



OPERATING PROCEDURES

B747-400



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AIRCRAFT SPECIFICATIONS



AIRCRAFT SPECIFICATIONS

1.1 SEATINGS

747-400	416 passengers
747-400 Domestic	568 passengers
747-400 Combi	266 passengers plus 7 pallets
747-400 Freighter	---- passengers

Configurations: seating ranges from four- to ten-abreast with two aisles



1.2 WEIGHTS

MAXIMUM TAKEOFF WEIGHT

	BASIC	HGW
747-400	800.000 pounds (362.880 kg)	875.000 pounds (396.900 kg)
747-400 Domestic	600.000 pounds (272.000 kg)	600.000 pounds (272.000 kg)
747-400 Combi	800.000 pounds (362.880 kg)	875.000 pounds (396.900 kg)
747-400 Freighter	800.000 pounds (362.880 kg)	875.000 pounds (396.900 kg)



1.3 AIRCRAFT DIMENSIONS

Length 231 feet 10 inches (70.7m)

Wingspan

747-400/Combi/Freighter	211 feet 4 inches (64.4m)
747-400 Domestic	195 feet 8 inches (59.6m)

Tail height 63 feet 8 inches (19.4m) all models

1.4 NUMBER OF PARTS

Approximate 6 million parts.

1.5 PROGRAM KEY DATES

The FAA certified today's version of the 747-400 on 10 Jan, 1989. NWA puts the plane into service 30 days later. However the first 747 type rolls out of factory at Sept. 30 1968. On Sept. 10, 1993 the 1000th Boeing 747-400 rolls out of the factory.

1.6 WEIGHTS, RANGES, ENGINES, FUEL CAPACITY, SPEED & ALTITUDE

ZERO FUEL WEIGHT

747-400	493.900 pounds (224.500 kg)
747-400 Domestic	000.000 pounds (000.000 kg) unk
747-400 Combi	493.900 pounds (224.500 kg)
747-400 Freighter	493.900 pounds (224.580 kg)

**MINIMUM LANDING WEIGHT**

747-400	561.067 pounds (254.500 kg)
747-400 Domestic	000.000 pounds (000.000 kg) unk
747-400 Combi	561.067 pounds (254.500 kg)
747-400 Freighter	561.067 pounds (254.500 kg)

MAXIMUM LANDING WEIGHT

747-400	651.895 pounds (295.700 kg)
747-400 Domestic	000.000 pounds (000.000 kg) unk
747-400 Combi	651.895 pounds (295.700 kg)
747-400 Freighter	651.895 pounds (295.700 kg)

RANGE

747-400	7,335 nautical miles, 13,950 kilometers
747-400 Domestic	1,805 nautical miles, 3,360 kilometers
747-400 Combi	7,195 nautical miles, 13,385 kilometers
747-Freighter	4,450 nautical miles, 8,280 kilometers

THRUST

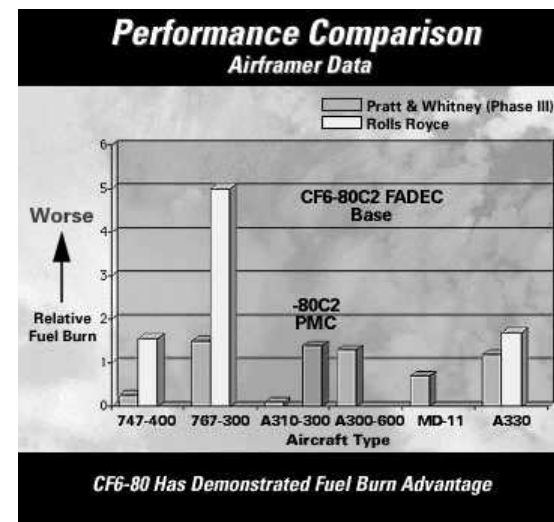
Pratt & Whitney 4000 56,000- to 62,000 pounds



Rolls-Royce RB211-524 56,000- to 62,000 pounds



General Electric CF6-80C2 56,000- to 62,000 pounds

**FUEL CAPACITY**

57,285 U.S. gallons (216,820 Liters) maximum capacity.
45,521 U.S. gallons (172,300 Liters) normal capacity.

CRUISE SPEED

Mach 0.85 (522 mph, 910 km/h)
Maximum Operating speed of 365 knots IAS at MSL.
Maximum Operating speed of Mach .92 at altitude.

ALTITUDE CAPABILITY

34,700 feet (10,580 m)- all versions
40,000 feet maximum capability



FLIGHT OPERATION PROCEDURES



FLIGHT PROCEDURES

2.1 INITIAL COCKPIT PREPARATIONS

1. Set aircraft exterior lighting
2. Check that Landing Gear lever is down
3. Check that the overhead panel is functional
4. Enter FMC Route Data
5. Verify the RTE and LEGS page
6. Verify the Takeoff REF page
7. Verify PERF INIT page
8. Verify the route entries

2.2 COCKPIT PREPARATIONS

1. Make Sure that Landing Lights are turned off
2. Taxi and strobe lights must be turned off too
3. Turn Fuel pump switches off
4. Set the EFIS control panel
5. F/D switches must be turned on
6. Autopilot switches must be turned off
7. Set the IAS/ MACH Selector
8. Set the altitude Selector
9. Check and set the clock
10. Check the standby instruments
11. Check the GPS
12. Autobrake selector is RTO
13. Set the Parking Brake
14. Make sure that the speed brake lever is up
15. The Yaw Damper must be off



16. The throttles must be closed
17. The reverse thrust levers must be down
18. Check the flap lever
19. Set the transponder
20. Get ATIS information

2.3 FINAL COCKPIT PREPARATIONS

1. Verify the Fuel sheet
2. Get clearance from ATC
3. Review and set the takeoff data
4. Set the IAS/MACH selector
5. Set the heading selector
6. Set the Altitude selector
7. Complete the departure briefing
8. Turn Pitot Heat on

2.4 PUSHBACK PROCEDURES

1. Doors must be closed
2. The cabin must have been prepared
3. Pushback clearance must be obtained

2.5 ENGINE START PREPARATIONS

1. Turn beacon switch on
2. Turn fuel pumps on
3. Turn strobes on

NOTE: Turn beacon switch on



2.6 ENGINE START

1. Display secondary engine indications
2. Start ignition selectors
3. Run the Fuel Control Switches
4. Monitor the engine indications
5. Turn anti-ice switches on after engine start
6. Get clearance for taxi

2.7 TAXI

1. Set the flaps
2. Check Flight Controls
3. Confirm Takeoff Performance
4. Set stabiliser trim
5. Display LEGS page
6. Complete cabin notification
7. Turn transponder on
8. Arm Autopilot switches needed

2.8 TAKEOFF

1. Receive takeoff clearance
2. Turn landing lights on
3. Parking brake must be released
4. Apply Thrust (see guidance)

**2.9 AFTER TAKEOFF**

1. Engage Autopilot (see guidance)
2. Retract flaps and landing gear (see guidance)
3. Monitor thrust
4. Turn yaw damper on

2.10 CLIMB

1. Set altitude
2. Set altimeters
3. Turn landing lights off at 6, 000 feet

2.11 CRUISE

1. Monitor Cruise Thrust
2. Monitor Flight Progress
3. Monitor Fuel Management

2.12 DESCENT AND APPROACH

1. Get ATIS information
2. Enter Arrival Entries
3. Complete Legs Page
4. Accomplish approach and landing briefing
5. Autobrake switch is as required
6. Turn Landing Lights on at 6,000 feet
7. Set the altimeters

**2.13 FINAL APPROACH**

1. Check Flight instruments
2. Extend flaps as required
3. Lower landing gear
4. Speed brake lever must be armed
5. Turn yaw damper off

2.14 TAXI AND PARKING

1. Turn Landing lights off
2. Disengage Autopilot
3. Speed brake lever must be down
4. Turn strobe lights off
5. Turn Autobrake selector off
6. Retract flaps
7. Set transponder on standby
8. Once in parking spot, set parking brakes
9. Cut off Fuel Control Switches
10. Turn Fuel Pump Switches off
11. Turn exterior lights off
12. Turn Pitot Heat off

NOTE: Remember to set parking brakes

747-400	6,025 cubic feet (170.8 m3)
747-400 Domestic	6,025 cubic feet (170.8 m3)
747-400 Combi	8,950 cubic feet (253.4 m3)
747-400 Freighter	27,470 cubic feet (693 m3)

Cargo capacity of maximum 113,590 kg's.



