

FLIGHT PLANNING AND PERFORMANCE

INTRODUCTION

The Flight Planning section is provided to assist in determining fuel requirements when a computer flight plan is unavailable. The following data is based on the PS1 744 with General Electric CF6-80C2B1F engines.

In comparison with other 744 engine types, the PW4056 and RB211-524G/H burn approximately 1% to 3% more fuel than the CF6, respectively.

The following tables are supplied to assist in manual flight planning:

- Simplified Flight Planning .86 mach cruise**
- Optimum altitude and short distance cruise altitude**
- Holding planning**
- Simplified alternate flight planning at LRC**

The Performance section is provided in the event that the automated displays of the FMC become inoperative and airline performance charts are unavailable.

- PS1 744 takeoff data**
- Altitude/Maneuver capability**
- Enroute climb 340 KIAS/ .84 mach**
- Wind-Altitude trade**
- .86 mach cruise**
- LRC cruise mach schedule**
- Enroute holding**
- Descent**
- PS1 744 landing data**
- Flight with unreliable airspeed/mach indication**

FLIGHT PLANNING

FLIGHT PLANNING ALLOWANCES

GROUND OPERATIONS

Average APU (Auxiliary Power Unit) fuel flow rates under normal operation are 300 KG per hour on the ground; 270 KG per hour at normal operating altitudes.

Taxi fuel allowance is 45 KG per minute. Average taxi fuel is 700 to 1000 KG. During peak departure times, taxi times may range from 30 to 45 minutes at large international airports.

CLIMB

The FAA requires that 250 KIAS (Knots Indicated Airspeed) or minimum speed to maintain control not be exceeded below 10 000 feet. Approximately 400 KG of additional fuel is burned when this 250 KIAS restriction is imposed. Enroute climb charts do not take this penalty into account.

A standard climb will burn approximately 6000 KG, which will increase optimum and maximum altitudes by nearly 400 feet from takeoff to Top of Climb.

ALTITUDE SELECTION

The best fuel mileage for a given speed is achieved at optimum altitude. The fuel mileage penalty for operation of off-optimum altitudes at Mach .86 is listed below:

- 2000 feet above optimum, fuel penalty 1%
- 2000 feet below optimum, fuel penalty 2%
- 4000 feet below optimum, fuel penalty 6%
- 8000 feet below optimum, fuel penalty 15%
- 12 000 feet below optimum, fuel penalty 25%

If operation below optimum altitude is required due to ATC requirements or outside circumstances, operation at LRC cruise speed will minimize excess fuel burn and prevent low arrival fuels. The fuel mileage penalty for LRC:

- 2000 feet above optimum, fuel penalty 1%
- 2000 feet below optimum, fuel penalty 1%
- 4000 feet below optimum, fuel penalty 3%
- 8000 feet below optimum, fuel penalty 7%
- 12 000 feet below optimum, fuel penalty 12%

CRUISE

Maximum Range Cruise (MRC) is the cruise speed used when fuel conservation and range is of primary importance. This speed provides the maximum aircraft range at optimum altitudes. MRC may be determined by entering Cost Index 0 into the FMC. The resulting ECON cruise speed will be MRC. MRC for the 744 is typically Mach .84.

Long Range Cruise (LRC) is the recommended speed to minimize trip fuel. LRC is a speed that will provide 99% of the maximum fuel mileage but is slightly faster than MRC. For cruise operation within 2000 feet of optimum altitude, LRC can be approximated by flying a constant Mach .86 speed schedule.

Economy Cruise (ECON) is that cruise speed flown when a valid Cost Index number is entered into the FMC (CI 0 to 9999). The ECON speed is flown to minimize either the cost of fuel or cost of flight time. If a Cost Index 0 is entered, ECON speed will attempt to minimize the use of fuel. If Cost Index 9999 is entered, ECON speed will attempt to minimize the flight time.

Increase total fuel flow during cruise by 260 KG/HR for engine anti-ice on or 420 KG/HR for engine and wing anti-ice on.

