FL 200, and whenever possible, prior to the metering fix."

Profile descent procedures were published at Denver, Atlanta, St. Louis, Los Angeles, Miami and San Francisco. Time-based metering programs were developed at Denver and Ft. Worth Centers as an extension of the NAS En Route Stage A program. The metering function has been integrated into the NAS Stage A software and delivered to all centers. Beyond the current metering program the FAA has several advanced flow management concepts under study or development. These include metering and spacing, en route metering, automated en route ATC and strategic control.

Present ATC developments indicate an evolution of the system into a strategic control concept of air traffic management wherein a central control authority determines, and assigns to each participating airplane, a conflict-free, four-dimensional route-time profile. The route-time profile assignments are long-term as compared with the short-term, immediate nature of tactical control instructions. The route-time profiles are determined in a manner that provides for predictable and efficient use of both airspace and available runway operation times. This concept results in terminal area capacity increases, delay reductions, safety improvement, controller workload reductions and reduced fuel use. Maximum benefits are expected to occur at the busy terminal areas where demand is high and airspace is at a premium.

The Local Flow Management (LFM) avionics research objective is to define airborne navigation/guidance capabilities for efficient operation in the ATC integrated flow management system under development. The NASA TCV program Local Flow Management avionics research plan is shown in figure 1. This plan was developed under NAS1-14880, Task Requirement AB-11. Subtasks 1 and 2 under NAS1-14880 (Task Requirement A-100) have been completed and a contractor report was published, which delineated the major areas to be addressed in the LFM research plan. Subtasks 3 and 9 identified in Figure 1 are being pursued as part of the long-range research effort.

As part of TR A-103, two tasks were completed. A generalized path definition algorithm for operating in the flow management environment was developed satisfying

1) determination of minimum-fuel profile descent from cruise altitude to near the airport without an assigned metering fix time; and

2) determination of minimum-fuel descent profile to the metering fix with an assigned metering fix time and profile descent from the metering fix to near the airport.

In addition, an interim path definition algorithm was also developed and used in early flight tests at Denver in 1979. The design of the generalized algorithm to provide path definition computations was completed in July 1979. The development of additional capabilities

Subtasks performed as part of the algorithm development activity were:

1) Functional logic development;
2) Trade studies and analysis;
3) Algorithm design;
4) Software implementation, test and validation;
5) Interim algorithm development, flight test and evaluation;
6) Algorithm refinements and extensions; and
7) Documentation.

This report documents the algorithm design and software implementation, test, and validation subtasks.

Based on trade study results and analysis, a set of design ground rules was formulated.

1) Let-downs employ clean configuration and idle-thrust trajectories wherever possible.
2) Let-downs employ conventional Mach/CAS indicated airspeed schedules.
3) Point-mass, steady-state equations of motion are used by the trajectory generation algorithm.
4) Basic airplane performance data used by the algorithm include thrust, drag, fuel flow and operational speed limits.
5) Geometry and ATC constraints accommodate all FAA-published profiles with or without metering.

The algorithm that has been developed provides fuel-efficient altitude and airspeed profiles consistent with ATC restrictions over a fixed ground track. These profiles provide a reference trajectory allowing efficient operations in an LFM/PD environment. Specific design constraints that have been assumed in the algorithm design activity include: (1) accommodation of both published runway profile descent procedures and unpublished profile descents, (2) fuel efficiency as a flight profile criterion, (3) flight performance capabilities of the Boeing 737-100 with JT8D-7 engines, (4) standard air traffic navigation and control procedures, (5) 4-D holding and path stretching capability in the LFM environment, and (6) accommodation of anti-icing power requirements.
The Local Flow Management/Profile Descent algorithm as now operational includes an optimized vertical path for any of the published profile descent procedures (at Denver or other applicable airport) by input of the desired approach procedures file. The following operational features have been incorporated:

1) Descent to provide minimum fuel,

2) Descent to meet an assigned metering fix time with minimum fuel,

3) Descent to meet an assigned metering fix time with holding at optimum altitude using minimum fuel,

4) Descent to meet an assigned metering fix time when holding at an ATC-assigned altitude using minimum fuel,

5) Descent to meet an assigned metering fix time with stack holding using minimum fuel,

6) Descent to meet an assigned metering fix time with path stretching using minimum fuel, and

7) Descent with anti-ice power in preselected altitude band to meet a metering fix time using minimum fuel.

Figure 2 provides a summary of model input, processing and output elements. Model inputs include an approach geometry file, current and forecast wind and temperature data, an aircraft performance data base, the aircraft initial conditions (time, position, weight) and ATC clearance data (metering fix times, holding instructions). The model computes an optimum path by determining lateral path parameters required (path segment distance and course information), constructing wind and temperature models for the descent, computing a trial speed schedule (Mach and calibrated airspeeds), integrating the vertical path to provide clean, idle descents where consistent with approach constraints to minimize fuel use, evaluating the descent profile (times and fuel used), iterating as required to meet 4-D constraints, and displaying outputs. Outputs include an input report, the output path array, data detailing segments requiring thrust or drag, detailed holding information and summary outputs.

The algorithm is currently operational on a CYBER 175 computer, written in FORTRAN IV. The development of an airborne version of the generalized path definition algorithm for installation, testing and demonstration is the next step in the algorithm development plan.

Following sections of this report describe the LFM/PD Algorithm Functional Logic (Section 4), Computer Model Structure (Section 5) and Computer Model Test/Validation Approach (Section 6).
3.0 SYMBOLS AND ABBREVIATIONS

\( \gamma \)  flight path angle, in radians

\( \tau_s \)  holding fix crossing time interval, in minutes

\( \Delta h \)  altitude interval, in feet

\( D \)  drag force, in pounds

\( L \)  lift force, in pounds

\( T \)  engine thrust, in pounds

\( \Delta VTAS \)  difference in true airspeed, in knots

\( W \)  airplane gross weight, in pounds

\( AAE \)  above airport elevation

\( ATC \)  air traffic control

\( BOD \)  bottom of descent

\( CAS \)  calibrated airspeed

\( CDU \)  control and display unit

\( CTA \)  calculated time-of-arrival

\( FAA \)  Federal Aviation Administration

\( HPD \)  high profile descent

\( IFR \)  instrument flight rules

\( ISA \)  International Standard Atmosphere

\( KCAS \)  knots calibrated airspeed

\( kn \)  knots

\( LAX \)  Los Angeles International Airport

\( LFM/PD \)  Local Flow Management/Profile Descent

\( MF \)  metering fix

\( NAS \)  national airspace system
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<td>nmi</td>
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<tr>
<td>N1</td>
<td>airplane turbine rpm at station 1</td>
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<tr>
<td>POD</td>
<td>point of descent</td>
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<tr>
<td>RPD</td>
<td>runway profile descent</td>
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<td>TOD</td>
<td>top of descent</td>
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<tr>
<td>TSRV</td>
<td>Transport System Research Vehicle</td>
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4.0 LFM/PD ALGORITHM FUNCTIONAL LOGIC

This section of the Local Flow Management/Profile Descent Guidance Algorithm Development report provides an overview of the algorithm designed to provide fuel-efficient descents. Section 5, Computer Model Structure, provides an overview of the computer implementation of the algorithm. Figure 3 indicates the top level functions involved in the generation of a profile descent. Seven functions are indicated. First, the in-plane geometry data and ATC speed and altitude constraints are input. Second, the wind and temperature forecast data are input and wind and temperature versus altitude models constructed. The next five functions are repeated, once for each profile computed. The descent initialization function consists of inputting the current path, altitude, speed and weight data, either for a nominal or revised path. The descent profile is now constructed for the last portion of the descent (from the metering fix to an aimpoint near the runway). Next, the aeroperformance envelope is determined (fast- and slow-speed boundaries and Mach-to-indicated airspeed transition altitudes). The High Profile portion of the descent provides a speed schedule and altitude profile from cruise altitude to the metering fix. The High Profile provides a letdown with or without a metering fix time assignment. Holding or path stretching to make good a metering fix time is also accommodated. Finally, the algorithm displays the resultant profile. If another letdown is desired, the algorithm returns to the descent initialization step. The following paragraphs describe each of the seven functional areas in greater detail.

4.1 IN-PLANE GEOMETRY AND ATC CONSTRAINTS

This section of the functional logic description details the geometry and ATC constraints for which the profile descent is generated. An approach path is defined for each metering fix to runway combination. Each approach path is broken into path segments. A path segment is comprised of a beginning and an ending waypoint, together with a segment distance and track. A waypoint can be defined for any speed or altitude constraint or for a heading change. As an example of the in-plane geometry and ATC constraints definition process, a published profile descent for Los Angeles International Airport Runways 24 and 25 will be considered. Figure 4 shows the form of the published profile from Peach Springs and Figure 5 indicates the published ILS approach for runway 25L. The sequence of waypoints and chart information contained in these two figures, which are used in the LFM/PD algorithm, is summarized in table 1. The table contains the altitude and speed constraints, and segment distances and headings for each waypoint.

Within the algorithm computation process, four of these waypoints have special designations. The first waypoint in the sequence (PGS in this example) is called the entry fix. The last waypoint (LIMMA) is the aimpoint. One intermediate waypoint (CIVET) is designated the metering fix. A second intermediate waypoint (BAIRS) is designated as the holding fix. Profiles are computed from the entry fix to the aimpoint. Time assignments (to allow ATC to meter aircraft to the runway) may be required at the metering fix. Holding to absorb excess ATC delay occurs at the holding fix. Various initial conditions for the aircraft can be assumed at the entry fix. A profile is constructed to the specified speed and altitude at the aimpoint.

In addition to the published waypoints (in the LAX example, those noted in table 1), additional waypoints are supplied in the algorithm computation process to indicate to the pilot when to initiate an acceleration or deceleration or a descent form a level cruise condition. The algorithm computation process completes the speed and altitude profile for the descent within the constraints imposed at the waypoints.
Figure 6 summarizes the functional logic of the approach geometry and ATC constraints process employed in the model. The number of approach paths to be defined is read initially. For each approach path the following data are obtained:

1) The number of path segments,
2) The fixed waypoint distances (referenced to the outer marker),
3) Those waypoint speeds that are ATC-constrained,
4) Those waypoint altitudes that are ATC-constrained (either floors, ceilings or “hard” altitudes), and
5) Course data for each path segment (referenced clockwise from local magnetic North).

### 4.2 WIND AND TEMPERATURE MODELING

The wind and temperature data employed in the descent profile generation process consist of preflight forecasts and real-time updates of wind and temperature at the altitude of descent initialization. Forecast data provided during preflight include forecast altitude, wind direction, wind magnitude and temperature. The wind modeling process converts wind forecast data into zonal and meridional components. At descent initialization the forecast profiles are updated with current wind and temperature data at altitude. An error function is constructed by assuming measured data at altitude and by linearly approaching the forecast profile as aimpoint elevation is approached. The corrected forecasts are then connected by piecewise linear functions into profiles. The resultant corrected profiles are shown in Figure 7. Based on this modeling, wind components and temperature data are available in the profile construction process from any altitude between en route cruise and airport elevation.

Figure 8 summarizes the functional logic employed in the preflight wind/temperature forecast entry process. The development of linear wind and temperature models and the correction based on real-time inflight data are summarized in Figure 9.

### 4.3 DESCENT INITIALIZATION

The descent initialization process involves the entry into the on-board flight management system of those real-time data elements and operational decisions required in the descent calculation process. Specific data and decisions required to begin the profile construction process include:

1) Wind at altitude
2) Temperature at altitude
3) Initial gross weight
4) Descent path selected (metering fix and runway)
5) Metering fix time assigned (if metering is in effect)
6) Cruise Mach number
7) Cruise altitude
8) Estimated time of arrival at the entry fix
9) Engine anti-ice region, if required
10) Holding information, if needed

The sequence of operations performed in the descent initialization is summarized in Figure 10. Revisions to the path geometry beyond the metering fix, forced by runway changes, weather diversions, ATC vectors or area navigation routing, are accommodated in the algorithm.

### 4.4 RUNWAY PROFILE DESCENT (RPD) CALCULATION

The Runway Profile Descent (RPD) calculation process involves the complete definition of the descent profile from the metering fix to the aimpoint. The calculation process begins at the aimpoint and works backward to the metering fix (in the RPD calculation process), and then proceeds from the metering fix to the entry fix in the High Profile Descent (HPD) calculation (described in subsection 3.6). Figure 11 shows the relationship between the data input elements of the program and the RPD and HPD functions. In both RPD and HPD calculations a speed schedule is first determined. For the RPD profile the airspeeds are based on ATC constraints. In the HPD profile, computation speed schedules are determined subject to basic aircraft performance data. In the HPD calculations, speed schedules may be iterated to generate multiple descent profiles until a desired time criterion is achieved at the metering fix or a minimum fuel letdown may be selected. A holding or stretched path to absorb time in excess of a slow-speed descent to the metering fix is also calculated in the HPD profile.

In either case (RPD or HPD), after the speed schedule is specified a series of path segment calculations take place. These calculations proceed from the aimpoint out toward the entry fix. An estimate of aircraft gross weight at the aimpoint is made based on entry fix weight and distance from entry fix to aimpoint. The segment calculation process takes into account changing gross weight with fuel burn, and an iterative convergence to aimpoint gross weight is used as required. Each path segment is analyzed to determine whether an acceleration or deceleration is required and whether altitude constraints require descent. Figure 12 summarizes the functional logic used in the path segment calculations. This logic is illustrated in Figure 13 for one pair of waypoints (designated the initial and final waypoints). The path determination process is assumed to have been completed to the initial waypoint (that is, a speed and altitude have been determined). The speed at the initial waypoint is then compared to the assigned speed at the final waypoint. If a speed change is required, a change of speed waypoint is determined following the initial altitude. Either a level decelerating or a level accelerating segment calculation module is employed. A clean, idle (or anti-icing thrust) descent trajectory is next constructed from the bottom-of-descent (BOD) point (here the change of speed waypoint) to the final waypoint. An idle (or anti-ice) descent over a fixed distance path segment calculation module is employed. If the resultant altitude at the final waypoint lies within the minimum and maximum altitude constraints, the clean idle (or anti-ice) trajectory is used and the associated altitude at the final waypoint is assigned. If the clean, idle (or anti-ice) trajectory altitude is too low (below the minimum altitude constraint) a steeper trajectory is required. The spoiler descent over a fixed altitude and distance calculation module is then used to determine the amount of drag required and the resultant time and fuel used. Similarly, if the clean idle (or anti-ice) altitude at the final waypoint is too high (as indicated in the figure) additional thrust is required to descend. In this situation, the minimum fuel strategy is to compute a top-of-descent point employing the module
that calculates idle (or anti-ice) descent between two altitudes (the initial altitude and the maximum constraint altitude). A level, constant speed segment calculation module is used to compute the remaining time and fuel from the point of descent to the final waypoint. Alternatively, a thrusted descent over a fixed distance calculation module can be employed, which determines the added thrust required to descend the fixed altitude interval and distance required.

All of the path calculations described in the preceding paragraph employ seven basic path segment calculation types. These are summarized in Figure 14 together with corresponding inputs required and outputs determined. The seven path segment types developed are:

1) A level, constant speed segment over a fixed distance
2) A level, decelerating segment between two fixed airspeeds
3) A level, accelerating segment between two fixed airspeeds
4) An idle (or anti-ice power) descent over a fixed distance
5) An idle (or anti-ice power) descent between two fixed altitudes
6) A spoiler descent between two fixed altitudes and distances
7) A thrusted descent between two fixed altitudes and distances

The solution of each path segment provides those inputs required to process the next path segment in the calculation sequence. At each step (for each path segment) the calculation process results in the complete altitude, time, distance and fuel specification of the descent profile.

The solution of each segment itself involves an iterative computation of the basic point-mass, steady-state equations of motion of the aircraft. Where a descent computation is involved, an altitude iteration is employed until a distance or altitude step is achieved. Figure 15 summarizes the basic forces solved in each altitude step. Specific computation steps over an interval, Δh (500 ft), involve

1) Computation of the true altitude interval employing the modeled temperature profile,
2) Determination of the change in true airspeed from beginning to end of the altitude interval given the speed schedule,
3) Computation of average ground speed over the interval employing the wind profile and segment heading,
4) Computation of thrust, drag and fuel flow parameters given current altitude and airspeed (including anti-ice power),
5) Computation of an acceleration factor,
6) Computation of rate of descent,
7) Determination of flight path angle, and

8) Computation of time, fuel and distance over the interval.

The computation is repeated for the next altitude interval until the required altitude or distance step is traversed. In the iteration process, the final state of the previous interval is used as the initial state of the next interval.

The functional logic of the RPD calculation process is summarized in Figure 16. The RPD calculations end at the metering fix with the descent profile specified to that point.