OPERATIONS AND GUIDANCE



OPERATIONS & GUIDANCE

3.1 TAXI ONTO RUNWAY

Taxi to runway **ONLY** after positive clearance from tower. Checklists must be completed, and the preflight briefing can be performed now.

Monitor constantly the engine readout's.

TYPICAL THRUST N1 FOR TAXI AT VARIOUS WEIGHTS

20% N1 at takeoff weight 600.000 pounds (272.000 kg)

25% N1 at takeoff weight 800.000 pounds (362.880 kg)

30% N1 at takeoff weight 875.000 pounds (396.900 kg)

Note that barometric pressure, icing and overall weather conditions have influence on the exact setting. Do not exceed thrust above settings to prevent nose-wheel slipping at turns or loss of control. Brake if necessarily before turning. Do not use thrust-reversers for braking due the possibility of ingestion foreign bodies into engine inlet and causing fan damage.

Maximum taxi-speed is 25 knots.



3.2 TAKEOFF

Before entering the runway a positive clearance must be obtained from tower/departure.

Line-up exactly on the center of the runway, unless a strong cross-wind (greater than 15 knots) is active.

In such case center offset into the direction of the cross-wind, to prevent drifting off course.

TYPICAL THRUST SETTINGS FOR NORMAL TAKEOFF

94% N1 at takeoff weight 600.000 pounds (272.000 kg)

96% N1 at takeoff weight 800.000 pounds (362.880 kg)

105% N1 at takeoff weight 875.000 pounds (396.900 kg)

Do not exceed setting of 105% N1 for longer then 10 minuts.

REQUIRED RUNWAY LENGHT FOR NORMAL TAKEOFF

At 20 C by 1013mb.

Max.-Takeoff Weight 11,500 feet at 875.000 pounds (396.900 kg)

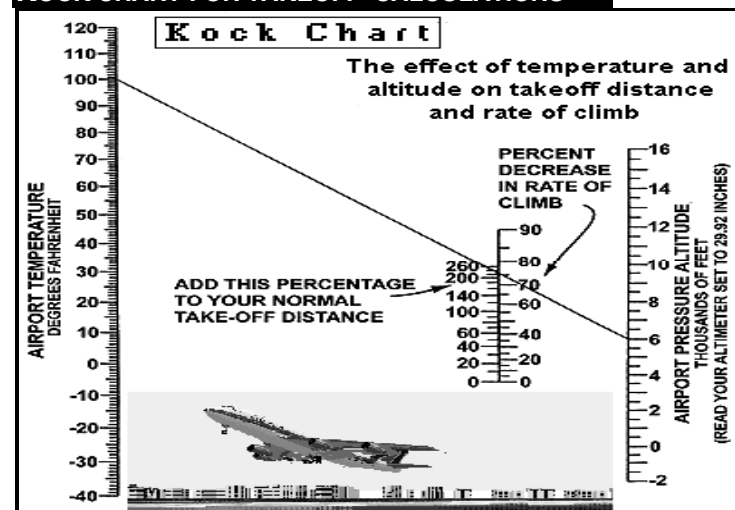
Normal Takeoff Weight 7200 feet at 800.000 pounds (362.880 kg)

Note that above length's are minimum required runways.
In snow and ice conditions MTOW length is 14,000 feet.
At MLW length is 6,500 feet minimums.

Note that thrust settings can differ due barometric variances, temperature, TAT and runway elevation.



KOCK CHART FOR TAKEOFF CALCULATIONS



REFERENCE SPEEDS

- V_1 Velocity 1, airplane can stop within runway length
- V_r Velocity Rotate, rotate aircraft to 10°-13° degrees
- V_2 Velocity 2, airplane cannot stop, MUST fly !
- V_{ref} Velocity Reference
- V_{zf} Velocity Zero Flaps
- V_{mc} Velocity Minimum Control Speed
- V_s Velocity Stall (clean)
- V_{so} Velocity Stall (landing configuration)

Note that speed will differ widely with different takeoff weights. Stall speeds can vary up to 45 knots IAS from MTOW to MLW.



VELOCITY OVERVIEW

	MTOW	MLW	NTOW	NLW	
V_1	151	136	149	133	
V_r	171	146	159	143	
V_2	181	166	179	163	
V_s	206	189	205	186	
V_{so}	158	141	157	138	
$V_{refFlp30}$	156	139	150	136	
$V_{refFlp20}$	166	149	160	146	
$V_{refFlp10}$	186	169	180	166	
$V_{refFlp5}$	198	179	190	176	
$V_{refFlpUP}$	236	219	230	216	
V_{mc}	256	239	250	236	

MTOW

Maximum Take Off Weight (396 m.t.)

MLW

Maximum Landing Weight (297,5 m.t.)

NTOW

Normal Take Off Weight* (380 m.t.)

NLW

Normal Landing Weight* (280 m.t.)

*(Normal situation and desired optimum performance weight situation. Weights are the BASIC weight as in specifications, and landing with approx. 30.000 kgs fuel and are from real aviation figures, and testing in flightsimulator. Figures can vary with models!)

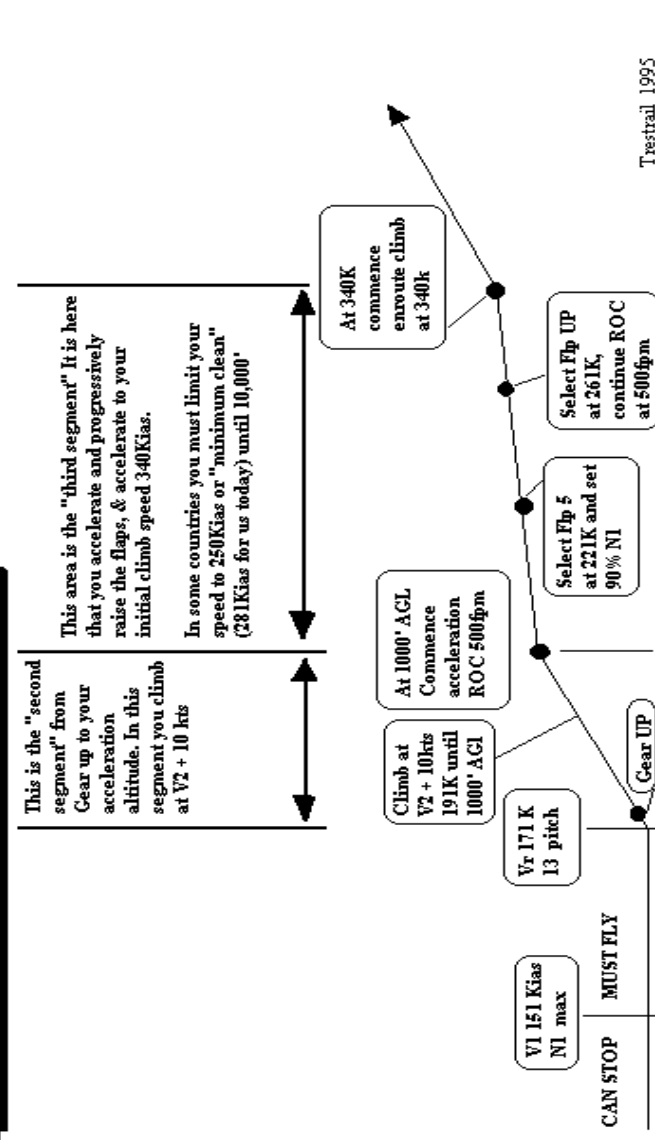
Normally we fly never slower than 130 % of the stall speed.
See appendix section 7.1 and 7.2 for detailed calculations on this subject.