Every 4400 KG reduction in landing weight decreases trip fuel at optimum altitude by 1%.

STEP CLIMBS

There is an optimum altitude to fly a plane, based on its weight. As the weight of the plane changes, so does its optimum altitude. Therefore, as fuel burns during cruise, the optimum altitude increases. In addition, as fuel burns off, the airplane's tendency is to climb.

Typically, airlines are not allowed to do a climbing cruise, i.e. allow the airplane to slowly climb as fuel burns off. Rather they must fly at specified altitudes. For this reason, a step climb procedure is used.

The object is to climb as high as feasible after takeoff to reach an altitude, where fuel consumption is minimal (optimum altitude). Under normal circumstances, 4000 foot step-climbs are utilized to save fuel over long distance flights.

The normal procedure to accomplish this is to first climb to an altitude, which is slightly above (1000 to 2000 feet) the optimum altitude at takeoff. Then maintain this cruising altitude, until the optimum altitude has drifted upwards to an altitude approximately 2000 feet above your present altitude. This process takes approximately 3 hours (required time to burn off the necessary fuel weight).

The aircraft is then climbed 4000 feet, to again be higher than the optimum altitude (this procedure is known as bracketing). This allows the aircraft to straddle the optimum altitude, while minimizing the number of en-route step climbs (burn per step-climb is approximately 1200 KG of fuel).

If the step-climb altitude cannot be sustained for at least 200 nm prior to the top of descent point, the fuel benefits are negated.

Following the above procedure will save approximately 5-10% fuel, when compared to flying at one constant altitude over the entire trip.

DESCENT

Time, fuel and distance for descent are shown for four descent speed schedules. This data includes the effect of a speed restriction of 250 KIAS or minimum speed to maintain control below 10 000 feet and includes a straight-in approach with gear down and landing flaps 30 at the outer marker. Add additional fuel for flaps down maneuvering at the rate of 90 KG per minute. Add additional fuel for flaps and gear down maneuvering at the rate of 295 KG per minute.

MISSED APPROACH

Approximately 635 KG of fuel is burned during the missed approach maneuver, based on applying go-around power from the landing configuration, retracting the flaps and gear while climbing to 1500 feet then accelerating to 250 KIAS or minimum controllable speed.

SIMPLIFIED FLIGHT PLANNING .86 MACH CRUISE

The Simplified Flight Planning (SFP) charts are provided to determine the trip fuel and time from brake release to touchdown, when a computer generated flight plan is unavailable. The data is based on a flight profile of 340 KIAS/.84 Mach climb, .86 Mach cruise speed, and .84 Mach/290/250 KIAS descent. Burn is based upon a 4000 feet step climb procedure, maintaining an altitude within 2000 feet of the optimum.

Air distance = ground distance multiplied by the ratio $\text{Average TAS}/(\text{Average TAS} + \text{Wind Component})$, where headwind and tailwind are negative and positive respectively. Average TAS (True Airspeed, knots) can be obtained from the .86 Mach cruise tables in the performance section.

To determine trip fuel and time enter the chart with the air distance for the trip. Air distance is the ground distance corrected for anticipated enroute wind component. Trip fuel is listed below the reference landing weight (planned

landing weight at destination). Trip time is read from the column alongside the air distance.

Example:

Ground Distance = 4500 nm

Average TAS = 500 knots

Wind Component = 50 knots headwind

Air Distance = 5000 nm

Planned Landing Weight = 230 000 KG

Trip Fuel = 102 000 KG

Trip Time = 10 hrs 23 minutes

OPTIMUM ALTITUDE AND SHORT DISTANCE CRUISE ALTITUDE

The optimum altitude for best fuel mileage is presented for LRC or .86 Mach speed schedules at various cruise weights. The fuel mileage penalty for operating off-optimum altitude is listed under the Altitude Selection section.

The distance to perform a climb and descent may limit the short distance operation. The short distance chart shows the highest altitude at which the level cruise portion of flight is at least one minute.