**4.5 AEROPERFORMANCE ENVELOPE DETERMINATION**

The aeroperformance envelope determination consists of the development of high- and low-speed boundaries as a function of altitude for descent and the definition of the altitude at which a Mach to calibrated airspeed schedule transition occurs. Figure 17 shows the B737’s operating envelope in terms of altitude and true airspeed. High-speed limits are based on (1) maximum operating Mach, (2) high-speed initial buffet, (3) thrust limits, and (4) maximum operating velocity. Low-speed limits are based on (1) low-speed buffet and (2) procedural flap extension speeds. The high-speed limit is determined for a particular weight and altitude by taking the minimum of the four high-speed factors. The low-speed limit is determined by taking the maximum of the two low-speed factors.

The determination of the transition altitude for moving from a constant Mach to constant calibrated airspeed (CAS) schedule is based on a sensitivity study of various Mach/CAS transitions. An important model design consideration was to make maximum use of the available time envelope, consistent with Mach/CAS procedures and gross weights, by the model's defining a constant CAS descent at minimum speed and the fastest Mach/CAS descent at maximum speed. An empirical linear relationship (altitude vs true airspeed) assumed between the two limits, as depicted in Figure 17, closely approximated the Mach/CAS families of descent speed schedules suggested in the B737 flight operations manual.

The functional sequence of calculations to define the aeroperformance envelope is shown in Figure 18. The envelope construction is determined before the High Profile Descent routine, to provide a family of speed schedules for use in the HPD generation process.

**4.6 HIGH PROFILE DESCENT (HPD) CALCULATION**

The High Profile Descent (HPD) calculation process completes the definition of the descent profile, which specifies speed schedules and altitude/range relationships between the metering fix and the entry fix. The speed schedule derived is based on making good an assigned time at the metering fix, or alternatively, provides a minimum-fuel speed schedule. When additional delay is needed beyond the maximum delay attainable with a slow-speed descent to the metering fix, a path stretching maneuver or holding path is constructed. As in the RPD calculation process, once the speed schedule is assigned, the segment calculation routines are employed. Beginning at the metering fix a sequence of segment calculations is made. The functional logic for the path segment calculations and the types of calculation modules are exactly the same as in the RPD computation process described in subsection 4.4.

Figure 19 summarizes the functional logic employed in the HPD calculation process. Note that the solution of a metering fix time assignment involves an iteration process that selects various speed schedules within the aeroperformance envelope.
4.7 DELAY CALCULATION

When additional delay is required to make good a metering fix time, the algorithm determines the extra delay needed. Excess delay absorption techniques in the algorithm include holding and path stretching and become operational in the HPD portion of the descent. Figure 20 illustrates the delay logic employed by the algorithm.

Holding is required if other airplanes ahead are holding or if the additional delay is at least a single, minimum-time circuit around the designated holding fix, calculated at the nearest approved holding altitude intersecting the fuel-efficient, minimum-speed descent path.

To establish a holding exit time, a fuel-efficient path is constructed from the metering fix back to the holding fix from which the airplane would leave at a predetermined exit altitude.

Then, the holding fix entry (crossing) time is determined based on the calculation of a fuel-efficient path from the top-of-descent to the holding fix at the assigned entry altitude. The difference between the entry and exit times specifies the additional delay required to make good the metering fix time. With the delay and wind conditions known, the algorithm specifies the number of patterns to be flown, the turn and straight leg parameters, and bank angle requirements. To effect the timing mechanization, the time interval $\tau_1$ is defined as the holding fix crossing interval; i.e., the amount of time taken between two successive holding fix crossings. Its value is determined by circular revolution time given a prescribed bank angle and the no-wind leg times applicable at the assumed exit altitude and within ATC constraints.

Another aspect of the holding mechanization is that the airplane makes its fixed bank angle turns relative to the air mass instead of a defined racetrack ground pattern with semicircular ends and takes into account drift in the turns and straight legs. With wind, this implementation requires no modulated bank angle coupling to the autopilot during the turns and solves for the unequal inbound and outbound leg times while satisfying ATC inbound leg time constraints at all applicable holding altitudes. The following cases are incorporated in the algorithm:

1) Single airplane holding:
   a) Holding at the aircraft-determined optimum altitude (i.e., the altitude intersecting the normal, no-holding slow-speed descent path). This procedure presumes no other aircraft holding ahead and an ATC clearance.
   b) Holding at a single ATC-assigned altitude

2) Multiple airplane holding: holding in a stack

When the required additional delay is less than the minimum circuit time as described in the previous section, then the logic calls for path stretching to be carried out at cruise altitude, prior to the top of descent. The algorithm constructs a parallel path offset from the inbound course, computing the offset distance and the times of the outbound and inbound legs. The legs are assumed to be perpendicular to the inbound course and constrained to a maximum offset of 10 nmi. The current mechanization does not model the times to turn away from and return toward the inbound path during the banks and, therefore, assigns all the excess delay to the legs.
4.8 DISPLAY OF RESULTS

The final LFM/PD guidance algorithm function is the display of the completed profile. Tables 2 and 3 show the results of the profile generation process. Table 2 shows a typical example of a completed profile. Table 3 shows the summary data extracted from profile for presentation to the flight crew. The profile shown is for the Los Angeles International Airport Profile Descent (CIVET 25) described in subsection 4.1, In-Plane Geometry and ATC Constraints, and illustrated in Figures 4 and 5. The resultant altitude profile is shown plotted in Figure 21 as a function of path distance together with the altitude constraints for the descent.

Figure 22 shows the logic flow of the algorithm functions to display the profile generation results.
5.0 COMPUTER MODEL STRUCTURE

This section of the LFM/PD report describes the computer model implementation of the algorithm. The first two subsections describe the considerations used in the algorithm's design, while the remaining subsections describe considerations used in the implementation of the design.

5.1 DESIGN APPROACH

The Profile Descent Algorithm was created with a top-down functional approach. In this context, a function refers to those elements which contribute to the execution of a single task. The top-down approach used to design this algorithm was accomplished in two steps.

First, the profile descent was expressed in terms of the functions that the algorithm must perform. Each function was then considered individually and expressed in terms of subfunctions necessary to accomplish the parent function. This process was continued level by level until the solution to the problem was completed and the problem was represented by a hierarchy of functions.

The second part of the design process was step-wise refinement. This process analyzed the interrelationships between the components on a given level of the functional hierarchy and then took into consideration the actual sequence and timing of each function on that level.

This top-down approach produces an algorithm that is modular in nature and has the advantage that both the design and the code are more easily tested during development. Furthermore, the finished product is more reliable and easier to maintain.

The functional design produced a hierarchy that had nine functions at the first level and continued until reaching eleven levels. The program was coded to conform to the functional decomposition as much as possible. The modules were transformed into SUBROUTINES and, at the lowest level, FORTRAN FUNCTIONS. The current version of the program contains 164 subroutines and functions.

5.2 PROGRAM MODULES SUMMARY DESCRIPTION

The program PROFIL modules here are grouped into seventeen functional areas:

1) Profile construction modules
2) Segment analysis modules
3) Segment computation modules
4) Descent computation modules
5) Geometry, ATC constraints, and descent initialization input modules
6) Wind and temperature forecast modules
7) Wind model modules
8) Temperature model modules
9) Aeroperformance computation modules
10) Aeroenvelope construction modules
11) Atmosphere parameter modules
12) Delay modules
13) Altimeter and altitude modules
14) Speed conversion modules
15) Anti-icing modules
16) Output modules
17) Program utility modules

A description of inputs, processing and outputs for each program element follows in figure 23. They are grouped by the seventeen function areas.

5.3 INPUT/OUTPUT SPECIFICATIONS

5.3.1 INPUT DESCRIPTION

The information required to generate the profile can be divided into five areas:

• Profile geometry
• FAA winds aloft forecast
• Specific approach information
• Current cruise information
• Method selected to satisfy altitude constraints

The algorithm has been designed to be capable of accessing required data either interactively or from local files. The current algorithm configuration accesses the profile geometry from the local file TAPE1 and the FAA winds aloft forecast from the local file TAPE2. The remaining information is supplied interactively.

Two calculation options are provided at the start of the program for segments unable to meet an altitude floor. Segments can be considered on an individual basis; in this case, the current computational situation is displayed before requesting the selection of a level cruise to intercept a minimum-thrust descent or a thrusted descent over the interval. The results of the selection are displayed and will be discussed further in the output section. The other option provides automatic selection of level cruise in each case.
Each routine containing I/O operations reads from the file INFILE and writes to the file OUTFILE. The local files INFILE and OUTFILE are defined in data statements in the declarative section of the routines. Therefore, all that is required to change the I/O configuration is to redefine the file numbers for INFILE or OUTFILE in the data statement.

5.3.2 SAMPLE INPUT

It has previously been explained that data for the program can be accessed either from local files or interactively. Sample interactive input that describes the profile geometry for the CIVET 25 Profile Descent into Los Angeles International Airport is shown in Table 4. Each input record follows the input designator, I >.

Table 5 shows the same profile geometry when the information is accessed from a local file. The formats for the individual records can be identified by locating the corresponding input record in the interactive input.

A sample interactive input for FAA winds aloft section for Denver is for the test situation of nonzero winds and nonstandard temperatures and is shown in Table 6. Table 7 shows the same information when accessed from a local file. Table 8 is the section of input which contains the specific approach information and the current cruise information. These data are most commonly supplied interactively with the algorithm allowing iterations for different cruise conditions and different profile geometries.

Additional input is required when time-based metering is in progress. Table 9 shows the information required to initiate the calculation. It should be noted that an acceptable time interval for the metering fix time assignment is displayed.

Table 10 shows the choices of either a thrusted descent or a level cruise when segments are considered on an individual basis. Since the profile is calculated from the aimpoint to the entry fix, segments requiring thrust show altitude constraints violated in the direction of the profile calculation. The altitude constraint of 10,000 feet at ARNES refers to the inability to compute the segment from ARNES to CSFIX1 with the current thrust setting. In this instance, a thrust-assisted descent is performed. For the segment from DIKES to EMMEY, the option to cruise level until reaching the point of descent (the point which intercepts the idle clean path) is calculated. This point is inserted into the waypoint stream and in this case is also the top-of-descent (TOD). If altitude restrictions must be violated to complete the profile, a prompt is given requesting ATC approval to complete the profile.

5.3.3 OUTPUT DESCRIPTION

The output description is divided into three sections: a section describing the deviations from minimum-thrust clean descents, a detailed description of the profile descent, and a summary section.

The first section describes deviations from a minimum-thrust, clean-configuration required to conform to altitude restrictions. Drag to be added is reported as a percentage of maximum spoiler drag available. When thrust is required, the selection of a level cruise to intercept a minimum-thrust, clean descent or a continuous thrust-assisted descent is made. For the level cruise option, the point of interception with the idle clean path is calculated and inserted into the waypoint stream as a point of descent (POD). For a thrust-assisted descent, the thrust to be added is reported as a percentage of maximum cruise thrust.
5.3.4 SAMPLE OUTPUT

The outputs that describe the nonmetered profile are in Tables 11 and 12. If drag is required it is reported under the heading "DESCENT REQUIREMENTS." Table 11 shows the full profile.

The summary section is shown in Table 12. This section provides descent summary items, such as profile distance, information pertaining to entry points, change of speeds, and metering.

The completed profile for a metered case is illustrated in Tables 13 and 14.
6.0 COMPUTER MODEL TEST/VALIDATION APPROACH

Testing of the profile descent algorithm was performed to establish the algorithm's conformity to design specifications.

The overall approach of the testing was to determine whether correct inputs produced predictably accurate and appropriate results. Test cases were selected to examine representative data, data for limit/boundary conditions, and data to test all functional paths through the algorithm.

To accomplish these goals, the algorithm was tested on both a subsystem and system level.

6.1 SUBSYSTEM TESTS

This group of tests used individual subroutines and functions that are combined to form self-contained modules. Inputs were chosen so as to operate the modules over a wide range of input values and to identify cases where incorrect operation occurs. Tests supported the following conclusions.

6.1.1 WIND MODULE

Wind speeds ranging from 1 to 200 knots are routinely handled, as are windshear conditions. The wind module accepts as many as 9 or as few as 3 forecast points. Cruise altitudes for the known wind ranging from meter fix altitude to the highest forecast altitude are accepted, as are aimpoint altitudes from the ground up to the MF altitude. The modeling of winds outside the range of forecast altitudes produced reasonable values.

6.1.2 TEMPERATURE MODULE

Testing of the temperature module indicated that large, small, positive, zero, and negative temperatures are correctly processed. As many as 9 or as few as 3 forecast points are accepted. Cruise altitudes ranging from meter fix altitude to the highest forecast altitude are acceptable, as are aimpoint altitudes from ground level up to the meter fix altitude. Temperature inversions are also correctly processed. The modeling of temperatures above the highest forecast altitude may not produce valid results when the highest forecast altitude is 39,000 feet or greater. The modeling of temperatures below the lowest forecast altitude produces reasonable values.

6.1.3 CRITICAL ALTITUDE MODULE

This module consists of aeroperformance, temperature, and airspeed conversion subroutines. Temperature and gross weight variations produce reasonable changes in the critical altitude function. Slow- and high-speed buffet boundaries, maximum operating speeds, flap extension speeds, and thrust-limited speeds are correctly compared. Airspeed conversions are properly made, and the critical altitude correctly defined.

6.1.4 SEGMENT CALCULATION MODULE

This module uses thrust, drag, fuel flow, true altitude, airspeed conversion, and speed profile subroutines to calculate the 4-D paths for the various types of segments. Various gross weights and altitudes produced reasonable fuel flows, speeds, distances, and times.
6.1.5 TRUE ALTITUDE MODULE

Testing of the true altitude module indicates correct trends and reasonable values for various temperature profiles resulting in lapse rates from -1.5X standard to +1.5X standard.

6.1.6 ATMOSPHERE MODULE

Testing of this module indicates correct trends and reasonable values of atmospheric pressure and density for various temperature profiles.

6.1.7 EXCESS DELAY MODULE

The excess delay module was verified for path stretching, optimum altitude holding, ATC-assigned-altitude holding, and holding in a stack. Results were verified against published holding restrictions. Also, computations for each type of additional delay were made using performance manual values for various altitudes, speeds, and thrust settings. All tests produced reasonable values of fuel flow, leg lengths, and circuit times.

6.1.8 ANTI-ICING MODULE

The anti-icing was tested using an aeroperformance program to drive the routines. Results were checked against engineering performance data. The anti-icing module accepts upper and lower altitude boundaries for the icing region. The minimum thrust required for thermal anti-icing is input as percent N1 rpm.

6.2 BASELINE VALIDATION

The program was validated by checking the results of a typical profile descent into Denver, the KEANN 26 Profile Descent. The results of the calculated profile were checked by manual calculation, using B737 performance handbook data. The profile results were then considered to be a baseline against which other system tests could be compared.

The baseline cruise parameters were:

- Cruise altitude—35,000 feet
- Entry fix speed—.765 Mach
- Gross weight—85,000 pounds
- ISA temperatures
- Zero wind
- No metering

The baseline validation results are found in Tables 15 and 16.
The level flight speed, time, and fuel are in agreement with handbook figures, and Mach/airspeed conversions agree with standard charts. Level deceleration times and distances are not available in performance handbooks but were validated using another Boeing aerop erformance computer program. Idle descent speeds and times also are not available as handbook data, so they were validated using another computer program. Idle fuel flow is in agreement with published data.

6.3 SYSTEM LEVEL TESTS

This group of tests uses the program in its complete form, as did the baseline validation. Nine categories of tests were identified, with each category examined in turn while baseline conditions were retained for all other inputs.

6.3.1 NONSTANDARD TEMPERATURES

Nonstandard temperature conditions were tested to study their effect on airspeed conversions, critical altitude, fast/slow Mach, and true altitude calculations. Two methods of varying the temperature were used: ISA plus a constant increment, and lapse rate deviations of 1/2 standard and 1 1/2 standard lapse rates.

The major effect of ISA plus an increment is to vary the elapsed time for a distance-constrained segment, due to the airspeed dependence on temperature. The major effect of nonstandard lapse rates is to vary waypoint altitudes, due to true altitude dependence on lapse rate. All expected effects were noted and confirm proper operation of the program.

6.3.2 WIND VARIATIONS

Wind variations on a system level were tested by comparing the segment elapsed time to a calculated time using the segment distance, headwind, and true airspeed. All effects noted due to wind were the same as those calculated manually.

6.3.3 GROSS WEIGHT VARIATIONS

Gross weight variations were tested for their effect on critical altitude by noting the resulting Mach/CAS descent schedules. Weight burnoff compared with performance manual values.

6.3.4 CRUISE ALTITUDE VARIATIONS

Fuel flow and speed trends were as expected and confirm proper operation of the program.