Save operation is to maintain a minimum of $V_{ref} + 5$ knots at least.



747-438 Take Off Profile at MTOW 396,800 Kg

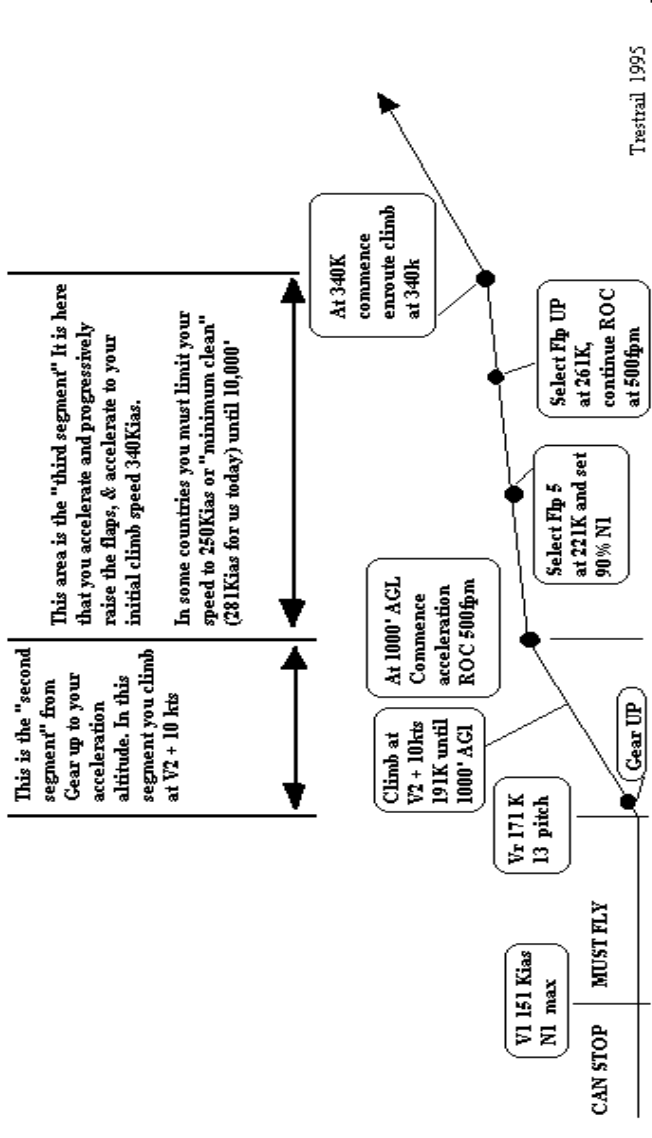
I have used 500 fpm in the 2nd and 3rd segments as a "rule of thumb" for F&F use. In the real aircraft the ROC will vary, in this segment the pilot usually flies a commanded pitch attitude and accepts the resultant acceleration and ROC



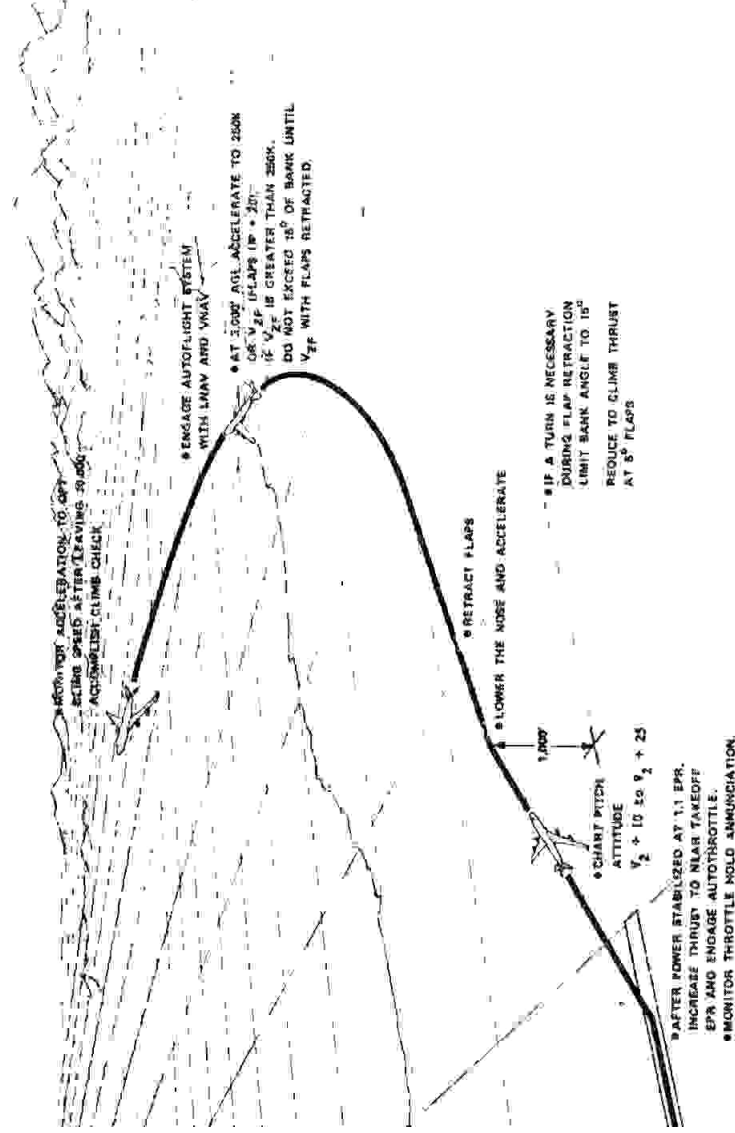


747-438 Take Off Profile at MTOW 396,800 Kg

I have used 500 fpm in the 2nd and 3rd segments as a "rule of thumb" for FSS use. In the real aircraft the ROC will vary, in this segment the pilot usually flies a commanded pitch attitude and accepts the resultant acceleration and ROC



NORMAL TAKEOFF





3.3 CLIMB (STEPCLIMB)

CLIMBING TO INITIAL CRUISE LEVEL

The VS (vertical-speed) depends of the different weights at take-off, weather conditions and noise abatement procedures.

Use the step climb procedure for climbing to cruise level.

After take off at 1000 feet level off and accelerate to 200 knots IAS.

At accelerated speed start climbing to 3000 feet and level off. Accelerate to 250 knots IAS or V_{zi} (Flaps UP+20)

Start climbing to 10.000 feet at 250 knots IAS maximum, there after climb with 330 knots IAS maximum until 31,000 feet is reached.(Then switch to mach 0.82)

TYPICAL THRUST SETTINGS

Until 1000 feet, maintain takeoff thrust setting

Until 3000 feet, reduce thrust to 96% N1 if was higher

Until 10000 feet, reduce thrust to 90% N1 if was higher

See also climb schedule figure.



3.4 CRUISE

Depending on the weight and fuel start normal cruise level on 31.000 feet MSL.

Accelerate to economic cruise speed of 0.85 Mach. Do not exceed speed.

Typical thrust setting is around 90% N1 for cruising.

After fuel burn, indicated with a higher speed or reduced N1 readout start climbing to level 35.000 feet.