HOLDING PLANNING

The table provides total fuel flow information for determining holding and reserve fuel requirements. The chart is based on the optimum hold speed schedule. At or below 15 000 feet the flaps up optimum hold speed is based on $V_{ref30} +$ speed increment which provides a minimum margin of 40° of bank to stick shaker. At 20 000 feet and above, the optimum speed corresponds to the minimum drag speed restricted to .83 Mach. The best holding speed for Flaps 1 configuration is $V_{ref30} + 60$ knots at all weights.

The total hourly fuel flow is based on a racetrack pattern. For holding in straight and level flight, reduce table values by 5%.

SIMPLIFIED ALTERNATE FLIGHT PLANNING AT LRC

The alternate chart includes fuel burn and time for a missed approach, climb to cruise, cruise at LRC, descent and a straight-in approach to touchdown.

The data is based on a flight profile of 340 KIAS/.84 Mach climb, LRC cruise speed, and .84 Mach/290/250 KIAS descent. Burn is based on the Short Distance Cruise Altitude chart for trip distances up to 400 nm air distance. For longer trips use the Simplified Flight Planning .86 Mach Cruise charts.

Air distance = ground distance multiplied by the ratio: $\text{Average TAS} / (\text{Average TAS} + \text{Wind Component})$, where headwind and tailwind are negative and positive

respectively. Average TAS (True Airspeed, knots) can be obtained from the chart, from the column alongside Cruise FL.

To determine trip fuel and time enter the chart with the air distance for the trip. Air distance is the ground distance corrected for anticipated enroute wind component. Trip fuel is listed below the reference landing weight (planned landing weight at alternate). Trip time is read from the column alongside the air distance.

Example:

Ground Distance = 300 nm

Average TAS = 383 knots

Wind Component = 25 knots tailwind

Air Distance = 282 nm

Planned Landing Weight @ Alternate = 220 000 KG

Alternate Fuel* = 6 600 KG

Time = 46 minutes

Short Distance Cruise Altitude = FL350

*Also referred to as Diversion Fuel.

BASIC FLIGHT PLANNING

Regulations require that flight planning take into account both meteorological conditions and any delays that are expected in flight. The flight must carry sufficient fuel and oil to ensure a safe completion; in addition, reserve fuel shall be carried to provide for contingencies.

TAXI FUEL - Normal fuel allowances for engine start and taxi out including APU use. When statistical taxi times are unavailable, default values may be used (1000 KG). Additional taxi fuel should be loaded for known delays.

TRIP FUEL - Fuel required from start of takeoff, through climb, cruise, descent and approach to touchdown at destination assuming departure on the departure procedure from the most used runway and arrival on the longest likely approach. This data is obtained from the SFP .86 Mach cruise chart. Note: effects of temperature deviation on trip fuel are negligible.

ALTERNATE FUEL - Fuel to execute a missed approach at the planned destination; thereafter, to divert to the alternate airport, execute an approach and landing. The alternate is normally the nearest suitable alternate. In addition, certain International operators add a 5% contingency amount to the Alternate Fuel. The simplified flight planning chart does not include the 5% adjustment.

RESERVE FUEL - The minimum fuel remaining in the tanks at normal landing weight. This amount is calculated at 30 minutes holding fuel at 1500 feet flaps

up at the average holding weight above the alternate airport. A requirement to include a possible unusable fuel amount, may require a 20% increase in reserve fuel. A default reserve value of 4200 KG can be used for manual flight planning purposes.

CONTINGENCY FUEL - An additional amount of fuel to provide for the increased consumption on the occurrence of any potential contingencies, including errors in forecast wind/temperature, as well as ATC restrictions on Flight Level, route, and speed schedule.

The contingency fuel amount is the greater of:
5% of trip fuel or 15 minutes of holding fuel at 1500 feet flaps up at the planned landing weight at the destination.

If en-route alternates are available the contingency amount is the greater of:
3% of trip fuel or 15 minutes of holding fuel at 1500 feet flaps up at the planned landing weight at the destination, or 5% of trip fuel required from abeam/overhead an en-route alternate to the destination.