6.3.5 ENTRY FIX SPEED VARIATIONS

Trends in deceleration time and distances, and fuel flows were as expected.

6.3.6 METER FIX TIME VARIATIONS

Meter fix time variations reflect the proper selection of critical altitude as shown by the resultant Mach/CAS descent schedules. Cases where delay is required, or the descent is impossible are correctly identified, along with testing the complete range of meter fix time assignments. An example of processing a metering fix time assignment is shown in Table 17.
6.3.7 SYSTEM DELAY

The results of the excess delay capability indicate the proper choice of path stretching or holding. Table 18 is an example of path stretching using parallel offset, since required delay beyond that available by slowing is less than one complete minimum holding pattern.

Tables 19 through 21 give examples of optimum altitude holding, ATC-assigned-altitude holding and holding in a stack, respectively. In addition, an example of holding in a stack in the presence of wind is given in Table 22. (Wind values are given in Table 6.)

Each case provided reasonable values of holding parameters and conformed to ATC constraints, such as maximum bank angle, minimum four-minute turns, minimum holding airspeed, maximum leg lengths, and holding altitudes.

6.3.8 ANTI-ICING

System level tests indicate the proper use of anti-icing. The anti-icing boundaries are correctly inserted into the descents. Multiple checks of anti-icing performance indicate expected performance. An example of anti-icing is given in Table 23.

6.3.9 PROFILE RE-INITIALIZATION

The use of revised geometry provides a means of using a selected portion of the profile from the first usable waypoint and inserting new waypoints at the desired distances and headings. The capability for introducing course changes and re-initialized paths was checked and validated. A sample case is given in Table 24.

6.4 SAMPLE INPUT/OUTPUT DATA SETS

The following are typical of the input and output data sets used for test and validation of the computer program.

The algorithm has been tested by calculating typical profile descents selected from each of the published profile geometries and were updated using Jeppesen charts. Two exceptions have been made. Although a published procedure exists at Atlanta, it is defined by only one point and was not calculated. Conversely, although no procedure has been published for Dallas-Fort Worth, time-based metering is used there in conjunction with the STARS. Therefore, a calculation has been made assuming that metering occurs at the cornerposts. The results of these profile calculations are shown in Tables 25-30. The profile calculation for CIVET 25 is given in Tables 2 and 3.

The BIG SUR profile descent, Table 28, illustrates a situation in which the geometry would not allow a normal profile descent to occur. Even with the spoilers deployed to flight limit, the descent required between waypoints CSFIX1 and D20/BSR was beyond the descent capabilities of a B737. When this occurs the caution shown in Table 28 is displayed.
7.0 FIGURES AND TABLES
Figure 1. Local Flow Management Avionic Research Approach
Figure 2. Summary of Model Input, Processing, and Output Elements
Figure 3. LFM/PD Algorithm Functional Flow
Figure 4. Profile Descent for Los Angeles International Runways 24 and 25 Via Peach Springs
Figure 5. ILS Approach for Los Angeles International Runway 25L
Figure 6. Flow for Obtaining Approach Geometry and ATC Constraint Data
Process:
1. Preflight temperature, winds aloft forecast
2. Conversion of altitudes to pressure altitudes
3. Conversion of winds to zonal, meridional components
4. Entry of temperature, wind at altitude
5. Revision of forecast with error function

Figure 7. Wind and Temperature Modeling
Figure 8. Flow for Obtaining Wind and Temperature Forecast Data
**Figure 9. Wind and Temperature Model Computations**

1. **Obtain known wind at altitude**
2. Convert wind to zonal, meridional components
3. Compute forecast error at altitude
4. Construct wind error function: zonal, meridional
5. Apply error function to forecast components
6. Obtain known temperature at altitude
7. Compute forecast error at altitude
8. Construct temperature error function
9. Apply error function to forecast components
10. Return
Figure 10. Flow to Initialize Descent Calculation
Figure 11. RPD and HPD Segment Calculations
Figure 12. Functional Logic for Path Segment Calculations
Figure 13. Path Segment Geometry
Figure 14. Path Segment Calculation Modules
Computation steps over $\Delta h$:

1. Compute true altitude interval
2. Compute $\Delta$ VTAS
3. Compute average ground speed
4. Compute thrust, drag, fuel flow
5. Compute acceleration factor
6. Compute rate of descent
7. Compute flight path angle, $\gamma$
8. Compute $\Delta$ time
9. Compute $\Delta$ fuel ($\Delta$ gross weight)
10. Compute $\Delta$ distance

Figure 15. Computation of Equations of Motion Over Altitude Interval
Figure 16. Runway Profile Descent Calculation
Figure 17. Aerodynamic Performance Envelope
Figure 18. Determination of Aerodynamic Performance Envelope
Figure 19. High-Profile Descent Calculation
Figure 20. Delay Parameters Calculation
Figure 21. CIVET 25 Profile Descent
OUTPUT
COMPLETED
PATH ARRAY

OUTPUT
PROFILE
TIME AND
FUEL

OUTPUT
INITIAL CRUISE
AND LETDOWN
SPEEDS

OUTPUT
ENTRY FIX
AND POINT OF
DESCENT
DISTANCE

OUTPUT
METERING AND
INNER FIX
ALTITUDES

RETURN

Figure 22. Display of Results
PROFILE CONSTRUCTION MODULES

Accesses geometry and weight; determines altitude and speed constraints at waypoints for desired path; assigns selected geometry to path array; obtains initial conditions for the descent profile; controls path geometry revisions.

Controls processing sequence in construction of profile from outer marker back to metering fix: segment computation modules used.

Selects method of computing the high profile required to meet metering conditions.

Determines descent mach to meet time required at metering fix.

Translates assigned metering fix time into the required elapsed time for the high profile, using estimated entry fix time.

Controls processing sequence in construction of profile from metering fix back to entry fix for a given speed schedule, using segment computation modules.

Determines descent calibrated airspeed for a given critical altitude and mach number.

Creates working path arrays for the high-profile calculation, using the runway profile results.

Figure 23. PROFIL Modules
### SEGMENT ANALYSIS MODULES

<table>
<thead>
<tr>
<th>Module</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>CSFIX</td>
<td>Inserts change-of-speed fixes before waypoints at which an acceleration or deceleration is required</td>
</tr>
<tr>
<td>ASGNV</td>
<td>Assigns the ATC CAS constraints from aimpoint to metering fix</td>
</tr>
<tr>
<td>ASGNA</td>
<td>Assigns the ATC-constrained maximum altitudes for all waypoints</td>
</tr>
<tr>
<td>STPATH</td>
<td>Transfers information between working and permanent path arrays</td>
</tr>
<tr>
<td>ITYPE</td>
<td>Determines the segment type, considering current airspeed and altitude and next waypoint's airspeed and altitude constraints</td>
</tr>
<tr>
<td>INSERT</td>
<td>Creates a new waypoint position in the path array</td>
</tr>
<tr>
<td>INSRTT</td>
<td>Creates new positions in the segment total time and fuel arrays</td>
</tr>
<tr>
<td>REMOVE</td>
<td>Eliminates unnecessary change of speed segments</td>
</tr>
<tr>
<td>NUMID</td>
<td>Numbers descent point and change of speed fix waypoints</td>
</tr>
<tr>
<td>INSPOD</td>
<td>Inserts descent point distance, speed, and altitude into the path array</td>
</tr>
<tr>
<td>WAYPTS</td>
<td>Inputs waypoint identifiers and identifies metering fix waypoint</td>
</tr>
<tr>
<td>STNIDL</td>
<td>Transfers information between working and permanent arrays for thrusted or spoiler descents</td>
</tr>
<tr>
<td>TRNSFR</td>
<td>Creates working array from selected profile geometry</td>
</tr>
</tbody>
</table>

**Figure 23. PROFIL Modules (Continued)**
### SEGMENT COMPUTATION MODULES

<table>
<thead>
<tr>
<th>PATH SEGMENT TYPE, DATA</th>
<th>SEGMENT TIME, DISTANCE, FUEL, ALTITUDE</th>
<th>SEGMENT TIME, ΔTIME, ΔFUEL, ΔALTITUDE</th>
<th>SEGMENT TIME, ΔTIME, ΔFUEL, ΔALTITUDE</th>
</tr>
</thead>
<tbody>
<tr>
<td>ALTIMETER, ΔDISTANCE, ΔVCAS</td>
<td>SEGS1</td>
<td>SEGS2</td>
<td>SEGS3</td>
</tr>
<tr>
<td>ΔALTITUDE, ΔVCAS</td>
<td>SEGS1</td>
<td>SEGS2</td>
<td>SEGS3</td>
</tr>
<tr>
<td>ΔDISTANCE, ΔALTITUDE</td>
<td>SEGS1</td>
<td>SEGS2</td>
<td>SEGS3</td>
</tr>
<tr>
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**Figure 23. PROFIL Modules (Continued)**
DECENT COMPUTATION MODULES

INITIAL ALTITUDE → DSAS → ALTITUDE STEP, VCAS, VT → Establishes altitudes and speeds for an altitude step in a descent calculation

ALTITUDE, AIRSPEEDS → ICPE → THRUST, DRAG, FUEL FLOW → Computes engine idle, clean-configuration thrust, drag, and fuel flow for an altitude step in a descent calculation

ALTITUDES, AIRSPEEDS, SPOILER SETTING → DGPER → THRUST, DRAG, FUEL FLOW → Computes engine idle thrust, drag, and fuel flow for an altitude step in a descent calculation, given spoiler setting

ALTITUDES, AIRSPEEDS, THRUST SETTING → THPER → DRAG, FUEL FLOW → Computes clean-configuration thrust, drag and fuel flow for an altitude step in a descent calculation, given thrust setting

ALTITUDE → DCTTOT → TIME, DISTANCE, FUEL → Totals time, distance, and fuel for each altitude step in a descent calculation

DISTANCE ERROR → ADJTLD → TIME CORRECTION, FUEL CORRECTION, ALTITUDE CORRECTION → Adjusts segment totals for distance-constrained descents for time, fuel, and altitude

ALTITUDE ERROR → ADJTLA → TIME CORRECTION, FUEL CORRECTION, DISTANCE CORRECTION → Adjusts segment totals for altitude-constrained descents for time, fuel, and distance

INITIAL ALTITUDE, TRUE COURSE, DISTANCE → RODALT → ALTITUDE DIFFERENCE → Compiles information for segments using thrusted or spoiler descents

INITIAL ALTITUDE, TRUE COURSE, DISTANCE → NIREC → Provides profile calculation termination messages due to insufficient descent rate

Figure 23. PROFIL Modules (Continued)
GEOMETRY, ATC CONSTRAINTS, AND DESCENT INITIALIZATION INPUT MODULES

AIRFIELD PATHS, PATH NUMBER
- GEOMRD
  Controls acquisition of profile geometries

VELOCITY, ALTITUDE,
- GTSEGS
  Controls routines that access information defining profile geometries

DISTANCE, AND COURSE DATA
- CRUALT
  Supplies current cruise altitude for initialization of descent calculations

CRUISE ALTITUDE
- MTRING
  Determines if metering is in progress

MF TIME
- MFTIM
  Obtains assigned metering fix time

WT737
Obtains entry fix gross weight acceptable within zero fuel and maximum operating weights

STGWT
Estimates aimpoint gross weight based on cruise, distance, and holding considerations

EVGWT
Evaluates aimpoint gross weight estimate by comparing entry fix calculated gross weight with input value

PATH NUMBER
- ROUTE
  Inputs airway magnetic courses and variation and course distances

PATH NUMBER
- ALTSPD
  Obtains altitude and speed constraints at each waypoint

- RVGEOM
  Creates revised path course, distance, altitude constraints

- REVISED PATH INFORMATION

- HAPT
  Obtains airfield elevation

- ATCAPP
  Requests ATC approval for required deviations from geometry-defined minimum altitude restrictions

Figure 23. PROFIL Modules (Continued)
WIND AND TEMPERATURE FORECAST MODULES

ATMOS

Controls construction of wind and temperature models

GTWAF

Controls sequence of inputs of forecast and conversion of winds into component form

GTFCST

Reads number of forecast altitudes and, for each altitude, the forecast wind direction and speed and forecast temperature

CONVRT

Transforms wind forecast from rho-theta system to “to wind” zonal and meridional components

IFALT

Determines index of wind and temperature model element closest to input altitude

ALTITUDE, TEMPERATURE, WIND

WIND DIRECTION, WIND SPEED

ALTITUDE

WIND MODEL MODULES

Obtains wind at cruise altitude; computes error function; applies error function to forecast

CORRCPW

CRUISE ALTITUDE

Determines forecast wind at cruise altitude

FCSTKA

Computes a piecewise linear wind profile for both zonal and meridional components using corrected forecast points

FORECAST POINTS

LINMODW

TEMPERATURE MODEL MODULES

Obtains temperature at cruise altitude; computes error function; applies error function to forecast

CORRCPT

CRUISE ALTITUDE

Determines forecast temperature at cruise altitude

FCSTKAT

FORECAST POINTS

Computes piecewise-linear temperature profile using corrected forecast points

LINMODT

Figure 23. PROFIL Modules (Continued)
AERODYNAMIC PERFORMANCE ENVELOPE CONSTRUCTION MODULES

**WEIGHT** → **HCCalc** → **HC SLOPE** → **HC INTERCEPT**
Computation of the critical altitude model (for transition from Mach to CAS speed schedule) as a function of true airspeed

**WEIGHT** → **VSLOW** → **VCAS**
Determines low-speed CAS limit for a given altitude and weight

**WEIGHT** → **VFAST** → **VCAS**
Determines high-speed CAS limit for a given altitude and weight

**WEIGHT** → **SLMACH** → **MACH**
Determines slowest mach/CAS descent within aeroparameter limits of the aircraft

**WEIGHT** → **FAMACH** → **MACH**
Determines fastest mach/CAS descent within aeroparameter limits of the aircraft

**VCAS** → **DMACH** → **MACH**
Determines equivalent cruise Mach that will transition at the critical altitude to the input calibrated airspeed

**VTAS** → **HCRIT** → **CRITICAL ALTITUDE**
Determines critical altitude from model computed in HCCALC

ATMOSPHERE PARAMETER MODULES

**ALTITUDE** → **WNDDIR** → **WIND DIRECTION**
Evaluates wind model at given altitude to determine wind direction

**ALTITUDE** → **WNDSPD** → **WIND SPEED**
Evaluates wind model at given altitude to determine magnitude of wind velocity

**ALTITUDE** → **TEMPC** → **TEMPERATURE**
Evaluates temperature model at given altitude to determine forecast temperature

**ALTITUDE** → **DELTA** → **PRESSURE RATIO**
Determines pressure ratio at given altitude

**ALTITUDE** → **SIGMA** → **DENSITY RATIO**
Determines atmospheric density ratio at given altitude, employing forecast temperature

**ALTITUDE** → **RHO** → **DENSITY**
Determines atmospheric density at given altitude

*Figure 23. PROFIL Modules (Continued)*
DELAY MODULES

1. DELAY
   - Controls construction of delay profile

2. HLDPRF
   - Controls computation of the holding path

3. HPRHLD
   - Coordinates construction of high-profile path with holding

4. COMPCL
   - Completes altitude and airspeed information in the path array when the calculation reaches cruise altitude

5. HLDINF
   - Obtains inputs to initiate holding path calculations

6. HLDSTA
   - Obtains assigned top and bottom stack altitudes

7. HLDSA
   - Obtains valid single altitude assignment

8. HLDOA
   - Determines the closest holding altitude intersecting the calculated fuel-efficient profile at the holding fix

9. HLDSPD
   - Obtains valid holding airspeed

10. IDHWPT
    - Obtains valid holding fix identifier

11. BANK ANGLE
    - Computes holding bank angle

---

Figure 23. PROFIL Modules (Continued)
Figure 23. PROFIL Modules (Continued)
DELAY MODULES (Continued)

Calculates altitudes and speeds for an altitude step in a descent calculation between holding altitudes

Computes initial number of circuits to absorb holding delay

Verifies that headwind components do not compromise timing at all holding altitudes

Computes time to complete one circular revolution at constant bank angle

Computes inbound leg time

Computes outbound leg time

Controls calculation of inbound and outbound turn times

Calculates angle between inbound and outbound leg headings

Computes outbound turn time

Computes inbound turn times

Determines all holding altitudes between specified top and bottom altitudes

Computes along track wind magnitudes

Computes angle between inbound true heading and wind

Figure 23. PROFIL Modules (Continued)
DELAY MODULES (Concluded)

- **ADJTL1**: Adjusts altitude, time, fuel, and weight totals at the end of a descent calculation between holding altitudes.
- **PSMTRF**: Computes minimum circuit time given wind at optimum altitude.
- **PATHST**: Controls computation of path-stretching parameters.
- **RVPAPS**: Revises path array to include offset waypoints required for path stretching.
- **PSOFFST**: Computes path offset distance and leg times.

