OPERATIONS MANUAL

FLT CREW TRAINING

**PROJECT OPENSKY B737NG**

TAXI, TAKEOFF, CLIMB, CRUISE, DESCENT & LANDING**By Warren C. Daniel**

Project Opensky

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procedures, or airline carriers are strictly coincidental.

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The procedures contained within are this author’s interpretation of generic flight operations.

These procedures are not always accurate in all situations.

All diagrams have been recreated to mimic actual procedures or scenarios, however, are not

taken from actual materials whatsoever.

This manual is not intended for real world flight.

I have modeled this aircraft as accurately as possible to the best of my personal knowledge,

experience and available documentation. The only way I could model this aircraft further is if I

could arrange dedicated FAA Level D simulator time on this specific model and/or if I could obtain

further information. If you can help, I’d be happy to hear from you at:

Warren@projectopensky.com

**Project Opensky aircraft are intended as a freeware add-on for Microsoft Flight Simulator**

**2004.**

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3

**Project Opensky Boeing 737-700, -800, -900 Series**

**Version 2005.9.2**

**Model Designer**

Hiroshi Igami

**Flight Dynamics, Scenario, Effects Designer**

Warren C. Daniel

**Test Pilots**

Project Opensky Members

Flight model based on a full-flight training simulator used for pilots of a particular airline carrier,

737-700, -800, -900 data, as well as full-motion FAA simulator experience.

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4

**PREFACE**

This manual serves as a reference for operating procedures and training maneuvers. The flight

profiles show the basic recommended configuration during flight.

The maneuvers should normally be accomplished as illustrated. However, due to airport traffic,

ATC distance separation requirements, and radar vectoring, modifications may be necessary.

Exercise good judgment.

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5

**PRINCIPLE DIMENSION AND AREAS**

**Boeing 737-700, -800, -900 – Aircraft Reference Manual**

Flight Simulator 2004 Professional Edition

1) Height – 52 ft and 0 in

2) Length -- 159 ft and 2 in

3) Width -- 156 ft and 1 in

4) Engine to Ground Distance:

Minimum -- 2 ft and 5 in

Maximum -- 2 ft and 10 in

5) Fuselage to Engine Distance: (fuselage centerline to engine centerline)

28 ft and 8 in (255 in)

6) Landing Gear:

Track -- 15 ft 3 in

Wheelbase -- 64 ft and 7 in

There are 40 physical damage strike points on the 737NG model, as follows:

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**BASIC PILOT INFORMATION**

Pilot’s view reference point is approximately 12 feet 3 inches from the ground, with ground

visibility limited to 37 feet 7 inches looking down at an angle of 15 degrees. For proper engine

and aircraft operations, the captain must view the EICAS as the engines and wings **are not**

visible from the flight deck. Pilot’s rearward view is based on the captain’s eye reference point

with 130 degrees of travel.

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**Payload/Range for Long Range Cruise**

Review the payload and range for long range cruise for the trip gross weight.

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**Takeoff Runway Length Requirement**

Review the required takeoff runway length requirement for the aircraft at the trip gross weight.

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**Landing Runway Length Requirements**

Review the landing runway length requirements for the trip gross weight.

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**737NG V-speed calculation table**

Review the 737-800 v-speed calculation table. Recommended Opensky takeoff flap position is

Flaps 15. Please see the 737NG documentation by Matt Zagoren:

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**737NG Takeoff N1 Speeds**

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13

**TAXI**

1) The nose wheel steering and the engine thrust are used to taxi the airplane.

2) Make sure you have the necessary clearance when you go near a parked airplane or other

structures.

3) Set takeoff flaps. Opensky recommended setting is Flaps 15.

4) When the APU in the taxi airplane or the parked airplane is on you must have a minimum

clearance of 50 feet between the APU exhaust port and the adjacent airplane's wingtip (fuel

vent).

5) The taxi speed must not be more than approximately 30 knots. Speeds more than 30 knots

added to long taxi distances would cause heat to collect in the tires. Recommended speed is 20

knots. Beware of changing GS numbers due to tailwinds during taxi.

6) Before making a turn, decrease the speed of the airplane to a speed of approximately 8 to 12

knots. Make all turns at a slow taxi speed to prevent tire skids.

7) Do not try to turn the airplane until it has started to move.

8) Make sure you know the taxi turning radius.

9) Monitor the wingtips and the horizontal stabilizer carefully for clearance with buildings,

equipment, and other airplanes.