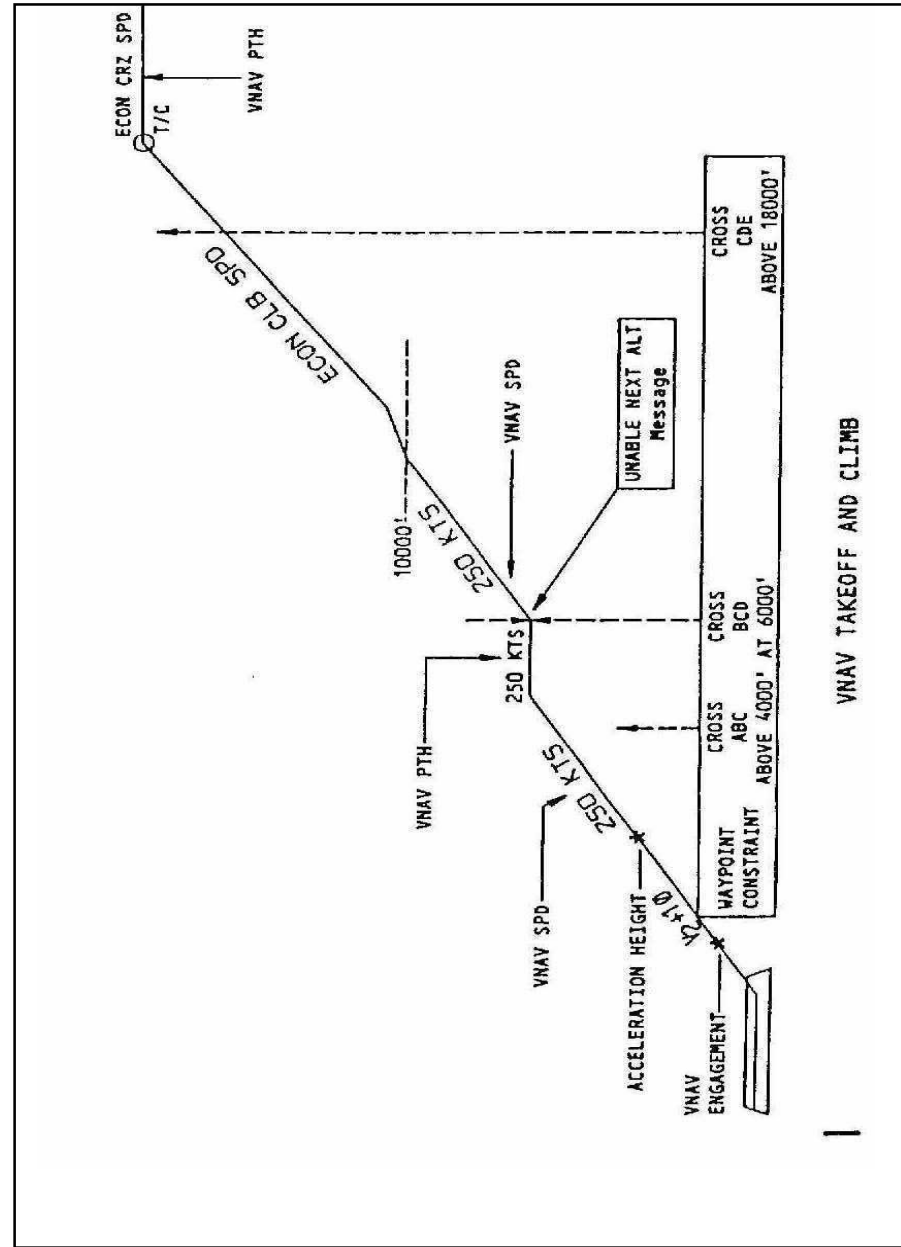
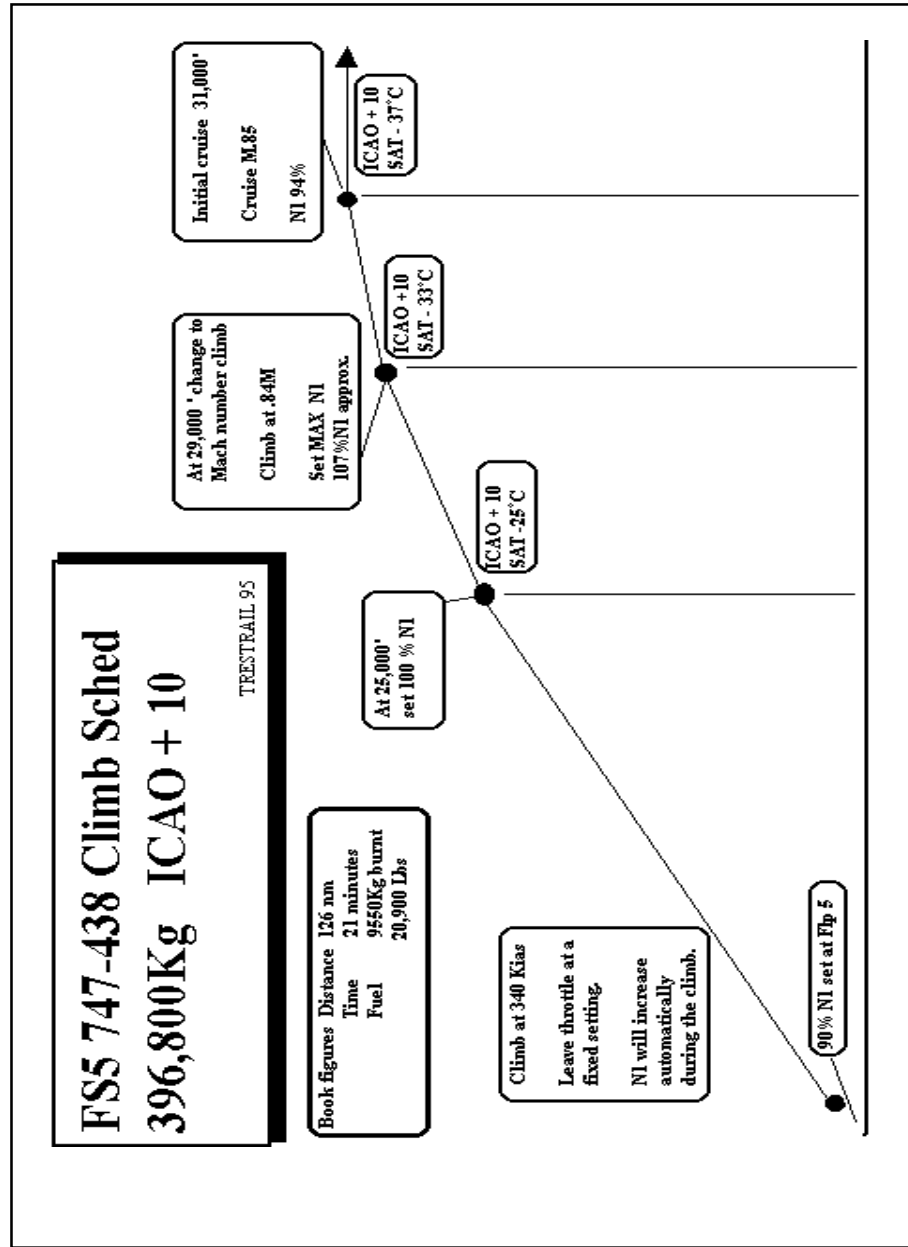
After level off at this altitude repeat above and go to final cruise level of 38.000 feet.