The normal contingency fuel ranges from a minimum of 2100 KG to a maximum of 4500 KG.

ISLAND RESERVE - If operating to an isolated destination airport, which requires an island reserve fuel, alternate and reserve fuel are replaced by a holding reserve calculated at 2 hours fuel at normal cruise fuel consumption at FL350. Default reserve value of 19 500 KG can be used for manual flight planning.

EXTRA FUEL - Fuel carried in addition to required fuel is known as extra fuel. Extra fuel may be carried for operational or economic reasons. Typical extra fuel is carried for possible destination holding or economic fuel tankering.

The following is an example of the steps used to determine the proper fuel loading using the flight planning charts and allowances (in the event a computer flight plan is unavailable).

Example:

Departure = WSSS (Singapore)

Destination = YSSY (Sydney)

Alternate = YMML (Melbourne)

Dry Operating Weight = 180 000 KG

Payload = 40 000 KG

Zero Fuel Weight = 220 000 KG

1. Add the Reserve Fuel to the Zero Fuel Weight (ZFW), to determine the planned landing weight at the alternate airport. Reserve Fuel = 4200 KG (based on 30 minute hold at 1500 feet)

2. Planned landing weight at the alternate is 224 200 KG. Determine the required alternate fuel to divert from YSSY to YMML using the simplified alternate flight planning chart.

Ground Distance (YSSY to YMML) = 385 nm
Alternate Route = YSSY WOL1 WOL Q38 TAREX LIZZY3 YMML
Average TAS = 406 knots
Wind Component = 10 knots tailwind
Air Distance = 376 nm
Planned Landing Weight @ Alternate = 224 200 KG
Alternate Burn = 8200 KG
5% Alternate Contingency = 410 KG
Alternate Fuel = 8610 KG
Air Time = 56 minutes
Short Distance Cruise Altitude = FL370

3. Add the alternate fuel (8610 KG) to the planned landing weight at the alternate (224 200 KG) to derive the planned landing weight at the destination.

4. Determine the trip fuel using the simplified flight planning chart and calculate the required contingency fuel.

Departure = WSSS (Singapore)
Destination = YSSY (Sydney)
Alternate = YMML (Melbourne)
Route = WSSS TAN2A TI A576 PKS H204 BIK RIVET2 YSSY
Ground Distance (WSSS to YSSY) = 3429 nm
Average TAS = 496 knots
Wind Component = 30 knots headwind
Air Distance = 3650 nm
Planned Landing Weight @ Destination = 232 810 KG
Trip Fuel Burn = 73 200 KG
Contingency = 3660 KG (5% of Trip Fuel)
Air Time = 7 hrs 40 minutes

The total required fuel should include taxi fuel, trip fuel, alternate fuel, reserve fuel, and contingency fuel. Island reserve fuel should be used when applicable.

Taxi Fuel = 1000 KG
Trip Fuel = 73 200 KG
Alternate Fuel = 8610 KG
Reserve Fuel = 4200 KG

Contingency Fuel = 3660 KG
Total Tank Fuel = 90 670 KG

AIRCRAFT PERFORMANCE SECTION

PS1 744 TAKEOFF DATA

The takeoff performance tables represent the maximum brake release weight, accounting for field length, maximum tire speed, and brake energy limits. The second segment climb limit weight is listed in the right column. The actual takeoff weight must not exceed the brake release weight, the climb limit weight, or the maximum structural takeoff weight. The lowest value is the maximum allowable takeoff weight.

Performance adjustments are listed in rows below the main data. Corrections for per knot of headwind (HW) and tailwind (TW), air-conditioning pack operation, and anti-ice systems are available.

The tables cover runway lengths from 2200 meters to 4100 meters with temperatures ranging from 0°C to 50°C. All data is based on a maximum thrust.

The maximum weights are presented for Flaps 20, the most utilized setting. The performance is based on a takeoff with all air-conditioning packs on and engine anti-ice off. The data was based on a 0% slope runway and a pressure altitude of 400 feet MSL. Corrections for elevations above or below are available. The maximum pressure altitude for this data is 1000 feet MSL. For operations above or below these values consult airline performance engineering.