*Figure 23. PROFIL Modules (Continued)*
ALTIMETER AND ALTITUDE MODULES

```
<table>
<thead>
<tr>
<th>Flow</th>
<th>Module</th>
<th>Function</th>
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</thead>
<tbody>
<tr>
<td>STATION</td>
<td>ALTMTR</td>
<td>Supplies station altimeter setting</td>
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<tr>
<td>PRESSURE</td>
<td></td>
<td></td>
</tr>
<tr>
<td>MEAN SEA</td>
<td>CMSLPA</td>
<td>Converts MSL value to pressure altitude, using station pressure correction</td>
</tr>
<tr>
<td>LEVEL</td>
<td></td>
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</tr>
<tr>
<td>PRESSURE</td>
<td>PAMSL</td>
<td>Converts pressure altitude to MSL, using station pressure correction</td>
</tr>
<tr>
<td>ALTITUDE</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PRESSURE</td>
<td>TRUALT</td>
<td>Converts pressure altitude into geopotential altitude, using temperature</td>
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<tr>
<td>ALTITUDE</td>
<td></td>
<td>lapse rate and the hydrostatic equation</td>
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<tr>
<td>WAYPOINTS,</td>
<td>CONMSL</td>
<td>Controls conversion of pressure altitudes to MSL altitudes</td>
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<tr>
<td>PRESSURE</td>
<td></td>
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</tr>
<tr>
<td>ALTITUDE</td>
<td>CONTPA</td>
<td>Controls conversion of MSL altitudes to pressure altitudes</td>
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<td></td>
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</tbody>
</table>
```

Figure 23. PROFIL Modules (Continued)
SPEED CONVERSION MODULES

VCAS, ALTITUDE \(\rightarrow\) CMACH \(\rightarrow\) MACH

\(\text{Converting a calibrated airspeed at altitude to a mach number}\)

MACH, ALTITUDE \(\rightarrow\) TAS \(\rightarrow\) VTAS

\(\text{Computes true airspeed, given altitude and mach number}\)

VTAS, ALTITUDE, COURSE \(\rightarrow\) GNDSPD \(\rightarrow\) VG

\(\text{Computes groundspeed, given altitude, true airspeed, and course information}\)

VTAS, ALTITUDE \(\rightarrow\) TMACH \(\rightarrow\) MACH

\(\text{Computes mach number for a given altitude and true airspeed}\)

MACH, ALTITUDE \(\rightarrow\) CAS \(\rightarrow\) VCAS

\(\text{Computes calibrated airspeed, given altitude and mach number}\)

\(\text{Calculates drift from true course due to wind}\)

*Figure 23. PROFIL Modules (Continued)*
ANTI-ICING MODULES

ICESET

ICING

Obtains $N_1$ setting and icing altitude limits

Tests whether anti-icing procedures are in effect

N1, ALTITUDES, AIRSPEEDS, SPOILER SETTING

DGPERT

THRU3T, DRAG, FUEL FLOW

 Computes thrust, drag, and fuel flow for an altitude step in a descent calculation, given spoiler setting and $N_1$ thrust

TSTPER

THRU3T, DRAG, FUEL FLOW

 Computes thrust, drag, and fuel flow for an altitude step in a descent calculation, given a clean configuration and $N_1$ thrust

CORRECTED N1, MACH, ALTITUDE

EPR

EPR

Determines engine EPR given corrected $N_1$ rpm, mach number, and altitude

CORRECTED N1, MACH, ALTITUDE

TSTPAR

$F_{n/8}$

Determines net thrust, given mach number, altitude, and corrected rotor speed

Figure 23. PROFIL Modules (Continued)
OUTPUT MODULES

- REPORT
  Formats and writes the computed profile descent

- PDDIS
  Displays tabular course, distance, time, altitude, speed, and fuel information for profile

- DETHLD
  Displays detailed holding requirements

- DISDTI
  Displays thrusted or spoiler descent requirements

- MSEC
  Converts time in decimal minutes to minutes and seconds

- SUMARY
  Controls summary of important profile information

- SUMDLY
  Displays summary of holding information

- SEGTOT
  Computes total time and fuel for profile

- MFETA
  Computes metering fix ETA using assigned metering fix time and arrival time differential

- IROUND
  Rounds input variable to nearest integer for display purposes

Figure 23. PROFIL Modules (Continued)
GENERAL UTILITY MODULES

- **VALDTE**
  Validates input records after they have been displayed

- **TBLU2**
  Two-dimensional table look-up routine providing polynomial interpolation of array of two variables

- **TBLU3**
  Three-dimensional table look-up routine

- **LINREG**
  Linear regression computation

*Figure 23. PROFIL Modules (Concluded)*
Table 1. Los Angeles International Profile Descent Geometry and ATC Constraint Inputs

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<tr>
<th>WAYPOINT</th>
<th>ALTITUDE MINIMUM (ft)</th>
<th>ALTITUDE MAXIMUM (ft)</th>
<th>SPEED CONSTRAINT (kcas)</th>
<th>SEGMENT DISTANCE (nmi)</th>
<th>SEGMENT HEADING (deg mag)</th>
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<td>4.9</td>
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</table>
Table 2. CIVET 25 Profile Descent Path Segment Array

THE FOLLOWING ALTITUDES ARE REQUIRED TO COMPLETE THE PROFILE
THE DESIRED ALTITUDE AT HUNDA IS AT OR BELOW 3436. FT
WILL ATC APPROVE THESE REVISIONS - (Y OR N)
I>Y
DISPLAY FULL PROFILE - (Y OR N)
I>Y

CIVET 25 PROFILE DESCENT

<table>
<thead>
<tr>
<th>SEGMENT DESCRIPTION</th>
<th>MAG COURSE</th>
<th>DISTANCE (NMI)</th>
<th>TIME (SEC)</th>
<th>ALTITUDES BEGIN</th>
<th>ALTITUDES END</th>
<th>SPEEDS (CAS) BEGIN</th>
<th>SPEEDS (CAS) END</th>
<th>FUEL (LB)</th>
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<td>1892</td>
<td>210</td>
<td>180</td>
<td>15.5</td>
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</tbody>
</table>

DESCENT REQUIREMENTS

STARTING AT BASET 21.9 PERCENT OF MAXIMUM SPOILER DRAG
MUST BE ADDED FOR THE SEGMENT TO DOWNE TO MAINTAIN THE PROFILE

STARTING AT HUNDA 100.0 PERCENT OF MAXIMUM SPOILER DRAG
MUST BE ADDED FOR THE SEGMENT TO CSFIX TO MAINTAIN THE PROFILE
Table 3. CIVET 25 Summary

CIVET 25 SUMMARY

ENTRY FIX  PGS
METERING FIX  CIVET
AIMPOINT  LIMMA

PROFILE DISTANCE  257.5 NMI

ENTRY INFORMATION:

CRUISE SPEED .765 MACH (259 KCAS)
CHANGE SPEED TO 228 KCAS AT PGS

DESCENT INFORMATION

TOP OF DESCENT  99.3 NMI FROM LIMMA
DESCENT SCHEDULE .682 MACH / 250 KCAS

METERING FIX INFORMATION

ALTITUDE AT CIVET  16771
AIRSPEED AT CIVET  250

AIMPOINT INFORMATION

ALTITUDE AT LIMMA  1892
AIRSPEED AT LIMMA  180
GROSS WT AT LIMMA  82959 LB

SEGMENT TOTALS

TOTAL TIME  43 MINUTES 19.1 SECONDS
TOTAL FUEL  2040.7 LB
Table 4. Interactive Geometry Input

GEOMETRY INPUT SECTION

ENTER NUMBER OF PATHS (MAXIMUM OF 16)
I>1
  NUMBER OF PATHS 1
  IS INPUT CORRECT - (Y OR N)
I>Y
ENTER PATH IDENTIFIER - 10 CHARACTERS LEFT-ADJUSTED
I>CIVET 25
  PATH IDENTIFIER CIVET 25
  IS INPUT CORRECT - (Y OR N)
I>Y
THE FOLLOWING SECTION OBTAINS THE INFORMATION WHICH DEFINES
CIVET 25
ENTER THE NUMBER OF WAYPOINTS (MAXIMUM OF 15)
I>12
  CIVET 25 HAS 12 WAYPOINTS
  IS INPUT CORRECT - (Y OR N)
I>Y
ENTER WAYPOINT IDENTIFIERS BEGINNING AT AIMPOINT
7 CHARACTERS LEFT-ADJUSTED
WAYPOINT 1
I>LIMMA
  WAYPOINT 2
I>HUNDA
  WAYPOINT 3
I>DOWNE
  WAYPOINT 4
I>BASET
  WAYPOINT 5
I>ARNES
  WAYPOINT 6
I>CIVET
  WAYPOINT 7
I>TP
  WAYPOINT 8
I>BAIRS
  WAYPOINT 9
I>EMMEY
  WAYPOINT 10
I>DIKES
  WAYPOINT 11
I>ABREE
  WAYPOINT 12
I>PGS
Waypoint identifiers:

Waypoint 1: Limma
Waypoint 2: Hunda
Waypoint 3: Downe
Waypoint 4: Baset
Waypoint 5: Arnes
Waypoint 6: Civet
Waypoint 7: TP
Waypoint 8: Bairs
Waypoint 9: Emmey
Waypoint 10: Dikes
Waypoint 11: Abree
Waypoint 12: Pgs

Is input correct - (Y or N)

I> Y

Enter the waypoint number of the metering fix

I> 6

Waypoint 6: Civet is the metering fix

Is input correct - (Y or N)

I> Y

Enter variation:

Negative for East variation, positive for West variation

I> -15

Variation is -15.0

Is input correct - (Y or N)

I> Y

Enter course then distance for each path segment:

Pgs to Abree
I> 227 120
Abree to Dikes
I> 226 15
Dikes to Emmey
I> 226 24
Emmey to Bairs
I> 226 24
Bairs to TP
I> 226 22
TP to Civet
I> 248 8
Civet to Arnes
I> 248 18
Arnes to Baset
I> 248 11.5
Baset to Downe
I> 248 7.3
Downe to Hunda
I> 248 2.8
Hunda to Limma
I> 248 7.9
Table 4. Interactive Geometry Input (Continued)

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<thead>
<tr>
<th>PATH SEGMENT</th>
<th>COURSE</th>
<th>DISTANCE</th>
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<tr>
<td>PGS TO ABREE</td>
<td>227.</td>
<td>120.0 NM</td>
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<tr>
<td>ABREE TO DIKES</td>
<td>226.</td>
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</tr>
<tr>
<td>DIKES TO EMMEY</td>
<td>226.</td>
<td>24.0 NM</td>
</tr>
<tr>
<td>EMMEY TO BAIRS</td>
<td>226.</td>
<td>24.0 NM</td>
</tr>
<tr>
<td>BAIRS TO TP</td>
<td>226.</td>
<td>22.0 NM</td>
</tr>
<tr>
<td>TP TO CIVET</td>
<td>248.</td>
<td>8.0 NM</td>
</tr>
<tr>
<td>CIVET TO ARNES</td>
<td>248.</td>
<td>18.0 NM</td>
</tr>
<tr>
<td>ARNES TO BASET</td>
<td>248.</td>
<td>11.5 NM</td>
</tr>
<tr>
<td>BASET TO DOWNE</td>
<td>248.</td>
<td>7.3 NM</td>
</tr>
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<td>DOWNE TO HUNDA</td>
<td>248.</td>
<td>2.8 NM</td>
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<tr>
<td>HUNDA TO LIMMA</td>
<td>248.</td>
<td>7.9 NM</td>
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IS INPUT CORRECT — (Y OR N)  
I>Y

ENTER WAYPOINT CONSTRAINTS

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<tr>
<th>WAYPOINT</th>
<th>MAXIMUM ALTITUDE</th>
<th>MINIMUM ALTITUDE</th>
<th>AIRSPEED</th>
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<td>4000</td>
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<td>7000</td>
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Table 4. Interactive Geometry Input (Concluded)

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<th>SPEED</th>
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<tr>
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IS INPUT CORRECT - (Y OR N)

I>Y
Table 5. Local File Input—Geometry

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</table>
### Table 6. Interactive Input—FAA Winds Aloft Forecast

**FAA WINDS ALOFT FORECAST INPUT SECTION**

**ENTER NUMBER OF FORECAST ALTITUDES**

I>7  
**NUMBER OF FORECAST ALTITUDES 7**  
**IS INPUT CORRECT - (Y OR N)**  
I>Y  
**FOR EACH FORECAST ALTITUDE INPUT**  
**ALTITUDE WIND DIRECTION WIND SPEED TEMPERATURE**  
**BEGIN AT LOWEST PUBLISHED FORECAST ALTITUDE**  
**ENTER VALUES FOR ALTITUDE 1**

I>9000 280 38 0  
**ALTITUDE 9000. DIRECTION 280. SPEED 38. TEMPERATURE 0.0**  
I>Y  
**ENTER ALTIMETER SETTING**

I>29.92  
**ALTIMETER SETTING 29.92**  
**IS INPUT CORRECT - (Y OR N)**  
I>Y  
**ENTER VALUES FOR ALTITUDE 2**

I>12000 280 42 -6  
**ALTITUDE 12000. DIRECTION 280. SPEED 42. TEMPERATURE -6.0**  
I>Y  
**ENTER VALUES FOR ALTITUDE 3**

I>18000 270 50 -19  
**ALTITUDE 18000. DIRECTION 270. SPEED 50. TEMPERATURE -19.0**  
I>Y  
**ENTER VALUES FOR ALTITUDE 4**

I>24000 260 60 -31  
**ALTITUDE 24000. DIRECTION 260. SPEED 60. TEMPERATURE -31.0**  
I>Y  
**ENTER VALUES FOR ALTITUDE 5**

I>30000 240 71 -43  
**ALTITUDE 30000. DIRECTION 240. SPEED 71. TEMPERATURE -43.0**  
I>Y  
**ENTER VALUES FOR ALTITUDE 6**

I>34000 240 64 -47  
**ALTITUDE 34000. DIRECTION 240. SPEED 64. TEMPERATURE -47.0**  
I>Y  
**ENTER VALUES FOR ALTITUDE 7**

I>39000 250 51 -47  
**ALTITUDE 39000. DIRECTION 250. SPEED 51. TEMPERATURE -47.0**  
I>Y
Table 6. Interactive Input–FAA Winds Aloft Forecast (Concluded)

<table>
<thead>
<tr>
<th>ALTITUDE</th>
<th>DIRECTION/SPEED</th>
<th>TEMPERATURE</th>
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<tr>
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<td>50.</td>
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<td>24000.</td>
<td>260.</td>
<td>60.</td>
</tr>
<tr>
<td>30000.</td>
<td>240.</td>
<td>71.</td>
</tr>
<tr>
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<td>64.</td>
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<tr>
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<td>51.</td>
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</tbody>
</table>

THE CURRENT CRUISE ALTITUDE IS 0.  IS ANOTHER ALTITUDE DESIRED - (Y OR N) I>Y
ENTER CRUISE ALTITUDE I>35000
CRUISE ALTITUDE 35000.  IS INPUT CORRECT - (Y OR N) I>Y
ENTER WIND DIRECTION AND SPEED AT CRUISE ALTITUDE I>245 70
WIND DIRECTION 245. WIND SPEED 70.  IS INPUT CORRECT - (Y OR N) I>Y
ENTER OAT AT CRUISE ALTITUDE I>-47
OAT IS -47.0  IS INPUT CORRECT - (Y OR N) I>Y
Table 7. Local File Input—FAA Winds Aloft Forecast

<table>
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<tr>
<th>Y</th>
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<th>38</th>
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</tbody>
</table>
Table 8. Specific Approach Input

SELECT CALCULATION OPTION FOR PATH SEGMENTS REQUIRING THRUST:
1 USE LEVEL CRUISE UNTIL INTERCEPTING A CLEAN-IDLE DESCENT
2 CONSIDER SEGMENTS ON AN INDIVIDUAL BASIS
I>1

PATH ARRAY INPUT SECTION

ENTER GROSS WEIGHT AT ENTRY FIX
I>85000
GROSS WEIGHT IS 85000.
IS INPUT CORRECT - (Y OR N)
I>Y

AVAILABLE PROFILE DESCENT GEOMETRIES
1 CIVET 25
ENTER NUMBER OF DESIRED PATH
I>1
DESIRED PATH CIVET 25
IS INPUT CORRECT - (Y OR N)
I>Y

THE CURRENT AIRFIELD ELEVATION IS 0.
IS ANOTHER VALUE DESIRED - (Y OR N)
I>Y

ENTER AIRFIELD ELEVATION
I>126
AIRFIELD ELEVATION IS 126.
IS INPUT CORRECT - (Y OR N)
I>Y
REVISE SELECTED GEOMETRY - (Y OR N)
I>N