10) When a left or right engine is used to help make a turn, use only the minimum power

possible.

11) Do not let the airplane stop during a turn.

12) Do not use the brakes to help during a turn. When you use the brakes during a turn, they will

cause the main and nose landing gear tires to wear.

13) When it is possible, complete the taxi in a straight-line roll for a minimum of 10 feet.

NOTE: This will remove the tensional stresses in the landing gear components, and in the tires.

14) Use the Inertial Reference System (IRS) in the ground speed (GS) mode to monitor the taxi

speed.

15) If the airplane taxi speed is too fast (with the engines at idle), operate the brakes slowly and

smoothly for a short time. NOTE: This will decrease the taxi speed.

16) If the taxi speed increases again, operate the brakes as you did in the step before.

17) Always use the largest radius possible when you turn the airplane. NOTE: This will decrease

the side loads on the landing gear, and the tire wear will be decreased.

18) Extra care must be given to turn the aircraft due to the fuselage length and wingspan. A

minimum distance from the edge of the pavement must be maintained to reverse the aircraft’s

direction. Minimum distance is 75.2 FT.:

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19) Operate the brakes to stop the airplane.

20) Set the parking brake after the airplane has stopped.

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**TAKEOFF**

1) Align aircraft with runway centerline.

2) Increase power to approximately 55% N1, pause briefly to verify that engines have stabilized.

3) Watch EICAS indicator for engine problems or aircraft alarms.

4) Increase power smoothly to pre-determined N1 speeds based on aircraft takeoff weight,

(85% - 105% N1). This can either be done manually or using the autothrottle with the

autopilot engaged.

5) At Vr, smoothly rotate aircraft 8 degrees upwards at a pitch rate of 2 – 3 degrees per second.

DO NOT rotate more than 8 degrees to avoid tail strike. Tail strike will occur at 9 degrees

rotation.

6) Hold nose at +12 - 15 degrees after positive rate of climb is confirmed, then raise landing

gear after V2 (see below).

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7) Set initial climbout speed to V2+10 KTS.

8) Maintain +15 degrees climb to 1000 FT, or obstacle clearance, whichever is higher. +10

degrees climb after 1000 FT.

9) At 1000 FT above field elevation, begin slat retraction per retraction table. Maximum slat

speed limits are:

Flaps degrees KIAS

1 **230**

2 **230**

5 **225**

10 **210**

15 **195**

25 **190**

30 **185**

40 **158**

10) Increase speed to 230 – 250 in accordance with ATC instructions (max 250 KTS below

10,000 FT).

11) For full maneuverability beneath 10,000 FT, slats must be fully retracted with aircraft at

minimum safe airspeed.

**CLIMB**

1) Select highest CLB N1 setting. Once climb thrust or airspeed is set, the autopilot will

compensate for environmental condition changes automatically during the climb.

2) It is recommended that the aircraft be flown manually up to 15,000 FT, weather and ATC

traffic conditions permitting. However, in high traffic conditions, to easy the workload of the

pilot, the autopilot MCP altitude intervention may be engaged above a minimum altitude of 80

FT with the landing gear up.

3) Climb settings use a 10 – 20% derate of thrust up to 10,000 FT, then increases linearly to

max thrust at 30,000 FT.

4) For **enroute climb**, climb at a rate of 1800 - 3000 FPM, pursuant to ATC and traffic

conditions. If there is no altitude or airspeed restriction, accelerate to the recommended

speed. The sooner the aircraft can be accelerated to the proper climb speed, the more fuel

and time efficient the flight.

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5) As **engine and wing icing** may occur during the climb and descent, the engine anti-icing

system should be in the AUTO or ON position whenever icing is possible. NOTE: Failure to

do so may result in engine stall, overheating, or engine damage.

6) **For normal economy climb**, follow ATC speed restrictions of 250 KTS below 10,000 FT. If

permitted by ATC and no speed restriction below 10,000 FT, increase speed to 280 KTS.

Above 10,000 FT, climb at 300 KTS or .785 MACH. Climb speed table is as follows:

**ALTITUDE SPEED**

Sea Level to

10,000 FT

250 KTS

Above 10,000

FT

300 KTS/.785

MACH

7) **Max climb speed** is 300 knots until reaching .785 MACH at initial cruise altitude.

8) **For engine out climb**, speed and performance various with gross weight and altitude,

however 260 knots at 1000 – 1500 FPM may be used.