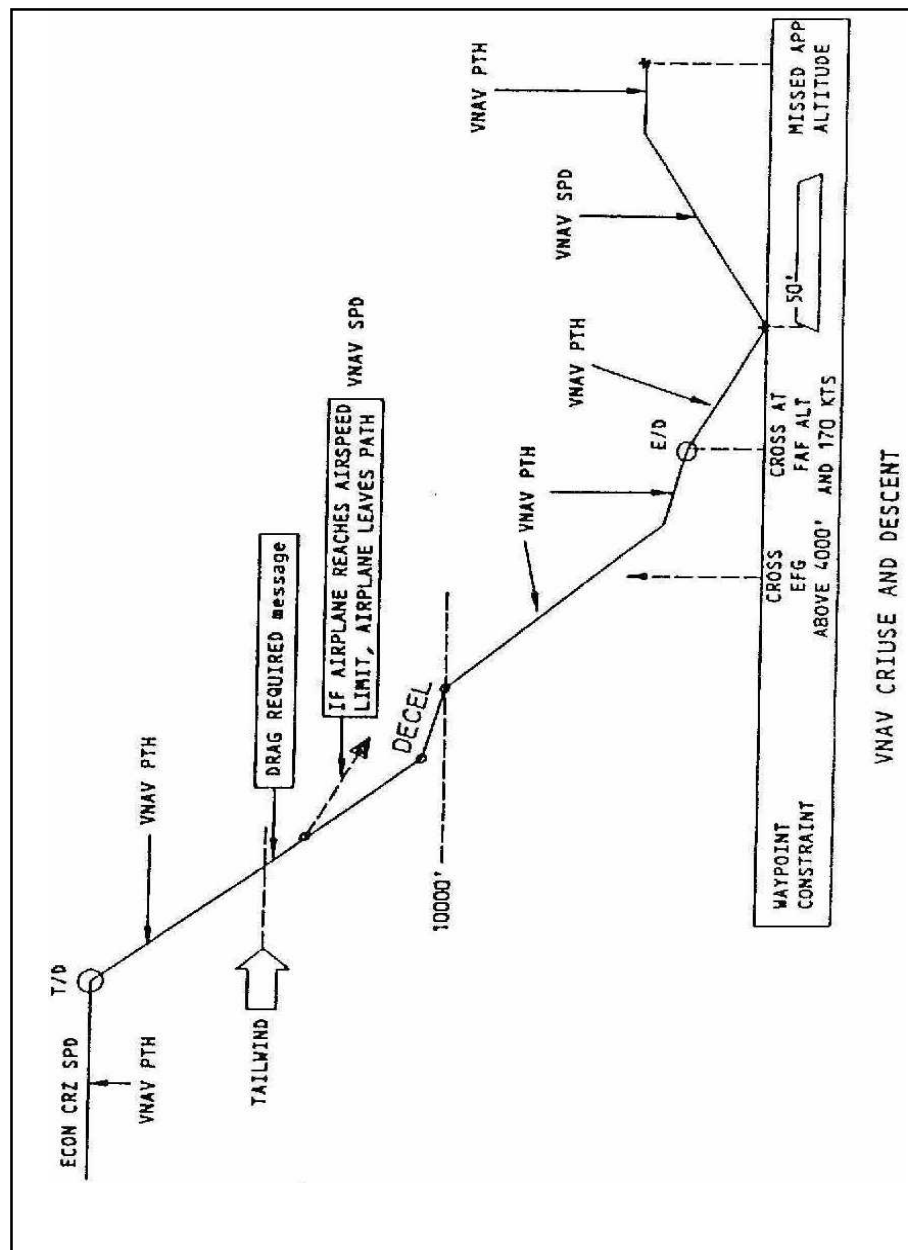
Monitor engine and fuel readouts constantly.

Do not exceed econ. -cruise speed of 0.85 Mach.

Set altimeter to 1013hPa/29.92inchHg passing through transition level (USA 18,000ft; NZ 11,000up/13,000dwn)

On the next page a MTOW climb schedule is given with enhanced figures for optimum performance. Notice higher speeds and higher thrust settings.





EMERGENCY PROCEDURES



EMERGENCY PROCEDURES

4.1 ENGINE OUT EMERGENCY

However engine out problems are rare, they can happen. Especially during the takeoff phase of flight constant monitoring of the engine read-outs is mandatory and a RTO (rejected take off) must be initiated if possible. Normally until V_1 is reached.

After that when V_2 is reached normal RTO and roll out until complete stop at the runway is not possible due to the heavy weight of the airplane at NTW.

The preflight briefing should include the taken action if an engine failure occurs.

OPERATIONS FOR ENGINE OUT

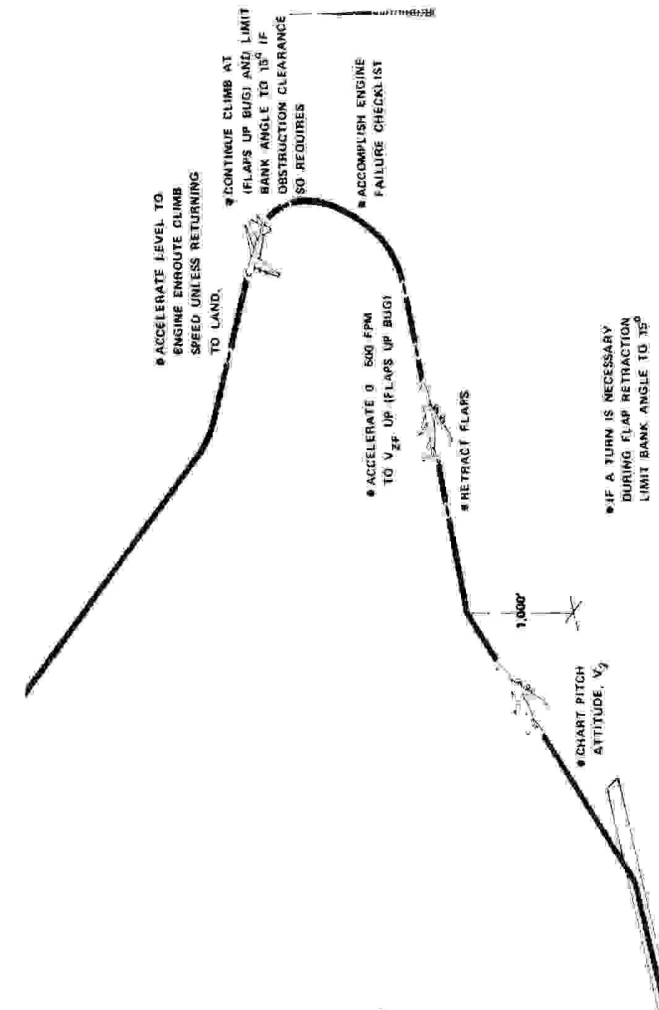
1. Maintain pitch and V_2 until 1000 feet AGL
2. Retract flaps. If turn is necessary limit bank angle to 15°
3. Accelerate to V_{zf} up with 0-500 VS
4. Accomplish engine failure checklist
5. Continue climb at normal flaps up height/speed
6. Accelerate level.

Procedure complies to multi engine failure.

Procedure for all engine failure on the following pages.



ENGINE FAILURE ON TAKEOFF



**ALL ENGINES OUT.**

Theoretically it is certainly possible to accomplish a landing after a prolonged glide in the 747, as long as the pilot was able to have ALL of the airspace to the airport for his own use. In other words, all other traffic would have to be cleared out of the area.

The 747 has a "range" of at least 120 nautical miles for "gliding" if the airplane is cruising at 39,000 feet. Using the Moving Map display function on the NAV Display use the "Fix" function and draw a 120 nautical mile "arc" around present position. Any adequately sized airport that fell within that "arc" would be fair game for a try ! Try to arrive at a 30 nautical mile point from the airport at an altitude no lower than 12000 feet, and at that time still have the airplane in a "clean" configuration with no flaps or gear extended.

If in fact all 4 engines were shut down due to fuel starvation the hydraulic engine driven pumps on each engine would still be serviceable for the extension of the trailing edge flaps and landing gear due to the engines windmilling from the forward airflow. However, the leading edge flaps that are normally extended with pneumatic power would not be useable. This would increase the approach speed by about 15 knots. There is a backup system for the leading edge flaps, but it is electrical in nature and there is doubt if the on battery(s) would have enough power for extension, and because of the much slower extension speeds of the leading edge flaps, it would be hard to "schedule" them into this exciting approach !!!

Fly over the Outer Marker at an altitude of at least 1500 feet above the normal target altitude over that beacon and from that point forward extend the remaining trailing edge flaps and lower the landing gear. Keep the Flight Spoilers as back up for any errors that become obvious from being too high on the approach. The key to the whole operation is to conserve the altitude and then bleed it off with the various drag devices.