ENTER CAS AT AIMPOINT
I>180
CAS AT AIMPOINT 180.
IS INPUT CORRECT - (Y OR N)
I>Y

THE CURRENT CRUISE ALTITUDE IS 35000.
IS ANOTHER ALTITUDE DESIRED - (Y OR N)
I>N

ENTER CRUISE MACH AT ENTRY FIX
I>:.765
CRUISE SPEED AT ENTRY FIX .765 MACH 259. CAS
IS INPUT CORRECT - (Y OR N)
I>Y
IS ICING ANTICIPATED - (Y OR N)
I>N
IS HOLDING ANTICIPATED - (Y OR N)
I>N
Table 9. Time-Based Metering Input

IS METERING IN PROGRESS - (Y OR N)
I>Y
ENTER ENTRY FIX ETA - HH MM SS.S
I>12 00 00
   ENTRY FIX TIME  12 HR 0 MIN 0.0 SEC
IS INPUT CORRECT - (Y OR N)
I>Y

FOR LOW SPEED PROFILE - METERING FIX ETA SHOULD BE 36 MINUTES 52.5 SECONDS
AFTER ENTRY FIX ETA

FOR HIGH SPEED PROFILE - METERING FIX ETA SHOULD BE 28 MINUTES 32.4 SECONDS
AFTER ENTRY FIX ETA

THE CURRENT METERING FIX TIME ASSIGNMENT IS  0 HR 0 MIN 0.0 SEC
IS ANOTHER TIME DESIRED (Y OR N)
I>Y
ENTER METERING FIX TIME - HH MM SS.S
I>12 32 00
   METERING FIX TIME  12 HR 32 MIN 0.0 SEC
IS INPUT CORRECT - (Y OR N)
I>Y

THE FOLLOWING ALTITUDES ARE REQUIRED TO COMPLETE THE PROFILE

THE DESIRED ALTITUDE AT HUNDA IS AT OR BELOW 3436. FT

WILL ATC APPROVE THESE REVISIONS - (Y OR N)
I>Y
DISPLAY FULL PROFILE - (Y OR N)
I>Y
Table 10. Deviations From Minimum Thrust Descent

THE ALTITUDE CONSTRAINT OF 10000. HAS BEEN EXCEEDED WITH .7 NMI REMAINING TO ARNES
EITHER A THRUSTED DESCENT OR A LEVEL CRUISE WILL BE PERFORMED
IS A THRUSTED DESCENT DESIRED - (Y OR N)
I>Y
IS METERING IN PROGRESS - (Y OR N)
I>N

THE ALTITUDE CONSTRAINT OF 35000. HAS BEEN EXCEEDED WITH 23.0 NMI REMAINING TO DIKES
EITHER A THRUSTED DESCENT OR A LEVEL CRUISE WILL BE PERFORMED
IS A THRUSTED DESCENT DESIRED - (Y OR N)
I>N

THE FOLLOWING ALTITUDES ARE REQUIRED TO COMPLETE THE PROFILE

THE DESIRED ALTITUDE AT HUNDA IS AT OR BELOW 3436. FT
WILL ATC APPROVE THESE REVISIONS - (Y OR N)
I>Y
DISPLAY FULL PROFILE - (Y OR N)
I>Y
Table 11. Nonmetered Profile Generated From Example Input

### CIVET 25 PROFILE DESCENT

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<th>SEGMENT DESCRIPTION</th>
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**DESCENT REQUIREMENTS**

- **STARTING AT ARNES**  5.1 PERCENT OF MAXIMUM CRUISE THRUST
  MUST BE ADDED FOR THE SEGMENT TO CSFIX  TO MAINTAIN THE PROFILE

- **STARTING AT BASET**  21.9 PERCENT OF MAXIMUM SPOILER DRAG
  MUST BE ADDED FOR THE SEGMENT TO DOWNE  TO MAINTAIN THE PROFILE

- **STARTING AT HUNDA**  100.0 PERCENT OF MAXIMUM SPOILER DRAG
  MUST BE ADDED FOR THE SEGMENT TO CSFIX  TO MAINTAIN THE PROFILE
Table 12. Nonmetered Profile Summary

CIVET 25 SUMMARY

ENTRY FIX       PGS
METERING FIX    CIVET
AIMPOINT        LIMMA

PROFILE DISTANCE 257.5 NMI

ENTRY INFORMATION

CRUISE SPEED .765 MACH (259 KCAS)
CHANGE SPEED TO 228 KCAS AT PGS

DESCENT INFORMATION

TOP OF DESCENT 99.4 NMI FROM LIMMA
DESCENT SCHEDULE .682 MACH / 250 KCAS

METERING FIX INFORMATION

ALTITUDE AT CIVET       16750
AIRSPEED AT CIVET       250

AIMPOINT INFORMATION

ALTITUDE AT LIMMA       1892
AIRSPEED AT LIMMA       180
GROSS WT AT LIMMA       82971 LB

SEGMENT TOTALS

TOTAL TIME     43 MINUTES 19.0 SECONDS
TOTAL FUEL     2029.3 LB
Table 13. Metered Profile Generated From Example Input

CIVET 25 PROFILE DESCENT

<table>
<thead>
<tr>
<th>SEGMENT DESCRIPTION</th>
<th>MAG COURSE</th>
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<th>ALTITUDES BEGIN</th>
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<th>SPEEDS (CAS) BEGIN</th>
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**DESCENT REQUIREMENTS**

STARTING AT BASET    21.9 PERCENT OF MAXIMUM SPOILER DRAG
MUST BE ADDED FOR THE SEGMENT TO DOWNE TO MAINTAIN THE PROFILE

STARTING AT HUNDA    100.0 PERCENT OF MAXIMUM SPOILER DRAG
MUST BE ADDED FOR THE SEGMENT TO CSFIX TO MAINTAIN THE PROFILE
<table>
<thead>
<tr>
<th>Table 14. Metered Profile Summary</th>
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**CIVET 25 SUMMARY**

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<th>ENTRY FIX</th>
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<td>AIMPOINT</td>
<td>LIMMA</td>
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PROFILE DISTANCE 257.5 NMI

ENTRY INFORMATION

CRUISE SPEED .765 MACH (259 KCAS)
CHANGE SPEED TO 237 KCAS AT PGS

DESCENT INFORMATION

TOP OF DESCENT 95.7 NMI FROM LIMMA
DESCENT SCHEDULE .707 MACH / 272 KCAS

METERING FIX INFORMATION

ALTITUDE AT CIVET 16771
AIRSPEED AT CIVET 250
ETA TO CIVET 12 HR 31 MIN 47.2 SEC

AIMPOINT INFORMATION

ALTITUDE AT LIMMA 1892
AIRSPEED AT LIMMA 180
GROSS WT AT LIMMA 82939 LB

SEGMENT TOTALS

TOTAL TIME 41 MINUTES 55.4 SECONDS
TOTAL FUEL 2061.5 LB
Table 15. Baseline Validation

KEANN 26 PROFILE DESCENT

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<tr>
<th>SEGMENT DESCRIPTION</th>
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DESCENT REQUIREMENTS

STARTING AT WATKI 9.4 PERCENT OF MAXIMUM SPOILER DRAG MUST BE ADDED FOR THE SEGMENT TO CSFIX TO MAINTAIN THE PROFILE
Table 16. Baseline Profile Summary

KEANN 26 SUMMARY

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<td>AIMPOINT</td>
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PROFILE DISTANCE 189.2 NMI

ENTRY INFORMATION

CRUISE SPEED .765 MACH (259 KCAS)
CHANGE SPEED TO 228 KCAS AT EFIX

DESCENT INFORMATION

TOP OF DESCENT 87.7 NMI FROM ALTUR
DESCENT SCHEDULE .682 MACH / 250 KCAS

METERING FIX INFORMATION

ALTITUDE AT KEANN 19077
AIRSPEED AT KEANN 250

AIMPOINT INFORMATION

ALTITUDE AT ALTUR 7200
AIRSPEED AT ALTUR 180
GROSS WT AT ALTUR 83649 LB

SEGMENT TOTALS

TOTAL TIME 32 MINUTES 10.5 SECONDS
TOTAL FUEL 1351.0 LB
Table 17. Results of Time Assignment Requiring Descent Faster Than High Speed Boundary

IS METERING IN PROGRESS - (Y OR N)  
I>Y

ENTER ENTRY FIX ETA - HH MM SS.S  
I>12 00 00
   ENTRY FIX TIME   12 HR 0 MIN 0.0 SEC
IS INPUT CORRECT - (Y OR N)  
I>Y

FOR LOW SPEED PROFILE - METERING FIX ETA SHOULD BE 26 MINUTES 4.5 SECONDS AFTER ENTRY FIX ETA

FOR HIGH SPEED PROFILE - METERING FIX ETA SHOULD BE 20 MINUTES 5.0 SECONDS AFTER ENTRY FIX ETA

THE CURRENT METERING FIX TIME ASSIGNMENT IS 0 HR 0 MIN 0.0 SEC
IS ANOTHER TIME DESIRED (Y OR N)  
I>Y

ENTER METERING FIX TIME - HH MM SS.S  
I>12 18 00
   METERING FIX TIME   12 HR 18 MIN 0.0 SEC
IS INPUT CORRECT - (Y OR N)  
I>Y

CURRENT METERING FIX TIME REQUIRES A DESCENT 2.1 MINUTES FASTER THAN THE HIGH SPEED LIMIT
* REQUEST A NEW METERING FIX TIME *
Table 18. Path Stretching

IS METERING IN PROGRESS - (Y OR N)
I>Y
ENTER ENTRY FIX ETA - HH MM SS.S
I>12 00 00
ENTRY FIX TIME 12 HR 0 MIN 0.0 SEC
IS INPUT CORRECT - (Y OR N)
I>Y
FOR LOW SPEED PROFILE - METERING FIX ETA SHOULD BE 26 MINUTES 4.5 SECONDS
AFTER ENTRY FIX ETA

FOR HIGH SPEED PROFILE - METERING FIX ETA SHOULD BE 20 MINUTES 5.0 SECONDS
AFTER ENTRY FIX ETA

THE CURRENT METERING FIX TIME ASSIGNMENT IS 0 HR 0 MIN 0.0 SEC
IS ANOTHER TIME DESIRED (Y OR N)
I>Y
ENTER METERING FIX TIME - HH MM SS.S
I>12 29 00
METERING FIX TIME 12 HR 29 MIN 0.0 SEC
IS INPUT CORRECT - (Y OR N)
I>Y
CURRENT METERING FIX TIME REQUIRES A DESCENT 2.9 MINUTES SLOWER
THAN THE LOW SPEED LIMIT

* DELAY ABSORPTION PROCEDURES WILL BE REQUIRED *

ENTER HOLDING FIX WAYPOINT IDENTIFIER
HOLDING FIX MUST BE BETWEEN (BUT MAY NOT INCLUDE)
METERING FIX AND ENTRY FIX
I>WIGGI
WAYPOINT WIGGI IS ASSIGNED AS THE HOLDING FIX
IS INPUT CORRECT - (Y OR N)
I>Y
IS STACKING IN PROGRESS - (Y OR N)
I>N
WILL A HOLDING ALTITUDE BE ASSIGNED - (Y OR N)
I>N
ENTER HOLDING AIRSPEED (KCAS)
MINIMUM SPEED 200. KCAS
RECOMMENDED AIRSPEED 210. KCAS
MAXIMUM AIRSPEED 230. KCAS
I>210
HOLDING AIRSPEED IS 210. KCAS
IS INPUT CORRECT - (Y OR N)
I>Y
ENTER INBOUND HOLDING MAG COURSE
I>226
INBOUND COURSE IS 226.
IS INPUT CORRECT - (Y OR N)
I>Y
TO ABSORB 175.5 SECONDS DELAY, AN OFFSET OF 8.8 NM MUST BE FLOWN
WILL ATC APPROVE THIS REVISION - (Y OR N)
I>Y
ENTER DIRECTION OF OFFSET - (L OR R)
I>R

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**Table 18. Path Stretching (Continued)**

KEANN 26  PROFILE DESCENT

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<th>SEGMENT DESCRIPTION</th>
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<td>8.2</td>
<td>123.6</td>
<td>10000</td>
<td>7200</td>
<td>210</td>
<td>210</td>
<td>48.7</td>
</tr>
<tr>
<td>CSFIX3 ALTUR</td>
<td>258</td>
<td>1.9</td>
<td>32.2</td>
<td>7200</td>
<td>7200</td>
<td>210</td>
<td>180</td>
<td>13.3</td>
</tr>
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</table>

**DESCENT REQUIREMENTS**

STARTING AT WATKI 9.4 PERCENT OF MAXIMUM SPOILER DRAG MUST BE ADDED FOR THE SEGMENT TO CSFIX TO MAINTAIN THE PROFILE
<table>
<thead>
<tr>
<th>Table 18. Path Stretching (Concluded)</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>KEANN 26 SUMMARY</th>
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</thead>
<tbody>
<tr>
<td>ENTRY FIX   EFIX</td>
</tr>
<tr>
<td>METERING FIX  KEANN</td>
</tr>
<tr>
<td>AIMPOINT   ALTUR</td>
</tr>
<tr>
<td>PROFILE DISTANCE  206.9 NMI</td>
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<tr>
<td>ENTRY INFORMATION</td>
</tr>
<tr>
<td>CRUISE SPEED  .765 MACH (259 KCAS)</td>
</tr>
<tr>
<td>CHANGE SPEED TO 210 KCAS AT EFIX</td>
</tr>
<tr>
<td>DESCENT INFORMATION</td>
</tr>
<tr>
<td>TOP OF DESCENT  99.3 NMI FROM ALTUR</td>
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<tr>
<td>DESCENT SCHEDULE .631 MACH / 210 KCAS</td>
</tr>
<tr>
<td>DELAY TOTALS</td>
</tr>
<tr>
<td>DELAY TIME   2 MIN 55.5 SEC</td>
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<td>DELAY FUEL   93. LB</td>
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<td>METERING FIX INFORMATION</td>
</tr>
<tr>
<td>ALTITUDE AT KEANN  19077</td>
</tr>
<tr>
<td>AIRSPEED AT KEANN  250</td>
</tr>
<tr>
<td>ETA TO KEANN  12 HR 29 MIN 0.0 SEC</td>
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<td>AIMPOINT INFORMATION</td>
</tr>
<tr>
<td>ALTITUDE AT ALTUR  7200</td>
</tr>
<tr>
<td>AIRSPEED AT ALTUR  180</td>
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<tr>
<td>GROSS WT AT ALTUR  83463 LB</td>
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<tr>
<td>SEGMENT TOTALS</td>
</tr>
<tr>
<td>TOTAL TIME  37 MINUTES 49.4 SECONDS</td>
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<tr>
<td>TOTAL FUEL  1536.8 LB</td>
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Table 19. Optimum Altitude Holding

<table>
<thead>
<tr>
<th>IS HOLDING ANTICIPATED - (Y OR N)</th>
<th>I&gt;Y</th>
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<tbody>
<tr>
<td>ENTER EXPECTED DELAY IN MINUTES AND SECONDS MMM SS.S</td>
<td>I&gt;15 00</td>
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<tr>
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<tr>
<td>IS INPUT CORRECT - (Y OR N)</td>
<td>I&gt;Y</td>
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<tr>
<td>ENTER HOLDING FIX WAYPOINT IDENTIFIER</td>
<td>I&gt;WIGGI</td>
</tr>
<tr>
<td>HOLDING FIX MUST BE BETWEEN (BUT MAY NOT INCLUDE) METERING FIX AND ENTRY FIX</td>
<td>WAYPOINT WIGGI IS ASSIGNED AS THE HOLDING FIX</td>
</tr>
<tr>
<td>IS INPUT CORRECT - (Y OR N)</td>
<td>I&gt;Y</td>
</tr>
<tr>
<td>IS STACKING IN PROGRESS - (Y OR N)</td>
<td>I&gt;N</td>
</tr>
<tr>
<td>WILL A HOLDING ALTITUDE BE ASSIGNED - (Y OR N)</td>
<td>I&gt;N</td>
</tr>
<tr>
<td>ENTER HOLDING AIRSPEED (KCAS)</td>
<td>I&gt;210</td>
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<tr>
<td>MINIMUM SPEED 200. KCAS</td>
<td>HOLDING AIRSPEED IS 210. KCAS</td>
</tr>
<tr>
<td>RECOMMENDED AIRSPEED 210. KCAS</td>
<td>IS INPUT CORRECT - (Y OR N)</td>
</tr>
<tr>
<td>MAXIMUM AIRSPEED 230. KCAS</td>
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</tr>
<tr>
<td>ENTER INBOUND HOLDING MAG COURSE</td>
<td>I&gt;226</td>
</tr>
<tr>
<td>INBOUND COURSE IS 226.</td>
<td>IS INPUT CORRECT - (Y OR N)</td>
</tr>
<tr>
<td>I&gt;Y</td>
<td></td>
</tr>
<tr>
<td>IS METERING IN PROGRESS - (Y OR N)</td>
<td>I&gt;Y</td>
</tr>
<tr>
<td>ENTER ENTRY FIX ETA - HH MM SS.S</td>
<td>I&gt;12 00 00</td>
</tr>
<tr>
<td>ENTRY FIX TIME 12 HR 0 MIN 0.0 SEC</td>
<td>IS INPUT CORRECT - (Y OR N)</td>
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<td>I&gt;Y</td>
<td></td>
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FOR LOW SPEED PROFILE - METERING FIX ETA SHOULD BE 26 MINUTES 3.5 SECONDS AFTER ENTRY FIX ETA