REDUCED THRUST TAKEOFF (ASSUMED TEMPERATURE)

As the ambient takeoff temperature increases, the allowable takeoff weight decreases. If the actual takeoff weight is less than the maximum allowable takeoff weight, you may be able to use the assumed temperature method to reduce takeoff thrust. The assumed temperature method uses the maximum temperature that meets all the takeoff performance requirements at the expected takeoff weight for the planned departure runway. The assumed temperature method is conservative. This is because of the effect of temperature on true airspeed and on engine thrust.

Most takeoffs are performed at weights below the maximum brake release weight. In such circumstance, maximum takeoff thrust may not be required. It is preferred when conditions permit, to perform a reduced thrust takeoff, which reduces engine fatigue and prolongs engine life. This procedure is accomplished by entering an assumed (SEL) temperature above actual OAT (Outside Air Temperature) into the FMC thrust limit page. The result is the thrust commands

a lower %N1 setting, thus reducing takeoff thrust. The key is to determine the SEL assumed temperature to provide for a safe and efficient takeoff.

Begin with the planned takeoff weight for the flight, add a weight buffer of 10 000 KG, include any required performance or altitude adjustments. Enter the PS1 744 takeoff data chart with the takeoff runway length and climb limit, follow down the column until the revised planned takeoff weight (including 10 000 KG pad) is found (if exact number not present round numbers up to next higher weight). Compare the runway limit and climb limit, using the lower value. Move across the row to the OAT column to determine the SEL assumed temperature setting. This number is then entered into the FMC thrust limit page.

Example 1:

Planned Takeoff Weight = 360 000 KG (370 000 KG with pad)

Flaps = 20

A/C Packs = ON

Pressure Altitude = 400 feet

Runway Slope = 0%

Runway Length = 4000 meters

Wind = NIL

OAT = 20°C

Assumed Temperature = 48°C

Example 2:

Planned Takeoff Weight = 300 000 KG (310 000 KG with pad)

Flaps = 20

A/C Packs = ON

Pressure Altitude = 0 feet

Runway Slope = 0%

Runway Length = 2600 meters

Wind = NIL

OAT = 32°C

Assumed Temperature = 48°C

Maximum assumed temperature is dependent on: airport elevation, runway conditions, flap position, and wind.

Reduce thrust takeoffs should not be performed when runways are contaminated with standing water, ice, slush, snow, or when windshear is possible.

ALTITUDE/MANEUVER CAPABILITY

The maximum altitude that an airplane can fly is limited by either the thrust of the engines (altitude capability) or by the ability of the wing to generate enough buffet-free lift (maneuver capability).

Cruise weights are shown for a given altitude and maneuver capability. This table takes into account the most limiting of either speed buffet limits or thrust limits. Any data which is thrust limited is denoted by an asterisk and represents a thrust limited condition with 100 ft/min residual rate of climb. Flying above these altitudes with banks in excess of 15 degrees may cause the airplane to lose speed and/or altitude.

The optimum altitude, shown in the tables result in buffet related maneuver margins of 1.5 g (48° bank) or more.

The "g" margin is expressed in terms of level flight bank angle that corresponds to the given "g" loading. For example, an airplane flying in a 44 degree bank while maintaining a level flight altitude will generate a loading of 1.3 g.

While operating in areas of moderate or severe turbulence, it is suggested that operations be limited to within 1.5 g limits.

ENROUTE CLIMB 340 KIAS/ .84 MACH

Climb distance, time, and fuel data is tabulated from brake release to altitude for a climb schedule of 340 KIAS/ .84 Mach, which approximates economy climb. Data is shown at ISA (International Standard Atmosphere = at sea level, temperature 15°C and pressure 1013 millibars) and below, ISA + 10°C, and ISA + 20°C. No distance allowances from brake release to 1500 feet are included in the climb tables.

A fuel adjustment should be made for high field elevations, as shown on the bottom section of the climb table. Climb performance is based upon maximum climb thrust.