9) Set **standard barometer** above airport transition level (depends on local airport geography).

**CRUISE**

1) **Cruise** at .785 - .80 MACH.

2) **Headwinds** will increase engine power, reduce cruise speed and decrease range.

3) **Tailwinds** will decrease engine power, increase cruise speed and increase range.

4) Follow previously entered FMC waypoints.

5) **Fuel Freeze --** Extended operation at cruise altitude will lower fuel temperature. Fuel cools at

a rate of 3 degrees C per hour, with a max of 12 degrees C in extreme conditions. Fuel

temperatures tend to follow TAT (total air temperature). To raise fuel temperature/TAT, a

combination of factors can be employed:

- Descend into warmer air.

- Deviate to warmer air.

- Increase Mach speed.

An increase of 0.01 MACH will increase TAT by 0.5 – 0.7 degrees C.

6) **Increased fuel burn** can result from:

- High TAT

- Lower cruiser altitude than originally planned.

- More than 2,000 FT above the optimum calculated altitude.

- Speed faster or slower than .80 MACH cruise.

- Strong headwind.

- Unbalanced fuel.

- Improper aircraft trim.

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7) **Fuel penalties** are:

- 2000 FT above optimum – 3 percent increase in fuel usage

- 4000 FT below optimum – 5 percent increase in fuel usage

- 8000 FT below optimum –12 percent increase in fuel usage

- M.01 above M.80 – 3 percent increase in fuel usage

- Higher climb rates, 3000 fpm over 29,000 – increased fuel usage

8) In the case of **engine out cruise**, it may be necessary to descend. NOTE: For 737 **ETOPS**

**(Extended Twin-engine Operations)** limitations, divert to the nearest available airfield within

**180 minutes** (3 hr) to avoid overstressing engines and unnecessary risk. Use good

judgement to select an airfield that can accommodate an aircraft of this size. Consideration

must also be giving to ground facilities to accommodate number of passengers on board.

9) Trim aircraft for proper elevator alignment.

10) In case of engine out cruise, trim rudder for directional alignment.

11) Deviate from flight plan for weather, turbulence, or traffic as necessary after receiving

clearance from ATC.

**DESCENT**

1) Descent at pre-determined TOD (Top of Decent)

2) Descend at 300 KT above 10,000 FT.

3) Use speedbrakes or thrust to minimize vertical path error.

4) Proper descent planning is necessary to ensure proper speed and altitude at the arrival point.

Distance required for descent is 3NM/1000FT. Descent rates are as follows:

**Intended Speed Decent Rate**

CLEAN WITH

SPEEDBRAKES

.785 MACH/300

KTS

2300 FPM 5500 FPM

250 KTS 1400 FPM 3500 FPM

VREF 30 +

80 KTS

1100 FPM 2400 FPM

5) Plan to descend so that aircraft is at approximately 10,000 FT above ground level, 250 KTS,

30 miles from airport.

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6) At average gross weights, it requires 60 seconds and 5 NMs to decelerate from 290 KTS to

250 KTS for level flight without use of the speedbrakes. It requires 100 seconds to slow from

290 KTS to minimum clean airspeed. Using speedbrakes will reduce the times and distances

by half.

7) Arm speedbrakes and autobraking to position 2 or 3 on initial descent.

8) Set airport altimeter below transition level.

9) Avoid using the landing gear for drag above 180-200 KTS to avoid damage to doors or

passenger discomfort.

10) **Recommended approach planning**, ATC and airport rules permitting:

- 250 KTS below 10,000 FT, 30 miles from airport.

- 180-230 KTS, 23 miles from airport.

- 160 KTS, 16 – 17 miles from airport.

- VREF, 5 – 7 miles from airport.

11) **In case of rapid descend due to depressurization**, bring aircraft down to a safe altitude as

smoothly as possible. Using the autopilot is recommended. Check for structural damage.

Avoid high load maneuvering.

12) **Bank Angle Protection (BAP)** is not available on the 737. Over 36 degrees of bank, an

audio “bank angle” alarm will sound.

13) **Stall recovery** can be accomplished by lowering the aircraft’s nose and increasing power at

once to gain airspeed. Beware of terrain. Accelerate to VREF 30 + 80 KTS. Do not retract

gear until confirmed stall recovery and positive rate of climb. Keep nose at 5 degrees above

the horizon or less.

14) If deployed, do not retract slats during the recovery, as it will result in altitude loss.