FOR HIGH SPEED PROFILE - METERING FIX ETA SHOULD BE 20 MINUTES 5.1 SECONDS AFTER ENTRY FIX ETA
<table>
<thead>
<tr>
<th>SEGMENT DESCRIPTION</th>
<th>MAG COURSE</th>
<th>DISTANCE (NMI)</th>
<th>TIME (SEC)</th>
<th>ALTITUDES BEGIN</th>
<th>ALTITUDES END</th>
<th>SPEEDS(CAS) BEGIN</th>
<th>SPEEDS(CAS) END</th>
<th>FUEL (LB)</th>
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<tbody>
<tr>
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<td>226</td>
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<td>751.9</td>
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<td>210</td>
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<td>14000</td>
<td>210</td>
<td>210</td>
<td>2.0</td>
</tr>
<tr>
<td>POD3 WATKI</td>
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<td>14000</td>
<td>10000</td>
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<td>210</td>
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<td>7200</td>
<td>210</td>
<td>210</td>
<td>48.8</td>
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<tr>
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<td>210</td>
<td>180</td>
<td>13.3</td>
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</table>

DISPLAY DETAILED HOLDING INFORMATION - (Y OR N)

I>Y

DETAILED HOLDING INFORMATION

<table>
<thead>
<tr>
<th>ALTITUDES TIMES</th>
<th>FUELS</th>
</tr>
</thead>
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<tr>
<td>MINUTES SECONDS</td>
<td>MM SS.S</td>
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<td>TURN LEG TURN</td>
<td>LEG AT HLD DSCT FM</td>
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<td>21000 2 0.0 1 16.4 2 0.0 1 16.4 13 5.5 0 0.0</td>
<td>874.2 0.0</td>
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</table>

DESCENT REQUIREMENTS

STARTING AT WATKI 6.3 PERCENT OF MAXIMUM SPOILER DRAG MUST BE ADDED FOR THE SEGMENT TO CSFIX TO MAINTAIN THE PROFILE
Table 19. Optimum Altitude Holding (Continued)

| THE CURRENT METERING FIX TIME ASSIGNMENT IS 0 HR 0 MIN 0.0 SEC |
| IS ANOTHER TIME DESIRED (Y OR N) |
| I>Y |
| ENTER METERING FIX TIME - HH MM SS.S |
| I>12 40 00 |
| METERING FIX TIME 12 HR 40 MIN 0.0 SEC |
| IS INPUT CORRECT - (Y OR N) |
| I>Y |
| CURRENT METERING FIX TIME REQUIRES A DESCENT 13.9 MINUTES SLOWER THAN THE LOW SPEED LIMIT |

* DELAY ABSORPTION PROCEDURES WILL BE REQUIRED *

| STANDARD HOLDING PATTERN - (Y OR N) |
| I>Y |
| DISPLAY FULL PROFILE - (Y OR N) |
| I>Y |
Table 19. Optimum Altitude Holding (Concluded)

KEANN 26 SUMMARY

ENTRY INFORMATION

CRUISE SPEED .765 MACH (259 KCAS)
CHANGE SPEED TO 210 KCAS AT EFIX

DESCENT INFORMATION

TOP OF DESCENT 110.5 NMI FROM ALTUR
DESCENT SCHEDULE 210 KCAS

HOLDING INFORMATION

HOLDING ALTITUDE IS 21000 FT

PATTERN INFORMATION

STANDARD TURNS
HOLDING AIRSPEED 210 KCAS
INBOUND COURSE 226.

DELAY TOTALS

DELAY TIME 13 MIN 5.5 SEC
DELAY FUEL 874. LB

METERING FIX INFORMATION

ALTITUDE AT KEANN 19086
AIRSPEED AT KEANN 250
ETA TO KEANN 12 HR 40 MIN 0.0 SEC

AIMPOINT INFORMATION

ALTITUDE AT ALTUR 7200
AIRSPEED AT ALTUR 180
GROSS WT AT ALTUR 83576 LB

SEGMENT TOTALS

TOTAL TIME 48 MINUTES 47.2 SECONDS
TOTAL FUEL 2316.8 LB
Table 20. ATC-Assigned-Altitude Holding

<table>
<thead>
<tr>
<th>Instruction</th>
<th>Response</th>
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<td>IS HOLDING ANTICIPATED - (Y OR N)</td>
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</tr>
<tr>
<td>EXPECTED DELAY IS 15 MIN 0.0 SEC</td>
<td></td>
</tr>
<tr>
<td>IS INPUT CORRECT - (Y OR N)</td>
<td>Y</td>
</tr>
<tr>
<td>ENTER HOLDING FIX WAYPOINT IDENTIFIER</td>
<td>WIGGI</td>
</tr>
<tr>
<td>HOLDING FIX MUST BE BETWEEN (BUT MAY NOT INCLUDE) METERING FIX AND ENTRY FIX</td>
<td></td>
</tr>
<tr>
<td>WAYPOINT WIGGI IS ASSIGNED AS THE HOLDING FIX</td>
<td></td>
</tr>
<tr>
<td>IS INPUT CORRECT - (Y OR N)</td>
<td>Y</td>
</tr>
<tr>
<td>IS STACKING IN PROGRESS - (Y OR N)</td>
<td>N</td>
</tr>
<tr>
<td>WILL A HOLDING ALTITUDE BE ASSIGNED - (Y OR N)</td>
<td>Y</td>
</tr>
<tr>
<td>ENTER ASSIGNED ALTITUDE</td>
<td>20000</td>
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<tr>
<td>THE ASSIGNED HOLDING ALTITUDE IS 20000. FT</td>
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<tr>
<td>IS INPUT CORRECT - (Y OR N)</td>
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<tr>
<td>ENTER HOLDING AIRSPEED (KCAS)</td>
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<tr>
<td>MINIMUM SPEED 200. KCAS</td>
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<tr>
<td>RECOMMENDED AIRSPEED 210. KCAS</td>
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<td>MAXIMUM AIRSPEED 230. KCAS</td>
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<tr>
<td>ENTER ENTRY FIX ETA - HH MM SS.S</td>
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<tr>
<td>ENTRY FIX TIME 12 HR 0 MIN 0.0 SEC</td>
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<tr>
<td>IS INPUT CORRECT - (Y OR N)</td>
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</tr>
</tbody>
</table>

FOR LOW SPEED PROFILE - METERING FIX ETA SHOULD BE 26 MINUTES 4.8 SECONDS AFTER ENTRY FIX ETA

FOR HIGH SPEED PROFILE - METERING FIX ETA SHOULD BE 20 MINUTES 6.1 SECONDS AFTER ENTRY FIX ETA
Table 20. ATC-Assigned-Altitude Holding (Continued)

THE CURRENT METERING FIX TIME ASSIGNMENT IS 0 HR 0 MIN 0.0 SEC
IS ANOTHER TIME DESIRED (Y OR N)
I>Y
ENTER METERING FIX TIME - HH MM SS.S
I>12 40 00
METERING FIX TIME 12 HR 40 MIN 0.0 SEC
IS INPUT CORRECT - (Y OR N)
I>Y
CURRENT METERING FIX TIME REQUIRES A DESCENT 13.9 MINUTES SLOWER
THAN THE LOW SPEED LIMIT

* DELAY ABSORPTION PROCEDURES WILL BE REQUIRED *

STANDARD HOLDING PATTERN - (Y OR N)
I>Y
DISPLAY FULL PROFILE - (Y OR N)
I>Y
Table 20. ATC-Assigned-Altitude Holding (Continued)

**KEANN 26 PROFILE DESCENT**

<table>
<thead>
<tr>
<th>SEGMENT DESCRIPTION</th>
<th>MAG</th>
<th>DISTANCE COURSE</th>
<th>TIME (SEC)</th>
<th>ALTITUDES BEGIN</th>
<th>ALTITUDES END</th>
<th>SPEEDS (CAS) BEGIN</th>
<th>SPEEDS (CAS) END</th>
<th>FUEL (LB)</th>
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<tbody>
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<td>210</td>
<td>13.3</td>
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**DISPLAY DETAILED HOLDING INFORMATION - (Y OR N)**

I>Y

**DETAILED HOLDING INFORMATION**

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<th>ALTITUDES</th>
<th>ALTITUDES</th>
<th>ALTITUDES</th>
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<td>(MINUTES SECONDS - MM SS.S)</td>
<td>(LB)</td>
<td>(LB)</td>
<td>(LB)</td>
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<td>2</td>
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<td>1</td>
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**DESCENT REQUIREMENTS**

STARTING AT WATKI 6.3 PERCENT OF MAXIMUM SPOILER DRAG
MUST BE ADDED FOR THE SEGMENT TO CSFIX TO MAINTAIN THE PROFILE
Table 20. ATC-Assigned-Altitude Holding (Concluded)

KEANN 26 SUMMARY

---

ENTRY FIX EFIX
HOLDING FIX WIGGI
METERING FIX KEANN
AIMPOINT ALTUR

PROFILE DISTANCE 189.2 NMI

ENTRY INFORMATION

CRUISE SPEED .765 MACH (259 KCAS)
CHANGE SPEED TO 210 KCAS AT EFIX

DESCENT INFORMATION

TOP OF DESCENT 113.6 NMI FROM ALTUR
DESCENT SCHEDULE 210 KCAS

HOLDING INFORMATION

HOLDING ALTITUDE IS 20000 FT

PATTERN INFORMATION

STANDARD TURNS
HOLDING AIRSPEED 210. KCAS
INBOUND COURSE 226.

DELAY TOTALS

DELAY TIME 12 MIN 53.3 SEC
DELAY FUEL 866. LB

METERING FIX INFORMATION

ALTITUDE AT KEANN 19110
AIRSPEED AT KEANN 250
ETA TO KEANN 12 HR 40 MIN 0.0 SEC

AIMPOINT INFORMATION

ALTITUDE AT ALTUR 7200
AIRSPEED AT ALTUR 180
GROSS WT AT ALTUR 83494 LB

SEGMENT TOTALS

TOTAL TIME 48 MINUTES 49.4 SECONDS
TOTAL FUEL 2327.2 LB
Table 21. Holding in a Stack

IS HOLDING ANTICIPATED - (Y OR N)
I>Y
ENTER EXPECTED DELAY IN MINUTES AND SECONDS MMM SS.S
I>45 00 00
   EXPECTED DELAY IS 45 MIN 0.0 SEC
IS INPUT CORRECT - (Y OR N)
I>Y
ENTER HOLDING FIX WAYPOINT IDENTIFIER
HOLDING FIX MUST BE BETWEEN (BUT MAY NOT INCLUDE)
METERING FIX AND ENTRY FIX
I>WIGGI
   WAYPOINT WIGGI IS ASSIGNED AS THE HOLDING FIX
IS INPUT CORRECT - (Y OR N)
I>Y
IS STACKING IN PROGRESS - (Y OR N)
I>Y
ENTER TOP STACK ALTITUDE THEN BOTTOM STACK ALTITUDE
I>25000 21000
   TOP STACK ALTITUDE IS 25000.
   BOTTOM STACK ALTITUDE IS 21000.
IS INPUT CORRECT - (Y OR N)
I>Y
ENTER HOLDING AIRSPEED (KCAS)
   MINIMUM SPEED 200. KCAS
   RECOMMENDED AIRSPEED 210. KCAS
   MAXIMUM AIRSPEED 230. KCAS
I>210
   HOLDING AIRSPEED IS 210. KCAS
IS INPUT CORRECT - (Y OR N)
I>Y
ENTER INBOUND HOLDING MAG COURSE
I>226
   INBOUND COURSE IS 226.
IS INPUT CORRECT - (Y OR N)
I>Y
IS METERING IN PROGRESS - (Y OR N)
I>Y
ENTER ENTRY FIX ETA - HH MM SS.S
I>12 00 00
   ENTRY FIX TIME 12 HR 0 MIN 0.0 SEC
IS INPUT CORRECT - (Y OR N)
I>Y
   FOR LOW SPEED PROFILE - METERING FIX ETA SHOULD BE 30 MINUTES 38.6 SECONDS
   AFTER ENTRY FIX ETA

   FOR HIGH SPEED PROFILE - METERING FIX ETA SHOULD BE 23 MINUTES 32.1 SECONDS
   AFTER ENTRY FIX ETA
Table 21. Holding in a Stack (Continued)

THE CURRENT METERING FIX TIME ASSIGNMENT IS 12 HR 40 MIN 0.0 SEC
IS ANOTHER TIME DESIRED (Y OR N)
I>Y
ENTER METERING FIX TIME - HH MM SS.S
I>13 15 00
  METERING FIX TIME 13 HR 15 MIN 0.0 SEC
IS INPUT CORRECT - (Y OR N)
I>Y
CURRENT METERING FIX TIME REQUIRES A DESCENT 48.9 MINUTES SLOWER
THAN THE LOW SPEED LIMIT

* DELAY ABSORPTION PROCEDURES WILL BE REQUIRED *

STANDARD HOLDING PATTERN - (Y OR N)
I>Y
DISPLAY FULL PROFILE - (Y OR N)
I>Y
Table 21. Holding in a Stack (Continued)

KEANN 26 PROFILE DESCENT

<table>
<thead>
<tr>
<th>SEGMENT DESCRIPTION</th>
<th>MAG COURSE</th>
<th>DISTANCE (NMI)</th>
<th>TIME (SEC)</th>
<th>ALTITUDES BEGIN</th>
<th>ALTITUDES END</th>
<th>SPEEDS (CAS) BEGIN</th>
<th>SPEEDS (CAS) END</th>
<th>FUEL (LB)</th>
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<tbody>
<tr>
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<td>226</td>
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<td>48.6</td>
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DISPLAY DETAILED HOLDING INFORMATION - (Y OR N)

Y

DETAILED HOLDING INFORMATION

<table>
<thead>
<tr>
<th>ALTITUDES</th>
<th>TIMES</th>
</tr>
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<tr>
<td>(MINUTES SECONDS - MM SS.S)</td>
<td>FUELS (LB)</td>
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<tr>
<td>TURN LEG TURN LEG AT HLD DSCT FM</td>
<td>AT HLD DSCT FM</td>
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<td></td>
</tr>
<tr>
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<td>2 0.0 1 28.7 2 0.0 1 28.7 9 2.8 0 41.5</td>
</tr>
<tr>
<td>24000</td>
<td>2 0.0 1 28.7 2 0.0 1 28.7 9 4.5 0 39.8</td>
</tr>
<tr>
<td>23000</td>
<td>2 0.0 1 28.7 2 0.0 1 28.7 9 4.4 0 39.9</td>
</tr>
<tr>
<td>22000</td>
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<tr>
<td>21000</td>
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</tr>
</tbody>
</table>

DESCENT REQUIREMENTS

STARTING AT WATKI 12.5 PERCENT OF MAXIMUM SPOILER DRAG MUST BE ADDED FOR THE SEGMENT TO CSFIX TO MAINTAIN THE PROFILE
Table 21. Holding in a Stack (Concluded)

KEANN 26 SUMMARY

ENTRY FIX EFIX
HOLDING FIX WIGGI
METERING FIX KEANN
AIMPOINT ALTUR

PROFILE DISTANCE 189.2 NMI

ENTRY INFORMATION
CRUISE SPEED .765 MACH (259 KCAS)
CHANGE SPEED TO 210 KCAS AT EFIX

DESCENT INFORMATION
TOP OF DESCENT 97.6 NMI FROM ALTUR
DESCENT SCHEDULE 210 KCAS

HOLDING INFORMATION
STACK INFORMATION
TOP ALTITUDE 25000.
BOTTOM ALTITUDE 21000.

PATTERN INFORMATION
STANDARD TURNS
HOLDING AIRSPEED 210. KCAS
INBOUND COURSE 226.