The final backup is, if still too high would be to "slip" the airplane much as one does with a biplane. This is entirely possible in a 747 and it is done during an approach to JFK's Runway 13L after a Canarsie approach....an approach that rivals Hong Kong's infamous ILS for edge of the seat flying without any mountains in the way.

LANDING ON WATER

No one ever wants to try and ditch a 747 but it COULD be done. The recommended procedures always include the pilots determining the primary and secondary "swell" of the ocean surface. DISREGARD the wind caused smaller swell and to plan our heading for water contact in a parallel direction to the larger and primary swell. Slamming into a large wave swell at 130 knots is not going to be a good deal ! Landing parallel to it is better. It is recommended that the gear remain retract and use FULL flaps. It is suggested that to take the airplane down to ONE foot and hold her off as long as possible !!!

EMERGENCY DESCENT

Emergency descent from high altitude (e.g. 35,000 feet) in case of multi engine flameout, decompression or other hazardous situation must be completed within the aircraft specifications of maximum operation speed of 0.92 mach during the descend, gear extension limit of 270 knots or 0.82 mach. Try raise the nose first to lower airspeed after throttles to idle to speed limitations and deploy spoilers, extend gear and use full flaps for speed braking until a safe flight-level is obtained.

**STALL RECOVERY**

A stall occurs when a wing reaches its critical angle of attack. Regardless of load factor, airspeed, bank angle, or atmospheric conditions, a wing always stalls at the same critical angle of attack

There is only one way to recover from a stall—reduce the angle of attack. Apply forward pressure on the control yoke or stick to reduce the angle of attack, and add power to minimize loss of altitude.

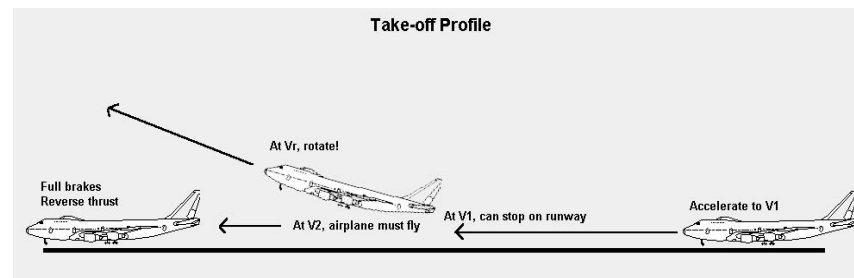
Stall recovery consists of recovery at:

- low altitude, low speed
add full thrust for later climb out
watch altitude, lower nose for about 5°
or below 1000 feet, level off and pray.
- high altitude, high speed
lower nose maximum
do not add thrust to prevent overspeed
choose a lower flight-level after recovery

**REJECTED TAKE-OFF**

In case the captain, or pilot flying (PF) decides to reject the takeoff the following procedure must be completed.

- only attempt to RTO when rolling at V_1 max until V_r after that the aircraft must fly!
- if autobrakes are set to RTO, the autobrake system will apply maximum braking when throttle is put to idle
- apply reverse thrust as needed
- extend spoilers to prevent lift

**GO-AROUND**

Go-Around will normally initiated after a missed approach. However some parameters must be carefully monitored when performing a Go-Around. First monitor the rate of climb and retract landing gear as soon as possible after a positive rate of climb, monitor thrust after using the TOGA switch. (autothrottles must be engaged for TOGA usage) Continue climb for normal takeoff procedure.

Limit bank angle to 15° .

Refer to normal-take-off chart in the take-off section.



FUEL USAGE & CALCULATIONS



FUEL USAGE

5.1 FUEL USAGE

AVERAGE FUEL FLOWS

<i>Pounds</i>	p/hr (4 eng)	p/hr (1 eng)
Taxi	8,000 lbs	2,000 lbs
Takeoff	60,000 lbs	15,000 lbs
Climb	36,000 lbs	9,000 lbs
Cruise	24,000 lbs	6,000 lbs
Descent	8,000 lbs	2,000 lbs

<i>Liters</i>	p/hr (4 eng)	p/hr (1 eng)
Taxi	2,100 lit	500 lit
Takeoff	15,800 lit	4,000 lit
Climb	9,500 lit	2,500 lit
Cruise	6,300 lit	1,500 lit
Descent	2,100 lit	500 lit

<i>Kilograms</i>	p/hr (4 eng)	p/hr (1 eng)
Taxi	1,500 kg	360 kg
Takeoff	11,400 kg	2,900 kg
Climb	6,800 kg	1,800 kg
Cruise	4,500 kg	1,100 kg
Descent	1,500 kg	360 kg

Note that cruise usage of fuel differ with aircraft weight, but can be estimated on average of 24,000 lbs per hour.



Note carefully that FS98 uses about 15% less than real 747's. Above averages are from real aircraft.

5.2 EXPLANATION CRUISE AVERAGE FUEL FLOW.

At the start of the flight at Flight Level 310 the engines would be using kerosine at about 7500 lbs a per engine. Towards the end of the flight while at Flight level 390 they may only be burning at the 4500 lbs setting, per engine.

A simple mental calculation from the flight plan to see if the computer provided fuel burn for the entire flight was correct is as follows:

Every time it will turn out that if, simply divided the total number of hours of the flight INTO the total number of pounds of fuel required that, will come up with 24,000 lbs per hour.

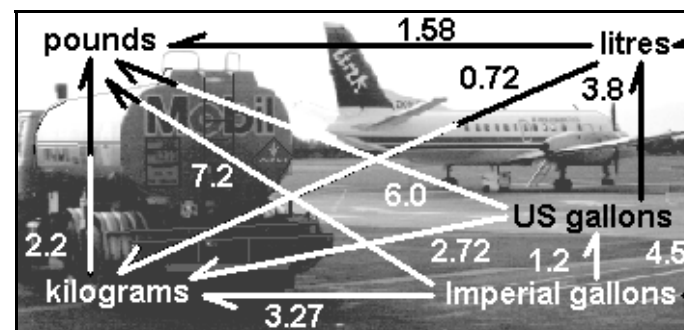
After taking off with over 338,000 lbs of fuel we will often land with less than 8% of the fuel remaining, somewhere in the 26 to 30,000 pound level.

Do not add additional fuel to the matrix on the page before, because FS98 uses about 15% fuel less than real aircraft. You can add reserves, but use chart below for those calculations.



Kilograms	p/hr (4 eng)	p/hr (1 eng)
Taxi	1,225 kg	306 kg
Takeoff	9,960 kg	2,490 kg
Climb	5,780 kg	1,445 kg
Cruise	3,825 kg	956 kg
Descent	1,225 kg	306 kg

Conversion for international used systems:





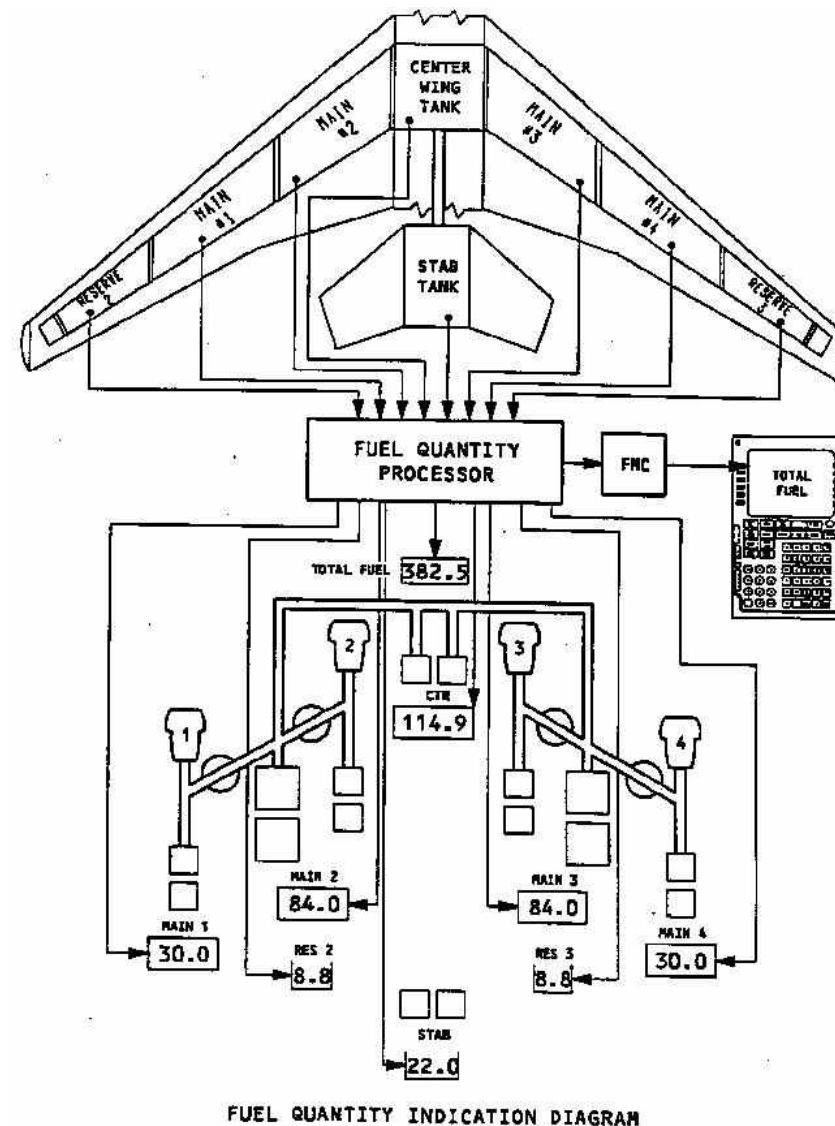
5.3 TRIP FUEL

PLANNING TRIP FUEL USAGE

Planning trip fuel must take in consideration the following events:

- Taxi and hold time at terminal pre departure of 1 hour (8,000 lbs p/hr)
- Initial cruise level cleared lower than requested of 1 hour at least.
- Headwinds during cruise
- Hold pattern at arrival terminal of ½ hour at low level (< 24,000 lbs p/hr)
- Alternate airport diversion for 250 nm (< 24,000 lbs p/hr)
- Missed approach during landing (10 min, 6,000lbs approximate)
- Taxi and hold time at terminal for ramp clearance of 1 hour (8,000 lbs p/hr)

All these events are, behold a few, difficult to anticipate, so an extra amount of fuel of 15 -20% is on the safe side.





ACKNOWLEDGEMENTS

6. Acknowledgements

This operation procedures manual for the 747-400 is only for flight-simulation purposes. No real aviation usage of this manual may be conducted. It seems very unlikely that someone does!. The information in this manual is gathered from various sources, even a real 747 pilot. The pictures are copyrighted, and may not be used without prior written notice from the publisher. The manual in it's whole is copyrighted as it is, it may be distributed freely, but no alterations may be done.

The author is completely aware of the fact that this manual is in no comparison with the real thing, but for flight-simulator purposes it looks enough. The real manual includes all operations procedures for electrical, hydraulic, pneumatic and other technical in depth topics. For flight-simulator these topics are not available.

The author thanks the following people for their cooperation on usage of material:

Capt'n Tarmack a retired 747 pilot, for the many in depth issues regarding flying the queen.

Wagner B Beskow, for usage of his graphics.

Juan Cabeza, for usage of his graphics.

And of course many creators of 747 flight models and the Boeing web-site for much information.



EDITORIAL NOTES

In case of the printed results of the takeoff, landing and engine out graphics are unreadable on your printer the following text is written in them, from left to right.

Normal Takeoff

- after power stabilized at 1.1 epr increase thrust to near takeoff epr and engage autothrottle, monitor throttle hold annunciator
- chart pitch attitude $v2+10$ to $v2+25$
- lower the nose and accelerate
- retract flaps
- if turn is necessary during flap retraction limit bank angle to 15 degrees
- reduce to climb thrust at 5 degrees flaps
- at 3000' AGL accelerate to 250 k or Vz (flapsUp+20), if Vz is greater than 250k do not exceed 15 of bank until Vz with flaps retracted
- engage autoflight system with Inav and vnav
- monitor acceleration to opt climb speed, after leaving 10000' accomplish climb check

Automatic Approach and Landing

Up left to down left (following path)

- Proper freq. Selected and identified, proper appr. Courses selected, vor adf switches set, marker on, volume set, minimums agreed and DH set as req.
- if vectored by atc use hdg sel, if nav with fmc use Inav, vnav and spd interventions, monitor progress using legs page of fmc and no map display
- maintain Vz
- establish maneuver conf. Vso as to cross outer marker in maneuver config with flaps 10
- select apr, monitor approach on PFD
- establish landing config.gear down, flaps 25
- maintain specified appr. Speed
- monitor annunciations on PFD
- make final check of pfd, annunciations at alert height
- monitor flare and roll out annunciations on PFD

Engine failure on takeoff

From left down, upwards

- chart pitch attitude V2
- if turn is necessary during flap retraction limit bank angle to 15 degrees
- retract flaps
- accelerate 0-500 fpm to Vz Up (flaps up bug)
- accomplish engine failure checklist
- continue climb at (flaps up bug) and limit bank angle to 15 dgrs if obstruction clearance so requires
- accelerate level to engine enroute climb speed unless returning to land



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Johan Dees, The Netherlands, 7 November 1998
johd@zeelandnet.nl

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Uwe Rademacher, Hannover, Germany, 8 March 2000
URademacher@t-online.de



APPENDICES



APPENDIX 7.1

7.1 CALCULATE REFERENCE SPEEDS

To properly calculate the reference speeds by hand the following values for stall speed are used as starting point:

	MTOW	NTOW	NLW	MLW
$V_{refFlp30}$	156	151	129	136

Note that V_1 , V_r and V_2 speeds are given in the takeoff section. Below is for FLAP configuration only.

FLAP CALCULATION.

So lets take the MLW of 297,500Kg (654,500Lbs). The Full Flap reference speed for this case is 131 KIAS. The speed for each flap is follows :

Minimum Clean	$V_{ref} + 100\text{Kias}$	$136+100 = 236$ Kias
Flap 0	$V_{ref} + 80$ Kias	$136+80 = 216$ Kias
Flap 5	$V_{ref} + 40$ Kias	$136+40 = 176$ Kias
Flap 10	$V_{ref} + 30$ Kias	$136+30 = 166$ Kias
Flap 15	$V_{ref} + 20$ Kias	$136+20 = 156$ Kias
Flap 20	$V_{ref} + 10$ Kias	$136+10 = 146$ Kias
Flap 30/full	$V_{ref} + 0$ Kias.....	$136+0 = 136$ Kias

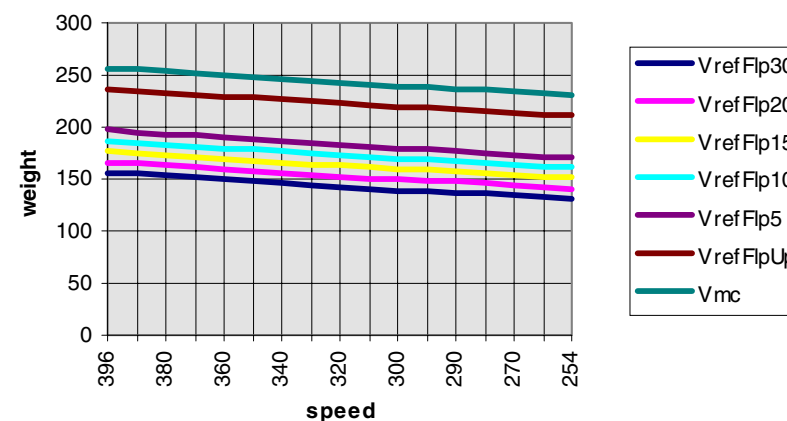
"Minimum Clean" This is the minimum speed that we want to fly in the Clean or Flaps up configuration. Minimum Clean is V_{ref} for Flaps30 plus 100Kias , or in other words Flaps UP speed plus 20Kias. (216+20)