15) In the event of engine out approach, approach at VREF+5 @ flaps 20.

16) Under normal conditions land at VREF @ flaps 30.

17) **ILS Approach** - During initial maneuvering for the approach, extend flaps to 5 and slow to

180-200kts. When the localizer is alive, extend flaps to 15 and slow to 170kts. At one dot

below glideslope intercept, extend the landing gear and flaps to 20. Begin slowing to final

approach speed. At the final approach fix, extend flaps to 30 and slow to Vref + 5. Be

stabilized by 1000 feet above field level. This means, gear down, flaps 30, Vref +5 and

engines spooled. Plan to cross the runway threshold at Vref.

18) **Visual Approach** - Similar to the ILS approach. The major difference is that aircraft must be

stabilized by 500 feet above field level, as opposed to 1000 feet.

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19) A stabilized approach at Vref +5 will result in a pitch attitude of 2-3 degrees nose up. Cross

the threshold at Vref. Begin the landing flare at about 30ft. Only about 1-2 degrees of pitch up

is necessary. The tail will strike at approximately 9 degrees. Slowly reduce thrust to nearly

idle. Landing with thrust at idle will result in a firm touchdown. Set thrust just above idle. At

touchdown, fly the nosewheel on. At touchdown, autospoilers should deploy. Deploy reverse

thrust. Normally, auto brakes 1 is sufficient stopping power. 2 is sufficient for short or wet

runways. Be out of reverse thrust by 80kts to prevent foreign object damage to the engines.

20) For **wind correction**, add ½ the steady state wind plus all of the gust factor to the Vref. Do

not add more than 20 kts. When landing in a crosswind, do not bank excessively as wingtip

or engine pod strike may occur.

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21

**737NG Landing VREF Speed Chart**

21) The Project Opensky 737NG is a CATII/III aircraft, meaning the aircraft is capable of landing

on autopilot in conditions where visibility is down to 50ft AGL.

22) Land the aircraft.

23) Disengage (autopilot autothrottle will disengage) reverse thrust at 80 knots.

24) Disengage auto braking at 60 knots or as necessary.

25) Turn off onto high-speed taxiways at 30 knots or less.

26) Reverse thrust is most effective at higher speeds. Slow to safe taxi speed with braking and

exit the runway.

27) Decelerate to 8 – 12 knots for 90 degree turns.

28) Taxi to gate.

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**Project Opensky Boeing 737NG – Frequently Asked Questions**

**Q) OMG, the FDE is much harder to fly than before. The plane is more difficult to handle.**

**What happened?**

A) After spending time in DC-10, 737, 747-400, 757, 767, and 777 Level D simulators, I realized

that the performance for the previous generation of FDEs was there, however, I grossly

underestimated the actual “feel” of large aircraft. In large commercial airliners the control surfaces

are effective, however, the sheer mass and inertia of the plane cause delays in how quickly the

aircraft reacts to inputs.

To date, all FDEs I have flown (including my own) have failed to capture this critical element –

inertia. This new generation of FDEs is designed to show the average flight simmer exactly how

difficult it is to fly a large aircraft, particularly in adverse weather or emergency conditions.

I have flown small aircraft, Level D simulators, and have been designing FDEs for nearly 10 years

now. I can confidently say now, THIS is how the real aircraft FEELS and PERFORMS. I feel I

have captured about 95% of how the actual aircraft feels in a Commercial Level D simulator and

actual flight. The remaining 5% I could not capture are things such as airframe vibration through

wing flap (fueled wings which are off-center have quite a lot of inertia of their own) and control

surface slip (first the control surfaces “bite” into the air, then they begin to move the aircraft after

some point in time– this feeling is difficult to mimic without an actual motion sim, although I have

added more “slip).

The control surfaces are heavy, but effective. If you actually take the time and LOOK at a large

aircraft, you will notice the control surface, say an aileron, has only a small surface area in

relation to the rest of the plane. These surfaces must “push” the aircraft in the desired direction.

As in the actual aircraft, you will find yourself often “overcompensating” and correcting when you

fly manually until you become used to the feel.

If you find the aircraft a challenge to fly, imagine an engine out emergency, landing in gusty or

side wind conditions, or on wet/icy runways. My goal is to show you what an actual commercial

pilot experiences.

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**Q) But the controls are SO heavy. Are you sure this is right?**

A) The control surfaces require 45 – 55 lbs of force to move the yoke, control wheel and rudders.