DELAY TOTALS
DELAY TIME 48 MIN 41.5 SEC
DELAY FUEL 3270. LB

METERING FIX INFORMATION
ALTITUDE AT KEANN 18924
AIRSPEED AT KEANN 250
ETA TO KEANN 13 HR 15 MIN 0.0 SEC

AIMPOINT INFORMATION
ALTITUDE AT ALTUR 7200
AIRSPEED AT ALTUR 180
CROSS WT AT ALTUR 87306 LB

SEGMENT TOTALS
TOTAL TIME 83 MINUTES 47.5 SECONDS
TOTAL FUEL 4866.6 LB
Table 22. Holding in a Stack With Wind

IS HOLDING ANTICIPATED - (Y OR N) 
I>Y

ENTER EXPECTED DELAY IN MINUTES AND SECONDS MMM SS.S 
I>45 00 00

EXPECTED DELAY IS 45 MIN 0.0 SEC

IS INPUT CORRECT - (Y OR N) 
I>Y

ENTER HOLDING FIX WAYPOINT IDENTIFIER

HOLDING FIX MUST BE BETWEEN (BUT MAY NOT INCLUDE)

METERING FIX AND ENTRY FIX

I>WIGGI

WAYPOINT WIGGI IS ASSIGNED AS THE HOLDING FIX

IS INPUT CORRECT - (Y OR N) 
I>Y

IS STACKING IN PROGRESS - (Y OR N) 
I>Y

ENTER TOP STACK ALTITUDE THEN BOTTOM STACK ALTITUDE 
I>25000 21000

TOP STACK ALTITUDE IS 25000.
BOTTOM STACK ALTITUDE IS 21000.

IS INPUT CORRECT - (Y OR N) 
I>Y

ENTER HOLDING AIRSPEED (KCAS)

MINIMUM SPEED 200. KCAS
RECOMMENDED AIRSPEED 210. KCAS
MAXIMUM AIRSPEED 230. KCAS
I>210

HOLDING AIRSPEED IS 210. KCAS

IS INPUT CORRECT - (Y OR N) 
I>Y

ENTER INBOUND HOLDING MAG COURSE 
I>226

INBOUND COURSE IS 226.

IS INPUT CORRECT - (Y OR N) 
I>Y

IS METERING IN PROGRESS - (Y OR N) 
I>Y

ENTER ENTRY FIX ETA - HH MM SS.S 
I>12 00 00

ENTRY FIX TIME 12 HR 0 MIN 0.0 SEC

IS INPUT CORRECT - (Y OR N) 
I>Y

FOR LOW SPEED PROFILE - METERING FIX ETA SHOULD BE 30 MINUTES 38.6 SECONDS AFTER ENTRY FIX ETA

FOR HIGH SPEED PROFILE - METERING FIX ETA SHOULD BE 23 MINUTES 32.1 SECONDS AFTER ENTRY FIX ETA
Table 22. Holding in a Stack With Wind (Continued)

The current metering fix time assignment is 0 hr 0 min 0.0 sec. Is another time desired (Y or N)?

I> Y

Enter metering fix time - HH MM SS.

I> 13 15 00

Metering fix time - 13 hr 15 min 0.0 sec.

Is input correct - (Y or N)?

I> Y

Current metering fix time requires a descent 44.4 minutes slower than the low speed limit.

* Delay absorption procedures will be required *

Standard holding pattern - (Y or N)

I> Y

Display full profile - (Y or N)

I> Y
## Table 22. Holding in a Stack With Wind (Continued)

### KEANN 26 PROFILE DESCENT

<table>
<thead>
<tr>
<th>SEGMENT</th>
<th>COURSE</th>
<th>MAG DISTANCE</th>
<th>TIME BEGIN END</th>
<th>ALTITUDES BEGIN END</th>
<th>SPEEDS(CAS)</th>
<th>FUEL (LB)</th>
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<tr>
<td>Description</td>
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<td>END</td>
<td>BEGIN</td>
<td>END</td>
<td></td>
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<td>259</td>
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<tr>
<td>ECSFIX TOD</td>
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<td>210</td>
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<td>21000</td>
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<td>210</td>
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<td>250</td>
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<td>152</td>
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<td>7200</td>
<td>210</td>
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</tbody>
</table>

DISPLAY DETAILED HOLDING INFORMATION - (Y OR N)

I>Y

DETAILED HOLDING INFORMATION

<table>
<thead>
<tr>
<th>ALTIMETERS</th>
<th>TIMES (MINUTES SECONDS - MM SS.S)</th>
<th>FUELS (LB)</th>
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</thead>
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<td>LEG OUTBND</td>
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<tr>
<td>21000</td>
<td>1 13.4</td>
<td>0 23.8</td>
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Table 22. Holding in a Stack With Wind (Concluded)

KEANN 26 SUMMARY

<table>
<thead>
<tr>
<th>ENTRY FIX</th>
<th>EFIX</th>
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<tbody>
<tr>
<td>HOLDING FIX</td>
<td>WIGGI</td>
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<tr>
<td>METERING FIX</td>
<td>KEANN</td>
</tr>
<tr>
<td>AIMPOINT</td>
<td>ALTUR</td>
</tr>
</tbody>
</table>

PROFILE DISTANCE 189.2 NMI

ENTRY INFORMATION

CRUISE SPEED .765 MACH (259 KCAS)
CHANGE SPEED TO 210 KCAS AT EFIX

DESCENT INFORMATION

TOP OF DESCENT 91.0 NMI FROM ALTUR
DESCENT SCHEDULE 210 KCAS

HOLDING INFORMATION

STACK INFORMATION
TOP ALTITUDE 25000.
BOTTOM ALTITUDE 21000.

PATTERN INFORMATION
STANDARD TURNS
HOLDING AIRSPEED 210. KCAS
INBOUND COURSE 226.

DELAY TOTALS
DELAY TIME 43 MIN 53.3 SEC
DELAY FUEL 2960. LB

METERING FIX INFORMATION

ALTITUDE AT KEANN 19748
AIRSPEED AT KEANN 250
ETA TO KEANN 13 HR 15 MIN 0.0 SEC

AIMPOINT INFORMATION

ALTITUDE AT ALTUR 7200
AIRSPEED AT ALTUR 180
GROSS WT AT ALTUR 87447 LB

SEGMENT TOTALS

TOTAL TIME 84 MINUTES 29.3 SECONDS
TOTAL FUEL 4949.7 LB
<table>
<thead>
<tr>
<th>Question</th>
<th>Answer</th>
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<tbody>
<tr>
<td>IS ICING ANTICIPATED - (Y OR N)</td>
<td>Y</td>
</tr>
<tr>
<td>IS 55 PER CENT N1 DESIRED - (Y OR N)</td>
<td>Y</td>
</tr>
<tr>
<td>ANTIICING FROM 20000 FT TO GROUND - (Y OR N)</td>
<td>Y</td>
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<tr>
<td>IS HOLDING ANTICIPATED - (Y OR N)</td>
<td>N</td>
</tr>
<tr>
<td>IS METERING IN PROGRESS - (Y OR N)</td>
<td>N</td>
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</table>

**Table 23. Anti-Icing**

The following altitudes are required to complete the profile.

The desired altitude at WATKI is AT OR BELOW 9066. FT

WILL ATC APPROVE THESE REVISIONS - (Y OR N)                                   | Y      |
| DISPLAY FULL PROFILE - (Y OR N)                                            | Y      |
Table 23. Anti-Icing (Continued)

KEANN 26 PROFILE DESCENT

<table>
<thead>
<tr>
<th>SEGMENT DESCRIPTION</th>
<th>MAG COURSE</th>
<th>DISTANCE (NMI)</th>
<th>TIME (SEC)</th>
<th>BEGIN ALTITUDE (FT)</th>
<th>END ALTITUDE (FT)</th>
<th>BEGIN SPEED (CAS)</th>
<th>END SPEED (CAS)</th>
<th>FUEL (LB)</th>
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<tr>
<td>EFIX ECSFIX</td>
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<td>7200</td>
<td>210</td>
<td>180</td>
<td>53.1</td>
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</table>

DESCENT REQUIREMENTS

- STARTING AT KEANN: 84.4 PERCENT OF MAXIMUM SPOILER DRAG MUST BE ADDED FOR THE SEGMENT TO CSFIX TO MAINTAIN THE PROFILE
- STARTING AT FLOTS: 40.6 PERCENT OF MAXIMUM SPOILER DRAG MUST BE ADDED FOR THE SEGMENT TO WATKI TO MAINTAIN THE PROFILE
- STARTING AT WATKI: 100.0 PERCENT OF MAXIMUM SPOILER DRAG MUST BE ADDED FOR THE SEGMENT TO CSFIX TO MAINTAIN THE PROFILE
Table 23. Anti-Icing (Concluded)

<table>
<thead>
<tr>
<th>ENTRY FIX</th>
<th>EFIX</th>
</tr>
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<tbody>
<tr>
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<tr>
<td>AIMPOINT</td>
<td>ALTUR</td>
</tr>
</tbody>
</table>

PROFILE DISTANCE 189.2 NMI

ENTRY INFORMATION

CRUISE SPEED .765 MACH (259 KCAS)
CHANGE SPEED TO 228 KCAS AT EFIX

DESCENT INFORMATION

TOP OF DESCENT 96.5 NMI FROM ALTUR
DESCENT SCHEDULE .682 MACH / 250 KCAS

ANTIICE INFORMATION
AN N1 SETTING OF 55 SHOULD BE USED BETWEEN 20000 AND 0 FT

METERING FIX INFORMATION

ALTITUDE AT KEANN 17000
AIRSPEED AT KEANN 250

AIMPOINT INFORMATION

ALTITUDE AT ALTUR 7200
AIRSPEED AT ALTUR 180
GROSS WT AT ALTUR 83552 LB

SEGMENT TOTALS

TOTAL TIME 32 MINUTES 43.4 SECONDS
TOTAL FUEL 1448.4 LB
Table 24. Profile Re-Initialization

REVISE SELECTED GEOMETRY - (Y OR N)
I>Y

PUBLISHED PATH GEOMETRY - KEANN 26

<table>
<thead>
<tr>
<th>PATH SEGMENT</th>
<th>BEGIN</th>
<th>END</th>
<th>COURSE</th>
<th>DIST</th>
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<td>1</td>
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<tr>
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<td>KEANN</td>
<td>226.</td>
<td>10.0</td>
</tr>
<tr>
<td>3</td>
<td>KEANN</td>
<td>FLOTS</td>
<td>226.</td>
<td>17.0</td>
</tr>
<tr>
<td>4</td>
<td>FLOTS</td>
<td>WATKI</td>
<td>152.</td>
<td>12.1</td>
</tr>
<tr>
<td>5</td>
<td>WATKI</td>
<td>ALTUR</td>
<td>258.</td>
<td>10.1</td>
</tr>
</tbody>
</table>

ENTER THE NUMBER OF THE FIRST USABLE PATH SEGMENT
I>2

FIRST USABLE PATH SEGMENT IS WIGGI TO KEANN

IS INPUT CORRECT - (Y OR N)
I>Y

ENTER IDENTIFIER FOR WAYPOINT PRIOR TO WIGGI
7 CHARACTERS LEFT-ADJUSTED
I>REVGFIX

ENTER COURSE AND DISTANCE FOR REVGFIX TO WIGGI
I>205 130

REVGFIX TO WIGGI COURSE 205. DISTANCE 130.0

IS INPUT CORRECT - (Y OR N)
I>Y

ADD ANOTHER PATH SEGMENT - (Y OR N)
I>N

ENTER MAXIMUM AND MINIMUM ALTITUDES FOR NEW WAYPOINTS
ENTER ALTITUDE CONSTRAINTS AT REVGFIX
I>35000 30000

NEW WAYPOINT CONSTRAINTS
MAXIMUM MINIMUM
WAYPOINT ALTITUDE ALTITUDE
REVGFIX 35000. 30000.

IS INPUT CORRECT - (Y OR N)
I>Y

ENTER CAS AT AIMPOINT
I>180

CAS AT AIMPOINT 180.

IS INPUT CORRECT - (Y OR N)
I>Y

THE CURRENT CRUISE ALTITUDE IS 35000.
IS ANOTHER ALTITUDE DESIRED - (Y OR N)
I>N

ENTER CRUISE MACH AT ENTRY FIX
I>.765

CRUISE SPEED AT ENTRY FIX .765 MACH 259. CAS

IS INPUT CORRECT - (Y OR N)
I>Y

IS ICING ANTICIPATED - (Y OR N)
I>N

IS HOLDING ANTICIPATED - (Y OR N)
I>N

IS METERING IN PROGRESS - (Y OR N)
I>N

DISPLAY FULL PROFILE - (Y OR N)
I>Y
### Table 24. Profile Re-Initialization (Continued)

**KEANN 26 PROFILE DESCENT**

<table>
<thead>
<tr>
<th>SEGMENT DESCRIPTION</th>
<th>MAG COURSE</th>
<th>DISTANCE (NMI)</th>
<th>TIME (SEC)</th>
<th>ALTITUDES BEGIN</th>
<th>ALTITUDES END</th>
<th>SPEEDS (CAS) BEGIN</th>
<th>SPEEDS (CAS) END</th>
<th>FUEL (LB)</th>
</tr>
</thead>
<tbody>
<tr>
<td>REVGFIX ECSFIX</td>
<td>205</td>
<td>5.4</td>
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<td>35000</td>
<td>35000</td>
<td>259</td>
<td>228</td>
<td>14.0</td>
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<tr>
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<td>205</td>
<td>85.9</td>
<td>788.0</td>
<td>35000</td>
<td>35000</td>
<td>228</td>
<td>228</td>
<td>902.6</td>
</tr>
<tr>
<td>TOD WIGGI</td>
<td>205</td>
<td>38.7</td>
<td>367.2</td>
<td>35000</td>
<td>22536</td>
<td>228</td>
<td>250</td>
<td>110.2</td>
</tr>
<tr>
<td>WIGGI KEANN</td>
<td>226</td>
<td>10.0</td>
<td>106.1</td>
<td>22536</td>
<td>19050</td>
<td>250</td>
<td>250</td>
<td>31.8</td>
</tr>
<tr>
<td>KEANN CSFIX1</td>
<td>226</td>
<td>13.7</td>
<td>155.4</td>
<td>19050</td>
<td>14000</td>
<td>250</td>
<td>250</td>
<td>47.7</td>
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<td>CSFIX1 FLOTS</td>
<td>226</td>
<td>3.3</td>
<td>41.8</td>
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<td>14000</td>
<td>250</td>
<td>210</td>
<td>13.5</td>
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<tr>
<td>FLOTS POD2</td>
<td>152</td>
<td>1.1</td>
<td>1.2</td>
<td>14000</td>
<td>14000</td>
<td>210</td>
<td>210</td>
<td>1.4</td>
</tr>
<tr>
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<td>152</td>
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<td>173.0</td>
<td>14000</td>
<td>10000</td>
<td>210</td>
<td>210</td>
<td>59.5</td>
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<tr>
<td>WATKI CSFIX2</td>
<td>258</td>
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<td>123.6</td>
<td>10000</td>
<td>7200</td>
<td>210</td>
<td>210</td>
<td>48.7</td>
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<tr>
<td>CSFIX2 ALTUR</td>
<td>258</td>
<td>1.9</td>
<td>32.2</td>
<td>7200</td>
<td>7200</td>
<td>210</td>
<td>180</td>
<td>13.3</td>
</tr>
</tbody>
</table>

**Descent Requirements**

Starting at WATKI, 9.4 percent of maximum spoiler drag must be added for the segment to CSFIX to maintain the profile.
Table 24. Profile Re-Initialization (Concluded)

KEANN 26 SUMMARY

ENTRY FIX REVGFIX
METERING FIX KEANN
AIMPOINT ALTUR

PROFILE DISTANCE 179.2 NMI

ENTRY INFORMATION

CRUISE SPEED .765 MACH (259 KCAS)
CHANGE SPEED TO 228 KCAS AT REVGFIX

DESCENT INFORMATION

TOP OF DESCENT 87.9 NMI FROM ALTUR
DESCENT SCHEDULE .682 MACH / 250 KCAS

METERING FIX INFORMATION

ALTITUDE AT KEANN 19050
AIRSPEED AT KEANN 250

AIMPOINT INFORMATION

ALTITUDE AT ALTUR 7200
AIRSPEED AT ALTUR 180
GROSS WT AT ALTUR 83757 LB

SEGMENT TOTALS

TOTAL TIME 30 MINUTES 35.4 SECONDS
TOTAL FUEL 1242.9 LB
**Table 25. Drako 26 Profile Descent, Denver, Colorado**

The following altitudes are required to complete the profile

The desired altitude at TFINL is at or below 8244 ft.