WIND-ALTITUDE TRADE

Wind is a factor which may justify operations considerably below optimum altitude. For example, a favorable wind component may have a percentage effect on ground speed which more than compensates for the range loss. Using the trade tables, it is possible to determine the break-even wind to maintain the same range at another altitude.

The tables make no allowance for climb or descent time, fuel or distance, and are based on comparing ground fuel mileage.

.86 MACH CRUISE

Cruise tables are provided for .86 Mach speed schedules with all engines operating assuming normal engine bleed for air conditioning. The primary purpose of the cruise tables is to establish a target %N1 thrust setting for the .86 Mach speed schedule.

Explanation of data blocks:

ISA %N1 REQUIRED -

Target ISA %N1 required per engine for the given aircraft weight and pressure altitude.

MAX TAT FOR THRUST RATING -

Highest TAT (Total Air Temperature) at which %N1 can be set without exceeding maximum cruise thrust limits. If actual TAT exceeds limits, it will be necessary to either descend to a lower altitude where the speed schedule can be maintained or to select a slower cruise speed at the same pressure altitude.

ISA FUEL FLOW PER ENGINE -

The fuel flow shown is the average fuel burn per engine in ISA conditions.

Planned fuel burn can increase due to:

- Temperature above ISA.
- Lower cruise altitude than planned.
- More than 2000 feet above/below optimum altitude.
- Speed faster than planned or appreciably slower than LRC, if planned at LRC.
- Stronger headwind components.
- Unbalanced fuel.
- Improperly trimmed airplane.
- Excessive thrust lever adjustments.

LRC CRUISE MACH SCHEDULE

Cruise speed tables are provided for LRC schedules with all engines operating, one engine inoperative and two engines inoperative. The primary purpose of the LRC tables is to establish a target speed for LRC with the FMC unusable.

One engine inoperative tables are predicated on the use of maximum continuous thrust limits. Two engine inoperative tables are predicated on maximum continuous thrust and one air conditioning pack on.

ENROUTE HOLDING

%N1, IAS, and fuel flow is tabulated for holding flaps up based on the speeds outlined in the Holding Planning section.

The fuel flow is based on a racetrack pattern. For holding in straight and level flight, reduce table values by 5%.

DESCENT

Time, fuel and distance for descent are shown for a .84 Mach/290/250 KIAS speed schedule. This schedule corresponds with recommended turbulence air penetration speed and approximates economy descent. This data includes the effect of a FAA speed restriction of 250 KIAS below 10,000 feet. Allowances are included for a straight-in approach with gear down and landing flaps 30 at the outer marker.

Other descent speed schedules are provided for special user requirements.

PS1 744 LANDING DATA

The landing performance tables are provided for determining the maximum landing weight, limited by field length or climb requirements for Flaps 25 and 30.

The actual landing weight must not exceed the charted maximum landing weight or the maximum structural landing weight. The maximum OAT temperature limit must also not be exceeded during landing as this ensures approach and landing climb requirements.

Performance adjustments are listed in columns, right of the main data. Corrections for per knot of headwind (HW) and tailwind (TW) are available.

Flaps 25, is the typical landing setting when runway length and contamination are not a factor, as it provides a low drag, low fuel approach. The performance is based on a landing with all air-conditioning packs on, engine anti-ice off, and anti-skid operative.

The tables cover runway lengths from 2000 meters to 4000 meters with pressure altitude ranging from sea level to 5,000 feet. For operations above or below these values consult airline performance engineering.

VREF landing speeds are provided for Flaps 25 and 30 in the event of an FMC failure.

FLIGHT WITH UNRELIABLE AIRSPEED/ MACH INDICATION (FLIGHT WITHOUT RADOME)

Body Attitude and %N1 required information is provided in the event of unreliable Airspeed/Mach indications resulting from blocking or freezing of the pitot system. Loss of radome may also cause unreliable airspeed/Mach indications.

Speed information is based on recommended turbulent air penetration speed schedule of 290 KIAS/.84M.