This new generation of FDEs places emphasis on both performance AND feel. I am not trying to

make a video game – I’m designing flight simulator dynamics.

**Q) It’s hard to keep her on the runway with a stiff crosswind. What do I do?**

A) Typically, you will want to crab into the wind as you approach the airport. On reaching the

threshold, you want to aim at the side of the runway into the wind. As you touchdown, use the

rudder to yaw the aircraft straight. You will feel the tires scrubbing across the pavement as the

wind and your momentum pushes you across the runway with the direction of the wind.

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**Q) It’s hard to stop. Reverse thrust is very un-effective. How do I stop more effectively?**

A) The majority of stopping power when landing is from the brakes. The thrust reversers do

almost nothing to stop the airplane. Set your auto brakes to position 2 on initial decent, but don’t

be afraid to use position 3. On shorter fields and higher gross weights, it may be necessary to

use position 4 or max braking.

**Q) I can’t climb as high as I thought. What is wrong? Am I too heavy?**

A) Most likely. **See Matt’s 737 performance document included in this package.**

**Q) Why is it that when I load the aircraft in FS2004, it’s usually overweight?**

A) Typically, when you load an aircraft into FS2004, it maximizes everything – both fuel and

payload. I design the FDEs so that you know the MAXIMUM capacity of the payload or fuel tank

on a typically route. It is up to you, the pilot, to REMOVE fuel for higher payload capacity.

Conversely, for longer range, you must add fuel and REMOVE payload. I design the FDEs this

way to eliminate questions on “what is my maximum or typical allowed capacities”.

**Q) What sound settings do you recommend?**

A) Set your sound options to the following:

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For the most part, you mainly hear the hiss of pressurized air and the sounds of the flight deck.

You practically don’t hear the engines at all, except on takeoff, climb out, and when the thruster

reverses engage. Other than that, the large PWs, RR Trents, or GEs are quiet as a mouse. My

sound files are mixed for these settings. Not using these settings will not result in the desired

effect.

**Q) When I taxi, I can’t turn. What’s wrong?**

A) You must slow down to 30 knots for high speed turnoff taxiways, 8 to 12 knots for 90 degree

turns, and about 3 - 5 knots for turns over 120 degrees. Basically, the maximum turn angle of the

737NG nose gear is 78 degrees. Slip causes you to only achieve 75 degrees of effective steering.

Attempting to turn at higher speeds will result in tire rollover and push, resulting in the airplane

still going straight ahead.

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**Q) How can I perform trip/flight planning and fuel planning?**

A) Use the default Microsoft flight planner and navigation log. When you plan your trip, then look

at the navigation log for the fuel required for your trip. The value listed at the top includes your as

trip block fuel. However, it does NOT include your taxi and reserve/deviation fuel quantities. For

the 737, add 5,000 lbs of reserve fuel, plus 1,200 lbs taxi fuel, for a total of 6,200 extra lbs of fuel.

To use the flight planner: 1) Load the aircraft, 2) download real-world weather or set your

weather, 3) use the trip planner, then 4) review your navigation log. The 737 FDE is now adjusted

for the default Microsoft Fuel Planner, however, you will notice on longer haul flights with real

world wind, the Flight Planner does not take into account headwinds/tailwinds.

**Q) The thrust reversers are very ineffective. I can’t stop? Is this right?**

A) The thrust reversers are very ineffective. 80% of the stopping power actually comes from the

wheel brakes.

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**Q) What is the proper trim for takeoff?**

A) It depends on your weight and station loading according to the MAC% of the plane for your

flight. However, in general, it should be about neutral trim at 7 degrees, to nose up of 7.5 degrees.

In flight, it may be necessary to adjust your trim up or down depending on your conditions. Note, if

you takeoff and the plane either noses up too early, or is hard to lift the nose with excessive nose

down attitudes, you are mis-trimmed and would need to adjust your trim settings.

**Q) What is this Lesson you have included in the package?**

A) This is a sample, real-world flight in the B737-800 from Chicago O’Hare to Boston Logan.

Read the scenario for all the details of your flight. The goal is to present more real-world aviation

knowledge to the Flight Simulator Community. Enjoy your flight.

**Q) What are good sources of online information on the 737?**

A) I cannot stress these links enough for 737 fans:

**Boeing Website - 737 Family -** Filled with official Information

http://www.boeing.com/commercial/737family/technical.html

**The Boeing 737 Reference Website -** Filled with procedures and information

http://www.737.org.uk/