Will ATC approve these revisions - (Y or N)

\[ \text{I>Y} \]

Display full profile - (Y or N)

\[ \text{I>Y} \]

---

### Drako 26 Profile Descent

<table>
<thead>
<tr>
<th>SEGMENT DESCRIPTION</th>
<th>MAG COURSE</th>
<th>DISTANCE (NMI)</th>
<th>TIME (SEC)</th>
<th>ALTITUDES BEGIN</th>
<th>ALTITUDES END</th>
<th>SPEEDS (CAS)</th>
<th>FUEL (LB)</th>
</tr>
</thead>
<tbody>
<tr>
<td>EFIX ECSFIX</td>
<td>133</td>
<td>5.4</td>
<td>46.8</td>
<td>35000</td>
<td>35000</td>
<td>259</td>
<td>228</td>
</tr>
<tr>
<td>ECSFIX TOD</td>
<td>133</td>
<td>105.7</td>
<td>970.1</td>
<td>35000</td>
<td>35000</td>
<td>228</td>
<td>228</td>
</tr>
<tr>
<td>TOD DRAKO</td>
<td>133</td>
<td>38.8</td>
<td>369.7</td>
<td>35000</td>
<td>22450</td>
<td>228</td>
<td>250</td>
</tr>
<tr>
<td>DRAKO JASIN</td>
<td>133</td>
<td>18.0</td>
<td>196.6</td>
<td>22450</td>
<td>16000</td>
<td>250</td>
<td>250</td>
</tr>
<tr>
<td>JASIN POD2</td>
<td>133</td>
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<td>40.5</td>
<td>16000</td>
<td>16000</td>
<td>250</td>
<td>250</td>
</tr>
<tr>
<td>POD2 TDWND</td>
<td>133</td>
<td>6.7</td>
<td>78.2</td>
<td>16000</td>
<td>13487</td>
<td>250</td>
<td>250</td>
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<tr>
<td>TDWND CSFIX1</td>
<td>80</td>
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<td>112.7</td>
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<td>250</td>
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<td>38.7</td>
<td>10000</td>
<td>10000</td>
<td>250</td>
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<td>TBASE TFINL</td>
<td>170</td>
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<td>75.2</td>
<td>10000</td>
<td>8244</td>
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<td>210</td>
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<td>TFINL CSFIX2</td>
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<td>2.2</td>
<td>33.2</td>
<td>8244</td>
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<td>210</td>
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<tr>
<td>CSFIX2 ALTUR</td>
<td>260</td>
<td>1.9</td>
<td>32.2</td>
<td>7200</td>
<td>7200</td>
<td>210</td>
<td>180</td>
</tr>
</tbody>
</table>

### Descent Requirements

Starting at TBASE 12.5 percent of maximum spoiler drag must be added for the segment to TFINL to maintain the profile.

Starting at TFINL 100.0 percent of maximum spoiler drag must be added for the segment to CSFIX to maintain the profile.
Table 25. Drako 26 Profile Descent, Denver, Colorado (Concluded)

DRAKO 26 SUMMARY

ENTRY FIX    EFIX
METERING FIX DRAKO
AIMPOINT     ALTUR

PROFILE DISTANCE 199.4 NMI

ENTRY INFORMATION

CRUISE SPEED .765 MACH (259 KCAS)
CHANGE SPEED TO 228 KCAS AT EFIX

DESCENT INFORMATION

TOP OF DESCENT 88.2 NMI FROM ALTUR
DESCENT SCHEDULE 228 KCAS

METERING FIX INFORMATION

ALTITUDE AT DRAKO 22450
AIRSPEED AT DRAKO 250

AIMPOINT INFORMATION

ALTITUDE AT ALTUR 7200
AIRSPEED AT ALTUR 180
GROSS WT AT ALTUR 83517 LB

SEGMENT TOTALS

TOTAL TIME 33 MINUTES 13.9 SECONDS
TOTAL FUEL 1483.3 LB
### Table 26. Blue Ridge 17L STAR, Dallas, Texas

#### BLUE RIDGE PROFILE DESCENT

<table>
<thead>
<tr>
<th>SEGMENT</th>
<th>MAG</th>
<th>DISTANCE</th>
<th>TIME</th>
<th>ALTITUDES</th>
<th>SPEEDS (CAS)</th>
<th>FUEL</th>
</tr>
</thead>
<tbody>
<tr>
<td>DESCRI</td>
<td>COURSE</td>
<td>(NMI)</td>
<td>(SEC)</td>
<td>BEGIN</td>
<td>END</td>
<td>BEGIN</td>
</tr>
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<td>TUL ECSFIX</td>
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<td>47.2</td>
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<td>35000</td>
<td>259</td>
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<tr>
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<td>35000</td>
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<td>228</td>
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<td>35000</td>
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<td>35000</td>
<td>29372</td>
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<td>YARBB RADEX</td>
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<td>250</td>
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<td>RADEX BUJ</td>
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<td>312.9</td>
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<td>250</td>
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<td>169.9</td>
<td>14886</td>
<td>9592</td>
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<td>BATON ALKID</td>
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<td>102.7</td>
<td>9592</td>
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<td>250</td>
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<td>100.4</td>
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<td>250</td>
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<td>36.2</td>
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<td>250</td>
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<td>70.3</td>
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<td>2287</td>
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<td>30.5</td>
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</table>

110
Table 26. Blue Ridge 17L STAR, Dallas, Texas (Concluded)

BLUE RIDGE SUMMARY
---------------------
ENTRY FIX TUL
METERING FIX BUJ
AIMPOINT JIFFY

PROFILE DISTANCE 217.0 NMI

ENTRY INFORMATION

CRUISE SPEED .765 MACH (259 KCAS)
CHANGE SPEED TO 228 KCAS AT TUL

DESCENT INFORMATION

TOP OF DESCENT 97.8 NMI FROM JIFFY
DESCENT SCHEDULE .682 MACH / 250 KCAS

METERING FIX INFORMATION

ALTITUDE AT BUJ 14886
Airspeed at BUJ 250

AIMPOINT INFORMATION

ALTITUDE AT JIFFY 2287
Airspeed at JIFFY 180
GROSS WT AT JIFFY 83392 LB

SEGMENT TOTALS

TOTAL TIME 36 MINUTES 42.2 SECONDS
TOTAL FUEL 1607.6 LB
Table 27. Leila 27 Profile Descent, Miami, Florida

LEILA 27  PROFILE DESCENT

<table>
<thead>
<tr>
<th>SEGMENT DESCRIPTION</th>
<th>MAG COURSE</th>
<th>DISTANCE (NMI)</th>
<th>TIME (SEC)</th>
<th>ALTITUDES BEGIN</th>
<th>END</th>
<th>ALTITUDES BEGIN</th>
<th>END</th>
<th>SPEEDS(CAS)</th>
<th>FUEL (LB)</th>
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<tbody>
<tr>
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<td>5.4</td>
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<td>67.3</td>
<td>35000</td>
<td>32479</td>
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<td>105.6</td>
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<tr>
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<td>1459</td>
<td>1459</td>
<td>210</td>
<td>180</td>
<td>15.7</td>
<td></td>
</tr>
</tbody>
</table>

DESCENT REQUIREMENTS

STARTING AT TWND 96.9 PERCENT OF MAXIMUM SPOILER DRAG MUST BE ADDED FOR THE SEGMENT TO TBASE TO MAINTAIN THE PROFILE
Table 27. Leila 27 Profile Descent, Miami, Florida (Concluded)

**LEILA 27 SUMMARY**

<table>
<thead>
<tr>
<th>ENTRY FIX</th>
<th>SRQ</th>
</tr>
</thead>
<tbody>
<tr>
<td>METERING FIX</td>
<td>MFIX</td>
</tr>
<tr>
<td>AIMPOINT</td>
<td>KEYES</td>
</tr>
</tbody>
</table>

PROFILE DISTANCE 178.8 NMI

**ENTRY INFORMATION**

CRUISE SPEED .765 MACH (259 KCAS)
CHANGE SPEED TO 228 KCAS AT SRQ

**DESCENT INFORMATION**

TOP OF DESCENT 108.2 NMI FROM KEYES
DESENT SCHEDULE .682 MACH / 250 KCAS

**METERING FIX INFORMATION**

ALTITUDE AT MFIX 17000
AIRSPEED AT MFIX 250

**AIMPOINT INFORMATION**

ALTITUDE AT KEYES 1459
AIRSPEED AT KEYES 180
GROSS WT AT KEYES 83748 LB

**SEGMENT TOTALS**

TOTAL TIME 31 MINUTES 47.0 SECONDS
TOTAL FUEL 1251.8 LB
Table 28. Big SUR 28 Profile Descent, San Francisco, California

SELECT CALCULATION OPTION FOR PATH SEGMENTS REQUIRING THRUST:
1 USE LEVEL CRUISE UNTIL INTERCEPTING A CLEAN-IDLE DESCENT
2 CONSIDER SEGMENTS ON AN INDIVIDUAL BASIS
I>1

PATH ARRAY INPUT SECTION

ENTER GROSS WEIGHT AT ENTRY FIX
I>85000
  GROSS WEIGHT IS 85000.
  IS INPUT CORRECT - (Y OR N)
I>Y

AVAILABLE PROFILE DESCENT GEOMETRIES
  1 BIG SUR 28
ENTER NUMBER OF DESIRED PATH
I>1
  DESIRED PATH BIG SUR 28
  IS INPUT CORRECT - (Y OR N)
I>Y
  THE CURRENT AIRFIELD ELEVATION IS 0.
  IS ANOTHER VALUE DESIRED - (Y OR N)
I>Y
  ENTER AIRFIELD ELEVATION
I>11
  AIRFIELD ELEVATION IS 11.
  IS INPUT CORRECT - (Y OR N)
I>Y
  REVISE SELECTED GEOMETRY - (Y OR N)
I>N
  ENTER CAS AT AIMPOINT
I>180
    CAS AT AIMPOINT 180.
    IS INPUT CORRECT - (Y OR N)
I>Y
    THE CURRENT CRUISE ALTITUDE IS 35000.
    IS ANOTHER ALTITUDE DESIRED - (Y OR N)
I>N
  ENTER CRUISE MACH AT ENTRY FIX
I>0.765
    CRUISE SPEED AT ENTRY FIX 0.765 MACH 259. CAS
    IS INPUT CORRECT - (Y OR N)
I>Y
    IS ICING ANTICIPATED - (Y OR N)
I>N
    IS HOLDING ANTICIPATED - (Y OR N)
I>N
    IS METERING IN PROGRESS - (Y OR N)
I>N
Table 28. Big SUR 28 Profile Descent, San Francisco, California (Concluded)

THE DESCENT REQUIRED FROM ECSFIX TO D20 CANNOT BE ACCOMPLISHED USING ONLY FLIGHT LIMIT SPOILERS FOR DRAG. AIRCRAFT PERFORMANCE REQUIRES A FLIGHT PATH ENDING AT 30918. FT WHICH IS BELOW THE CRUISE ALTITUDE OF 35000. FT.

*******************************************************************************
*** CURRENT PROFILE CALCULATION IS TERMINATED ***
*** REVISE THE GEOMETRY OR SELECT A NEW PROFILE ***
*******************************************************************************

IS ANOTHER PROFILE DESIRED (Y OR N)
I>N
Table 29. ATLIS 24 Profile Descent, St. Louis, Missouri

ATLIS 24 PROFILE DESCENT

<table>
<thead>
<tr>
<th>SEGMENT DESCRIPTION</th>
<th>COURSE</th>
<th>MAG DISTANCE</th>
<th>TIME (SEC)</th>
<th>ALTITUDES</th>
<th>SPEEDS (CAS)</th>
<th>FUEL</th>
</tr>
</thead>
<tbody>
<tr>
<td>COLIE ECSFIX</td>
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<td>5.4</td>
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<td>35000</td>
<td>259  228</td>
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<td>ECSFIX TOD</td>
<td>116</td>
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<td>308.8</td>
<td>35000</td>
<td>35000</td>
<td>228  228</td>
</tr>
<tr>
<td>TOD UIN</td>
<td>116</td>
<td>9.9</td>
<td>90.3</td>
<td>35000</td>
<td>31517</td>
<td>228  247</td>
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<td>UIN ATLIS</td>
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DESCENT REQUIREMENTS

STARTING AT WIRED 14.1 PERCENT OF MAXIMUM SPOILER DRAG
MUST BE ADDED FOR THE SEGMENT TO CSFIX TO MAINTAIN THE PROFILE

STARTING AT MENNA 6.3 PERCENT OF MAXIMUM SPOILER DRAG
MUST BE ADDED FOR THE SEGMENT TO CSFIX TO MAINTAIN THE PROFILE
Table 29. ATLIS 24 Profile Descent, St. Louis, Missouri (Concluded)

ATLIS 24 SUMMARY

ENTRY FIX COLIE
METERING FIX WIRED
AIMPOINT ZUMAY

PROFILE DISTANCE 137.1 NMI

ENTRY INFORMATION

CRUISE SPEED .765 MACH (259 KCAS)
CHANGE SPEED TO 228 KCAS AT COLIE

DESCENT INFORMATION

TOP OF DESCENT 98.0 NMI FROM ZUMAY
DESCENT SCHEDULE .682 MACH / 250 KCAS

METERING FIX INFORMATION

ALTITUDE AT WIRED 10000
AIRSPEED AT WIRED 250

AIMPOINT INFORMATION

ALTITUDE AT ZUMAY 2000
AIRSPEED AT ZUMAY 180
GROSS WT AT ZUMAY 84229 LB

SEGMENT TOTALS

TOTAL TIME 24 MINUTES 32.1 SECONDS
TOTAL FUEL 770.7 LB
### Table 30. MODUC 06 Profile Descent, St. Louis, Missouri

**MODUC 06 PROFILE DESCENT**

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<thead>
<tr>
<th>SEGMENT DESCRIPTION</th>
<th>MAG COURSE</th>
<th>DISTANCE (NMI)</th>
<th>TIME (SEC)</th>
<th>BEGIN ALTITUDE</th>
<th>END ALTITUDE</th>
<th>SPEED (CAS)</th>
<th>FUEL (LB)</th>
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</table>

**DESCENT REQUIREMENTS**

Starting at ARCHO, 3.1 percent of maximum spoiler drag must be added for the segment to CSFIX to maintain the profile.
Table 30. MODUC 06 Profile Descent, St. Louis, Missouri (Concluded)

MODUC 06 SUMMARY

ENTRY FIX DENNI
METERING FIX FLORA
AIMPOINT TONNI

PROFILE DISTANCE 119.9 NMI

ENTRY INFORMATION

CRUISE SPEED .765 MACH (259 KCAS)
CHANGE SPEED TO 228 KCAS AT DENNI

DESCENT INFORMATION

TOP OF DESCENT 104.1 NMI FROM TONNI
DESCENT SCHEDULE .682 MACH / 250 KCAS

METERING FIX INFORMATION

ALTITUDE AT FLORA 12000
AIRSPEED AT FLORA 250

AIMPOINT INFORMATION

ALTITUDE AT TONNI 2200
AIRSPEED AT TONNI 180
GROSS WT AT TONNI 84387 LB

SEGMENT TOTALS

TOTAL TIME 22 MINUTES 8.5 SECONDS
TOTAL FUEL 612.7 LB
8.0 CONCLUSIONS

The LFM/PD algorithm can compute fuel-efficient descent profiles in an ATC flow management environment with or without time-based metering over a fixed ground track. These profiles conform to all ATC restrictions and procedures and to performance capabilities of the Boeing 737-100 airplane with JT8D-7 engines. All pertinent constraints are stored in the navigation, engine and airframe data bases and serve as boundary conditions of the point-mass, steady-state aerodynamic equations of motion to derive airplane airspeed and altitude data at all published and performance-generated waypoints. Waypoint crossing times and fuel burn throughout the descent are also computed. When no ATC system delay is required, the algorithm constructs a fuel-efficient descent profile from the entry fix to the aimpoint. When metering is in effect and an ATC metering fix time is assigned to the TCV airplane, a fuel-efficient profile requiring an airspeed schedule consistent with making good the fix crossing time is computed, including holding or path stretching to absorb excess ATC delay. Ground speeds at all waypoints are derived from the metered profile and serve as the guidance reference for time-based navigation. Profiles requiring anti-ice power are also accommodated. Finally, the algorithm displays a profile table and summary data.
The Local Flow Management/Profile Descent (LFM/PD) algorithm designed for the NASA Transport System Research Vehicle program is described. The algorithm provides fuel-efficient altitude and airspeed profiles consistent with ATC restrictions in a time-based metering environment over a fixed ground track. The model design constraints include accommodation of both published profile descent procedures and unpublished profile descents, incorporation of fuel efficiency as a flight profile criterion, operation within the performance capabilities of the Boeing 737-100 airplane with JT8D-7 engines, and conformity to standard air traffic navigation and control procedures. Holding and path stretching capabilities are included for long delay situations.