APPENDIX 7.2

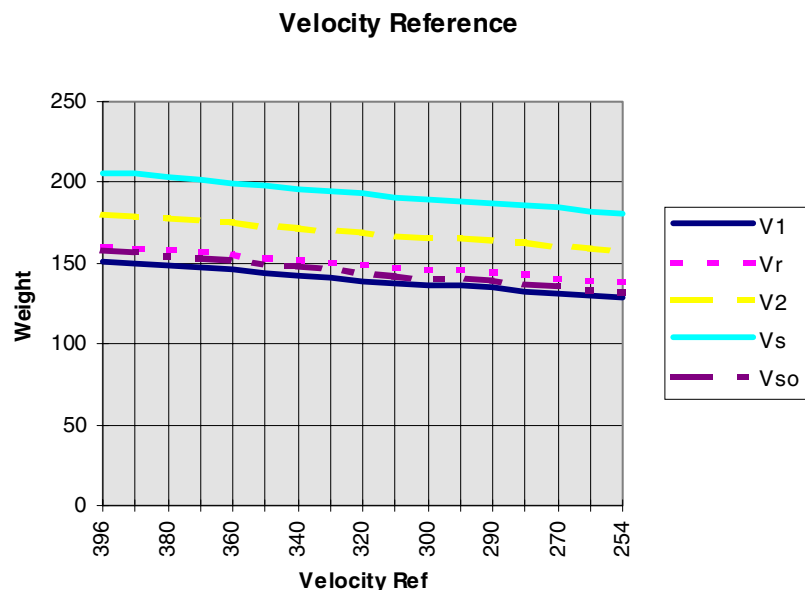
7.2 SPEED PADS

Flap configuration stall speeds 747



Above velocity reference chart displays the various stall speeds for takeoff with different weights.

Note that stall speeds in the chart are calculated and CAN differ with flightmodels. They are in fact a guideline.



Above velocity reference chart displays the various stall speeds for flap settings with different weights.

Note that stall speeds in the chart are calculated and CAN differ with flightmodels. They are in fact a guideline.

The speed pads on the following pages gives the stall speed at the corresponding configurations.

Add 20% for Vref calculations.



ton->	396	390	380	370	360	350
flap30full	156	155	153	151	150	148
flap20	166	165	163	161	160	158
flap15	176	175	173	171	170	168
flap10	186	185	183	181	180	178
flap5	198	195	193	191	190	188
flapUp	236	235	233	231	230	228
Min clean	256	255	253	251	250	248
v1	151	150	149	147	145	144
vr	161	160	159	157	155	154
v2	181	180	179	177	175	174
vs	206	205	203	201	200	198
vs0	158	157	155	153	152	150

ton->	340	330	320	310	300	297,5
flap30full	146	144	143	141	139	139
flap20	156	154	153	151	149	149
flap15	166	164	163	161	159	159
flap10	176	174	173	171	169	169
flap5	186	184	183	181	179	179
flapUp	226	224	223	221	219	219
Min clean	246	244	243	241	239	239
v1	142	141	139	138	136	136
vr	152	151	149	148	146	146
v2	172	171	169	168	166	166
vs	196	194	193	191	189	189
vs0	148	146	145	143	141	141



ton->	290	280	270	260	254
flap30full	137	136	134	132	131
flap20	147	146	144	142	141
flap15	157	156	154	152	151
flap10	167	166	164	162	161
flap5	177	176	174	172	171
flapUp	217	216	214	212	211
Min clean	237	236	234	232	231
v1	135	133	131	130	129
vr	145	143	141	140	139
v2	165	163	161	150	159
vs	187	186	184	182	181
vs0	139	138	136	134	133

V_{ref} Calculation

V_{ref} is the value needed for the current situation.

V_{ref} is 120% of the stall speed, calculated in above tables.

Add 5 knots to the V_{ref} value for safety reasons.

Use V_{ref} factor 120% for normal operation, and 130% factor for safer operations at worse weather conditions.

Note that 130% will increase the landing speed higher than 120%.

V_{ref} is the value that the airplane must be operated with!



RULES OF THUMB

- TOD** (Top of Descent) = 3 x (Current Altitude - Airport Elevation) (e.g. 3 x 39,000ft - 1,500ft elev = 113nm from airport). Use (b) to set the appropriate vertical speed based on TAS. Add 10% for unexpected tail wind.
- Descent Rate** (for 3° glide slope) = 5 x TAS (e.g. 5 x 400KTAS = 1200ft/min).
- Descent Altitude Check** = glide slope angle x 100 x Distance from RWY in nm (e.g. 3 x 100ft x 10nm = 3,000ft). For 4°, 400 x Distance; for 5°, 500 x D etc.
- TAS** = [(IAS x 2%) x (ALT/1,000ft)] + IAS. So, if IAS=300 and ALT=20,000: 300 x 0.02 x 20 + 300 = 420 kts TAS.
- Bank Angle** for Std Turns (i.e. Props 3°/s or 360° in 2 min; Jets 1.5°/s or 360° in 4 min). Props: BA = (TAS / 10) + 7; Jets: BA = (TAS / 10) x 0.75. Airliners: plan BA to be max. 25° for passenger's comfort.
- Rollout Angle** = BA / 2. (e.g. current HDG = 090; desired HDG = 270; BA = 30; RA = 30 / 2 = 15; so start RA when HDG 285 (i.e. 15° before reaching HDG 270).



NOISE ABATEMENT TAKEOFF PROCEDURE

The basic procedure is to climb out at a VERY steep climb angle....usually at V2 + 10 knot speeds, and then at 1000 feet above ground level the airplane nose is lowered to allow speed to build up WHILE the power is pulled back to a computer generated reading of the EPR(Engine Pressure Ratio) for that day's temperature and that day's airplane gross weight. In ballpark figures the EPR or engine power would be reduced some 15-20% from full climb power.

Allowed power is however to always give at least a 500 foot per minute climb rate while also giving a "target" pitch attitude that would allow an acceleration of the airplane for the flap retraction, depending on current weather conditions.



GROUND PROXIMITY WARNING SYSTEM

The 747-400 is equipped with a Ground Proximity Warning System, or GPWS. This system offers the following features to the aircraft and crew:

- OVERSPEED warning above 29,000' feet at 362 Kias or .92 Mach
- FLAP configuration (beep-beep) for take off wrong set. Minimum of 15 degree flap.
- PARKING brake configuration, detects improper use of the parking brake, like setting TO thrust with park-brakes on.
- STAB config, warns when TO trim is incorrect
- GEAR config, detects wrong gear configuration, i.e to low, use the gear etc.
- AP disconnect, when disconnect a siren sounds.

Inflight GPWS warning modes are:

1. Excessive descent rate alert: voice: "sink rate"
2. Excessive terrain closure rate alert: voice: "terrain, voop voop pull up"
3. Altitude loss after take off or go around alert: voice "don't sink"
4. Unsafe terrain clearance while not in landing configuration alert: voice: "to low flap" and/or "to low gear"
5. Below glideslope deviation alert: voice: "glide slope"
6. Windshear alert: voice: "windshear, windshear, windshear"



Another useful feature of the GPWS system is the altitude call out's during the final approach until touchdown. Altitude call-outs voices are given at the altitude's of:

500, 400, 300, 200, 100, 50, 40, 30, 20 and 10 feet AGL.

These altitudes are measured by the on-board altitude radar and are very accurate.

It is highly recommended to use the 300 - 200 feet warnings as the Decision Height warning if NO published DH's are available for the terminal area.

Pilots must always take appropriate action to the warnings.

For example:

- windshear alert at approach: a go-around must be initiated!
- glide-slope alert at ILS approach: a go-around must be initiated!
- pull-up warning: during landing a go-around must be initiated.

